جامعة الملك سعود
King Saud University

Mechanical Engineering Department

Heat transfer Project

R-Value of composite walls using different type of insulation materials.

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Thursday, 12th of December 2019

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Nomenclature:

R-value	Thermal Resistance	[m^2.K/W]
k	The thermal conductivity	[W/m.K]
L	Thickness of the material	M

Introduction:

Having a properly insulated home is key to energy efficiency. Your home's insulation acts as a thermal resistor that controls the airflow passing in and out of your home. If you have noticed a steady increase in electric bills, yet you feel like you are consuming a consistent amount of energy, your insulation could be in need of replacement. In addition, insulation goes beyond just maintaining energy efficiency; it also reduces outside noise, moisture. By having the proper R-value, your home's insulation will be more effective. You can cut down on those utility bills by as much as 30% and even be eligible for a federal tax credit. Having the correct amount of insulation in your home reduces the heat flow, which in turn reduces the amount of energy required to heat or cool your home. To maximize energy efficiency, your home should be insulated from the basement through the attic. Start by determining what type of insulation is needed to meet the required R-value level. R-value is the level that your home can resist heat flow going through its walls and insulation. A home's thermal resistance is based on the R-value, where the higher the R-value, the greater the effectiveness of the insulation resisting unwanted airflow. Several factors determine what R-value is needed for your home including the insulation material, its thickness, and its density. There are recommended R-value levels for each climate zone and those values can even be narrowed down to whether the insulation is installed in the basement or the attic.

Objective:

- To thermally insulate walls by comparing and choosing the best insulator with respect to the R-value and the cost using 5cm thickness insulation materials.

Analysis and theory:

This Formula can calculate R-Value:

$$R - value = \frac{L}{K}$$

Where L = 5cm = 0.005m

In order to find the best insulator first we need to choose insulation material and find the cost and the thermal conductivity for each one of them, the material that have been chosen is in the following table:

Table 1 Material name, Thermal conductivity, cost and R-value

Material	Thermal conductivity (W/m.k)	Cost (SR/m^2)	R-value (m^2.k/w)	Cost/R-value (SR.w/k)
Glass wool	0.032	1.81	0.156	11.6
Rock wool (Earth wool)	0.035	1.67	0.143	11.7
Phenolic (Kooltherm K5)	0.023	10.6	0.217	49
extruded polystyrene	0.034	5.2	0.147	35
Polyisocyanurate board	0.023	9.713	0.217	44.76

Polystyrene board	0.042	2.3	0.12	19.17

Result:

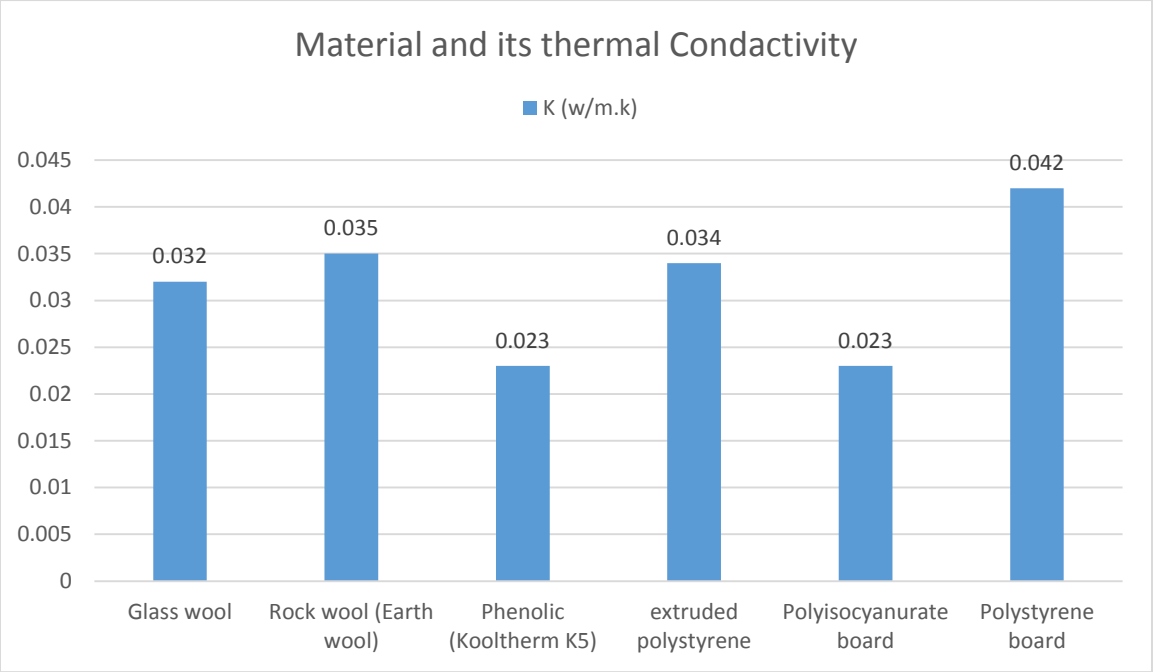

Figure (1) K value for chosen materials

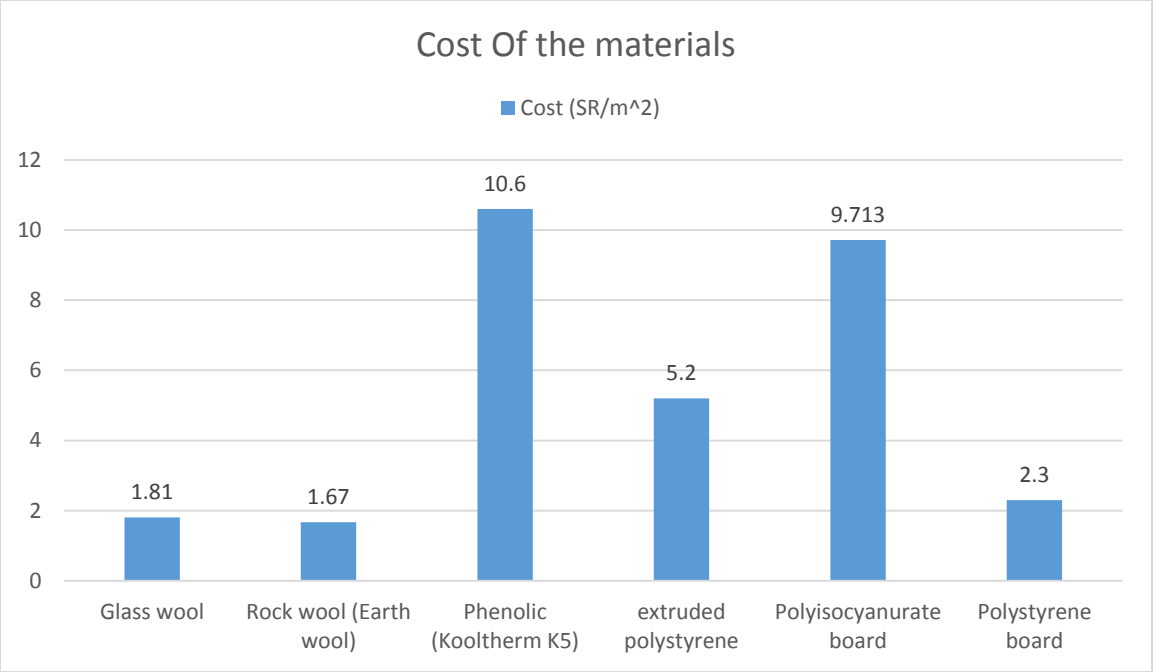

Figure 2 Cost for chosen materials

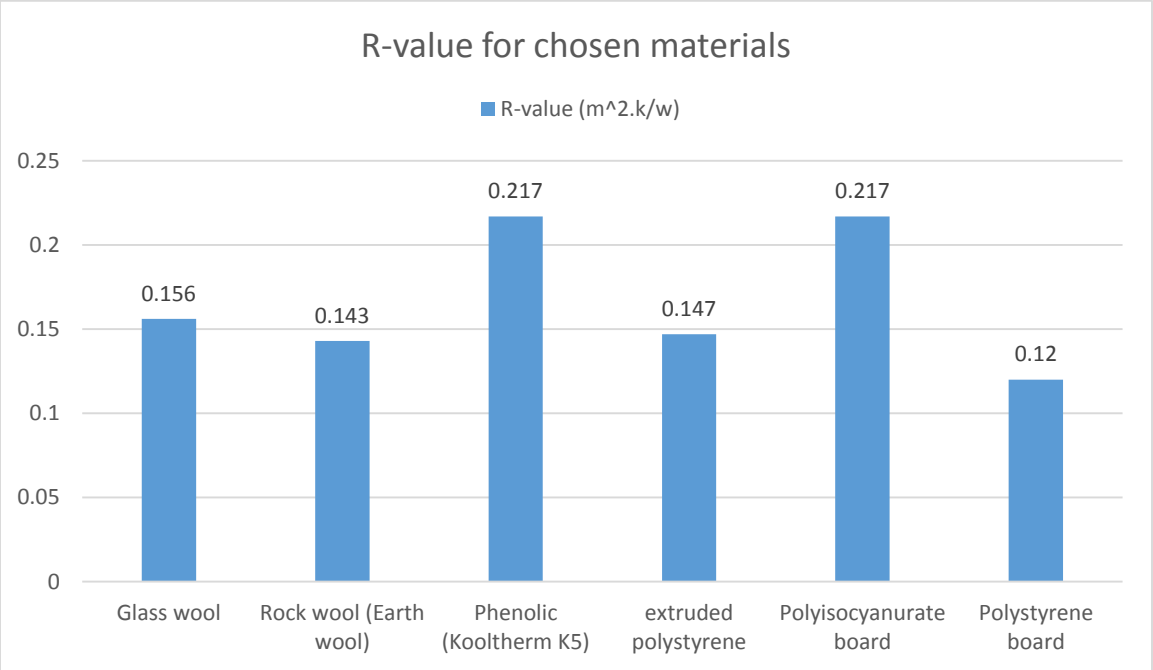

Figure 3 R-value for chosen materials

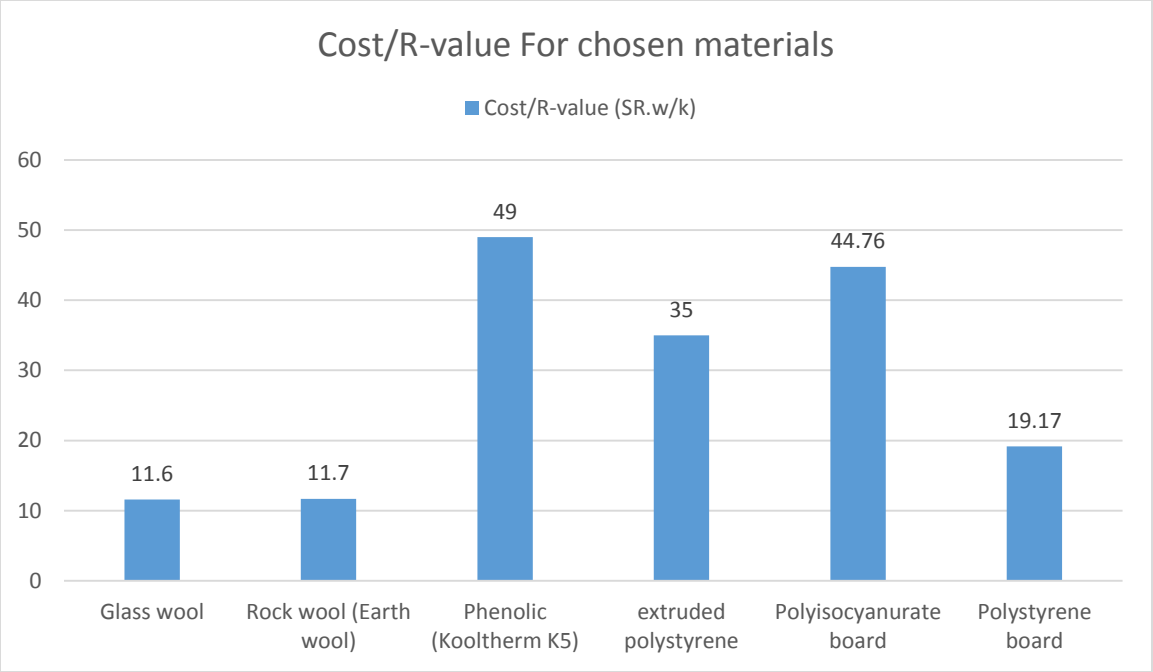

Figure 4 Cost/R-value For chosen materials

Sample of calculation:

Choosing three random material from the table to show the calculations:

1) Glass wool:

Thermal conductivity K= 0.032 (W/m.k) , Cost = 1.81 (SR/m^2)

$$\text{R-value} = \frac{L}{k} = \frac{0.005}{0.032} = 0.156\ W/mK$$

$$\frac{SR}{Rvalue} = \frac{1.81}{0.156} = 11.6$$

2) Phenolic:

Thermal conductivity K= 0.023 (W/m.k) , Cost = 10.6 (SR/m^2)

$$\text{R-value} = \frac{L}{k} = \frac{0.005}{0.023} = 0.217\ W/mK$$

$$\frac{SR}{Rvalue} = \frac{10.6}{0.217} = 49$$

3) Polystyrene:

Thermal conductivity K= 0.042 (W/m.k) , Cost = 2.3 (SR/m^2)

$$\text{R-value} = \frac{L}{k} = \frac{0.005}{0.042} = 0.12\ W/mK$$

$$\frac{SR}{Rvalue} = \frac{2.3}{0.12} = 19.17$$

Discussion:

In order to find the best insulation material we need to compare the result between the materials, in **figure 1** we can see that **Polystyrene board** has the highest thermal conductivity (K) and both the **Polyisocyanurate board** and **Phenolic** has the lowest thermal conductivity (K). **Figure 2** show the cost per meter square and we can see that **Phenolic** is the most expensive one and the **Rockwool (Earth wool)** is the cheapest. In figure after using the equation we found the R-Value for every materials, we can see from **figure 3** that the **Polyisocyanurate board and Phenolic board** has the highest R-value, that's mean it's the best insulation materials regardless of the price, and the lowest R-value was for the **polystyrene**, which means it is the worst comparing with the other materials.

To consider the effect of the price we found the ratio between the cost and R-value, which can be seen in **figure 4, Rock wool (earth wool) and Glass wool** have the best result which is equal to 11.6 and 11.7 respectfully, the lowest result was for the **Phenolic board** and **Polyisocyanurate** board with result equal to 49 and 44.76 respectfully.

Conclusion:

To conclude the result, the **Phenolic** board and **Polyisocyanurate** board is the best insulation material and **polystyrene** was the worst if we consider R-value only (figure 3), but if we consider the cost the **Phenolic** board and **Polyisocyanurate** board will be the worst (figure4), that's mean both of the material is so expensive with respect to its thermal conductivity (K).

Rock wool (earth wool) and **Glass wool** have average R-value comparing with other materials, but it is the best insulation materials if we consider the cost.

References:

1) All prices have been taken from the insulation shop website: https://www.insulationshop.co/