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Thermal Insulation of Insulated Concrete Form

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ABSTRACT

Conventional building technique has long dominated the Malaysia construction field, but one of its weakness is that these materials all have relatively low thermal resistance properties. This will lead to the building interior temperature varies when the exchange of day and night circle. Therefore, human comfort in the building is less guarantee. To counter with that, the best way is to use the air conditioning unit, but this will consume lots of electrical energy. Although the Insulated Concrete Form (ICF) technique has been long introduced in the North America and Europe countries, the awareness related to building thermal insulation is relatively low when compared to Asia countries, including Malaysia. This has caused a high electrical power consumption, in the meantime accelerates the use of non-renewable natural resources to generate electricity. Therefore, introducing ICF into the Malaysia construction field can help to solve this problem because the ICF combines the polystyrene panels into its construction. In common, polystyrene is popular in the food industry sector due to its naturally excellent thermal resistance property. Therefore, this research will be conducted by creating a polystyrene block. Three blocks with a different outer surface, which are 2 inches, 4 inches and 6 inches are involved in this research. The outer surface will be illuminated and heated with the use of a halogen lamp, and the temperature on both outer and inner surface will be recorded with the use of an infrared thermometer. The thermal resistance slightly increases with the increased thickness of the outer layer. The difference is between I to 2°C when increasing the thickness by 2 inches. Further research can be conducted on a larger scale sample such as ICF wall or a complete ICF house which could more accurately determine the effectiveness of ICF to achieve human comfort.

Keywords:
Insulated Concrete Form ICF; thermal insulation; green building technology; Global warming; human comfort

1. Introduction

The ICF has other significant advantages when compared to conventional building materials, such as stronger structural integrity, higher R-Value against heat infiltration, high durability of both insulation and structural components, lightweight, high versatility, and more resilient towards natural disaster, fire and impact [1].

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The concept of stay-in-place formwork was first to come out during World War II, where the Britain Army tends to find a cost-effective method to repair war-damaged buildings. Back there the blocks of treated wood fibers held together by cement. Improvements were made, until the 1980s, the Insulating Concrete Form Association (ICFA) was founded to research and promotion of the products and building code acceptance. Until today, the ICF technique can be used in a variety of commercial projects such as apartments, condos, hotel, retail, single-family residential and multifamily [2].

The Insulated Concrete Form (ICF) is manufactured from mainly three components, polystyrene as the molding device, concrete as the core and plastic webbing that serves to hold the polystyrene from bursting when pouring in the concrete. Compared to the similar size of the Concrete Masonry Unit (CMU), the ICF is 29 times lighter and construction period can reduce to half. Moreover, the construction can speed up since the ICF stays in place while awaits the concrete sets. The construction process was to place the hollow foam blocks or panels into the shape of the walls of a building, then fill with steel-reinforced concrete that will form a solid structure, which is sandwiching by light but high insulation foam, which are airtight, strong, quiet, highly insulated, pest and fire resistance [3].

2. Methodology

The ICF block was made up from two different components, which are polystyrene and concrete. The polystyrene was cut into the desired dimension before they were used to assemble the block which acts as a mould to hold the concrete inside them. To ensure the block was withstood the pushing factor of the freshly poured concrete, thus the thickness of the panels used to assembly is 2 inches thick. After the assembling of polystyrene panels into a complete block, freshly made concrete was poured into it and set for 28 days before proceeding down to the next step of the experiment.

In order to study the efficiency of the block thermal resistance, continuous heating and cooling will be carried out on the block outer surface. A 1,000W halogen lamp is used to illuminate heat source onto the outer surface of the block, continuously for 1 hour, then entering a cooling period for another 1 hour. Each progress is carried out three times, which is a total of 6 hours per testing. The purpose is to stimulate a day and night circle changing, where the building outer wall is heated and cooled repeatedly. For every 15 minutes during the test, both outer and inner surface temperature will be recorded by using Infrared Thermometer, which allows the user to remotely measure the temperature without touching the surface. Different thickness of outer wall was tested, which are 2 inches, 4 inches and 6 inches, which aims to determine how effective the external wall thickness can affect the heat energy transfer from one side to another through conduction.

3. Results

Two inches wall is the most common thickness used in the ICF manufacture companies, which claimed that under this thickness can provide the most minimum requirement where one could enjoy the benefits of ICF built house. Thus, the 2 inches outer wall will be tested for 3 times, and to obtain an average, but more accurate results on the effectiveness of ICF block.

Table 1
Average Reading on 2 Inches Outer Wall

t/min	Activity	Outer surface temperature, θ(°C)	Inner surface temperature, θ(°C)
0		26.47	26.43
15		33.03	26.73
30	Heating	37.93	26.83
45		43.6	27.07
60		47.7	27.13
75		45.93	27.2
90	Cooling	44.6	27.17
105		41.93	27
120		38.53	26.8
135		40.87	26.73
150	Heating	44.37	26.9
165		46.97	27.07
180		49.2	27.3
195		47.17	27.37
210	Cooling	44.87	27.3
225		41.7	27.17
240		39.07	27
255		41.4	26.97
270	Heating	44.9	27.2
285		47.43	27.47
300		49.57	27.57
315		47.6	27.6
330	Cooling	44.93	27.5
345		42.1	27.37
360		39.63	27.13

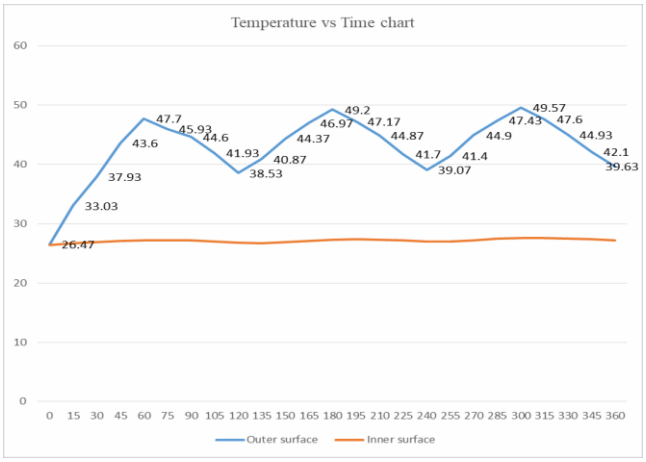

Fig. 1. Average Reading on 2 Inches Outer Wall

Table 2
Temperature Comparison for 2 Inches, 4 Inches and 6 Inches Outer Wall

t/min	2 inches		4 inches		6 inches	
	Outer, °C	Inner, °C	Outer, °C	Inner, °C	Outer, °C	Inner, °C
0	26.47	26.43	26.7	26.6	26.7	26.6
15	33.03	26.73	32.7	26.8	32.5	26.7
30	37.93	26.83	37.5	27	37.1	26.9
45	43.6	27.07	41.6	27	40.9	27
60	47.7	27.13	46.8	27.1	46.1	27.1
75	45.93	27.2	44.7	27.1	43.6	27.2
90	44.6	27.17	41.3	27	41.1	27
105	41.93	27	39.1	26.9	38.5	26.8
120	38.53	26.8	36.9	26.9	35.4	26.6
135	40.87	26.73	39.4	26.7	38.4	26.7
150	44.37	26.9	43.1	26.7	42.4	26.8
165	46.97	27.07	46.8	26.7	45.1	26.8
180	49.2	27.3	48.8	26.8	47.9	27
195	47.17	27.37	45.9	26.9	45.2	27.1
210	44.87	27.3	42.3	26.9	41.3	27
225	41.7	27.17	39.8	26.8	38.5	26.8
240	39.07	27	36.7	26.7	36.1	26.9
255	41.4	26.97	40.1	26.6	39.7	26.7
270	44.9	27.2	42.7	26.7	42.5	26.8
285	47.43	27.47	45.9	26.7	45.1	26.8
300	49.57	27.57	47.9	26.9	46.8	26.9
315	47.6	27.6	45.6	27	44.9	27
330	44.93	27.5	43.1	27	42.2	27
345	42.1	27.37	41.4	26.8	39.7	26.8
360	39.63	27.13	37.2	26.7	36.5	26.7

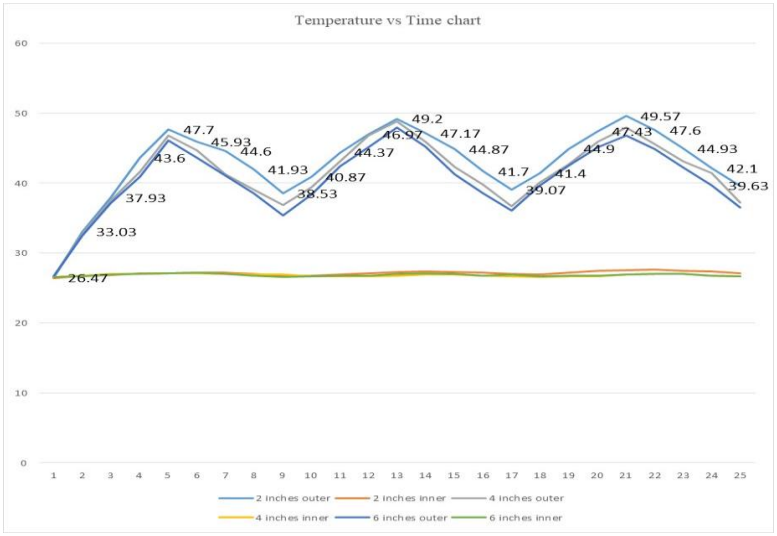

Fig. 2. Graph Comparison between Thickness 2, 4 and 6 Inches Outer Wall

4. Conclusions

The increase outer layer thickness will increase the block thermal resistance value, but at an insignificant amount. Thus, it is recommended that choosing the suitable thickness for the construction can not only cut down the budget but also generating more spaces in the house since the wall thickness can be reduced. Moreover, polystyrene is not the only recommended material that can be used for the building thermal insulation purpose. Some other materials such as fiberglass, mineral wool and cellulose are also widely used in building thermal insulator layer and worth making a comparison with the polystyrene, which is the ICF.

The eco-friendly building material had high demand in the market as to reduce the environmental issues. Based on the result obtained from the research, it is clearly showed that the ICF can effectively hinder the heat transfer. But however, the ICF will be slightly costly due to the combined of formwork into part of the building system. Conventional methods allow the formwork to be removed once the concrete set, while the ICF does not. On the other hand, this provides the ICF to have naturally installed thermal insulation layer where the R-Value is higher compared to conventional methods. For a long term, the money spent on purchasing the ICF will be converted into the saves obtained from using less electrical energy, where this not only solves the building thermal insulation problem but also consuming less natural resources to be burned to generate electricity.

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