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جامعة الأخوين
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POLYSTYRENE AND 65% POLYSTYRENE CONCRETE, CELLULOSE WITH GYPSUM, AND TREATED GLASS WOOL Insulations for a Model House in Zaouiat Sidi Abdessalam: Comparative Study

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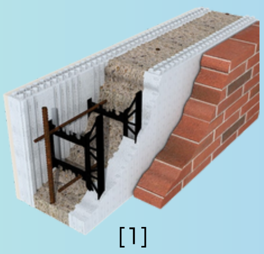
Introduction

In recent years, there has been a growing interest in using polystyrene, Cellulose, and fiberglass as building materials due to their energy efficiency and durability as wall insulation. In cold regions like Zaouiat Sidi Abdessalam, where humidity, mold, and cold are major concerns for homeowners, the use of one of these materials can offer a cost-effective solution to insulate the walls and prevent moisture buildup.

The model house in Zaouiat Sidi Abdessalam suffers from high moisture buildup and thermal conductivity. The house is attached to two buildings from the east and west only. The insulation should be applied to the north and south facades of the house because they are the free facades and the ones that have the most humidity due to their direct contact with the precipitations. The walls are built with limestone and limestone clay.

This study aims to compare the thermal conductivity and water absorption ratio of three types of insulation materials: ICF with 65% polystyrene concrete, cellulose with gypsum boards, and SH-AF-coated glass wool. The analysis will evaluate the performance of these materials and determine the most suitable option for this specific project. The results of this study will help homeowners and builders in Zaouiat Sidi Abdessalam make informed decisions on selecting the most appropriate insulation material for their homes at an affordable price while improving the overall energy efficiency and comfort of their living spaces.



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Methodology

The main purpose of this paper is to identify the most suitable insulation method that will prevent both water absorption and heat leaks. The approach is as follows:

- Step 1: Analysis of the ICF with 65% polystyrene concrete's thermal resistivity, water absorption, and heating/cooling demand after the installation.
- Step 2: This step aims to analyze the thermal resistivity and water absorption of the cellulose insulation, as well as study its heating and cooling performance after its implementation.
- Step 3: The third step has the purpose of identifying the same characteristics of the fiberglass insulation and studying its heating/cooling performance under certain criteria after being installed.
- Step 4: The final step serves as a trade-off analysis and discussion to identify the best insulation at affordable costs.

The formulas used for this study are as follows:

- Thermal resistivity (K·m²/W) = $R = e/\lambda$
- Water Absorption (%) = Wt = Volume Fraction * Water Absorption %
- Thermal Transmission Gains (Wh) = Etr= U*A*(T0-Ti)*1
- Ventilation & Infiltration Gains (Wh) = Event+inf= (mv + mi)* Cp*(To-Ti)
- Solar Gains (Wh) = Esol= fglass* gshade* A*Psol*2
- Internal Gains (Wh) = Eint= Eint.people+ Eint.appliances+ Eint.lighting

Results and Discussion

The following step aim to identify the best insulator and water absorption prevention to install on the model house walls in the region of Ifrane. The current walls' thickness is 200mm made of stone and stone clay. The characteristics of the current walls and house are summarized in Tables 1 and 2. The heating and cooling analysis is conducted on only two walls, one facing north and the other one facing south, since they are the only walls to be insulated

Table 1: Current wall's parameters

	Limestone
Thickness	150 mm
Thermal Conductivity	1.26 W/(m.k)
Water Absorption Ratio	11.69%

Table 2: Heating/Cooling Demand Analysis Assumptions

Parameter	Value
North Facade Area	20 m²
North Facade Window	1 m²
North Facade Area	17 m²
North Facade Window	1 m²
ACH	1
Interior Temperature	20 Degree C.
Exterior Temperature	-5 Degree C.
Number of Residents	4
Mass Flow of infiltration, mi	0.058 kg/s
Mass Flow of Ventilation, mv	0.06 kg/s
Specific heat of air, Cp	1000 J/KgK
Volume of the house	174 m3
Appliances	6 Incandescent light bulbs Stove Fidge 2 phone chargers 1 Television

Table 3: ICF Insulation's parameter

	Polystyrene Foam	65% Polystyrene Concrete
Thickness	70 mm	20mm
Thermal Conductivity	0.04 W/(m.k)	0.295 W/(m.k)
Water Absorption Ratio	2%	4.5%

Table 4: Cellulose Insulation's parameter

	Cellulose	Gypsum Board	Polyethylene Vapor
Thickness	60 mm	26mm	5 mm
Thermal Conductivity	0.04 W/(m.k)	0.29 W/(m.k)	0.4 W/(m.k)
Water Absorption Ratio	50%	2%	Perm = 0.070 perm

Table 5: Glass Wool Insulation's parameter

	SH-AF- Coated Glass Wool
Thickness	100 mm
Thermal Conductivity	0.038 W/(m.k)
Water Absorption Ratio	0.46%

Discussion

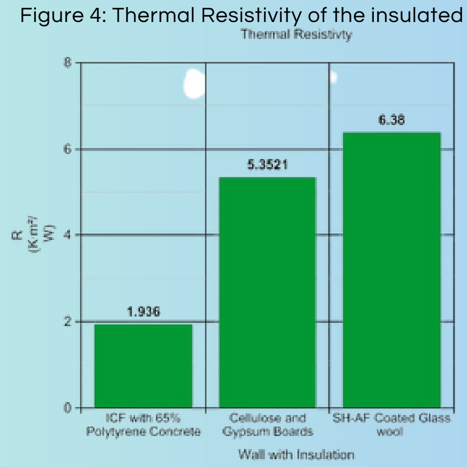
The results of three different types of insulation applied in a wall for a lower-middle-class house in a chilly climate are shown in the table below. Thermal Resistivity (measured in Km2/W), Water Absorption (measured in%), and Heating/Cooling Demand (measured in Wh) are the parameters for which the findings are provided.

ICF with 65% polystyrene concrete has the lowest Thermal Resistivity of the three at 1,936 Km2/W. It is therefore less effective in retaining heat within the home. It does, however, have the lowest water absorption rate of 2.53%, which is advantageous for places that receive a lot of precipitation or moisture.

The Thermal Resistivity of cellulose and gypsum boards is 5,3521 Km2/W, suggesting that they provide superior insulation than ICF. It does, however, absorb a lot of water (19.49%), which can cause structural damage and mold growth over time.

The best insulator among the three is SH-AF Coated Glass Wool, which has the maximum Thermal Resistivity of 6.38 Km2/W. It also has a reduced water absorption rate of 7.8 percent, which is lower than that of cellulose and gypsum boards. However, it must be handled with caution because it may emit microscopic glass particles that can cause lung issues.

Figure 4: Thermal Resistivity of the insulated wall



In Figure 6, the cooling demand increases with the increase of thermal resistivity due to the lack of heat transferred between the warm interior and cold exterior. The ICF with 65% polystyrene concrete has the lowest heating and cooling demand of 705,826 Wh, showing that it is the most energy-efficient of the three. Cellulose and gypsum boards, on the other hand, have the highest heating and cooling demand of 1010,2966 Wh, followed by SH-AF Coated Glass wool with 1038,1785 Wh.

Table 6: Cost of the three insulation materials

	ICF with 65% Polystyrene Concrete	Cellulose with Gypsum Boards	SH-AF Coated Glass Wool
Cost	$$$$	$$	$$

Based on the results obtained and the costs, SH-AF Coated Glass Wool looks is the greatest option for insulation in a lower-middle-class house in a cold region, as it has the highest Thermal Resistivity, a reduced water absorption rate, and a fair heating and cooling demand.

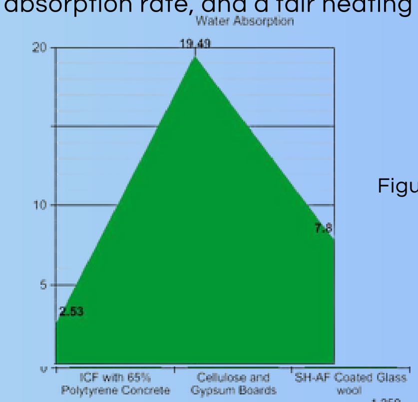


Figure 5: Water Absorption of the insulated wall

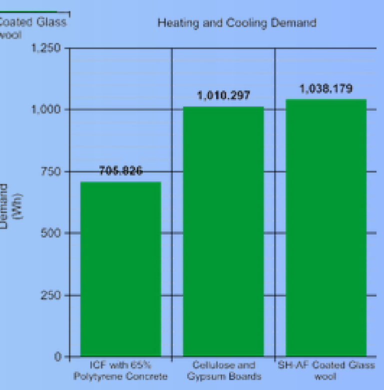


Figure 6: Heating/Cooling Demand of the insulated wall

Conclusion

This research article described a study to increase the energy efficiency and sustainability of a model house in Zaouiat Sidi Abdessalam. The goal of this article is to pick one insulation material that would reduce moisture absorption and improve the heat transfer resistivity of the house. Insulated concrete form (ICF) made of 65% polystyrene concrete, cellulose with gypsum board, and SH-AF-coated glass wool were evaluated based on their thermal conductivity, water absorption, and heating and cooling energy demand within the house. The trade-off analysis determined the most cost-effective insulation material for the Ifrane region. The calculations and analyses revealed that SH-AF-coated glass wool is the best insulation for lower-middle-class homes in cold climates. This insulation has strong thermal resistance, moderate moisture resistance, good fire resistance, a low requirement for cooling and heating systems, is inexpensive, and is environmentally benign. The study advises that additional research be conducted to increase the moisture resistance and water absorption of the SH-AF-coated glass wool by incorporating a moisture barrier.

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