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**Title:**

EIFs vs. Stucco system of residential buildings in Western Region KSA

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## Abstract

Since KSA residential buildings lack thermal insulation, hot air can enter, affecting system efficiency due to low resistance to hot climates. Building insulation strategies must be used to reduce heating and cooling costs, increase comfort, and align with engineers' goals of providing the most comfortable environment for residents. As part of this study, the study examines insulated exterior finishing materials (EIFS) in the Western Region of Saudi Arabia, comparing them with another type of insulating finishing material (Traditional Stucco System) in terms of how they affect or work. In order to accomplish our goal, three methods were used. Review the previous studies about insulation finishing materials, communicate with companies to determine what thermal insulation systems are commonly used in residential buildings, and a software program (Excel sheet) compares two insulating materials between two hot-dry cities using a specific calculation.

The results show contrasts in many aspects such as cost, U-value, layers, efficiency, and insulation rate. All values gathered from companies and Excel sheets were on the same line as in the study. The efficiency values of the EIFs were the highest of all. EIFs offer better long-term costs by reducing energy consumption. It offers 100% insulating conformation based on the sbc.gov.sa, and 80% insulation overall. The results also revealed that the user's bill showed a decrease in energy consumption. Not only that, but they also mentioned its efficiency in reducing outdoor noise. Due to the effectiveness of EIFs in numerous aspects, the results of this study could be used as a tool to promote their use.

# Chapter 1:

## Introduction

### Project Overview

This Project deals with evaluating insulated exterior finishing materials (EIFS) system in Western Region in KSA, by comparing this system with another type of insulating finishing materials (Traditional Stucco System) from several aspects and how they affect or work effectively.

### Significance of the Study

Insulation in any kind of building is so important because it provides resistance to heat flow and lowers the heating and cooling costs. Properly insulating the buildings not only reduces heating and cooling costs, but also improves comfort, and the main goal of the research is to provide a comfortable level to the residents as much as possible.

### Scope and Boundaries

The project will address the insulated exterior finishing systems Traditional Stucco VS. EIFS system in Western Region for residential buildings, through basic points such as:

- The historical review of using the Traditional Stucco and the EIFS systems.
- Comparison between the insulated exterior finishing systems Traditional Stucco VS. EIFS system.
- Study cases that can be helped to adjudgment.
- The effectiveness of the Traditional Stucco System VS. EIFS system.

### Objectives of the study

The study objectives are itemized below:

- Compare the two most famous types of insulators (Traditional Stucco VS. EIFS system) used in residential buildings.
- Choose which of the two Systems is most beneficial in the Western Region for residential buildings based on their safety, security, quality of life, and thermal comfort.
- Study the reduction in energy consumption when using appropriate insulators while evaluating the influence on cost and sustainability.
- Ensure the efficiency of the EIFs system as an insulator in the hot-dry climate compared to Traditional Stucco Systems.

- Determine which of the two insulators is more appropriate in the Saudi market by comparing the R-Values to the SBC (Saudi building code) requirements.

## Methodology of the Study

The research compares two types of insulation system and Traditional Stucco by incorporating various kinds of methods. To enable a systematic and structured comparison between the two types of insulation on several dimensions to evaluate the two insulation systems, which are:

- Review the previous studies about insulating finishing materials and evaluate it according to this project (literature review).
- Communicate with companies to find out which thermal insulation systems are most widely applied in residential buildings.
- A software (Excel sheet) compares the two insulating materials by a specific calculation between two cities in hot-dry Region. To evaluate which material is more effective.

The comparative method serves as a general framework and the use of these methods ensures a comprehensive analysis of the similarities and differences between the two by identifying the critical parameters, variables, and indicators relevant to the comparison. Finally, the environmental impact of each of the systems was taken into consideration.

## Literature review

### Thermal Insulation Material Used in Residential Buildings in Saudi Arabia.

Awareness of energy and environmental issues has led to increased searches for ways to save energy. This will lead to huge savings for consumers and will reduce the financial and environmental burdens on electricity companies. One of the main energy conservation techniques is the use of thermal insulation in residential buildings. Studies have shown that the Kingdom of Saudi Arabia can save up to 33% of its annual energy consumption. <sup>[1]</sup>

In the Kingdom of Saudi Arabia, the use of thermal insulation materials has expanded significantly in recent years. This is due to tenants' need for better thermal comfort requirements in residential, commercial and government buildings, as well as higher energy expenditures for heating and cooling. Buildings consume a large amount of energy in Saudi Arabia, representing approximately 73% of the country's total electrical energy consumption in 1995. The use of electrical energy in industry also increased by 24.9% over the previous year. This includes the eastern region of Saudi Arabia, which leads industrial consumption due to established companies

such as Saudi Aramco and SABIC. In some regions of the Kingdom, the percentage of buildings operating with electricity may exceed 90% [Authority of Electrical Affairs, 1995]

The **most used type of insulating materials** in the Kingdom of Saudi Arabia, and it is also Recommended by Electrical Affairs Agency SCECO (EAA), 1995].

1. Polyurethane foam/polyisocyanurate. This is an organic substance that is produced from oil. It has extremely high insulation efficiency and density and low water permeability. It is usually used to insulate side walls.

2. Extruded and expanded polystyrene. It is also an organic material with conductivity. Extremely low thermal and water absorption. One of its important characteristics is that. It is light and does not contribute much weight to the structure. This type is usually used in. Insulating roofs and walls.

3. Fiberglass. It has an extremely low thermal conductivity, and this conductivity depends on fiber density. Therefore, the higher the density, the lower the thermal conductivity. This type is usually used to insulate duct systems.

4. Mineral fiber. It is a natural material produced from the smelting of natural minerals. Ovens and the product are manufactured. It has very low thermal conductivity.

According to **table 1.1**, the masonry materials used in newly constructed homes are stone, concrete and brick and the steel bars needed for reinforcement. Wall structures vary from region to region. In general, brick, concrete and stone walls are sometimes used in Saudi Arabia. <sup>[1],[2]</sup>

Table 1: Structures and thermal characteristics of walls used mostly in Saudi Arabian Residential buildings

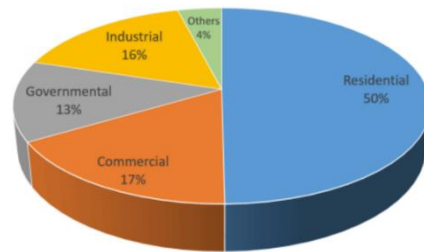
Wall Type	Thickness of wall components (m)	Thermal conductivity of wall components W/mK	Wall Conductance U (W/m <sup>2</sup> K)	Wall Resistance (m <sup>2</sup> K/W)
Wall I				
External plaster	0.02	1.20	<b>2.25</b>	<b>0.44</b>
Hollow bricks	0.20	0.90		
Internal plaster	0.03	1.20		
Wall II				
External plaster	0.02	1.20	<b>2.98</b>	<b>0.336</b>
Concrete	0.20	1.75		
Internal plaster	0.03	1.20		
Wall III				
Stone	0.20	1.70	<b>2.28</b>	<b>0.438</b>
Concrete	0.07	1.75		
Hollow bricks	0.20	0.90		
Plaster	0.03	1.20		
Wall IV				
Stone	0.20	1.70	<b>1.62</b>	<b>0.617</b>
Concrete	0.20	1.75		
Air gap	0.05	0.28		
Bricks	0.10	0.90		
Plaster	0.03	1.20		

**Table 1.1:** lists some typical building wall structures in Saudi Arabia and their characteristics. Thermal properties, including U-conductivity value and thermal resistance.

The most prevalent building in Saudi Arabia is Wall I, which consists of a hollow brick layer followed by a concrete layer and a plaster layer from both inside and outside. Some new residences utilize wall structures like wall IV to increase the thermal resistance of the structure and minimize cooling demands.

### The historical review of using the traditional Stucco and the EIFS systems.

In hot climates, thermal insulation acts as a resistor to prevent the outside air from penetrating the inside. As a result, a wide range of residential buildings in KSA lack insulation. A lack of insulation allows hot air to enter, greatly hindering the efficiency of the system. See **Figure 1.1**



**Figure 1.1** Energy consumption by building sectors in Saudi Arabia <sup>[3]</sup>.

The term thermal insulation refers to the reduction of heat transmission through walls, roofs, and windows, from inside to outside (thermal loss) or from outside to inside (thermal gain). Thermal insulation materials' energy efficiency is measured through the U-Value of all external building elements, according to the Saudi Energy Efficiency Centre. Considering the significant benefits thermal insulation provides to citizens and the nation, the cost of thermal insulation in buildings is acceptable at 3 to 5% of the total cost. As a result of thermal insulation, a moderate temperature can be maintained, energy consumption can be reduced, costs can be lowered, appliances and furniture can last longer, structural cracks can be reduced, fire resistance can be enhanced, construction loads can be reduced, and the environment can be protected. <sup>[4]</sup>

There will be two types of building insulation studied in this research. Synthetic Stucco (EIFS) and stucco are two of these systems. Materials and processes associated with those two materials have different historical backgrounds. As is well known, stucco is an old and traditional material in addition to its long history, it is also very well known around the world. Meanwhile, the EIFs system was introduced by the Europeans in the mid-1990s. During World War II, it was used to protect buildings from damage. Later, In the 1960s, EIFs became an option for exterior walls. <sup>[5,6]</sup>

## Traditional Stucco VS. EIFS (exterior insulating and finishing system).

### 1- *Traditional Stucco*

Traditional stucco, also known as hard cut stucco, is an exterior covering made of cement, sand, limestone powder, water, and other ingredients. It is applied to walls, ceilings, and other surfaces in one coat or three coats. The external textures of stucco homes and buildings can range from a nearly smooth wall to a rough, pebbled finish. Since its introduction into construction in 1824, stucco has undergone numerous improvements and has maintained its status as a long-standing favorite in both architecture and design. Stucco is simple to fix, dries rapidly, and is inexpensive for both professionals and homeowners. The following are some of the key advantages of utilizing traditional stucco:

A great appearance - Stucco can be easily painted over or dyed to achieve a particular look. Many homeowners prefer to keep the surface as is.

- Fire Resistance - A 7/8-inch coating of stucco can withstand a one-hour fire, so it's perfect for burning buildings.
- It's durable - Stucco can last for years when installed correctly and under the right climate conditions.

### Types of Stucco

1. A one-coat or two-coat proprietary system (to meet the required code), proprietary systems are also available in as thin as 3/8 inch.
2. A traditional "three-coat" stucco system (most common). These systems are 7/8 inch thick when installed according to building codes. There are 9 types under this layering: StoPowerwall, StoPowerwall ci, StoPowerwall ci Inbound, StoPowerwall DrainScreen, StoPowerwall DrainScreen MVES, StoPowerwall EtraSeal, StoPowerwall EtraSeal MVES, StoPowerwall HI, StoPowerwall MVES.

### Complications of Stucco

Several factors can lead to cracks in stucco, including improper flashing, sealing, thickness, and curing procedures, as well as movement and settlement of the building. It is usually beyond the installer's control how these cracks develop. Cracks and trapped water can cause water intrusion into the stucco system, causing structural damage to the building. This issue can also be caused by improper design, oversight, and installation.

## 2-EIFs (External Insulated Finishing System)

Since EIFS is more flexible and durable than traditional stucco, it has become a popular alternative to traditional stucco. To achieve desired performance and finish, EIFS consists of several synthetic materials. The layers consist of polystyrene foam board, fiberglass mesh, and a finishing coat. As a result, traditional stucco is less insulating and less protective.

Despite its greater flexibility, EIFS takes longer to install. Due to this, traditional stucco is slightly more expensive than EIFS. However, depending on your location (especially if you live in a wetter, cooler climate), it may be a better choice since it will last longer.

### Types of EIFs

- Class "PB" EIFs (most prevalent type of EIFS). "PB" refers to a cementitious "polymer-based" system.
- The EIFS system was developed as a "Barrier System," which repels all water from the face of the cladding.
- Drainage EIFS - Designed to shed or drain penetrating water.

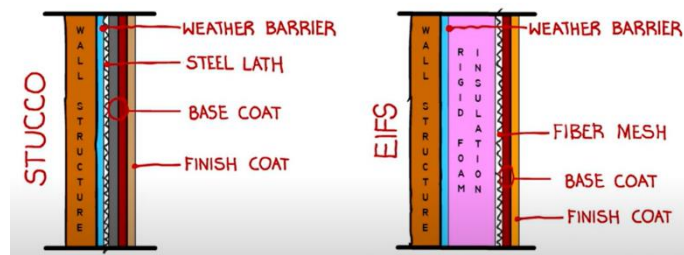
### Complications of EIFs

According to approved drawings, industry standards, or manufacturer requirements, the EIFS walls may not be installed as a "Barrier System" without drainage, resulting in damage. Water damage can result from improperly installed expansion joints and sealants, as well as incorrect or missing flashing. There are many reasons for water intrusion, including poorly sealed penetrations, incorrect flashing, a lack of drainage, and improperly installed water recovery systems.

### Layers of Stucco VS. EIFs

As shown in **Figure 1.2**, the two exterior finishes are both applicable to any wall structure, thus the types of layers implemented, order of layers, and number of layers vary between the two. In the Stucco case, with a three-layer process, the first thing to be implemented after ensuring the wall is appropriately in place is the Weather Barrier. Secondly, a Galvanized Steel Lath that holds the base and finish coat providing stability. Next, goes on the Scratch Coat as a layer to be combined by a followed Brown Coat, forming a combination called Base Layer. Lastly, the Finish Coat represents the exterior finish of the wall. The three layers are made of Portland cement, which provides a strong type of exterior finish. Since cement is known to be vapor permeable the wall can dry out itself in cases of high humidity or wetness. The process of Stucco layering offers the wall

several characteristics that make it preferable in some regions more than others, such as Moderate to cold regions like some states in America with low humid percentage. Similarly, the case of EIFS systems for the Start and Finish layers. On the wall, the start is with a Weather Barrier. However, what makes the main difference is following the Weather Barrier with a huge Rigid Foam Insulation. On top insulation is placed the Fiber Mesh that holds the following Base Coat (Finish Coat). The characteristics of EIFS layering make the wall unbreathable and susceptible to high damage if moisture occurs. Therefore, it is more suitable in hot climates such as Madinah, and Riyadh. [7],[21]



**Figure 1.2** – Layers of Traditional Stucco VS. EIFS

Although both materials seem beneficial for specific regions, only the EIFS system offers higher energy efficiency due to additional layered coats and thick insulation. To make that system applicable in all cities in the western region of KSA, it must offer itself in two cases. The original one just defined and is available all around in manufacturing places. And another one suggested by the research is to follow the same coating amount but with an additional layer of moisture absorbent to protect from damage. Therefore, the EIFs with high energy efficiency can be not only the economical option in the long run, but also it can be implemented in both hot and humid climates covering all cities in the western region. [7,21]

### Case study of residential building in Jeddah's.

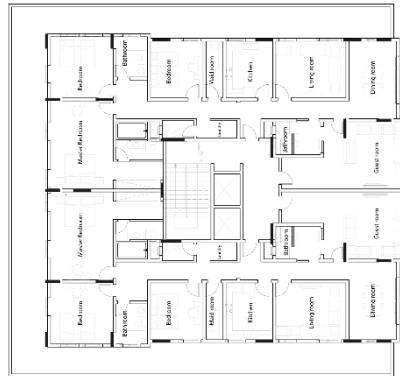
The chosen case study was a residential building in Jeddah's climate, where temperatures fluctuate between 32 and 49 degrees Celsius (Jeddah), and indoor temperatures should ideally be maintained between 18 and 24 degrees Celsius. The building position that was subsequently chosen was based on simulated testing of six common building positions in an urban area. The worst situation was then chosen, with the highest average energy use.

A residential building's land area generally varies between 20 m 20 m, 20 m 30 m, 25 m 30 m, and 30 m 30 m, with a maximum built-up ratio of 60%. The instance is based on a 750 m<sup>2</sup> (25 m 30 m) plot of land, resulting in a built-up floor space of around 450 m<sup>2</sup>. As shown in **figures 1.3,**

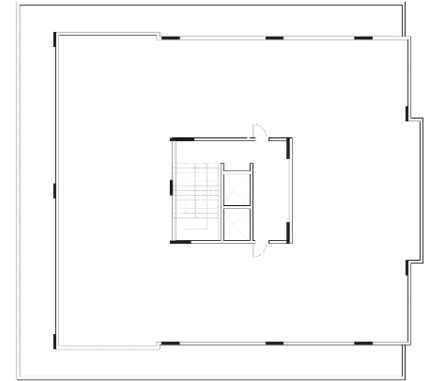
the chosen building comprises eight flats (two per floor), with parking spots and other utilities such as driving rooms and the main entrance on the first floor (ground floor). The apartments mostly face west or east. The east and north sides, on the other hand, face the neighboring buildings, while the west and south sides face the street. Each of these elements influences the average annual energy consumption. See **figures 1.4 and 1.5**.



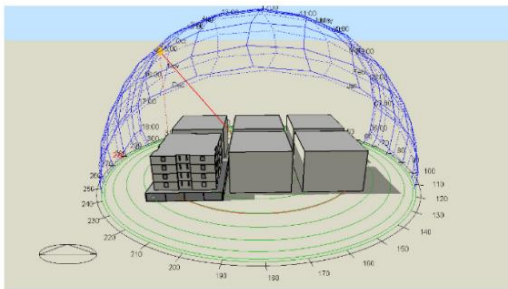
**Figure 1.3.a** First floor plan (ground floor) (14 Parking spots, 6 Driver rooms, and 1 guest room).



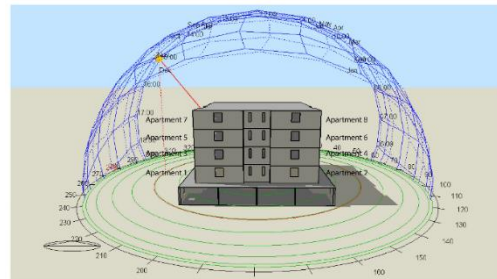
**Figure 1.3.b** Repeated floor plan (3 bedrooms, 1 maid room, 1 kitchen, 1 living room, 3 bathrooms, 1 dining room, and 1 guest room).



**Figure 1.3.c** Roof Floor plan



**Figure 1.4** South orientation



**Figure 1.5** South- west orientation

## Energy Retrofitting Scenario Description

**Table 1.2** displays each energy upgrade scenario as well as the interventions that were carried out. Tables 1.2 and 1.3 also represent the scenarios designed to satisfy the SBC (Saudi Building Code) criteria, with red indicating that the value did not meet the SBC energy demands and green indicating that the value did meet the SBC energy needs. The concept achieves high-resolution scenarios by starting with minimal changes and gradually increasing engagement until an efficient scenario that matches the SBC is achieved (green labels in Tables 1.2 and 1.3). The design was divided into two categories: indoor situations and outdoor scenarios, outdoor scenarios are explained in more detail below:

Outdoor Scenarios	
Base Case	Base Case Corner Face SW + SB
Scenario 1	EIFS Wall (EPS 10 cm)
Scenario 2	EIFS Wall (XPS 10 cm)
Scenario 3	EIFS Wall (XPS 10 cm) + Replace Windows Wintek HD Plus Grey
Scenario 4	EIFS Wall (XPS 10 cm) + Replace Windows (Creative Windows CO.)
Scenario 5	EIFS Wall (XPS 10 cm) + Replace Windows (Creative Windows CO.) + Upgrade Roof with XPS 10 cm
Scenario 6	EIFS Wall (XPS 10 cm) + Replace Windows (Creative Windows CO.) + Upgrade Roof with XPS 15 cm
Scenario 7	EIFS Wall (XPS 10 cm) + Replace Windows (Creative Windows CO.) + Upgrade Roof XPS 10 cm+ Replace ACs with COP 4

**Table 1.2** Overview of indoor and outdoor scenarios. Detail for the scenario construction in table 1.3.

	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
N50 (ACH50)	20.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Wall (U-Value) (W/m <sup>2</sup> K)	2.68	0.31	0.27	0.27	0.27	0.27	0.27	0.27
Thickness (m)	0.24	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Roof (U-Value) (W/m <sup>2</sup> K)	2.51	2.51	2.51	2.51	2.51	0.27	0.19	0.27
Thickness (m)	0.35	0.35	0.35	0.35	0.35	0.45	0.50	0.45
G-Floor (U-Value) (W/m <sup>2</sup> K)	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27
Thickness (m)	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
R-Floor (U-Value) (W/m <sup>2</sup> K)	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Thickness (m)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Window Glazing Type	Single 3 mm	Single 3 mm	Single 3 mm	6 mm-12 mm air-6 mm	6 mm-12 mm air-6 mm	6 mm-12 mm air-6 mm	6 mm-12 mm air-6 mm	6 mm-12 mm air-6 mm
Window Glazing (U-Value) (W/m <sup>2</sup> K)	5.89	5.89	5.89	2.69	2.13	2.13	2.13	2.13
Glazing Type	Clear	Clear	Clear	Gray hd plus	Gray reflective SHANGHAI	Gray reflective SHANGHAI	Gray reflective SHANGHAI	Gray reflective SHANGHAI
Window Glazing (SHGC)	0.86	0.86	0.86	0.25	0.25	0.25	0.25	0.25
Window Frame Type	Aluminum	Aluminum	Aluminum	UPVC wintek	UPVC Creative Windows	UPVC Creative Windows	UPVC Creative Windows	UPVC Creative Windows
Window Frame (U-Value) (W/m <sup>2</sup> K)	5.89	5.89	5.89	1.79	1.33	1.33	1.33	1.33
Window Ratio (WWR)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lighting (W/m <sup>2</sup> -100 lux)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
AC Type	AC Window	AC Window	AC Window	AC Window	AC Window	AC Window	AC Window	AC Split
(CoP)	1.80	1.80	1.80	1.80	1.80	1.80	1.80	4.00

**Table 1.3** Outdoor energy retrofit scenarios for a residential building in Jeddah (red color indicates did not meet the SBC and green color indicates the value meets the SBC). <sup>[9] [10]</sup>

In both table 1.2 and table 1.3, the green color indicates that the value reached the SBC minimum standards. Scenarios 1 and 2 in table 1.3 include external insulation and finishing systems (EIFSs) as optional interventions to improve the U-value of the walls. Scenarios 3 and 4 expand on Scenario 2 by replacing the windows. Scenarios 5 and 6 use the same method as Scenario 4, including increasing the U-values of the roof. Finally, Scenario 7 contains the steps from Scenario 5, but also involves upgrading air-conditioning systems with more energy-efficient options.

Tables 1.2 and 1.3 show how and what the possibilities are. The main idea behind building the energy refit scenarios was to create scenarios ranging from a simple upgrade to a larger upgrade using mixed energy retrofitting methodologies (add-in, add-on, replace-it, and wrap-it) to meet the SBC energy requirements. <sup>[10]</sup>

## Chapter2:

### The Result

Based on the results gathered from the literature review, companies contacted for site visits, Excel sheet calculations, and similar cases studied the conclusion has drawn itself to prove the efficiency of EIFs System. Although several insulating systems are implemented in the western regions' Hot-Dry climate, the EIFs efficiency values were the best among all. EIFs offered a better cost in the long run by reducing energy consumption. It offers a 100% insulating conformation based on the sbc.gov.sa, and 80% insulation overall.

#### 1. Excel sheets:

Since it is important to use both data (theoretical and actual), these excel sheets are gathered from several sources compared to the government values for additional information and better accuracy. To start the comparison between the several systems of insulation, it is important to understand the limited values required by the government. The U-Value that must not be exceed equals  $0.6 \text{ W/m}^2\text{K}$ . Therefore, the R-Value must be greater than  $1.667 \text{ m}^2\text{K} / \text{W}$ . not to forget about the K-Value which is thermal conductivity. It is a very considerable variable since it is highly affected by the quality of material produced and brought to site for construction. A comparison between the values of Insulators is shown in the **table 2.1** below. based on the research progress, the main comparison between stucco and EIFs shows to be unreliable for the stucco case. Stucco has a 2-3cm width, and is treated as a thermal bridge since it allows the heat to flow in. Interestingly, a 2-3cm stucco seems to insulate much better than what is known as sandwich building system for insulating, and EIFs seems better than both. For the best results people will head to use the EIFs system.

types system	R-value (W/m <sup>2</sup> K)	Opeque Areas % (Without thermal bridges nor columns)	Thermal insulation efficiency	
EIFS 8cm	2.58	0%	100%	
Traditional	0.43	30%	9%	
The Red	0.61	30%	10%	
Sandwich panel	0.98	30%	12%	
Volcanic	1.15	30%	15%	
Two Walls Assorted	2.1	30%	54%	
Spiroex white block	1.64	30%	47%	
Columns & Bridges	0.12			

**Table 2.1** Comparison between insulation systems based on efficiency and resistance.

The company of Dira Almagbani was trying to present the ideal thickness that offers the best values and pays back on the shorter time possible and recommended to build with a 7 to 7.5cm thickness maximum. As the companies' owner says (A 7cm thickness will offer a U-value of approximately 0.387, and an R-value of 2.58 with a payback difference noticed on almost five years. Meanwhile, increasing the thickness to 8-9-10 will only decrease the value of U by less the 0.01 while significantly a high jump in the price that will starts to payback after 25 years of implementation.). The values in the following **tables 2.2 and table 2.3** of government and companies' actual values show evidence on the efficiency of a 7cm thickness EIFs. [16,17,18]

Thickness(cm)	U-value 18	U-value 20	The difference
1	1.457	1.426	0.031
1.5	1.222	1.191	0.031
2	1.053	1.022	0.031
2.5	0.925	0.895	0.03
3	0.825	0.796	0.029
3.5	0.744	0.717	0.027
4	0.678	0.652	0.026
4.5	0.622	0.598	0.024
5	0.575	0.552	0.023
5.5	0.535	0.513	0.022
6	0.499	0.478	0.021
6.5	0.469	0.449	0.02
7	0.441	0.422	0.019
7.5	0.417	0.399	0.018
8	0.395	0.378	0.017
8.5	0.376	0.359	0.017
9	0.358	0.342	0.016
9.5	0.342	0.327	0.015
10	0.327	0.312	0.015

**Table 2.2.a** U-Value compared between pressure of 18 and 20.

prussure	Thickness(cm)	U-value	the difference in U-		Thickness(m)	prices( sar/m)
			value			
20	1	1.426	0.235		0.01	2.875
	1.5	1.191	0.169		0.015	4.3125
	2	1.022	0.127		0.02	5.75
	2.5	0.895	0.099		0.025	7.1875
	3	0.796	0.079		0.03	8.625
	3.5	0.717	0.065		0.035	10.0625
	4	0.652	0.054		0.04	11.5
	4.5	0.598	0.046		0.045	12.9375
	5	0.552	0.039		0.05	14.375
	5.5	0.513	0.035		0.055	15.8125
	6	0.478	0.029		0.06	17.25
	6.5	0.449	0.027		0.065	18.6875
	7	0.422	0.023		0.07	20.125
	7.5	0.399	0.021		0.075	21.5625
	8	0.378	0.019		0.08	23
	8.5	0.359	0.017		0.085	24.4375
	9	0.342	0.015		0.09	25.875
	9.5	0.327	0.015		0.095	27.3125
	10	0.312	X		0.1	28.75

**Table 2.2.b** U-Value in a pressure of 20 in-detail.

prussure	Thickness(cm)	U-value	the difference in U-		Thickness(m)	prices( sar/m)
			value			
20	1	1.426	0.235		0.01	2.875
	1.5	1.191	0.169		0.015	4.3125
	2	1.022	0.127		0.02	5.75
	2.5	0.895	0.099		0.025	7.1875
	3	0.796	0.079		0.03	8.625
	3.5	0.717	0.065		0.035	10.0625
	4	0.652	0.054		0.04	11.5
	4.5	0.598	0.046		0.045	12.9375
	5	0.552	0.039		0.05	14.375
	5.5	0.513	0.035		0.055	15.8125
	6	0.478	0.029		0.06	17.25
	6.5	0.449	0.027		0.065	18.6875
	7	0.422	0.023		0.07	20.125
	7.5	0.399	0.021		0.075	21.5625
	8	0.378	0.019		0.08	23
	8.5	0.359	0.017		0.085	24.4375
	9	0.342	0.015		0.09	25.875
	9.5	0.327	0.015		0.095	27.3125
	10	0.312	X		0.1	28.75

**Table 2.2.c** U-Value in a pressure of 18 in-detail.

Region 1	Heat transfer Coefficient	Thermal Conductivity	Wall thickness	Insulation thickness	Constructing system used on the exterior wall of the building
SBC 602	U-value (W/m²K)	k = W/m.K	Cm	Cm	
	0.598	0.040	5+20	5	Concrete block wall with an EIFs exterior insulation system
	0.564	0.037	5+20	5	
	0.516	0.033	5+20	5	
	0.479	0.030	5+20	5	
	0.440	0.027	5+20	5	
	0.399	0.024	5+20	5	
	0.520	0.040	6+20	6	
	0.489	0.037	6+20	6	
	0.446	0.033	6+20	6	
	0.413	0.030	6+20	6	
	0.378	0.027	6+20	6	
	0.342	0.024	6+20	6	
	0.460	0.040	7+20	7	
	0.432	0.037	7+20	7	
	0.393	0.033	7+20	7	
	0.363	0.030	7+20	7	
	0.332	0.027	7+20	7	
	0.299	0.024	7+20	7	
	0.413	0.040	8+20	8	
	0.387	0.037	8+20	8	
	0.295	0.033	8+20	8	
	0.351	0.030	8+20	8	
	0.324	0.027	8+20	8	
	0.266	0.024	8+20	8	
	0.374	0.040	9+20	9	
	0.350	0.037	9+20	9	
	0.317	0.033	9+20	9	
	0.292	0.030	9+20	9	
	0.266	0.027	9+20	9	
	0.240	0.024	9+20	9	

**Table 2.3** Building system used in outer wall. (Note: Green represents acceptable, Red represents unacceptable)

Finally, using the government excel sheet that shows if the EIFs system meets the standard requirement alone successfully. The layers of EIFs are added based on what markets offer within our country and specific region. See following **table 2.4a**. [15]

Region	Madinah
City	AlMadinahAlMunawwarah
Building Type	Low-rise Residential (SBC602)
AlMadinahAlMunawwarah is located in Climate	1

Layer	Density (kg/m <sup>3</sup> )	Thermal Conductivity K (W/m.K)	Thickness cm	Thermal Resistance (m <sup>2</sup> .K/W)
External Air film	-	-	-	0.030
Paint/ rendering	1300	1.000	0.001	0.000
External Cement Plaster	1500	1.000	0.001	0.000
Expanded polystyrene	25	0.031	7	2.258
Hollow Concrete Block	848	0.671	10	0.173
Cement Mortar	1500	1.000	1	
Internal Cement Plaster	1500	1.0000	2	0.020
Paint/ rendering	1300	1.0000	0.001	0.000
Internal Air film	-	-	-	0.120
Resultant Resistance R <sub>R</sub>				2.601
U-Value (W/m <sup>2</sup> .K)				0.384

System Thickness	19.0 cm
U-Value	0.384
Result	Complies with SBC

**Table 2.4.a** Excel sheet values calculated based on Madinah Region within Western Region to ensure acceptances.

## 2. Communicate with companies.

In the second method of directly contacting companies and visiting sites, two of which have accepted participating by answering the questions. These questions were meant to confirm if real-life values present the strength of EIFs just as the literature review does. [16,17,18,19,20,22]

### The questions are:

#### 1- What type of insulation do you use, Stucco or EIFS system?

Answer: There are two insulation systems we used:

- The traditional stucco system that is common:

Block + partial insulation+ plastering = 15% insulation rate

- EIFS system:

Regular block + total insulation + special plastering = 100% insulation rate

#### There are four types:

1. EPS polystyrene (extended)
2. GEPS polystyrene (black and unexecuted in Saudi Arabia because it is expensive to replace with white by providing fish for better and cheaper isolation than lions)
3. XPS polystyrene (received)
4. RW rock wool (only the sound is isolated without heat) and from previous types the heat is isolated)

### **Our work:**

It is the second system.

We take the building from you, bone, and hand it over to you, isolated and not from the outside, with special courtesy.

### 2- What systems do customers prefer? and why?

Answer: Customers prefer the system with the best price and efficiency, so they choose EIFS system because of the execution price:

115 riyals per square meter, including tax, insulation, plastering, materials, and labor wages.

And you have saved from the traditional system:

- 1- 18 riyals the cost of plastering materials per meter.
- 2- 65 riyals the cost of insulating blocks per meter, because one meter contains 12.5 blocks.
- 3- 80% of electricity per month.

For efficiency, remember that you will recover the difference within a few years by saving on electricity bills.

### 3- Are there any complaints about that system?

Answer: Mostly there are no complaints because it fulfills the SBC (Saudi building code) requirements as it is the most efficient Insulating system. It also has an economic impact in reducing the energy consumed to operate buildings, for example in some projects that were implemented with this system, it was found that this system is considered one of the best systems for facade cladding as it achieves thermal insulation with unlimited facade designs.

### 4- Is there an implementation of the system in residential buildings, and how was the experience?

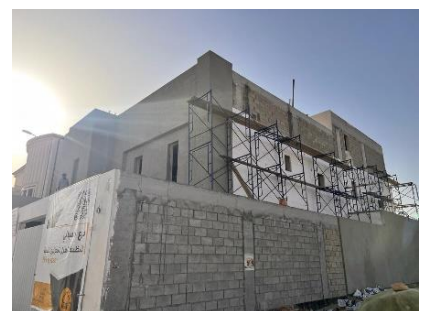
Answer: Yes, we have implemented many residential projects this some examples:



**Figure 2.1.a** Example 1



**Figure 2.1.b** Example 2



**Figure 2.1.c** Example 3

And this experience of one of our customers includes a summary of electricity consumption for a year, noting that the insulation was installed in July.



**Figure 2.2** electricity consumption for a year of customer.

5- If stucco is less efficient, why do some people use it? Why would people not use EIFs and heat to other insulating types even if they knew its benefits?

They head to stucco in hot climates if and only if they wanted a smaller change in insulation with only enough efficiency to reduce energy consumption by a small percentage, with the least costs and space possible.

6- what causes EIFs to seem expensive? even though its good in the long run?

This runs back to several reasons, such as:

- Increment in thickness of insulator, even though on an evidence based there is no need to exceed 7cm.
- The duration of instruction and laborer fees.
- Unfollowing the appropriate implementing process during site construction.

7. Are there any operational errors when working with EIFS?

The more wrongs that faced when working with EIFs are:



**Figure 2.3** This implementation of the box is correct, but the pipes are wrong. It is assumed that the pipes are broken inside the wall like an interior work.



**Figure 2.4** It is an error to tape the box with cement instead of nails, and to not break to the pipes inside the wall. Correct: Nail the box to the wall and insert the pipes.

## Chapter3

### Discussion

Appropriate implementations and choice of insulating system offer sustainability and payback in both the long and short run. As a result, types of insulations were studied and tested based on several methods to provide a suggested type. Therefore, two types of insulation were studied traditional Stucco and EIFs. The Traditional Stucco represents a traditional way of building which is not meant for insulation, yet it offers a low percentage of insulation. On the other hand, the EIFs system was a several-layer insulating system that is mainly used for thermal insulation. As indicated in the study, the literature review, methods, and results have shown a corollary of the efficiency of the EIFs system. The results were gathered from the companies contacted for site visits, Excel sheet calculations, and similar cases studied provided quite accurate values. All values gathered from companies and Excel sheets were on the same line as the study. Yet, for additional evidence, some users were asked to provide bills and significant notices before and after the insulation. Interestingly, these users' bills showed such a decrease in energy consumption. Not only that, but they also mentioned its efficiency in reducing outdoor noise. Even though the thickness of 7cm has proven to be the best in the short run to payback. It also offers nearby values to the 9-10cm and greater values, but users desired a higher thickness than 7cm. To wrap up, it is especially important to consider choosing the system and start implanting it according to the appropriate results for achieving sustainability and reaching maximum comfort.

### Recommendations

- It is preferable to add more materials to improve the efficiency of the EIFs insulation system, like:
  - A. Fire resistant materials.
  - B. Moisture resistant materials.
- Expansion joints are recommended to guard against cracking from lumber shrinkage while implementing EIFs in a bit higher humid region.
- When building an EIFs system, it is preferable to stick with a thickness of 7cm. based on evidence this is the cheapest in cost among accepted thickness, and the fastest to pay back on the long run. Additional to the fact of higher thickness increasing the values of U by a non-significant number.

- For the best results, any cladding system better have yearly inspections and cleanings. EIFS are no exception, despite their strong resistance to dirt pickup. Regularly inspecting, cleaning, and maintaining your EIFS cladding can help it preserve its original appearance.

## Conclusion

The main objective of this study was to clarify the importance of appropriate thermal insulation systems and accurate step-by-step implementation. As a result, a traditional way of building, characterized by almost no insulation but only small insulating properties like Traditional stucco, is compared to what seemed at first to be the best thermal insulating system among all, namely EIFs. In comparison, nothing was far from what was expected, but instead more evidence and proofs were presented based on calculations that were close to accurate. Several institutions have made the EIFs stand out as the most sustainable, energy-efficient, and fastest to pay back, as well as being ready for application. A thickness of 7 cm is ideal, an acceptable U-Value, and a price that pays back in the shortest amount of time. While higher thicknesses of 9, 10, or more would provide a higher U-value due to the microscale difference, an owner will have to pay approximately 25 years to get the payback with the higher price. On the other hand, the 7cm will pay back its value in less than 5 years. However, both will show a decrease in energy consumption after the first month through electricity bill. According to the evidence, the EIFs system is one of the best types of insulation if not the best in our western region.

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