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Low Cost Green Building with Low Energy Consumption towards use PP in External Envelope

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Abstract

The role of external envelope is very important to control heat gain and loss through it. So, should improve building envelope, design, and materials to increase thermal resistance. In Additional to increase thermal resistance, that can help to decrease energy consumption internal building space. Energy efficient in the building is one of the most significant principals in economic benefits of green architecture. The study point out the significant that design housing external envelope is more sensitive to the thermal comfort indoor living in low house costing. Therefore the study will include some cross sections in walls without opening which can use to design the external envelope of building in North Sinai to achieve the most suitable section in wall appropriate with the environment of north Sinai that reduces the Overall heat transfer coefficient on the external envelope of the building. Finding will improve the indoor thermal comfort which can impact directly in decrease use equipment (which used for cooling in summer– heating at winter) internal the building to achieve thermal comfort and that effect on energy consumption in the low-cost house in North Sinai.

***Keywords**: Low cost house, energy consumption, Thermal comfort, Heat Transfer, Energy consumption, Heat flux density, Building envelope, Thermal conductivity, Thermal Resistance, Thermal Efficiency, Sinai.*

1. Introduction

Sinai Peninsula is a part of Egypt from the first dynasty of ancient Egypt. It is the northeastern extremity of Egypt; therefore it located in Asia and connected between Asia and Africa. The state is working toward development cities in Sinai by building new residential neighborhoods. The design and shape of this residential building are not satiable completely for such a dry hot climate. In additional to that, the external envelope structure is designing without taking attention to thermal efficiency and thermal comfort indoor building.

2. Goals and Objective

The primary objective of this study is achieving to the suitable cross section of external envelope building, that improve the inside thermal comfort, which is the main element has to impact on energy consumption. Because the way in which we construct and design buildings have a critical effect on the environment.

3. Methods

These study methods have been following:

1. The experimental methods using Fourier's law the coefficient of heat transmission for the following cross sections.
2. Analysis the result using the diagram.

4. Theoretical frame work

4.1 The External Envelope

The building envelope includes the roof, walls, ground, windows and door. Also, it contains structural materials and finishes that surround space. The external envelope is separating inside from outside spaces. It should achieve the requirements for daylight and ventilation, also compatible with the climatic conditions of the site [1]. The envelope is the most effective element in reducing energy costs.

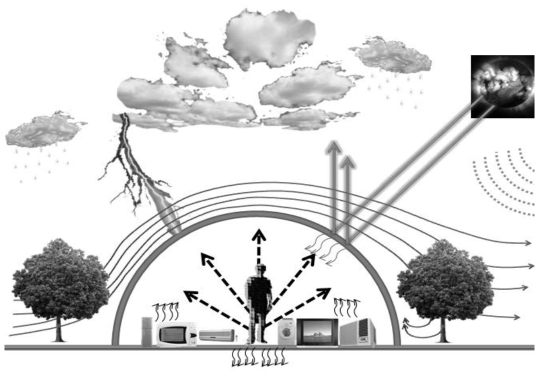


Figure 1: Explain the Role of External Envelope in Protection the Indoor Building Environment

The external envelope is the main factor in the building which controlling the heat gain and loss. In additional to that, it effects directly on the thermal comfort inside the building. Therefore, it impacts in the thermal efficiency interior building by decreases the Energy efficient. The energy consumption is affecting directly when to use equipment to cool in summer and heat at winter internal the building to achieve thermal comfort.

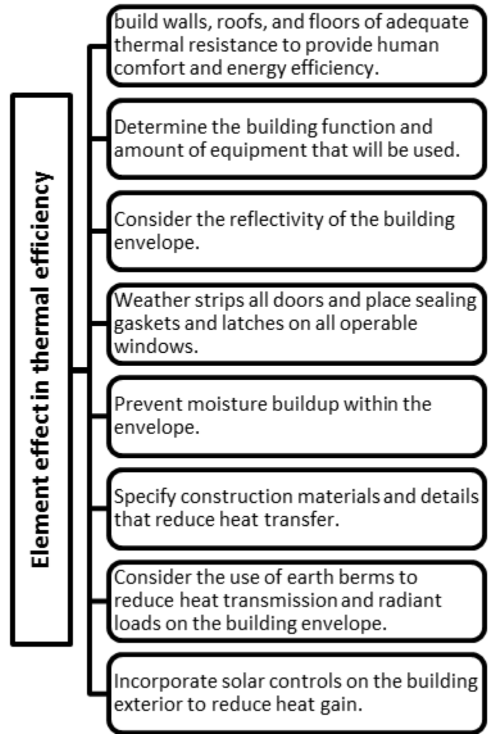


Figure 2: The Main Element Effect in Thermal Efficiency

4.2 Thermal Comfort

The most important parameter today is creating a thermally comfortable environment when designing buildings. Thermal comfort conditions impact in energy consumption at the building.

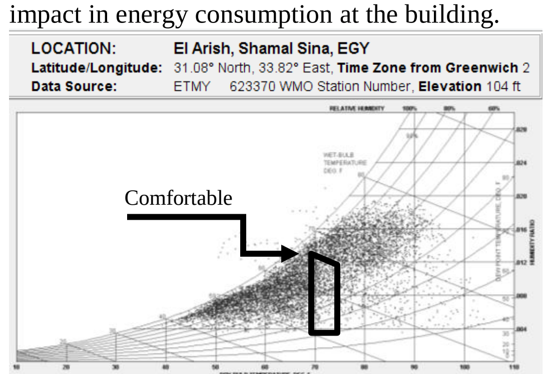


Figure 3: Explain the Comfort in El-Arish (7% comfortable - 93% not comfortable) from Climate Consultant 5.0 Program

The main factors that influence thermal comfort are those that determine heat loss and gain, clothing insulation, namely metabolic, air temperature, air speed, mean radiant temperature and relative humidity. Psychological parameters such as individual expectations also affect thermal comfort. [2]

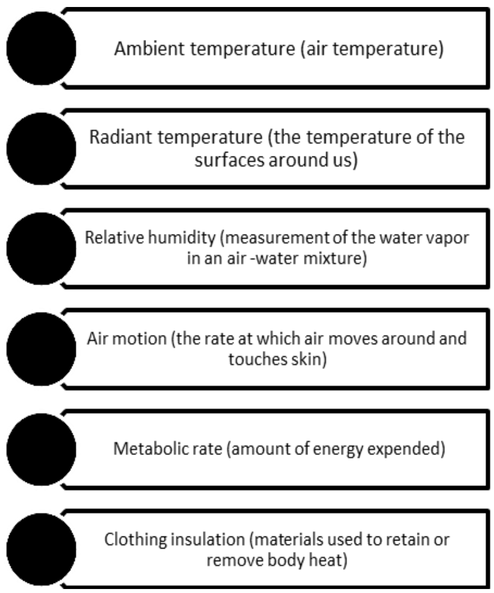


Figure 4: The Six Primary Thermal comfort Variables

4.3 Green Material

The process to selection material needs to incorporate life-cycle assessment elements and the most conventional criteria such as cost, performance, aesthetics, availability, manufacturer warranty, and code. [1]
Green building materials and green products have some or all of the following Characteristics:

- Decrease embodied energy (total energy to make, use and distribute the product).
- Positive social effect, contributing to well-being and health.
- Recycled-content (can be easily recycled after use).
- Durable (this is an often overlooked attribute of green products, but quite significant).
- Uses renewable resources from agriculture and forests.
- Low or no environmental effect in manufacturing as well as in use and disposal.
- Energy efficient in operation, such as high-thermal resistance value of glazing products.
- Harvested, extracted and processed within 300 to 500 miles, supporting regional economies and decreasing transportation.
- A-fordable, preferably fewer cost than conventional alternatives with lower green characteristics.
- Reduce waste in manufacture and use, including engineered wood products from scrap. [3]

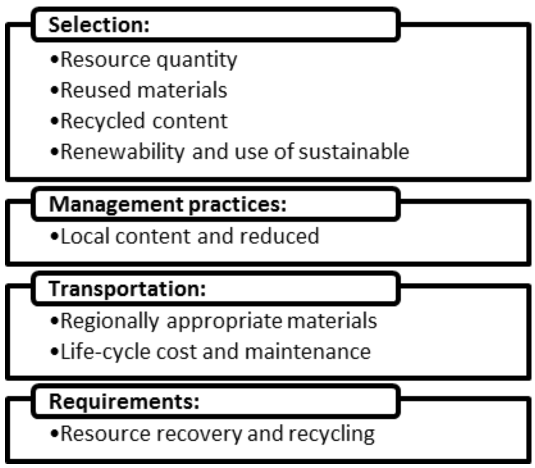


Figure 5: Explains Consider the Following Criteria in Materials

4.4 Polypropylene in Building Construction

To raise the efficiency of the external building envelope, we need to select the material carefully and take in attention the design and construction of the wall, according to the climate of the region. So, we will add the Polypropylene in building construction to changing the shape and design of the block brick, which use in building nowadays. This change will help to decrease the impact on the environment, decrease the time of construct and improve building simulations.

Properties of Polypropylene:

- Semi-rigid
- Translucent
- Good chemical resistant
- Tough
- Good fatigue resistance
- Integral hinge property
- Easy of manufacture
- Good heat resistance

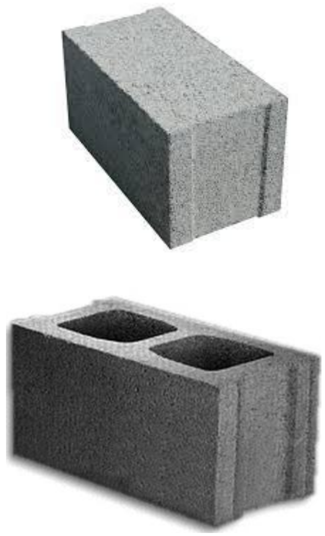


Figure 6: Two Type for Traditional Brick

New Block Brick from Polypropylene:

The brick from polypropylene is designing according to the golden ratio. Also, the dimension has been taken from Fibonacci numbers, so the dimension of this brick is length 55 cm, width 34cm, and height 21 cm.

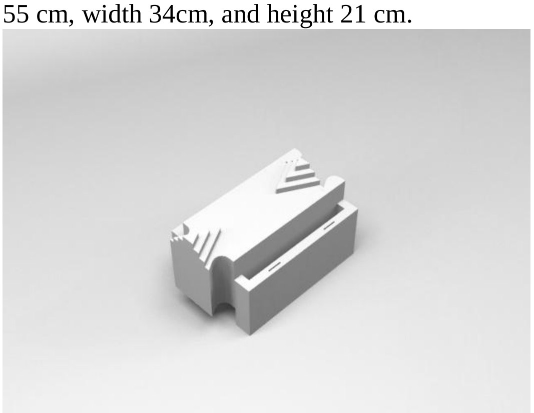


Figure 7: The Shape of the Brick

The design of the brick from polypropylene is hollowing from the inside, to make easy for using it because that help to fill this brick with the material needed for construction (such as sand and gypsum – cement– ordinary concrete). In additional to that, the brick can fill with material from the around environment (dry sand – sand and stone). Also, it contains two pieces (the main block and the cover). This brick does not need for material to connect bricks together.

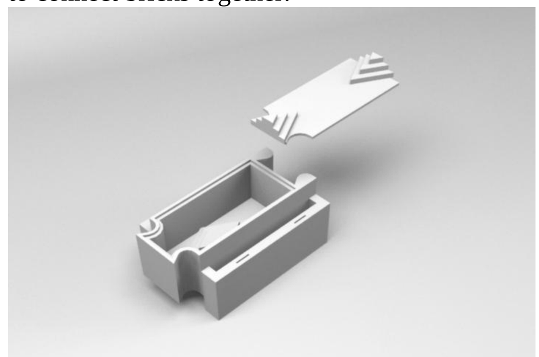


Figure 8: The Shape of Main Block and the Cover which but after fill with Material

Characterize of the new block brick (which made from polypropylene) **the main features**:

- Healthy
- Low cost
- Durable and degrade very slowly.
- Resistant to most natural processes of degradation.
- Low environment impact
- Recycle can be easy after use
- Low conductivity help saves energy.

5. Case Study and Analysis

To achieve the suitable section in the wall to use in building, which saving energy consumption by control total Heat Transfer through this wall on the building in the summer season in north Sinai. So the study will include some cross sections in walls without opening. Also, Compare analyzes graphically between the overall resistance and the coefficient of heat transmission for the following cross sections.

The study will include (7) examples cross section in the wall. The sections from (1) to (6) are for traditional examples and the number (7) section is for the new block brick from polypropylene. The first step will calculate the thermal resistance of these deferent walls.

Using Fourier's law:

$$q = \frac{1}{R}\left(t_1 - t_2\right)$$

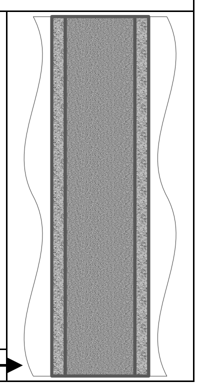
$$R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$$

$$U = \frac{1}{R_t}$$

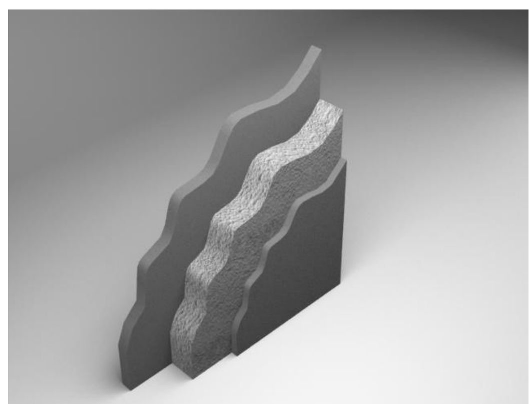
$Q = U.A.(t_1 - t_2)$

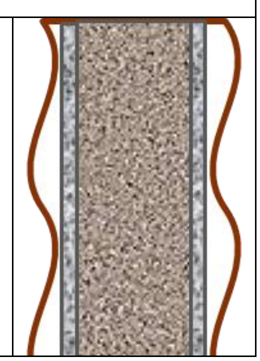
(Q) The heat flux density.
(R) Thermal Resistance. **M² c°/w**
(X) Thickness (cross section of material)
(F) Film coefficient, W/m2.C°.
(U) Overall heat transfer coefficient, **w/m² c°**.
(k) Thermal conductivity for material, W/M.C°
.
$\Delta T = (t_1 - t_2)$
(t_1) The external temperature = 32.75 C° (The average temperature in summer)
(t_2) The internal temperature = 25 C°

F_i = 9.37 W/m2.C°. (Static air)
F_o = 22.7 W/m2.C°. With speed 24 km/h (Wind in summer season)

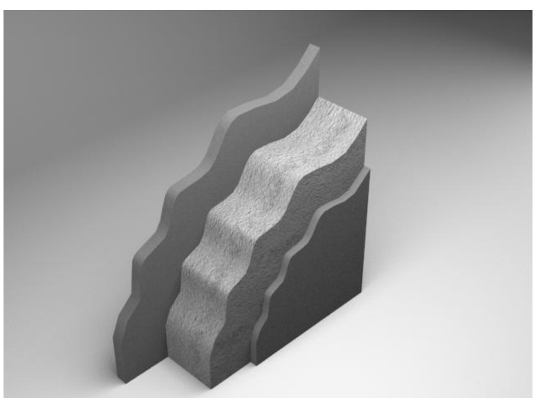
Wall **1:**		
Contains & shape	- cement Portland - brick work, dense - cement Portland	
	Section in wall →	

Calculate	
	K_a (cement Portland) = .29 W/M.C° K_b (brick work, dense) = 1.6 W/M.C° K_c (cement Portland) = .29 W/M.C° X_a = .02 m X_b = .12 m X_c = .02 m $R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$ R = 1/9.3 + .02/.29 + .12/1.6 + .02/.29 + 1/22.7 R = .3645 **m² c°/w** $U = \frac{1}{R_t}$ U = 1/ .3645 U = 2.74 **w/m² c°** $Q = U.A.(t_1 - t_2)$ Q = 2.74 * 15 * 7.25 Q = 297.975 w

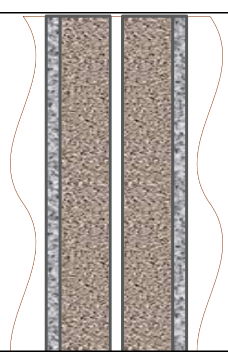


Wall **2:**		
Contains & shape	- cement Portland - brick work, dense - cement Portland	

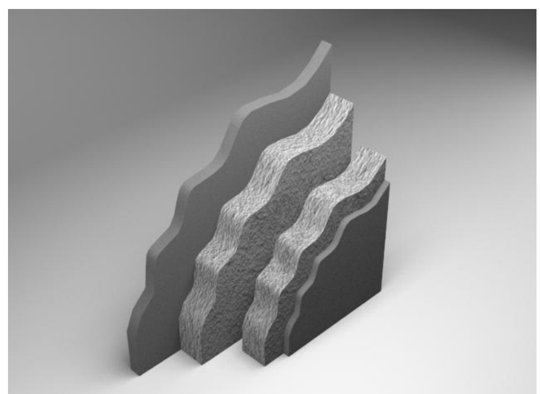
	Section in wall →
Calculate	K_a (cement Portland) = .29 W/M.C° K_b (brick work, dense) = 1.6 W/M.C° K_c (cement Portland) = .29 W/M.C° X_a = .02 m X_b = .25 m X_c = .02 m $R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$ R = 1/9.3 + .02/.29 + .25/1.6 + .02/.29 + 1/22.7 R = .4457 **m² c°/w** $U = \frac{1}{R_t}$ U = 1/ .4457 U = 2.243 **w/m² c°** Q = U.A.($t_1 - t_2$) Q = 2.243 * 15 * 7.25 Q = 243.926 w



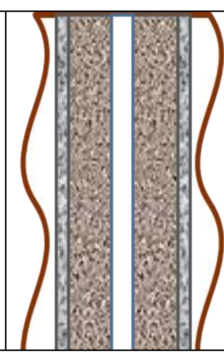
Wall 3:

Contains & shape	- cement Portland - brick work, dense - air cavity - brick work, dense - cement Portland	

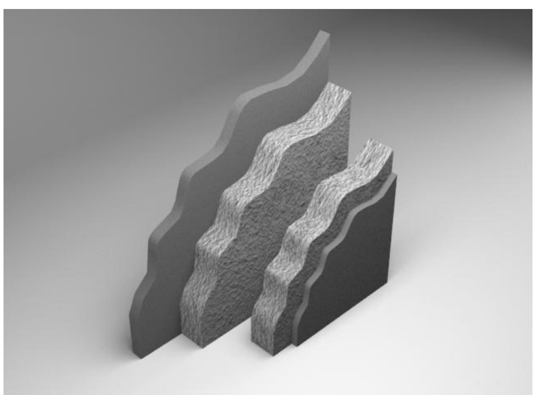
	Section in wall →
Calculate	K_a (cement Portland) = .29 W/M.C° K_b (brick work, dense) = 1.6 W/M.C° K_c (air cavity) =.024 W/M.C° K_d (brick work, dense) = 1.6 W/M.C° K_e (cement Portland) = .29 W/M.C° X_a = .02 m X_b = .12 m X_c = .025 m X_d = .12 m X_e = .02 m $R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$ R = 1/9.3 + .02/.29 + .12/1.6 + .025/.024 + .12/1.6 + .02/.29 + 1/22.7 R = 1.4811 **m² c°/w** $U = \frac{1}{R_t}$ U = 1/ 1.4811 U = .6751 **w/m² c°** Q = U.A.($t_1 - t_2$) Q = .6751 * 15 * 7.25 Q = 73.417 w

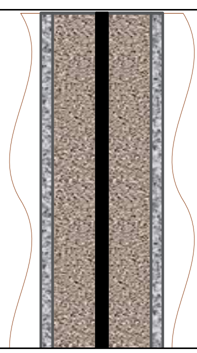


Wall 4:

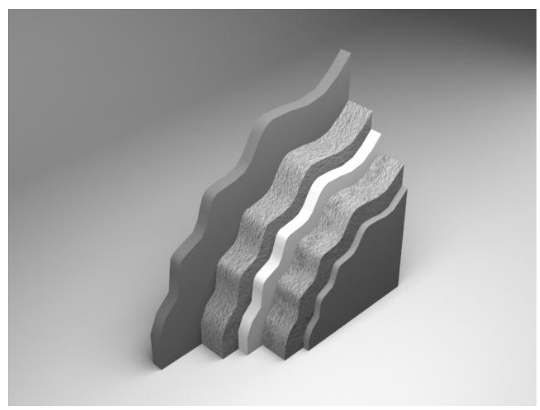
Contains & shape	- Cement Portland - Brick work, dense - Air cavity - Brick work, dense - Cement Portland	

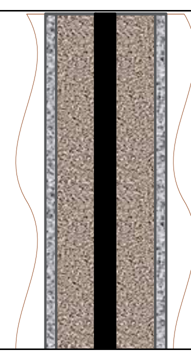
	Section in wall →
Calculate	K_a (cement Portland) = .29 W/M.C° K_b (brick work, dense) = 1.6 W/M.C° K_c (air cavity) =.024 W/M.C° K_d (brick work, dense) = 1.6 W/M.C° K_e (cement Portland) = .29 W/M.C° X_a = .02 m X_b = .12 m X_c = .05 m X_d = .12 m X_e = .02 m $R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$ R = 1/9.3 + .02/.29 + .12/1.6 + .05/.024 + .12/1.6 + .02/.29 + 1/22.7 R = 2.5228 **m² c°/w** $U = \frac{1}{R_t}$ U = 1/ 2.5228 U = .39 **w/m² c°** $Q = U.A.(t_1 - t_2)$ Q = .39 * 15 * 7.25 Q = 42.415 w



Wall **5:**		
Contains & shape	- Cement Portland - Brick work, dense - Polystyrene, expanded Styrofoam. - Brick work, dense - Cement Portland	

	Section in wall →
Calculate	K_a (cement Portland) = .29 W/M.C° K_b (brick work, dense) = 1.6 W/M.C° K_c (polystyrene) =.03 W/M.C° K_d (brick work, dense) = 1.6 W/M.C° K_e (cement Portland) = .29 W/M.C° X_a = .02 m X_b = .12 m X_c = .025 m X_d = .12 m X_e = .02 m $R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$ R = 1/9.3 + .02/.29 + .12/1.6 + .025/.03 + .12/1.6 + .02/.29 + 1/22.7 R = 1.2728 **m² c°/w** $U = \frac{1}{R_t}$ U = 1/ 1.2728 U = .785 **w/m² c°** $Q = U.A.(t_1 - t_2)$ Q = .785 * 15 * 7.25 Q = 85.368 w



Wall **6:**		
Contains & shape	- Cement Portland. - Brick work, dense. - Polystyrene expanded Styrofoam. - Brick work, dense. - Cement Portland.	

Section in wall

Calculate

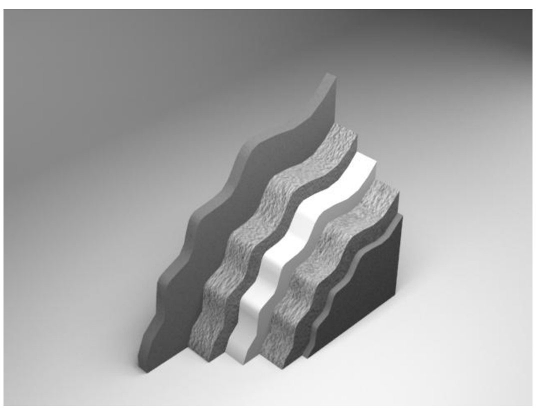
K_a (cement Portland) = .29 W/M.C°
K_b (brick work, dense) = 1.6 W/M.C°
K_c (polystyrene) =.03 W/M.C°
K_d (brick work, dense) = 1.6 W/M.C°
K_e (cement Portland) = .29 W/M.C°
X_a = .02 m
X_b = .12 m
X_c = .05 m
X_d = .12 m
X_e = .02 m

$$R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$$

R = 1/9.3 + .02/.29 + .12/1.6 + .05/.03 + .12/1.6 + .02/.29 + 1/22.7
R = 2.106 **m² c°/w**

$$U = \frac{1}{R_t}$$

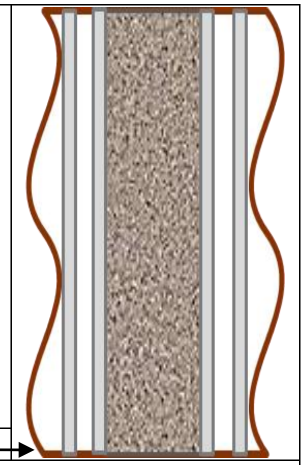
U = 1/ 2.106
U = .474 **w/m² c°**
$Q = U.A.(t_1 - t_2)$
Q = .474 * 15 * 7.25
Q = 51.5475 w



Wall **7: new block brick**

Contains & shape

- polypropylene
- Air cavity
- polypropylene
- concert stone
- polypropylene
- Air cavity
- polypropylene



Section in wall

Calculate

K_a (polypropylene) = .22 W/M.C○
K_b (Air cavity) = .024W/M.C○
K_c (polypropylene) =.22 W/M.C○
K_d (concert stone) = 1.7 W/M.C○
K_e (polypropylene) = .22 W/M.C○
K_f (Air cavity) = .024 W/M.C○
K_g (polypropylene) = .22 W/M.C○

X_a = .03 m
X_b = .03 m
X_c = .02 m
X_d = .18 m
X_e = .02 m
X_f = .03 m
X_g = .03 m

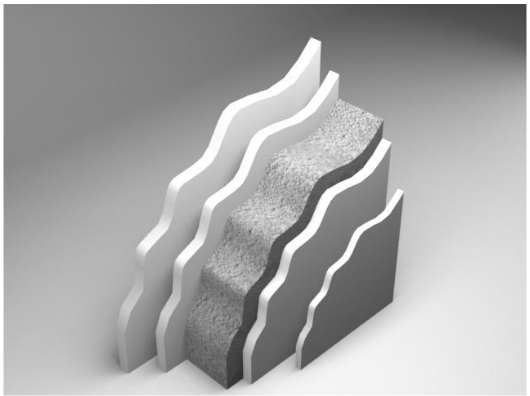
$$R_t = \frac{1}{f_i} + \frac{x_a}{k_a} + \frac{x_b}{k_b} + \frac{x_c}{k_c} + ... + \frac{x_n}{k_n} + \frac{1}{f_o}$$

R = 1/9.3 + .03/.22 + .03/.024 + .02/.22 + .18/1.7 + .02/.22 +.03/.024+.03/.22+ 1/22.7
R = 3.212 m² c°/w

$$U = \frac{1}{R_t}$$

U = 1/ 3.212
U = .311 w/m² c°

$Q = U.A.(t_1 - t_2)$
Q = .31 * 15 * 7.25
Q = 33.712 w



6. Result

Comparative analysis the heat flux density through all seven cross sections walls without opening during the summer season in north Sinai.

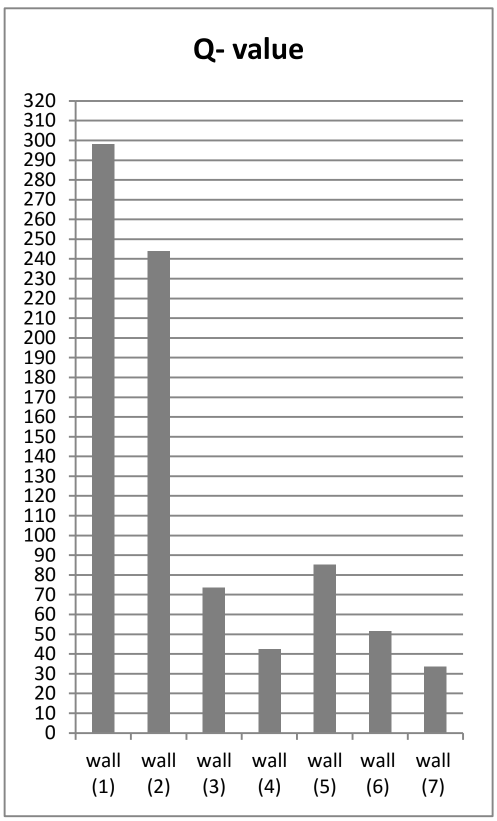


Table 1

Description	Q – value
Wall (1)	297.975
Wall (2)	243.926
Wall (3)	73.417
Wall (4)	42.415
Wall (5)	85.368
Wall (6)	51.5475
Wall (7)	33.712

The cross section of the wall (7) is the suitable wall in building at the site of case study because it has the lowest heat flux density through the wall in the building during the summer season. Rearranging another cross sections walls exponentially after wall (7) is wall (4), wall (6), wall (3), wall (5), wall (2) and wall (1), wherever the heat flux density increase through the wall in the building.

7. Conclusions

Conclusions and recommendations:

The design external envelope has main importance in reducing energy consumption in the building because it decreases the heat transfer through the wall building. Additional, it helps to increase the energy efficiency in building.
To achieve the thermal comfort indoor environment, should do stable design construction to external envelope of the building .The external envelope can be controlled in heat gain and heat loss at the indoor environment. So the search achieved to Strategies Savings by design construction and select material which can use at region study:
New block brick from polypropylene is suitable for the site of case study because it has the highest thermal resistant to heat transfer toward internal spaces. In additional, it characterized Low conductivity help at saving energy indoor environment in the building. Also, it is helping to achieve thermal comfort to building occupants. And this will impact on the behavior of building occupants towards use equipment where that will use it. Directly that will increase the thermal efficiency in building.
In another side, new block brick from polypropylene should be more economy to use in the low-cost building. In addition, it is Resistant to most natural processes of degradation, Low

environment impact; Recycle can be easy after use and Healthy.

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