Energy Conservation Through Heat Transfer Treatment In Buildings, Case Study "Building B At The British University In Egypt (Bue)"

Samar M. Sheweka, Mahmoud F. El-Sayed

Abstract: Nowadays, the most important problem facing the world is the problem of energy. Egypt needs about 20% more than the power station provides to avoid the electricity shortage [1] But it is not only about energy production; a part of the current problem solution is to save energy and reduce the energy consumption through the building envelope. At this study the researchers are intending to reduce the heat transfer from outside the buildings to inside through the walls, by using different types of thermal walls insulations. A discussion for each type will be held with its impact on energy consumption rate used in cooling process. Building "B" at the British University in Egypt has been selected and thermal wall insulation strategies were applied to achieve the best kind of thermal wall insulation preventing the heat transfer from outside to inside the building. A simulation study has been conducted to calculate the amount of heat entering the building in the summer, and how much energy does the air condition consume to cool the building spaces for each kind of thermal wall. The research ended up with different recommendations and conclusions for buildings with sustainable approaches in arid climate regions.

Index Terms: Energy Efficiency, Building Insulation.

1 INTRODUCTION

Nowadays, the most important problem facing the world is the problem of energy, for example, the electricity shortage in Egypt, nowadays. More than six electricity shortage happened daily for more than two hours each. Egypt needs about 20% more than the power station provides to avoid the electricity shortage [1] Most of the energy used up in buildings is in the Cooling process, where from 36.7% of the energy used in buildings in summer used to dismiss the heat moving into the building through the walls (air conditions), therefore walls are vital to a building's energy consumption. Heat can flow from the hot place to the cool place. In winter, the heat transfer from inside the building to outside, when the difference in temperature happened. In the summer, heat transfer from the outside to side through the wall. The heat that transferred into the building in the summer should be replaced by the air conditioner, also the heat lost from inside the building to outside the building should be replaced by the electronic heater, so this heat transfer cost electricity, that's why thermal wall insulation is important because it decrease the heat transfer and decrees the electricity consumption rate. The thermal wall insulation used in buildings plays a fundamental role of the energy shortage problem, by transmitting warmer temperature into the buildings that need to be ventilated well; therefore people tend to use alternative options such as air conditions to dismiss or contort their selves from, and this lead to high rate of energy consumption. The thermal wall insulation in a building supposed to decrease the heat transfer to provide the comfort for the building, with using air conditions and heater less than the wall without thermal insulation.

- *Samar M. Sheweka, Mahmoud F. El-Sayed*
- *Associate Professor, Architecture Engineering Department, Faculty of Engineering, the British University in Egypt (BUE)*
- *Researcher and Architect at El nady for Engineering & Agencies.*

The thermal resistance of the wall has an important effect in the energy consumption rate [2]. The function of the wall is to minimize the heat transfer from outside to inside and to increase the energy that can use to reduce the heat from inside to outside. There are many types of thermal wall insulation, use of thermal wall insulation will decrease the rate of heat being conducted into building and this will lead to decrease of the energy used by cooling systems such as air conditions, so we need the higher thermal wall insulation to save the energy, but every kind of the wall have its own insulation rate, so we need to achieve the highest thermal wall insulation due to The thermal resistance of the wall, The thermal resistance (U value) is the amount of the heat loses in the building through the walls. Low thermal resistance means high insulation and high thermal resistance means low insulation. The thermal resistance for the insulation materials is very important to know it before using this material or to know the best material for thermal wall insulation. The thermal resistance must be calculated for the insulation material before using it, to avoid reworking to achieve the best thermal insulation for the building.

2. ENERGY EFFICIENCY

Energy efficiency is the reducing of energy consumption rate; at the same time provide the same service. Change a normal wall with another with thermal wall insulation in a building, the new wall with thermal insulation reduce the heat transfer from outside to inside the building in the summer and from inside to outside the building in the winter, this will lead to using less energy with providing the same service [3]

3. ENERGY CONSERVATION

There is a big different between energy efficiency and energy conservation, energy conservation is reducing the service to save energy or going without this service to save energy. The best example for energy conservation is turning off the air conditions to save electricity, but using thermal wall insulation to prevent heat transfer from outside to inside building, so the air conditions does not run as usual to save electricity, it is energy efficiency[3]

4. THERMAL INSULATION

Thermal insulation is the Reduce of heat transfer from the outside to the inside the buildings in summer and from inside to outside in winter [4] Heat defeats across external walls and rooftops report for more than 70% of the total warmth defeats in buildings. Therefore, enhancing thermal insulation is the most competent method to save energy. At the same time it will aid enhance thermal comfort. The warmth seeping across the walls and ceilings in summertime embodies the bulk of the warmth to be removed alongside the air conditions [4].The building concerning about 36.7 % of the electrical power consumed in the summertime goes to cool the building. That most of the power goes to become clear of warmth leaking from walls and ceilings and from here we notes the importance of thermal insulation as it plays a big role in reducing the consumption of electrical energy used for air conditioning by reducing heat leakage through the walls, and this leads to substantial saving of energy. Through the summertime the temperature inside the building envelope is usually higher than it is outside. As a result, heat is lost through the envelope and, unless this heat is replaced, the inside of the building cools down adjusting to the outdoor temperature. The inverse applies for hot climates (or during hot periods) with excessive heat entering the building through its envelope [4] Therefore, it makes sense to restrict the heat flow in any building irrespective of the climate – and this is where thermal protection comes in. Good thermal protection can be achieved for all construction methods and has already been successfully implemented in solid construction, timber construction, prefabricated building elements, formwork element technology, steel construction [4] and all types of mixed constructions. A high level of insulation can also be applied to existing buildings at any given point of time.

4.1 Thermal Insulation Materials.

There are different criteria for choosing thermal wall insulation materials like; the price of the material, the insulation of the material, heat resistance and availability in stock. In addition to different requirements for choosing the thermal insulation materials like; coefficient of thermal conductivity, the low coefficient of thermal conductivity, the best thermal insulation resistance, the thickness of the wall, the more thickness of the wall means the more thermal insulation, the durability of the thermal insulation's material. The material must keep the ability of insulation to match with the life of the building, also, The thermal insulation materials must have the resistant to fire, or have the property of self-extinguishing.

5. EMPIRICAL STUDY

5.1 Introduction

Design builder simulation software has been selected [5],[6], and used to calculate the amount of heat entering the building and the air conditions consumption rate while using each kind of thermal wall insulation. Computer lab at Building B at the British University in Egypt was selected and thermal wall insulation strategies were applied to achieve the best kind of thermal wall insulation preventing the heat from outside to inside the building and test the amount of heat entering the building in the summer, and the consumed energy through air condition to cool the building in the existing condition and in case of each type of thermal wall insulation.

5.2 Simulation Information

The below table describe the main data concerning the location of the Building.

Table 1 *Describes the Main Data Concerning the Location of the Building*

Location :	Cairo
Source :	ASHRAE
Longitude :	31.40
Latitude :	30.13
Standard Pressure :	100.4 kpa
Time Zone :	GMT +02:00 Cairo
Start of winter :	October
Start of Summer :	March
End of summer :	September
Legislative region:	Egypt

5.3 Existing Condition for the computer lab

This computer lab located in building B at the British University in Egypt, it was selected as it is the most room that consumes electricity at the University as shown in the below calculations.

Figure 1 *Represents Section of the Existing Wall Layers*

Table 2 *Describes the Main Data Concerning the Lab.*

Area :		16m*3
Number of windows :6 windows Size of window :1.5*1.5 m Type of window: 2 aluminum sliding sashes.		
Number of doors:		One door
Door size 2*3m No of wall layers .5		
Layer no. one	Plaster Board	20 mm
Layer no. two	Mortar	50 mm
Layer no. three	Masonry	120 mm
Layer no. four	Mortar	50 mm
Layer no. five	Plaster Board	20 mm

5.3.1 Simulation Results for existing condition

U Value: 2.401
R Value: 0.586 m2k/w window to wall %: 30

5.3.2 Electricity consumption for existing condition

4 Air conditions (3h):
Each AC consume 3*3730/1000 = 11.190 kw/h
AC working for 6 hours daily: 6*11.190= 67.140 kw daily

Ac working 6 days a week: 67.140 * 6 = 402.840 kw per week [7]
AC working 4 weeks a month: 402.840 * 4 =1611 kw per month
According to the ministry of electricity prices, this electricity consumption at category 6. (1611 * 0.48) = (1611 * 0. = 733.28 EGP + 161.1 = 894 .38 EGP per month. So this room consume 894.38 * 12 = 10732 EGP per year for one Air condition, so this room consume 10732 * 4 = 42928 EGP for the 4 air conditions. When:

U value = 2.401
R value = 0.586 m2k/w

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5.4 SIMULATION OF OPTIMIZED WALLS

During the optimization process a 50 mm Polyurethane foam has been added to the existing walls in order to decrease the heat transfer through the outer wall as shown in table 4.

Figure 2 *Represents Section of the optimized wall Table 4 Represents all Layers for the Optimized Walls:-*

Table 3 *Represents Optimization Information*

Layer	Materials	Thickness
Layer 1	Plaster	20 mm
Layer 2	Polyurthane foam	50 mm
Layer 3	Mortar	50 mm
Layer 4	Brick	250 mm
Layer 5	Mortar	50 mm
Layer 6	Polyurtahne foam	50 mm
Layer 7	Plaster	20 mm

5.5 SIMULATION RESULTS:-

After the optimization the Heat losses decreased U value became 0.351 instead of 2.401 and R value became 2.847 instead of 0.586 k2mk/w. so we can use less number of air conditions to make this room comfort to the human needs, so we can use 2 ACS instead of 4, and this will save electricity consumption.

Window to wall%: 20
U value: 0.351
R Value: 2.847

5.5.1 Energy Consumption after Optimization:

4 Air conditions (3h):
Each AC consume 3*3730/1000 = 11.190 kw/h [7]
AC working for 6 hours daily: 6*11.190= 67.140 kw daily
Ac working 6 days a week: 67.140 * 6 = 402.840 kw per week
AC working 4 weeks a month: 402.840 * 4 =1611 kw per month

Table 4 *represents the areas of wall elements*

area	16 m * 6
No. of windows	4 windows
Size of window	0.75 m * 1.20 m
Door size	1.2 * 3 m

According to the ministry of electricity prices, this electricity consumption at category 6. (1611 * 0.48) = (1611 * 0. = 733.28 EGP + 161.1 = 894 .38 EGP per month. So this room consume 894.38 * 12 = 10732 EGP per year for one Air condition, so this room consume 10732 * 2 = 21720 EGP for the 2 air conditions. The difference between the existing condition and after optimization:

42928 EGP – 21720 EGP = 21720 EGP

5.5.2 Cost of optimization

The price of one meter of polyurethane in Egypt will cost 200 EGP, and the room needs[7]:

- (w*h)*2) – (window size + door size) = (16 * 4) * 2 = 128 – (door size) = 128 – 4.5 =123.5 m
- (6 * 4) * 2 – (size of windows) = 48 – ((0.75 * 1.20)* 4) =48 – 3.6 = 44.4 m

Total = 123.5 + 44.4 = 167.9 m
Total area will cost 167.9 * 200 = 33580 EGP

So Payback period:
33580 / 21720 =1.55
Pay back will return after 1.55 year.

5.6 SIMULATION STUDY SUMMARY

Table 5 *Represents the simulation information for both existing and optimize conditions*

	Existing condition	optimization
Simulation Information	Area: 96 m No. of windows: 6 Size of window: 2 m * 1.50 m No of doors: 1 door Size of door: 2 m * 3 m No. of wall layers: 5 layers	Area: 96 m No. of windows: 4 Size of window: 0.75 m * 1.20 m No. of doors: 1 door Size of doors: 1.2 m * 3 m No. of wall layers: 7 layers
Materials	Masonry Mortar Plaster	Plaster Polyurethane Morter brick
U Value W/m2k	2.401	0.351
R Value m2k/w	0.586	2.847
Electricity consumption cost / vear	42928 EGP	21720 EGP
Optimization cost	Already built	33580 EGP

5.7. EMPIRICAL STUDY CONCLUSIONS

simulation studies shows that it's very important to use thermal wall insulation, because The thermal wall insulation used in buildings plays a fundamental role of the energy shortage problem, by transmitting warmer temperature into the buildings that need to be ventilated well; Therefore people tend to use alternative options such as air conditions to dismiss or contort their selves from, and this lead to high rate of energy consumption. The thermal wall insulation in a building supposed to decrease the heat transfer to provide the comfort for the building, with using air conditions and heater less than the wall without thermal insulation. The thermal resistance of the wall has an important effect in the energy consumption rate as shown in this simulation.

6. CONCLUSIONS

This research shows that it's very important to use thermal wall insulation, as it plays a fundamental role of solving the energy shortage problem, by preventing transmitting warmer temperature into the buildings that need to be ventilated _This study succeeded to reduce the heat transfer from outside to inside building B at the British University in Egypt (BUE), as it succeeded to reduce the use of air conditions in the Summer and electronic heaters in winter, and accordingly that will lead to reduce the energy consumption rate in the building. The thermal wall insulation in a building supposed to decrease the heat transfer to provide the comfort for the building, with using air conditions and heater less than the wall without thermal insulation. The thermal resistance of the wall has an important effect in the energy consumption rate as shown in this simulation. There is a need to higher thermal wall insulation to save the energy, but every kind of wall have its own insulation rate, so we need to achieve the highest thermal wall insulation due to The thermal wall resistance, The thermal resistance must be calculated for the insulated material before using it, to avoid reworking to achieve the best thermal insulation for the building.

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