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Building Conversion to An Energy Efficient Building

Improvement Thermal Transmittance of A Higher Educational Building in Egypt

Sherif El Sayed El Said Mohamed
Assistant Professor, Department of Architecture
Faculty of Architecture and Planning, Qassim University
Qassim, Kingdom of Saudi Arabia

Ahmed Yehia Ismail
Associate Professor, Department of Architecture
Faculty of fine Arts, Helwan University
Cairo, Egypt

Abstract - **Energy saving is one of the world's most important issues because of the lack of energy expected in the future as the urgent need for efficient energy applications for buildings in Egypt is necessary to help reduce demand for cooling and efficient heating. Moreover, solar energy applications are not cheap even with their availability. That is why solar energy is not contributing to energy production, which is often the most expensive, despite rising natural gas and oil prices. On the other hand, many buildings in Egypt are characterized by poor design with respect to the ventilation and insulation system.**

The materials used for the construction of buildings are usually made of bricks, concrete, stone and metal. There is no internal or external insulation. Later, these buildings have a bad internal climate characterization. Therefore, this paper aims at achieving the requirements of energy-efficient buildings in hot and dry climates. As well as to achieve new solutions for the reconstruction of those buildings. Then, we can significantly reduce power consumption to compare to current consumption.

To achieve the main objective of this paper, all factors affecting the design of the building will be introduced to reach thermal comfort such as building, building, steering, and envelope construction. As well as discussing the problems that have emerged in non-structural components such as external and internal walls, ceilings, openings, and other building components. On the other hand, this objective can be reached by verifying the experience of using various relevant technical solutions in developing countries in the same climatic conditions as traditional design elements in Egypt. The goal is to export the concept of energy efficient buildings as much as possible to maximize indoor comfort by minimizing the adverse climate impact with minimal energy consumption.

Keywords - Energy consumption; Energy efficient; Building envelope; Natural ventilation; Thermal comfort.

I. INTRODUCTION

The construction sector alone accounts above 33% of world energy consumption which making it the biggest single supporter of the total energy intake [1]. The countries of the south-eastern Mediterranean are expected to witness a population growth of 40 million and new housing units, reaching 24 million by 2030 [2]. Increasing population, housing and improving living standards will therefore increase energy demand. As more families use electrical appliances such as washing machines, refrigerators, and air conditioners, the main reason for the rapid increase in electricity demand is the latest. As a result, primary energy consumption increased by about 50% between 2000 and 2009, and the final consumption of electricity almost doubled. Thus, the "business as usual" approach will double the final demand for electricity by 2020.

The International Energy Agency asserts that "Energy efficiency improvements in buildings, appliances, transport, industry and power generation represent the largest savings and the least expensive" in emissions [3]. So, reducing electricity consumption will now most effective have environmental and economic advantages, however may also aid electricity safety and a cleaner environment. At the national level, this will also provide financial resources for the needy sectors such as health and education. At the individual level, the family budget will be relaxed.

The correct approach starts from the architectural design stage and the preparation of the initial drawings. In addition, simple strategies such as orientation, insulation, window size and shading will reduce net energy demand by about 30% as well as improve indoor comfort.

Before, the building design of depended on construction rehearses created after the experiment and the realization of right or wrong proportions, but now, designer changes the buildings designs significantly and turn out to be extra strength efficient. There were 3 important adjustments inside the way we construct buildings:

- Thermal insulation changing.
- Enhance air tightness
- Air conditions emergence & heating systems [4].

II. BASIC PRINCIPLES IN ENERGY EFFICIENT BUILDING DESIGN

A. Building Orientation

Primarily, the building orientation has a great effect on energy consumption. Quantity, ratio, orientation of the glazed surface are 3 criteria for this case, where the large glass surface on the southern oasis of the constructing increases the heat absorption capability of the building inside the wintry weather. To reduce sun warmth acquisition throughout summer season, the glazed surface ought to be furnished with appropriate shading devices [5].

B. Building form

Building shape is a very essential detail at an early degree of design and strongly affects the building energy consumption. The building with compact form is higher than others. Furthermore, L-shaped building expends extra energy than a cubic meter because of the span of the wall surface, resulting in more heat losses [6].

C. Shading

Shading limits solar radiation, where it is most important in hot weather, especially in summer [4]. To control solar heat, gain rates, low-cost solar crushers can be absorbed as they take in and reflect a big part of sunlight before reaching windows. On the other hand, the use of shading devices will be appropriate in the summer because it will reduce the cooling energy, such as the hanging devices, umbrellas and curtains that can be used for this purpose [5].

III. BUILDING ENVELOPE

Building envelope controls the heat exchange among external and internal areas. The two principle thoughts to decrease this thermal exchange are insulation and the thermal mass.

Thermal mass is powerful while the temperature distinction among day and night is more 140 °C [7]. Materials with a huge thermal mass have a high ability to heat storage as these materials are heavy weight and have a high density such as clay bricks and natural stone and therefore they can assimilate and store heat amid the day and afterward discharged around evening time.

Insulation materials decrease heat transfer during building casing because of low thermal conductivity (under 0.1W/m). Little air bubbles also decrease heat transfer. This is why insulation materials have lightweight & low density. During warmer regions, well insulated buildings are characterized by lower cooling loads due to lower heat transfer from the outdoor to the inner. This, in turn, results in better internal quality, which reduces the comfort and productivity of individuals, as the need for additional cooling loads is reduced. Insulation materials vary between fibers or cell insulation, and should keep going as long as the building is in place (approximately 50 years).

A. Thermal insulation position

Insulation can be carried out to various locations within the building; either indoor, outdoor, or among two layers as follows:

Indoor insulation makes solar heat penetrate through the external wall. so, the thermal transfer rate is reduced in the insulation layer. This choice is effective in cold atmospheres with warming as a main power requirement. If there should be an occurrence of heat exchange from internal to external, internal warmth won't be consumed from the wall.

Outdoor insulation decreases the heat flow at the external building's envelope. Therefore, this solution is preferred in hot climates [8].

Insulation between thermal mass layers is a combination of above alternatives, the most appropriate for blended atmospheres that require cooling and heating. It is a great solution, because the protection material is surrounded by two strong components, which provides sturdiness. however, it's far hard to replace them.

The simplest way to choose the appropriate protection material is to compare U-values. It means that the heat exchange limit of the materials. lower U-value, better protection limit.

B. Wall construction

The walls materials choice need to make sure the desired of the building energy performance. because the walls often occupy the building's biggest surface. their U-value (thermal transmittance) significantly affects cooling request (For calculation of the U-value see page 4). This consists of dark (closed) walls and windows and doors (glass and body). It is worth noting that the more materials used in building and finishing the walls more resistant to external environmental factors, the lower the thermal conductivity and also the rate of transfer of thermal energy inside the building

Alongside the wall thermal conductivity, also the color and the surface texture affect the indoor cooling load. Mild colored wall displays extra energy than a dark one. Rough surface makes shade on itself. so, it decreases the heat retention. In the two cases, thermal transmission decreased beside the cooling load.

TABLE I. THERMAL TRANSMITTANCE (U-VALUE) OF AN INSULATED CAVITY WALL IN EGYPT.

Elements	Thichnes (m)	Thermal Conductivity λ (*W/mC*)	Thermal Resistance (*W/m^{2}C*)
External Surface (R_{so})	-	-	0.050
External Brick	0.10	0.960	0.100
Cavity filled with foam	0.10	0.040	2.500
Internal Block	0.10	0.550	0.180
Plaster	0.01	0.480	0.020
Internal surface (R_{si})	-	-	0.120
Total Thermal Resistance (R_t)			2.970
U-value = (1/Rt)			**0.340**

C. Roof construction

The roof of the building receives most of the sun's rays per square meter. In this way, it's important the rooftop has a high thermal capacity and thermal insulation. Like the wall, the U-value are the thermal transmittance indicator for the roof.

Figure 1 indicates two different rooftop constructions. one is insulated and the alternative isn't. By evaluating the thermal transmittance of those rooftops, we see that the insulated roof has a very lower thermal transmittance and accordingly a higher thermal resistance. so, rooftop insulation is most favored for all atmospheres.

The roof shading components, for example, solar thermal, pergolas, and so forth decrease the solar radiation and the heat load on the rooftop [8].

Above all, a basic method to decrease the cooling load by coloring the rooftop with light color such as white painting which reflects much sun heat and along these lines it requires longer time for warm up the rooftop. so, it takes longer before warm the indoor space, this operation called "The time lag".

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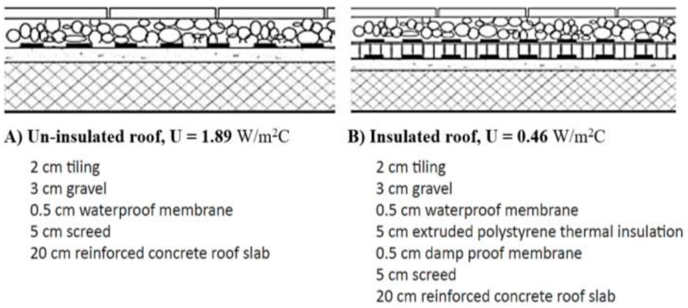

Figure 1: Roof construction examples.

D. Thermal bridges

Thermal bridges problem is that it interrupts the insulation layer. This makes thermal switch on the building components connections, which includes wall-floor, and wall-window connections, as in fig. 2 (left). In case of building without correct insulated, Thermal bridges constitute low losses (always under 20%) as compared with the energy losses through the building envelope. but, thermal bridges might also cause condensation issues amid winter in humid areas, see figure 4 (right).

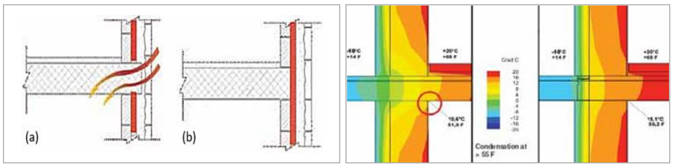

Figure 2: (Left) (a); Thermal bridge at the wall-floor connection, (b); Good insulation without thermal bridge.
(Right); Temperature flow at the wall-floor connection

When the roof and walls are all around insulated, the losses percent because of thermal bridges turns into high (over 30%), in comparison with losses via the envelope. so, In energy efficient buildings, thermal bridges need to be avoided [9]. Above all, The reinforced concrete structure are the common construction method in the Mediterranean region which contain (columns, beams and floor slabs), and brick walls, This all enhances the presence of thermal bridges.

Solve thermal bridges as following:

- For interior insulation, the solution complex because the wall and roof should be wrapped with insulation for round 50 cm from the wall.
- Continuous external insulation is an ideal strategy to resolve thermal bridges at floor-wall connection.
- When insulation between two construction layers, the problem can be solved by adding to the frame work edge (3cm polystyrene) earlier than adducing concrete.

E. Glazing

In the same area, Windows may lose heat around 5 times more than a wall. so, the window glazing U-value must be improving or taken into consideration.

Glazing types

- **Single glazing:** The normal type in the middle east, as it's the least expensive, it additionally has the biggest thermal transmittance. so, it produces a huge heat exchange.

- **Double glazing:** Often utilized for sound decrease. In addition, it reduces the amount of heat transfer and cooling load.

Glazing specifications

Glazing thermal transmittance: which is comparable for roofs & walls, such as:

- Single glazing; U-value =5.88 W/m² C
- Double glazing; U-value = 2.88 W/m²C. by adding argon to the air cavity, the U-value can be lower.

To calculate the whole window thermal transmittance, the window frame must be taken into consideration.

G-value: Indicate the energy transmission through the glass, as in fig., 3. To decrease face light, G-value ought to be higher. However, to reduce glare in spaces with an exceptionally external light, a decrease G-value ought to be conceded.

The emissivity: measure of thermal radiation which emitted by the glass. To improve Glass overall performance, we will use special low emission coatings. which we referred to as Low-E glass.

- Emissivity of the same glass has around 0.840.
- Emissivity of Pyrolytic covering can accomplish roughly 0.400 [10].

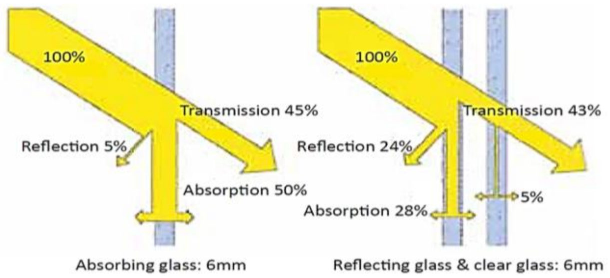

Figure 3: Solar radiation to glazing is transmitted, absorbed, and reflected.

F. Air tightness in buildings

Heat loss and heat gain also caused by tiny air gaps between layer of building elements or components such as walls, doors, and windows. So, Air tightness must be addressed during the selection of bonding materials between building elements. this must ensure that the seal can be done correctly. On the other hand, the implementing agency have to know the significance of air tightness and subsequently implement during the various stages of building construction. Above all, the air gap width has to calculated precisely on sketches. So, the site supervisor can know the locations of the critical points. The following points have to take into consideration during the construction phase:

Wall

- Make certain to fill the mortar junction completely.
- Avoid gaps among the elements that appeared through the construction of walls and roof.

Windows & Exterior Doors:

- Make certain that the windows and doors are included with the air strips to get a suitable tight arbitrator when closing.
- All pieces in the building have to closed using permanent materials like plaster and rubber.

G. Material preference

The building materials preference is a substantial part of passive architecture design. Beside the architectural features, thermal properties have to take into consideration we when decide to select building materials. Ameliorating the building energy performance need to be assessed the following characteristics:

Thermal transmittance (Heat transfer coefficient) - U-value (W/m²C): This is the sum of the resistors (Rc) for each building material and the external surface resistors (Rso) and the envelope inner faces as in figure 4.

The R-value (m²C/W): This is the material thermal resistance, and calculated from relation: R= t/λ (m²C/W), (t) material thickness in meter, (λ) the thermal conductivity of material.

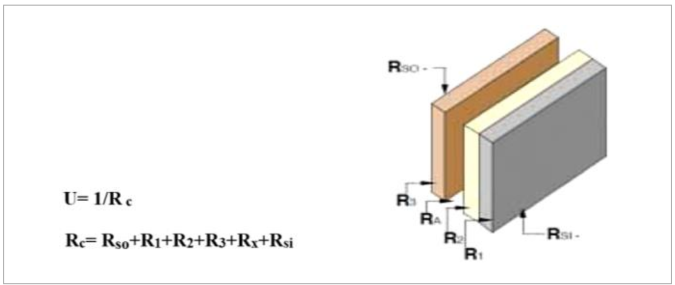

Figure 4: U-value calculation

H. Envelope requirements

The energy efficient buildings envelope recommendations are lists in the following table in summer and winter climate. It depends on the number of building floors.

TABLE II. THE MEANNING OF LIGHT CONSTRUCTION (TRADITIONAL BUILDINGS CONSTRUCTED WITH WOOD WALLS, FLOORS, AND ROOF) AND HEAVY CONSTRUCTION (TRADITIONAL BUILDINGS CONSTRUCTED WITH MASSIVE WALLS, CONCRETE BLOCKS, AND CONCRETE UNIT).

Building envelope components		Thermal transmittance (U-value) W/m²C	
		Light Construction	Heavy construction
Roof	≥ 10 floors	≤ 0.40	≤ 0.80
	7-9 floors	≤ 0.40	≤ 0.80
	4-6 floors	≤ 0.40	≤ 0.80
	≤ 3 floors	≤ 0.40	≤ 0.60
Exterior Wall	≥ 10 floors	≤ 0.50	≤ 0.10
	7-9 floors	≤ 0.50	≤ 0.10
	4-6 floors	≤ 0.50	≤ 0.10
	≤ 3 floors	≤ 0.40	≤ 0.80
Ceiling (Slabs)		≤ 1.50	≤ 1.50

IV. COMMON THERMAL BUILDING PROBLEMS IN HOT REIGONS

The aim of house building is to get the population free from external conditions like sun rays and humidity in summer and snow, rains, and wind storm in winter. Thus, a desirable indoor environment for buildings should be stablished. The cause of worldwide concern over the energy resources and weather is to identify more factors for design buildings.

Architects and/ or designers must be study the climate features of their environmental designs. Moreover, according to this awareness, they can classify building thermal problems and propose ways to get rid of them which is known as a climate design, concerning the characteristics of climate in the desired region.

To introduce a building with a good indoor climate and thermal comfort in all climates, the common building thermal problems must first be determining. The below points are commonly referred to in several studies:

- Higher temperature.
- Higher solar radiation.
- high RH level or Moisture.
- Increase excessive heat in the summer.
- Heat loss during the winter [11].

Thermal radiation from sun one of the factors must be taken into consideration in studying Egyptian climate as well high temperature, summer heat gains and lose to achieve thermal comfort and good indoor climate. The objective in this study is:

- Decrease the consumption in building energy.
- Achieve a higher thermal comfort level.

In this paper, a typical building (Modern Academy for Engineering and Technology) will be analyzed which construction in El Moqatam, Cairo city, Egypt. For this purpose, the properties of various parts of the building will be studied and analyzed.

V. ANALYZE AN EDUCATIONAL INSTITUTION BUILDING (ARCHITECTURAL DEPARTMENT)

The Architectural department building considers a relative large educational building. The project built in 1993. It includes 5 floors and floor area of 2414 m². All floors of the building use for engineering educational purposes. The project direction is (south north) and not attached buildings around it.

Figure 4: (Up); Layout of the modern academy, (Bottom); Modern academy Architectural building (Basement, Ground, Typical, and Roof) floors.

The building has small natural ventilation windows because it relies heavily on central air conditioning, which causes thermal discomfort in summer when power is off.

Figure 5: (Right) Modern academy main entrance, (Left) Architectural departement drawing hall.

VI. BUILDING ENVELOPE CHARACTERISTICS

A. Outside walls characteristics

The outside wall is one of the most important part of the building. Lots of heat loss through non-insulated walls. The walls exterior insulation is the best to increase the energy efficient. Reducing the cooling and heating requirements of buildings depends on the insulation ways which known as the thermal transmittance.

It refers to the flow of heat within 1 m^2 of the wall at a constant temperature difference of 1°C. Table III show the materials used to build and finish the building walls (from internal to external).

TABLE III. THE PROJECT WALL MATERIALS. EXTERIOR WALL NOT INSULATED. THE THERMAL TRANSMITTANCE PROPOSED BY THE BUILDING CODE ISN'T OVER TO 0.8 W/M^2°C. BUT THE REALIZED THERMAL TRANSMITTANCE IS 1.84 W/M^2 °C AND IS FAR FROM THE PROPOSED U VALUE REQUIREMENTS (SEE FIGURE 7).

Materials	Thichnes (cm)	Thermal Conductivity λ (W/mC)	Thermal Resistance **Rc** (m^2°C/W)	**U-value** (1/Rt)
			R_{si} = 0.12	
Portland cement	3	0.175	0.34	
Clay Brick	25	0.6	0.59	
Portland cement	3	0.175	0.34	
Hard gypsum finishing layer	2	0.15	0.30	
			R_{so}= 0.04	
Total	34		**R_t** = 2.25	0.444

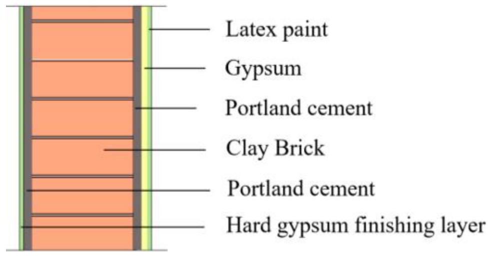

Figure 6: Section in wall construction which isn't use thermal insulation. The wall U-value is 0.444 W/m^2°C.

B. Roof properties

Building roof is an important component. because it contributes of heat losses in a large part of the building. the roof elements and properties showing in the following table (from up to down).

TABLE IV. THE PROJECT ROOF MATERIALS. THE ROOF HEAT LOSSES ACCOUNTS 30% OF THE TOTAL ENERGY LOSS. BY THE BUILDING CODE, THE U-VALUE ASSUMED ISN'T MORE THAN 0.6 W/M^{2}C. BUT REACHED IS 1.70 W/M^{2}C WHICH IS HIGHER OF ASSUMED U-VALUE. FOR DETAILS, (SEE FIGURE 7).

Materials	Thichnes (cm)	**λ** (W/mC)	**Rc** (m^2.°C/W)	**U-value** (1/Rt)
			R_{si} = 0.10	
Mozaico Tiles	2	1.6	0.018	
Portland cement	2	0.175	0.028	
Sand	6	1	0.25	
Ren. concrete	15	2.5	0.06	
Gypsum	2	0.22	0.091	
			R_{so}= 0.04	
Total	27		**R_t** = 0.587	1.70

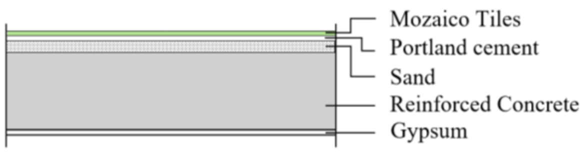

Figure 7: Roof costruction cross section, no thermal insulation in it. The roof thermal transmittance is 1.70 W/m^{2}C.

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C. Slab properties

The building slab insulation characteristics show in the following table (from up to down).

TABLE V. THE SLAB CROSS SECTION OF THE BUILDING. BY THE BUILDING CODE, THE U-VALUE ASSUMED IS 1.5 W/M²C (SEE TABLE II), WHILE THE ACHIEVED U-VALUE IS 1.70 W/M²C. FOR DETAILS, (SEE FIGURE 8).

Materials	Thichnes (cm)	**λ** (W/mC)	**Rc** (m²°C/W)	**U-value** (1/Rt)
			R_{si} = 0.10	
Marble Tiles	1	1.6	0.018	
Portland cement	2	0.175	0.028	
Sand	6	1	0.25	
Ren. concrete	15	2.5	0.06	
Gypsum	2	0.22	0.091	
			R_{so}= 0.04	
Total	26		R_t = 0.587	1.70

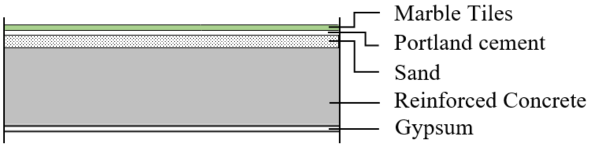

Figure 8: Slab construction cross section. Floor coating with marble tiles which near of reinforced concrete layer. This usually produced problems like (condensation and mold growth) under the floor coating.

D. Windows &Exterior doors

The building Windows are single-glazed & aluminum frame. It has characteristics as follow:

- Total Solar heat gain coefficient (SHGC) = 0.76
- Total Solar transmittance (T) = 0.81
- The thermal transmittance (U-value) = 3.5 W/m² C

VII. BUILDING CONVERSION TO AN ENERGY EFFICIENT BUILDING

we will improve the previous educational institution project to an energy efficient building. so, a lot of factors ought to be conceded as follow.

A. Wall properties (Wall insulation)

Improving the external wall properties demand reducing the U-value to reach less than 0.8 W/m²°C [12]. To reduce it, we must use the thermal insulation [13]. The heat insulation layer thickness must be between 10-60cm [14]. Table VI show a recommended roof material (from indoor to outdoor).

TABLE VI. THE WALL CONSTRUCTION CHARACTERISTICS AFTER CONVERSION. TO IMPROVE EXTERNAL WALLS THERMAL TRANSMITTANCE, A CAVITY INSULATION LAYER IS APPLIED WHICH CONTRIBUTES TO 82% OF THE WHOLE COMPONENT THERMAL RESISTANCE, AS A RESULT, THE U-VALUE OF 0.20 W/M² C IS ACHIEVED (LESS THAN 0.8 W/M² C).

Materials	Thichnes (cm)	**λ** (W/mC)	**Rc** (m2.°C/W)	**U-value** (1/Rt)
			R_{si} = 0.10	
Latex paint	1	0.19	0.52	
Gypsum board	2	0.39	0.22	
Polyurethane	6	0.026	2.48	
Portland cement	3	0.175	0.34	
Clay Brick	25	0.6	0.59	
Portland cement	3	0.175	0.34	
Hard gypsum finishing layer	2	0.15	0.30	
			R_{so}= 0.04	
Total	42		R_t = 4.953	0.20

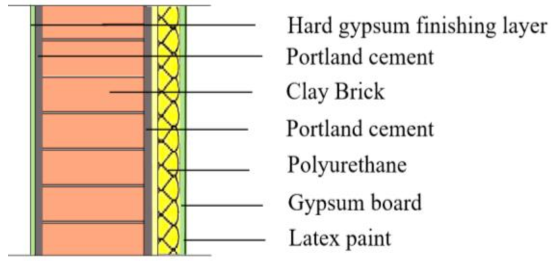

Figure 9: The conversed wall construction cross section. By adding a thermal insulation layer (polyethylene) and a layer of gypsum board. The U-value of the wall is improved until its value reach to 0.20 W/m² C.

B. Roof properties (Roof insulation)

The roof thermal transmittance must ≤ 0.4 [12]. to reach it, insulation layer should in average 20 to 40 cm [14]. So, a foam glass layer insulation is provided over RC which it not allows the sun heat to reach the concrete slab and inside building. Furthermore, it, when water proof layer becomes broken, foam glass no longer able moisture to spread throughout the roof [15]. table VII show a recommended roof material (from down to up).

TABLE VII. THE PROPERTIES OF ROOF CONSTRUCTION AFTER CONVERSION. TO IMPROVE THE ROOF U-VALUE, A LAYER OF FOAM GLASS IS APPLIED WHICH WAS 1.70 W/M² C. AFTER CHANGING, THERMAL TRANSMITTANCE REACH TO 0.18 W/M² C (LESS THAN 0.4 W/M² C).

Materials	Thichnes (cm)	**λ** (W/mC)	**Rc** (m².°C/W)	**U-value** (1/Rt)
			R_{si} = 0.10	
Gypsum	2	0.220	0.090	
Ren. concrete	1.5	2.50	0.060	
Bitumen	0.5	0.170	0.290	
Foam glass	20	0.040	5	
Bitumen	1	0.170	0.050	
Polyester	1	0.170	0.050	
Gravel	5	0.70	0.070	
			R_{so}= 0.040	
Total	44.5		R_t = 5.750	0.18

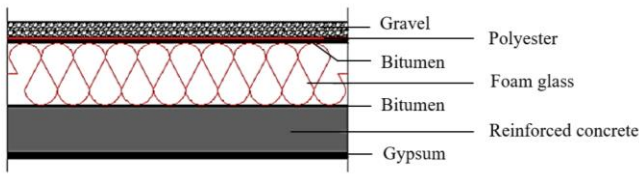

Figure 10: The conversed roof construction cross section. By adding a thermal insulation layer (foam glass), the wall construction is improved. furthermore, it, The bitumen 2 layers' act to a vapor barrier. The wall thermal transmittance is improved until its reach to 0.18 W/m² C.

C. Slab properties (Slab insulation)

The building slab consist of reinforced concrete. It's higher thermal transmittance is 1.68 W/m² C. we should reduce this value to less than 1.5 W/m² C [12]. Over the concrete slab, a layer of polystyrene should be (See figure 15). To reduce the building air infiltration, links between exterior wall and slab foundation must be closed [4].

A recommended slab construction material and their properties as in table 6 (from down to up).

TABLE VIII. THE SLAB CHARACTERISTICS AFTER CONVERSION. FOR SLAB, THE REQUIRED THERMAL TRANSMITTANCE MUST NOT EXCEED 1.5 W/M² C. THE BUILDING SLAB U-VALUE IS 1.68 W/M² C. TO IMPROVE THIS VALUE, A LAYER OF EXTRUDED POLYSTYRENE OVER CONCRETE SLAB IS APPLIED, AS A RESULT, THE U-VALUE OF 0.824 W/M² C IS ACHIEVED. FOR DETAILS, (SEE FIGURE 11).

Materials	Thichnes (cm)	λ (W/mC)	**Rc** (m^2.°C/W)	**U-value** (1/Rt)
			R_{si} = 0.17	
Ceramic tiles (porcelain)	1	1.40	0.18	
Extruded polystyrene	2	0.036	0.556	
Bitumen	1	0.170	0.059	
Concrete slab	20	0.70	0.118	
Gypsum	2	0.22	0.091	
			R_{so}= 0.04	
Total	26		R_t = 1.214	0.824

Figure 11: Cross section of the conversed slab construction. As a vapor barrier, a bitumen layer acts which allows passing the moisture in a slow, due to extruded polystyrene compressive strength, controlled manner used.

D. Windows and External doors

Building windows with high glazing characteristics could make any building comfortable. The buildings with perfect thermal transmittance. In summer, the outdoor temperature moves the inner glass surface temperatures down near of the room air temperature. So, it causes inconvenience because of drafts and brilliant heat loss.

Windows which have a minimum thermal transmittance is better choice for this trouble, in hot weather climates, all windows in buildings should have minimum solar heat gain coefficient values. in order to block the sun heat to enter the building. Low heat-gain coatings will decrease outside heat gain beside achieving comfortable, views and daylight.

Good windows should have a thermal transmittance =1.3 W/m² C and SHGC = 0.29 or less. To do that, Coating building windows by low heat-gain coatings. Or use double low-e-glazing windows in new building. On the other hand, Exterior doors should have a U-value up to 1.25 W/m² C. For exterior doors, Steel doors, fiber glass doors, and stave-core are recommended materials which give a good overall performance in phrases moisture motion, chemical damages and thermal movement [11].

E. Improving the building envelope transmission losses

The building thermal insulation is greatly improved compared with the original building. specific transmission losses (U-value) of the original building shows in the following table before and after conversion.

TABLE IX. TRANSMISSION LOSSES (U-VALUE) OF THE ORIGINAL BUILDING BEFORE CONVERSION. PROPORTION EQUAL THE PERCENTAGE OF TOTAL SPECIFIC HEAT LOSSES. TOTAL VALUE EQUALS THE ENTIRE BUILDING ENVELOPE.

	U-value (1/Rt)	Area (m^2)	**U-A** ($W/m^{2\,O}C$)
	Befor		Befor
External walls	1.84	3075	5658
Roof	2.63	1914	5033.82
Slab	0.24	9374	2249.76
Windows including frames (North)	3.33	412	1371.96
Windows including frames (South)	3.33	412	1371.96
Windows including frames (East)	3.33	810	2697.3
Windows including frames (West)	3.33	486	1618.38
Total	**1.71**	**16483**	**28185.93**

TABLE X. TRANSMISSION LOSSES (U-VALUE) OF THE ORIGINAL BUILDING AFTER CONVERSION. PROPORTION EQUAL THE PERCENTAGE OF TOTAL SPECIFIC HEAT LOSSES. TOTAL VALUE EQUALS THE ENTIRE BUILDING ENVELOPE. AFTER CONVERSION, THE CHANGE IN THERMAL TRANSMITTANCE FOR ALL PROJECT ENVELOPE WEIGHTED DECREASED 1.4W/°C AS IN TABLE.

Materials	**U-value** (1/Rt)	Area (m^2)	**U-A** ($W/m^{2\,O}C$)
	After		After
External walls	0.17	3075	522.75
Roof	0.18	1914	344.52
Slab	0.22	9374	2062.28
Windows including frames (North)	1.46	412	601.52
Windows including frames (South)	1.46	412	601.52
Windows including frames (East)	1.46	810	1182.6
Windows including frames (West)	1.46	486	709.56
Total	**0.31**	**16483**	**5109.73**

VIII. CONCLUSION

The study shows the next advantages of energy efficient project characteristics by using the building energy outside as in Egypt, during the hot summer and cold winter in addition to the important differences between day and night:

- To improve the external walls U-value, a cavity insulation layer should have applied to achieve a lower U-value which contributes to 82% of the whole component thermal resistance.
- Improving the roof U-value by applied a layer of foam glass which achieve a U-value less than 0.4 W/m² C.
- To improve the building slaps U-value, a layer of extruded polystyrene over concrete slab is applied which achieve a U-value less than 1.5 W/m² C.
- Coating building windows by low heat-gain coatings. Or use double low-e-glazing windows and low solar shading coefficient factor.
- Installing the exterior doors with U-value up to 1.25 W/m² C.

Design process and implementing energy efficient projects faces many challenges as follow:

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- Components availability.
- Existence and best warranty.
- People accept and understand these new applications and motivate them.
- Lowering energy prices to drive people to use.

Designing process energy efficient projects isn't "one-man show" which done by the designer, customers and developers also play a key role in this process and therefore all actors have the same responsibility. Architects with experience and expertise in this area can be the initiators of designing energy-efficient buildings. Hence their effective role in influencing developers and customers. Customers should also be informed about the amount of energy and costs that can be saved through effective energy building.

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AUTHER AND AFFILIATION

SHERIF EL SAYED EL SAID, graduated from Faculty of Engineering - Ain Shams University, Egypt in 2004, then obtained a master's degree from Cairo University in 2007 and P.H.D. degree in 2014. Now, He working as an assistant professor in Department of Architecture, College of Architecture and Planning, Qassim University, Kingdom of Saudi Arabia.

AHMED YEHIA ISMAIL, graduated from Faculty of Fine Arts - Helwan University, Egypt in 1999, then obtained a master's degree from Helwan University in 2003 and P.H.D. degree in 2009. He Obtained the Associate Professorship promotion in 2016. Now, He working as an associate professor in Department of Architecture, College of Fine Arts, Helwan University, Cairo, Egypt.

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