THE HEAT EFFICIENCY OF RESIDENTIAL BUILDINGS IN LIBYA

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Submission date: 14-Mar-2020 03:50PM (UTC+0700)
Submission ID: 1275444086
File name: B1.pdf (2.01M)
Word count: 6186
Character count: 31987

ZIBELINE INTERNATIONAL PUBLISHING

Journal of Mechanical Engineering Research and Developments (JMERD)

***DOI** : http://doi.org/10.26480/jmerd.01.2019.34.41*

ISSN: 1024-1752
CODEN : JERDFO

CrossMark

REVIEW ARTICLE

THE HEAT EFFICIENCY OF RESIDENTIAL BUILDINGS IN LIBYA

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ARTICLE DETAILS

Article History:

Received 20 November 2018
Accepted 26 December 2018
Available online 22 January 2019

ABSTRACT

Various studies have been conducted regarding the heat problem of Libya's building recently. The current method is to create a heat barrier in all parts of the building. Thermal insulation R-value of each material and the heat transfer coefficient such as U-value confirms to the Egyptian standards. This research was conducted by using a new design of double wall heat insulation materials which are available in Libya. This new design is to be compared to previous research. The proposed double wall and generated R-value provide higher efficiency than the best efficiency ever done.

KEYWORDS

Desert buildings, Hot Climate, Residential Buildings, R-value, Thermal Efficiency.

1. INTRODUCTION

Libya, is one of the most remarkable desert country, which was well known for its accommodation to the harsh desert climate [1]. Desert climate was one of the most important factors that affected its planning and buildings features as compact urban fabric, covered streets, narrow passageways and unique design houses and building materials and construction, which proved its success through generations [2]. Architecture in Libya, accommodated to harsh desert climate through protection, modifying and adaptation. Protection was basically from dense solar radiation, high temperatures and dusty wind, then modifying and get adapted to these harsh conditions, in order to create a comfortable internal microclimate, through sensitive and conscious solutions and construction technologies and well-studied planning and design by using suitable building materials of certain thermal properties that corresponded to the ambient environment.

The design theory has developed within mechanical engineering, many interesting observations with potentially major consequences have emerged. The concept of affordances includes both positive and negative versions however and this is where it stars to have real meaning for the discipline of architectural technology [3]. The observation that adding extra heating capacity to an existing building in temperate climates can have unforsence consequences. The new design idea is now understanding the relationships between insulation, heating sources and losses, moisture control and condensation, etc. Desert buildings represent living monument for the correspondence of buildings to the severe ambient environment especially harsh desert climate. Libya is that was well known for its correspondence to the harsh desert climate. Temperature conditions in Libya are very extreme, very hot air conditions during the day. This makes it uncomfortable to be outdoors, so the necessity of building the cold air conditions to make the body feel comfortable during the day.

2. METHODS

2.1 Energy Efficiency

To optimize building efficiency, it is necessary to understand the technical products that deliver the best outcome, the performance requirements of the building as a whole, and the goals and needs of the people inside the building. An integrated design process can put these elements together, optimizing energy performance, to help get the energy efficient green building we desire.

Energy efficiency of buildings can be achieved through the following elements:

1.bioclimatic architecture: shape and orientation of the building, solar protections, passive solar systems
2.high performing building envelope: thorough insulation, high performing glazing and windows, air-sealed construction, avoidance of thermal bridges
3.high performance-controlled ventilation: mechanical insulation, heat recovery

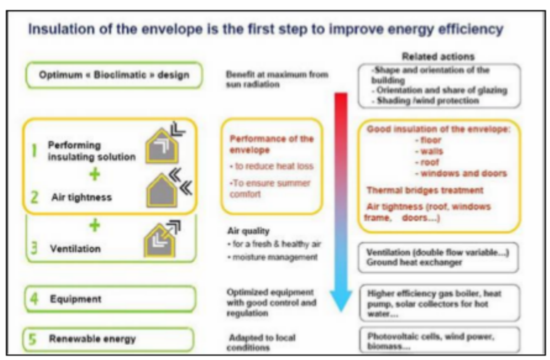

Figure 1: Step approach of developed efficiency energy building [4]

Figure 1 explain that energy efficiency is the first step toward achieving sustainability in buildings. Energy efficiency helps control rising energy costs, reduce environmental footprints, and increase the value and competitiveness of buildings. Energy efficiency is most effective when partnered with water efficiency, renewable energy technology and data enhancements, as well as educated building occupants.

2.2.1 Thermal Value of Material (New Idea)

The R-value is a measure of thermal resistance used in the building and construction industry [5]. Under uniform conditions it is the ratio of the temperature difference across an insulator and the heat flux. The formula heat transfer per unit area can be known by equation 1 [5].

$$R = \frac{\Delta T}{Q_a} \quad (1)$$

Where ΔT is the temperature difference across insulator and Q_a is a heat flux.

The calculation of R-value of a multi-layered installation that have some individual layers can be added by equation 2 [6].

$$R_{value-total} = R_{value(outside-air-film)} + R_{value(brick)} + R_{value(sheating)} + R_{value(insulation)} + R_{value(plasterboard)} + R_{value(inside-air-film)} \quad (2)$$

R-value expressed the thickness of the material normalized to the thermal conductivity, where the unit thermal conductance of a material is the reciprocal of the unit thermal resistance. This can also be called the unit surface conductance. The higher number can be concluded that the building insulation's theoretical effectiveness is being better. Thermal resistance varies with temperature but it is common practice in construction to treat it as a constant value. An R-value is a unit thermal resistance for a particular material or assembly of materials (such as an insulation panel). The R-value depends on a solid material's resistance to conductive heat transfer. For loose or porous material, the R-value accounts for convective and radiation heat transfer through the material. A material's thermal resistance or resistance to heat flow is measured by its R-value. High R-value enclosures are an important area of research in the development of ultralow energy buildings. BSC's on going High R-value Enclosure project, undertaken for the US Department of Energy's Building America program, aims to identify and evaluate residential assemblies that cost-effectively provide a 50 percent improvement in thermal resistance over current building code minimums.

The effectiveness of bulk insulation is commonly evaluated by its R-value, of which there are two - metric (SI) and US customary, the former being 0.176 times the latter. For attics, it is recommended that it should be at least R-38 (US customary, R-6.7 metric). However, an R-value does not take into account the quality of construction or local environmental factors for each building. Construction quality issues include inadequate vapor barriers, and problems with draft-proofing. In addition, the properties and density of the insulation material itself is critical [7]. When determining the overall thermal resistance of a building assembly such as a wall or roof, the insulating effect of the surface air film is added to the thermal resistance of the other materials. In practice the above surface values are used for floors, ceilings, and wall in a building, but are not accurate for enclosed air cavities, such as between panes of glass. The effective thermal resistance of an enclosed air cavity is strongly influenced by radiation heat transfer and distance between the two surfaces. A U-value is a measure of heat loss in a building element such as a wall, floor or roof. It can also be referred to as an overall heat transfer co-efficient and measures how well parts of a building transfer heat. This means that the higher the U value the worse the thermal performance of the building envelope. A low U value usually indicates high levels of insulation. They are useful as it is a way of predicting the composite behavior of an entire building element rather than relying on the properties of individual materials. The U-factor or U-value is the overall heat transfer coefficient that describes how well a building element by equation 3 [5].

$$U = \frac{1}{R} = \frac{\dot{Q}_a}{\Delta T} = \frac{k}{L} \quad (3)$$

Where *k* is the material's thermal conductivity and *L* is its thickness.

The elements are commonly assemblies of many layers of components such as those that make up wall/floors/roofs etc. It measures the rate of heat transfer through a building element over a given area under standardized conditions [7]. The usual standard is at a temperature gradient of 24 °C (75 °F), at 50% humidity with no wind (a smaller U-factor is better at reducing heat transfer). This means that the higher the U value the worse the thermal performance of the building envelope. A low U value usually indicates high levels of insulation. They are useful as it is a way of predicting the composite behavior of an entire building element rather than relying on the properties of individual materials.

The phrase U-Factor (which redirects here) is used in the US to express the insulation value of windows only, R-value is used for insulation in most other parts of the building envelope (wall, floors, roofs). Other areas of the world generally use U-Value/U-Factor for elements of the entire building envelope: including windows, doors, wall, roof & ground slabs.

2.1.2 Temperature limits of some common insulation materials

Temperature limits of some common insulation materials are indicated in the Table 1.

Table 1: Temperature range of some common insulation materials [8]

Insulation	Low		High	
	(°C)	*(°F)*	*(°C)*	*(°F)*
Calcium Silicate	-18	0	650	1200
Cellular Glass	-260	-450	480	900
Elastomeric foam	-55	-70	120	250
Fiberglass	-30	-20	540	1000
Mineral Wool, Ceramic fiber			1200	2200
Mineral Wool, Glass	0	32	250	480
Mineral Wool, Stone	0	32	760	1400
Phenolic foam			150	300
Polyisocyanurate or polyiso	-180	-290	150	300
Polystyrene	-50	-60	75	165
Polyurethane	-210	-350	120	250
Vermiculite	-272	-459	760	1400

Calcium Silicate Insulation, non-asbestos Calcium Silicate insulation board and pipe insulation feature with light weight, low thermal conductivity, high temperature and chemical resistance. Cellular glass insulation is composed of crushed glass combined with a cellulating agent. These components are mixed, placed in a mold, and then heated to a temperature of approximately 950 °F. During the heating process, the crushed glass turns to a liquid. Cellulose Insulation is made from shredded recycled paper, such as newsprint or cardboard. It's treated with chemicals to make it fire- and insect-resistant, and is applied as loose-fill or wet-sprayed through a machine. Fiberglass Insulation is the most common type of insulation. It's made from molten glass spun into microfibers. Mineral Wool Insulation is made from molten glass, stone, ceramic fibred or slag that is spun into a fiber-like structure. Inorganic rock or slag are the main components (typically *98%*) of stone wool. The remaining *2%* organic content is generally a thermosetting resin binder (an adhesive) and a little oil. Polyurethane insulation is an organic polymer formed by reacting a polyol (an alcohol with more than two reactive hydroxyl groups per molecule) with a diisocyanate or a polymeric isocyanate in the presence of suitable catalysts and additives. Polyurethanes are flexible foams used in mattresses, chemical-resistant coatings, adhesives and sealants, insulation for buildings and technical applications like heat exchangers, cooling pipes and much more. Polystyrene is an excellent insulator. It is manufactured in two ways: Extrusion - which results in fine, closed cells, containing a mixture of air and refrigerant gas; Molded or expanded - which produces coarse, closed cells containing air. Extruded polystyrene, or XPS, is a closed-cell, thermal plastic material manufactured by a variety of extrusion processes. The main applications of extruded polystyrene insulation are in building insulation and construction in general. Molded or expanded polystyrene is commonly called bead board and has a lower R-value than extruded polystyrene. Polyisocyanurate Insulation or polyiso is a thermosetting type of plastic, closed-cell foam that contains a low-conductivity gas (usually hydrochlorofluoro-carbons or HCFC) in its cells [9].

2.2 Date Analysis

This study analyzes energy efficiency residential building located in Libya, where the building can be shown in Figure 2 and Figure 3. Libya is a country in the Maghreb region of North Africa. Libya lies between latitudes 19° and 34°N, and longitudes 9° and 26°E. The three traditional parts of the country are Tripolitania, Fezzan and Cyrenaica. With an area of almost 1.8 million square kilometer (700,000 sq mi), Libya is the fourth largest country in Africa, and is the 17th largest country in the world. The largest city and capital, Tripoli, is home to over one million of Libya's six million people.

At 1,770 kilometers, Libya's coastline is the longest of any African country bordering the Mediterranean. The climate is mostly extremely dry and desert like in nature. However, the northern regions enjoy a milder Mediterranean climate. Natural hazards come in the form of hot, dry, dust-laden sirocco (known in Libya as the *gibli*). This is a southern wind blowing from one to four days in spring and autumn. There are also dust storms and sandstorms. Oases can also be found scattered throughout Libya, the most important of which are Ghadames and Kufra. Libya is one of the sunniest and driest countries in the world due to prevailing presence of desert environment. The Libyan Desert, which covers much of Libya, is one of the most arid and sun-baked places on earth. In places, decades may pass without seeing any rainfall at all, and even in the highlands rainfall seldom happens, once every 5–10 years [10].

Likewise, the temperature in the Libyan Desert can be extreme; on 13 September 1922 the town of 'Aziziya, which is located southwest of Tripoli, recorded an air temperature of 57.8 °C (136.0 °F). Considered to be a world record. In September 2012, however, the world record figure of 57.8 °C was overturned by the World Meteorological Organization.

Figure 2: Building experiment in Libya

Figure 3: Sketch Residential Building

Thermal resistivity R-value of a building element is the inverse of the conductance. In the case of the mass insulations, the R-value is essentially a material property that can be determined by various measurement techniques, where Figure 4 represents about the R-value multi layers including thermal circuits for each material. The reflective foil insulations on the other hand, decrease heat transfer by altering the system in which they are placed. The R-value of the single layer can be expressed by equation 4 [5].

$$R = \frac{1}{C} = \frac{l_t}{K} \quad (4)$$

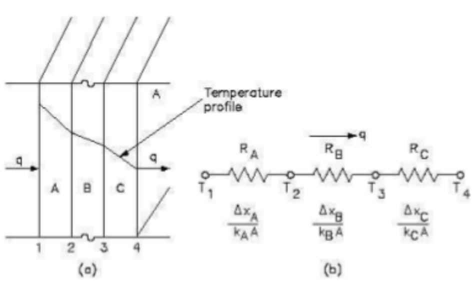

Figure 4: R-value multi layers

Based on the single layer equation, the R-value of the multi layers can be decided by equation 5 [5].

$$R_t = \frac{l_{i,1}}{K_1} + \frac{l_{i,2}}{K_2} + \frac{l_{i,3}}{K_3} + \frac{l_{i,4}}{K_4} + \dots \quad (5)$$

Where C is a conductance of heat flow through unit area in unit time (W/m²K), K is a layer conductivity (Btu in/hr ft² °F, W/mK), and l_t is a thickness of layer (inches, m).

A U-value is a measure of heat loss in a building element such as a wall, floor or roof. It can also be referred to as an overall heat transfer co-efficient and measures how well parts of a building transfer heat [4]. This means that the higher the U value the worse the thermal performance of the building envelope. A low U value usually indicates high levels of insulation [5]. U-values are important because they form the basis of any energy or carbon reduction standard. In practice, nearly every external building element has to comply with thermal standards that are expressed as a maximum U-value that occurs in the wall, floor or roof. U-value is the inverse of R-value, where the construction consisting of several layers can be expressed by equation 6 [5].

$$U = \frac{1}{R} \quad (6)$$

$$R = R_1 + R_2 + R_3$$

The overall of heat transmission coefficient - U - can be calculated by equation 7 [5].

$$U = \frac{1}{\left(\frac{1}{C_1} + \frac{X_1}{K_1} + \frac{X_2}{K_2} + \frac{X_3}{K_3} + \dots + \frac{1}{C_0}\right)} \quad (7)$$

For wall and floors against earth - can be modified to equation 8 [5].

$$U = \frac{1}{(Rj + R_1 + R_2 + R_3 + \dots + R_d + R_e)} \quad (8)$$

Where C_i is a surface conductance for inside wall (W/m²K), x is a thickness of material (m), k is a thermal conductivity of material (W/mK), C_o is a surface conductance for outside wall (W/m²K), R_i is a thermal resistivity surface inside wall (m²K/W), R_L is a thermal resistivity in the separate wall/construction layers (m²K/W), R_o is a thermal resistivity surface outside wall (m²K/W), R_e is a thermal resistivity of earth (m²K/W), U is a Heat Transfer Coefficient (Btu/hr ft² °F, W/m²K) and R is a R-value the resistance to heat flow in each layer (hr sq.ft °F/Btu, m²K/W).

Typically, the internal resistance for a wall is 0.13 m²K/W and the external resistance is 0.04 m²K/W. Current limiting U values [area weighted] in England and Wales are 0.35 W/m²K for wall and 0.25 W/m²K for roofs. Where the $T_{f,o}$ initial fluid temperature, T_h surface temperature of heated impeller, the a convective heat transfer coefficient of the heated fluid to the impeller mass m_f [7, 12].

2.2.1 Heat through Floors

The equation used for sensible loads from the floors based on the accepting further that heat loss grows linearly that can be shown in equation 9 [4].

$$Q = U \bullet A \bullet (T_2 - T_1) \quad (9)$$

Where Q is a sensible heat gain (Btu/Hr), U is a thermal Transmittance for floor, 1997 ASHRAE Fundamentals, Chapter 24 or 2001 ASHRAE Fundamentals, and Chapter 25. (Unit- Btu/Hr Sq-ft °F), An area of floor calculated from building plans (sq-ft), T_a is a temperature of adjacent space in °F (Note: If adjacent space is not conditioned and temperature is not available, use outdoor air temperature less 5 ° F), T_r is a inside room design temperature of conditioned space in °F (assumed constant usually 75°F). Heat loss from slab-on- grade foundations is a function of the slab perimeter rather than the floor area. The losses are from the edges of the slab and insulation on these edges will significantly reduce the heat losses.

The slab heat loss is calculated by using the following equation 10 [4].

$$Q = F \bullet P \bullet (T_3 - T_0) \qquad (10)$$

Where Q is a sensible heat loss (Btu/hr); F is a Heat Loss Coefficient for the particular construction and is a function of the degree days of heating. (Unit- Btu/Hr Sq-ft °F); Heat loss from slab-on-grade foundations is a function of the slab perimeter rather than the floor area; P Perimeter of slab (ft); T_i is a inside temperature (°F); T_o is a outside temperature (°F)

2.2.2 *Heat through Wall*

The loads from the walls are conductive loads that described by Global solar radiation on the field vertical (Gv) can be calculated mathematically with use the following equation 11 [13]:

$$Q_v = H_v + D_v + R_v \qquad (11)$$

Hv is direct beam radiation: Hv = Ib. F shading. Cos ▯▯▯Dv is radiation by diffuse the sun: Dv = Id. F sky, Rv is frflected radiation: Rv = Ir. So the formula of global solar radiation on field vertical is:

$$Q_v = Ib \bullet F_{shading} \bullet \mathrm{Cos}\,\theta + Id \bullet F_{sky} + Ir \qquad (12)$$

Where Ib is direct beam radiation, Id is radiation diffusion sky, Ir is radiation reflected from the ground, ▯ is, F shading is shadowing factor (1 if not shielded, 0 if pictured), F sky is factors sky that can be seen.

The formula for problem no radiation loads [4] is:

$$Q = U \bullet A \bullet (T_{outdoor} - T_{indoor}) \qquad (13)$$

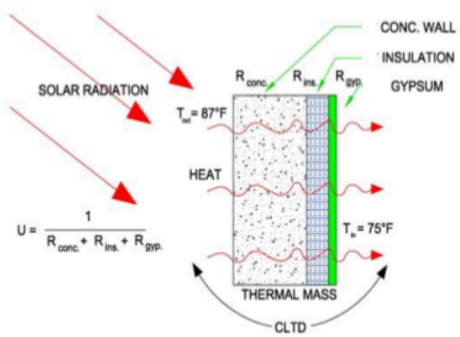

Figure 5: Heat gain through walls with radiation load

The heat gain through a wall in summer or winter [13] is:

$$Q_{summer} = U \bullet A \bullet (T_s - T_i) \qquad (14)$$

$$Q_{winter} = U \bullet A \bullet (T_i - T_o) \qquad (15)$$

The different method, the formula for radiation in wall or roof [13] is:

$$Q_{summer} = A \bullet U \bullet CLTD \qquad (16)$$

$$Q_{winter} = A \bullet U \bullet (T_1 - T_o) \qquad (17)$$

The equation for convection can be expressed as:

$$Q_{convection} = h \bullet A \bullet dT \qquad (18)$$

Where: q = heat transferred per unit time (W), A = heat transfer area of the surface (m²); h_c= convective heat transfer coefficient of the process (W/(m²K) or W/(m²°C)); dT = temperature difference between the surface and the bulk fluid (K or °C)

2.2.3 *Heat through Roofs*

The loads from the roofs are conductive loads. Heat from the outside roof is conducted through the roofs materials as it enters the space. The radiation from the sun onto the building and the time it takes for the heat to transmit through the materials must be taken in to account, illustrated in Figure 6.

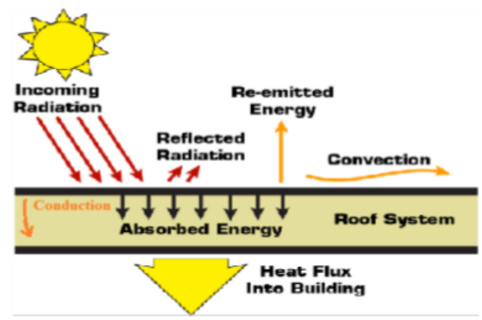

Figure 6: Energy balance on roof surface

The heat gain through a wall or roof [13] is:

$$Q_{summer} = U \bullet A \bullet (T_s - T_i) \qquad (19)$$

$$Q_{winter} = U \bullet A \bullet (T_i - T_o) \qquad (20)$$

The different method, formula for problem radiation loads is [13]:

$$Q_{summer} = A \bullet U \bullet CLTD \qquad (21)$$

Where: Q describes Sensible heat flow (Btu/Hr); U = Thermal Transmittance for roof, See 1997 ASHRAE Fundamentals, Chapter 24 or 2001 ASHRAE Fundamentals, chapter 25. (Unit- Btu/Hr Sq-ft °F); A = area of roof, wall or glass calculated from building plans (sq-ft); CLTD = Cooling Load Temperature Difference (in °F) for roof. For winter months CLTD table is (Ti - T0) which is temperature difference between inside and outside. For Summer cooling load, this temperature differential is affected by thermal mass, daily temperature range, orientation, tilt, month, day, hour, latitude, solar absorbance, roof facing direction and other variables and therefore adjusted CLTD table values are used. Refer 1997 ASHRAE Fundamentals, Chapter 28, tables 30, 31, 32, 33 and 34.

For green roof, heat flux is a measurement of the rate of heat transfer through a material per unit area. A low heat flux means that less heat is moving across a certain layer.

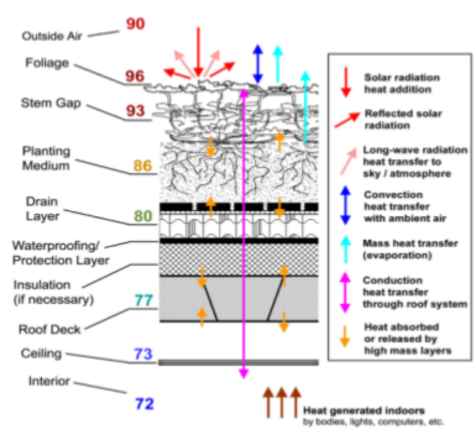

Figure 7: Vegeted roof layer temperatures at afternoon (degrees) °F [14].

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2.2.4 Heat through Windows

Heat transfer through glazing is both conductive and transmission illustrated in Figure 8.

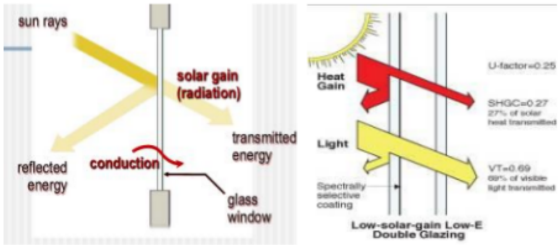

Figure 8: Heat transfer glazing [15]

The net heat rate through a three-layered wall (glass-vacuum-glass) of thicknesses L1, L2 and L3 with thermal circuit accordingly is presented in Figure 9.

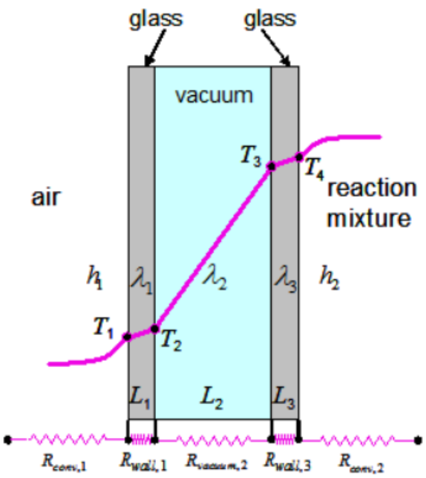

Figure 9: The net heat transfer in glazing

$$R_{total} = \underbrace{\frac{1}{h_1 A}}_{R_{conv,1}} + \underbrace{\frac{L_1}{\lambda_1 A}}_{R_{glass,1}} + \underbrace{\frac{L_2}{\lambda_2 A}}_{R_{vacuum,2}} + \underbrace{\frac{L_3}{\lambda_3 A}}_{R_{glass,3}} + \underbrace{\frac{1}{h_2 A}}_{R_{conv,2}} \quad (23)$$

As h1<< h2, λ1<<λ2 and λ3<<λ2 (because λvacuum<<λglass), it can be assumed that:

$$R_{total} \approx \underbrace{\frac{1}{h_1 A}}_{R_{conv,1}} + \underbrace{\frac{L_2}{\lambda_2 A}}_{R_{vacuum2}} \quad (24)$$

The formula of CLTD for glazing is [13]:

$$CLTD_{coit} = CLTD + (78 - t_{in}) + (t_{ex} - 85) \quad (25)$$

Heat transfer through glazing is both conductive and transmission. It is calculated in two steps.

1) Heat gain from solar radiation through windows can be expressed by the following equations [13]:

$$Q_{solar} = A \bullet I \bullet \theta \quad (26)$$

Where ▯ is solar gain factor.

2) The different method, the equation used for radiant sensible loads from the transparent/translucent elements such as window glass is [13]:

$$Q = A \bullet SHGC \bullet CLF \quad (27)$$

Where Q = Sensible heat gain (Btu/Hr); A = area of glass calculated from building plans (sq-ft); SHGC = Solar Heat Gain Coefficient. See 1997 ASHRAE Fundamentals, Chapter 28, table 35; CLF = Solar Cooling Load Factor. See 1997 ASHRAE Fundamentals, Chapter 28, table 36; SC = Shading Coefficient.

3) The equation used for sensible loads from the conduction through glass is [13]:

$$Q = U \bullet A \bullet CLTD \quad (28)$$

Where Q = Sensible heat gain (Btu/Hr); U = Thermal Transmittance for roof or wall or glass. See 1997 ASHRAE Fundamentals, Chapter 24 or 2001 ASHRAE Fundamentals, chapter 25. (Unit- Btu/Hr Sq-ft °F); A = area of glass calculated from building plans (sq-ft); CLTD = Cooling Load Temperature Difference (in °F) for glass. Refer 1997 ASHRAE Fundamentals, Chapter 28, tables 30, 31, 32, 33 and 34.

2.2.5 Heat through Door

Thermal conductivity also occurs in the door, because the door opposite the solid conduction heat conduction, express in Figure 10.

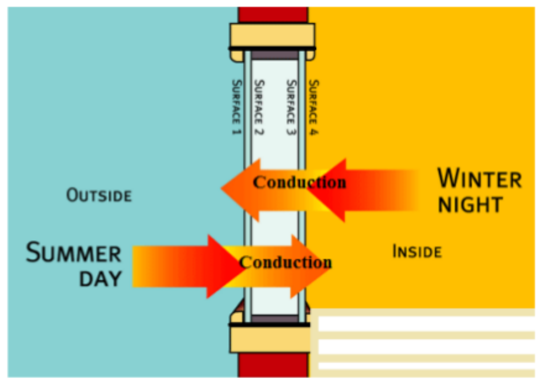

Figure 10: Heat transfer in the door [16]

The heat loss, or norm-heating load, through doors in summer can be calculated as:

$$Q_1 = A \bullet U \bullet (T_o - T_i) \quad (29)$$

If in winter can be calculated as:

$$Q_1 = A \bullet U \bullet (T_i - T_o) \quad (30)$$

Where Q_t = transmission heat loss (W); A = area of exposed surface (m^2); U=overall heat transmission coefficient (W/m^{2}K); T_i = inside air temperature (°C); T_o= outside air temperature (°C)

2.2.6 Heat through Ventilation

Ventilation air is the amount of outdoor air required to maintain Indoor Air Quality for the occupants (refer ASHRAE Standard 62 for minimum ventilation requirements) and makeup for air leaving the space due to equipment exhaust, exfiltration and pressurization.

The heat loss due to ventilation without heat recovery can be expressed as [17]:

$$Q_1 = C_p \bullet \rho \bullet q_v \bullet (T_i - T_o) \quad (31)$$

Where H_v = ventilation heat loss (W), c_p = specific heat capacity of air (J/kg K), ρ = density of air (kg/m^3), q_v = air volume flow (m^3/s), T_i = inside air temperature (°C), T_o = outside air temperature (°C)

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2.2.7 Heat through Infiltration

Infiltration is described as outside air that leaks into a building structure. These leaks could be through the building construction or through entry doors. The heat loss caused by infiltration can be calculated as [17]:

$$Q_{\inf iltration} = C_p \bullet \rho \bullet \frac{N}{3600} \bullet V \bullet (T_i - T_o) \quad (32)$$

Where: Q_{infil} = heat loss infiltration (W), c_p = specific heat capacity of air (J/kg/K), ρ = density of air (kg/m^3),N = number of air shifts, how many times the air is replaced in the room per hour, V = volume of room (m^3), T_i = inside air temperature (°C), T_o = outside air temperature (°C)

Heat loss by infiltration are indicated in the charts below.

3. RESULTS AND DISCUSSION

The results in Table 2 can be known by equation of efficiency on the equation 33.

$$\eta = \frac{Q_2 - Q_3}{Q_1} \times 100\% \quad (33)$$

Table 2: Calculation of building energy efficiency is shown below.

Summer				
	Q- without obstacle	Q - with obstacle	Difference Q	Efficiency
Floor	103,074.43	44,075.21	58,999.22	57%
Walls	31,712.53	23,887.18	7,825.35	25%
Roof	32,307.97	16,040.37	16,267.60	50%
Windows	684,310.91	596,903.13	87,407.78	15%
Door	1,027.00	996.60	30.40	3%
Infiltration & ventilation	246,766.95	239,462.56	7,304.39	3%
Winter				
	Q -without obstacle	Q - with obstacle	Difference Q	Efficiency
Floor	25,821.63	42,922.82	17,101.19	66%
Walls	13,222.36	63,945.59	50,723.23	384%
Roof	2,334.91	9,243.04	6,908.13	296%
Windows	3,833.67	4,792.09	958.42	20%
Door	1,798.42	2,248.03	449.61	25%
Infiltration & ventilation	432,126.00	540,157.50	108,031.50	25%

From the above calculation in Table 2, appears that all parts of the building there is efficiency after use new design that uses obstructions such as walls, roof tree, and carpet. This shows the use of the design barrier very effective to impede the flow of heat and cold, the thermal efficiency appears in Table 3, where it can be known by the equation of efficiency on the equation 34.

$$\eta = \frac{T_2 - T_1}{T_1} \times 100\% \quad (34)$$

Table 3: Calculation of building thermal efficiency is shown below.

Summer				
	T- without obstacle (°F)	**T- with obstacle (°F)**	**Difference T**	**Efficiency**
Floor	107.33	77.00	30.33	28%
Walls	107.33	77.46	29.87	28%
Roof	112.93	106.45	6.48	6%
Windows	107.33	77.46	29.87	39%
Door	107.33	77.46	29.87	28%
Infiltration & ventilation	107.33	77.46	29.87	28%
Winter				
	T- without obstacle (oF)	T- with obstacle (oF)	Difference T	Efficiency
Floor	75.60	80.60	5.00	7%
Walls	80.60	86.00	5.40	7%
Roof	77.00	86.00	9.00	12%
Windows	80.60	86.00	5.40	6%
Door	80.60	86.00	5.40	7%
Infiltration & ventilation	80.60	86.00	5.40	7%

In this research, used two models of the structure of the building. The first model with a standard that is used in Libya and the second model uses the additional wall to block the sunlight. The designations employed and the results of heat calculations are shown as in the Table 4, Table 5 and Table 6.

The result temperature of design is:

Table 4: Temperatures of result research

Summer		
	T- without obstacle (°F)	T- with obstacle (°F)
Floor	107.33	77.00
Walls	107.33	77.46
Roof	112.93	106.45
Windows	107.33	77.46
Door	107.33	77.46
Infiltration & ventilation	107.33	77.46
Winter		
	T- without obstacle (°F)	T- with obstacle (°F)
Floor	75.60	80.60
Walls	80.60	86.00
Roof	77.00	86.00
Windows	80.60	86.00
Door	80.60	86.00
Infiltration & ventilation	80.60	86.00

Table 5: Heat of result research

	Type heat barrier	U Value	U Egypt	Efficiency Q at Summer	Efficiency Q at Winter
Floor	Carpet	0.28	-	57%	66%
Main Walls	Obstacle wall	0.10	1	25%	384%
Roof	Green roof	0.11	0.6	50%	296%
Windows	Obstacle wall & double glass	0.25	-	15%	20%
Door	Obstacle wall	0.27	-	3%	25%
Heat loss Infiltration & ventilation	Obstacle wall	-	-	3%	25%

Table 6: The result of efficiency temperatures is:

	Type heat barrier	U Value	U Egypt	Efficiency T at Summer	Efficiency T at Winter
Floor	Carpet	0.28	-	28%	7%
Main Walls	Obstacle wall	0.10	1	28%	7%
Roof	Green roof	0.11	0.6	6%	12%
Windows	Obstacle wall & double glass	0.25	-	39%	6%
Door	Obstacle wall	0.27	-	28%	7%
Heat loss Infiltration & ventilation	Obstacle wall	-	-	28%	7%

Based on the calculation of heat that occurs, it generates a positive efficiency in all parts of the building. Thus the design used by researchers using a barrier wall, green roof and carpet turns a positive impact. Based on the calculation of heat that occurs, it generates a positive efficiency in all parts of the building. Thus the design used by researchers using a barrier wall, green roof and carpet turns a positive impact. Although this design is very different from existing designs in Libya but design researchers give favorable results of thermal efficiency.

Thus the barrier wall design sunlight and heat from the surrounding environment greatly help reduce the heat that enters the building through walls, doors, windows, cracks, floor and roof. So that the design of the residential buildings made by the researcher can provide energy savings are used to cool the room in summer and warms the room in winter. While the value of retaining heat when using a reference standard of Egypt then the U-value is below the permissible standards. Therefore, this design meets the standards for the Libyan territory in warm climates and changed drastically.

While the results of previous studies on energy efficiency in buildings has also been done, but different methods of building design. The results of previous studies, among others, Hanna studied the effect of building envelope to save energy associated with the total electricity consumed for residential buildings in Egypt (Cairo and Alexandria cities) [2]. The analysis shows that the over-all thermal transfer value (OTTV) for the exterior wall should not exceed 30 W/m^2 for Cairo but Alexandria does not need any insulation. The roof needs 50 mm insulation to reach 25W/m^2. Hanna summarized the results of energy simulation analysis to determine the effectiveness of building characteristics in reducing electrical energy consumption and saving for office building in Egypt [2]. The main conclusion of these results is that a significant energy saving can be achieved by selecting materials with appropriate design techniques.

Sheble evaluates the effect of window to wall area ratio (WWR) for different buildings types to save energy associated with the total electricity consumed [16-17]. The analysis was agreed for different outdoor climate conditions in Egypt. The results show that decreasing the WWR generally saves more energy. For the very hot dry region it is recommended to reduce the WWR and prevention of natural ventilation during the day. The WWR up to 20% is preferred for commercial buildings to have energy efficiency. Guirguis, shows a remarkable effect of the building envelope construction on the electricity consumption for different weather cities in Egypt [6]. The prefabricated panel with 10 cm insulation gives lower electricity consumption and higher energy saving reaches up to 40 % in comparison with other higher U-value brick wall. The wall insulation gives energy saving nearly 40%, 33% and 41% for Cairo, Alexandria and Aswan cities respectively. Based on the results obtained from some previous researchers to study the author made, it turns out that the average efficiency of researchers produce higher when compared with other researchers in the area around Libya. Thus the authors designed by using a barrier wall sunshine and heat rate is very useful to improve energy efficiency in buildings. So that this design can be used for Libyan territory and other regions that hot temperature changes drastically at night.

4.CONCLUSIONS

The conclusions of this research show that new design idea using local standard materials are better than previous researches. The proposed double wall and generated R-value provide higher efficiency than the best efficiency ever done.The resulting efficiency values in the summer to the floor by 57%, on the walls of 79%, on the roof of 54%, 15% window, and the door 38%. While the efficiency of the resulting value in the winter to the floor by 66%, on the walls of 90%, on the roof of 34%, 20% window, and the door 25%.

REFERENCES

[1] Ekhlat, M., Salah, I.M., Kreama, N.M. 2007. Energy efficiency and renewable energy. Libya – National Study. Sophia Antipolis: UNEP, Plan Bleu, Regional Activity Centre.

[2] Hanna, G.B., Guirguis, N.M., Osman, H.S., Hussein, M.A. 2004. Energy analysis for new residential buildings in Egypt. International Conference: Future Vision and Challenges for Urban Development, Cairo, Egypt, pp. 20-22.

[3] Emmitt, S. 2012. Architectural Technology: Research and Practice, Wiley-Blackwell.

[4] Shinde, S.L., Goela, J. 2006. High Thermal Conductivity Materials. Springer Science & Business Media.

[5] Guirguis, N.M. 2010. Energy Efficiency of Flat for Different Egyptian Regions. World Renewable Energy Conference, WREC, Abu Dhabi.

[6] Desjarlais, André, O. 2013. Which Kind of Insulation Is Best? Oak Ridge National Laboratory.

[7] British Standards Institute Staff. 2007. Thermal Performance of Curtain Walling. Calculation of Thermal Transmittance, B S I Standards.

[8] [Online]. Available: http:/ / www. almazoptics.com/ sapphire. Accessed: December 9th, 2014

[9] Miller, F.P., Vandome, A.F., McBrewster, J. 2009. R-Value (Insulation), Alphascript Publishing.

[10] [Online]. Available: http:/ / www. Energystar. Gov/ index.

[11]Bougdah, Sharples. 2010. Environment, Technology and Sustainability. Taylor & Francis (places concepts such as the U value in a wider perspective).

[12] Liu, K., Baskaran, B. 2003. Thermal Performance of Green Roofs through Field Evaluation. National Research Council of Canada. Report No. NRCC-46412.

[13] Christopher Wark. 2011. Senior Energy Analyst Viridian Energy & Environmental. Chicago.

[14][Online]. Available: http://www.commercialwindows.org/, Accessed: December 9th, 2014

[15] [Online].Available:http://www.isover.com/Q-A/Green-facts-energy-efficiency/How-to-design-and-build-an-energy-efficient-building.

[16] Hanna, G.B., Guirguis, N.M., Sheble, S.S. 2005. Energy Code for New Office Building. IIR Middle East Electricity Conference, Dubai, 2005

[17] Baggs, D., Mortensen, N. 2006. Thermal mass in building design. Australian Institute of Architects: Environment design guide, DES 4.

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