Research Inventy: International Journal of Engineering And Science
Vol.13, Issue 5 (May. 2023), PP 111-118
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Energy Saving of Buildings

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ABSTRACT
In this study, calculated the cooling load of the building is a service, the city of Sabha in the south Libya by used 4.9 HAP program where the building consists of the two floors and contains 12 rooms, In this study was proposed two models A and B of this building with the graphic design of the building, and the use of traditional materials available in the local market, as illustrated in table B model, but this material is better in terms of thermal characteristics, and calculated the two models A,B in terms of (construction costs and the expense of the cost of air-conditioning equipment and the cost of electricity consumption). Though the results after the comparison between the two models A, B in table (4), for comparison, has been getting the total reduction in convection between the two models up to 18.14%. the cost of building a model (A) less than (b) of 18.59%. the electricity bill saving rate of almost a month, the value of electricity consumption for air conditioning machine per month equal to 2587.68 D.L

***Keywords**:Cooling load; Energy Saving; Air conditioning, Energy efficiency*

Date of Submission: 14-05-2023 Date of Acceptance: 26-05-2023

I. INTRODUCTION

The use of energy in buildings has increased in recent years due to the growing demand in energy used for heating and cooling in buildings. Without energy buildings could not be operated or inhabited. Improvements have been made in insulation, plant, lighting and controls and these are significant features that help towards achieving an energy efficient building. At this stage it is important to know what is meant by “Energy Efficiency” [1].Energy efficiency means utilizing the minimum amount of energy for heating, cooling, equipment’s and lighting that is required to maintain comfort conditions in a building. An important factor impacting on energy efficiency is the building envelope. This includes all of the building elements between the interior and the exterior of the building such as: walls, windows, doors, roof and foundations. All of these components must work together in order to keep the building warm in the winter and cool in the summer. The amount of energy consumed varies depending on the design of the fabric of the building and its systems and how they are operated.[1] The heating and cooling systems consume the most energy in a building, however controls such as programmable thermostats and building energy management systems can significantly reduce the energy use of these systems. Some buildings also use zone heating and cooling systems, which can reduce heating and cooling in the unused areas of a building. In commercial buildings, integrated space and water heating systems can provide the best approach to energy-efficient heating.[1]. It is easier to design energy efficient features into new buildings, however existing buildings comprise approximately 99% of the building stock. This sector thus provides the greater challenge for implementation of energy efficiency as well as the greater opportunity for overall energy efficiency gains. Although energy efficiency initiatives for existing buildings can be demonstrated to be cost effective, there has been limited success in convincing large organizations and building owners to undertake energy efficiency projects such as retrofits, and retro commissions.[2]. An important factor is the use of benchmarks which stand as representative standards against which buildings can be compared and the performance monitored. For example, the comparison of energy consumption with a square metre of floor area to the benchmark will allow the decision maker to notice and assess the amount of energy consumed and where improvements can be made to minimize the consumption within that specific area. Energy efficient buildings do not cost necessarily more to build than normal buildings, if they are well maintained and manage energy effectively, they are set to be very reliable, comfortable and as productive as a normal building. Researchers in many countries have undertaken studies regarding residential energy efficiency. Yang et el. [3] conducted an assessment of residential buildings based on indicators of energy efficiency relating to climate diversity and building type in China. Zavrl et al. [4] proposed a simple tow step method for assessing the energy sustainability of a residential building. Hass [5] focused on identifying energy efficiency indicators attempting to institute and create a set of crucial factors of energy efficiency indicators for use in cross country comparisons. The current study aims to comparison between two models of building structure to reduction in convection.

II. COOLING LOAD ESTIMATION

The space-cooling load is the rate at which heat must be removed from a space in order to maintain the desired conditions in the space, generally a dry-bulb Temperature and relative humidity. The cooling load for a space can be made up of many components, including:

- Conduction heat gain from outdoors through the roof, exterior walls, Skylights, and windows. (This includes the effects of the sun shining on These exterior surfaces).
- Solar radiation heat gain through skylights and windows.
- Conduction heat gain from adjoining spaces through the ceiling, interior Partition walls and floor.
- Internal heat gains due to people, lights, appliances, and equipment in the space.
- Heat gains due to hot, humid air infiltrating into the space from outdoors through doors, windows, and small cracks in the building envelope.

In addition, the cooling coil in the building HVAC system has to handle other components of the total building cooling load, including:

- Heat gains due to outdoor air deliberately brought into the building for ventilation purposes.
- Heat generated by the fans in the system and possibly other heat gains in the system.

Conduction through Surfaces

Conduction is the process of transferring heat through a solid, such as a wall, roof, floor, ceiling, window, or skylight. Heat naturally flows by conduction from a higher temperature to a lower temperature. Generally, when estimating the maximum cooling load for a space, the temperature of the air outdoors is higher than the temperature of the air indoors. We will focus on the most common conduction heat gains to a space: through the roof, external walls, and windows. Although often not applicable,a simplifying assumption when estimating the conduction heat gain through an exterior surface is to assume that the surface is completely shaded at all times. With this assumption, the amount of heat transferred through the surface is a direct result of the temperature difference between the space and outdoors. This assumption, however, does not include the additional heat transfer that occurs because of the sun shining on the surface. This will be discussed next. The amount of heat transferred through a *shaded* exterior surface depends on the area of the surface, the overall heat transfer coefficient of the surface, and the dry-bulb temperature difference from one side of the surface to the other.

The equation used to predict the heat gain by conduction is:

$$\mathbf{Q = U * A * \Delta T} \qquad \textbf{(1)}$$

Where:

Q = heat gain by conduction, [W]

U = overall heat-transfer coefficient of the surface, [$W/m^2.°C$]

A = area of the surface, [m^2]

ΔT = dry-bulb temperature difference across the surface, [°C]

In the case of a shaded exterior surface, this temperature difference is the design outdoor dry-bulb temperature (To) minus the desired indoor dry-bulb temperature (Ti).

The overall heat transfer coefficient is also called the **U-factor**. The U-factor describes the rate at which heat will be transferred through the structure.Walls and roofs are typically made up of layers of several materials. The U-factor for a specific wall or roof is calculated by summing the thermal resistances (R-values) of each of these layers and then taking the inverse. The*ASHRAE Handbook—Fundamentals* tabulates the thermal resistance of many common materials used in constructing walls, roofs, ceilings, and floors.

$$\mathbf{U = 1/ R_{total}} \qquad \textbf{(2)}$$

$$R\ total = 1/\ R\ outdoor\ air + R\ layer\ 1 + R\ layer2 + R\ indoor\ air$$

$$R = X / K$$

Where:

X: is the thickness of the layer.

K: is the thermal conductivity**.**

Most exterior surfaces of a building, however, are exposed to direct sunlight during some portion of the day. Solar heat energy is generated by the sun and radiated to earth. Radiant heat is similar to light, in that it travels in a straight line and can be reflected from a bright surface. Both light and radiant heat can pass through a transparent surface (such as glass), yet neither can pass directly through an opaque or non-transparent surface

(such as a brick wall). When the sun's rays strike an opaque surface, however, a certain amount of radiant heat energy is transferred to that surface, resulting in an increase in the surface temperature. The amount of heat transferred depends primarily on the color and smoothness of the surface, and the angle at which the sun's rays strike the surface. Most exterior surfaces of a building, however, are exposed to direct sunlight during some portion of the day. Solar heat energy is generated by the sun and radiated to earth. Radiant heat is similar to light, in that it travels in a straight line and can be reflected from a bright surface. Both light and radiant heat can pass through a transparent surface (such as glass), yet neither can pass directly through an opaque or non-transparent surface (such as a brick wall). When the sun's rays strike an opaque surface, however, a certain amount of radiant heat energy is transferred to that surface, resulting in an increase in the surface temperature. The amount of heat transferred depends primarily on the color and smoothness of the surface, and the angle at which the sun's rays strike the surface.When the sun's rays strike the surface at a 90º angle, the maximum amount of radiant heat energy is transferred to that surface. When the same rays strike that same surface at a lesser angle, less radiant heat energy is transferred to the surface. The angle at which the sun's rays strike a surface depends upon the latitude, the time of day, and the month of the year. Due to the rotation of the earth throughout the day, and the earth orbiting the sun throughout the year, the angle at which the sun's rays strike a surface of a building is constantly changing. This varies the intensity of the solar radiation on an exterior surface of a building, resulting in a varying amount of solar heat transferred to the surface throughout the day and throughout the year.
As mentioned previously, the assumption that the surface is completely shaded does not account for the additional heat gain that occurs when the sun shines on a surface. Solar heat, therefore, must be considered, as it constitutes an important part of the total cooling load of most buildings.

$$\mathbf{Q = U \times A \times CLTD} \qquad \textbf{(3)}$$

A factor called the **cooling load temperature difference (CLTD)** is used to account for the added heat transfer due to the sun shining on exterior walls, roofs, and windows, and the capacity of the wall and roof to store heat. The CLTD is substituted for _T in the equation to estimate heat transfer by conduction.

Solar Radiation through Glass

Previously, we estimated the heat transferred through glass windows by the process of conduction. A large part of the solar heat energy that shines on a window or skylight is radiated through the glass and transmitted directly into the space. The amount of solar heat radiated through the glass depends primarily on the reflective characteristics of the glass and the angle at which the sun's rays strike the surface of the gla While glass windows of double- or triple-pane construction do an excellent job of reducing heat transfer by conduction, they do not appreciably reduce the amount of solar radiation directly into a space. To limit the amount of solar radiation entering the space, heat-absorbing glass, reflective glass, or internal or external shading devices can be used. The equation used to predict the solar heat gain through glass is:

$$\mathbf{Q = A \times SC \times SCL} \qquad \textbf{(4)}$$

Where:
_ Q = heat gain by solar radiation through glass, [W]
_ A = total surface area of the glass, [m^2]
_ SC = shading coefficient of the window, dimensionless
_ SCL = solar cooling load factor, [W/m^2]

The solar cooling load (SCL) factor is used to estimate the rate at which solar heat energy radiates directly into the space, heats up the surfaces and furnishings, and is later released to the space as a sensible heat gain. Similar to CLTD, the SCL factor is used to account for the capacity of the space to absorb and store heat.

The value of SCL is based on several variables, including the direction that the window is facing, time of day, month, and latitude. These four variables define the angle at which the sun's rays strike the surface of the window. The next two variables, the construction of the interior partition walls and the type of floor covering, help define the capacity of the space to store heat. This affects the time lag between the time that the solar radiation warms up the space furnishings and the time that the heat is released into the space. The last variable, whether or not internal shading devices are installed, affects theamount of solar heat energy passing through the glass.
The shading coefficient (SC**)** is an expression used to define how much of the radiant solar energy, that strikes the outer surface of the window, is actually transmitted through the window and into the space. The shading coefficient for a particular window is determined by comparing its reflective properties to a standard reference

window. The table on this slide includes shading coefficients for common window systems. When the value for the shading coefficient decreases, more of the sun's rays are reflected by the outer surface of the glass

Internal Heat Gains

The next component of the space cooling load is the heat that originates within the space. Typical sources of internal heat gain are people, lights, cooking processes, and other heat-generating equipment, such as motors, appliances, and office equipment. While all of these sources contribute sensible heat to the space, people, cooking processes, and some appliances (such as a coffee maker) also contribute latent heat to the space

Heat generated by people

people generate more heat than is needed to maintain body temperature. This surplus heat is dissipated to the surrounding
air in the form of sensible and latent heat. The amount of heat released by the body varies with age, physical size, gender, type of clothing, and level of physical activity. This table is an excerpt from the *1997 ASHRAE Handbook—Fundamentals*. It includes typical sensible and latent heat gains per person, based on the level of physical activity. The heat gains are adjusted to account for the normal percentages of men, women, and children in each type of space.
The equations used to predict the sensible and latent heat gains from people in the space are:

$$\mathbf{QS = number\ of\ people \times sensible\ heat\ gain/person \times CLF} \quad (5)$$

$$\mathbf{QL = number\ of\ people \times latent\ heat\ gain/person} \quad (6)$$

Where:
_ QS = sensible heat gain from people, [W]
_ QL = latent heat gain from people, [W]
_ CLF = cooling load factor, dimensionless

CLF factors for people Similar to the use of the CLTD for conduction heat gain and SCL for solar heat gain, the **cooling** load factor (CLF**)** is used to account for the capacity of the space to absorb and store heat. Some of the sensible heat generated by people is absorbed and stored by the walls, floor, ceiling, and furnishings of the space, and released at a later time. Similar to heat transfer by conduction through an external wall, the space can therefore experience a time lag between the time that the sensible heat is originally generated and the time that it actually contributes to the space cooling load. For heat gain from people, the value of CLF depends on 1) the construction of the interior partition walls in the space, 2) the type of floor covering, 3) the total number of hours that the space is occupied, and 4) the number of hours since the people entered the space.

Heat gain from lighting

Heat generated by lights in the space is a significant contribution to the cooling load. For example, a 120-watt light fixture generates 410 Btu/hr [120 W] of heat—approximately the same amount of heat gain generated by an average office worker. Additionally, when estimating the heat gain from fluorescent lights, approximately 20% is added to the lighting heat gain to account for the additional heat generated by the ballast. The equation used to estimate the heat gain from lighting is:

$$\mathbf{Q = watts \times 3.41 \times ballast\ factor \times CLF} \quad (7)$$

$$\mathbf{Q = watts \times ballast\ factor \times CLF} \quad (8)$$

Where:
_ Q = sensible heat gain from lighting, [W]
_ Watts = total energy input to lights, W
_ 3.41 = conversion factor from W to Btu/hr (when using I-P units)
_ Ballast factor = 1.2 for fluorescent lights, 1.0 for incandescent lights
_ CLF = cooling load factor, dimensionless
Similar to the sensible heat gain from people, a cooling load factor (CLF) can be used to account for the capacity of the space to absorb and store the heat generated by the lights.

Heat generated by equipment

There are many types of appliances and equipment in restaurants, schools, office buildings, hospitals, and other types of buildings. This equipment may generate a significant amount of heat and should be accounted for when estimating the space cooling load.The data on this slide is an excerpt from the *1997 ASHRAE Handbook—Fundamentals*. The handbook contains tables of sensible and latent heat gains from various types of office and restaurant equipment, although data for the actual piece of equipment is preferred, if available.

generated by the lights. If the lights are left on 24 hours a day, or if the air-conditioning system is shut off or set back at night, the CLF is assumed to be equal to 1.

Infiltration

In a typical building, air leaks into or out of a space through doors, windows, and small cracks in the building envelope. Air leaking **into** a space is called **infiltration**. During the cooling season, when air leaks into a conditioned space from outdoors, it can contribute to both the sensible and latent heat gain in the space because the outdoor air is typically warmer and more humid than the indoor air.Before estimating the heat gain from infiltration, we must first estimate the amount of air that is leaking into the space. There are three methods commonly used to estimate infiltration airflow. The air change method is the easiest, but may be the least accurate of these methods. It involves estimating the number of air changes per hour that can be expected in spaces of a certain construction quality. Using this method, the quantity of infiltration air is estimated using the equation:

$$\textbf{infiltration airflow} = (\textbf{volume of space} \times \textbf{air change rate}) \div 60 \qquad (9)$$

$$\textbf{infiltration airflow} = (\textbf{volume of space} \times \textbf{air change rate}) \div 3{,}600 \qquad (10)$$

where:
_ Infiltration airflow = quantity of air infiltrating into the space, [m3/s]
_ Volume of space = length × width × height of space, [m^3]
_ Air change rate = air changes per hour
_ 60 = conversion from hours to minutes
_ 3,600 = conversion from hours to seconds

The crack method is a little more complex and is based upon the average quantity of air known to enter through cracks around windows and doors when the wind velocity is constant. The effective leakage-area method takes wind speed, shielding, and “stack effect” into account, and requires a very detailed calculation. The equation used to estimate the sensible heat gain from infiltration is:

$$\mathbf{QS = 1.085 * airflow * \Delta T} \qquad (11)$$

$$\mathbf{QS = 1{,}210 * airflow * \Delta T} \qquad (12)$$

Where:
_ QS = sensible heat gain from infiltration, [W]
_ 1.085 [1,210] = product of density and specific heat, [J/m^3 _ ºK]
_ Airflow = quantity of air infiltrating the space, [m^3/s]
_ ΔT = design outdoor dry-bulb temperature minus the desired indoor drybulb temperature, [ºC] The equation used to estimate the latent heat gain from infiltration is:

$$\mathbf{QL = 0.7 * airflow * \Delta W} \qquad (13)$$

$$\mathbf{QL = 3{,}010 * airflow * \Delta W} \qquad (14)$$

Where:
_ QL = latent heat gain from infiltration, [W]
_ 0.7 [3,010] = latent heat factor, [J . kg/m^3. g]
_ Airflow = quantity of air infiltrating the space,[m^3/s]
_ ΔW = design outdoor humidity ratio minus the desired indoor humidity

ratio, grains of water/lb of dry air [grams of water/kg of dry air] The psychrometric chart can be used to determine the humidity ratio for both outdoor and indoor conditions.

Ventilation

Outdoor air is often used to dilute or remove contaminants from the indoor air. The intentional introduction of outdoor air into a space, through the use of the building's HVAC system, is called **ventilation**. This outdoor air must often be cooled and dehumidified before it can be delivered to the space, creating an additional load on the air-conditioning equipment. Should never depend on infiltration to satisfy the ventilation requirement of space. On days when the outdoor air is not moving (due to wind), the amount of infiltration can drop to zero. Instead, it is common to introduce outdoor air through the HVAC system, not only to meet the ventilation needs, but also to maintain a positive pressure (relative to the outdoors) within the building. This positive pressure reduces, or may even eliminate, the infiltration of unconditioned air from outdoors. To pressurize the building, the amount of outdoor air brought in for ventilation must be greater than the amount of air exhausted through central and local exhaust fans. The amount of outdoor air required for a space is often prescribed by local building codes or industry standards. One such standard, ASHRAE Standard 62, *Ventilation for Acceptable Air Quality*, prescribes the quantity of outdoor air required per person (or per unit area) to provide adequate ventilation for various types of spaces.
The sensible and latent loads from ventilation are calculated using the same equations as for infiltration.

System Heat Gains

There may be others sources of heat gain within the HVAC system. One example is the heat generated by fans. When the supply fan, driven by an electric motor, is located in the conditioned airstream, it adds heat to the air.Heat gain from a fan is associated with three energy conversion losses.Fan motor heat is due to the energy lost in the conversion of electrical energy (energy input to the motor) to mechanical energy (rotation of the motor shaft).It is dissipated as heat from the motor and is represented by the inefficiency of the motor. a motor heat gain = power input to motor × (1 – motor efficiency) If the fan motor is also located within the conditioned airstream, such as inside the cabinet of an air handler, it is considered an instantaneous heat gain to the airstream. If it is located outside the conditioned airstream, it is considered a heat gain to the space where it is located. Fan-blade heat gain is due to the energy lost in the conversion of mechanical energy to kinetic energy (moving of the air). It is dissipated as heat from the fan blades, it is considered an instantaneous heat gain to the airstream, and it is represented by the inefficiency of the fan.

fan blade heat gain = power input to fan × (1 – fan efficiency) (15)

Finally, the remaining (useful) energy input to the fan, the energy used to pressurize the supply duct system, is eventually converted to heat as the air travels through the ductwork. For simplicity, most designers assume that this heat gain occurs at a single point in the system, typically at the location of the fan.

duct friction heat gain = power input to fan × fan efficiency (17)

It is important to know where the fan heat gain occurs with respect to the cooling coil. If the fan is located upstream and blows air through the cooling coil, the fan heat causes an increase in the temperature of the air entering the coil. If, however, the fan is located downstream and draws air through the cooling coil, the fan heat causes an increase in the temperature of the air supplied to the space.

Heat Gain in ductwork

Another source of heat gain in the system may be heat that is transferred to the conditioned air through the walls of the supply and return ductwork. For example, if the supply ductwork is routed through an unconditioned space, such as a ceiling plenum or an attic, heat can be transferred from the air surrounding the duct to the supply air.

Supply ductwork is generally insulated to prevent this heat gain and the associated increase in temperature of the supply air. An increased supply air temperature requires a greater amount of supply air to maintain the desired space conditions, resulting in more fan energy use. Insulation also reduces the risk of condensation on the cool, outer surfaces of the duct.

Return ductwork, on the other hand, is generally not insulated unless it passes through a very warm space. Any heat picked up by the return air is generally heat that would have eventually entered the space as a cooling load. Therefore, the cooling load caused by this heat gain to the return air is not wasted.

III. RESULT AND DISCUSSION

In this study the cooling load of the building of a service consists of two floors and contains 12 rooms as shown in figure 1 have been calculated by using HAP4.9 program, taking the design conditions forthe city of SABHA, design calculations and architectural drawings for the project to extend the facility.

Where it was necessary to work on two models A and B of this building with traditional form and materials used in construction and available in the local market shown in tables (1), (2) and (3). As used in the model B traditional model used in construction and available in the local market but the best in terms of thermal characteristic. The two models account construction costs and the cost of air-conditioning equipment and the cost of electricity consumption).

The results presented in table (4) and (5) by comparison, total reduction in convection between the two models has been obtained up to 18.14%. The cost of building a model (A) is less than (B) by 18.59%.

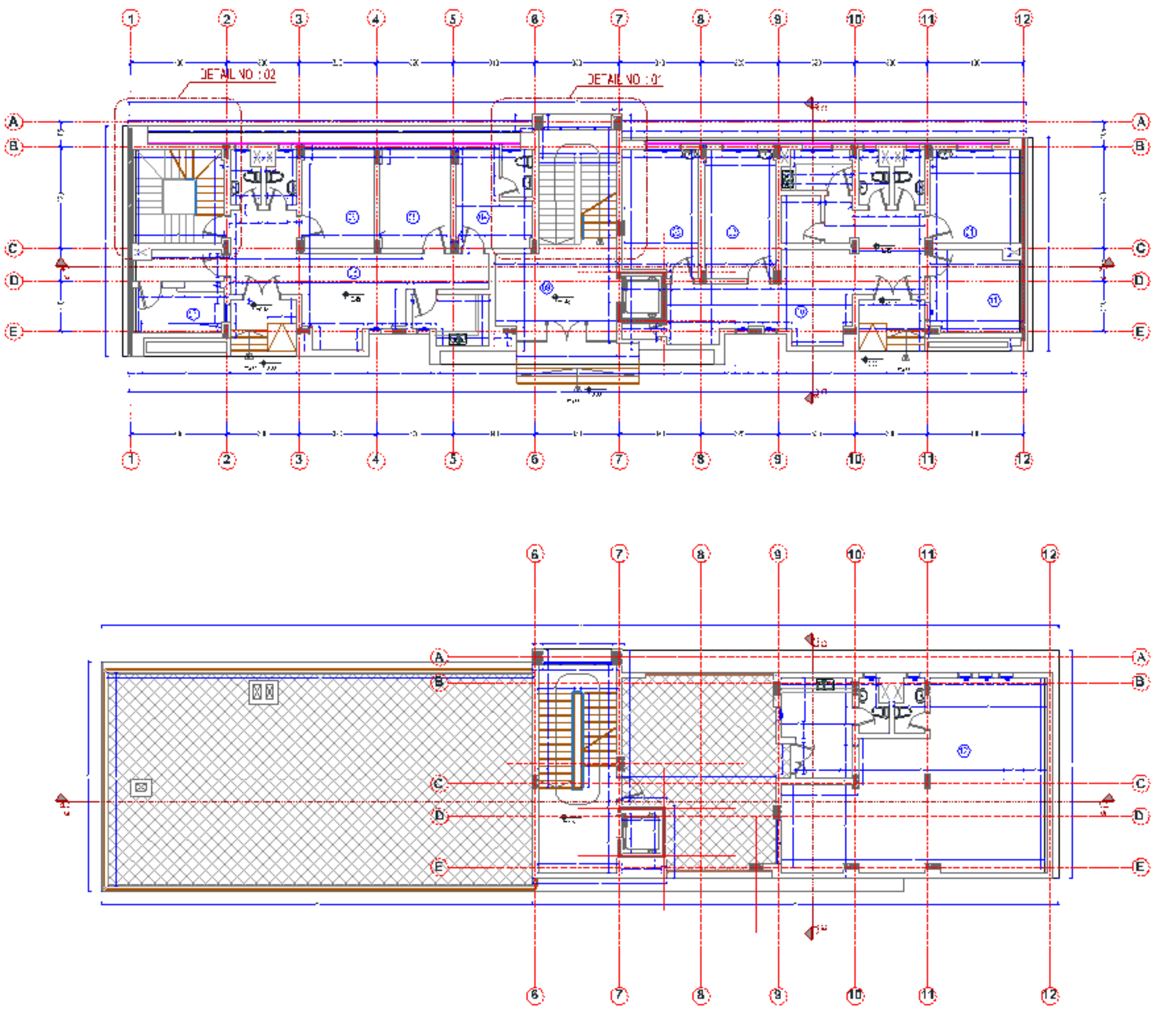

Fig.1. The model

Table (1) Wall constructions

Wall Details	Model A	Model B
Outside surface color	Medium	Medium
Absorptivity	0.675	0.675
Overall U-value, $W/(m^2.^oK)$	2.115	1.736

Table (2) Window constructions

Window Details	Model A	Model B
Frame type	Aluminum with Thermal breaks	Aluminum with Thermal breaks
Internal shade type	None	None

Overall U-value, W/(m^2.°K)	6.117	3.296
Overall shade coefficient	0.845	0.751
Glass (Gap Type)	6 mm Air Space	13 mm Air Space

Table (3) Roof constructions

Roof Details	Model A	Model B
Inside Surface resistance	Medium	Medium
Absorptivity	0.675	0.675
Overall U-value, W/(m^2.°K)	2.450	0.556

Table (4) Comparison between the models (A)& (B)

ROOM NUMBER	MODEL A	MODEL B	REDUCTION PERCENTAGE RATIO
	TOTAL COOLING LOAD (W)	TOTAL COOLING LOAD (W)	
1	4141	3638	12.15
2	4573	3666	19.83
3	4628	3695	20.16
4	3267	2686	17.78
5	3787	3062	19.14
6	3825	3086	19.32
7	4401	3449	21.63
8	10068	8452	16.05
9	6059	5022	17.12
10	9173	8282	9.71
11	4153	3575	13.92
12	21192	16278	23.91
TOTAL COOLING LOAD FOR ALL THE BUILDING	79267	64891	18.14

Table (5) Cost of construction of the buildings models (A) & (B)

	MODEL A	MODEL B
	L.D	L.D
THE COST OF CONSTRUCTION	14980.29	18401.5
THE COST OF THE AIR CONDITIONING EQUIPMENT	67943	55620
THE VALUE OF ELECTRICITY CONSUMPTION FOR AIR CONDITIONING MACHINE PER YEAR	14268.06	11680.38

IV. Conclusions

The energy efficiency of a building can be influenced by how the space within the building is utilized. In order to maximize energy efficiency within a building, heat losses within the building e must be kept to a minimum. This is achievable via insulation to the roof, walls, windows and floors. The selection of appropriate materials used in the building combination is necessary to conserve energy. This is what has been deduced in this study. As shown table (5) where the cost of construction of the building installations model (B) the highest 22% of the model (A) due to the increased cost of materials used in it. It has been improved to reduce the thermal load of 18% and 18% the cost of electricity to become a total cost of model (B) less 11% of the model (A).

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