Evaluating the thermal performance of the external walls in the residential houses at the dry and hot areas

Dr. Samah Sobhy Mansour

Lecturer at architecture department- October high institute of engineering and technology at 6th October city.sameh.mohamed

nagiub2017@gmail.com

Research summary:

The research represents the circle of communication among architecture, environment, economy and the integrated relation of that system- as the design of most of the buildings ignoring the surrounding climate effect in performing the internal spaces of the building and realizing the thermal comfort for the users, as most of the time mechanical means have been relied on as they use non-renewable energy sources, which cause high pollution percent, so there have to be ways and solutions to assist the architect to provide energy at the buildings relying on mechanical means. As the landscape sector is the second most electric energy consuming sector in Egypt, where it consumes 38.6% of the whole electricity consumption ratio in Egypt. External walls are one of the most important element of the external cover of the building that consume energy. So the research is aiming to improve the thermal performance of the external walls of the building based on studied criteria to reduce the consumed energy and realize thermal comfort for the users.

By adding certain methodology of the thermal performance of the external walls in the residential houses at the hot, dry areas and calculating the energy saving depending on mathematical ways to evaluate the thermal performance through analyzing the thermal performance and calculating the saving in energy in the external walls in building block in Aswan city with area 90 m^2 that relies on mechanical means.

By following the mathematical steps, the external walls are designed as one of the most significant elements making the external cover of the building with thermal performance convenient to the hot and dry areas' climate and ease the designing decision of choosing the type of external walls based on studied criteria of the thermal performance and the energy saving.

We can calculate the energy saving through mathematical ways by applying that on various types of rocks, the effect of the wall thickness on the energy saving and determine the resistance of each type and each thickness of the different walls and calculating the energy saving, so as to study the effect of the thermal isolators thickness and determine the effect of the resistance on the energy saving, the effect of the finishing materials on the energy saving.

Key words:

Thermal performance- the external cover of the building- calculating methods- energy saving- thermal isolation.

Introduction:

Traditional architecture in hot areas offered architectural solutions that provided automatic protection from a very cruel weather conditions without previous link to certain architectural or fine art considerations. It expressed rightfully the function and the natural, cultural and social common environment. As it was a honest reflection of the environmental conditions

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that aroused in it with all it's natural and social dimensions, in the environments with hot and dry climate, planning, integrated patterns appeared in connected constructional texture to provide shaded areas, the internal spaces were used to achieve privacy and protection from external dangers and cruel environment, the walls were thick made of materials with large thermal range to control the huge differences in the temperature.

That building represents lessons that could be used in extracting group of designing guidance to be handled in the architectural projects, so making a methodology to analyze the thermal performance of the external walls is necessary based on studied criteria of the thermal performance and the energy saving.

The research methodology:

To realize the target of the research, the methodology was based on the following:

Analyzing the thermal performance and calculating the saving in energy of the external walls of a residential block of 90 m^2 area, the area of the external walls is 100 m^2, the area of the glass windows 15 m^2 - the external walls were built from blocks of cement solid rocks with thickness 25, the ceiling tile from concrete with thickness 10 cm, external and internal surfaces of the walls with light cement color with thickness 2.5 cm-the outer surface of the external ceiling of the horizontal ceiling with cement tiles and the internal ceiling with cement.

By fixing the thermal performance of the ceiling with the previous thickness and finishing, and fixing the thermal performance of the individual glass. The building works for 15 hours a day and relying on air conditioners, where the energy saving of the external walls is calculated by depending on the mathematical methods by studying the following effects:

1- The type of the building material.
2- The effect of the wall thickness.
3- The thickness of the thermal isolating layer.
4- The type of the finishing material.
5- Presence or absence of the thermal isolating layer.

The thermal transmission	The type of the used material
2.5 w/m^2	Concrete ceiling with thickness 10 cm., the internal and external surfaces are cement 2.5, the horizontal ceiling is cement tiles and the internal surface is cement.
5 w/m^2	Evacuated cement rocks with thickness 25 cm.
5.6 w/m^2	Individual glass.

Table 1 shows the used materials and their thermal conductivity;

The general steps of the calculation methods;

The concrete ceiling with the mentioned thickness is used with the individual glass with the thermal conductivity of 5.6 w/m^2

The external walls are being changed, calculating the save in energy as the following:

1- Change the type of the building material of the wall.
2- Change the wall thickness.

3- Change the thickness of the temperature isolating layer.
4- Change the finishing material.
5- Change the presence or the absence of the temperature isolating layer.

The mathematical method that the measuring is counting on:

Calculating the save in energy from the next equation:

$E=H8A8(u_b-u_a)c_{dd}$

: the save in energy (is calculated for the external walls). E.

: H (the functioning period of the building) for residential houses it is 15 hours.

: the area (of the external walls). A

: the thermal transmission of the external walls before improvement. u_b

: the thermal transmission of the external walls after improvement. u_a

The degree of a cooling day for Aswan city and it is calculated 4200: c_{dd} on the basis of 25 degrees from the following equation.

$C_{dd=}E_{12}E_{24}(T-25)$

To calculate the total thermal resistance of the wall;

The total resistance of the wall which is consisted of many layers is calculated by calculating the resistance of each individual layer then adding them all together, putting into consideration the external and internal air resistance from the sector using the following relation:

$R_1=R_{0+\sum}R+R_i$

The resistance of any of the wall elements vary according to the variation of the material and it's thickness, it could be calculated from the relation:

$R=L/K$

The thermal resistance of the matter R.

The thickness of the material L.

The thermal conductivity K.

To calculate the thermal transmission, it is the algebraic reverse of the total resistance of the wall.

$U=1/R_t$

The results :-

From the previous mathematical measurements, the following is shown:

The save in energy	The used case	The case number
1701000 watt	Change the external walls from evacuated cement bricks into---- cement solid bricks	The first
7056000 watt	Change the external walls from evacuated cement bricks into----evacuated clay bricks.	The second
504000 watt	Change the external walls from evacuated cement bricks into----evacuated sand bricks	The third
1908000 watt	Change the external walls from evacuated cement bricks into----clay bricks	The fourth

5508000 watt	Change the external walls from evacuated cement bricks into----evacuated leica bricks	The fifth
7488000 watt	Change the external walls from evacuated cement bricks into----light sand bricks.	The sixth

1- Types of bricks arranged according to the thermal performance, the highest in the thermal resistance is the light sand bricks- the evacuated clay bricks- the evacuated leica bricks-solid clay- hollow cement-hollow sandy-solid cement.
Table 12 shows the various states to change the external walls and the amount of the save in energy for each state.
2- The save in energy is increased by increasing the thickness of the external wall and keeping the wall material constant.
3- The save in energy is increased using the thermal isolating materials by increasing the total resistance of the external walls and the decrease of the thermal transmission.

The save in energy	The used case	The case number
1440000 watt	Change the external wall with thickness 12 cm. hollow cement bricks and thermal isolating layer 2 cm. from polystyrene and thickness 12 cm. from hollow cement bricks into--- light sand bricks with thickness 12 cm. and thermal isolating layer 2 cm. from polystyrene with thickness 12cm.	The first
900000 watt	Change the external wall with thickness 12 cm. hollow cement bricks and thermal isolating layer 3 cm. from polystyrene and thickness 12 cm. from hollow cement bricks into--- light sand bricks with thickness 12 cm. and thermal isolating layer 3 cm. and light sand bricks with thickness 12cm.	The second
468000 watt	Change the external wall with thickness 12 cm. hollow cement bricks and thermal isolating layer 5 cm. from polystyrene and thickness 12 cm. from hollow cement bricks into--- light sand bricks with thickness 12 cm. and thermal isolating layer 5 cm. and light sand bricks with thickness 12cm.	The third

Table 13 shows the various cases of changing the thickness of the thermal isolating materials in the external walls and the amount of the save in energy for each case.
4- The effect of the thermal isolating material is great and obvious on the total resistance of the wall as it affects by the double on the total resistance of the wall, also by the double on the thermal transmission by keeping the rest of the elements constant, the material, the thickness and any extra factors affecting the wall, at the comparison between the double wall with air voids and the double wall with thermal isolation inside the voids between the two walls.

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