Activating the environmental role of the Building envelope to improve the energy performance of social housing units in Giza Governorate- Egypt

Dr. Mahmoud Attiya Mohamed

Lecturer of Architecture, October High Institute for Engineering and Technology in 6 October city- Giza.

attiyagroup@yahoo.com

Dr. Samah Sobhy Mansour

Lecturer of Architecture, October High Institute for Engineering and Technology in 6 October city- Giza.

sameh.mohamed.nagiub2017@gmail.com

Abstract:

The housing problem is one of the most complex problems in most countries of the world. Therefore, most countries resort to finding solutions and initiatives for social housing units that take into account the needs of users and fulfill their basic requirements. The Egyptian state has a major role in the construction and reconstruction of cities where huge initiatives have been taken to establish social housing units for low-income people .The main aim of this research paper is to improve energy performance within social housing units at Sixth of October City by treating the building envelope and using thermal insulation for walls and choosing the type of low-emission glass in order to improve the energy performance of social housing buildings in the New Sixth of October City in Giza Governorate, and this was through an applied study of the Design Builder v 6.0 program for social housing units, taking into account the design determinants and variables such as orientation and type of the used glass, occupancy rate and building materials used in the building envelope, down to how to improve their energy performance. The results of the simulation showed the effect of the architectural dimensions of the building materials, and their effects on thermal comfort and the rate of energy consumption through the treatment of the outer covering, thus proving the validity of the hypothesis, which is a thermal insulation thickness of 6 cm in the walls and 8 cm in the surface and the wall thickness of 25 cm, red bricks and double-reflective glass of 6 mm and low emission E-Glass in the building envelope, hence energy consumption can be saved by more than 50% over the base case.

Keywords:

Energy Saving, Social Housing Units, Thermal Comfort, Thermal Insulation.

1- Introduction:

The Egyptian state is looking for different solutions to solve the housing crisis and provide housing units appropriate to the needs and requirements of citizens while providing economic support for housing units. From this point of view, more bold decisions have been taken to implement the Social Housing Initiative for Low Income [(1)], which are units of 90 meters, including services and with increasing awareness and orientation of the global trend towards creating more environmentally friendly and energy-saving buildings, it was necessary to construct energy-saving buildings, starting from treating them to the outer shell and applying the requirements of the energy code for residential buildings [(2)] until the desired result was achieved in contributing to reducing operating costs and helping low-

DOI: 10.21608/MJAF.2021.56933.2170

income people to benefit from such energy saving and direct it to other life requirements that can help them bear the burdens of life.

2- Literature review

Many studies have dealt with the rapid urbanization of cities and the resulting steady increase in social housing buildings in all cities of the world [13], [14] and the effect of designing these types of buildings on energy performance and how to achieve thermal comfort within their spaces where a group of researchers in Spain [3], [4], [5] worked on evaluating the energy consumption performance of social housing buildings using computer simulations and the actual energy consumption of the units, and the results showed that the users of these buildings consume less actual energy than the results of energy consumption in the simulation given the circumstances. Taking into account that the standard thermal comfort level may lead to significant differences between computer-aided energy simulation and actual consumption data [3], and another study of the social housing experience in Canada has dealt with concerns of not achieving thermal comfort as the degrees of indoor temperature in the summer in most units is very close to the outside temperature during heat waves, and this means that users will be exposed to high temperatures during long periods of time. This is a major concern for users, who are at increased risk of developing heat-related illnesses [11]. The UK Social Housing Experience, an international model, indicates that building defects, especially those occurring in the building envelope, contribute to the energy performance gap in the building. The interruption of the layers of insulation and thermal bridges across the building elements leads to the unwanted loss of heat, and thus increases the use of energy for heating the vacuum, because the climate of the United Kingdom is a cold climate, and the study concluded that the outer envelope of residential units must be treated and the implementation of these treatments should be monitored with high quality in order to provide Power Consumption [12]. The Design Builder 6.0 program was used in this study to verify and explore the results as many studies used this program because of its accuracy in showing simulation results when compared to the actual results. The results of a study indicated that Design Builder 6.0 achieved the same actual results by comparing them with Depreciation Bills while eQUEST had a 7% deviation in results. [15]

3- Research problem:

The increase in energy consumption within social housing units in high quantities as a result of Environmental Inefficiency in the Building Envelope [6] and non-application of the energy code for residential buildings [7], [12].

4- Research and practical study objectives:

This study aims to improve the energy performance within the social housing units in the 6th of October City by activating the environmental functions of the components of the Building Envelope.

5- Research questions:

A- How to achieve the best energy performance within the social housing units in the Greater Cairo Region?

B- How to improve energy consumption efficiency in social housing units by activating the environmental role of the components of the building envelope?

C- What is the role of low-e glass that can be used in openings to -improve the thermal performance and energy efficiency of the housing of social housing units?

6- Research hypothesis:

The use of thermal insulation and emission-reducing glass in the Building Envelope of social housing units improves energy performance.

7- The used Methodology:

To achieve the objectives of the research, a theoretical approach is based on reviewing previous studies and what has been achieved and their impact on the current study, and an analytical approach to study the basic case for a housing unit model of social housing buildings in the New Sixth of October City, which follows the Greater Cairo region, and an applied approach that uses simulation using Computer through the simulation tool Design Builder 6.0 program and studying the environmental aspects, and that was by changing the orientation, changing the thickness and type of the walls in the building envelope, changing the type of glass, then coming out with the simulation results for each case separately to explore the abundance through the application of treatments, then clarifying the results and comparing them, and thus achieving the objectives of the research and previous studies and their results.

8- The climate in the Greater Cairo region:

Climate in the Greater Cairo region Cairo is located on a circuit of 30 degrees' north latitude, in the transition zone between the warm temperate climate and the hot tropical climate. The climate of Cairo is characterized by high temperature in the summer and low temp. in the winter, yet the Nile breeze plays a role in reducing the temperature during the summer. (10)

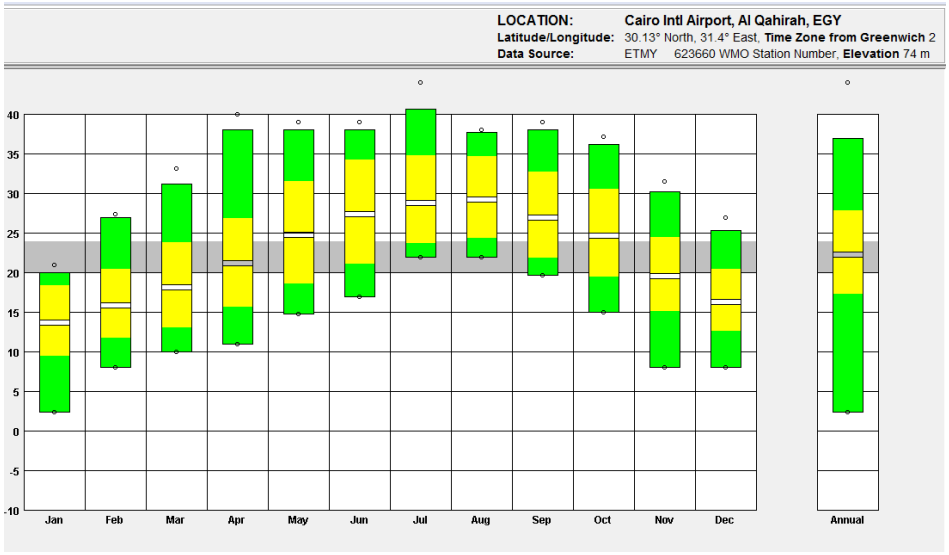

Figure (1) shows the temperature and wind speed in the Greater Cairo Region in the climate consultant 6.0 (8)

As the average annual temperature is 37 ° C, July is the warmest month at 41 ° C on average, January is the coldest month during the year as the average temperature reaches 20 ° C in the Greater Cairo region and wind speeds do not exceed 8.5 M / second in most months of the year.

9. Case Study:

The study of social housing units in the 6th of October City in Giza governorate, which belongs to the Greater Cairo region including the characteristics of the model that have been identified in the housing unit.

9-1- The main steps of the simulation were as follows:

1. Evaluate the environmental performance of the proposed model using the Design Builder 6.0 simulation program:

Climate data analysis. Solar radiation analysis.

2. Identify the energy consumption (thermal performance, cooling loads), depending on the following patterns:

- Directive, type of the used glass, occupancy rate and building materials that are used in the outer shell of social housing units.

9-2- Basis for selecting the case study:

The study case is located in the new 6th of October city, which is located in Giza governorate of Greater Cairo region, and it is one of the regions with a hot dry climate and the buildings of social housing units were not treated as environmental remedies that resulted in the lack of thermal comfort within the spaces in the social housing units, which negatively affected the user, and to achieve the goal of the study, the following must be observed:

- The existence of this case study for a specific climatic region, which is the Greater Cairo Region.

- Provide the required information to prepare it for the simulation and evaluation phase.

- Selecting projects that require a study of the effect of building materials in achieving efficiency and environmental friendliness standards.

9-3- The technical method for collecting and documenting data for the model under study:

The following methods were taken in collecting information on study cases:

Research and previous studies that dealt with the study cases

Field visits and photographic documentation.

Architectural and aerial maps of case studies.

9-4- Applied study methodology: -

A- Analysis of climatic data for the study area.

B- Analytical description of the social housing units under study, (architectural description, description of current building materials, occupancy rate, openings ratio, and orientation).

C- Evaluating the basic situation using simulations, for the models of the social housing units under study using the Simulation 6.0 Design Builder program, and then evaluating it.

D- Develop alternatives by testing the proposed methodology for the case studies using appropriate treatments. The orientation, materials, and glass type of the openings were studied to obtain the best results by using a simulation program to analyze the thermal performance of the building.

E- Comparing and discussing the results.

In this way, various alternatives and material alternatives can be evaluated in order to choose the best solutions that contribute to achieving comfort requirements and providing a good environment.

This simulation aims to:

A- Study the effect of building materials on thermal comfort inside the building of social housing units.

B - Analyzing the materials that are used in the social housing units and the extent of their impact on the internal environment.

C- Conducting a simulation of the required cooling loads in the current building and developing alternatives.

D- Estimating the percentage of energy savings by using different alternatives, whether design or materials alternatives.

9-5- Analyzing social housing units' models: The analysis is done through:

A- Climatic data analysis for the study area, Greater Cairo Region.

Climatic data for the Greater Cairo region were used using a 6.0 climate consultant program.

-Data of a housing unit model for social housing:

Architectural design data:

The aim of studying a housing unit model for social housing before and after proposing treatments is to find the effect of materials on the thermal performance, orientation, and glass type of openings with different architectural dimensions and thus the effect on the rate of energy consumption. A comparison will be made between the current situation of the social housing unit and the amendment after setting the alternatives, and the comparison will deal with the rate of energy consumption in each case with the difference in the orientation and the use of thermal insulation in the walls with a thickness of 6 cm and the roof with a thickness of 8 cm and the rates of energy consumption between the highest energy consumption and the lowest energy consumption and the savings rates for each suggested treatment with guidance and comparing it to the base case.

Thermal gain:

There are two sources of heat (indoor and outdoor), and indoor heat is generated from: occupants and lighting. As for the external heat, it is caused by the sun's heat, which seeps into the space through the building envelope.

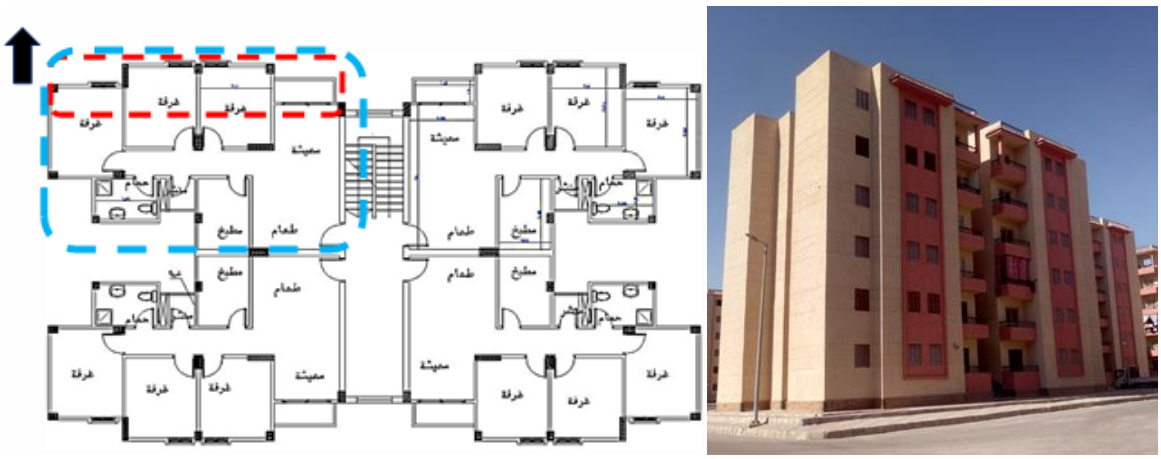

Figure (2), (3) shows a model of a residential building - social housing of 800 acres - New 6th of October City - Giza.

9-6- Evaluating a model of a social housing unit using simulation: This is done through:

A- Simulation methodology:

The specifications and dimensions of the building are inserted into the program, and a model and a simulated model that simulates the reality of the building is created, so that this model simulates everything related to energy consumption in the building as it appears in the following model taken from the Design Builder 6.0 program, it is a program that analyzes the inputs in the entire study case..

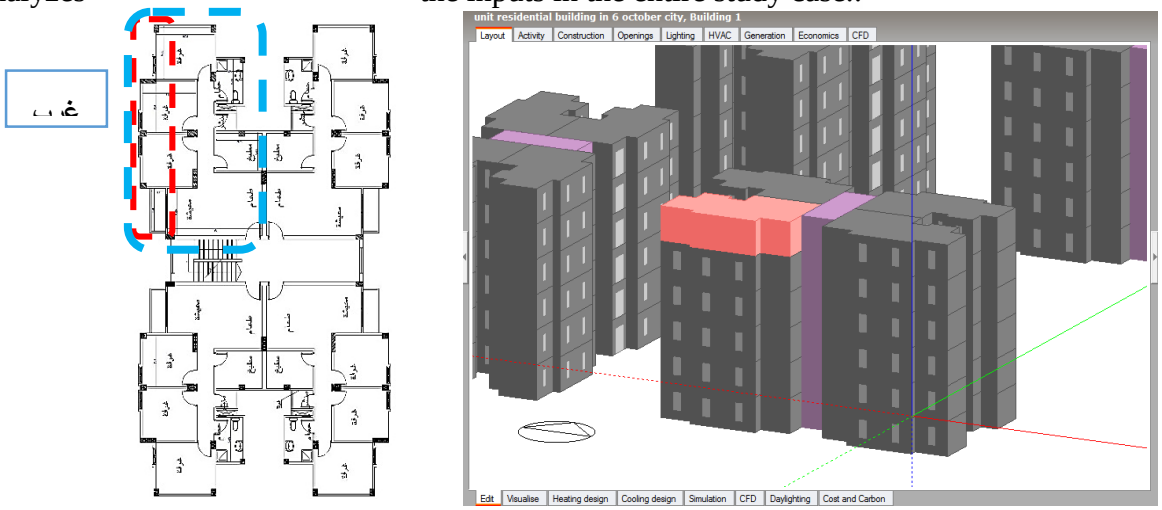

Figure (5) shows the case study in the 6.0 Design Builder program, source: https://designbuilder.co.uk/(11)

9-7- The simulation results:

The simulation results show that the highest rate of energy consumption for the social housing unit model in the first case is the wall thickness of the building envelope 12 cm red bricks, and transparent single glass 3 mm without applying the energy code without thermal insulation on the roof and on the walls, so the average energy consumption was 158.26 kilowatt hours per meter^2. The results of the second case, which is the wall thickness of the building envelope, indicate 25 cm in red brick and single transparent glass 3 mm, the rate of energy consumption decreased to 100.74 kilowatt hours per square meter at a rate of 58 kilowatt hours per square meter by 37% from the base case, and the results of the third case indicate in the case of adding 8 cm thermal insulation to the surface and a wall thickness of 25 cm red bricks and 6 cm thermal insulation on the walls and a single 3 mm transparent glass, so the rate of energy consumption decreased to 69.4 kilowatt hours per square meter at a rate of 88.86 kilowatt hours per square meter by 56% from the base case, and the results of the fourth case indicate, that in the case of adding an 8 cm thermal insulation to the roof and a wall thickness of 25 cm, red bricks and 6 cm thermal insulation on the walls and double 6 mm reflective glass, the energy consumption rate decreased to 57.71 kilowatt hours per square meter at a rate of 100.55 kilowatt hours per meter^2, by 64% from the base case.

10- Conclusion:

The possibility of applying the results of the research and simulation studies to the models of social housing units that are built by the competent authorities in those areas to achieve thermal comfort and improve energy consumption performance, and it is clear to us that both the architectural dimensions and the thickness of the materials greatly affect the rate of energy consumption of social housing units. The architects take these dimensions into consideration during the design process, and they will improve the energy consumption performance of the social housing units.

- The results of the average energy consumption of social housing units were shown, focusing on the role of guidance and its impact on energy consumption, and applying the energy code for residential buildings by treating the elements of the building envelope (walls, openings and roof).

In summary, the results showed the effect of the architectural dimensions and the dimensions of the building materials, and their effects on thermal comfort and the rate of energy consumption through the treatment of the building envelope and thus prove the validity of the hypothesis which is the use of thermal insulation and double glazing of 6 mm Low-E Glass in the outer envelope of social housing units. It works to improve the energy performance of social housing units and thus respond to the problem and achieve the research goal, which is to improve the energy performance of social housing units in the New Sixth of October City, taking into account the appropriate directions for residential units and addressing the building envelope through the application of energy code for residential buildings.

11- Recommendations:

1- The role of the architect: Architects must take these environmental dimensions into consideration during the design process with the choice of the appropriate direction ((North) (North-East) - (North-west) - (East)) and the use of thermal insulation 8 cm in the roof and 6 cm in the walls with wall thickness of at least 25 cm which is red brick and double glazing 6 mm thickness which reduces emissions, as it improves the energy consumption performance of social housing units.

2- The role of the educational institution: As a decision maker, it is necessary to apply the results of the research and simulation studies to the models of social housing units that are built by the competent authorities in those areas to achieve thermal comfort and improve energy consumption performance, and it is clear to us that both the architectural dimensions and the thickness of the materials greatly have effect on the average energy consumption of social housing units.

3- The role of the state: The energy code for residential buildings must be applied and work on treating the building envelope of social housing units by using a wall thickness of not less than 25 cm red bricks and 6 cm thermal insulation with the use of double low-e emission of reduction glass ((SHGC) = 0.43), (((LT) = 0.634), ((UV) = 0.233)) with thermal insulation of the roof with a thickness of not less than 8 cm for the last round in order to improve the energy performance of the social housing units in the Greater Cairo Region.

12- References:

[1] - https://www.almasryalyoum.com/news/details/415826. 27/8/2020 .

[2] The National Center for Housing and Construction Research (2005), “The Egyptian Code for Improving Energy Efficiency in Buildings”, Part One, Ministry of Housing, Utilities and Urban Development, Arab Republic of Egypt.

[3] - Aranda, J., Zabalza, I., Llera-Sastresa, E., Scarpellini, S., & Alcalde, A. (2018). Building energy assessment and computer simulation applied to social housing in Spain. *Buildings*, *8*(1), 11.

[4] - Escandón, R., Suárez, R., Sendra, J. J., Ascione, F., Bianco, N., & Mauro, G. M. (2019). Predicting the impact of climate change on thermal comfort in a building category: The Case of Linear-type Social Housing Stock in Southern Spain. *Energies*, *12*(12), 2238.

[5] - Pérez-Fargallo, A., Rubio-Bellido, C., Pulido-Arcas, J. A., Gallego-Maya, I., & Guevara-García, F. (2018). Influence of adaptive comfort models on energy improvement for housing in cold areas. *Sustainability*, *10*(3), 859.

[6] -Fahmy, M., Mahdy, M. M., & Nikolopoulou, M. (2014). Prediction of future energy consumption reduction using GRC envelope optimization for residential buildings in Egypt. *Energy and Buildings*, *70*, 186-193.

[7] -Ahmed, A. N., Samaan, M. M., Farag, O. M., & El Aishy, A. S. (2011, November). Using simulation tools for enhancing residential buildings energy code in Egypt. In *12th Conference of International* Building Performance Simulation Association, Sydney (pp. 14-16).

[8]- https://designbuilder.co.uk/ -14-8-2020.

[9]- http://ad2050.weebly.com/1575160215751604161016O5.html 15-8-2020.

[10]-http://www.energy-design-tools.aud.ucla.edu/climate-consultant/request-climate-consultant.php- 15-8-2020.

[11]- Patiño, E. D. L., Vakalis, D., Touchie, M., Tzekova, E., & Siegel, J. A. (2018). Thermal comfort in multi-unit social housing buildings. Building and Environment, 144, 230-237.

[12]- Alencastro, J., Fuertes, A., Fox, A., & de Wilde, P. (2019). The impact of defects on energy performance of buildings: Quality management in social housing developments. Energy Procedia, 158, 4357-4362.

[13] - Andargie, M. S., Touchie, M., & O'Brien, W. (2019). A review of factors affecting occupant comfort in multi-unit residential buildings. Building and Environment, 160, 106182.

[14]-. McNicoll, G. (2005). United Nations, Department of Economic and Social Affairs: world economic and social survey 2004: international migration. Population and Development Review, 31(1), 183-185.

[15]- Chen, P. H., Kan, M. S., & Chang, L. M. (2014). Sustainable Design for Hospitals in Taiwan. In Scientific cooperation's international workshops on engineering branches. Istanbul (Turkey): Koc University.

[14]-. McNicoll, G. (2005). United Nations, Department of Economic and Social Affairs: world economic and social survey 2004: international migration. Population and Development Review, 31(1), 183-185.

[15]- Golley, J., & Meng, X. (2012). Income inequality and carbon dioxide emissions: the case of Chinese urban households. Energy Economics, 34(6), 1864-1872.

[16] Al-Hadidi. H , Fahmy, S .(2020), "Sustainable Architecture as a Concept for Rationalizing Consumption and Improving the Environment", Journal of Architecture, Arts and Human Sciences, Cairo, Volume Five, Issue 1 Conference, Special Issue, Pages (41-59)

[17]- Patino, E. D. L., & Siegel, J. A. (2018). Indoor environmental quality in social housing: A literature review. Building and Environment, 131, 231-241

[18]- https://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-014-x/2011002/tbl/tbl03-eng.cfm 22 -10 -2020

[19]- McManus, A., Gaterell, M. R., & Coates, L. E. (2010). The potential of the Code for Sustainable Homes to deliver genuine 'sustainable energy' in the UK social housing sector. Energy Policy, 38(4), 2013-2019.