A STUDY TO ENHANCE THE PERFORMANCE OF HISTORICAL BUILDINGS IN ALEXANDRIA, EGYPT [CASE STUDY: FACULTY OF ENGINEERING ADMINISTRATION BUILDING]

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Abstract— The Historical buildings in Egypt are neglected, although their value and importance. It is a unique opportunity to reach higher levels of environmental performance and reduce energy consumption and CO2 emissions. Working in a sustainable way brings environmental, social and economic advantages. The main scope of this paper is to indicate the environmental prospects to evaluate the performance of the buildings.
The Faculty of engineering in Alexandria is one of the most important historical buildings in Alexandria, as it was built in 1941 and it occupies every year more than three thousands student, it is located in one of the main roads in Alexandria (Abou Quer St.) close to Manshia district (downtown).
To achieve this aim, simulation software's (diva-for-rhino & Autodesk Vasari) were used to conduct a series of sensitivity analysis on a set of design parameters which influence the building performance, using low cost solutions and simple strategies for environmental treatments which is the method to assess the environmental performance of buildings and in decision-making for sustainable buildings.

Index Terms— Energy, Day Lighting Performance, Sustainable Rehabilitation, Green Building Solutions, Energy Simulations.

I. INTRODUCTION

A. problem definition

Historical buildings is considered as an important architecture trait. As it defines the identity of any city. However, it can't achieve the sustainability impacts which nowadays green buildings are fulfilled although the plenty features which are already existed in these buildings for a variety of reasons. The main reason is that it doesn't depend on natural light which leads to use artificial light units. Another key reason, is the misusing of the natural ways of ventilation and utilize an applications of synthetic conditioning systems instead of it. A final point is the disability of controlling noise from both outside and inside the building.

B. Sustainable Development through Architecture

The goal of sustainable development is to improve living standards and the quality of people's lives, both now and for future generations [1]. Since architecture relates with the environment, it is therefore important that the protection of such environment should be paramount in the conceptual developments of the architect. This study therefore looks into the concept of sustainable development with a view to examining the contribution of architecture to its goals. [2]

According to Egyptian green building council

For the past two decades, the Egyptian government has worked feverishly to improve building energy efficiency and address greenhouse gas emissions. At the time, detailed studies had shown the close link between population growth and energy. For that reason, Egyptian stakeholders and government officials have looked for methods to reduce power consumption and Gas emissions. In that sense, developing energy efficiency building codes was a critical first step in that process and identifying alternative paths towards energy efficiency has been a second. Within the building sector, efforts at enforcement have been non-existent. Proposals to improve performance in this area have been put forward but interest and manpower have been lacking. While many people are examining this dilemma others are searching for alternative systems to address the same issues and increase awareness regarding their importance. [3]

C. Energy Simulation Tools

Building performance simulation tools can be used at the earliest design stage to asses various design options. Methodologies for calculating annual energy use of buildings and assessing the building performance have developed to complex dynamic energy performance simulation tools which are flexible and accurate tools for indicating relative changes in energy use, and comparisons between design options which can be used to determine whether the project as a whole is meeting the established energy target [4].

II. SIMULATION APPROCH

A. Research objectives

The main scope of this paper is to present an environmental solutions for an existed historical public building, to be able to acclimate to climate change in Alexandria. Energy modeling programs are used throughout the process, as both a design-

decision making tool and an assessment tool for the building envelope with respect to the minimum energy consumption used as the main target.

B. Simulation Tools

• Auto desk Vasari for energy simulations used to calculate the energy use in the selected building
• Day lighting Simulation: DIVA (Design Iterate Validate Adapt) an environmental analysis plugin for the Rhinoceros used to interface Radiance and Daysim for annual simulation and illuminance computation.

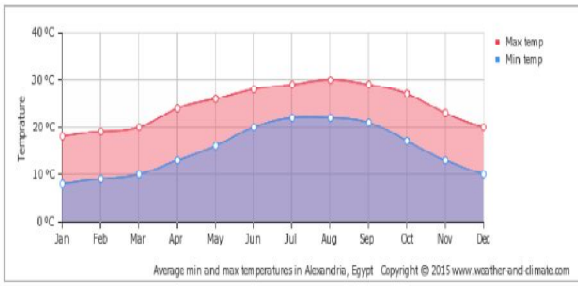
C. Simulation Methodology

In order to achieve the stipulated aim, the simulation-study traces the following steps:
• The location of Alexandria, Egypt (Climate Region 4A) and the associated weather files are loaded for accurate results.
• A room within the Architecture department at the faculty of Alexandria as a prototype followed by post-decision trial and error approach where simulation parameters are tested. Then, results are compared to the baseline value.
• Experimentation is conducted for a year round day lighting performance using the Dynamic Daylight Performance Metrics (DDPM) [5] and the possibility of glare occurrence is studied.
• A new proposal for the openings including windows and doors is simulated to calculate its annual total energy consumption.
• Law e-coating for the windows to simulate the possibility of glare and occurrence is studied also mirrors will be added to simulate the light percentage inside the building.

III. BASELINE-CASE

A. Alexandria's climate

Alexandria has a moderate climate (Köppen climate classification: BWh), Alexandria's climate is influenced by the Mediterranean Sea, moderating its temperatures, causing variable rainy winters and moderately hot summers that, at times, can be very humid. With annual rainfall between 100 and 300 millimeters (mm). The rainfall regime is stormy, occurring mostly during the winter months. The temperature can fall close to 0°C during the winter and reach over 40° C in the summer months, with the annual mean temperature around 24° C.



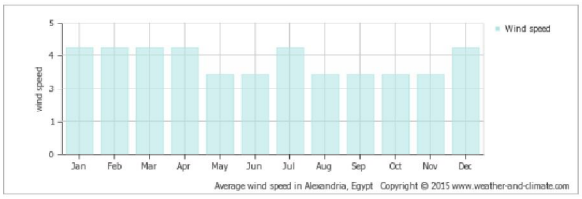


Figure 1, 2: Psychometric Chart, Alexandria, Climate Consultant. [6]

B. Case study weather analysis

The building is oriented 20 degrees north west. The selected prototype room is located at the south of the building.



Figure 3: Shows orientation of the building

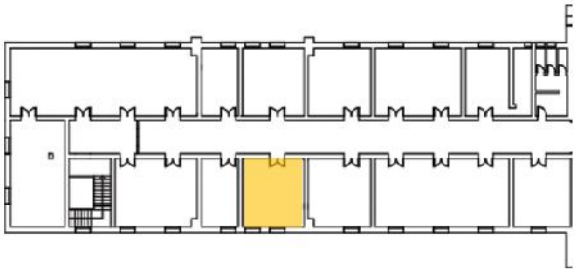


Figure 4: Location of the selected room

The room is used for post graduates students who work together on a meeting table. Floors are ceramic tiles, wall and ceiling are painted with plastic white paint, doors and windows are wood, 2 Fluorescent lamps are used and an air conditioning system, also curtains are used on the windows to decrease the glare inside the room .

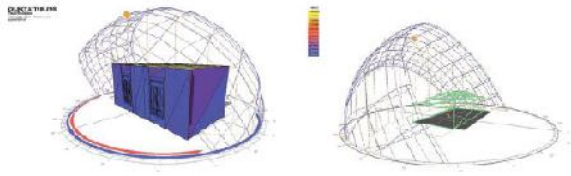


Figure 5: Shows sun path over the building

Maximum angle of sun in summer 79 degrees
Maximum angle of sun in winter 31 degrees
Simulations are performed to investigate the monthly cooling load and heating load in the building to calculate the how much energy the building use to be comfortable for the users, as shown in figure 6 and 7

the cooling loads are so high specially in august which reaches the maximum while in December, January and February not much energy used to cool the space.

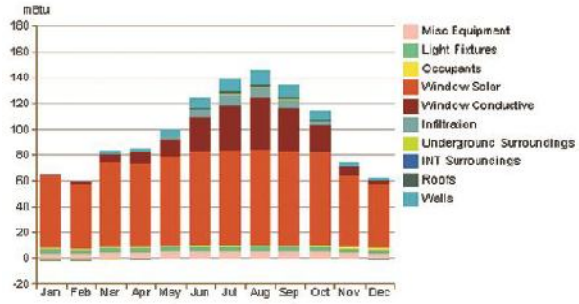


Figure 6: Monthly cooling load

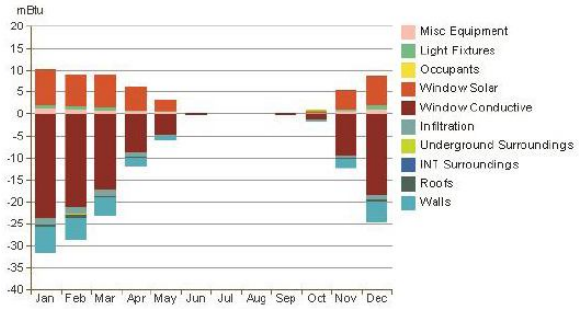


Figure 7: monthly heating load

C. proposed prototype

The proposed plan in Figure (4) for the prototype is 5.7*6m and 6m height, the total area is equal 34.5m2, each room has two windows 1.4*2.8m and a door 1.5*3.65m.

The plan has a semi squared form which oriented to the south east that's allowed it to receive the most intense heat from the sun.

D. Baseline-case Description

A schedule for the occupancy as indicated in (table 1) has also been selected to calculate the amount of the daylight from occupants of the room.

Table (1) Building Description Inputs Parameter Inputs

Parameter	Inputs
Location	Alexandria, Egypt
Climate	Mediterranean climate
Room Area	34.5 m²
Occupancy	The room can accommodate ten students In addition to one professor (Sat.-Thu.) 9:00 – 4:00 Taking into consideration July and August (Summer Holiday)
Wall construction	Single Red Brick Wall 125mm
Roof Construction	Concrete Slab
Floor Construction	Concrete Floor 200mm
Glazing Type	Single Clear 3mm
Lighting	Fluorescent

IV. SIMULATIONS

Simulations are performed to investigate the impact of varying the parameter values on design decision making for a less energy consumption design. Each parameter will be studied separately to examine the actual impact of each factor.

• Daylight Availability analysis

Simulations in a certain room have been done on three cases in order to increase the amount of the daylight, then the results compared to choose the less energy consumption solution to be used.

Case 1: horizontal shelves will be added to the current windows to decrease the amount of light entering the space which causes glare, those shelves will be 60 cm from each side of the window.

Case 2: adding low-emission coating sticker on the glass to decrease the amount of heat entering the space, which could be installed from the inside and also from the outside

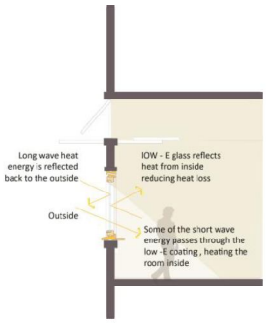
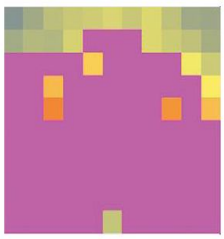


Figure 8

Case 3: combining both together to reach the maximum energy saving and to examine the results.

Current situation



Over lit	75%
Day lit	10%
Partially lit	15%

Figure 9: shows the results of the baseline prototype of the room with its current openings and design

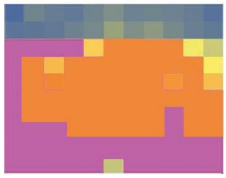
Case 1 with shelves



Over lit	46%
Day lit	21%
Partially lit	33%

Figure 10: adding horizontal shelves each one 60*60 cm, to decrease the light over lit and to reflect the light rays into the ceiling of the room, and not leading to direct sunlight rays which causes glare.

Case 2 with low e-coating



Over lit	32%
Day lit	48%
Partially lit	20%

Figure 11: Adding low-e coating on the current glass windows which helps to reflect heat outside, reducing solar gain during the warm months and thereby reducing cooling costs.

Case 3 with shelves and low e-coating



Over lit	21%
Day lit	50%
Partially lit	29%

Figure 12: combining both from case 1 and 2 to maximize the advantage of saving energy and to reduce the heat energy gained in the baseline case.

• Natural ventilation:

For hot climates, natural ventilation can help meet a building's cooling loads without using mechanical air conditioning systems.

As shown in figure (12) the door of the classroom which is located at the south kept open and also open the window and the door of the north classroom that will help to increase the wind pressure as show in the section diagram and will help in a good natural ventilation.

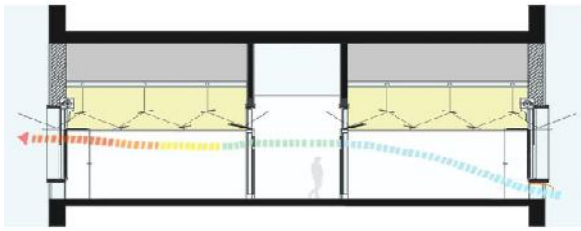


Figure 13: shows the cross ventilation method

• Natural light:

the daylight entering the building through the window openings is not enough to provide natural light into the corridors , so adding a light shelve mirror system inside the false ceiling will help in reflecting the light going to the inside of the building which will increase the natural lighting and will decrease the use of artificial light.

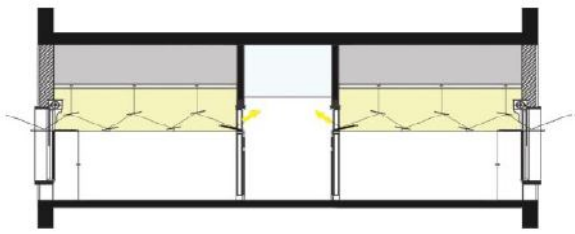


Figure 14: cross section shows the light shelf mirror system

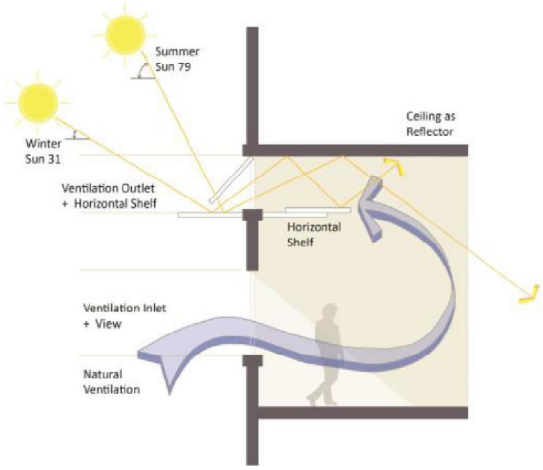


Figure 15: Shows the ventilation process and the light shelve mirror system

V. RESULTS AND FINDINGS

- Annual Simulation Results

After, applying the highest energy efficient tested parameters to the model. Annual energy simulation results were calculated 40.35 kWh/m², as shown in Figure (15)

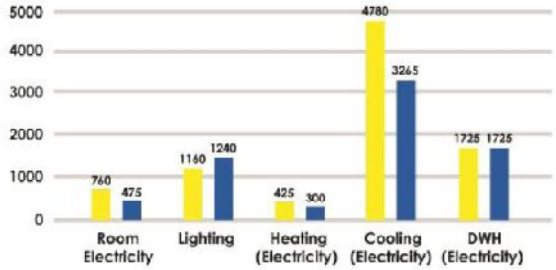


Figure 16: show Annual Net Site Energy Calculations (KWh) comparison between the baseline case and the new proposed solutions– Design-Builder Simulation.

- Daylight Simulation

A simulation which applied on three hypothetical cases (case 1 with shelves, case 2 with low e-coating and case 3 combining of shelves and the low e-coating) shows some results: there were considerable decrease in case 3, of approximately 45 percentage points compared to the normal case for the over lit (reaching 21%). However, the day lit and the partially lit both proved to have the greatest values, at 50% and 29% respectively, which means 40 and 14 percentage points higher than in the current situation. It is possible to devise that using both shelves and low e-coating achieve the required results of energy consumption.

- Natural ventilation

A significant improvement can be clearly seen in the natural ventilation technique, which is occurred by applying a cross ventilation system by allowing the cool air currents to get into the building through a lower small opening in the external wall and pull the hot air through a higher openings at the opposite wall.

By using these solutions most of the building can be ventilated naturally without using the artificial techniques. Therefore, more reduction of energy consumption can be achieved.

CONCLUSION

• A reduction of 39.2% in energy consumption which was achieved when changing the design of the current prototype; height of windows, glazing types and shading devices.

• Daylight affects visual, thermal comfort in buildings, therefore design strategies that affects the daylight performance must be studied on the historical buildings to achieve sustainable goals.

• The process of rehabilitation of the historical buildings should contain the optimum use of spaces And only the additions that increases the performance of the buildings according to the functional use first then to achieve the sustainable aim to be sure of the performance improvements

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