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Evaluation of the lighting design of an economic housing project using Well Rating System
(Study Case: Housing and Development Bank Building in New Damietta)

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Abstract:

Since the last decade, the Egyptian government has established several social housing projects to meet the growing demand for real estate and solve the housing problem nationwide (Saftawy 2019). Among these housing projects is the "Housing and Development Bank" project in New Damietta, which targets the middle and low-income social housing category. The existing residential units are currently fully finished and ready for use, and all electrical installations and internal and external lamps are almost uniform and pre-installed for all residential units. This study examines the performance of the design of external lighting and its health impact on some residents of residential units within it in the case of the study and also examines the performance of interior lighting design (new 2022). During the past years, the importance of hygienic design of buildings has emerged after the increasing phenomenon of sick building syndrome (Ashour 2014), which led to a decline in the productivity of users and affected their physical and mental performance. Because of the design of the buildings in which they work/reside. In the beginning the interest was It focuses on administrative and office buildings because the productivity of employees was translated directly into profits for employers, but later the importance of healthy design of residential buildings appeared, as the productivity of the employee is affected by the factors that affect the quality of his sleep and life in the hours spent at home also before arriving at work, hence the need for an approved evaluation standard that evaluates the performance of buildings in terms of health and its impact on the health, performance and psychology of users. The WELL Rating System, launched by IWBI (International WELL Building Institute) in 2017 (IWBI Delos Living LLC 2016), and the research measurement tool "WELL v2 Rating System", released in 2020, are released as the second version of WELL Building Standard TM. The research problem lies in the architects' disregard for the question of the effect of night outdoor lighting on the interior spaces of the rooms facing them when studying and designing residential projects (Bunjongjit and Ngaopitakkul 2018) social in the study area. The problem also came in the failure to evaluate the lighting design with the WELL classification system when studying and designing economic residential projects. The importance of research In that it seeks to achieve visual considerations when designing residential buildings, the most important of which is the exposure of facades to external artificial lighting that affects the internal spaces facing them, which provides psychological stability for their occupants and related to their health, and highlighting the importance of integrating sustainable and human-centered lighting solutions with the WELL classification system and achieving some of the sustainable development goals 2030. This study aims to evaluate the sample housing in New Damietta City using the WELL classification system to evaluate its performance on users in terms of designing good external and internal lighting, and to make proposals to improve the design of external and internal industrial lighting for better performance of the building, and taking into account the health and psychology of users, where three-dimensional models were created to simulate the state of the study and lighting using Computer programs for various simulations with their various versions, namely Revit, Relux and DIALux (Das, Mondal, and Ghosh 2021), then the data were discussed and analyzed, to examine the

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health effects of lighting design on the population in the case of the study. Several results were reached, including proposing alternatives to control the glare of the external light entering the bedrooms with samples, making adjustments to the window materials And change the types of lighting in the lighting poles to ensure the best performance of the sleep cycle system for all residents.The results of the research were reached, where most of the lighting standards of the WELL classification were not met, and several negatives were reached in the outer shell of the study case building (G.G.E.W. et al. 2020), so the optimal solution was proposed, which is to rebuild the outer shell by changing building materials, colors, openings, ceilings and lighting of both types (Daugaard et al. 2019), and the study recommended Working on finding local (Egyptian) standards through which to ensure the evaluation of sustainable residential buildings guided by the classification WELL to improve lighting performance related to health in housing, and the establishment of a lighting plan linked to the design of the building so as to achieve the standards.

***Keywords**: External and internal lighting - Social housing - Computer programs for simulation - - Relux - Revit DIALux - WELL classification system - Windows - Lighting poles - Exposure - Sustainable.*

1. Introduction:

Lighting design plays an important role on human health in architectural projects, enhancing the aesthetics and general functions of indoor and outdoor spaces (Ronald Gibbons 2023). Lighting design goes beyond just lighting, it has the ability to create the right atmosphere for the use of spaces, evoke emotions and highlight architectural features (A.K.A.A.O.W. 2006). In the case of the Damietta Housing Project, lighting design evaluation takes center stage with research as we explore its evaluation using the WELL rating system.

Architects and designers understand that lighting is not just about providing adequate visibility; it is about creating a comfortable place for residents. The right lighting design can transform the space, making it more attractive, comfortable, and inspiring. It can accentuate architectural elements, define spatial boundaries, and even influence the mood and well-being of residents.

In recent years, there has been increasing recognition of the impact of lighting on human health and well-being. The WELL rating system, which focuses on improving the health and wellness aspects of buildings, includes specific standards for lighting design. This system evaluates various factors, such as the quality of natural and artificial lighting, daily lighting strategies, glare reduction, color rendering, among others(Das, Mondal, and Chesh 2021).

The Damietta Housing Project provides a case study to evaluate the effectiveness of lighting design in a social housing environment. By examining its lighting design through the WELL rating system tool , we can gain insights into how it contributes to the well-being and comfort of its residents. This assessment will help us understand the importance of lighting design in architectural projects and highlight the importance of integrating sustainable and human-centered lighting solutions (Eshruq Labin et al. 2022).

In the following sections, we will delve deeper into the specific aspects of lighting design for Damietta housing project, explore the principles of the WELL evaluation system, and analyze how the project conforms to these principles. Through this assessment, we aim to highlight the excellence achieved in lighting design following the proposed solutions by research of this architectural state and highlight the potential impact it has on the well-being of its occupants. (Balshy 2018)

2. Problem

- Architects ignore the impact of nighttime outdoor lighting at bedtime on interior spaces when studying and designing social housing projects in the study (areavan Lieshout-van Dal, Snaphaan, and Bongers 2019).
- Failure to evaluate the lighting design with the WELL classification system whenstudying and ,designing economic residential projects (Egyptiann.d.).

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- Architectural and planning models for social housing projects are uniform throughout the project without taking into account the different orientation and climate of each site(Eshruq Labin et al. 2022) .

3. **Importance of Research**

- Securing the psychological and physical stability of the human being inside his home and related to his health, as the research contributes to achieving visual considerations when designing the lighting of residential buildings, the most important of which is the external artificial lighting that affects the internal (spaces at night sleep timesAli Al-Sanabani 2014).
- Highlight the importance of integrating sustainable and human-centered lighting solutions with the WELL rating system(Huda, M 2022.(

Achieving two Sustainable Development Goals 2030 in Egypt, (Smales and Warhurst 2015): No. (Good 3 Health) and No. 11 (Sustainable Cities and Communitie).

4. Objective .

1. Study visual considerations and derive the most important scientific foundations that achieve visual comfort in economic residential buildings in general and in selected housing inparticular (Juda et al. 2020).
2. Evaluation of sample housing in New Damietta City usingthe WELL classification system to evaluate its performance on users in terms of designing good external and internal industrial lighting (Zauner and Plischke 2021)
3. Submit proposals to improve the design of outdoor and indoor industrial lighting for better performance and health for the users of this project and for the building, taking into account the environmental aspects related to human health (El-wassimy 2011).

5. Methodology

In this context, it is necessary to prepare some studies that support the achievement of goals through .a specific methodology, *through*

- :***Theoretical part:*** using the descriptive-causal approach*, through*
  - scientific Review most of what has been written in this field, whether research - scientific journals - .theses - published articles - books and previous studies
  - Studying the concepts and principles of lighting and visual considerations for economic residential buildings in general, taking into account the environmental conditions of the new coastal city of Damietta.
  - A thorough review of the data and research related to the research was then conducted to gain insight .into the concepts underlying the lighting requirements of the WELL classification system
- ***Practical part:***
  - Field studies for the selected residential area were prepared through cadastral maps at an appropriate .scale as well as aerial drawings and photographs

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- Field architectural elevation of the places of light columns adjacent to the architecture selected from nature, analysis and classification through field visits.
- Using a lux meter to measure the intensity of illumination under the light poles adjacent to the selected .samples and to determine the lighting levels inside the selected samples
- Application of computer programs to simulate lighting, allowing a detailed comparison of the actual performance of these programs againstWELL standards.
- Analyze and evaluate the outputs of simulation programs for lighting, data and available documents .such as architectural drawings and technical specifications

Application of computer programs selected by research on the case of the study: *where:*

The research initially touched on the use of Google earth Pro. To determine the coordinates of the site on a cadastral map, then field upload the places of the light poles from the project site, then draw them on the 2D program (Auto CAD 2020), then create a three-dimensional model using the Revit 2020 program, then use :the following lighting simulation programs successively

DIALux 4.13- DIALux Evo (out door) - Relux desktop2022 (out door)- Relux CAD Revit2020 "To find alternatives to solutions to the research problem, as each program has a different advantage from others in finding alternatives to the solutions proposed by research, and through which internal lighting analyzes have been made in the spaces of the selected samples in the case of the study and analysis of the exposure of the facades to external lighting, and access to different data that help to deduce the foundations of lighting that .support healthy housing

6. Research hypothesis

The use ofWELLlighting systems to assess the health aspects of human lighting in residential buildings does not conflict with the use of green building evaluation systems such asLEED, but rather increases the efficiency of evaluation and the positive impact of lighting on the health of the occupants of these buildings and on the building itself.

Steps to apply the search method :

- Data collection and database building: It includes: collecting data from various sources, and building .databases
- Determine the locations of the lighting poles adjacent to the building of the residential sample using the tape measure, and sign them on the Auto CAD program at the general site of the study area.
- Building the three-dimensional model using the simulation programs are Revit, Relux and DIALux: to *determine the places of influence of night lighting poles on specific spaces in the dwelling in a specific repeated floor in buildings and to make internal lighting analyzes of spaces.*
- Analyze and apply the optimal appropriate model using lighting simulation and evaluation programs on the WELL system.
- Drawing conclusions: exit and suitability, and propose alternative solutions and treatments for the .building and lighting.

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7. Previous studies:

- **"Environmental Factors Affecting the Development of New Urban Communities" - Tariq Yousef Ibrahim Badr - Master Thesis 2008.**

The study dealt with clarifying the extent to which aspects of the social system, especially in its administrative and organizational aspects, affect the planning and development of new urban communities. It illustrates the impact of the factors of the social system and how they sometimes led to changing the locations of new urban agglomerations. *The* study used the descriptive experimental approach in addition to a field study that was identified on the northeastern sector of Greater Cairo to study the environmental factors that affected the development of those new communities.

- **Night Lighting in Architecture, Rana Mazen Mahdi, Working Paper - University of Technology in Baghdad, 2010.**

The thesis dealt with one of the aspects associated with artificial lighting, represented by night lighting for the building, and between the important role played by night lighting in enhancing the expressive aspects of the night scene and confirming the identity of the architecture, and the process of light design, its importance, objectives and various stages were discussed and analyzed, by explaining the classifications and levels of lighting, and some projects and study cases such as the Bibliotheca Alexandrina project in Egypt were analyzed to reach conclusions, including I think about light design from the early stages to develop ideas and design plans to ensure Integration occurs between the parts of the project and the lighting issue is not postponed to become as if it were an achievement.

- **Visual Considerations and the Foundations of the Study of Lighting when Designing Residential Buildings in Yemen, Ali Muhammad Al-Sanabani, Working Paper - Damascus .University Journal of Science and Engineering, 2011**

The research dealt with the general concepts of lighting, its problems and its importance in human life in terms of achieving psychological stability and visual health, where it discussed the research problem, which lies in the architects' ignoring the issue of lighting when studying buildings in general and residential buildings in particular, to reach foundations added to the laws and building legislation in Yemen. *The research concluded by* developing recommendations and proposals, including not adopting any architectural designs for residential buildings by the competent authorities unless they include a study of lighting and the formulation of architectural and urban standards and systems that take into account lighting to suit the requirements of the population and their needs in various segments.

- **Activating the role of residential urban spaces to accommodate the social and psychological needs " .2002 of the residents" - Waheed Farouk Abdul Muttalib - PhD thesis -**

It includes: Activating the role that can be played by the residential urban space in order to satisfy the social and psychological needs of its residents by setting a number of urban determinants and standards in the design stage, which works to achieve this activation and then alleviate the environmental pressures on individuals and society. *The study found the* method of analyzing residential urban spaces and the extent to which they are met to satisfy the needs of residents, and using recommendations to evaluate the urban spaces of residential areas.

- **The Role of Night Lighting in Highlighting the Aesthetics of Architectural Form, Nader Khalil Obaid, Master Thesis, Islamic University, 2011.**

The thesis dealt with the importance and role of night lighting in highlighting the aesthetics of the architectural form and specialized in public buildings in the Gaza Strip as a case study, due to the absence

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and neglect of the element of night lighting in those buildings and talked about the objectives of lighting design and lighting design standards and explained many international and local study cases, including a mosque in the Gaza Strip.

Theoretical study:

Definitions:

- **Sustainable Building:** It is the construction in which the relationship between cost, time and quality is exceeded to the economic determinants as a whole in addition to their environmental and social counterparts.

External environment of the building: includes all the surrounding building from a socio-psychological environment, a living environment and a physical environment from which the built .environment (dwelling) comes out.

- **Healthy HousHealthy House** Homes are places that are related to meanings, not just buildings, when a dwelling becomes a home, it means that it is simply a shelter where it cooperates and participates in meeting the material and emotional needs of its occupants, providing them with a good life, and describes the dwelling as a base for activities and daily life. And that healthy housing is the one that helps its residents to perform all physical, psychological and social functions normally, and in which the interdependence between the environment is achieved. and .Society (Moroccan and Attar 2021)
- **Sick House:** It is that dwelling that causes its residents to suffer from diseases that hinder th performance of physical, psychological and social functions so that a person loses attachment to the environment and society. The effect of the pathogenic dwelling on the human being and his internal environment appears as a result of not providing the necessary requirements and needs, in addition to that it becomes vulnerable to the influences of the external environment. This results in a feeling of fatigue, dissatisfaction and loss of security, which has a significant impact on his physical health. And psychological and social, the pathogenic dwelling has negative .manifestations that harm human health, (Zaki 2021)

- **Residential area:**

It is the place of private activities (rest, social life), and extends to public activities that achieve social, commercial and service exchange (Mathematics 2010). The residential area consists of: residential spaces (built frame and its related areas), area of roads and sidewalks, spaces designated for integrated and .complementary activities of housing (gardens, playgrounds, shops... etc)

- **Social House (Economical :**

It is housing that the state intervenes in supporting its completion in whole or in part, in order to support low- and middle-income families, either with financial assistance, reduction in interest rates or extension of the loan repayment period, to enable them to obtain one of the types of housing as the case may be. (Mathematics 2010)

- Social housing in Egypt:

It is the affordable housing offered for sale or rent in order to provide suitable housing for segments of society that cannot obtain housing through the real estate market, and its construction is developed based on standards with special requirements for each region, and there is no doubt that the government's support for these segments, whatever its cost, will be much less than the high price paid by society (Moslehi 2017), and these projects have been established in the new cities of all ,governorates of Egypt.

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Types of roads:

A- Methods according to the quality of their use:

The roads are either in the city or village or commercial, residential or industrial, and the street category is graded as follows (lane - road - street - link). As shown in the following table: No. (2).

B- Roads according to the implementation of the different street lighting design schemes:

According to the classification (International Commission on Lighting) CIE 12, methods are classified *into five types:*

- Heavy and high-speed traffic and the road separated by commas does not allow crossing. Highway example.
- Heavy and high-speed traffic. An example of a split road for slow traffic and pedestrians.
- Mixed traffic at moderate speed, such as the ring road. (Saftawy 2019)
- Slow traffic and pedestrians. Example of shopping streets.
- Mixed movement at a limited speed, such as the road linking residential areas. Such as: a local street with a width of 8 m (study area) (Al-Omrani 2012).

I- *Viewing through the openings: Vision Window*

- *Allow outdoor view*: Building users need to see the outside for many psychological reasons, especially when there is a distinctive view, and it is necessary that the windows allow the outside to see as much as commensurate with the importance of the external view (U.S. Department of Energy 2021).
- *Partial blocking of the external view: Sometimes the external view is ugly or part of it is not good, so it is useful to block the unwanted parts of the external view.*
- Protection from intrusion and protection of privacy: In most of the spaces (especially residential) it is important to protect the residents of the spaces from seeing others from outside the space, so the opening must be able to prevent the view from the outside to the inside, whether total prevention or at least prevent the distinction of the internal view accurately injures privacy. (Heerwagen 2007)
- Allow visibility from the outside: such as the case of shops that need to see the exhibits from the outside, when designing a façade, they must be protected from unwanted solar radiation and at the same time see the display windows well (Al-Gharbawi 2019).

II- *Visual Comfort for Humans: Sight Comfort*

Factors that determine visual comfort: The basic requirements that the lighting system must meet in order to provide the necessary conditions for visual comfort are as follows: uniform lighting - optimal lighting - no glare - suitable contrast conditions - correct colors - lack of effect or intermittent light (Mahdi 2020). Figure (5) shows the comfort scheme as a function of lighting and color temperatures.

The colors of light bulbs can be divided *into three groups related to their color temperature:*

White daylight - about 6,000 K - neutral white - about 4,000 K, warm white - about 3,000 K.

- ***Light Levels:*** ***Each activity requires a certain level of illumination in the*** area where the activity takes place. In general, the more difficult the visual perception, the higher the average level of illumination as well. Guidelines for minimum levels of illumination associated with different tasks are found in different publications. Concretely,

Visible Light Transmittance VLT or *Tv:*-

It is the ratio between the amount of visible light penetrating from the glass compared to the amount of visible light falling on it by natural lighting. The chance of this increases if it exceeds 0.60, where the

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angle of shades allowed increases from 45 to 60 degrees in the case of openings that do not exceed 30% and increases from 65 to 70 degrees if the percentage of openings exceeds that. - (Gharbawi 2019)

- ***Artificial Light External***

It is night lighting that depends on light bulbs. As follows (1) its specifications are clear:

- **Lighting Fixtures Specs**

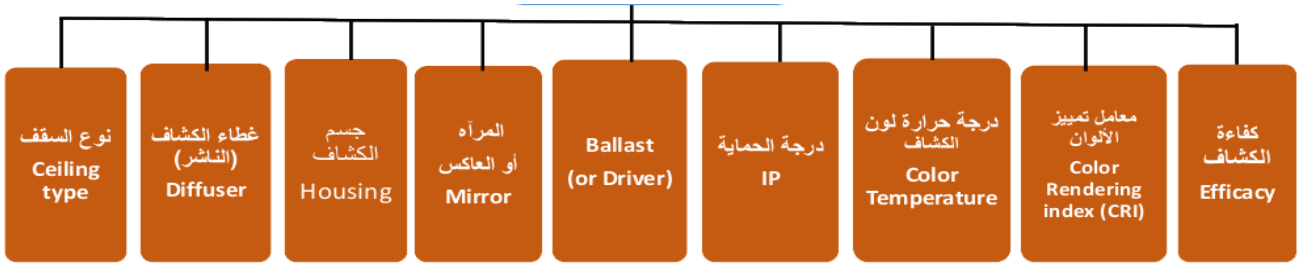

Figure (1) shows the specifications of industrial outdoor lighting headlights - (S.A.M. Others 2022)

- ***Pole in side walk*** :
  - These columns, whose heights are between 300 mm and 1000 mm, emit indirect lighting that goes to the floor of the walkway, and the walkway is determined by it and is not affected by the eyes of passers-by.
  - These poles are installed at equal distances and within 5 meters, either on one side of the corridor or on both sides alternately.
  - The body of this column is made either of strong plastic, electrostatic paint paint, hot galvanized, or sometimes from buildings to match the nature of the area with the use of the appropriate grounding method for the shaft body.

  Special attention must be paid to the dimensions of the feeding ends and the means of protection for this type of poles away from the tampering of children, as well as giving special attention to the thermal insulation of the parts exposed to the lamp and whose temperature rises. and Figure) 7) Classification of sources of light bulbs for lighting poles.
- ***Exterior Lighting :***
  External lighting has two types (service and decorative), and the main purpose of service lighting is to provide appropriate conditions for movement outside, and service lighting is generally subject to specific equations that provide correct clarity and orientation while avoiding the brilliant impact of the lights used.
  As for decorative lighting, the purpose of it is to cause certain effects in the eye and to add shadows, reflections and very bright spots to the objects that highlight the lights, giving them a stunning view without distinguishing their details, as well as lighting the gardens surrounding the dwelling.0 (Mahdi 2020)
- ***Light Distribution (*glare): Glare**
  The main factors in conditions affecting vision are the distribution of light and the contrast of illumination. As far as light distribution is concerned, it is better to have good general lighting rather than spot lighting to avoid glare. For this reason, electrical accessories should be distributed as uniformly as possible in order to avoid differences in the intensity of lighting. Constant navigation through unlit areas uniformly leads to eye strain, and over time this can reduce visual output.

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glare is produced when there is a bright source of light in the visual field; the result is a lack of ability to distinguish objects. Workers who experience the effects of glare continuously and sequentially can suffer from eye strain as well as functional disorders, although in many cases they are not aware of it. (Bunjongjit and Ngaopitakkul 2018)

Glow can be direct when its source is bright light sources directly in the line of sight, or by reflection when light is reflected on surfaces with high reflectivity. *The factors that enter the glare are:*

1. Light source illumination: The maximum allowable Lumi Nance live monitoring is 7,500 cd/m2. (Hwang and Jeong 2011)
2. *Light source location*: This type of glare occurs when the light source is within a 45-degree angle of the observer's line of sight and will be minimized to the point that the light source is located outside that angle. Ways and methods to avoid direct glare and reflection can be seen. - (Specs 2019)

Exposure timeframe: Even low-light light sources can cause glare if the exposure is too long. Avoiding glare is a relatively simple proposition and can be achieved in different ways. One method is, for example, to place grids under light sources, by using coated diffusers or equivalent reflectors that can correctly direct light, or by installing light sources in such a way that they do not interfere with a viewing angle. When designing a website Work, the correct distribution of lighting is just as important as the lighting itself, but it is also important to take into account that a very regular distribution of illumination makes the three-dimensional and spatial perception of objects more difficult. ("Building Electricity 2000-1" Senior Resident Consultant).

- ***Un comfortable Glare***

It is lighter than obstructive glare, and it may be present in indoor places and is divided into two types, which is a feeling of discomfort for a period of time in a place with a small amount of glare, (Soliman, Al-Eisawy, and Ahmed 2021) *and is divided into two types:*

- **Direct glare:** caused by high-luminous surfaces and light sources.

- **Reflex glare:** It is the result of regular reflections from polished surfaces in the field of view or adjacent to it. Rural 2019)

- ***Uniform Glare Level UGRL***: An objective measure of glare used by lighting designers to help control the risk of building occupants being exposed to glare from artificial lighting.UGR is an expression of the relative intensity of light from the installation of light compared to the intensity of light from the surrounding area, as seen by the viewer. UGR values range from 40 (very intense glow) to 5 (very low glow). UGR is measured for installation , not for light installation. However, the design of lighting fixtures can have a significant impact on the UGR of the installation where it is used. (Saber 2022)

- Uncomfortable glare is often the result of improper distribution of light or an increase in the brightness of the light source in the visual field. An annoying glare will usually not harm visual function, but people will feel uncomfortable. (Guidebook 2022)

- Long-term exposure to glare can cause visual strain and damage to eyesight. In addition, glare is very annoying because it often makes people feel anxious, lack of concentration, and other psychological discomfort. It would cause severe insomnia and headaches worse ("Egyptian Code Part One (Ch7 to Ch11)). Pdf," n.d.). Figure (10) shows the difference between lighting in the presence of glare and no glare UGR .

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- ***Color Render Index: CRI or Ra***: The color rendering index is the ability of a light source to identify colors, measured on a scale of 1 to 100. The scale measures the quality of the light produced by the source. (Zaki 2021)

- ***The sidewalk around the Pedestrian building :***

It is the distance surrounding the port to protect the bottom of the building, which ends with Bardora towards the street. Lighting poles and trees are installed on the sidewalk and used as a pedestrian area,

The effect of the external lighting system on the building and the human being - as the gradual change in lighting levels allows people to adjust and reduce exposure to the light of lamps directly, which reduces glare and reduces undirected light.

- ***(Solar Heat Gain Coefficient) SHGC:***

It is the ratio between the amount of thermal energy that reaches the internal space compared to the solar radiation falling on the glass from the outside, and the code provides for the determination of a maximum permissible limit for this value, which changes with the change of orientation and decreases as the percentage of openings in the façade increases (Al-Zafarani 2006).

- ***Lighting Design***

❖ **Design of lighting works:**

When planning the design of interior lighting fixtures, the following factors must be taken into account: (Other 2023).

The level of lighting intensity required according to the quality of use of the place - the lighting systems used according to the type of use of the place - the nature of the site, the colors of the walls and ceilings, the area and proportions of the dimensions of the surface to be lit and finishing materials - the selection of types of lamps and the level of installation and installation of luminaires - the distribution of luminaires - dazzle levels - levels of distinguishing the colors of objects inside the place.

❖ ***Illumination Intensity Level: The*** level of illumination required for any visual subject depends on the *following factors:*

Type of work. Working period. The quality of the required production. The average age of the working group or the people for whom the level of light intensity is designed. The following Table (1) shows the level of lighting intensity required in the different spaces within residential buildings according to the Egyptian code.

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Table (1) The level of lighting intensity required in the different spaces inside residential buildings ("Egyptian Code of Lighting," n.d.).

Place	Luminous intensity (lux)
stairs	120
Corridors	60
Living rooms :	
year	150
reading	300
Dining room	120
Bedroom	120
Kitchen :	
year	120
Above countertops	500
***Bathroom*:**	300
Office Room :	
- year	300
- Above the desktop	500

Definition of Relux software: *It is a computer program released by a Swiss company called:* RELUX Informatik AG, a well-established company that has specialized in the development of lighting layout (Others 2022) and lighting product display software (including Philiphs), since 2010. This company has participated in many national and international committees, and there are several versions of the program that correspond to different lighting situations, and deal with different Autodesk programs, the most important of which is the user search, which is a version of the desk top Relux (out door) program that works through the Revit program called Relux CAD Revit: It is a lighting design program that allows architects and designers to create accurate three-dimensional models for their lighting designs. The program allows to create a simulation of lighting, which It can help designers visualize the lighting design in real time. The software also allows the creation of lighting plans which can help ensure that the lighting design is scientific and practical. (Others 2022)

Dialux: DIALux is a computer program that was released to simulate lighting in buildings and its versions (outdoor) DIALux 4.13- DIALux evo. It is a lighting design software that allows architects and designers to create accurate three-dimensional models for their lighting designs. (Saber 2021) The software allows the creation of lighting simulations, which can help designers visualize the lighting design in real time. The software also allows the creation of lighting plans, which can help ensure that the lighting design is practical. (Immaculate 2016)

Types of smart glass used in homes:

Smart windows are mainly important in the design of the house, they allow external light to enter the house, and can also be used for ventilation, as the solar energy that enters through the facing windows helps to heat the house and reduce the costs of heating the house in the winter, and to save energy more you have to choose smart windows. (El-kholaey 2023)

Types of smart glass used in homes:

There are two types of smart glass: active and passive, where you need an electric current to operate the active smart glass, but negative glass or "negative panels" do not need to use electricity, and glass is divided into the following sections:

- PDLC polymer dispersed liquid crystal glass This type of glass is used on privacy areas such as: intensive care unit areas, bathrooms, conference rooms,

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- Suspended particle glass, where liquid crystal particles float randomly in this panel and block or absorb light, its direction scatters light and gives the glass a transparent appearance, and you can apply different voltages to achieve different levels of opacity, and this glass is different from (PDLC) glass,
- Electrochromic smart glass: where the partial properties of the window change slowly when an electric current flows through it, and when you reach the level of dimming you want in your smart home, disconnect the power supply, then you will not lose the effect of smart glass, and then you can control how slowly the smart glass window changes. This type of smart glass is widely used and common, and is found in these places: museums, rearview mirrors in the car and building windows, and one of the disadvantages of this type is that it is not as durable as other technologies.
- *Photochrome smart glass* is one of the negative smart glass windows, because it does not rely on electricity to activate it, but rather uses photochrome glass light in particular.
- *Thermal glass* -Advantages of smart glass window. (D.Menachem Domb 2006),

WELLV2 classification concept requirements :

- ***Definition of LLWE classification: It is a performance-based system*** designed to measure, certify and monitor features of the built environment that affect human health and well-being, through air, water, nutrition, light, fitness, rest and mind. It is the first rating system that focuses solely on the healthy performance of the built environment rather than its sustainability. The system has ten performance concept categories, including air, water, nutrition, light, movement, sound, mind, etc.
- The new WELL Health-Safety rating is an evidence-based third-party certified assessment system that assists building owners, facility managers, and operators in implementing best practices to mitigate the spread of COVID-19 and to overcome this crisis and beyond.
- The WELL Health-Safety Rating: provides building operation and management teams across the industry with an effective tool to take all necessary steps in order to prioritize the health and safety of their employees, visitors and other stakeholders, while helping guide users in setting up their spaces. Re-entering the post-COVID-19 environment, instilling trust in users and the wider community.
- The concept of the light category requires certain prerequisites that must be met, as well as additional improvements that add to the rating score. All requirements are aimed at maximizing visual, physical and psychological comfort for the population. (IWBI Delos Living LLC 2016)

Recently, a new version of WELL Building Standard (WELL v) was released with the aim of providing spaces that promote human health and well-being . WELL Building Standard v 2 integrates the previous version and pilot schemes into a single classification system, which is designed to accommodate all projects. v 2 Projects are divided into two main groups, mainly determined by the type of ownership, as follows: Occupied by the owner: This building is mainly occupied by the entrepreneur (which may be different from the owner of the building).

The new building standard works as follows where the 2WELL Building Standard v consists of 110 points or degrees (performance metrics, design strategies and policies) which are grouped into 10 concepts: air, water, nutrition, light, movement, thermal comfort, sound, materials, mind and society. As in Figure (2).

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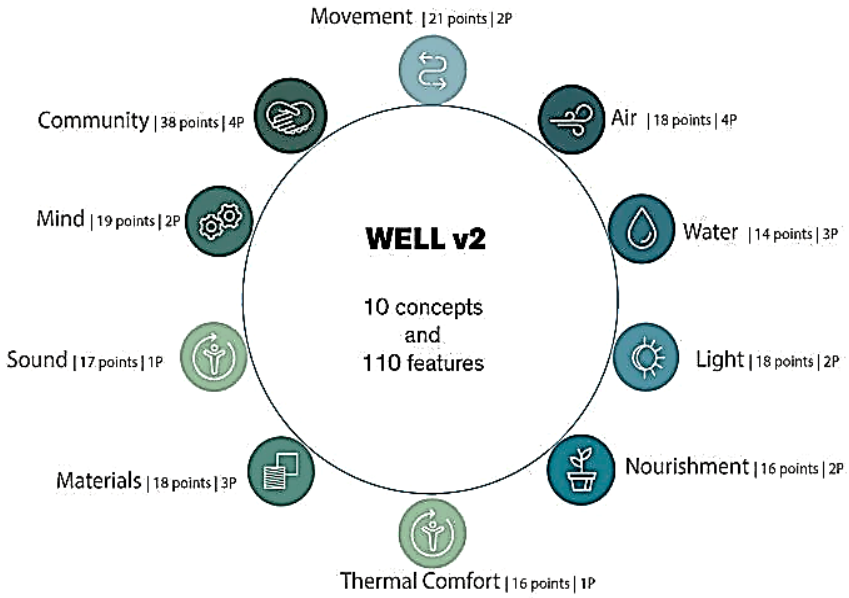

Figure (2) ideas and components (2 WELL B) :(Guidebook 2022)

WELL Certification Process : Buildings can be awarded WELL certification with a silver, gold or platinum rating (with platinum being the highest achievement). WELL-certified buildings require rehabilitation every 3 years. The following figure shows the ideas that the ranking focuses on and the number of points on which it is evaluated. Grades and Awards -Good certificate Projects earn more than 12 points per concept and a total of no more than 100 points across the ten concepts. Projects can also pursue an additional ten points in the concept of innovation. If the project wins more than 12 points in any concept, the bonus points will be counted in feature I01, provided that the maximum points in the innovation concept have not yet been reached. And table (2) shows the degrees of certificate (2 WELL B).

Table (2) Certificate degrees (2 WELL B) (Guidebook 2022)

Total points achieved	WELL Certification		WELL Core Certification	
	Minimum points per concept	Level of certification	Minimum points per concept	Level of certification
40 pts	0	WELL Bronze	0	WELL Core Bronze
50 pts	1	WELL Silver	0	WELL Core Silver
60 pts	2	WELL Gold	0	WELL Core Gold
80 pts	3	WELL Platinum	0	WELL Core Platinum

Light exposure in the WELL Light Exposure rating:

The concept of WELL Light enhances light exposure, aiming to create lighting environments that promote visual, mental and biological health. Light is the main driver of visual and circadian systems. Light enters the human body through the eye, where it is sensed by photoreceptors in the retina associated with the visual system and the biological clock. Humans are diurnal, which means that they are inherently prone to wakefulness during the day and sleepiness at night. Light exposure stimulates the circadian system that initiates in the brain and regulates physiological rhythms in all over the body" membranes and organs, such as hormone levels and the sleep-wake cycle. Humans and animals have internal clocks that synchronize physiological functions in a roughly 24-hour cycle called circadian rhythm. The circadian rhythm coincides with the natural day-night cycle through different environmental signals, the main signal being light.. (IWBI Delos Living LLC 2016).

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Practical part:

The subject of this study -

Sahrawi South Buildings Housing Project (Housing and Development Bank):

The South Buildings housing project in New Damietta consists of a group of units numbering approximately 1200 apartments, distributed over a group of buildings numbering approximately 60 buildings, each building consists of a ground floor and four floors, and Figure (19) shows the map of the selected area within the city of New Damietta.

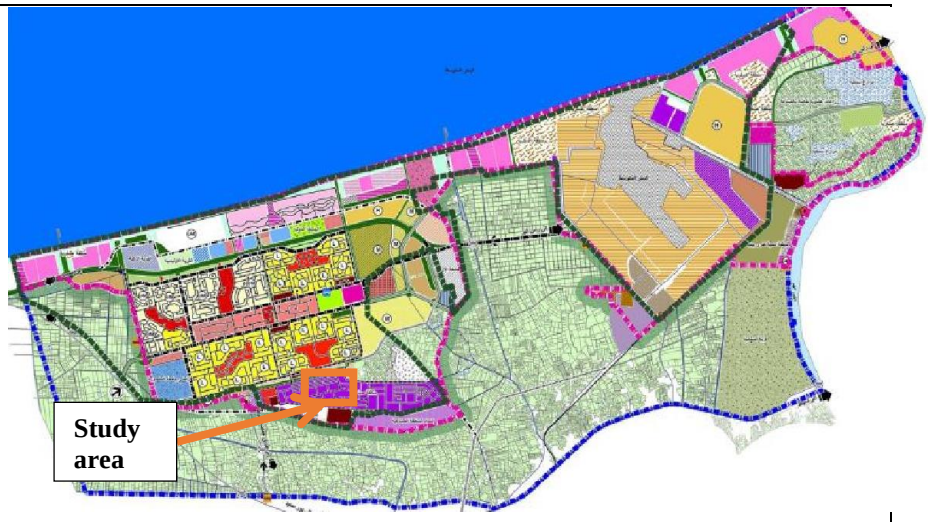

Figure (3) shows the map of the selected area within the new city of Damietta, (New 2022)

There are nearby services such as shops, a mosque, a school and other separate services. Figure (4) shows the map of the selected region of Google Earth Pro. *as follows:*

Figure (4) shows the map of the selected region , Source : Google Earth Pro. programm

The areas of the residential units in the project range from 100 to 150 meters distributed over 3 rooms and a hall, as in the attached figure No. (5) all units have been fully finished by the state, as well as Figure (6) shows the general location of the sample building on the area, and Figure (7) shows the places of the bedroom samples in the apartments in the selected building, the third floor. *as follows:*

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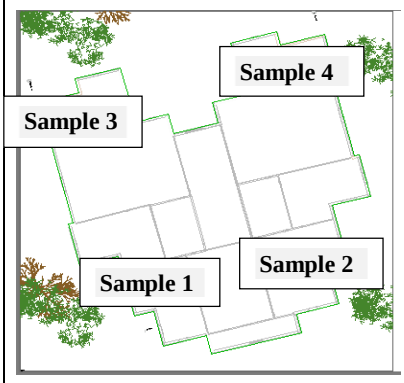

Figure (5) shows the places of the sample bedrooms in the apartments in the selected building, floor 3, Source : Researcher

Figure (6) shows the general location of the sample building on the countryside, Source: Researcher

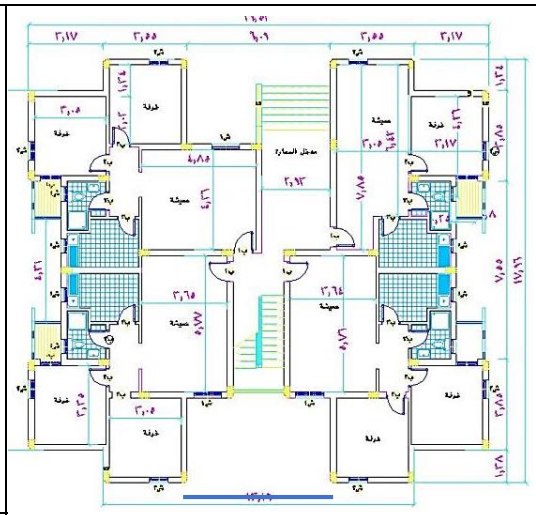

Figure (7) Horizontal projection of spaces in the repeated role of the selected architecture, (Al Shamis 2021)

- Basic case study:

To conduct this study after signing the columns of light on the sidewalks next to buildings and roads, a three-dimensional model was drawn on the program RevitTaking into account the height of one floor 3 meters, and the building consists of two walls with variable openings and the other two walls are considered running walls, and the percentage of openings in the walls can be controlled through the program by increasing or decreasing, *The main case in which the study was conducted is:*

- The outer walls with a thickness of 25 cm are clay bricks.
- The roof is 12 cm thick of reinforced concrete.
- The windows are a two-row shutter of ordinary wood shutters and in front of them is a 6mm clear glass sash.
- Walls without openings (euphemistically considered as running walls and completely insulated) to show the effect of exposed walls.

Factors will be taken to study them:

- **The shape of the building:** shape - direction - proportions of openings - glass.
- **Building materials:** This is studied in detail as will be mentioned in the following items.

- The effect of the shape of the building on the rate of energy consumption through the outer shell:

To study the effect of external lighting on the outer shell that connects to the corresponding internal spaces, a building was taken with the same specifications as the basic current Base Case As a basic building for comparison, the study was conducted on these models under the influence of the external climatic conditions of the new city of Damietta. The most appropriate shape is the rectangular shape, which is the ratio between

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length to width between 1.5, and the most appropriate direction is the north and south direction, while this ratio changes according to the change of direction.

Field measurements:

The area was visited three times day and night: as follows:

- First: Date: 26/12/2022 - 11 am and 8 pm.
- Second: On 26/3/2023 - 11 am and 8 pm.
- Third: on 26/6/2023 - at 11 am and 8 pm.

- By selecting samples and determining the measurement ruler and tools used in the field study.

❖ ***Luminous intensity***: using the Mini Light Meter: UNI-T specifications (UT383),

The intensity of the lighting was measured as follows:
First: External lighting at night (8 m) under the lighting poles facing the sample rooms.
Second: Interior lighting at night (after closing the internal lighting) in the bedrooms for samples for the 3rd floor at 8 pm next to the windows .The following Table (3) shows the field measurements, the devices used, and the limits of the permissible standards in the residential building,

Table (3) Measurements of field lighting intensity, the device used and the limits of the permissible standards in the residential building- Source: Researcher

Standard	Standards limits WELL	External field measurements at night under the lighting poles facing them				Standards limits حسب WELL	Internal field measurements at night in the bedrooms of the 3rd floor at 8 pm			
		sample 1	sample 2	sample 3	sample 4		sample 1	sample 2	sample 3	sample 4
Lighting intensity	(20-50) lux in front of the sidewalk of the façade of bedrooms under the lighting poles for industrial lighting 8 pm	34 In the color of yellow light	32 In the color of yellow light	28 In white light color	38 In the color of yellow light	300-200) Lux in Bedrooms for artificial lighting (for regularly occupied spaces such as sleeping and in which reading tables are allocated)	70	65	85	90

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The following Figure (8) the lighting intensity measuring device model (Mini Light Meter), and Figure (9) shows the camera - Samsung model and mobile camera - model OPPO A 94 ,Figure (10) shows a tape measure with a length of 100 m 1- Transverse dimensions between the light poles and the building and between each other - of the BTE model - and Figure (11) shows the icons of computer programs used in the research.

Figure (8) Mini Light Meter - Source: Researcher

Figure (9) shows the camera - model Samsung and mobile camera - model OPPO A 94 - Source : Researcher

Figure (10) shows a tape measure with a length of 100 m 1- Transverse dimensions between the light poles and the building and between each other - BTE model -Source : Researcher

Figure (11) shows the icons of the computer programs used In the research - Source : Researcher

The following Figure (12) shows the study area on the AutoCAD program signed by lighting poles and Figure (13) shows a snapshot showing the interface that contains sample 2 and 4 and Figures (14 to 21) shows out door lighting at night in reality and in CAD and Revit Program.

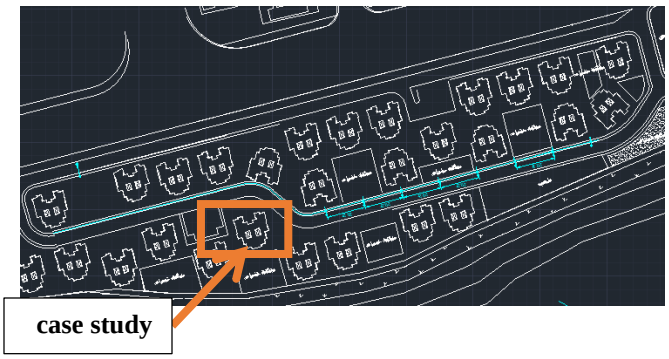

Figure (12) shows the study area on the AutoCAD program signed by lighting poles - Source: Researcher

Figure (13) shows a snapshot showing the interface that contains sample 2 and 4- Source: Researcher

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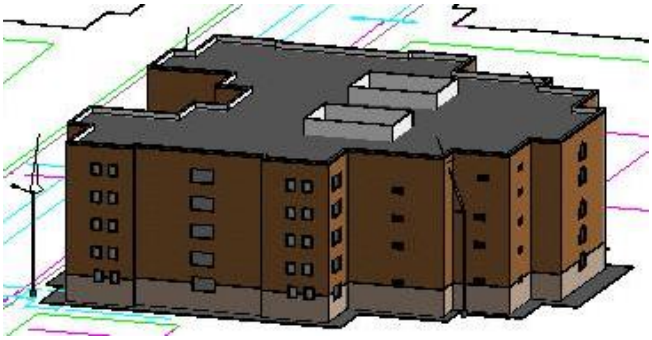

Figure (14) Building Block Selected on the Rivet - Source: Researcher

Figure (15) shows the lighting colors of the lighting pole in front of sample 3 - Source: Researcher

Figure (16) shows a simulation of the current lighting pole on the rifit when the direction of detection is facing the direction of the façade in which the bedrooms - Source: Researcher

Figure (17) shows the colors of the lighting searchlight on the sidewalk adjacent to the main façade of the entrance 0Source: Researcher

Figure (18) shows a simulation of the current lighting pole on the Revit when the direction of detection is opposite to the direction of the façade in which the bedrooms on the Revit are.
Source : Researcher

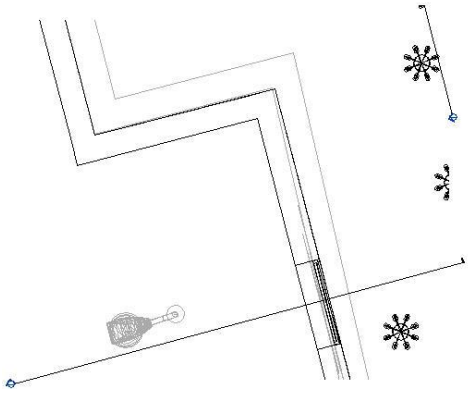

Figure (19) shows the location of the sector line in front of the current lighting pole on the Revit - Source: Researcher

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Figure (20) shows the lighting colors of the lighting pole - Source: Researcher

Figure (21) shows the lighting colors of the lighting pole in front of the sample Source: Researcher

The following Figure (22 to 29) shows indoor lighting in several spaces in flat in case study .

Figure (22) shows the light bulk in the sample room 4 – Source: Researcher

Figure (23) shows the window in the children's bedroom Sample 4, where an internal special glass was installed to block the lighting of the light pole – Source: Researcher

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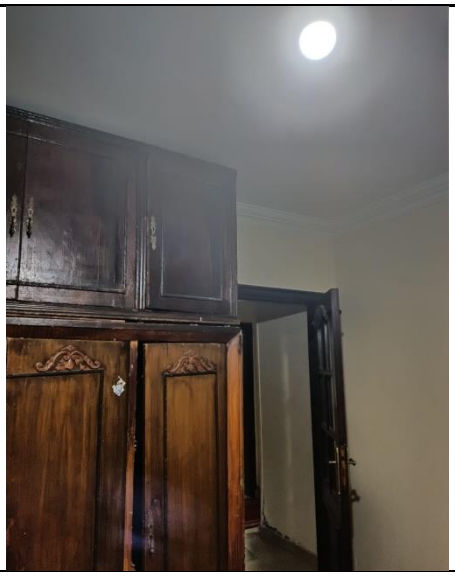

Figure (24) shows the floodlight in the sample room 4 - Source: Researcher

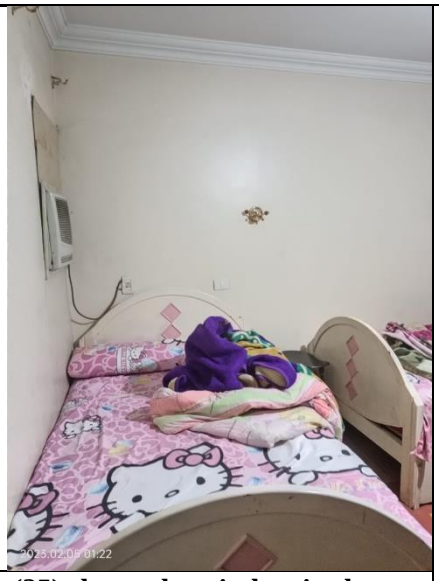

Figure (25) shows the window in the master bedroom in sample 4 showing the window opening that was used for air conditioning. - Source: Researcher

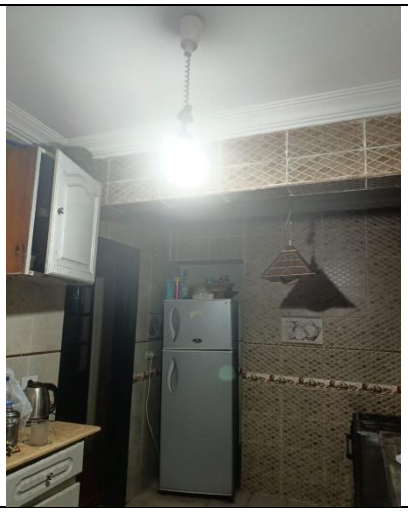

Figure (26) shows the kitchen lighting in sample 4 – Source: Researcher

Figure (27) shows living in the direction of the living room in sample 4 - Source: Researcher

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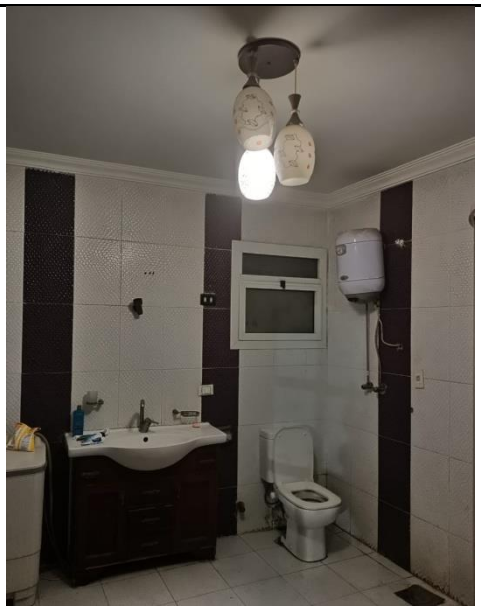


Figure (28) shows the water cycle -Source: Researcher

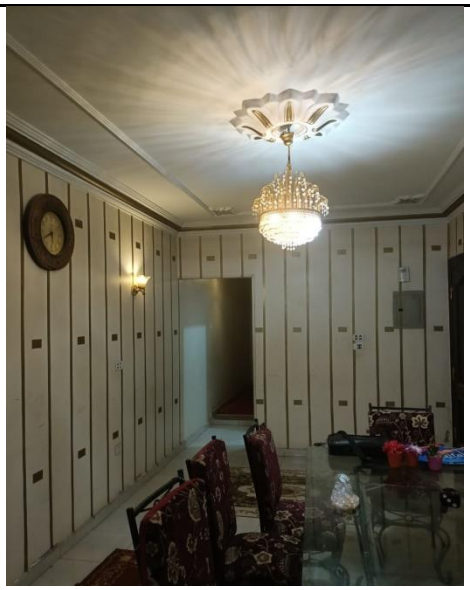
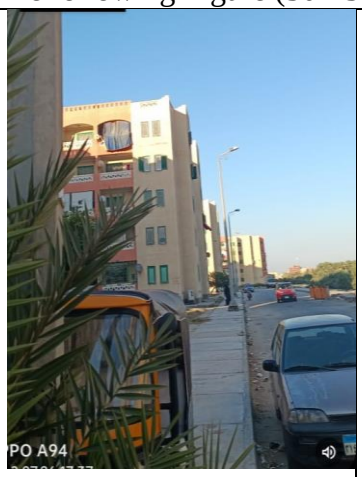


Figure (29) shows living in the direction of the road and the trip-Source : Researcher

The following Figure (30 - 31 a.b) shows out door Daylighting in reality .



a

b

Figure (30 a - b) shows the coordination of the site in the study area during the day. Source : Researcher

Figure (31) shows the coordination of the site in the study area during the day - Source: Researcher

<u>Using DIALux Evo in the design of lighting in the case of the study (for the proposed solution 1):</u>

Using DIALux Evo software: In the Damietta housing project, evo DIALux was used to create a lighting design that is functional, energy-efficient, and aesthetically pleasing. The use of spaces facing the lighting poles has been changed as a first alternative (solution 1). It became a living room instead of a bedroom and therefore the sleeping cycle of the occupants was not affected. The following Figures (32-33) show a model of the current building at night showing the location of the wall exposed to light in the sample.

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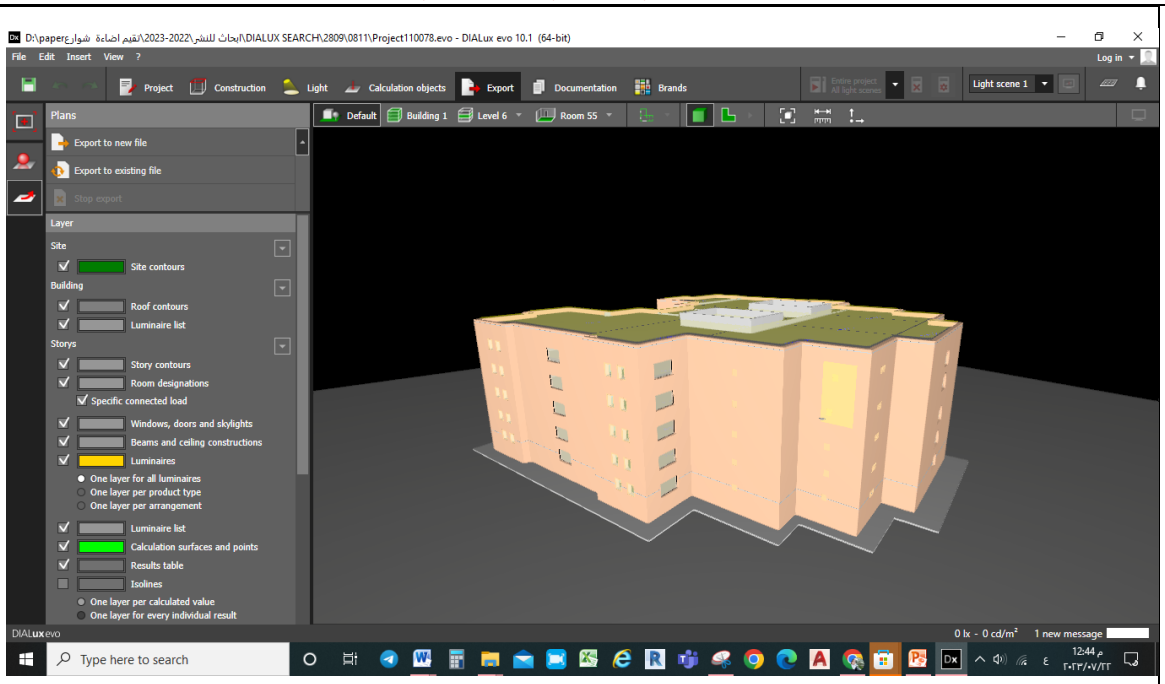

Figure (32) shows a model of the current building at night showing the location of the wall exposed to light in sample 4-
Source: Researcher

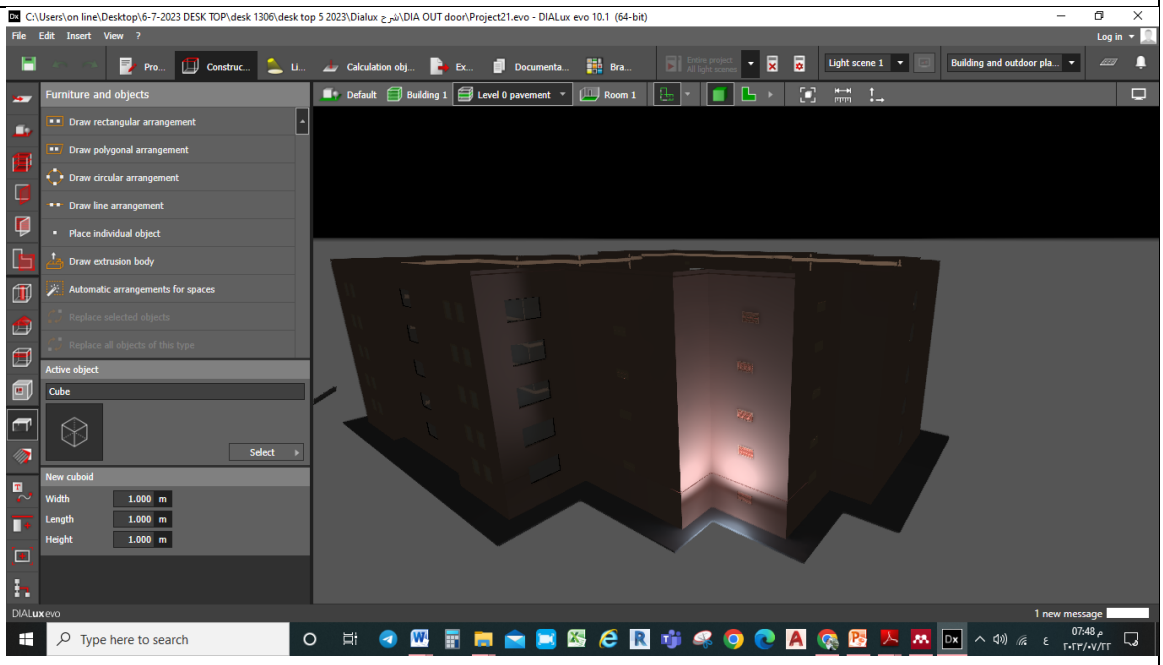

Figure (33) illustrates a model of the current building at nig ht by changing the light pole searchlight for the hand and changing its height-
Source: Researcher

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Using Relux CAD Revit and Desktop Relux in lighting design in Damietta housing project (Proposed Solution No. 2):

In the chosen Damietta housing project, Relux CAD Revit was used to create an external lighting design as an alternative to solve the problem of the study to avoid glare from the lighting pole opposite the windows of the bedrooms in the buildings from several sides, where the program was used to create three-dimensional models of the selected architecture and put internal and external lighting for it to simulate reality, one of the ways, for example, is to modify the windows sometimes by replacing a glass shelves with an internal special or smart glass (Electrochromic smart glass – as stated in the theoretical part of the research) (D.Menachem Domb 2006), where it was proposed manual internal shading can be controlled by users at all times, and the quality of the headlights was replaced for lighting poles of the existing halogen type to become LED, and it is possible to add a cover or smart control in the lighting timings where they are dimmed at exactly 8 m, and the height of the level of the lighting spotlight was reduced with the light pole above the sidewalk at other times, or by placing networks under the lighting sources , or by using coated diffusers or equivalent reflectors that can direct light correctly, or by installing light sources in a way that does not interfere with a viewing angle, then simulating the lighting in each case, and then practical measurement with Alex meter of the site to compare it with the results of the simulation program and evaluate cases with the WELL classification, so that the lighting is functionally successful and aesthetically pleasing. The figures (34-48) illustrate the following.

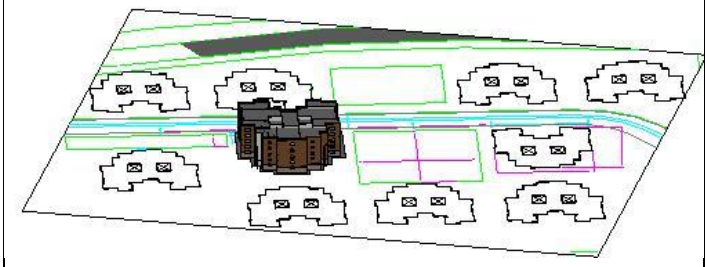

Figure (34) shows a three-dimensional model of the sample architecture on the Revit –
Source: Researcher

Figure (35) shows the general location of the Revit sample architecture-
Source : Researcher

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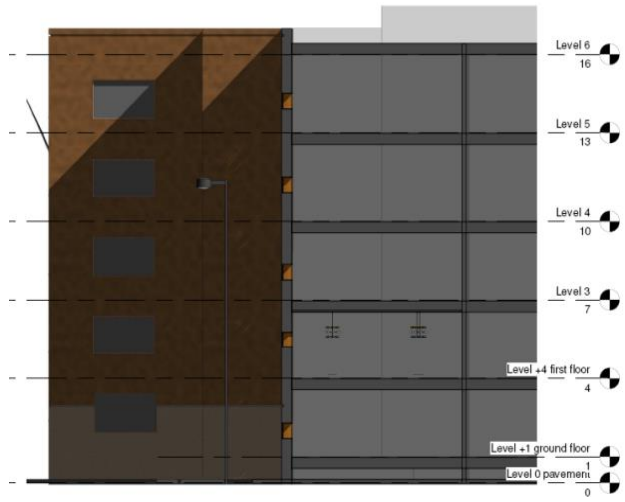

Figure (36) Vertical sector passing in samples 1 and 2 on the Revit –Source : Researcher

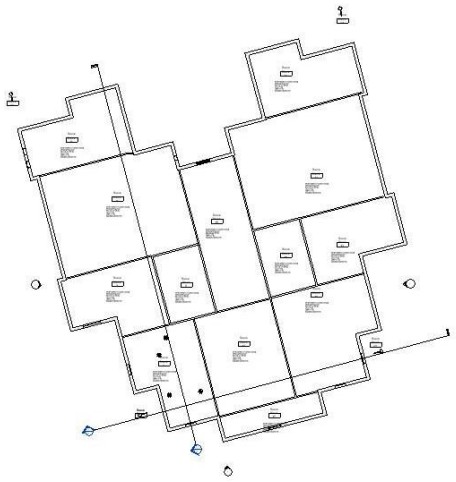

Figure (37) Horizontal projection of the selected architecture within the Revit
Source : Researcher

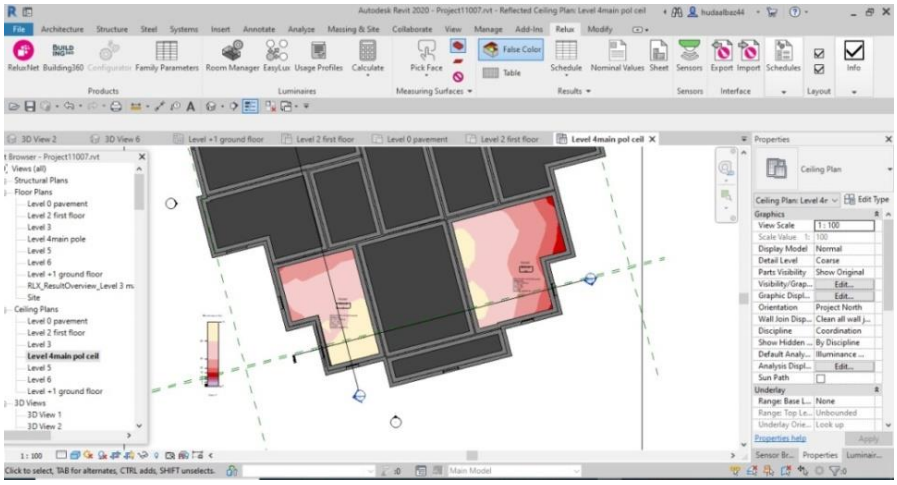

Figure (38) Internal lighting of samples spaces 1 and 2 on Revit-
Source: Researcher

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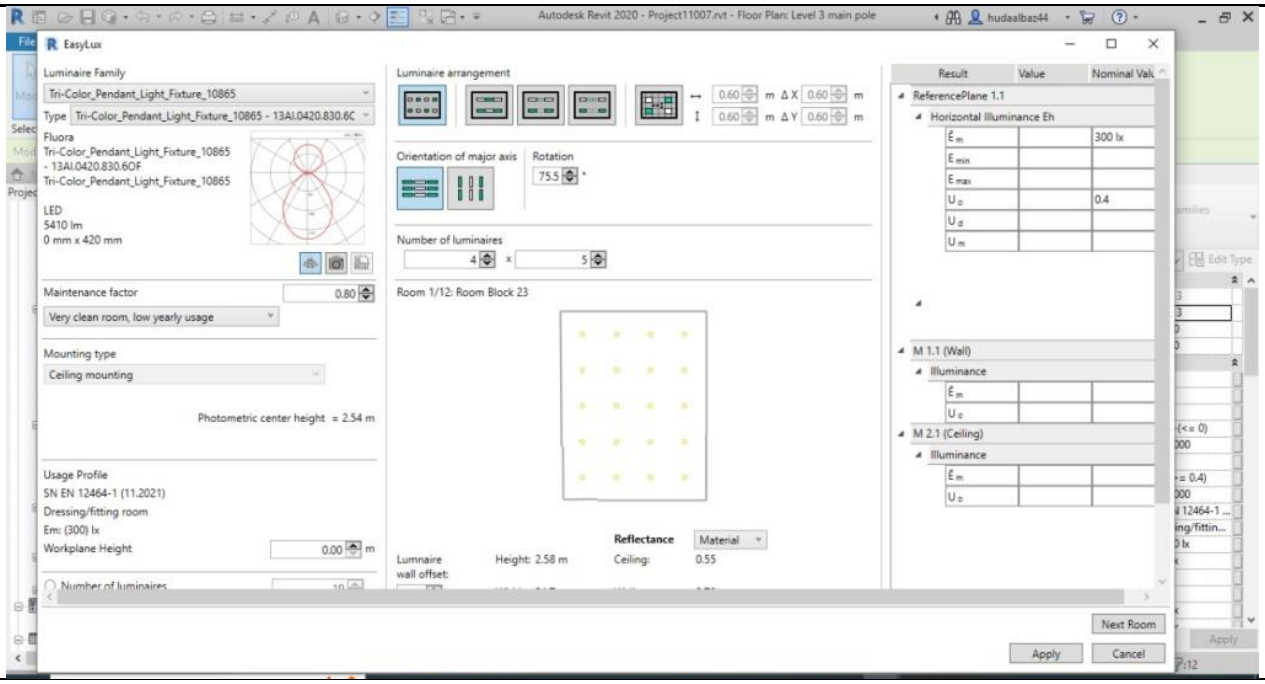

Figure (39) shows the method of distributing the interior lighting (chandelier) LED bulbs inside the rivete for the bedroom for sample 1 on the Revit-

Source: Researcher

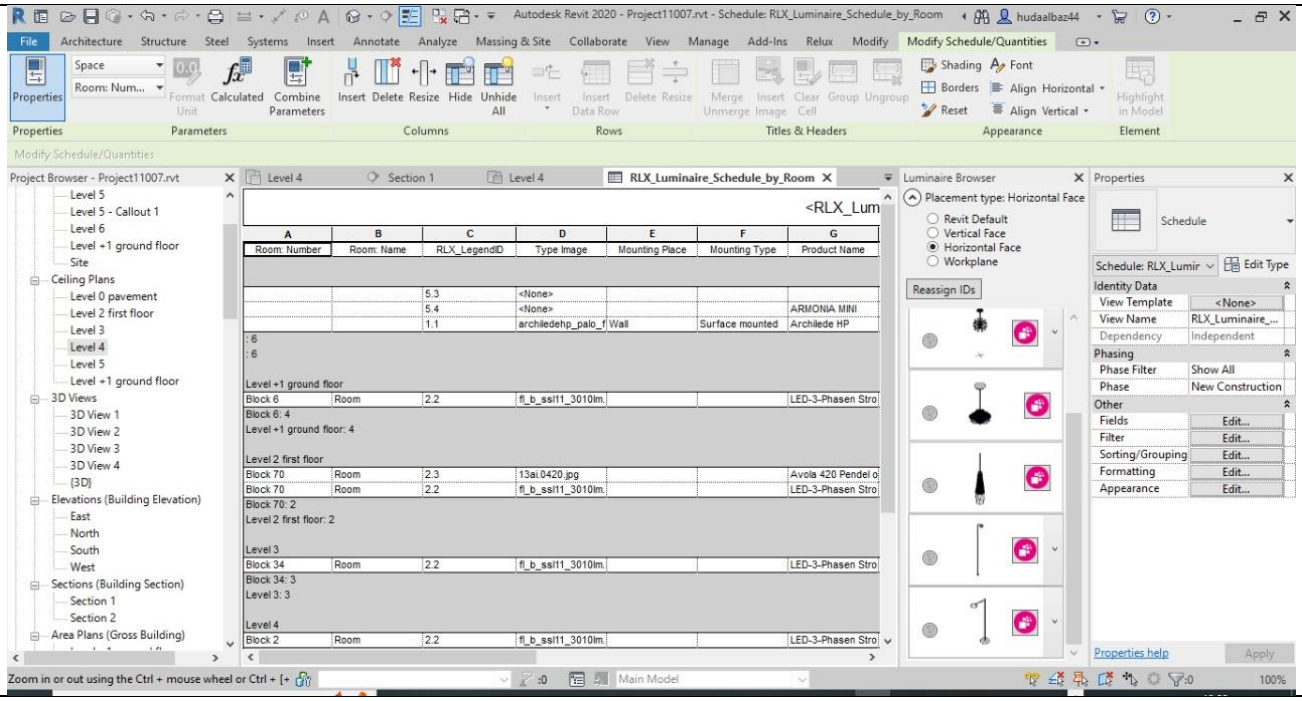

Figure (40) shows the table of patterns of light bulbs used in the sample and their calculations used in the case of the existing and proposed study.

Source : Researcher

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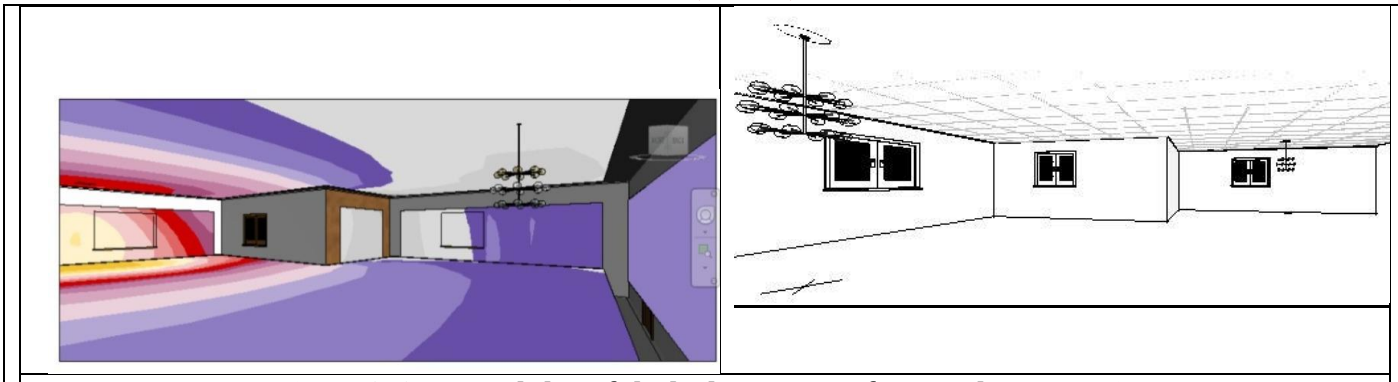

Figure (41) Internal shot of the bedroom space for sample 1 on Revit
- Source: Researcher

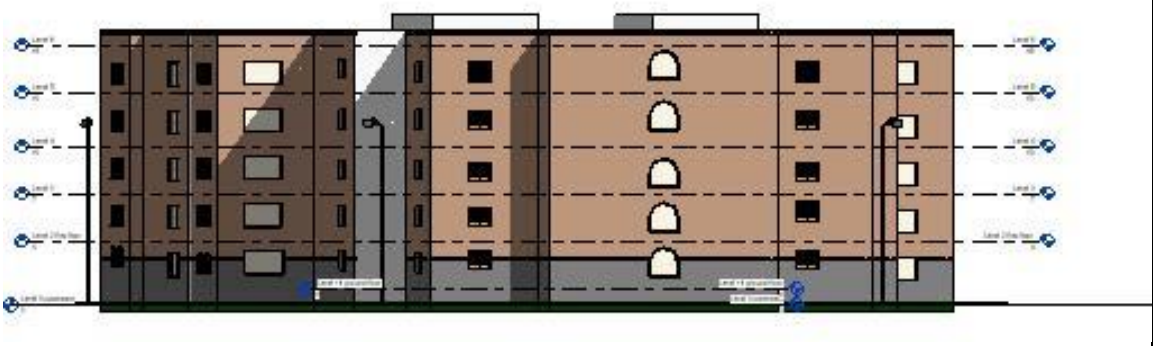

Figure (42) The southwest façade of the building with samples 3 and 4 –
Source : Researcher

Figure (43) The northeast façade of the entrance to the building with samples 1 and 2-
Source : Researcher

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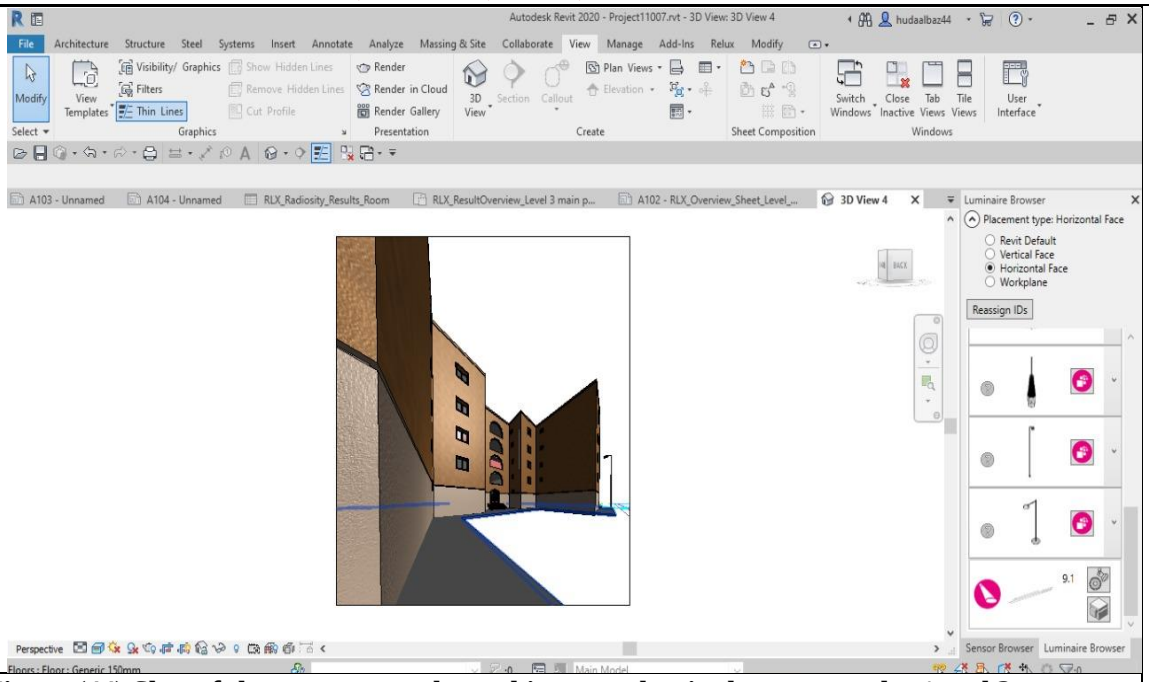

Figure (44) Shot of the entrance to the architecture that is close to samples 1 and 2-
Source : Researcher

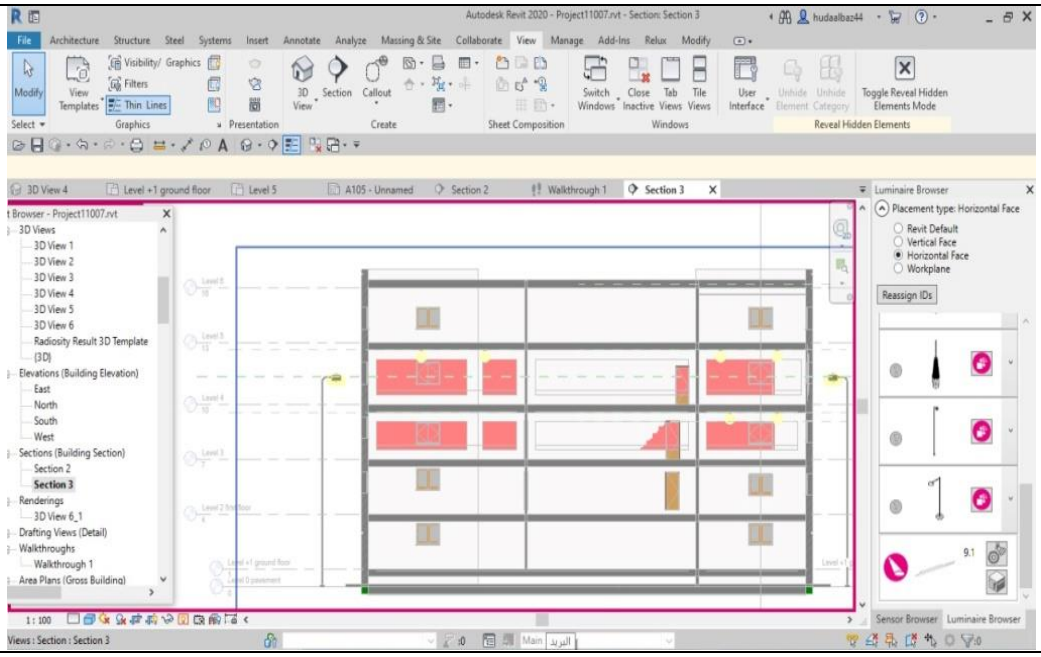

Figure (45) Vertical sector on the facades of selected samples 2 and 4
- Source: Researcher

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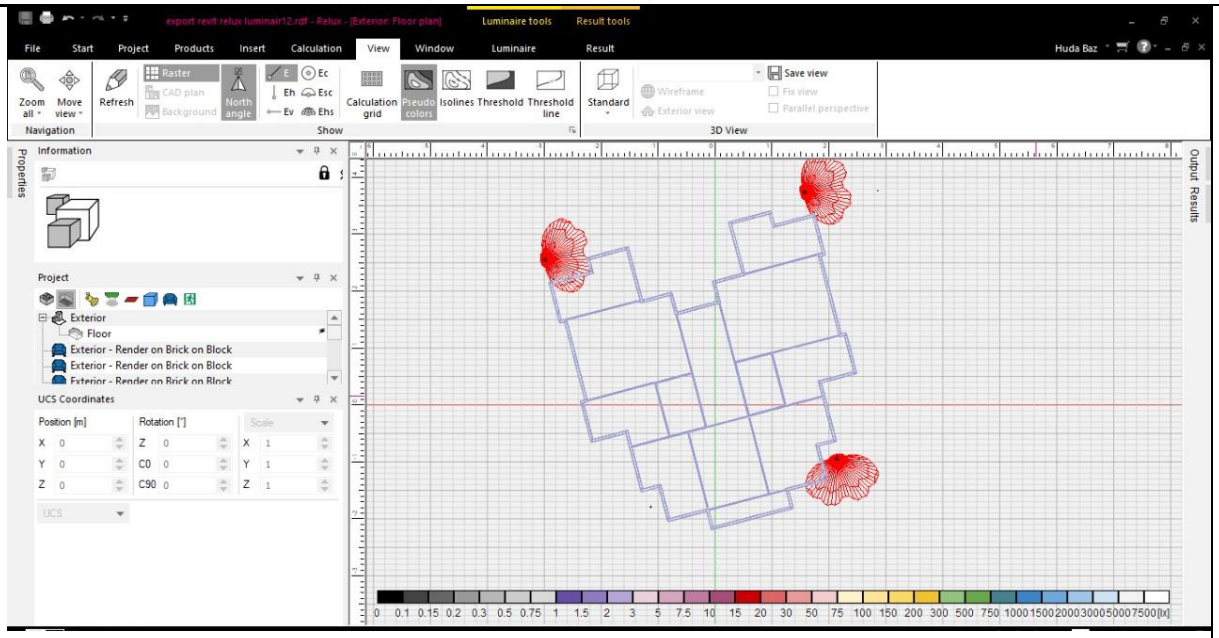

Figure (46) shows the gradient of the color ruler for the intensity of the external lighting of the light poles around the selected building on the Relux desk top-
Source: Researcher

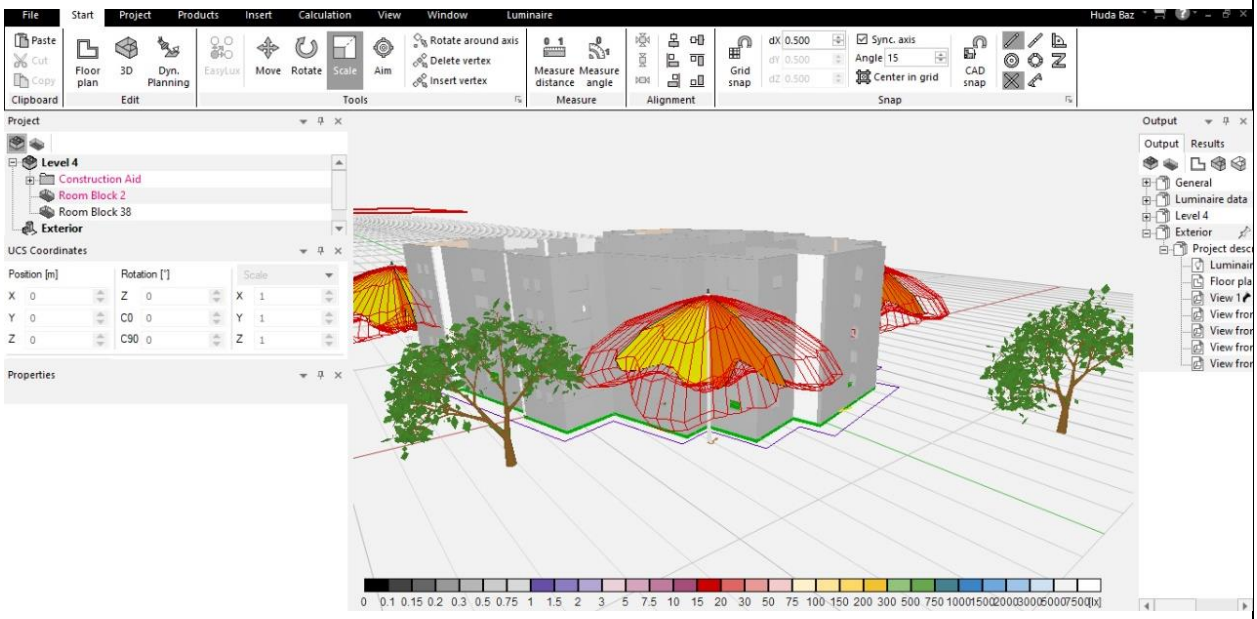

Figure (47) shows the lighting from the lighting poles for the situation based on the Relux desktop 2020 program –
Source : Researcher

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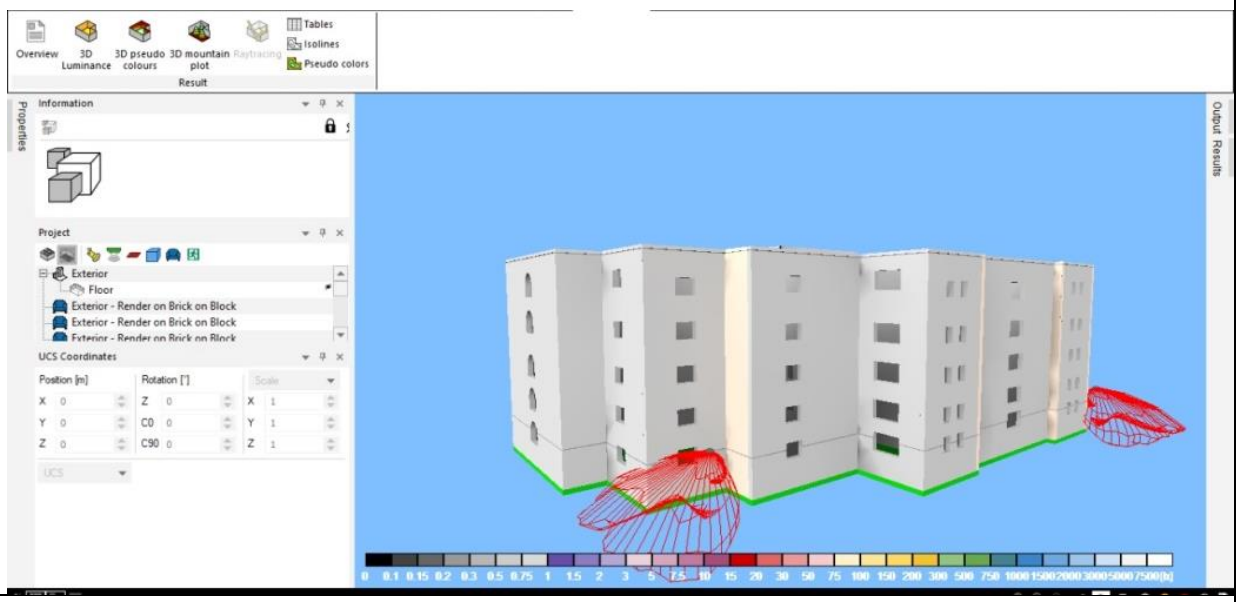

Figure (48) Simulation of one of the proposed solutions in maintaining the height of the light poles searchlights The color ruler appears on Relux Desktop –
Source : Researcher

DIALux 4.13 Using the program (Solution 3 Optimal Alternative to WELL Classification):

To redesign the outer shell of the building and to design the proposed lighting to achieve the gold evaluation criteria for the WELL classification.

The residential blocks were changed and rebuilt to become from other materials and in a light color and the work of umbrellas over the roof of the building as an alternative 3 to the proposed solution. Brick / light yellow white: Cream brick. tile or plaster Absorption coefficient (0.3 – 0.5) – emissivity coefficient (0.85 – 0.95) and glass transparent absorption coefficient (0.85) – emissivity coefficient (0.95). The figures (49-52) illustrate the following.

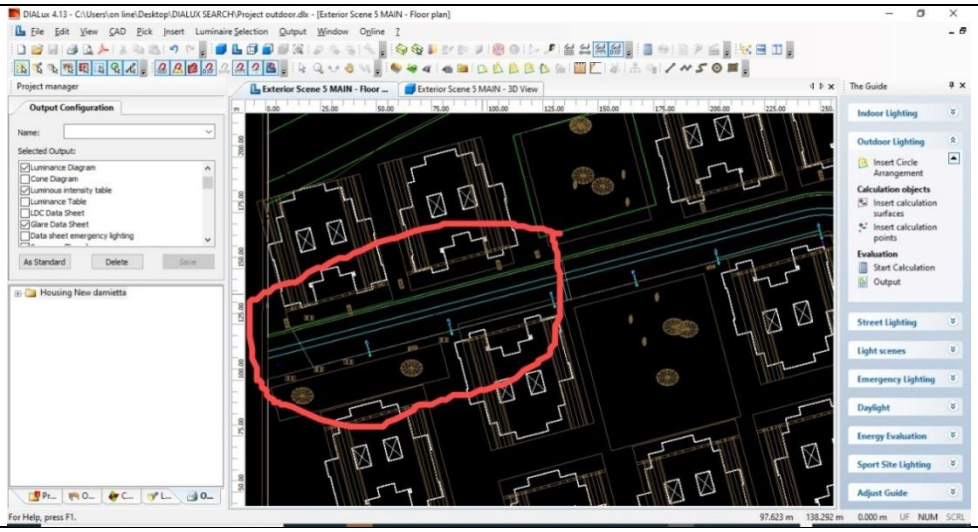

Figure (49) Current General Site Using DIALux 4.13 Program
–Source : Researcher

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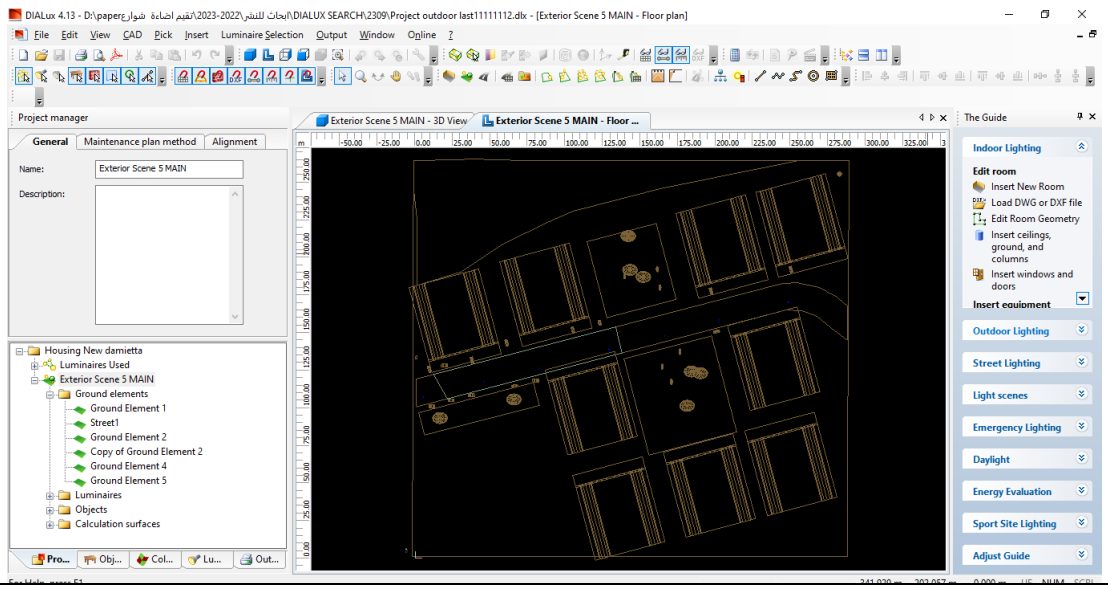

Figure (50) General site using DIALux 4.13 program for proposed solution 3 for the models after it and kiss –

Source: Researcher

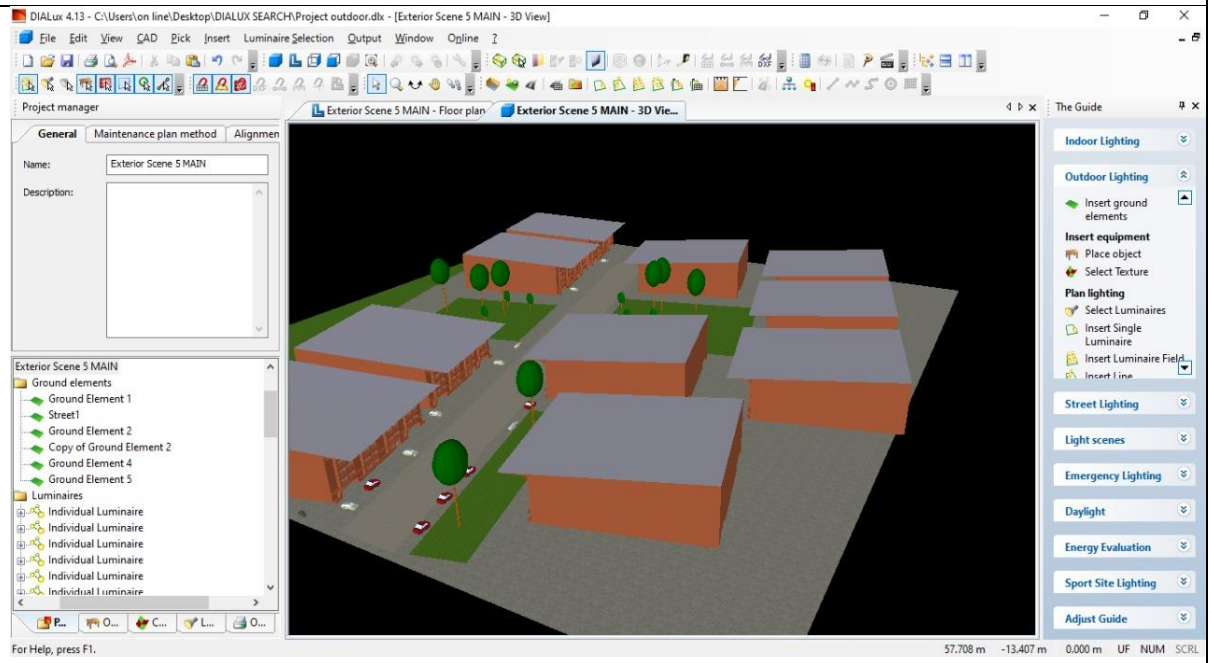

Figure (51) 3D models using DIALux 4.13 for the proposed solution 3-

Source: Researcher

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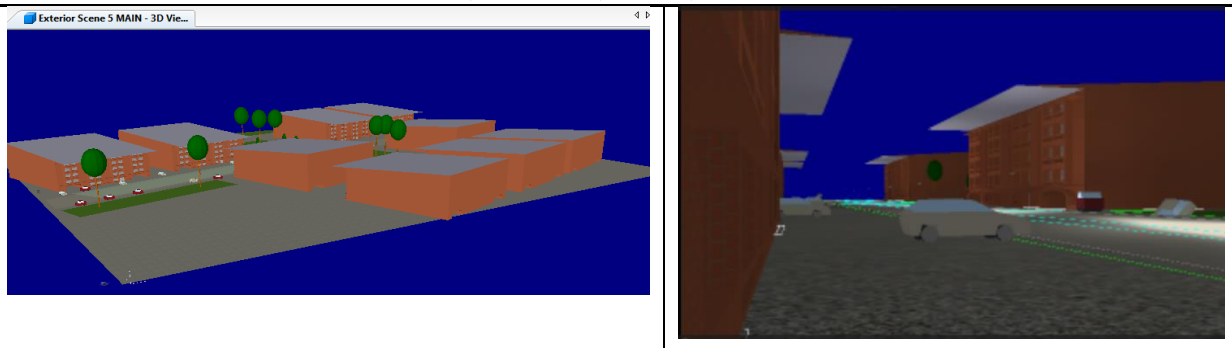

Figure (52) The outer shell shows the general location using DIALux 4.13 for the proposed solution 3 - Source: Researcher

- The following table shows some of the building control systems the case of the study in alternative No. 3 No. (4),

Table (4) shows the building control systems - Source: Researcher

M	Building Control Systems	Systems Negative Passive	Systems Manual Manual	Systems Automatic Automatic
1	Natural Light Control System (Reflection / Protection) Reflecting/protection Day light adjustment	▪	▪	
2	Glare control systems (sun breakers / shutters) Glare control – blinds /louvers/fixed	▪	▪	
3	Industrial Responsive Lighting Control System Responsive artificial lighting control		▪	▪
4	Heating Control System (Heating Control)		▪	
5	Heat Recovery System (Heating / Cooling) Heat recovery – warmth / cooling			▪
6	Cooling Control System Cooling recovery / control			▪
7	Ventilation Control System Ventilation control	▪	▪	
8	Fabric control – Windows/dampers/doors Doors, windows and control		▪	
9	Insulation system Insulation – night / solar	▪		

- Concept requirements for WELLV2 and assessment of their compatibility in the study sample project:

Evaluation of lighting design using the WELL classification system :

The lighting design of the Damietta Housing Project was evaluated using the WELL rating system. The lighting category of the WELL rating system evaluates the lighting design of a building based on several factors such as lighting, color rendering, and glare control. The evaluation process included measuring lighting levels in different areas inside and outside the samples of the selected building, evaluating the color display of the lighting design, and evaluating the applied glare control measures (Specs 2019). The following is a form of the website for registration for certification WELL and Table (5) Owner evaluation form for the project on the classification website WELL to apply for accreditation.

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Table No. (5) Owner evaluation form for the project on the classification website WELL to apply for accreditation for solution 3 - Source: Researcher of the classification WEL

No	Criteria of version: WELL v2, Q1-Q2 2023 (Light) Specifications of Weil Lighting Standards Versions 1 & 2	Check Status List	Point Maximum degree	Existing status score	Status score Proposed
1	**L05.1** **Implement Daylight Plan Daylight Design Strategies** **daytime**	Yes Maybe No	2	0	2
2	**L05.2** **Integrate Solar Shading** **Daylight Design Strategies** **Daylight Design Strategies**	Yes Maybe No	2	0	2
3	**L06.1** **Conduct Daylight Simulation** **Daylight Simulation Procedure for Daylight Simulation** **Daylight simulator**	Yes Maybe No	2	0	2
4	**L07.1** **Balance Visual Lighting Visual Balance**	Yes Maybe No	1	0	1
5	**L08.1** **Enhance Color Rendering Quality Electric Light Quality improve the quality of electric color rendering.** **Light Quality**	Yes Maybe No	1	0.5	1
6	**L08.2** **Manage Flicker Electric Light Quality**	Yes Maybe No	2	0	2
7	**L09.1** **Provide Indoor Light Light Exposure**	Yes Maybe No	P	P+	p
8	**L09.2** **Provide Supplemental Lighting** **Occupant Lighting Control** **Resident Lighting Control**	ID FEATUR FEATURE WEIGHT PURSUI		No	Yes
ID FEATURE WEIGHT PURSUING **Weight Search Feature**					
9	**L01.1** **Provide Indoor Light Light Exposure** **Provide exposure to indoor light**	Yes Maybe No	P	P+	p
10	**L02.1** **Provide Visual Acuity Visual Lighting Design** **Provide optical lighting design**	Yes Maybe No	P	No	p
11	**L03.1** **Meet Lighting for Day-Active People Circadian Lighting Design**	Yes Maybe No	3		3
12	**L04.1** **Manage Glare from Electric Lighting Electric Light Glare Control Glare Management from Electric Lighting Electric Lighting Glare Control**	Scorecard	2	0	2

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We note from the previous table that the criterion of providing exposure to indoor light is repeated twice because of its importance to human health and that in the existing case it exceeds the permissible limits. The following table shows (6) the evaluation criteria for the selected project, including the nine criteria in the WELL classification (lighting).

Table (6) shows the evaluation criteria for the residential project for classification WELL

M	Standard	Profile	Grade	
			before	Go away Solution3
1	**First: Light exposure (compulsory)** **:L01 LIGHT EXPOSURE | P**	Lighting 200 lux for more than 30% of the apartment area through natural lighting during at least 50% of daylight hours throughout the year	1	2
		Facade glass is not less than 7% of the total area of regularly occupied spaces inside the apartment (all rooms except the corsets, bathroom and kitchen).	1	2
2	**Second: Optical optical design (mandatory)** **: L02 VISUAL LIGHTING DESIGN | P**	The bathroom and kitchen lighting must match the minimum of one of the following codes: - **1. IES Lighting Handbook 10 Edition.** - **2. ISO 8995-1:2002(E) (CIE S 008/E:2001).** - **3. GB50034-2013.** - **4. CIBSE SLL Code for Lighting**	1	2
3	**Third: Bio photometric design (optional and part mandatory) : L03 CIRCADIAN LIGHTING DESIGN |**	1. The electric light in the apartment achieves the following specifications: At least 150 lux melanobic equivalent (or) the project achieves at least 120 lux melanobe equivalent + two points in requirement number 5 (natural light booster). – At least 240 lux melanobic equivalent (or) the project achieves 180 lux melanobic equivalent + two points in requirement number 5 (enhanced natural light).	1	2
		2. - The lighting in the entire apartment can be dimmed manually or automatically - if the dimming automatically must occur exactly 8 pm.	-	1
		3. Bathrooms and kitchens lighting is 140 cm above the ground and its place is in the middle of the space exactly - if there is a work surface (marble or table) there must be lighting at a height of 45 cm from the work surface as well.	-	1
4	**Fourth: Glare control from electric lighting (optional): L04 ELECTRIC LIGHT GLARE CONTROL | O**	1- All regularly occupied spaces are either one of two options: The first option : knowing the lighting units (Najaf): • 100% of the electrical lighting illuminates above the horizontal plane • UGR level of 16 or less. • Lighting units whose illumination does not exceed 6000 cd/m² have brightness angles between 45 to 90 degrees measured from the ground point directly below the unit.	-	-
		The second option: knowing the void: All regularly occupied vacuums have a uniform glare level value of UGR of 16 or less.	1	2

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M	Standard	Profile	before	Go away
5	(L05 DAYLIGHT DESIGN STRATEGIES | O	*Requirements for the outer cover of the building:* - Vertical exterior glass has an area of not less than 15% of the total area of the housing unit - and the value of the visible transmittance of light for this VLT glass is greater than 40%. - Vertical exterior glass is not less than 25% of the total area of the housing unit – and the value of the visible transmittance of this VLT glass is greater than 40%.	1	2
		In all regularly occupied spaces: Each vertical exterior glass has a shadow coefficient that meets one of these two: • Manual shading that can be controlled by users at all times – shading is opened regularly once a day for all days when the housing unit is used. • Automatic shading to prevent solar glare (outside light).	zero	2
6	**SIXTH: DAYLIGHT SIMULATION INSIDE THE BUILDING (OPTIONAL):** L06 DAYLIGHT SIMULATION |	A software simulation of the project is made, showing the *fulfillment of the following requirements for housing units* : 1- Target illumination of 300 lux for more than 50% of the single unit area throughout 50% of the daylight hours during the year (gets one point)	1	2
		2- Target lighting of 300 lux for more than 50% of the single unit area + target lighting of 100 lux for more than 95% of the unit area Single - throughout 50% of daylight hours during the year (gets 2 points)	zero	2
7	**VII: VISUAL BALANCE INSIDE THE BUILDING (OPTIONAL):** L07 VISUAL BALANCE | O	Ambient light in all regularly occupied spaces must meet at least 3 of the following conditions: 1- The optical contrast of the horizontal and vertical surfaces between each space and the adjacent space is not more than (10). 2- Photosynthetic regularity ratio Illuminance uniformity ratio Not less than 0.4 or 1 to 2.5 (lowest to average illumination rate) on all horizontal work surfaces within the space. 3- Any automatic changes in light intensity, temperature, color or distribution within the space must occur gradually so that it takes at least 10 minutes. 4.The light temperature in each room is consistent (plus or minus 200 K) at any time.	zero	1
			1	2
			zero	2
			-	-

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M	Standard	Profile	before	Go away
8	**EIGHTH: THE QUALITY OF ELECTRICAL LIGHTING INSIDE THE BUILDING (OPTIONAL): L08 ELECTRIC LIGHT QUALITY | O**	**Part 1: Enhance Color Rendering Quality** For all spaces inside the building except for the movement paths : All lighting units (except decorative lighting, emergency lighting and other lighting of a special nature) must meet at least one of the following requirements to adjust the colors of the light, if the white light is adjustable to tune, the following requirements must be met at intervals of 1000 K from the minimum (not less than 2700 K) to the upper limit (not more than 5000 K): A – The CRI Color Reference Index is greater than or equal to 90. B- CRI color reference index greater than or equal to 80 + the R9 red color scale is greater than or equal to 50. ج- فهرس ال **Lighting Handbook 10 Edition)**) IES قيمته **IES R ≥ 78, IES R ≥ 100, -1% ≤ IES R ≤ 15%. .** For all the spaces of the movement paths : All lighting units (except decorative lighting, emergency lighting and other lighting of a special nature) must meet at least one of the following requirements to adjust the colors of the light: A – The CRI color reference index is greater than or equal to 80. B- index IES value IES R ≥ 75, IES R ≥ 95, -7% ≤ IES R ≤ 15%**. .**	1	2
		Part 2: Adjust the frequency in the lighting: Part 2 Manage Flicker: For all spaces within the building: All lighting units (except decorative lighting, emergency lighting and lighting of a special nature) used within the spaces used regularly must match at least one of the following: (a) Lighting is classified as (**reduced flicker operation**) according to the **California Title code 24** when tested according to the requirements of the index (**Joint Appendix JA-10**). b. Recommendations 1, 2 and 3 as in **the IEEE standard 1789-2015 LED** . c. Its value should be **Pst LM≤ 1.0 and SVM≤ 1.6** for applications in interior spaces – according to **NEMA 77-2017**.	zero	1

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M	Standard	Profile	before	Go away
9	**Ninth: Users control lighting (optional): L09 OCCUPANT LIGHTING CONTROL | O**	**Part 1: Enhancing Users' Control of Lighting: Part 1 Enhance Color Rendering Quality** For all spaces inside the building : Lighting spaces: Ambient lighting systems meet *the following requirements:* All regularly occupied spaces contain lighting zones as in the table below (Note: single rooms smaller than the areas shown in the table and/or whose occupancy is less than shown in the table - the spaces are considered separate). Number of spreads: : space per 60 square meters (point per 10 users), (gets one spot). Number of spreads : space per 30 square meters (one point per 5 users), (two points).	2	2

Source: Researcher of the criteria of the classification system WELL

From the previous table, we note the following: that the nine criteria in the WELL classification were all achieved in the third proposed solution, and that in the existing case, the number (5) was not achieved and the rest was achieved at the minimum. *Overall: The evaluation of the lighting design of the* Damietta housing project using the WELL rating system showed that the lighting design is functional, energy-saving and aesthetically pleasing. Lighting levels were measured to be within the recommended levels, and the color rendering of the lighting design was evaluated to meet WELL standards. Applicable glare control measures have also been applied to be effective. The following table No. (8) shows the evaluation of the impact of lighting design for the occupants of the selected building in the samples in the proposed solution (3). Table (9) Evaluation of the impact of lighting design through the classification system WELL Selected architecture in the proposed solution (3), Table (11) Lighting design criteria through the classification system WELL Architecture selected in the proposed solution (3) and Table (7) Lighting design criteria through the classification system WELL Architecture selected in the proposed solution (3).

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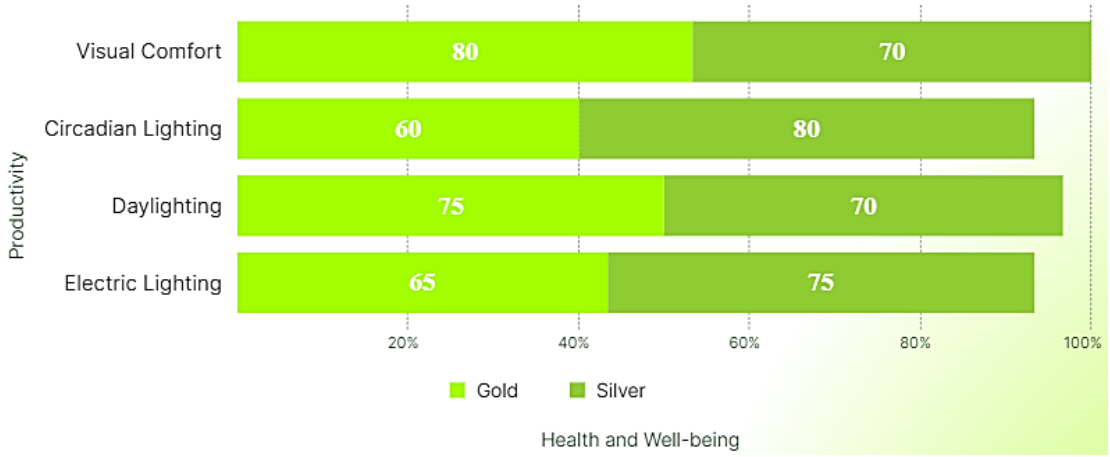
Table (7) Evaluation of the lighting design of the architecture selected in the samples in the proposed solution (3) - Source: Researcher from WELL website

Criteria	Rating
Visual Comfort	90%
Circadian Lighting	70%
Daylighting	80%
Electric Lighting	75%

We find that the evaluation of the lighting design of the architecture selected in the samples in the proposed solution (3) of the previous table: that visual comfort was achieved by 90%, the efficiency of daily lighting was achieved by 70%, natural daylight benefited from it by 80% and the efficiency of using industrial lighting by 75%. The following Table (8) Evaluation of the effect of lighting design for the occupants of the selected building in the samples in the proposed solution (3).

Table (8) Evaluation of the effect of lighting design for the occupants of the selected building in the samples in the proposed solution (3) - Source: Researcher from WELL



We find the evaluation of the impact of lighting design for the occupants of the selected architecture in the samples in the proposed solution (3) of the previous table: that visual comfort was achieved by 59% (gold), the efficiency of daily lighting was achieved by 40% (gold), natural daylight benefited from it by 50% (gold), the efficiency of using industrial lighting by 45% (gold), and the rest of the percentage in all criteria achieved points for the silver certificate. The following Table (9) Evaluation of lighting design through the WELL classification system for the architecture selected in the proposed solution.

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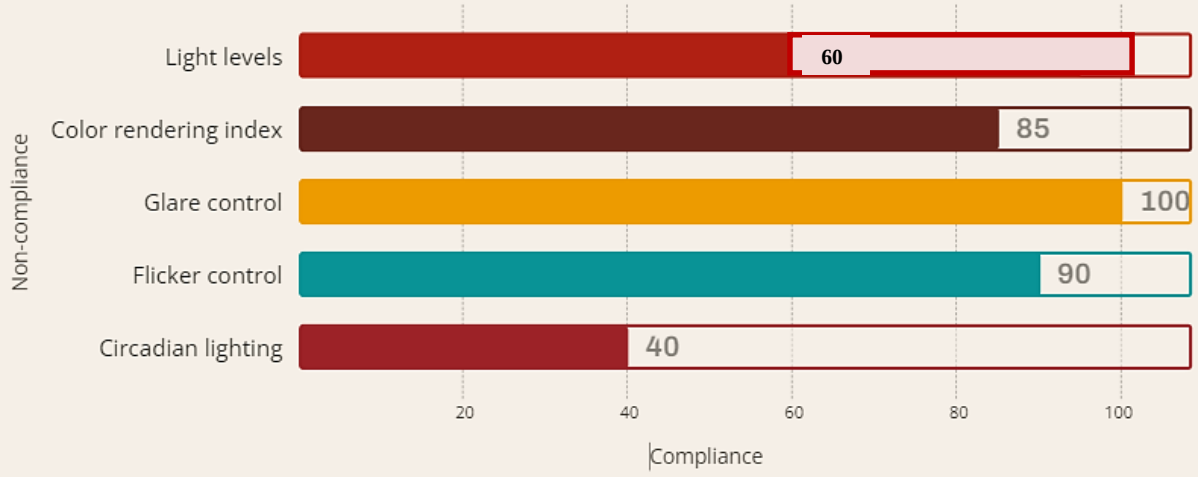
Table (9) Evaluation of lighting design through the WELL classification system for the architecture selected in the proposed solution (3) - Source: Researcher from WELL website



We find the evaluation of the lighting design through the WELL classification system for the selected architecture in the proposed solution (3) of the previous table: the lighting level corresponds to 60%, the color appearance index 85%, the glow control 100%, the light gradient control by 90%, and the daily lighting efficiency achieves 40%. The following Table (10) Lighting Design Criteria through the WELL Classification System The architecture selected in the proposed solution (10).

Table (10) Lighting Design Criteria through the WELL Classification System The architecture selected in the proposed solution (10) - Source: Researcher from WELL website

Criteria	Requirement	Compliance
Light levels	200-300	Yes
Color rendering index	80	Yes
Glare control	ULG ≤ 19	Yes
Flicker control	≤ 30% flicker	Yes
Circadian lighting	CCT 2700-4000K	No

From the previous table we note the following:

The five criteria (light level, color appearance index, glow control and light gradient control) in theWELL classification were achieved, as shown in the previous table, except for *the efficiency of daily* lighting.

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Results:

The research concluded the following results:

- Paying attention to the idea of sustainable design compatible with the environment, as Bath is a necessity necessitated by the requirements of the times and conditions to solve the problems of the residential environment related to energy and water consumption and achieve comfort for users.
- Educating the community about the role of sustainability in interior design to create a supportive public culture, and clarifying the concepts and treatments of sustainable interior design as a step towards social acceptance.
- The residential environment in our society cannot be considered sustainable unless the concepts of sustainability are adopted as a basic base for modern housing planning theories, by promoting social interaction and achieving a healthy environment free of pollution while providing an economic dimension by reducing energy consumption, all these dimensions are achieved by embracing the idea of joint creative design that adopts the principles of human design, for which the human being is the main goal.

- The research hypothesis has been proven: The use of WELL lighting systems to assess the health aspects of human lighting in residential buildings does not conflict with the use of green building evaluation systems such as LEED, but rather increases the efficiency of evaluation and the positive impact of lighting on the health of the occupants of these buildings and on the building itself.
- Various treatments have been applied to solve the research problem and achieve its objectives, including:

  The types of lighting have been changed with the lighting poles facing the apartment openings. Lighting strategies using electric lighting can be used to achieve the illumination required for exposure in the WELL system, when exposure to appropriate daylight is not available. Spectral characteristics of light, brightness levels and duration, timing and duration of exposure must be taken into account.

- The study revealed that the lighting design of the case buildings of the Solution 3 study successfully met several key aspects of the lighting requirements of the WELL Rating System. This includes appropriate daytime light levels in most indoor spaces, good color rendering, and energy-efficient combinations. However, some areas of improvement have been identified, such as uneven lighting levels, suboptimal daylight penetration into some rooms, and insufficient outdoor lighting around corridors and courtyards.
- The lighting design evaluation of the third proposed housing project using the WELL rating system showed that the lighting design was of high quality. The lighting design was practical, energy-saving and aesthetically pleasing. Lighting levels were measured to be within the recommended levels, and the color rendering of the lighting design was excellent. Glare control measures in place have also been proposed to be effective.
- The building is eligible for the WELL Silver Certificate .
- The assessment also revealed that the lighting design had a positive impact on the health and well-being of the population. The lighting design has helped create a bright and welcoming environment, improving the mood and productivity of residents. The lighting design also helped create a sense of community within the building, improving social bonds and reducing the feeling of isolation.

- *Exposure timeframe*: It was found that even low-light light sources can cause glare if exposure is too long.

Avoiding glare is a relatively simple proposition that can be achieved in different ways. One method is, for example, to change the type of searchlight or add a sash to the windows in the fime or to place grids under light sources, or by using coated diffusers or equivalent reflectors that can correctly direct the light, or by installing light sources in a way that does not interfere with the angle of view ... To the last solutions proposed by research, but the best alternative came to rebuild modern building models different in design and building materials. When designing a work site, the correct distribution of lighting is just as important as the lighting itself, but it is also important to consider that a very regular distribution of illumination makes three-dimensional and spatial perception of objects more difficult.

Recommendations:

Recommendations include optimizing window size and orientation to encourage greater penetration of natural daylight, adjusting energy-saving solutions such as occupancy sensors and dimmers, implementing glare control measures, and improving outdoor lighting for safety purposes.

1. Taking advantage of the possibilities of sustainable interior design in the field of reducing energy consumption in interior spaces, researching treatments that contribute to improving the quality of the internal environment, studying the effects of materials, and researching ways to rationalize water consumption inside the building.
2. Work on finding local (Egyptian) standards through which to ensure the evaluation of sustainable residential buildings guided by the classification WELL to improve lighting performance related to health in housing.
3. The need to take advantage of the natural resources and energies available in our country, including solar energy, in parallel with the design of residential buildings, although this technology is economically expensive at the present time, but it saves a lot in the long run.
4. Create a lighting plan linked to the design of the building so that it meets the standards, which ensures that the lighting design is practically mindful of the WELL classification.

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