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A Comparative Study of Natural Lighting Quality in Sharia Housing Based on Daylight Factor Evaluation Using Autodesk Revit

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ABSTRACT

The Islamic residential concept is the famous tagline that several real estate developers chose for their housing products today; it attracts customer attention, primarily from the Muslim community. But only some housing products are suitable to all the ideal criteria of the Islamic Residential concept. Excellent Sharia housing must fulfill all Islamic residential concept requirements, including public facilities, open space, and building quality. The strategy of the ideal Islamic housing concept requirement is optimal natural light and ventilation in the entire room. The inner courtyard is one of the solutions to afford this strategy. The types of openings also affect the daylight penetration in a room. Autodesk Revit Simulation evaluates this research about the daylight factor aspect of Islamic housing in Sharia housing. The research method is a qualitative, quantitative, and comparatively mixed method. The minimum requirement of daylight factor for housing is 5%. The study object shows that in the case of Medina Residence 1, it sufficiently offers the most daylight factor affordability in a Sharia housing project. The research hypothesis is to maximize the daylight factor by modifying several types of windows and adding skylight openings to increase the daylight factor of the entire room. Increased wall window ratio and more inner open spaces are the solutions for the minimum size of the building site. In the case of Medina residence 1, the skylight opening can be applied, but the effect is less significant than making more openings facing the open space.

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1. INTRODUCTION

As the world's largest Muslim community, Indonesian people are more concerned about religious values. Moreover, they are also worried about the Islamic value in planning and developing buildings. This fact is present in several building projects with a tagline of Sharia and Islamic types of buildings, such as Sharia guest houses, Islamic living housing, Sharia hotel, etc. The Islamic value applies the principles of Islamic architecture in the building. It will be different for the Islamic design and standard design because Islamic values are concerned with the deprivation of the user, especially the women user. Especially in Islamic

architecture, we must consider economic, social, technical, and psychological aspects. The principles of Islamic architecture must base on the Qur'an and Al-Hadith so that Islamic architecture can represent a good relationship between human relations and Allah SWT (*hablumminallah*), human relations with the environment (*habluminal'alamin*), and relationships among human beings (*hablumminannas*) [1]

Islamic Residential housing is the most frequently developed Sharia property sector, affected by increased housing needs yearly. One of the residential sectors that are currently emerging is the Islamic concept of residential, which applies religious values to housing. These values aim to bring spiritual values closer, giving the residents unique living benefits. Muslim people are more attracted to housing with a specific theme, primarily Islamic housing. It is creating a new market share in property competition. This situation caused many developers to implement the Islamic housing concept as a tagline for designed housing products. However, many housings with that concept have not met all the ideal criteria of the concept of Islamic housing, so an evaluation of the application of the idea in Sharia housing is needed. [2]

Land scarcity began In Malang City today; it affects some housing projects in Malang, which implement row housing or a couple of house concepts with minimum land area [3]. This scarcity has resulted in many housing areas with low daylight intensity and minimal ventilation openings, which can be uncomfortable for users. In architecture, we know the idea of natural daylighting and cross ventilation. It can be more efficient for housing to implement this concept because it will reduce the energy consumption of the building, and we do not need artificial lighting during the day. The Medina Residence 1 and 2 buildings have open land only in the front and middle of the building, so the bedroom has a minimum of sunlight reach. It can be so uncomfortable in the daytime that it will make the user use artificial lighting in the bedroom during the day. Based on this case, we evaluate and compare the daylight factor of the building to give design recommendations for maximized daylighting. The daylight factor is one of the aspects of the Islamic housing concept requirements based on evaluating the physical aspect of Islamic residential ideas in the Sharia housing project [2]. Natural light must penetrate the entire room, so no room with a daylight factor of 0 should exist.

However, in the existing design implementation, there are several complaints from the housing user that some rooms are dark and have less daylight and must use artificial lighting during the daytime. Based on the research background explained before, this research question is: How is the quality of the natural lighting based on daylight factor analysis using a comparative study? How will it meet the minimum requirement of daylight factor? To answer it, we can use several simulation software, such as Ecotech and Dialux [4], to evaluate the daylight factor. However, these programs need more flexibility to modify the design. In Dialux, we must produce new models for new simulations [5]. BIM-based applications have been developed to simplify and integrate several software functions, especially simulations, into one platform. Autodesk Revit as a BIM Software accommodates more features consisting of several simulations such as green building analysis, energy consumption simulation, building evaluation, structural evaluation, and visual evaluation simulation. BIM is more efficient because everything about building design can be simulated in one program in real time and measurable in location and orientation. Autodesk Revit, as a tool for building daylight factor simulation for a more effective and efficient design modification. Some previous research is concerned with making design aspects, such as green building and sustainability. Still, the Sharia housing project case study needs to research the quality of natural lighting. The research objective is to evaluate the quality of natural lighting and give standard design recommendations to maximize the penetration of natural lighting through the room. The evaluation must be objective and reliable, especially in the case of Medina Residence group housing. BIM-based software (Autodesk Revit) modeling evaluation is used for more suitable for modifying the existing design. This housing project has holistically implemented the Islamic Housing concept and will be compared among them.

2. LITERATURE REVIEW AND RESEARCH METHOD

To deepen the case study, we must know that Real Estate Development is an endeavor to build the worth of a property to produce benefits together. One of the projects in real estate development is to maximize land value by building a functional building over the less occupied or empty land and creating more advantages value of the land. Growing land ordinarily goes through a few phases in the most common way, such as pre-development, conception, design, project delivery, construction, finalization, sales, and estate management [6]. Every real estate project has a unique campaign sales promotion concept to attract consumers. The conception process must be arranged holistically for more comprehensive and reliable that

the idea is attractive and meets the objective value of the concept. One of the popular concepts that the Muslim community is attracted to is the Islamic Housing concept.

2.1. Islamic Housing Concept

A housing project implemented the Islamic housing concept if the physical or most typical housing development approach coherently with the Islamic Sharia arrangements discovered in the Qur'an and Al-Hadith. To apply the ideal Islamic housing concept, holistically assessing Islamic housing should serve as a benchmark for the base models. The thought stage is the study and discovery of arranging and planning rules with topics that follow the underlying thought. This honing stage in improving Sharia housing alludes to the regulations that absolute requirements be met to foster a land with the best Islamic housing idea. Following the best Islamic housing idea there are unique projects that aid in the implementation and operation of Islamic housing. [7]

However, in the case of detailing Islamic housing standards, other things must be researched deeper based on several sources, such as the suggestion's establishment, the inspiration of the Islamic city, and the experts' assessments of Islamic housing. The criteria of Islamic housing assembly are divided into three categories: things that are principles (compulsory), things that are recommended to be followed (sunnah), and things that are not ruled (mubah) [8]

To understand the concept of a community approach to thinking in Islamic housing, we can look at one of the ideas of Islamic private homes in Andalusia. Islamic houses in Andalusia are due to the social assimilation of the Middle East and Europe in the Andalusia region, equivalent to the condition of Islamic housing in Indonesia, namely the assimilation of the neighborhood, the Middle East, and contemporary culture. The most common method of building a house is based on two factors: the example of a room and outside space that shapes a private unit [9]. Furthermore, the central court in the home, the Andalusian communities, and the Mediterranean area of outdoor area zone that should be in the house are a few qualities that make up the house with the idea of Islamic housing [10]. It is expected for airflow or a consistent view into the entire room. This concept has also been discovered in settlements in Dhaka, Bangladesh. Even though the city is highly dense and filthy, the central park concept as a room component is still maintained. [11]

Usually, ventilation and daylight must reach entire rooms, with the garden as an open space inside, in front of, and behind buildings. In addition, by using shading gratings such as (Mashrabia). Privacy between room units must be maintained. Islamic housing must meet the needs of people based on their lifestyle, culture, and environment. Islamic housing must address family needs, environmental concerns, available resources, and building technology. All the Islamic housing concept requirements must be related to sustainable design and development that reflect the lives of Muslims. [10]

The core strength of the building design is sunlight, which plays an essential role in an individual's well-being and prosperity. It is also a significant asset in terms of economic and energy efficiency, as its accessibility reduces the use of artificial light and, as a result, minimizes the energy consumption of the building. According to recent studies, the energy required for lighting within structures remains at 20-40% of total consumption and is one of the primary supporters of CO2 outflows. [12]

2.2. Daylight Factor

The Daylight Factor (DF) is a sunlight accessibility metric that compares how much light is accessible inside a room (on a work plane) with how much light is accessible outside under cloudy sky conditions. The greater the DF, the greater the light available in the room. Rooms with a typical DF of 2% or higher can be considered daylight, but artificial lighting may be required to perform visual tasks. When the typical DF is 5% or higher, a space will appear prominently during daylight and not use artificial lighting during the day. This investigation will look into the use of Islamic housing. [13] . Based on SNI 03-2396-2001 about procedures for designing natural lighting systems on buildings, several factors affect the daylight factor of the building, such as the size of the light openings, the position of the light openings, and the distance of the media wall in front of the light openings [14]. The position of the light openings affects the value of the sky factor and distribution of light into the room as follows: 1). light openings of the same size have a more excellent DF value for higher positions. Up to a certain height, the fl value will be decreased again. (see Table 1). 2). The following table calculates the sky factor values for the measuring points located 2m from the plane of the practical light opening. The measuring point is lighting from a practical, square light opening with sides 20 cm at different heights. In this study, three main factors of daylight quality will be simulated using BIM Based Architecture

modeling software, Autodesk Revit. As a result, using a simulation research methodology, this study adopts the post-positivist paradigm.

Table 1. The relationship between the height of the light openings and the relative Daylight Factor value. Source: SNI 03-2396-2001

Height of the light openings (cm)	Relative Daylight Factor value (%)
0-20	1.0
20-40	2.0
40-60	3.5
60-80	4.0
80-100	5.0
100-120	5.0
120-140	5.0
140-160	5.0
160-180	4.5
180-200	4.0

The shape of the light opening influences the light distribution as follows: 1) widened light opening would be helpful to distribute the light more evenly across the room's width. 2) a practical light opening, which height is larger than its width, provides better penetration.

2.3. Autodesk Revit simulation as BIM Evaluation tool

Building Information Modeling (BIM) is popularly used in AECO ventures, and BIM models are used for sharing information among various experts involved in structure planning and development. The current study investigated the use of BIM for building implementation reenactments, focusing on integrating daylighting examination into a BIM environment and what challenges and benefits exist during the time spent coordinating BIM with daylighting simulation instruments. This paper describes the circumstances that contributed to the analysis of a model for simulation by the BIM-based software Autodesk Revit with daylighting simulation devices. [15]

BIM is also a popular design and approach method tool in architecture and construction research today. Some studies usually involve BIM technology with green building analysis simulation. It can fully capitalize on the advantages of the BIM model and is more efficient for evaluating green buildings. Because in BIM, we can input some parameters and modify them simultaneously until we give a more proper design that conducts the building concept, especially sustainable or green buildings [16]. BIM Models simplify changing and adjusting building designs for greater effectiveness and efficiency. BIM has several advantages, such as the sustainability of the design and construction process, also known as 6D (six dimensions) design and construction on BIM [17]. Simulating the design, construction, maintenance, and demolition of a building can be more efficient and effective. We know LOD (level of development) in the BIM design process that every level of development in BIM is recorded and possible to simulate, especially for environmental impact throughout the building design. [18] . We must influence environmental impact through building design to achieve more sustainable building design. If that design goes through the simulation stage, it will be more comprehensive. In the case of an existing building, we can simulate a modified building design using a passive method such as orientation, shading, glazing, sealing, and opening. [19] .

Table 2 lists several studies on the Islamic Housing Concept and BIM-based evaluation. We understand that one of the Islamic housing criteria is the physical aspect. Building design must evolve in response to changing environmental conditions. Sustainability is essential to building design because natural lighting and ventilation will make building energy consumption more effective and efficient. According to the studies listed below, BIM evaluation is a more effective method for evaluating the building design process at various LOD stages, from concept to demolition. We can simulate the design or building process.

Table 2. Previous studies of the Islamic Housing Concept and BIM-based evaluation

Author / Year	Journal	Theory	Method	Finding	Contribution
Perdana A (2020)[2]	Evaluation of Physical Aspect of Islamic Residential Concepts in The Sharia Housing Project	The physical aspect of the Islamic housing concept's principle	Post – Positivistic	There are several criteria in the physical aspect of developing Islamic housing.	One of the principles of the Islamic housing concept is to maximize daylight, which is at the cutting edge of this research.
Hwaish, A.-M (2018) [10]	Concept of Islamic House; A Case Study for Early Muslims Traditional House.	Characterist-ics as a precedent in the Islamic residential concept	Qualitative Literature Review	Several criteria exist in early Muslim traditional houses in Andalusia.	The inner courtyard and a wall opening provide natural lighting.
Guo KLi QZhang L et al. (2021) [16]	BIM-based green building evaluation and optimization: A case study	Green building standards and criteria	Literature Review	Green building evaluation systems can be built using BIM-based design.	Make sure that the design is based on green building principles.
Motawa I, Carter K (2013) [17]	Sustainable BIM-based Evaluation of Buildings	Model for Sustainable Building Design Based on BIM	Literature Review	A conceptual BIM-based model that can improve the post-occupancy evaluation process and meet industry standards for sustainable buildings.	Ascertain that BIM-based evaluation methods improve building design, particularly for existing structures.
Cavalliere CHabert GDell'Osso G et al. (2019) [19]	Continuous BIM-based assessment of embodied environmental impacts throughout the design process	embodied environmental impacts, level of development (LOD)	Life Cycle Assess-ment, Literature Review (LCA)	BIM (Building Information Modeling) can aid in the performance of LCA during the design process.	Ensure that BIM is used to assess embodied environmental impact throughout the design process.
Tushar QBhuiyan MZhang G et al. (2021) [18]	An integrated approach of BIM-enabled LCA and energy simulation: The optimized solution towards sustainable development	Building Energy Simulation	Life Cycle Assessment - Simulation and Rating Tool (LCA)	Passive design strategies such as orientation, shading, sealing, glazing, and insulation can significantly reduce the need for a forced heating-cooling system, which accounts for 40% of total energy usage in residential buildings.	The passive design solution for optimizing building design and Autodesk Revit as a simulation tool for optimizing sustainable building design.
Chel A, Tiwari G, Chandra A(2009) [20]	A model for estimation of daylight factor for skylight: An experimental validation using pyramid shape skylight over vault roof mud-house in New Delhi (India)	Daylight factor analysis, by models	Experi-mental measured data, daylight factor analysis	The daylight factor model was found to be in good agreement with the experimental value of the daylight factor. This model was modified for different practical horizontal surface levels inside the big and small dome rooms and validated using experimentally measured data. The yearly average value of the percentage daylight factor for big and small dome skylight rooms was determined as 2% and 6%, respectively.	Ensure that the research methods can be applied in this research, and make sure that the skylight opening can be a pyramid shape.
Chel A, Tiwari G, Singh H (2010) [21]	A modified model for estimation of daylight factor for skylight integrated with a dome roof structure of mud-house in New Delhi (India)	Daylight factor analysis, by models	Experi-mental measured data, daylight factor analysis	The prediction of the modified model agrees with experimental inside illuminance data based on values of root mean square percentage error (e) and correlation coefficient (r). The annual average daylight factor values for big and	Ensure that the research methods can be applied in this research, and make sure that the skylight opening can be a dome shape

				small dome skylight rooms are determined as 2.3% and 4.4%, respectively.	
Acosta I, et al.(2017) [22]	Analysis of daylight factors and energy saving allowed by windows under overcast sky conditions	Daylight factor analysis by simulation methods	simulation measured data, daylight factor analysis	After trials, it was concluded that square windows produce daylight factors slightly higher than those obtained with horizontal windows and noticeably higher than those measured with vertical windows, considering the same surface of openings. It is confirmed that the daylight factors are directly proportional to the glass surface, except in the area near the window.	Ensure that the research methods step by step can be applied in this research; make sure that square windows produce a daylight factor slightly higher than those obtained with horizontal windows.
Ahadi A, Saghafi M, Tahbaz M (2017) [23]	The study of effective factors in daylight performance of light wells with dynamic daylight metrics in residential buildings	Daylight factor analysis by simulation methods	simulation by using Autodesk ecotec, daylight factor analysis	the optimal height of the light well, orientation variation, and the slope of the light-well surrounding wall) to provide suggestions for better utilization of light wells in residential buildings.	Ensure that the research methods can be applied in this research, determine the factor that affected the daylight factor in residential building.
Bian Y, Ma Y (2017)[24]	Analysis of daylight metrics of side-lit room in Canton, south China: A comparison between daylight autonomy and daylight factor	Daylight factor analysis by simulation methods	simulation, daylight factor analysis	The result shows that a monthly daylight illuminance above 300 lx in a room in Canton requires a DF of no less than 1.8% for north-facing space.	Ensure that the research methods can be applied in this research and determine the factor that affected the daylight factor in other geographical locations.
Ahmad A, et. al (2022) [25]	Dynamic analysis of daylight factor, thermal comfort, and energy performance under clear sky conditions for building: An experimental validation	Daylight factor analysis by experimental methods	Experi-mental measured data, daylight factor analysis	Within the thermal comfort limit, the daylight factor was found in between 1 and 11% and 1–21% for the floor and wall. The theoretical model results are compared with experimental values. The best building orientation was found to be 180° from the north or towards the south.	Ensure that the research methods can be applied in this research, determine the factor that affected the daylight factor in other geographical locations, and the effect of daylight factor on energy performance.

2.4. Research Method

Today, architectural software developers are developing more architectural simulation programs. Sketchup, a popular free downloadable software from Google, provides an almost general view of the building in plan, section, bird's eye view, etc. Most people would consider Sketchup an educational tool because you always own and drive many of the ideas it generates. Unlike SketchUp, Revit is more innovative and competent software because it can recognize the input data provided and perform analysis related to it in real-time based on the input-building design variables. In Autodesk Revit, the information in the design can be more comprehensive and accurate in producing a clever design. SketchUp only works when the architect can interpret the actual condition by experience. Something closer to the simulation would be the sun path scenario. The Autodesk Revit program calculates the sun's position concerning the building at any time and from any location. It is a dynamic representation. However, that begins to provide dynamic information. Even more importantly, technological improvements may eventually lead to an infinite number of stable graphics to simulate the study results, rather than the other software's limited graphics.

The research methods procedure is based on SNI 03-2396-2001. In the initial step, we must decide on the object and the building function and then determine the minimum target requirement of daylight factor. The next step is measuring building opening, position, orientation, overstack, and glass type. After that, we must compile the data for measuring daylight factor using several formulas. However, in this research, the daylight factor measurement is replaced using Autodesk Revit simulation because it is faster, more accurate, and has more detailed output. For the first step of Autodesk Revit simulation, we will create an existing model of the object of research and make sure the current environmental condition setting of the building, such as location, opening position, opening size, building orientation, shading device, and glass type. After that step, we analyze the natural daylighting condition using daylight factor simulation in autodesk revit. Suppose the existing model does not fulfill the minimum requirement of natural daylighting. In that case, we must adjust it by adding more possibilities to maximize daylight penetration through the building using the SNI 03-2396-2001 standard by modifying the opening size, position, and building design and recommending optimizing daylight penetrating. This pragmatism will be simultaneously repeated until we get the optimal result. After that, we will compare several types of openings and analyze what strategy makes the design more optimized.

The research hypothesis is that the strategy to maximize daylight factor in housing is using a building opening with an 80 cm sill height and a maximum of 150 cm tall. The second strategy is to make the skylight opening for maximalize lighting penetrating from the top of the building. The second strategy can only be applied to single-story or top-story buildings. We will gain some advantages from this research, such as Autodesk Revit, a popular BIM Based Architectural software modeling and simulation, and a real-time digital architectural laboratory. In addition, we can recommend to real estate developers for the next project of Islamic housing concept to optimize natural daylight penetration that reduces building energy consumption, makes the housing healthier and more comfortable, and guarantees privacy.

3. RESULTS AND DISCUSSION

The primary object study is administratively located in the Medina Residence 1 housing complex in Klandungan, Landungsari Village, Dau District, Malang Regency (Figure 1). Medina residences are characterized by housing with a small cluster site plan. Every cluster has a mosque as a distinct facility and a public facility as an Islamic Housing. Medina Residence 1 has 30 housing units, most of which are single-story structures. This cluster has 30 housing units with a typical plan; most facades face east and west, so we use this condition as an environment setting of simulation in this study.

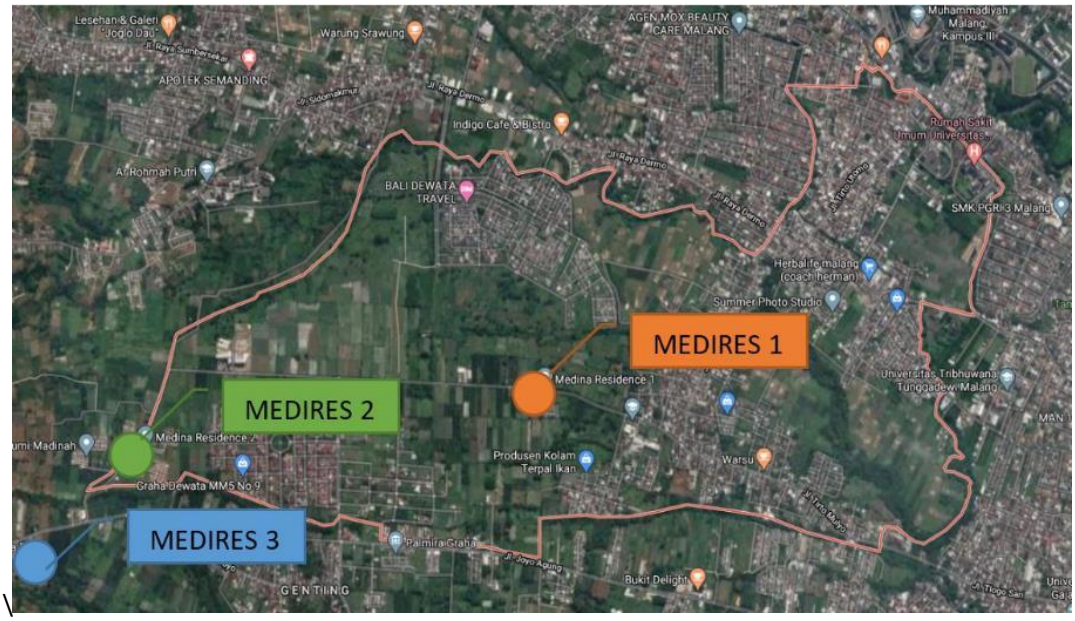


Figure 1. Map of the Research Location, Klandungan, Landungsari Village, Dau District, Malang Regency. Source: Google Maps.

3.1. Research Object

Medina Residence 1 (Figure 2) was chosen as the object of study because this housing correctly applied the Islamic housing concept. Regardless of the Medina Residence 1 housing as a correlation of the use of the idea of Islamic housing in the plan of building units and regions, the similar object of the Medina Residence 2 and 3 utilized in Figure.1, where these houses are under a similar developer, PT Insan Medina Propertindo, which situated in an area close to the Medina Residence 1. However, the two other objects will be used to compare the different plan views of the building and different room organization. The Medina Residence 1 has a unique design for the minimum land size. It has a central court and skylight in the middle of the room, but there is also a problem with the bedroom area, especially the bedroom that does not face the central park; its condition is dark during the daytime. It is a severe problem because it will make the bedroom unhealthy and uncomfortable during the day. So, we recommend that the house owner or the housing developer give a more healthy and comfortable design in the same land size using BIM Simulation.

Figure 2. Building design of Medina Residence 1, Klandungan, Landungsari, Dau District, Malang Regency
Source: Field Survey (2020)

PT. Insan Medina Propertindo created a housing project with Islamic attributes that are almost similar but have specifics of building design and quite different areas in every house building. The comparison of the evaluation among three objects of study, particularly on the daylight factor aspects of housing units, can be seen. One of the ideal criteria for implementing Islamic housing concepts is the presence of natural light opportunities that can reach the entire room. According to research conducted in 2021, this project has the highest level of consumer satisfaction. The occupancy satisfaction chart can lead to implementing Islamic housing concepts regarding environmental facilities and building characteristics. [26].

In this case, there are religious support facilities, clean infrastructure facilities, regional utility infrastructure facilities (electricity, water, telephone/internet), educational facilities (formal/informal), security supporting infrastructure facilities (security post, PJU), communal room (community hall, sports field, playground), health facilities (*posyandu*, clinics, etc.), shopping facilities (stalls/shops), and vegetation supporting the infrastructure. The second factor is building characteristics such as two entrances for men and women, a separation between the service room and the main room, the park as the primary orientation, a separation between the family room and the living room, Islamic-style ornament (plants, geometry, calligraphy, and flowers), solar shading and secondary skins for private occupant life, ornaments at the main entrance to be focal points of the entrance design, ventilation in each room, and open natural light openings

that can reach the entire building are considered in this regard are critical aspects of the Islamic housing concept that must be met.

Figure 3. Isometric Floorplan, Building Section, and the building opening of Medina Residence 1(top), Medina Residence 2 (middle), and Medina Residence 3 (bottom)
Source: Field Survey 2020

Figure 3 shows the Medina Residence 1 building, which has windows and glass blocks in each room. It improves the natural lighting in the building. There are window openings in the middle of the building unit and building lot voids in the middle of the building in the living room area. Medina residences 2 and 3 have openings in each building unit's room. It also demonstrates that the other two houses use Natural Lighting as their primary lighting source during the day. The Islamic housing concept emphasizes privacy as a method of maintaining personal issues such as drying underwear, the woman's *aurat*, and the visibility of non-mahram, so a more private space that is not visible to guests or strangers is required. According to the case study of Medina Residence 1, there is no designated drying area, so clothes are dried in the inner garden, which can still be seen from the family room and living room. As a result, when compiling recommendations, we must consider this aspect of privacy as one of the foundations for making design recommendations.

3.2. Autodesk Revit-Based Evaluation of Daylight Factor

Before simulating the building, we make the building models using Autodesk Revit 2023. We make the models based on the existing condition and design on the current site and compare them with the design blueprint. Daylight is not dependent on when the simulation begins. Otherwise, the sun's apparent annual motion did not influence the daylight factor. We make the building story as close as possible to the existing building. And then, we start the simulation by inputting the building information, such as location, north orientation, and building site.

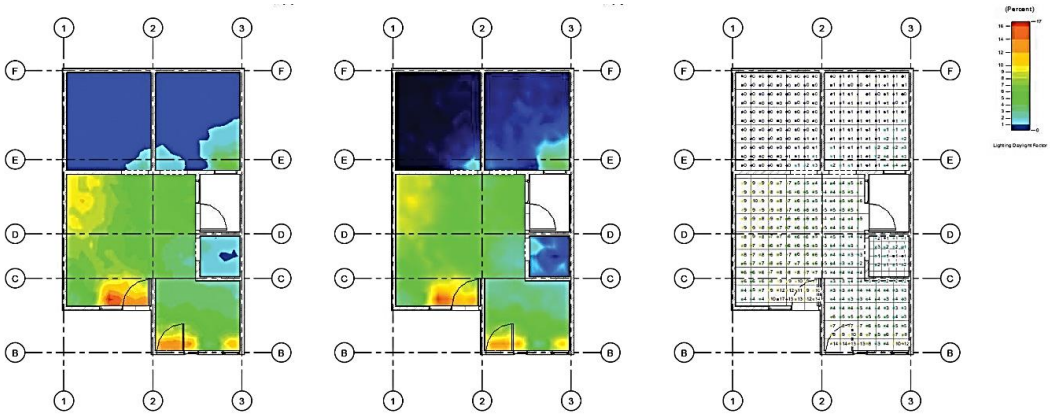


Figure 4. Access Daylight Factor in Medina Residence 1 (left) range scale, (middle) Gradient scale, the (right) percentage value of daylight factor.
Source: BIM Analysis Autodesk Revit 2022

The daylight factor conditions in the Medina Residence 1 residential room are depicted in Figure 4. The family room has the highest daylight factor range from 5% to 11.9%, with an average daylight factor of 5.3%. It already meets the minimum standard of not using artificial lighting. However, because there are no openings in the back of the room, the bedroom area is still below the 5% standard. In this case, there is no open space in the back of the building because the living room in the middle of the building is maximized. As a result, everything behind land boundaries is being built. So, because the bedroom only has a small window that leads into the living room, there is less daylight during the day.

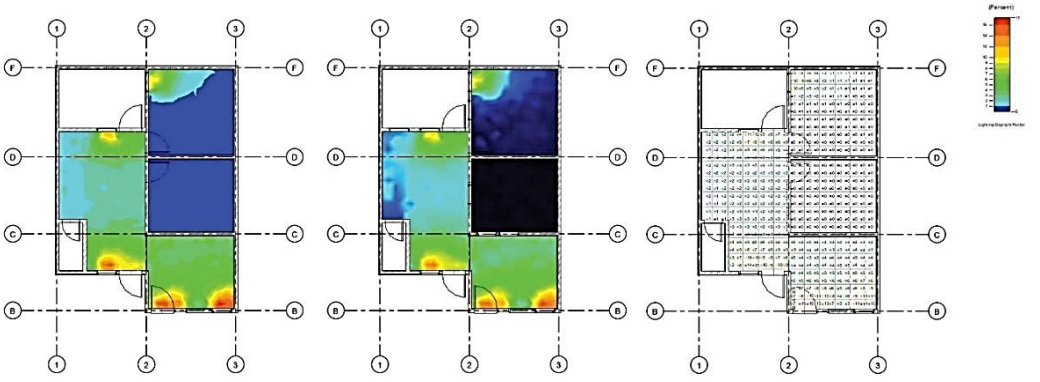


Figure 5. Access Daylight Factor in Medina Residence 2 (left) range scale, (middle) Gradient scale, (right) percentage value of daylight factor.
Source: BIM Analysis Autodesk Revit 2022

The highest daylight factor conditions in the Medina Residence 2 residential room are between 5% - 7.8%. Where it already meets the minimum standard of the room not to use artificial lighting can be seen in Figure 5 above. The average daylight factor in this building was 1.97%. However, it is still below the 5% standard in the bedroom area because no openings in the middle lead directly to open spaces. Because the

front bedroom can only reach the outdoor space through the other room, it has limited access to natural light. This room cannot be cross-ventilated and will require artificial lighting during the day.

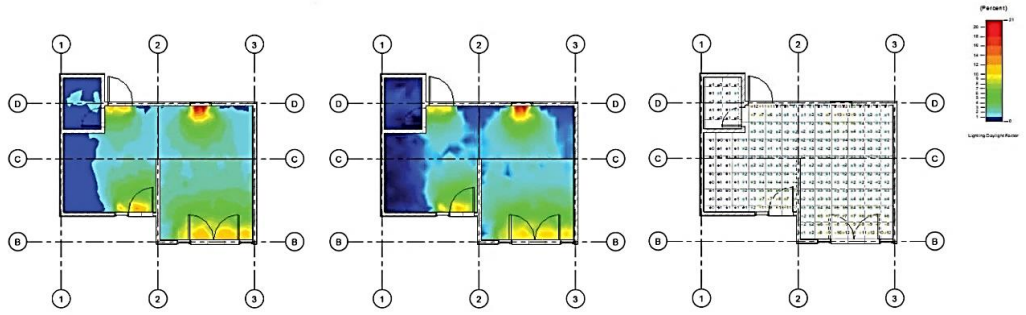


Figure 6. Access Daylight Factor in Medina Residence 3 First Floor (left) range scale, (middle) Gradient scale, (right) percentage value of daylight factor.
Source: BIM Analysis Autodesk Revit 2022

Figure 6 shows that the highest daylight factor conditions in the Medina Residence 3 1st floor housing room are in the living room, which has a value between 1% - 21% and already meets the minimum standard of the room not utilizing artificial lighting. However, the living room area on the first floor still needs to be below the 5% standard of average daylight factor, which is 2%-3%, due to a severe lack of openings.

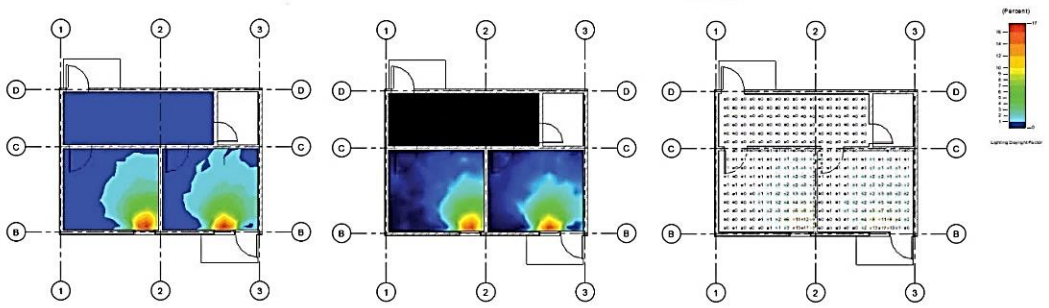


Figure 7. Access Daylight Factor in Medina Residence 3 Second Floor (left) range scale, (middle) Gradient scale, (right) percentage value of daylight factor.
Source: BIM Analysis Autodesk Revit 2022

The daylight factor condition in the Medina Residence 3 2nd floor residential room is depicted in Figure 7. The highest daylight factor is in the left-side bedroom, with a value range from 1% to 17%, which already meets the room's minimum standard of not using artificial lighting. However, due to the lack of massive openings in the walls, the circulation space and stairs remain below the 5% standard.

3.3. Comparison between quality and quantity of natural lighting.

Comparing the quality and quantity of natural lighting in housing with the Islamic housing concept can represent some of the simulation results above. The three objects studied almost met the standard criteria for allowing natural light into the room. However, some still need to be improved or optimal, so improvements to the position of the openings and the number of outlets to allow natural light into the space are required. Based on the previous evaluation, Medina Residence 1 is the closest to meeting the standard criteria of daylight factor on housing, which must mean achieving a 5% daylight factor in the building. On the other hand, the family room must be exposed to sunlight during the day because it is the house residents' activity hub. The natural lighting levels at Medina Residence 1 still need improvement, owing to the lack of a building lot void and a small opening in the bedroom. They have a minimum daylight factor value compared to the standards specified. As a result, we must modify the building design to maximize daylight penetration through the bedroom. The statements of housing investors in Table 3 below regarding evaluating the quality

of natural lighting in the room show the presence of a natural daylight entrance that can maximize daylight penetrating through the room.

Table 3. User Evaluation on Islamic housing concept specifics for Natural lighting

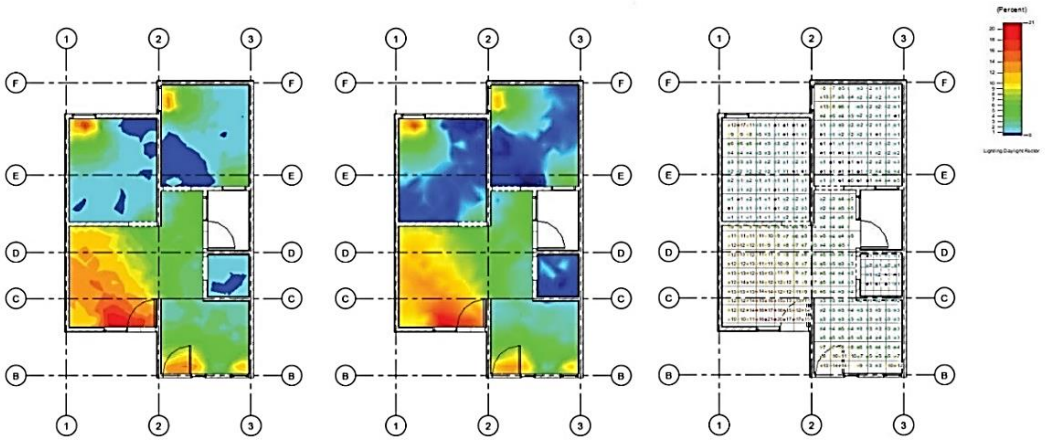
No	Variable	Min	Max	Mean score	Std. Deviation
1	The existence of natural light openings that can reach the entire space	4	6	5.278	0.752

Based on investor discussions, evaluation of the presence of natural light openings that can reach the entire building demonstrates that the object study meets the ideal criteria for the fact of natural daylight, as indicated by a mean score of 5.278 on a scale of 6. It stated that some rooms should have met the criteria but needed to. There must be some openings for daylighting to reach the entire building in Islamic housing. A small gap between the two lots on the middle side of the building has created a small opening in the middle.

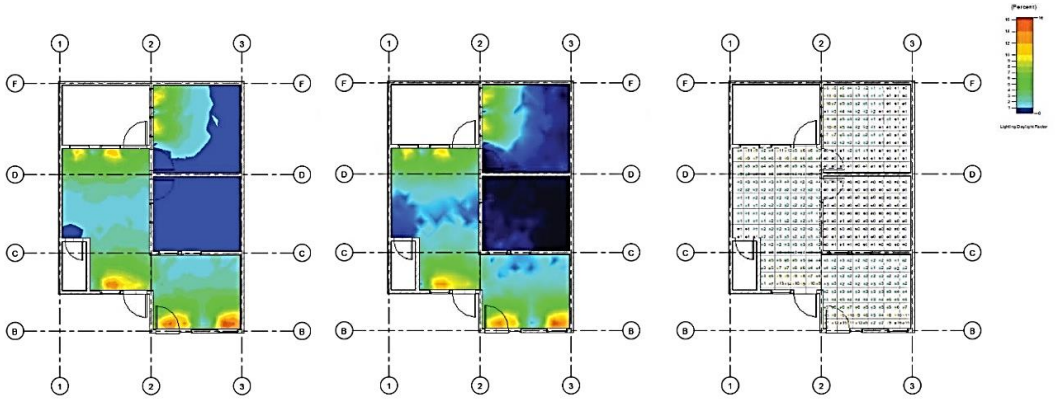
3.4. Design Recommendation for Maximalizing Natural Lighting on Medina Residence.

After several simulation trials, we got the most optimum daylight factor average in the medina residence 1, 2, and 3. We got that daylight factor average in Medina residence 1, which increased the average daylight factor from 3.7 % to 5% by adding more space in the back of the building lot and a window opening with an 80 centimeters wide and 150 centimeters tall dimension. For Medina Residence 2, we can increase the average daylight factor from 1.97% to 2.3 % by adding more window openings at the back and inner sides of the front bedroom. For Medina Residence 3, we can increase the average daylight factor from 2.3 % to 8.1 % by adding more window openings at the back of the building and making a curtain wall at the backside.

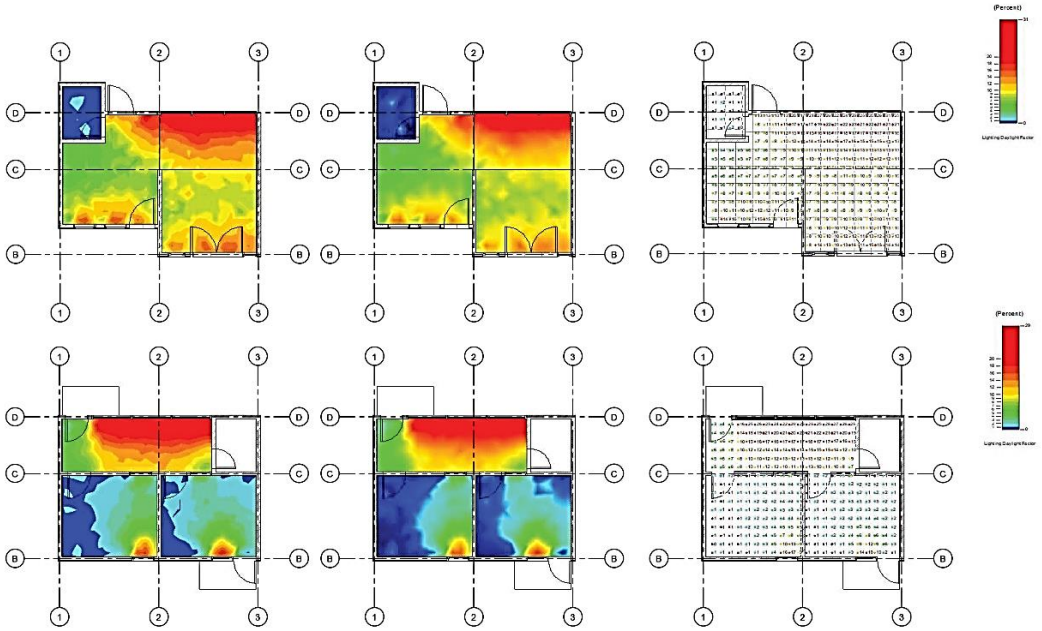
The main concern is in Medina Residence 1 due to the evaluation, and this housing project has the ideal condition in building design that accommodates the Islamic housing concept. By the simulation, we get the most significant daylight factor increase by the minimum wall opening adding. Figure 9 depicts the daylight factor conditions in the Medina Residence 1 residential room after a minor design change, namely shifting the bedroom and adding an opening in the form of a window on the back side of the building. The family room has the highest daylight factor, ranging from 9% to 15.4%, indicating that the room does not require artificial lighting. The daylight factor in the second bedroom ranges from 3.7% to 5%. It shows a greater level of sunlight penetration than the existing Medina Residence 1 design. According to this recommendation, we can maximize natural daylighting while having a small living room; however, we can use a mixed-use living room as a women's guest room and the terrace as a men's guest room. From the simulation, we can learn some modifications to maximize the daylight factor: window opening, window wall ratio, curtain wall, skylight opening, and open space in the building lot.



(A)



(B)



(C)

Figure 9. (A.) Access the Daylight Factor of Medina Residence 1 by adding a skylight opening and backyard. (B.) Access Daylight Factor in modification of building plan on Medina Residence 2 by adding more windows. (C.) Access Daylight Factor in modification of building plan on Medina Residence 3 by adding more windows and curtain walls.
Source: BIM Analysis Autodesk Revit 2022

4. CONCLUSION

The first study object is obtained based on the analysis results from the simulation results using BIM Autodesk Revit 2022 and the Insight Lighting Analysis feature, namely Medina Residence 1. It has a reasonably representative opening design compared to Medina Residence 2 and 3, due to the open space in the middle of the building, which allows light to enter the entire room. The functional non-built area also supports this in the middle of the building as an inner courtyard with many functions, such as the entry of natural light into the room, the access of air in the middle of the structure, and an outdoor recreation function for residents who still provide more privacy to protect the occupants' private parts. After making modifications to the Medina Residence 1 building by adding and selecting an opening on the back side of the building and providing an open area, the average daylight factor increased from 3.7% to 5%, demonstrating that two open spaces are required at the back and center of the building to fulfill the ideal criteria daylight factor for an Islamic residence. The type of building opening recommended for Medina Residence 1 is a glass roof opening that uses translucent material on the building roof. The skylight void measures only 30 centimeters wide by

285 centimeters long. We expand the building lot behind the building by 100 cm wide and 285 cm long. In this case, we can add a backyard door and maximize the backyard as a service area, such as a laundry room. It will benefit some people because of the premodified design and the lack of a service area for a laundry room that is not visible from the living room. Personal clothes drying will be more private for the user. Besides that, the window type and wall window ratio will provide more penetration of natural lighting during the daytime. In the case of Medina Residence 1, we got a minimum size of the window to maximize the penetration of natural lighting through the bedroom is 80 cm wide and 150 cm tall. Otherwise, we can add curtain walls that point into a private park to maximize the penetrating of natural lighting throughout the entire building. It is the best recommendation because curtain walls make the wall-window ratio 100% transparent, giving natural lighting that penetrates the whole building maximally. However, we must add a shading device to minimize glare and solar radiation, or we can add film on the translucent material to protect against UV and IR radiation of sunlight.

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