

# BIM Based Evaluation of Daylight Factor Aspect in the Sharia Housing Project That Implemented Islamic Housing Concept

Angga Perdana<sup>1</sup>

<sup>1</sup>Department of Architecture Engineering, Islamic State University Maulana Malik Ibrahim, Malang, Indonesia-65144  
Email address: anggaperdana@arch.uin-malang.ac.id

**Abstract**— Today Islamic residential concepts are chosen by several real estate developers for their housing products, but many housings product have not met all the ideal criteria of that concept. The ideal Islamic residential concept must fulfill some requirements, including parks and open spaces on the residential lots and natural light and ventilation able to reach the entire room. The inner courtyard is one of the solutions for the affordability of daylight factor and natural ventilation. Based on the evaluation results according to investors and in-depth analysis qualitatively and quantitatively by using BIM Simulation about the daylight factor aspect of the concept of Islamic housing in the sharia housing, the Object study shows that in the case of Medina Residence 1, it is sufficiently representative to offer the most daylight factor affordability in a sharia housing project. Skylights opening and more inner open space are the solutions for the minimum size of the building site.

**Keywords**— BIM, Daylight Factor, Islamic Residential Concept, Sharia Housing.

## I. INTRODUCTION

Indonesia is the largest Muslim community in the world. They are very concerned about religious values in their life and are also concerned with planning and developing buildings. This fact is present by applying the principles of Islamic architecture in the building. Creating a building needs to pay attention to the 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'alam), and relationships among human beings (hablumminannas) [1].

One of the most frequently developed property sectors is for residential purposes, which is affected by increased housing needs. 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. The development of Islamic housing with a specific theme becomes a branding that can attract consumers. Many developers implemented the Islamic housing concept as a tagline for developed housing products. However, many housings with that concept haven't met all the ideal criteria of the concept of Islamic housing, so an evaluation of the application of the idea in shari'a housing is needed [2].

Especially in Malang, some housing projects Implemented linear housing or couple house concepts with minimum land area. The low daylight intensity and minimum ventilation opening can be uncomfortable for the user. In architecture, we know the idea of daylighting and cross ventilation. It can be more efficient than housing implementing this concept because it will reduce the energy consumption of the building. The Medina Residence 1 building opens 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 the user must use artificial lighting. Based on this case, we must evaluate the daylight factor of the building to give design recommendations for maximalized daylighting.

The daylight factor is one of the aspects of the Islamic housing concept. Based on the evaluation of the physical aspect of Islamic residential concepts in the sharia housing project [2], The natural light must reach the entire housing space. Based on the background and formulation explained before, this research question is: How is the daylight factor aspect in the Sharia Housing Project That Implemented the Islamic Housing Concept? How will it meet the standard? To answer it, we can use several simulation software, such as Ecotech, and Dialux, to evaluate the daylight factor. But these several programs are not flexible to modify the design. We must produce new models for new simulations. Today Autodesk Revit as a BIM Software accommodates more features that consist of several simulations such as energy simulation, energy building evaluation, structural evaluation, and visual evaluation simulation. It can be more efficient in one program, and also we can modify the building design in real-time. So I choose BIM, especially Autodesk Revit, as a tool for building daylight factor simulation for a more effective and efficient design modification. Some previous research has not specified studies evaluating the daylight factor value in Islamic Housing.

The objectives of this study are to evaluate and give standard design recommendations for the daylight factor aspect of the Sharia Housing Project That Implemented the Islamic housing Concept, especially in the case of Medina residence 1, using BIM-based modeling evaluation. This housing project has implemented the Islamic Housing concept holistically. But in the design implementation, there are several complaints from the building user that some rooms are pretty dark and have less daylight in the daytime.

## II. LITERATURE REVIEW AND RESEARCH METHOD

To deepen our knowledge of the research object, we must know the meaning of real estate development. Real estate is an endeavor to build the worth of a property to produce benefits together. One of the executions of land is to change over less occupied or empty land into structures, creating an advantage. The outcome of land is not entirely set in stone by how the land cycle functions. Growing land ordinarily goes through a few phases of the most common way of arranging and planning [3]. Every real estate project has a concept as a tagline for its campaign sales promotion. One of the concepts I was attracted to is the Islamic Housing concept because today, it was popular.

### A. *Islamic Housing Concept*

Housing can be said to have an Islamic idea if the physical or the most common way of housing development isn't in a struggle with the arrangements of Islamic sharia contained in the Qur'an and Al-Hadith. To holistically apply the ideal Islamic housing concept, It should be formed as a benchmark for the base models for assessing Islamic Housing. The refinement of the thought stage is the course of study and unearthing of arranging and planning rules with topics following the underlying thought. In improving shari'ah housing, this honing stage alludes to the regulations that absolute requirements be met to foster a land with the best Islamic housing idea. After the best Islamic housing idea, at the refinement of the thought, there are unique projects that help the execution/acknowledgment of Islamic sharia in life [4]

Aside from these contentions in detailing Islamic housing standards, likewise added things that help these recommendations, like the foundation of the suggestion, the motivation of the Islamic city, and the specialists' assessments. The standards of Islamic housing assembly are into three classifications, in particular, first, things that are guidelines (compulsory), then something that is prescribed to be executed (sunnah), and third, things that are not ruled (mubah) [5].

To Figure out the idea of a private way of thinking in Islam, we can analyze one of the ideas of the idea of Islamic private homes in Andalusia. This is because the Andalusia district is encountering social assimilation of the Middle East with Europe, which is practically equivalent to the state of Islamic housing in Indonesia, which is the assimilation of a neighborhood, Middle East, and current culture. In building a house, two things underlie the most common way of building a house: the example of room and outside space that shapes a private unit [6]. Besides, a few qualities make up the house with the idea of Islamic housing [7], including the presence of the recreation area in the home, the Andalusian people group, and the Mediterranean area of open space region point that should be in the house. It is expected for airflow or regular view into space. This idea is additionally tracked down in settlements in Dhaka, Bangladesh. Albeit the city is exceptionally thick and grimy, the idea of the recreation area as a component of the room is as yet kept up with [8].

Otherwise, the Ventilation and Daylight Factor must reach all rooms, Using the yard for open space inside and in front of

and behind buildings. Privacy keeps by shading gratings such as (Mashrabia). Room units must have privacy between one unit and another. Islamic housing must meet human needs based on lifestyle, culture, and environment. Islamic housing must be related to family needs, environmental sensitivity, existing resources, and building technology. Meeting needs must fulfill functions that reflect the Muslim lives [7].

Sunlight is the main asset for building and plays a real job in an individual's well-being and prosperity. It is also a significant asset in economic and energy efficiency, and its accessibility permits to decrease in the utilization of artificial light and, subsequently, energy utilization. Recent studies have established that the energy required for lighting within the structures remains at 20-40% of all the consumption and is one of the fundamental supporters of CO<sub>2</sub> outflows [9].

### B. *Daylight Factor*

Daylight Factor (DF) is a sunshine accessibility metric that indicates how much sunlight is accessible inside a room (on a work plane) contrasted with how much-unhampered light is accessible externally under cloudy sky conditions. The higher the DF, the more light is accessible in the room. Rooms with a typical DF of 2% or more can be considered daylight, yet artificial lighting might be expected to perform visual errands. A room will show up emphatically during daylight when the typical DF is 5% or more, which will not utilize case artificial lighting during daytime. This exploration that will create examines the use of Islamic housing. Therefore, this research paradigms the post-positivist paradigm with a simulation research methodology [10].

### C. *BIM Evaluation*

At present, Building Information Modeling (BIM) is broadly utilized in AECO ventures, and BIM models are used for trading information among various experts associated with the plan and development of structures. The current paper examines the utilization of BIM for building execution reenactments and chiefly centers around how can integrate daylighting examination into a BIM climate and what difficulties and advantages exist during the time spent coordinating BIM with daylighting reproduction instruments. This paper presents the turn of events and approval of a model to coordinate the BIM-based tool Revit with daylighting reproduction devices [11].

BIM is also a standard design and approach method tool for today's architecture and construction research. Usually, some research combines BIM technology with green building analysis simulation. It can fully utilize the advantages of the BIM model and is more efficient for green building evaluation [12]. It is easy for BIM Model to modify and adjust building design for more effectiveness and efficiency. In BIM, we know several benefits, such as sustainability of the design and construction process that we know as 6D (six dimensions) of design and construction on BIM [13]. It can be more efficient and effective if we can simulate how the building is designed, constructed, maintained, and demolished. In the BIM design process, we know LOD (level of development) that every level of development in BIM is recorded and possible to

simulate, especially for environmental impact throughout building design [14]. For more sustainable building design, we must simulate environmental impact through building design. It will be more comprehensive if that design passes through the simulation stage. In the case of the existing building, we can make some simulations with a modified building design using a passive design such as orientation, shading, sealing, glazing, and opening. [15].

Based on table 1, we know several studies that concern on Islamic Housing Concept and BIM-based evaluation. We understand that the physical aspect is one of the Islamic

housing criteria. Building design must evolve adaptively throughout every environmental condition. Sustainability is an essential aspect of building design because it will make building energy consumption more effective and efficient by using natural lighting and natural ventilation throughout the building will decrease the energy consumption of the building. Based on several studies below, we know that BIM evaluation is a more effective method for evaluating the building design process in several LOD stages, starting from idea to demolition. We can simulate the design or construction process.

TABLE 1. Previous studies of the Islamic Housing Concept and BIM-based evaluation

Author / Year	Journal	Theory	Method	Finding	Contribution
Perdana A (2020)	Evaluation Of Physical Aspect of Islamic Residential Concepts in The Sharia Housing Project	Principle of the physical aspect of the Islamic housing concept	Post - Positivistic	There are several criteria in the physical aspect of developing Islamic housing	The state of the art of this research that maximalizes daylight is one of the principles of the Islamic housing concept.
Hwaish, A.-M (2018)	Concept of Islamic House; A Case Study for Early Muslims Traditional House.	A precedent of Characteristics in the Islamic residential concept	Qualitative Literature Review	There are several criteria in early Muslim traditional houses in Andalusia	The inner courtyard and opening on the wall contribute to natural daylighting.
Guo KLi QZhang L et al. (2021)	BIM-based green building evaluation and optimization: A case study	Green building criteria	Literature Review	BIM-based design can construct an effective evaluation system to assess green buildings	Make sure that BIM-based design provides green building design.
Motawa I, Carter K (2013)	Sustainable BIM-based Evaluation of Buildings	BIM-Based model for sustainable Building design	Literature Review	conceptual BIM-based model that can improve the post-occupancy evaluation process and meet the industry requirements for sustainable buildings.	Make sure that BIM-based on evaluation are methods to improve building design, especially for an existing building.
Cavalliere CHabert GDell'Osso G et al. (2019)	Continuous BIM-based assessment of embodied environmental impacts throughout the design process	Level of development (LOD), embodied environmental impacts	Literature review, Life Cycle Assessment (LCA)	Building Information Modelling (BIM) can help to perform LCA during the design process.	Make sure that BIM is a tool for the assessment of embodied environmental impact throughout the design process
Tushar QBhuiyan MZhang G et al. (2021)	An integrated approach of BIM-enabled LCA and energy simulation: The optimized solution towards sustainable development	Energy simulation	Simulation, Rating tool – Life Cycle Assessment (LCA)	Passive design strategies such as orientation, shading, sealing, glazing, and insulation can significantly reduce the necessity of an artificial heating-cooling system, accounting for 40% of total energy usage in residential buildings.	The passive design solution for optimizing building design and Autodesk Revit as a tool for simulation toward optimized, sustainable building design.

**D. Research Method**

In architectural research today, we know that architectural software developers are creating more architectural simulation programs. For example, Sketchup, a popular free downloadable software from Google, provides an almost all-around view of the building in plan, section, bird's eye view, etc., once the designer enters the dimensions. Most people would say Sketchup is an educational tool because many of the ideas it creates are always anchored and driven by you. It only works when the architect can interpret the actual condition by the experience. Something closer to the simulation would be something like the sun path scenario. The Autodesk Revit program works the sun's position relative to the building anytime and anywhere. However, it is a dynamic representation that begins to provide dynamic information. Perhaps more importantly, advances in computer technology may eventually lead to an infinite number of stable representations to simulate real-time behavior, as previously reported limited. [10].

Using Autodesk Revit, we will make the existing model of the research object and evaluate the natural daylighting condition by using daylight factor simulation. If several fewer fulfill the standard requirement of natural daylighting, we must modify the existing model by adding more openings or building lot voids to maximize daylight penetration through the building. From this research, we will receive some benefits such as we know that Autodesk Revit, as a popular BIM Based Architectural software modeling, is a real-time digital architectural laboratory, and also we can give recommendations for the real estate developer for the next project of Islamic housing concept to maximize penetration of natural daylight to reduce building energy consumption and make the housing more healthy, comfortable, and privacy guarantee.

**III. RESULTS AND DISCUSSION**

Administratively, the object study is in the Medina Residence 1 housing complex located in Klandungan, Landungsari Village, Dau District, Malang Regency, Figure.1.

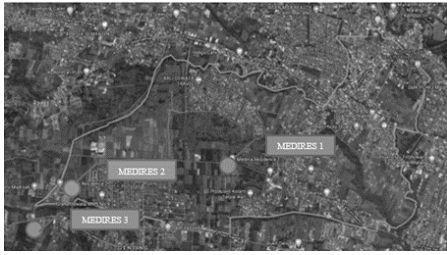


Fig. 1. Map of the Research Location of Klandungan Hamlet, Landungsari Village, Dau District, Malang Regency. Source: <https://www.google.com/maps/place/Dusun+Klandungan,+Landungsari,+Kec.+Dau,+Malang,+Jawa+Timur>.

The characteristic of medina residence is housing with a small cluster site plan. Every single cluster has a mosque as a unique facility and a public facility as an Islamic Housing. Medina residence 1 has 30 Units of housing that are mostly single-story buildings. This cluster has 30 units of housing with a typical plan; most facades orientation east and west, so in this research, we use this condition as an environment simulation.

A. Research Object

The object study is the Medina Residence 1 Figure.2, and this housing project was picked because it, by and significantly proposes the shari'a idea. The shari'a idea should be visible in the preparation, plan, financing, promotion, and home administration stages notwithstanding 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 tantamount object of the Medina Residence 2 and 3 utilized in Figure.1, where both these houses are likewise under a similar developer, PT Insan Medina Propertindo which situated in an area near from the Medina Residence 1 housing.



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

PT. Insan Medina Propertindo created a housing project that has attributes and Islamic qualities that are practical that are almost similar but have details of the design of buildings and areas that are quite different in each housing, so it can be seen how the comparison of the evaluation among the three objects of study, especially on the daylight factor aspects of housing units. The existence of natural light openings that can reach the entire space is one of the ideal criteria for implementing Islamic housing concepts. This project has

maximum consumer satisfaction based on the research in 2021. The occupancy satisfaction chart can cause environmental facility and building characteristics to be implemented Islamic housing concept [16].

Environment facilities in this case, as there are religious support facilities, security supporting infrastructure facilities (security post, PJU), clean infrastructure facilities, regional utility infrastructure facilities (electricity, water, telephone/internet), communal room (community hall, sports field, playground), Educational facilities (Formal / Informal), health facilities (posyandu, clinics, etc.), shopping facilities (stalls/shops) Vegetation supporting the area, and there are no 3D ornaments/works in the form of animals/humans. The second factor is Building characteristics such as two entrances for men and women, the separation between the service room and the main room, the separation between the family room and living room, the park as the primary orientation, Islamic-style ornament ( geometry, plants, and flowers), shading devices and Secondary skins for the privacy of the occupants, ornaments at the main entrance to be the focal points of the entrance design, ventilation in each room, openings of natural light that can reach the entire space, carrying the concept of climate responsiveness, building height does not exceed the surrounding environment (2 story building floor, maximum tile to ceiling distance of 5 meters) [2]. By this aspect, openings of natural light that can reach the entire space are crucial aspects that must be met in the Islamic housing concept.



Fig. 3. Access Daylight in Medina Residence 1(left), 2 (middle), and 3 (right) Source: Field Survey 2020

In Figure 3, Medina Residence 1 building, there are openings in each room in the form of windows and glass blocks. It helps natural lighting in the building. In the living room area, there are window openings in the middle of the building unit and building lot voids in the middle of the building. As a comparison, there are openings in Medina residences 2 and 3 in each building unit's room. It also shows that the other two houses use Natural Lighting as the primary lighting source during the day. The Islamic residential concept also emphasizes privacy as a form of application for maintaining personal matters such as drying underwear and so on, so a more private space is needed that is not visible to guests or strangers. Based on the case study of Medina Residence 1, there is no particular area for drying clothes, so drying clothes is done in the inner garden, which can still be seen from the family room and living room. For this reason, in compiling recommendations, we also need to pay attention to this aspect of privacy as one of the bases for making design

recommendations.

**B. BIM-Based Evaluation of Daylight Factor**

Figure 4 below shows the daylight factor conditions in the Medina Residence 1 residential room. The highest daylight factor is in the family room, which has a value between 5% - 11.9%, where it already meets the minimum standard of the room not using artificial lighting. However, the bedroom area is still below the 5% standard because there are no openings on the back side of the room. In this case, there isn't open space in the back of the building because the building maximizes the living room in the middle of the building. So all behind land boundaries are built. So the bedroom only has a small window that directs into the living room, so it's less daylight in the daytime.

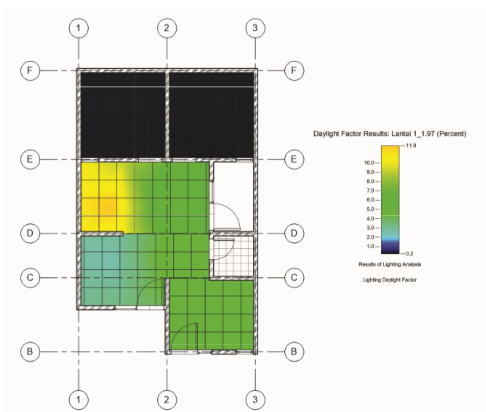


Fig. 4. Access Daylight Factor in Medina Residence 1  
Source: BIM Analysis Autodesk Revit 2022

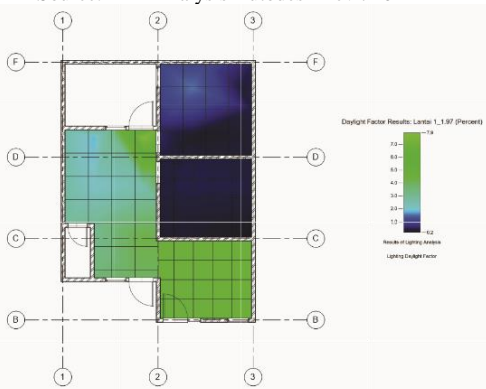


Fig. 5. Access Daylight Factor in Medina Residence 2  
Source: BIM Analysis Autodesk Revit 2022

In Figure 5 above, it can be seen that the daylight factor conditions in the Medina Residence 2 residential room, the highest daylight factor is in the Living room, which has a value between 5% - 7.8%, where it already meets the minimum standard of the room not to use artificial lighting. However, in the bedroom area, it is still below the 5% standard because there are no openings in the bedroom in the middle that lead to open spaces directly. The front bedroom can reach the outdoor space deadlock by the other room, so it has minimum access to natural daylight to enter the room. It is

impossible to apply cross ventilation in this room, and it will need artificial lighting during the daytime.

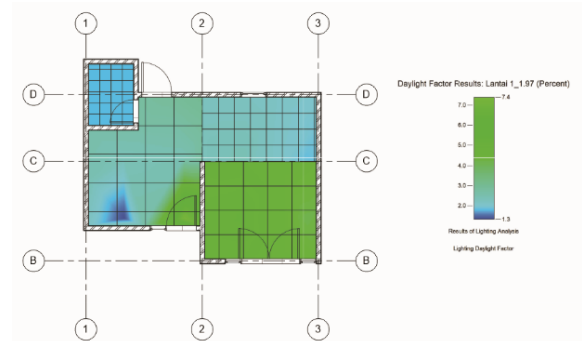


Fig. 6. Access Daylight Factor in Medina Residence 3 First Floor  
Source: BIM Analysis Autodesk Revit 2022

In Figure 6 above, it can be seen that the daylight factor conditions in the Medina Residence 3 1st floor residential room, the highest daylight factor is in the Living room, which has a value between 5% - 7.4% where it already meets the minimum standard of the room not to use artificial lighting. However, the living room area on the 1st floor is still below the 5% standard, which is in the range of 2%-3% because there is still a massive lack of openings in that area.

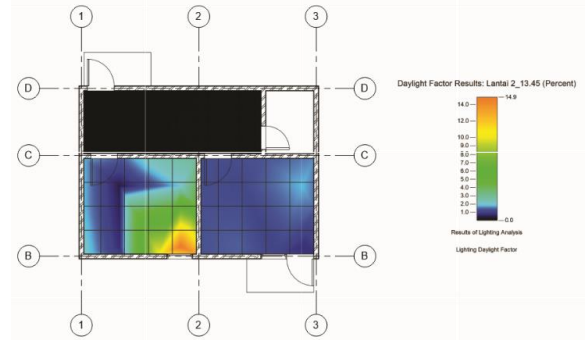


Fig. 7. Access Daylight Factor in Medina Residence 3 Second Floor  
Source: BIM Analysis Autodesk Revit 2022

Figure 7 above shows the daylight factor condition in the Medina Residence 3 2nd floor residential room. The highest daylight factor is in the left side bedroom, which has a value between 1% - 14.9%, where it already meets the minimum standard of the room not to use artificial lighting. However, the circulation space and stairs are still below the 5% standard due to the lack of massive openings in the walls.

**C. Comparison between quality and quantity of natural lighting.**

Based on some of the simulation results above, the comparison of the quality and quantity of natural lighting in housing with the concept of Islamic housing can represent. The three objects studied have almost met the standard criteria for penetrating daylight into the room, but some are still not good and not optimal, so improvements are needed to position the openings and the number of outlets to enter natural light into the space. Based on the evaluation before, Medina

Residence 1 has the nearest met the standard criteria of daylight factor on the housing, which has to mean achieved 5% of daylight factor in the building. However, the main room that must expose to sunlight during the day is the family room because this space is the center of activity for the house residents. The natural lighting conditions at Medina Residence 1 are still less reach the bedroom; the absence of the building lot void and a minimum of the opening in the bedroom can cause it. They have a minimum daylight factor value that compares to the specified standards. So we must modify the building design to maximize the penetrating of daylight through the bedroom. The Housing investors' statements regarding evaluating the quality of natural lighting in the room in table 2 below show the existence of a natural light opening that can maximize daylight penetrating through the room.

TABLE 2. Investor 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 interviews, evaluation of the existence of natural light openings that can reach the entire space shows that the object study fulfills the ideal criteria for the fact of natural lighting, as offered by a mean score of that variable is 5.278 on a scale of 6. It represented that some rooms have met the criteria but are not at all. In Islamic housing, there must be openings for natural lighting that can reach the entire space. There is a slight opening in the middle of the building by making a gap between the two lots on the middle side of the building.

D. Design Recommendation for Maximalizing Natural Lighting on Design on Medina Residence 1.

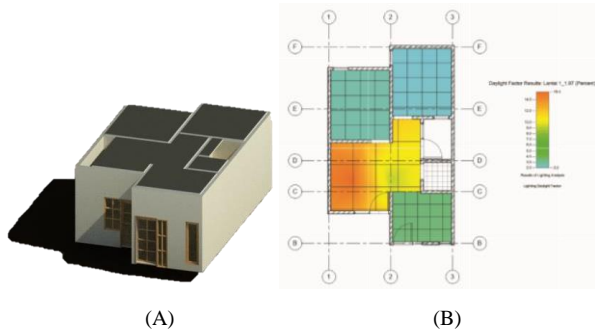


Fig. 9. (A.) BIM Model of Design Modify of Medina Residence by adding skylight opening and backyard 1 (B.) Access Daylight Factor in modification of building plan on Medina Residence 1 Floor  
Source: BIM Analysis Autodesk Revit 2022

As the primary research object, we are concerned about Medina Residence 1 because, based on the evaluation, this housing project has the ideal condition in building design that accommodates the Islamic housing concept. Figure 9 below shows the daylight factor conditions in the Medina Residence 1 residential room when a slight design change is made, namely shifting the bedroom and adding an opening in the form of a window on the back side of the building, the highest

daylight factor is in the family room which has a value between 9% - 15.4%, so the room does not require artificial lighting. The second bedroom has a daylight factor value of 2% to 4%. It indicates a higher level of sunlight penetration than the existing design of Medina Residence 1. This section, it is explained the results of the research and, at the same time, is given a comprehensive discussion. By this recommendation, we can maximalize natural daylighting but has a minimum space in the living room, but we can use a mixed-use living room as a women's guest room and the terrace as a men's guest room.

IV. CONCLUSION

Based on the analysis results from the simulation results using BIM Autodesk Revit 2022 and using the Insight Lighting Analysis feature, the first study object is obtained, namely, Medina Residence 1, which has a reasonably representative opening design compared to Medina Residence 2 and 3, this is due to the open space in the middle of the building, which allows light to enter the entire room. The function of the unbuilt space also supports this in the middle of the building as an inner courtyard which has many functions, such as the entry of natural light into the room, the entry of air in the middle of the building, a recreational function for residents who still provide more privacy to protect the private parts of the occupants.

After making design adjustments to the Medina Residence 1 building by adding an opening on the back side of the building and providing open space, the lighting in the bedroom, which was only 0.2-1%, increased to 2%-4%, shows that to meet the ideal criteria daylight factor for an Islamic residence, two open spaces required at the back and center of the building. In this specific recommendation for Medina Residence 1, the type of building opening is a skylight opening that uses transparent material on the building roof. The dimension of the skylight void is only 30 centimeters wide and 285 centimeters long.

Behind the building, we add more open space, 100 centimeters wide and 285 centimeters long, in the building lot. In this case, we can add a door to the backyard and a maximalized backyard as a service area, such as a laundry room. It will benefit some because of the premodified design and unavailable service area for a laundry room unseen from the living room. It will be more private for the user to dry personal clothes.

REFERENCES

- [1] M. B. Edrees, Konsep Arsitektur Islami Sebagai Solusi Dalam Perancangan Arsitektur, vol. 1. 2012. doi: 10.18860/jia.v1i1.1712.
- [2] A. Perdana, "Evaluation Of Physical Aspect Of Islamic Residential Concepts In The Sharia Housing Project," Journal of Architecture & Environment, vol. 19, 2020, doi: http://dx.doi.org/10.12962/j2355262x.v19i2.a6898.
- [3] M. E. U. L. Miles Institute, Real estate development: principles and process. Washington, D.C.: Urban Land Institute, 2013.
- [4] A. Perdana, "Evaluation of Real Estate Development Process in Sharia Housing Based on The Application of The Ideal Islamic Housing Concept," IPTEK Journal of Proceedings Series, no. 6, pp. 156-160, 2020, doi: http://dx.doi.org/10.12962/j23546026.y2020i6.9190.
- [5] Z. Amalia Bambang Pranggono, "Kajian Penerapan Prinsip-prinsip Perumahan Islami pada Perumahan Muslim Bukit Az Zikra," Seminar Penelitian Sivitas Akademika Unisba, vol. 3, no. 2, 2017.

- [6] M. B. Hermawan, "Explorasi "Rumah Tinggal Islami" Di Kota Pekanbaru," *Jurnal Arsitektur "Arsitektur Melayu dan Lingkungan,"* vol. 1, no. Januari 2014, pp. 1–16, 2014, [Online]. Available: <https://www.neliti.com/id/journals/jurnal-arsitektur-melayu-dan-lingkungan>
- [7] A.-M. Hwaish, *Concept of Islamic House ; A Case Study for Early Muslims Traditional House.* 2018.
- [8] I. M. Khan, "Liveability on Old Dhaka: Evolving residential patterns in Mohallas," *Regionalism in architecture,* 1985.
- [9] A. Mangione, B. Mattoni, F. Bisegna, D. Iatauro, and M. Zinzi, *On the Validity of Daylight Factor for Evaluating the Energy Performance of Building.* 2018. doi: 10.1109/EEEIC.2018.8494450.
- [10] L. N. W. Groat D., *Architectural Research Methods.* Wiley, 2013. [Online]. Available: <https://books.google.co.id/books?id=sUf5DPJyEqAC>
- [11] S. Kota, J. S. Haberl, M. J. Clayton, and W. Yan, "Building Information Modeling (BIM)-based daylighting simulation and analysis," *Energy Build,* vol. 81, pp. 391–403, 2014, doi: <https://doi.org/10.1016/j.enbuild.2014.06.043>.
- [12] K. Guo, Q. Li, L. Zhang, and X. Wu, "BIM-based green building evaluation and optimization: A case study," *J Clean Prod,* vol. 320, p. 128824, 2021, doi: <https://doi.org/10.1016/j.jclepro.2021.128824>.
- [13] I. Motawa and K. Carter, "Sustainable BIM-based Evaluation of Buildings," *Procedia Soc Behav Sci,* vol. 74, pp. 419–428, 2013, doi: <https://doi.org/10.1016/j.sbspro.2013.03.015>.
- [14] Q. Tushar, M. A. Bhuiyan, G. Zhang, and T. Maqsood, "An integrated approach of BIM-enabled LCA and energy simulation: The optimized solution towards sustainable development," *J Clean Prod,* vol. 289, p. 125622, 2021, doi: <https://doi.org/10.1016/j.jclepro.2020.125622>.
- [15] C. Cavalliere, G. Habert, G. R. Dell'Osso, and A. Hollberg, "Continuous BIM-based assessment of embodied environmental impacts throughout the design process," *J Clean Prod,* vol. 211, pp. 941–952, 2019, doi: <https://doi.org/10.1016/j.jclepro.2018.11.247>.
- [16] N. T. Pitasari, P. Setijanti, and S. Cahyadi, "Islamic Residential Concept on Sharia Housing Consumers' Satisfaction," *International Journal of Multidisciplinary Research and Publications (IJMRAP),* vol. 4, no. 7, pp. 11–15, 2021.