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Simulation of Solar Heat Distribution in Buildings Using FormIt Pro Software

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In a tropical climate like Indonesia, the sun plays an important role in architectural design. Sun simulation allows architects to understand and optimize the impact of sunlight on the building to be designed. It helps in designing sustainable and energy-efficient architectural designs by analyzing access to sun, shade, and natural lighting. Autodesk FormIt Pro is one of the most widely used software in industrial architecture, providing a solar simulation tool that allows architects to evaluate the best performance during the initial design stage. This study aims to provide an overview of the solar distribution simulation with FormIt Pro software in architectural design. The efficient solutions will be found to increase occupant comfort and reduce energy use for cooling. The method used is a simulation using FormIt Pro software, to describe the distribution of solar heat on the skin of the building. This research can help architects and engineers design buildings that are energy efficient. By knowing how to spread the sun's heat over structures, they can design buildings that are more comfortable and use less energy to cool.

Keywords: Sun simulation, Formit Pro, Architectural design

1. INTRODUCTION

Solar simulation in architectural design has significant importance in Indonesia. In buildings located in the tropics, thermal planning is often rarely taken into account (Purwanto, 2023). As a country with a tropical climate, Indonesia faces challenges in optimally utilizing sunlight to create sustainable and energy efficient buildings (Paramita & Koerniawan, 2013). Solar simulation allows architects to identify sunlight patterns during the year in different locations in Indonesia and understand their influence on design aspects such as daylighting, temperature regulation, and shading effects (Malyavina & Frolova, 2019). In both humid and dry tropical environments, heat calculations are used to calculate the amount of heat that enters the building through the walls due to sun exposure (Purwanto, 2019).

This study aims to offer a comprehensive exploration of the solar distribution simulation using the FormIt Pro software in the realm of architectural design. The primary objective is to provide an in-depth understanding of how this software facilitates the analysis of solar heat distribution within buildings. By focusing on the capabilities and features of FormIt Pro, the study aims to shed light on its role in optimizing architectural designs for enhanced energy efficiency and sustainability. The overview encompasses a detailed examination of the FormIt Pro software's tools and functionalities dedicated to simulating the distribution of solar radiation. Through this analysis, the study aims to elucidate how architects and designers can leverage the software to visualize and assess the impact of sunlight on various facets of building structures. This includes considerations such as natural lighting, thermal comfort, and the overall energy performance of the architectural design.

The study seeks to highlight the significance of solar distribution simulation within the broader context of architectural design. It aims to underscore how the integration of FormIt Pro into the design process contributes to informed decision-making and the creation of buildings that are not only aesthetically pleasing but also environmentally conscious. Furthermore, in the context of using FormIt Pro software for solar simulation in Indonesia, there is a need to explore the current state of affairs. Taking into account related research that has been conducted, as well as recent developments in solar simulation technology and architectural design, the planned research will serve as a new contribution to the use of FormIt Pro software for solar simulation in Indonesia. This research will help understand the potential use of solar simulation in the local context, facilitate sustainable building design, and support climate change mitigation efforts in Indonesia.

2. LITERATURE

By analyzing solar radiation, daylighting, shadows, and glare, architects can optimize design parameters and improve occupant comfort (Kim et al., 2016). Solar radiation energy intensity in Indonesia has an average of 4.5 - 4.8 kWh/day (Hasan et al., 2012: Putri et al., 2015; Tasri & Susilawati, 2014). In this context, research on the use of FormIt Pro software for solar simulation in Indonesia becomes relevant to support architecture that is responsive to the local climate and maintains occupant comfort. The integration of solar simulation in the FormIt Pro program improves analysis at the early design stage, increases energy efficiency, and facilitates design communication.

Many efforts have been made in research and development to improve solar simulation capabilities and its integration with architectural design software (Effendi & Danang Harito Wibowo, 2023). One of them is Ecotect software, which is a software for analyzing buildings that integrates 3D modeling with various types of building performance analysis and simulation (Putro, 2017). But since 2015, Autodesk shut down the development of Ecotect software to integrate functionality similar to Ecotect Analysis into the Revit product suite which was then replaced with Formit Pro software.

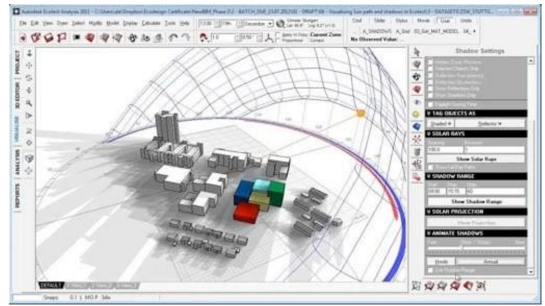

Figure 1: User interface Ecotect software

One of the related studies is a study conducted by Fikar (2019), which combines the use of BIM (Building Information Modeling) software with solar simulation to analyze the effect of sunlight on buildings in major cities in Indonesia (Fikar et al., 2019). Another related study tried to evaluate the performance of building facades for energy saving in Indonesia through thermal analysis and energy simulation (Widyaningrum, 2020). While not specifically focusing on solar simulation with FormIt Pro, this study provides an understanding of how building performance analysis can contribute to energy efficient design in Indonesia. There is also research using Sefaira software that uses solar simulation to evaluate the performance of the building envelope and to identify elements that have a significant influence on building performance (Octarino, 2022).

3. METHODOLOGY

This research uses a descriptive method to describe from the beginning of the research design to the research results. This research design uses Formit PRO software from Autodesk which can be directly connected to Revit. This research begins with determining the coordinate point or location which in this case is in the Gading Serpong area, where the building will be simulated. After determining the coordinate point or location, then draw the simplest form of building mass without using a roof. After that, the simulation of solar heat distribution on the building will show the difference in solar heat exposure to the building from the color notation displayed. The image will show which parts of the building will be exposed to more intense sunlight so that you can find out what to do to place any space in that part of the building.

Figure 2: Formit Pro Software

4. RESULT AND DISCUSSION

This research started with direct drawing using the Formit Pro program that has been developed by Autodesk to be more user-friendly. The drawing interface is designed in such a way that it is similar to the SketchUp program, with only slight differences in the icons used for drawing. It is intended that architects and architecture students can more easily operate this program, given the similarity of the interface with popular programs such as SketchUp. Thus, it is hoped that the use of Formit Pro can become more intuitive and familiar to its users in the architectural design process.

It is important to remember that in designing buildings in tropical climates, aspects such as natural ventilation, daylighting, and heat management are crucial. Therefore, Formit Pro's ease of use can help professionals and students to focus more on integrating these elements in their designs. The familiarity of the interface with similar programs can also speed up the design process and minimize the learning curve, thus allowing users to more efficiently respond to the specific needs required in designing buildings in tropical climates. In other words, the use of this program is expected to support the development of more optimal architectural designs that adapt to the tropical climate, resulting in comfortable and energy-efficient buildings that meet the needs of the local environment.

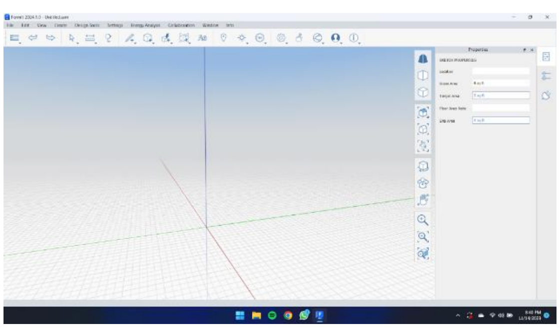
Figure 3: User interface *Formit Pro*

After entering the Formit Pro program, the first step is to set the unit settings to meters. This is important to ensure that the measurements and scales used in the creation of 3D models and simulations are in accordance with metric standards, which are commonly used in the world of architecture and building design. After changing the unit settings, the next step is to select the coordinate location where the building will be created to perform the simulation. This location selection involves determining the geographic coordinates where the building will be located. This information is particularly important in the context of analyzing local solar and climatic conditions, as factors such as latitude, solar declination, and solar movement throughout the year can vary depending on the geographic location.

By setting accurate coordinate locations, Formit Pro users can ensure that the resulting simulation reflects environmental conditions that match the actual place where the building will be constructed. This allows architects and designers to obtain more relevant and detailed information about the performance of the building in a specific geographical and climatic context.

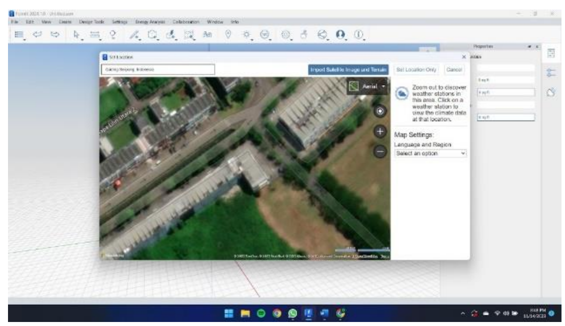
Figure 4: Determination of coordinate points

After establishing the specific coordinates and entering them into the work plane, the next step is to start creating a simple building model that corresponds to the predetermined location. In this case, we will create a rectangular building model with dimensions of 8 x 15 meters and 3 floors, each floor having a height of 3.5 meters. This building can be likened to a shophouse placed at certain coordinates.

First of all, the drawing of the building is done using the rectangle icon in the FormIt Pro software. By selecting the appropriate size, we create a rectangle with dimensions of 8x15 meters that represents the base of the building. Next, we elevate the building by selecting a part of its surface and pulling it upwards, so that it reaches a total height of 10.5 meters, which is equivalent to three floors. The process of dividing the building into 3 floors can be done by visually identifying each floor and ensuring that the height of each floor matches the desired height of 3.5 meters. Thus, we have successfully created a three-story representation of the building.

In addition to structure creation, FormIt Pro also provides area information per floor. This allows users to quickly and easily view and evaluate the distribution of space at each level of the building. By providing this data, FormIt Pro helps users to design buildings more efficiently, ensuring that the design meets the desired functional and aesthetic needs.

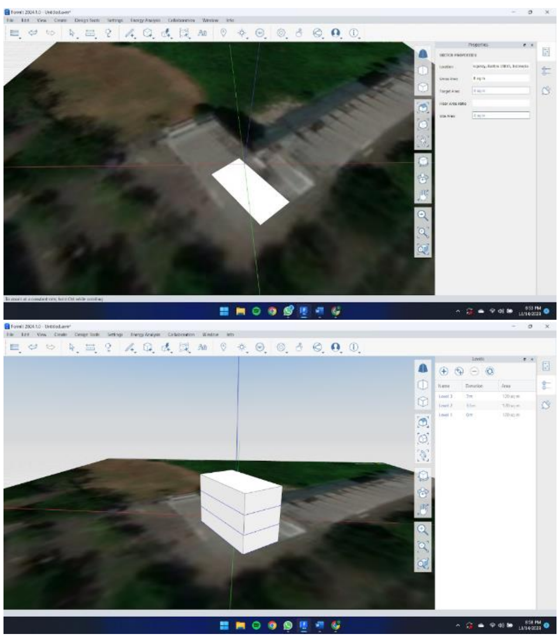

Figure 5: Modelling of a 3D model of the building on the specified site

After successfully creating a 3D model of the building to be simulated, the next step is to use the sun and shadow editor to reveal the shadowing that occurs on the structure, while also presenting a visualization of the sun's movement throughout the year. This process provides a deep insight into how sunlight interacts with the building during various times and seasons.

By utilizing the sun editor, users can specifically adjust the position of the sun to create realistic visual effects of shadows. This helps to evaluate the extent to which the building is exposed to sunlight at various angles and times of day. In addition, the use of shadows helps to clearly illustrate which areas may get direct sunlight and which areas may be more likely to be in shadow. Visualizing the movement of the sun throughout the year is also a key aspect of the simulation. By involving the element of time, users can see how the shading and sunlight patterns change with the seasons. This is important in designing buildings with aspects such as daylighting, improved energy efficiency, and space comfort in various weather conditions in mind.

Thus, the sun and shadow steps in this simulation not only provide an accurate visual representation, but also become an important tool for architects and designers to make informed decisions in building design, optimizing thermal and lighting factors to achieve the desired design goals.

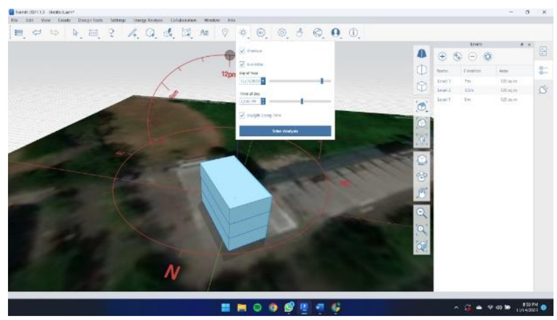

Figure 6: Sun editor and shadow

After obtaining visualization of shading and sunlight movement, the next step is to run solar analysis to perform solar simulation analysis on Formit Pro software. This process aims to get more in-depth information about the solar radiation received by the building at various times and conditions. Solar analysis brings a more comprehensive dimension to the analysis by considering factors such as solar declination, the latitude of a location, weather conditions, and the geographical location of the place. Solar declination refers to the angle between the sun's rays and the equatorial plane at any given moment, which affects the intensity of solar radiation received at that location. The latitude of the place where the building is located also plays an important role as it determines the height of the sun in the sky, which impacts the sunlight distribution of the place (Budiyanto et al., 2020; Susanto et al., 2022)

Weather factors and the geographical location of the site enrich the analysis by including variability in atmospheric conditions and differences in geographical position that can affect the intensity and duration of sunlight. All this information is combined to produce accurate data on the amount of solar radiation received at different parts of the building over time. By performing a solar analysis, architects and building designers can gain greater insight into the thermal performance of a building. This information becomes invaluable in optimizing designs to improve energy efficiency, daylighting and thermal comfort. By understanding the extent to which the building is exposed to solar radiation, Formit Pro users can make smarter and more informed decisions to achieve the desired design goals.

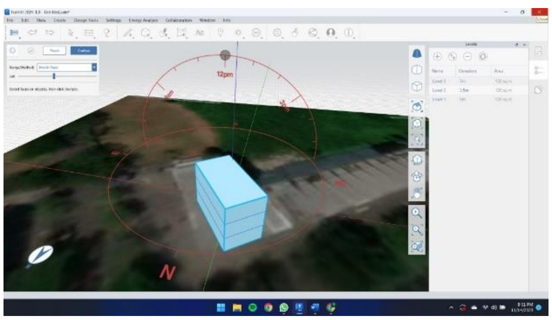

Figure 7: Interface solar analysis

When performing solar thermal analysis using the Formit Pro program, we can examine and understand the variations in heat distribution that occur on each side of the building that has been placed at predetermined coordinates. The simulation of solar radiation provides a clear visual picture, as seen in the figure below. In this simulation, the distribution of solar heat on each side of the building is represented by the use of different colors, according to the legend located at the bottom of the figure. The coolest color, which in this case is blue, reflects the area that receives the lowest intensity sun exposure or lower temperature. Conversely, the hottest color, indicated by yellow, indicates areas with the highest sun exposure or higher temperatures.

Through color representations that can be easily interpreted, Formit Pro users can quickly and accurately identify parts of the building that receive higher or lower sun exposure. This provides valuable insights in building design, allowing users to optimize window placement, use of shading elements, or other adjustments to achieve the desired thermal and lighting conditions. Thus, solar thermal analysis using Formit Pro not only provides quantitative information, but also provides a deep visual understanding of how sunlight interacts with each side of the building, allowing designers to make more informed decisions in the architectural design process.

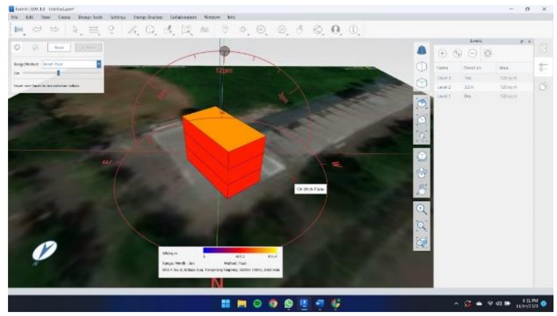

Figure 8: Simulation of solar anallisis seen from the north side

In the solar analysis simulation images, especially when viewed from the north side, the focus on 12 noon in June provides a deep understanding of the distribution of solar heat on different parts of the building. On the upper side of the building, located to the south, the most intense sunlight distribution is seen, indicated by the orange color reflected in the legend at the bottom of the figure. This orange color reflects the areas on the upper side of the building that receive the most intense sunlight at that time.

Meanwhile, on the northwest and northeast sides of the building, it appears that the intensity of sunlight was also quite high, although not as intense as on the top side of the building. The red color seen on these parts in the legend indicates that the sunlight was still quite hot in these areas at 12 noon in June. This information helps the observer to quickly identify the parts of the building that receive more significant sun exposure.

By illustrating the distribution of solar heat through the use of colors that can be easily interpreted, this simulation drawing provides a clear insight into how the intensity and distribution of sunlight varies on different sides of the building. This information is invaluable in the context of building design, as it allows designers to optimize design strategies such as window placement, addition of shading elements, or other modifications to achieve the desired thermal comfort within interior spaces.

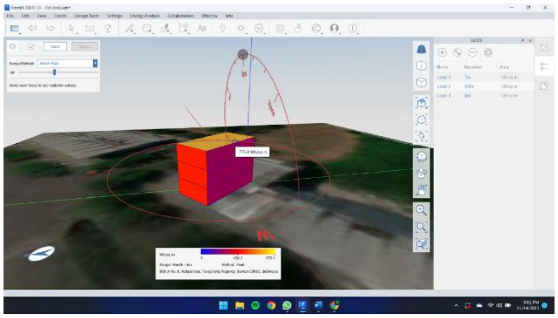

Figure 9: Simulation of solar anallisis seen from the west side

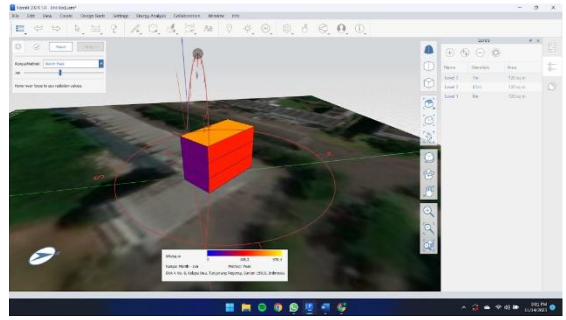

Figure 10: Simulation of solar anallisis seen from the east side

In the simulated solar analysis image viewed from the west side at 12 noon in June, the main attention is drawn to the distribution of sunlight on various parts of the building. On the upper side of the building, located to the east, the most intense sunlight distribution is seen, and this is indicated by the orange color listed in the legend at the bottom of the figure. This orange color indicates that the area on the upper side of the building received the most intense sunlight at that time.

On the northwest side of the building, it can be seen that the sunlight intensity was also quite high, and this area is marked in red in the legend. This red color reflects that the sunlight was quite hot on the northwestern part of the building at 12 noon in June. Furthermore, on the southwestern side of the building, it can be seen that the sunlight intensity is relatively lower compared to the northwestern section. This area is marked with a purplish-red color in the legend, indicating that the sunlight on the southwest side has a lower intensity or slightly cooler temperature compared to the other parts marked in red.

By presenting solar heat distribution information through the use of different colors, this simulation drawing provides a clear visual understanding of how sunlight intensity varies on different sides of the building at any given moment. This information is invaluable in the building design process, helping the designer to optimize the design to achieve the desired thermal comfort and daylighting.

In the simulated solar analysis image presented from the east side, focused at 12 noon in June, it shows different distributions of sunlight intensity on different parts of the building. The upper side of the building, which is to the southwest, receives the hottest sunlight distribution, and this is indicated by the orange color in the legend at the bottom of the image. This indicates that it received stronger sun exposure at that time. Meanwhile, on the northeast side of the building, it appears that the sunlight intensity is still quite hot, although not as intense as on the upper side of the building. This is reflected in the color map with red coloring in this area, indicating that sunlight remains significant in this section.

However, special attention is paid to the southeast side of the building, where the intensity of sunlight is seen to be the least of the entire building. This is indicated by the purple-to-blue coloration of the legend. This understanding provides valuable information in designing lighting and heat protection elements for certain parts of the building at certain times of the year. By interpreting these simulation results, architects and building designers can make more informed design decisions, such as window placement, material selection, or use of shading elements, to optimize thermal comfort and daylighting within the building throughout the year.

5. CONCLUSION

Formit Pro software plays an important role as an invaluable tool in understanding and analyzing heat distribution in buildings. Its ability to simulate solar heat distribution and provide real-time data throughout the year, based on user-selected coordinate points, makes it an ideal solution for the early design stages of the design process. By using this software, users can carry out a comprehensive analysis of heat distribution throughout the building space. These simulations provide an in-depth understanding of how solar heat penetrates into buildings at various times and weather conditions throughout the year. As a result, architects and building designers can make more informed and intelligent decisions in designing natural lighting, ventilation and temperature control systems in buildings.

The advantage of Formit Pro lies not only in its advanced capabilities, but also in its ease of use. As an accurate and user-friendly option, this software gives architectural professionals, students, and building designers an edge in simulating heat distribution in a building. In this way, users can optimize a building's thermal performance from the start of the design process, providing more efficient and sustainable results.

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