ECOTECT SIMULATION: ADVANCING ENVIRONMENTAL RESPONSIVENESS IN NATURE-BASED SCHOOL CONCEPTUAL DESIGN

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ABSTRACT

Balikpapan City focuses on the vision and mission of zero carbon emissions. One way to achieve this is to provide facilities with a sustainable natural school system with a green architectural approach. Students learn to care for ecosystems through hands-on, immersive experiences.
This research aims to obtain an optimal building design in response to the local climate to create user comfort in learning activities. A learning building must support a learning objective focusing on acquiring specific skills, knowledge, or competencies in a particular subject. Geographically, the design location is in a wet tropical sub-climate, so the potential for sunlight can be utilized as an alternative source of renewable energy in buildings. This research uses Ecotect simulations during the design process to ensure the schools are sustainable and environmentally friendly with a focus on ecological aspects and building performance.
This research uses quantitative methods to measure solar paths, radiation intensity, and shading indicators. The data collected guides the design process and creates energy-efficient and well-suited buildings to their environment. By integrating these insights from the beginning, nature-based schools in Balikpapan can become sustainability models, offering students an education deeply rooted in their natural surroundings. The results of this research are that the tropical climate at the design location can be used as an energy alternative in natural school buildings. However, the choice of building shape is a consideration in the design process because the shape of the building can influence the desired output.

Keywords: Balikpapan, Conceptual Design, Ecotect, Nature-Based School, Simulation

INTRODUCTION

Based on data released by the United Nations in terms of monitoring the impact of climate change, the greenhouse effect, which is a global pollution gas, comes from

carbon dioxide (76%), methane (6%), and fluorinated gas (2%) (the United Nations, no date). Derived from 2018, the government agreed to limit global temperature rise to no more than 1.5℃. However, the current carbon dioxide emissions pathway could increase global temperatures by as much as 4.4℃. This situation causes global warming, which is known as global warming. Global warming is the most critical problem for humanity today. Extensive use of energy is also the most significant contributor to carbon emissions because almost all power comes from fossil energy, which is non-renewable energy. It is necessary to implement strategies that target the reduction of greenhouse gas emissions to mitigate the impacts of climate change (Ainurrohmah, S., & Sudarti, 2022).

Numerous design concepts have emerged that attempt to overcome climate change issues. This approach is known as sustainable design, and it has led to the establishment of various building schools focusing on nature-friendly systems and sustainable technology, including green architecture, solar architecture, eco-architecture, etc. Eco-Tech architecture, as one of the streams of green architecture, focuses on integrating green architectural design and sustainable technology by using Ecotect simulation software to optimize the ecological aspects of buildings (Loiy, 2019).

A natural environment plays a crucial role in stimulating creativity among design students. The presence of greenery, natural topography, and a comfortable micro-climate are identified as essential elements that contribute to an ideal learning atmosphere (Anggraini, 2023). The concept is based on using nature's diversity as a learning space, where natural materials are used for students to create a sustainable environment. Nature schools prioritize practical learning over theory, allowing students to gain insights about the universe and the relationship between humans and the environment through hands-on experiences. Natural school buildings have their advantages compared to conventional schools. Natural school buildings adopt an environmentally friendly approach so that children can be healthier and more innovative (Safar, 2022). This is because the implementation of an environmentally friendly approach can make energy efficient, reduce carbon footprints, and good indoor air quality so that children are healthier and more comfortable. In addition, implementing the natural school education concept applies an environmentally based learning process so that students can apply the principles of sustainable resource management, such as collecting rainwater and using recycled goods that can reduce the overall environmental impact (Al Matsaany, 2024).

The fresh environmental conditions and strategic location make it an ideal site for developing a Nature-based School. This building is designed to serve as an integrated school for students from elementary to high school levels. It will include shared facilities to enable environmental sustainability, placing the site into specific needs that can be used together. This conceptual approach is applied to the design of nature-based school facilities by utilizing nature as alternative energy with the application of environmentally friendly technology, which is expected to become a forum for students by providing a natural, comfortable, and healthy space. The current challenge is utilizing eco-tech architecture with Ecotect simulation to create a design that responds to the climate. The goal and advantage of this design is to cultivate a nature-based school environment that leverages the natural surroundings

as an educational resource while fostering sustainable awareness among students. Based on the explanation above, the research question for this study emerged:

1. How does the design process produce building forms that appropriately respond to the climate?
2. What are the analysis results using Ecotect simulations regarding design recommendations that can make energy efficient?

THEORY / RESEARCH METHODS

Literature References

In modern times, architecture focuses more on sustainable buildings with the use of solar panels, water management, natural ventilation, employing various technologies and techniques including computer simulation (Ascione, 2017). The application of ecological architecture gradually changes the way conventional energy is used to energy that is more environmentally friendly and compatible with the environment.it encompasses a range of principles and practices aimed at creating buildings that are in harmony with the natural environment, using environmentally friendly technologies, and promoting a good quality of life for occupants. One application of ecological architecture is ecotect architecture.

Etymologically, Eco-Tech architecture comes from two words: ecology and technology. Ecology means natural science or the study of the reciprocal relationship between living things and the environment (Catherine Slessor, 1997). Meanwhile, technology can be interpreted as manipulating the environment to make human life more manageable. Based on this, the Eco-Tech Architecture concept utilizes existing technology by paying attention to the environment's and nature's potential to form an optimal built environment (Sukawi, 2008). A building design approach that uses environmentally oriented technology by paying attention to the potential of the surrounding climate is called the Eco-Tech architectural design approach. The principles of the Eco-Tech Architectural design approach are (D Trisnawan, 2017):

a. Energy Matters by using renewable energy sources, such as solar energy, wind energy, water energy, geothermal energy, and so on.
b. Urban Response, namely responding to the climate at the site location by using sustainable technology, which is then simulated using applications/software.
c. Making Connection, namely maintaining the relationship between buildings and nature by utilizing green roof technology and inner courts in building.
d. Structural Expression is the expression of a structure by utilizing technology. For example, it can use forms inspired by nature, such as kinetic facades inspired by four o'clock flowers responsive to the sun's heat.
e. Sculpting with light by applying unique geometric patterns to the building facade creates an attractive light display.

f. Civic Symbolism, namely the application of advanced technology, includes a natural schooltime facade, so that it becomes a symbol of technological progress in the local area.

In addition, as an eco-tech architecture design concept, the eco-architectural concept has several levels of operational systems used in building energy use with the following classification:

a. Passive System (passive mode) (Figure 1), by minimizing M.E. (Mechanical Electricity) from non-renewable resources is the lowest-cost way to reduce energy consumption (Ifechukwu Gil-Ozoudeh, Obinna Iwuanyanwu, Azubuike Chukwudi Okwandu, 2022).

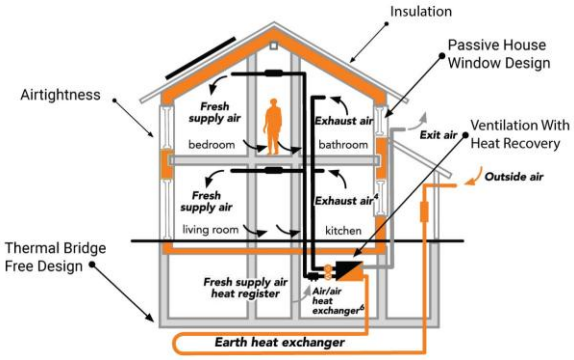


Figure 1. Passive House Diagram
Source: https://passivehouse.cy/

b. Hybrid System (mixed mode) (Figure 2), where some are assisted by the use of M.E. (Mechanical Electricity), and some do not use energy (energy independent).

Figure 2. Hybrid System Diagram
Source: deloitte.com

c. Active system (active mode), where all of them use M.E. (Mechanical Electricity) equipment, which comes from non-renewable energy (energy-dependent).
d. Productive system (productive mode), as systems that can provide their energy (on-site energy) from renewable resources, such as solar cell systems (photovoltaic) or solar collectors (thermosiphon).

Methodology

This study employs a quantitative descriptive method. After determining the location, the data will be simulated using the Ecotect program. Subsequently, an analysis will be conducted based on the planned design concept. The study utilizes literature and precedent studies to enhance comprehension of theories relevant to the discussion.

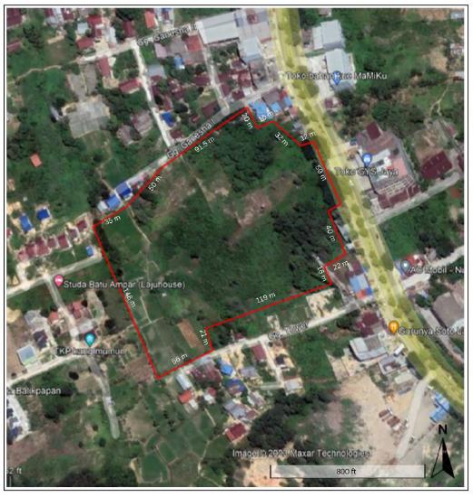


Figure 3. The location of the Nature-based School in North Balikpapan
Source: Google Earth, 2024

The research location is on MT Haryono Street, North Balikpapan, Balikpapan City (Figure 3). Balikpapan City has a tropical climate influenced by its geographical location which is located close to the equator. Balikpapan City has a wet tropical climate, where the average temperature tends to be stable, namely between 25°C to 31°C with quite intense rainfall that can reach 300 mm or more. The area of the research location is 16.8 hectares, where according to the Balikpapan City Spatial Planning document, Batu Ampar Village in North Balikpapan District serves Muara Rapak Village, Graha Indah Village, Gunung Samarinda Village, Gunung Samarinda Baru Village and Karang Joang Village with a function as a center for trade services on a sub-district scale and a city-scale education center.

Researchers analyzed the implementation of Eco-tech architecture in the design development process, and several shape simulations were carried out to

obtain a shape that could respond to the climate optimally. The shape is simulated using sun path analysis to react to sunlight and the surrounding environment (Figure 4). From several criteria for eco-tech architectural principles, there are several similarities in applying these criteria.

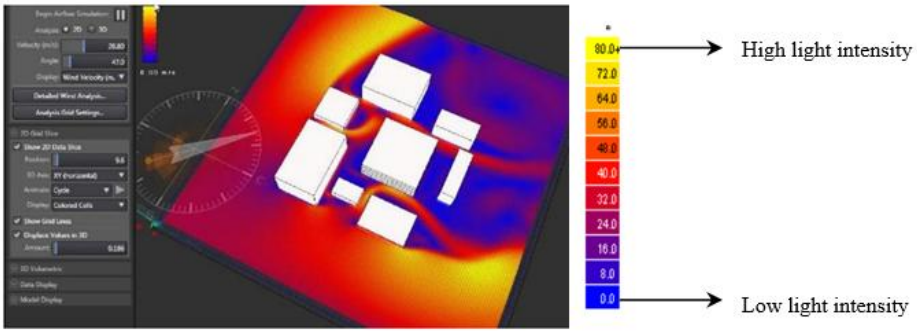


Figure 4. Display Simulation Result of Ecotect Software

The analysis was simulated using Autodesk Ecotect software, launched in 2010. Simulation with Vasari Autodesk Software was used to determine the performance of the Nature-Based School design with acoustic and thermal simulation of the room. After the analysis, it can be determined what alternatives can be used to optimize building performance. The Vasari project focuses on conceptual building design using geometric and parametric modeling. Building performance optimization is a crucial aspect of sustainable design, focusing on energy efficiency and environmental impact. Various studies have explored methods to optimize building performance through energy analysis, simulation tools, and optimization algorithms (Mohammed Sharar, Kofi Agyekum, Patrick Manu, Che Khairil Izam Che Ibrahim, Abdul-Majeed Mahamadu, Maxwell Fordjour Antwi-Afari, 2022). In the early stage of building design, the simulation software Ecotect is used to analyze and evaluate in design process, which mainly includes the modeling, parameter setting of ecotect, thermal environment analysis, and daylighting analysis, then makes corresponding adjustments to the design based on the simulation results (Yagi, 2023). The results of the Ecotect analysis are presented in diagrams and visualization images that display the color distribution of light factors affecting light intensity and room temperature. According to the simulation, the areas represented in yellow indicate high sunlight intensity and hot temperatures, while those closer to blue indicate low or no sunlight intensity and low temperatures.

The impact of this simulation is that architects can find out that the potential intensity of sunlight can be used as a substitute for lamps during the day. Therefore, the form used must have a cavity to let in sunlight. In addition, the orientation of the building also dramatically determines the design's success. In addition, based on the simulation results, it can be seen what technology is suitable to be applied to buildings to respond to climate and make energy efficient.

Thus, based on the above explanation, the following is the flowchart of the research conducted (Figure 5).

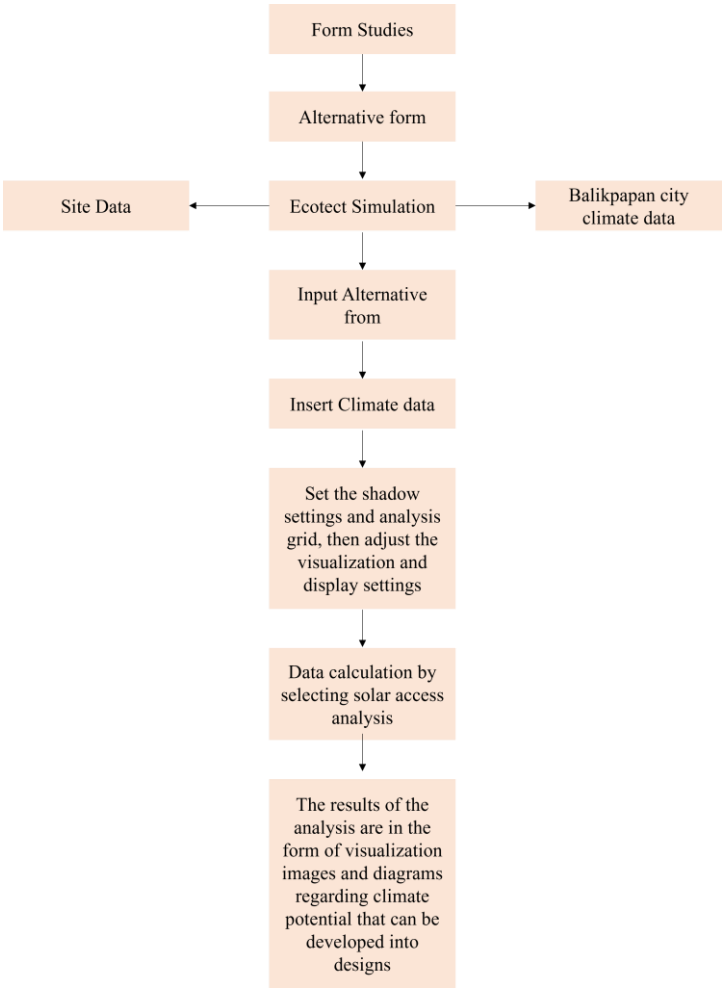


Figure 5. Flowchart of the Research

RESULTS AND DISCUSSION

In architecture, form is related to function, serving as a space to provide a particular expression. The connection between form and function can be explored through ontological modeling (Bhatt, M., Hois, J., & Kutz, 2012). Ecological architecture theory emphasizes harmonious relationships between natural and human elements, drawing inspiration from nature's forms and processes (Gamage, A., & Hyde, 2012). The natural functions and processes of ecological systems influence the building's shape, drawing inspiration from plants, animals, and humans. The form in this design is obtained based on the analogy of the human brain, which regulates the work of the body and organs, as well as emotions and emotional responses in the human body. The function is applied to the shape of the building with the hope that

normal children and children with special needs can manage and recognize their emotions well and have advantages in knowledge and expertise regarding sustainable systems. The study of form will be analogous to the form of the amygdala. The form is chosen based on the analogy of the human brain, which is the core that regulates all organisms and the performance of the human body (Marco, Mirolli., Francesco, Mannella., Gianluca, 2010). One part of the brain is the amygdala, a regulator of emotions and human emotional responses. The shape of the amygdala is based on the shapes of circles and oval shapes. The illustration can be seen in the following Figure 6 & 7.

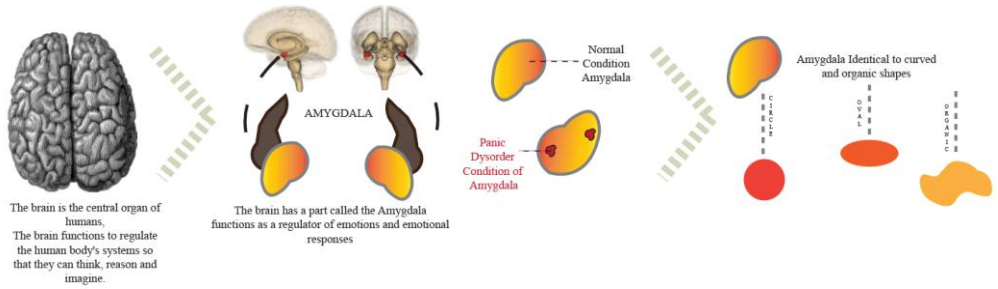


Figure 6. Form Transformation of Amygdala

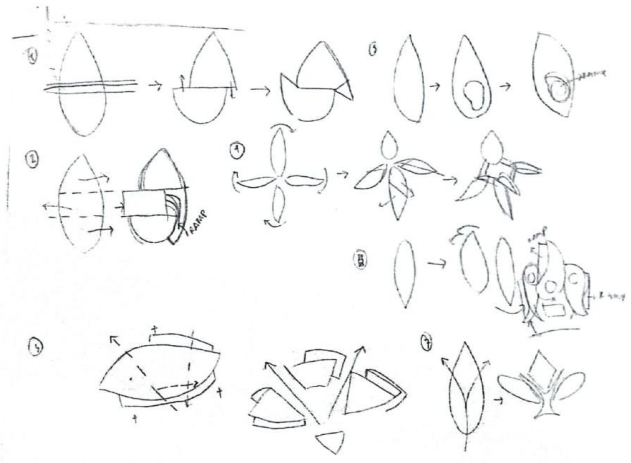


Figure 7. Exploration of Building Form

Circle Shape

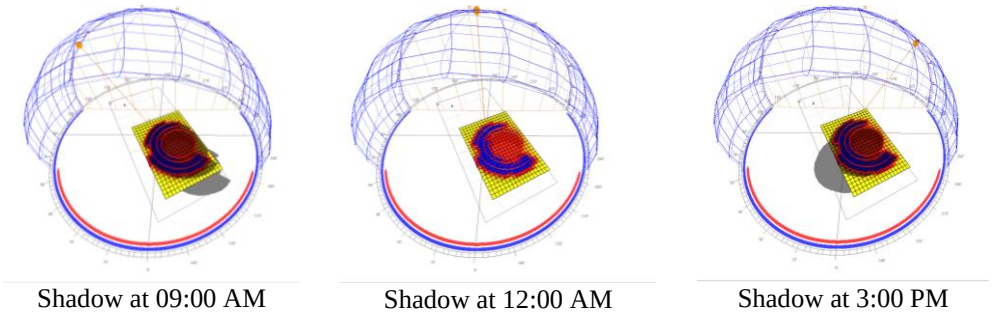


Figure 8. The Rotation of The Sun on a Site at a Particular Hour Using Western Indonesian Time

According to the Ecotect software simulation, the building is well-positioned to receive sunlight and maximize its benefits. The building is oriented 45 degrees north and provides plenty of shading to protect the surrounding area from excessive heat. However, the side of the building that is exposed to sunlight experiences intense heat, leading to hot and humid conditions inside, which makes it less comfortable to use. Additionally, a significant amount of energy is required to regulate the room temperature for improved comfort.

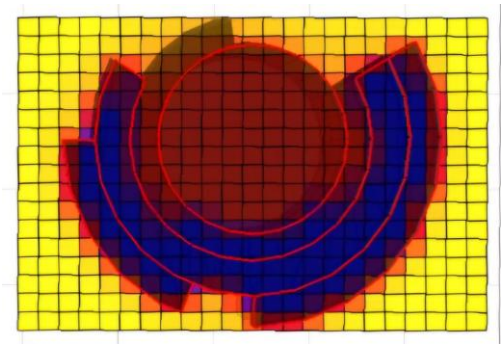
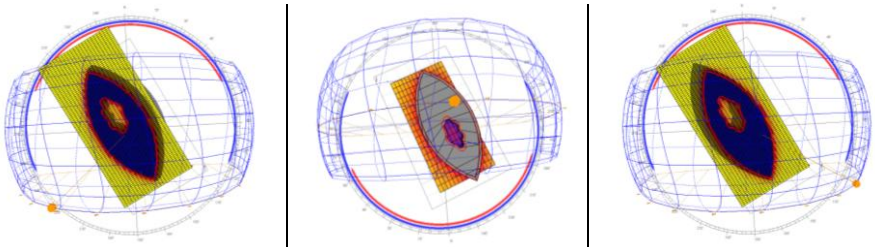


Figure 9. Daylight Simulation Results in Circle Forms

Simulations using circular shapes show that light distribution in buildings is invariant (Figure 8 & 9). This is because the circular shape does not have an angular surface, so the entire area of the shape can be exposed to sunlight. In the picture above, the center of the building is red, which means the area has high light intensity and warm temperatures. Meanwhile, the blue area means that the area has a low temperature and no sunlight intensity.

Oval Shape



Shadow at 09:00 AM | Shadow at 12:00 AM | Shadow at 3:00 PM

Figure 10. The Rotation of The Sun on a Site at a Particular Hour Using Western Indonesian Time

The oval shape shown in simulations with Ecotect software is based on the direction of sunlight (Figure 10). The building can respond well to sunlight on the site. Each side of the building faces 45 degrees North so that the longest side of the building faces east-west. Therefore, special treatment is needed on the longest side of the building, such as the addition of overhangs and sun shading to filter the light entering the building.

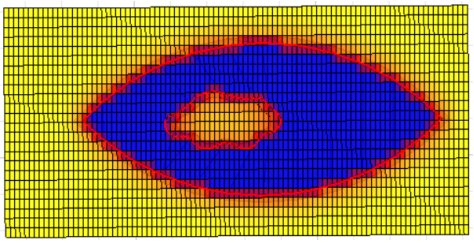


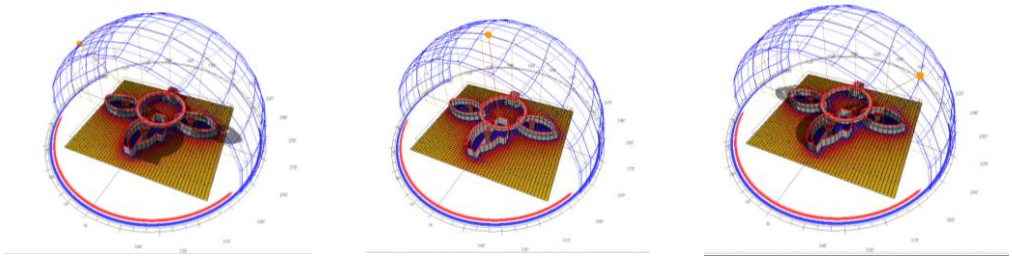
Figure 11. Daylight Simulation Results in Oval Forms

According to the simulation results, both oval and circular shapes are responsive to light due to their exposure to sunlight (Figure 11). Additionally, the void section plays a crucial role in allowing light and wind to enter the building, which helps to maintain a pleasant temperature in the room. Based on this analysis, the oval shape is the preferred form for the building's design. This shape effectively responds to the surrounding climate. It can be utilized as alternative energy in buildings, promoting sustainability and reducing the reliance on non-renewable energy for operating supporting equipment.

Final Shape

The building mass is separated into elementary school zones, middle school zones, and high school zones. In addition, to create interaction between users, corridors, and ramps connect all spaces to facilitate access to each space. Completing the

spatial layout is also aligned with the eco-tech design approach, namely by creating a connection between the building and the environment, where the garden is used as a barrier between one building and another. Apart from that, the building layout has also been adapted to the site's climate conditions so that it can be responded to by utilizing the climate as an element for lighting, ventilation, and alternative energy sources.



Shadow at 09:00 AM | Shadow at 12:00 PM | Shadow at 3:00 PM

Figure 12. The Rotation of The Sun on a Site at a Particular Hour Using Western Indonesian Time

Upon reviewing the analysis, it is evident that the primary form utilized in the design of this nature school is an oval shape. The oval shape effectively adapts to the surroundings and climate of the site. Moreover, its curved structure offers superior durability compared to geometric shapes as it evenly distributes the load, minimizing the risk of damage in an earthquake due to its increased stability. Additionally, the curved shape enhances the building's aesthetic appeal through a sense of harmony and rhythm. The decision to opt for this shape was influenced by its ability to optimize sunlight penetration and accommodate natural wind movement.

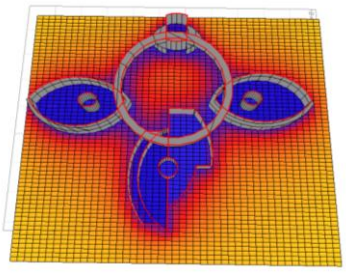
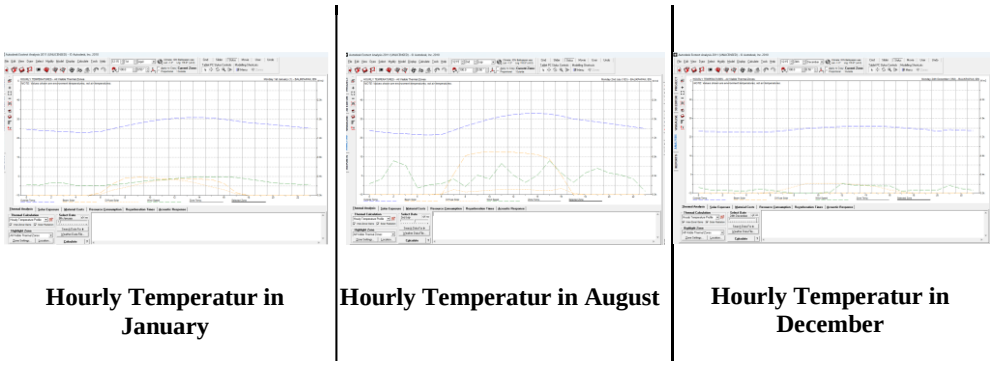


Figure 13. Daylight Simulation Results in Final Forms

The analysis of the sun's path has informed the design, effectively leveraging sunlight across the site, as evidenced by Ecotect simulations (Figure 12 &13). The simulations reveal a color-coded temperature response to sunlight exposure: areas depicted in blue indicate cooler temperatures, often in spaces shielded from direct

sunlight. In contrast, purple signifies regions receiving indirect sunlight, suggesting a moderate temperature increase. Adjacent areas are highlighted in orange, indicating they are bathed in sunlight without causing glare or excessive heat, making these spaces comfortable. The yellow color denotes areas where the sunlight is direct and intense, leading to higher temperatures. Despite this variation, the simulation shows a balanced distribution of light around the building, ensuring that the light intensity remains suitable for various activities without causing discomfort.

However, wider locations experience higher light intensity, with an average temperature of around 28°C and increasing to 34°C during the day (Occurring at 12 PM-1 PM). This underscores the need for architectural interventions like installing sunshades, overhangs, and canopies to mitigate the impact of direct sunlight. Furthermore, the site's exposure to solar heat presents an opportunity to harness solar energy as an alternative power source for the building, emphasizing a move towards sustainability and energy efficiency in the design process.



Hourly Temperatur in January | **Hourly Temperatur in August** | **Hourly Temperatur in December**

Figure 14. Hourly Temperature Profile in January (Early Year), July (Mid Year), and December (End of Year)

Based on Figure 14, it can be seen that the average daily temperature has differences in certain quarters, whereas in January, the daily temperature is 25°C - 32°C. It has average wind and sunlight intensity and is still within comfortable limits. In July, the daily temperature is 24°C - 34°C, with wind and sunlight having a higher intensity than in January and December. In December, the daily temperature is 23°C - 26°C, with the intensity of wind and sunlight being low and not as intense as in July. Based on the data above, the highest daily temperature is optimum at 12.00 AM - 01.00 PM. Light intensity begins to appear at 5.30 AM - 05.30 PM, and high wind speeds occur in July and August in the dry season.

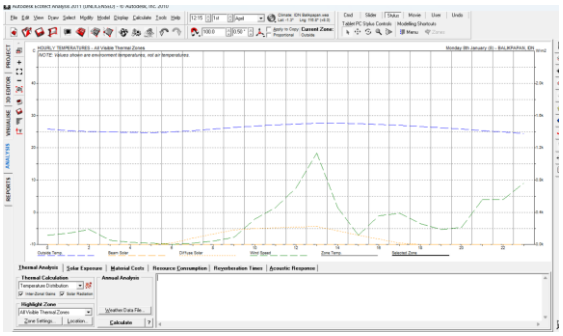


Figure 15. Annual Temperature Distribution in Final Form

Based on data from the Ecotect temperature distribution simulation, the temperature in the building is on the verge of comfortably warm, namely at 24°C - 27°C with a humidity level of 80% (Figure 15). The optimum point for wind speed at the site is 18 m/s at 01.00 PM. Diffuse solar radiation starts from 06.00 AM to 03.00 PM.

Based on the analysis done with the simulation software Ecotect Vasari, the results show that the form can affect the performance system and energy used in a building. The selection of building forms can be done by exploring the form and simulation to optimize the performance of sustainable buildings. Overall, integrating form optimization and performance analysis in the design process can significantly enhance building sustainability and energy efficiency. Ecotect simulation analyzes the sun's path on the site and building. The simulation results are in the form of local climate responses to the distribution of sunlight and wind in the building area, so the results are in the form of data used during the design process. With the simulation using Ecotect software, the results are in the form of diagrams regarding daily thermal and temperature on the site and building so that they can guide the design process and create energy-efficient buildings in the surrounding environment. So, nature-based schools can become sustainable models and offer students an education firmly rooted in nature.

Future Recommendation

The future recommendation will consider the principles of Eco-Tech Architecture and their implementation in building concepts.

a. Making Connection: Based on the circulation and access analysis, the building is grouped into public, semi-private, and private zones. The public zone is an open space that can be accessed by the public or the community around the site. In addition, the building's connections are designed with the analogy that users are interconnected across different floors, allowing them to see other users on the upper or lower levels, as illustrated in Figure 16.

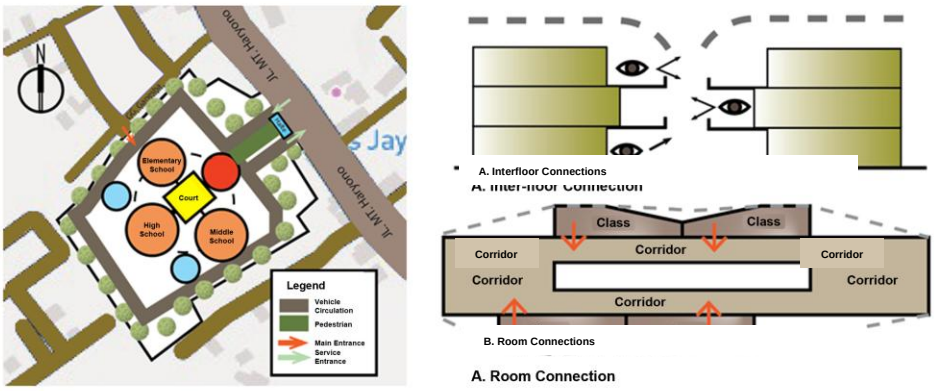


Figure 16. Building Zone and Connections

b. Urban Response: Based on the site analysis, the zoning around the site is still surrounded by green areas. Therefore, in the design of the inclusive nature school, the building only uses land efficiently, where the building will be made vertically upwards so that the potential of the green area can be maximized as a plantation area, park, and water absorption (Figure 17).

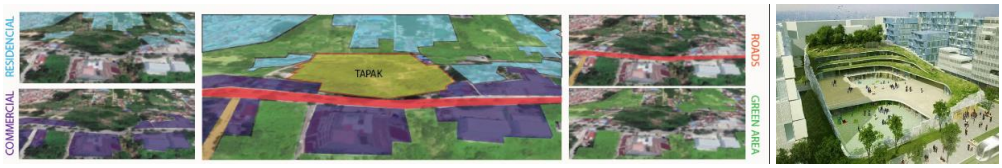


Figure 17. The Existing Site Conditions and The Implementation of the Green Roof Concept as a Responsive Solution

c. Civic Symbolism: A responsive facade to temperature and light, where the facade can automatically open and close by utilizing temperature and light sensors. Then, glass with a double-glazed system is used on the façade (Figure 18).

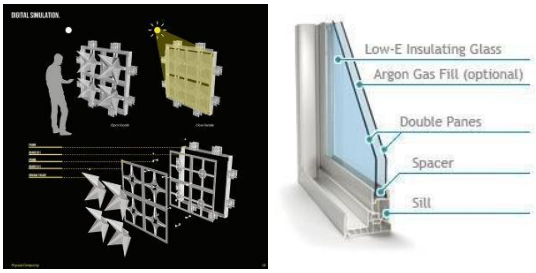


Figure 18. (a) Aplication of Kinetic Facade (b) Photovoltaic Glass System
Source: (a) behance.net (b) milgard.com

The use of local cultural elements as regional characteristics, such as implementing Kalimantan motif elements and typical East Kalimantan colors (Figure 19).

Figure 19. Local Culture as An Implementation of Technological Progress in the City of Balikpapan

d. Structural Expression: The structure is utilized as an aesthetic element, with a play of patterns in the sun shading (Figure 20). The pattern on the building has a linear pattern that is arranged in such a way as to form a texture as an expression of the structure, and the proportion of the structure uses different scale variations but has harmony so that it is easy to remember and can increase affective preferences for sensory stimuli.
The building has a dynamic shape with varying shapes, creating a building that is not monotonous. In addition, the separate shape allows the building to optimize natural ventilation and lighting.

Figure 20. Sun Shading as a Visual Feature and Structure as an Element of Aesthetics
Source: archdaily.com

e. Energy Matters: Using active, passive, and productive mode. Passive Mode utilize sunlight for natural lighting to the maximum during the day by facing the building orientation parallel to the sun's path and paying attention to building openings of no less than 10% (Figure 21).

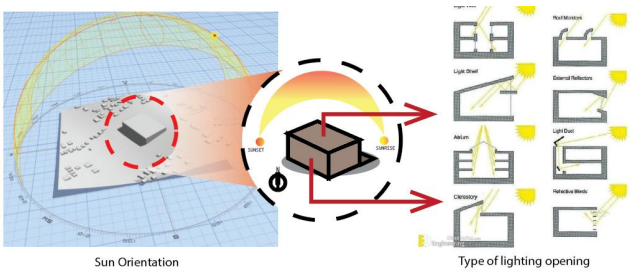


Figure 21. Utilization of Sunlight for Lighting as an Implementation of Passive Mode Strategy

Natural ventilation can be utilized as a substitute for artificial air conditioning (air conditioner) by making openings with ventilation sizes of not less than 5% of the floor area (SNI-03/6572/2001). The openings must be located in areas with wind flow so that they can work well. In addition, the opening system used is a cross-ventilation system (Figure 22).

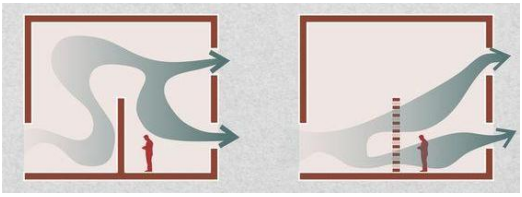


Figure 22. Implementation of a Coss-ventilation System

Utilizing rainwater in an innovative way can be processed for domestic purposes with a rainwater harvesting system (Figure 23).

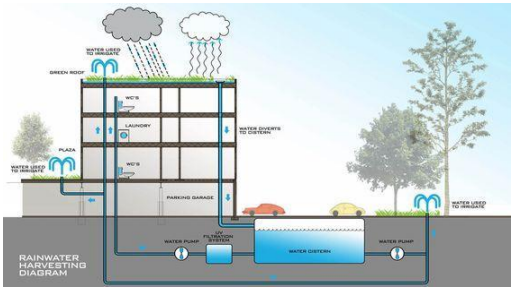


Figure 23. Implementation of a Rainwater Harvesting System
Source: i.pinimg.com

Optimization of vegetation as a heat shield. Vegetation used as a heat shield is vegetation with a wide canopy with a minimum diameter of 2 meters (Figure 24).

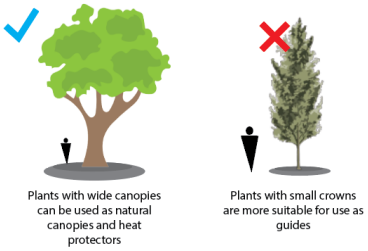


Figure 24. Use Plants with Wide Crowns as Shade

Utilization of sun protection (shading device). The shading device must be placed according to the location of the incoming sunlight. The shading devices used in buildings are sun shading, canopies, and overhangs. Active mode uses ventilation such as fans and air conditioners, considering the need for mechanical ventilation (Table 1).

Table 1. Air Circulation Requirements in Spaces with Mechanical Ventilation
Source: SNI 03-6572 (2001)

Type	Minimum fresh air supply	
	Air exchange / Hours	m^3 / Hours per person
Office	6	18
Restaurant/canteen	6	18
Supermarket/grocery store	6	18
Factory/workshop	6	18
Class/cinema	8	
Lobby/corridor/stairs	4	
Bathroom/toilet	10	
Kitchen	20	
Basement	6	

Productive mode uses photovoltaic solar cells or solar collectors (thermosiphon) (Figure 25).

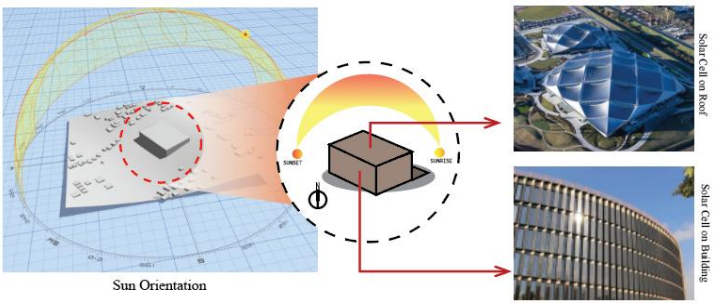


Figure 25. Application of a Solar Cell System

f. Sculpting with light: Including natural lighting and artificial lighting. To maximize lighting in the building, glass elements are used in each space for natural lighting (Figure 26).

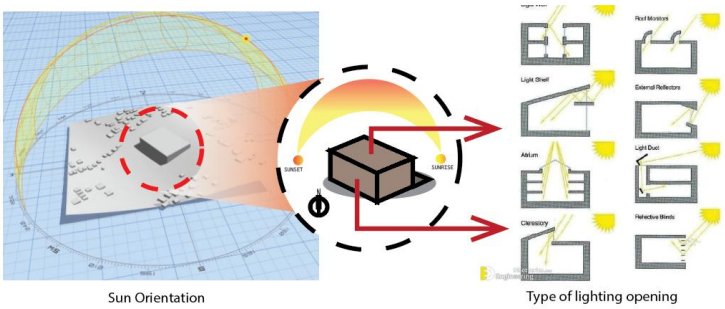


Figure 26. Application of Types of Openings in Buildings

For artificial lighting, Materials with light colors are used to reflect the lighting in the room. The play of light colors is also used as an addition to the ambiance in the room. The use of light colors that will be used are as listed in Figure 27.

COLOR TEMPERATURE	WARM WHITE	SOFT WHITE	NEUTRAL	COOL	SOFT DAYLIGHT	DAYLIGHT
KELVIN	2700K	3000K	3500K	4100K	5000K	6500K
MOOD & EFFECTS	FRIENDLY, PERSONAL, INTIMATE	SOFT, WARM, PLEASING LIGHT	FRIENDLY, INVITING, NON-THREATENING	NEAT, CLEAN, EFFICIENT	BRIGHT, ALERT	BRIGHT, COOL
APPLICATIONS	HOMES, LIBRARIES, RESTAURANTS	HOMES, HOTEL ROOMS, LOBBIES, RESTAURANTS, RETAIL STORES	EXECUTIVE OFFICES, PUBLIC RECEPTION AREAS, SUPERMARKETS	OFFICES, CLASSROOMS, MASS MERCHANDISERS, SHOWROOMS	GRAPHICS INDUSTRY, HOSPITALS	JEWELRY STORES, BEAUTY SALONS, GALLERIES, MUSEUMS, PRINTING

Figure 27. Light Color Scheme
Source: repository.ub.ac.id

Final Design

The final design was obtained based on data analysis processing and Ecotect analysis. With Ecotect analysis, we can produce better and optimal design results in responding to the climate and recognizing the potential that can be used and beneficial for sustainable buildings and the environment. Here are the results of the transformation of the building on the site with sun path and wind illustration (Figure 28 & 29).

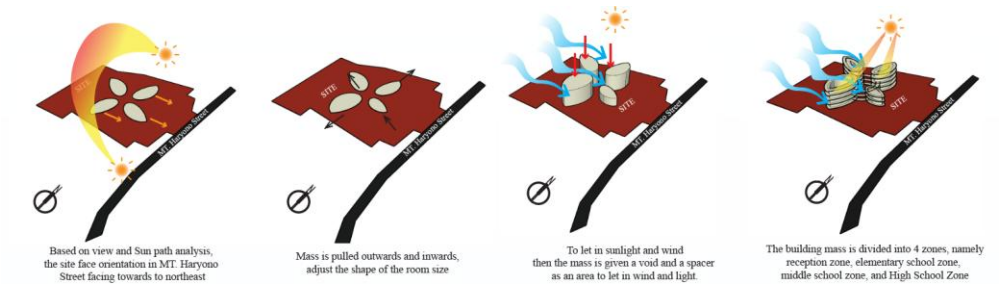


Figure 28. Transformation of Building Form Based on Response to The Surrounding Climate

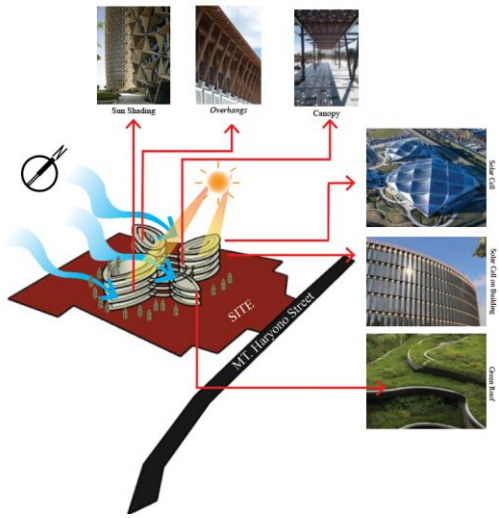


Figure 29. Implementation of Sustainable Features in the Final Design

CONCLUSIONS

Based on the analysis that has been made, it can be concluded that designing a natural school with an eco-tech architecture approach can be carried out by taking advantage of the tropical climate of the city of Balikpapan and the surrounding environmental conditions. Using an architectural eco-tech approach plays a role in increasing the ecological value of the environment. The eco-tech architectural approach is ideal because its principles are in harmony with the natural school, where eco-tech designs are usually designs that respond to the climate potential of the site by utilizing the latest technology.

The research's goal requires analyzing school design forms using Ecotect software, which helps to inspire the suit form by the amygdala's shape. The comfort and setting arrangement of the educational facility will contribute to achieving the learning goals. In exploring forms, architects choose natural forms that respond well

to nature. The nature form chosen is also based on the school's objectives. The forms that emerge during the design process are selected not only based on philosophical aspects but also through simulations so that the final result is most responsive to the surrounding climate. After analyzing several form options, a design result was achieved that answered the needs of a natural school by considering aspects of the Ecotect architecture approach, such as energy matters, Making Connections, Urban Response, Structural Expression, and sculpting with light. Aspects of this approach have appeared in the design recommendations subchapter by applying aspects of sustainable technology to the building concept. Apart from that, the application of technological systems such as the hybrid system and passive design has emerged with solar cells, cross-air ventilation, and natural lighting with void systems and wide openings in buildings. Additionally, sensors are used on lights (automatic lighting systems), water (automatic taps), and rainwater harvesting systems to streamline energy use.

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