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06

REDEVELOPMENT OF BOAT TERMINAL KUALA BESAR, KOTA BHARU, KELANTAN: SUSTAINABLE DESIGN APPROACH USING MIXED MODE SYSTEM IN A DESIGNATED BUILDING

Sali Amalia Razali, Aliyah Nur Zafirah Sanusi*, Zuraini Denan
Department of Architecture and Environmental Design, KAED, IIUM

ABSTRACT

The Boat terminal Kuala Besar is mainly used by villagers who live near Kuala Besar Village as their primary source of income for activities like fishing and transferring goods. In addition, it serves as the mode of transportation to Tumpat Island for daily commutes and tourism purposes. Nevertheless, the boat terminal now lacks several necessary facilities, such as a proper ticket booth, a decent waiting space for passengers, a functioning jetty, an accessible public restroom, and a prayer room. The projects also focus on how to integrate the systematic plan layout into building programming. Nevertheless, there are some environmental damages to the river, such as erosion and low and rising water levels in the Kelantan. Therefore, the intention is to redevelop the existing Boat Terminal Kuala Besar to meet the needs and demand based on the large capacity of the visitors concerning their comfort and safety through a sustainable design approach by using a mixed-mode system in a designated building. It is also in line with 2035 Kota Bharu (MPKB-BRI) local planning, the Lembaga Kemajuan Ikan Malaysia (LKIM), Boat Terminal Kuala Besar will become an agrotourism destination that will increase in the number of visitors (https://mpkbbri.kelantan.gov.my, 2022).

Keyword: Redevelopment, Boat Terminal, Sustainable Design, Mixed Mode System, Kuala Besar, Kelantan
* Corresponding author: aliyah@iium.edu.my

INTRODUCTION

According to McGee's (2013), passive design can help achieve thermal comfort within a structure by considering the hot and humid local climate, the building's site location, and the properties of building materials. By utilizing passive solar gain, cooling, and natural heat and air movement, passive design can significantly reduce a building's energy consumption. According to the Malaysian Standard 1525 code of practice, there are seven key passive design strategies: building orientation, natural ventilation, daylighting, thermal insulation, strategic landscaping, façade design, and renewable energy. This code is in the interest of many architects in the modern movement toward sustainable and passive design. The application of passive design aims to provide thermal comfort for users by leveraging natural heating and cooling methods, such as wind and solar breezes, to minimize temperature fluctuations and improve indoor air quality.

As a result, users will benefit greatly from the proper implementation of passive design strategies using a mixed-mode system. For instance, integrating daylighting, façade design, and thermal insulation, three of the seven sustainable design techniques, can optimize natural light and thermal comfort while minimizing solar heat gain. This approach enhances energy efficiency in the designated building.

RESEARCH ISSUES

This design thesis addresses three main concerns: overcrowding, lack of facilities, and difficulties with boat docking.

a. Overcrowding of local and international tourist

With the increasing number of visitors, it is crucial to ensure the comfort and safety of users, particularly tourists and the local communities of Kuala Besar and Tumpat Island. For instance, a 2021 Utusan Malaysia article highlighted the construction of a new jetty for Boat Terminal Kuala Besar, Kota Bharu, Kelantan, valued at RM100,000 (Fig. 1). The redevelopment of Boat Terminal Kuala Besar aims to provide comfort to the local community. It is also expected to attract more tourists to use the terminal to visit the floating markets on Pulau Suri and Sri Tanjung, Tumpat.

Figure 1: IZANI HUSIN (center) Inspects the location to build a new jetty in Kuala Besar, Kota Bharu for the convenience of the local community using the freight boat service to go to the floating market in Pulau Suri and Sri Tanjung at Tumpat Island. (Source: Rohana Mohd. Nawi/ Utusan Malaysia, 2021)

b. Lack of facilities

Another newspaper article from Harian Metro (2023) highlighted a second issue concerning Boat Terminal Kuala Besar in Kota Bharu, Kelantan. It mentioned that the terminal is proposed in response to public complaints about the lack of facilities for convenient travel to and from several islands in the Tumpat area. Fig.2 shows an example of a boat type, ‘Bot Penambang’, that docks at Kuala Besar Jetty.

Figure 2: The boat taxi service at Boat Terminal Kuala Besar as main transportation for villagers at Tumpat Island to go to the Kota Bharu City.
(Source: Nik Abdullah Nik Omar / Harian Metro, 2023)

c. Difficulty of boat docking

The third issue is the difficulty of boats to dock at the existing jetty (Fig. 3). Based on site observation, and the feedback from the villagers, the jetty should be redeveloped into a wider and longer decking. The length should be at least be 43.5 meters long to counter the low water tide of Sungai Kelantan, which results from the sand mining activity approximate to the site.

Figure 3: The boat taxi docking near the existing Kuala Besar Jetty, Kota Bharu, Kelantan.

RESEARCH AIM

This research aims to redevelop the existing Kuala Besar Jetty into a Boat Terminal at Kuala Besar, Kota Bharu, Kelantan to meet the need and demand based on large capacity of the visitor concerning their comfort and safety through sustainable design approach by using mixed mode system into a designated building.

RESEARCH OBJECTIVES

I. To ensure the comfort and safety for the users, especially tourists and the local community.
II. To upgrade the facilities of existing boat terminal services.
III. To encounter the changes in the low and rising water levels of the river in Kelantan.

METHODOLOGY

This research adopted both qualitative and quantitative data collection for the redevelopment of the boat terminal in Kuala Besar. The data were then evaluated to come up with a sustainable design approach for the designated building. Hence, the data collection comes from both primary and secondary data sources, such as:

1. Primary Data: On-site surveys are essential for conducting observation and investigating the issues.
2. Secondary Data: Information collected from Literature Review, News, or Journal Article.

LITERATURE REVIEW

PRECEDENT STUDY – LUMUT TERMINAL JETTY

Lumut Terminal Jetty was chosen as a precedent study (Fig. 4). The functional space requirements and spatial arrangement of the design were inspired by the Lumut Terminal Jetty. This terminal services boats traveling from Lumut to Pangkor Island, accommodating numerous visitors year-round.

Figure 4: Lumut Terminal Jetty, Lumut, Perak.

MALAYSIAN STANDARD 1525: 2019 CODE OF PRACTICE - ENERGY EFFICIENCY AND USE OF RENEWABLE ENERGY FOR NON-RESIDENTIAL BUILDINGS

The Malaysian Standard 1525 Code of Practice has been added to Malaysian structures to accomplish the well-studied results of energy conservation and renewable energy utilization. The study's findings highlight the need to know how to achieve passive energy efficiency in construction design projects.

In addition to the other reasons covered in this article is to emphasis the seven essential components; daylighting, façade design, natural ventilation, cross ventilation, stack ventilation, thermal insulation, and strategic landscaping, that architects may use to produce a more environmentally friendly building (Table 1).

Table 1: The table of 7 sustainable design

7 SUSTAINABLE DESIGN
1. SITE PLANNING AND ORIENTATION
2. DAYLIGHTING
3. FACADE DESIGN
4. NATURAL VENTILATION
5. THERMAL INSULATION
6. STRATEGIC LANDSCAPING
7. RENEWABLE ENERGY

MALAYSIA CLIMATE CONDITIONS

The performance of a structure is significantly impacted by the climate. The hot, humid tropical environment that Malaysia experiences is its defining feature (Fig. 5). A study by Attia S. et al. (2013) looked into how climate conditions affected design choices and underlined the significance of a "design with climate" approach. The building's overall energy performance has an impact on the technical and architectural solutions that affect performance. The thermophysical qualities of a building envelope hold great significance as they have a direct impact on indoor thermal comfort and energy conservation (Manioğlu G., Yılmaz Z., 2008). It is particularly challenging to enhance these qualities through design because of the high humidity and daytime temperatures, which lead to high indoor temperatures that surpass the ASHRAE summer comfort upper limit of 26 °C.

Malaysia's coordinates are 101.55 degrees east longitude and 3.12 degrees north latitude. The country has year-round high temperatures, high humidity, and abundant rainfall. In Malaysia, where it receives over 10 hours of sunshine each day and a yearly total radiation of about 4.31 kwh/m2, daylight is abundant throughout the year (A.T. Qahtan, N. Keumala, S.P. Rao, and Z.A. Samad, 2010). Therefore, the ideal hours for daylight harvesting in the building are from 8 a.m. to 6 p.m. Thus, the sky condition in Malaysia is categorized as intermediate to average, with clouds present in the sky 85.7% of the time and overcast conditions 14% of the time.

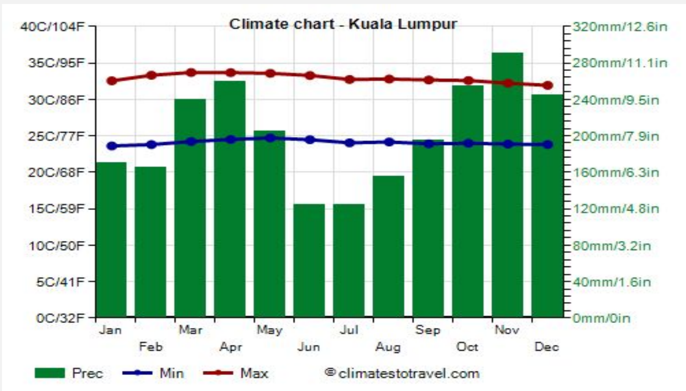


Figure 5: The annual climate of Kuala Lumpur, showing air temperature and precipitation. (Source: https://www.climatestotravel.com/climate/Malaysia, 2023)

PASSIVE DESIGN STRATEGY

SITE PLANNING AND ORIENTATION

The key to attaining thermal comfort and energy-efficient building design is the building's optimal orientation. The fundamental idea of proper orientation in Malaysia is to disperse openings away from intense solar radiation coming from the east and west with longer building facades facing north and south to reduce harsh morning and afternoon light. Additionally, it is necessary to examine microclimate data specific to the area, such as air temperature, relative humidity, air velocity, precipitation, radiant temperature, etc. Moreover, the majority wind speed in Malaysia is typically 15 knots coming from the southwest. In the northeast, the monsoon often begins in early November and lasts until March. Throughout this season, consistent winds of 10 to 20 knots are mostly easterly or north-easterly. Thus, the house's orientation and the prevailing winds' routes can both enhance the building's internal ventilation.

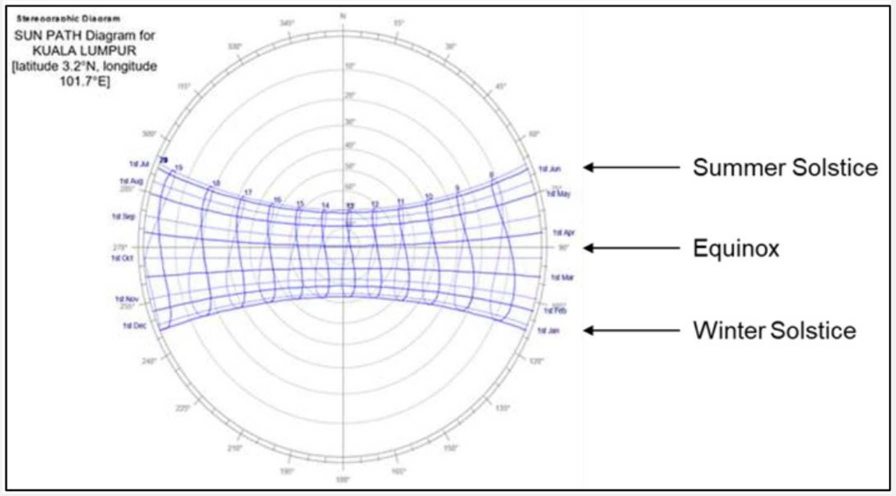


Figure 6: The annual sun path diagram in Kuala Lumpur (Source: Sanusi et al., 2014)

DAYLIGHTING

Daylighting ought to be taken into account from the first stages of design. The tropical climate of Malaysia can enable the building's interior areas to receive enough natural light from 8 a.m. to 6 p.m. As a result, an effective daylighting system should take into account the layout and orientation of the interior space, the internal wall, the surface characteristics of the floor and ceiling, the optical and physical glazing properties that allow light to penetrate and transmit through, the visual contrast between adjacent surfaces, and the protection against visual discomfort caused by both internal and external building elements. In addition, architects need to consider and work on improving the distribution of consistent daylight. In Malaysia, daylighting design is used in specific areas of buildings to create a pleasant internal atmosphere for occupants. This design minimizes glare from windows or glass structures while also letting natural light into the building.

Daylight distribution

Table 2 shows the recommended average illuminance levels for working interior spaces (MS 1525:2014).

Table 2: Recommended average illuminance levels (Source: MS 1525:2014)

b) Lighting for working interiors		
- Infrequent reading and writing	200	80
- General offices, shops and stores, reading and writing	300 - 400	80
- Drawing office	300 - 400	85
- Restroom	150	80
- Restaurant, canteen, cafeteria	200	80
- Kitchen	150 - 300	80
- Lounge	150	60
- Bathroom	150	80
- Toilet	100	60
- Bedroom	100	80
- Class room, library	300 - 500	80
- Shop/supermarket/department store	200 - 750	80
- Museum and gallery	300	80

FAÇADE DESIGN

The building's outer surface, known as the facade, serves multiple purposes: defining its appearance, regulating light ingress, and enhancing thermal comfort through passive design methods. To optimize these functions, additional shading elements should be incorporated into the east and west facades to minimize direct sunlight penetration, a common practice in Malaysia determined by analyzing sun path diagrams. Furthermore, applying light-colored or reflective coatings to both the interior and exterior of the facade can effectively reflect solar radiation, reducing internal heat gain.

NATURAL VENTILATION

The best ways to attain sustainable interior thermal comfort in tropical regions are through passive cooling or natural ventilation. A building's interior environment quality can be enhanced, and odors can be reduced with the help of fresh air. Based on the study, there are two methods which are cross ventilation and stack ventilation.

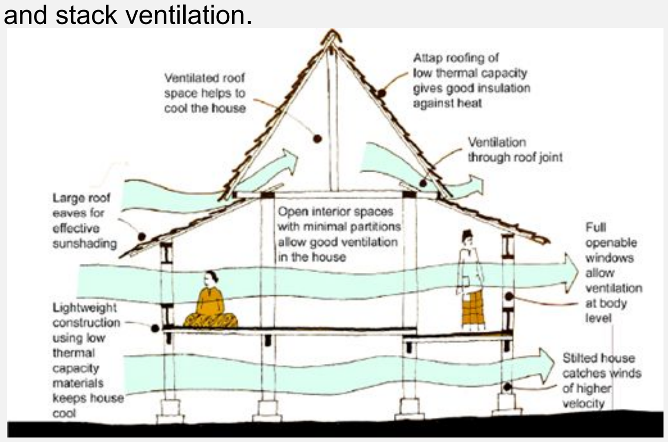


Figure 7: A cross section of a typical Malay Vernacular House (Source: Lim, 1987)

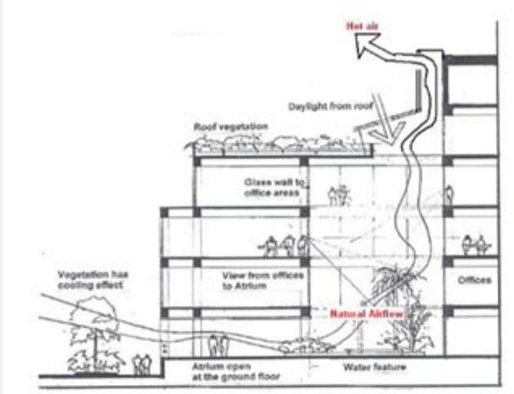


Figure 8: Natural ventilation and stack effect diagram of MEGTW building. (Source: Ramli, N. H., 2012)

In Malaysia, cross-ventilation is commonly employed, as evidenced by the traditional Malay vernacular house design (Fig. 7), which prioritizes occupants' thermal comfort and efficient airflow. Additionally, in the stack ventilation or vertical airflow method, openings positioned at higher levels facilitate the release of heated air generated by human activities into the colder air outside. This upward movement of heated air occurs through vertical elements (Fig. 8). Therefore, the effectiveness of stack ventilation relies on the variation in aperture heights and the temperature differential between the interior and exterior of the building.

THERMAL INSULATION

An essential approach to mitigate heat gain in buildings involves incorporating thermal insulation. Additionally, due to the low thermal conductivity of red bricks, thick walls contribute to reducing heat gain. The study emphasizes the significance of considering how various building components, including thermal insulation, impact external airflow to achieve optimal thermal performance. Thus, to minimize solar heat gain, it is advisable to opt for thicker construction materials for the external facade. Moreover, employing well-insulated ceilings or roofs serves as further measures to diminish heat influx, particularly during the evening (Fig. 9).

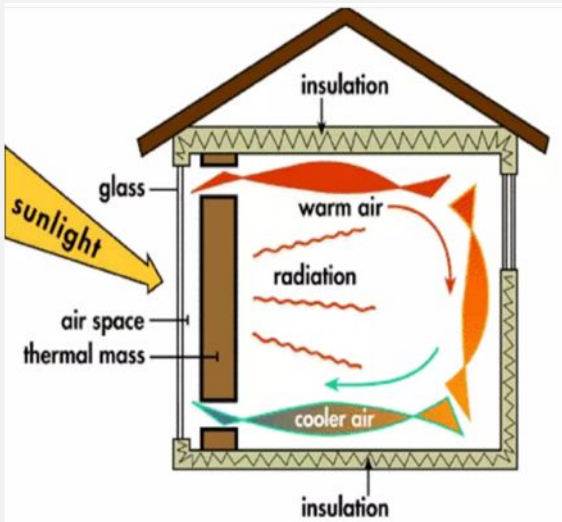


Figure 9: Thermal Insulation of the building (Source: Sheen, 2016)

STRATEGIC LANDSCAPING

Strategic landscaping plays a crucial role in heat reduction through various methods, such as utilizing trees for shading against direct sunlight, shielding from excessive penetration, and establishing a refreshing environment around the building. Moreover, a significant increase in temperature difference can lead to additional heat transfer within the building. Proactive measures, such as improving landscaping and creating a cooler microclimate around the structure, can mitigate this issue. To minimize solar heat gain in the designated area, designers and stakeholders involved in construction and planning must carefully consider suitable plants and materials for the hardscape..

RENEWABLE ENERGY

Renewable energy (RE) is derived from natural resources such as geothermal energy, biomass, wind, and tide. In addition to reducing dependency on non-renewable energy sources for things like pollution and energy use, renewable energy may also give users comfort and safety. This is especially important in areas with tropical climates, like Malaysia, in the early phases of building projects. Therefore, the determination of renewable energy that is suitable for a building project is determined by the natural resources of the selected country as well as the microclimate's state. Rainwater harvesting systems are the most suitable for renewable energy in Malaysia because the country has the highest average annual rainfall rate. See Fig. 10 for the renewable energy development in Malaysia.

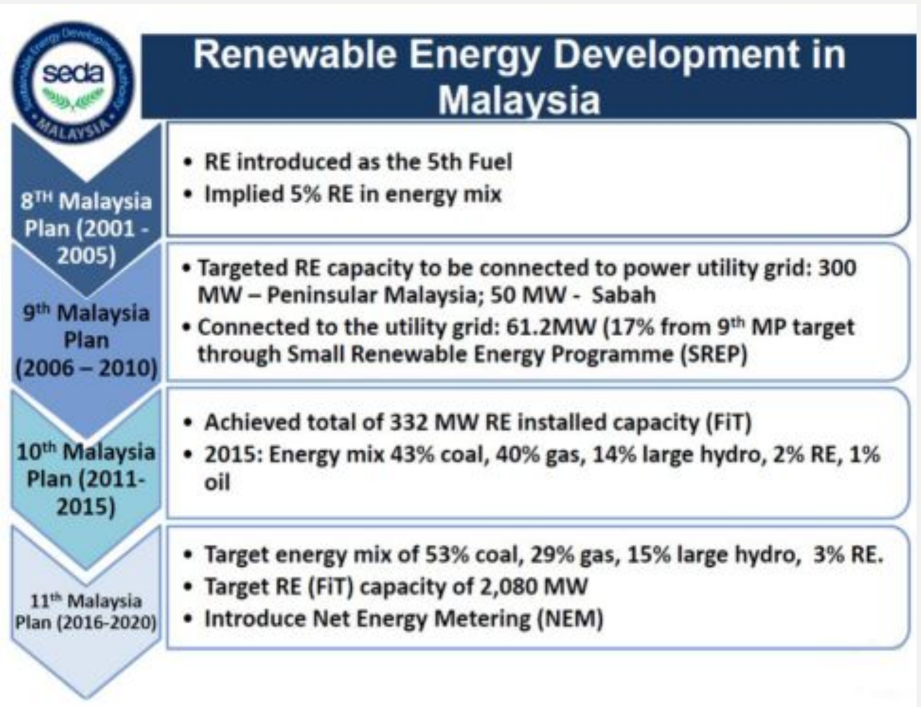


Figure 10: Renewable energy development in Malaysia.
(Source: SEDA Malaysia, 2021)

GLASS FAÇADE PERFORMANCE

Glass facades are integral components of contemporary building design, offering aesthetic appeal, functional and energy-efficient benefits. These structures provide a crucial barrier between indoor and outdoor environments, enhancing occupants' connection to the surroundings through natural light and views. Besides, when appropriately designed, glass facade contributes significantly to reducing energy usage by maximizing natural daylight penetration and minimizing reliance on artificial lighting.

During the design phase, careful consideration must be given to material selection and construction techniques to ensure superior energy performance. This involves choosing glass materials with suitable properties, including solar heat gain coefficients and thermal insulation values while integrating passive design strategies like orientation and shading devices.

Hence, glass facades play a multifaceted role in modern building design, offering functional, aesthetic, and energy-efficient benefits. By prioritizing research, innovation, and careful design considerations, designers can create buildings that not only enhance occupant comfort and well-being but also minimize environmental impact and energy consumption.

Three primary principles that govern the performance of glass facades are outlined in Fig. 11.

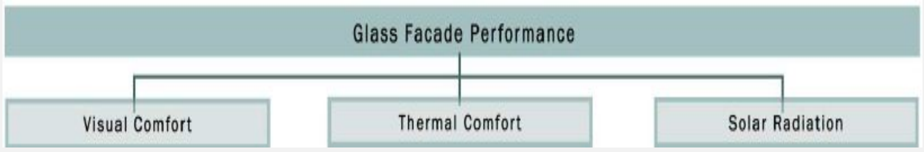


Figure 11: The fundamental principles of glass façade performance.

Variances between these environments result in environmental loads, with the most significant categorized as temperature, moisture, and air pressure. Temperature load stems from exterior factors such as air temperature, solar radiation, and wind, as well as interior factors like occupant activities, ventilation, and heating equipment.

a) Wind:

Glass facade designs are typically based on historical wind pressure data, However, designers may use the gust factor to account for sporadic gusts of wind. It is usual practice to estimate the unintentional moisture gains from wind-driven rain using this factor, which is defined as the ratio of maximum wind pressure to average wind pressure.

b) Solar radiation:

Solar radiation significantly affects glass facades by increasing surface temperatures, leading to higher drying rates and inward vapor flows. Predicting solar radiation involves considering its direct and diffuse components, influenced by atmospheric conditions such as absorption, reflection, refraction, and diffraction. Understanding solar radiation behavior aids in anticipating its location, duration, and intensity based on factors like the sun’s path and building orientation.

RELATIONSHIP BETWEEN LIGHT, SPACE AND HUMAN

The impact of architecture extends far beyond our expectations, influencing our emotions, well-being, actions, and overall health. The interplay of light, spatial design, and human interaction shapes the essence of architectural encounters. Architectural lighting isn't just an embellishment; it serves as a means to craft an enchanting spatial narrative. Besides aesthetics, the functionality of lighting is crucial, as it not only enhances productivity but also elevates mood, thereby enriching the activities carried out within the space (Table 3).

Table 3: The chart above from the illuminating Engineering Society (IES). (Source: TCP, 2017)

PSYCHOLOGICAL IMPACT	LIGHTING EFFECT	LIGHT DISTRIBUTION
Tense	Intense direct light from above.	Non-uniform
Relaxed	Lower overhead lighting with some lighting at room perimeter, warm color tones.	Non-uniform
Work/Visual Clarity	Bright light on workplane with less light at the perimeter, wall lighting, cooler color tones.	Uniform
Spaciousness	Bright light with lighting on walls and possibly ceiling.	Uniform
Privacy/Intimacy	Low light level at activity space with a little perimeter lighting and dark areas in rest of space.	Non-uniform

Content retrived from IES Light Logic (www.ieslightlogic.com)

Enhanced lighting is generally believed to increase alertness, and spaces with abundant daylight are usually favored by occupants over dimly lit areas (Mardaljevic et al., 2012). Daylighting has been associated with improved mood, higher morale, reduced fatigue, and less eye strain (Robbins, 1986).

DESIGN PROJECT

BOAT TERMINAL BUILDING PLANNING

The main idea behind the site plan is to engage with the surrounding context through near the attraction place LKIM as agro tourism and also the strategic place near the Kelantan mouth river especially it have a good view of Kelantan River (Fig. 12 – Fig. 18).

Figure 12: Site plan.

Figure 13: Ground floor plan.

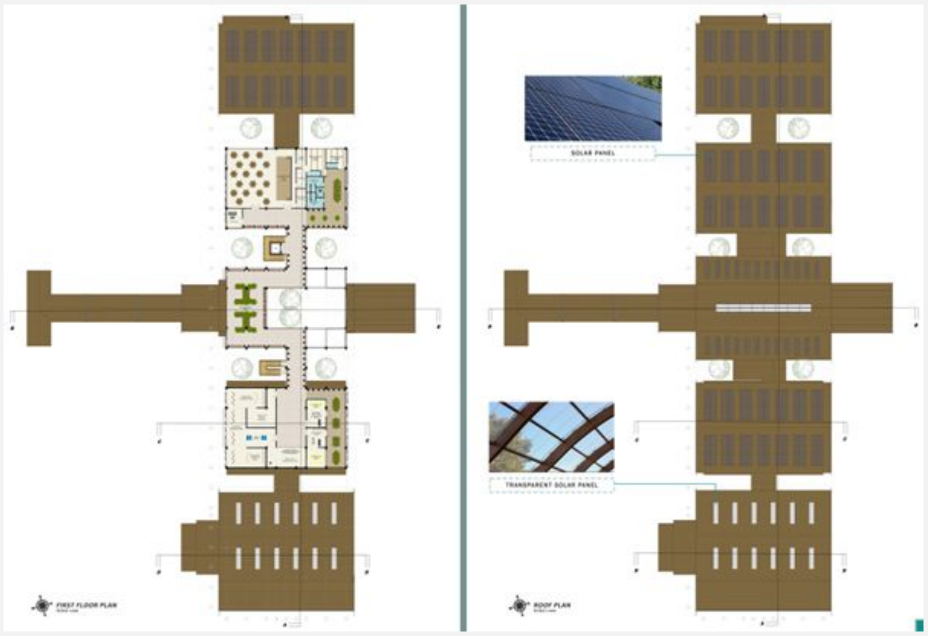


Figure 14: The first floor plan and roof plan.

Figure 15: The sectional perspective view of the Boat Terminal Kuala Besar

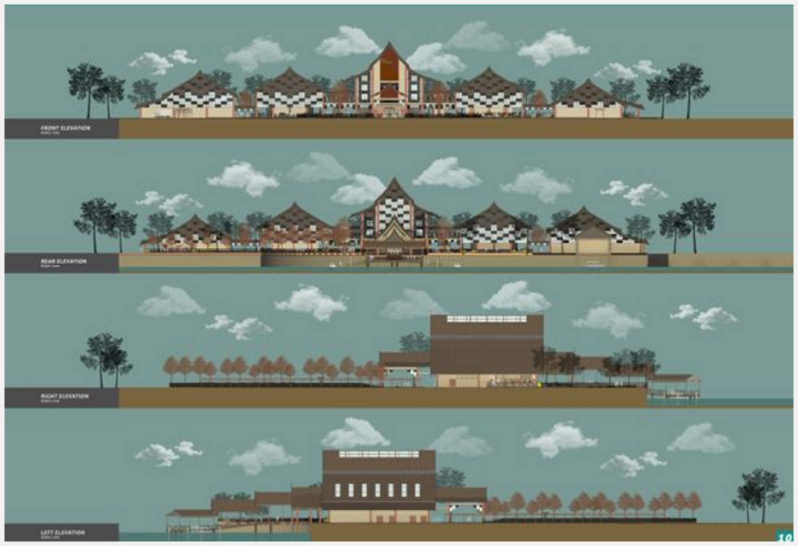


Figure 16: The 4 elevation of the building.

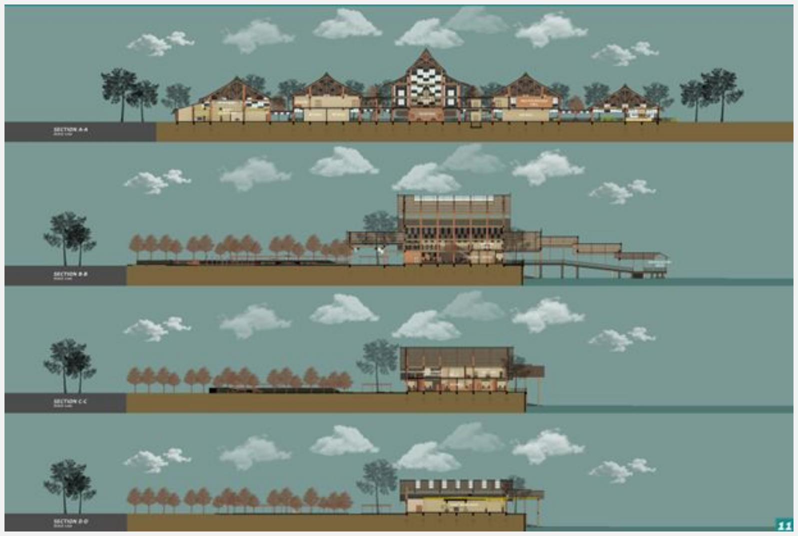


Figure 17: The 4 section of the building.

BUILDING ANALYSIS: BOAT TERMINAL KUALA BESAR

SITE PLANNING AND ORIENTATION

This project is oriented in accordance with the general building orientation concept, which states that the larger side should face either north or south and the smaller side should face either east or west.

As a result of the building being shielded from the sun, less heat will flow into the building. Besides, the building's design incorporates a range of tree and shading device components, such as double-skin facades that feature solid louvers and low-e glass panels on the east and west facades.

This building is constructed with four courtyards positioned in between the buildings to regulate the air flow throughout the entire building.

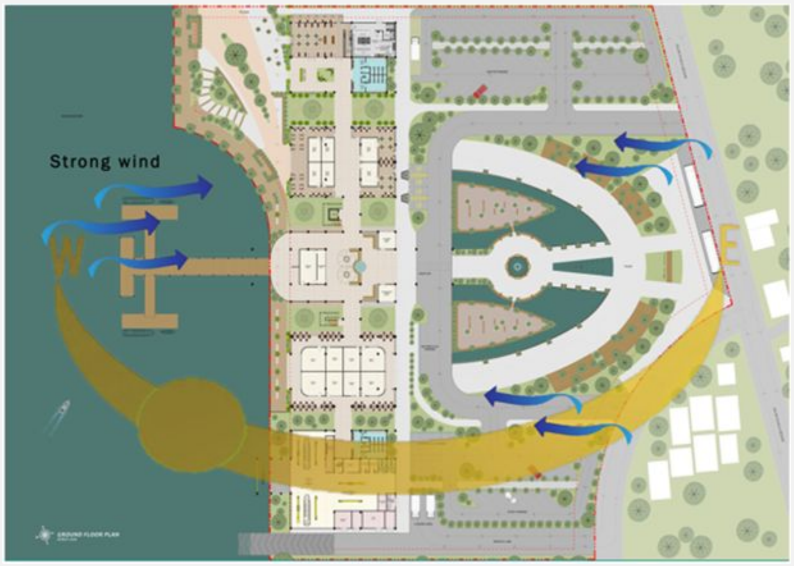


Figure 18: The site planning and orientation.

SOLAR ANALYSIS

The selected area received natural light from the solar panel to maximize the energy yield. In architecture, natural light is particularly crucial because it creates a sense of relaxation, enhances the building's aesthetic appeal, offers an immersive experience, and improves energy efficiency.

The PV Energy Production of the solar panel is around 567,062kWh/Year from sunrise until sunset. It is because there are no buffers to block the sunlight. It only takes about 12.6 years of payback, where when the higher the solar energy yield, the lower the number of payback. Hence, it can save RM 85,059 where the solar energy used for corridor lighting in the building (See Fig. 19 for the solar analysis).

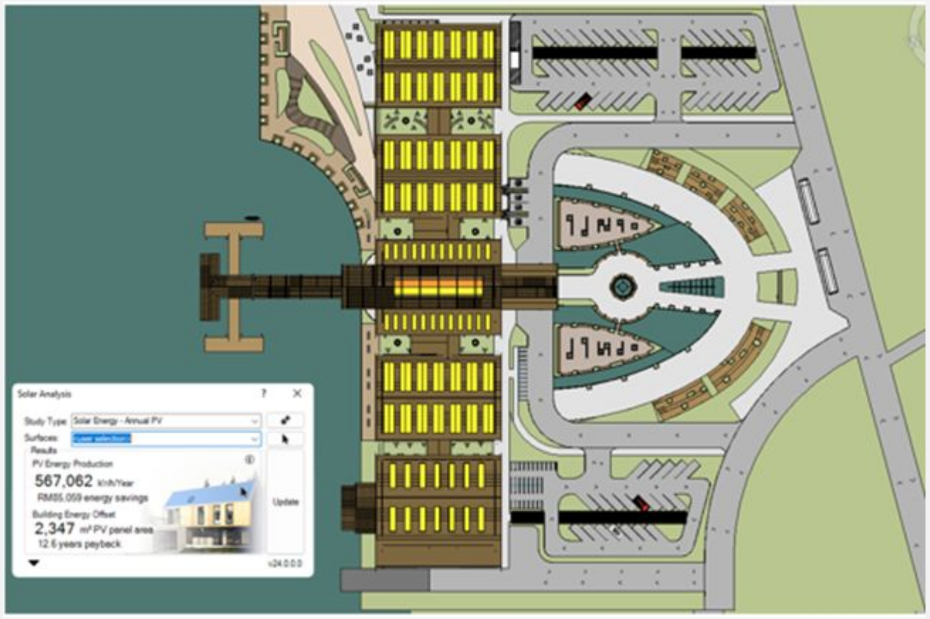


Figure 19: The solar analysis.

DAYLIGHTING ANALYSIS

Low E-glass at the glass facade with exterior solid panels and horizontal louvers acting as double-skin facades were installed on the east and west walls of the boat terminal Kuala Besar to optimizing daylighting and thermal comfort while reducing solar heat gain (Fig. 20).

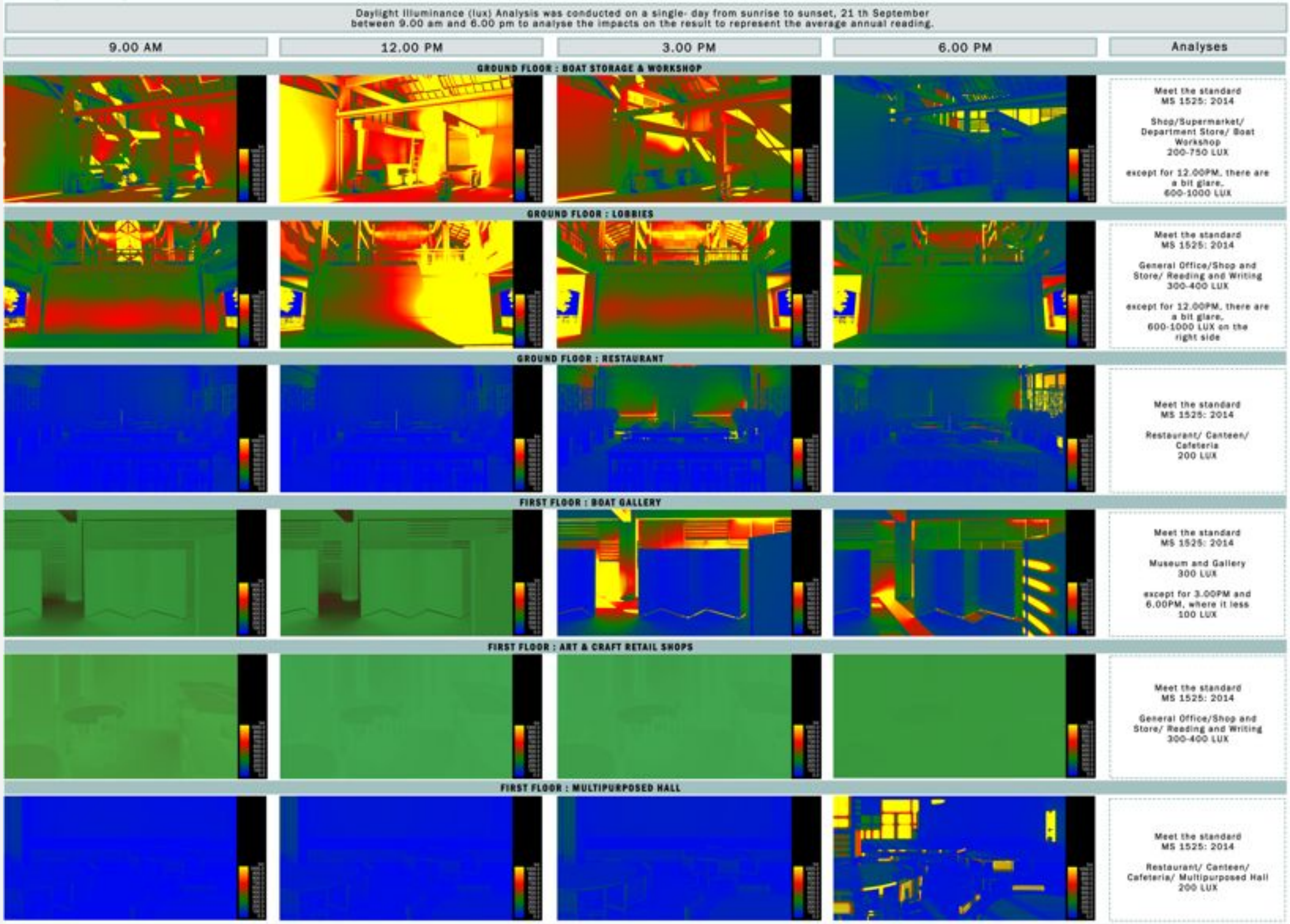
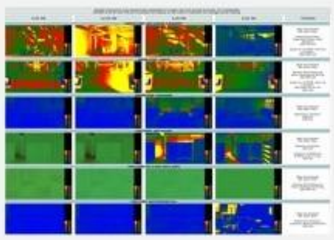


Figure 20: The daylighting analysis.

DISCUSSION

Table 4: Table of discussion: Solar Analysis and Daylighting.

ELEMENTS	ENVIRONMENTAL ANALYSIS OF BOAT TERMINAL	RETROFICATION OF STUDY
Solar Analysis	 Solar analysis shows that the roof of the building is fully exposed to the sun from early in the morning at 8.00 a.m.to 6.00 p.m as there is no tall building surrounding the building. During afternoon and evening, direct sunlight just hit the walls of the building especially from east and west facade. External roof surfaces have a PV Energy production of 567, 062 kWh/Year which is a huge amount of energy received. This analysis would suggest installing a solar energy panel with 12.6 years payback that could optimise the reusable solar heat capacity, thus improves its sustainability.	 Installation of solar energy panels on roof should be located on the east and west facing. It is because there are totally exposed to the morning and evening sun. The energy that had been production from solar panel can produce sufficient electricity and save electricity costs.
Daylighting Analysis	 Percentage of natural lighting receives adequate daylighting for the activities into the all selected area. It is according to the MS1525, recommended average illuminance levels except certain space; boat workshop and lobby around 12.00 p.m. where it received a bit glare, 600-1000 LUX. Hence, the selected study area was designed as passive design and does not need artificial lighting except after dusk 7pm.	Installation of double- skin façade with variety type of wall; fixed horizontal louvers, solid and glass at the front and rear side where it facing east and west, the most exposed façade toward the sun. The facade also acts as a light penetration and filtration as it allows the users to set the angle of each panel to prevent excessive direct sunlight either during morning or evening. It does not change much of the building design, and the circulation of natural ventilation is not affected as louvres have same gaps as before to let air flow.

CONCLUSION

The research study highlights the need for a sustainable design approach using a mixed-mode system to address the current issues at the Boat Terminal Kuala Besar, which include overcrowding, lack of facilities, and difficulties in boat docking. To resolve these problems, an architectural design strategy has been proposed. It is crucial to consider seven passive design methods early in the design process to achieve sustainable design and enhance health and safety in the built environment. The redevelopment of Boat Terminal Kuala Besar offers environmental benefits such as reduced energy consumption, improved thermal comfort, and upgraded facilities.

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