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Comparative Analysis using Revit BIM Between Traditional Malay House and Modern House in Natural Daylighting

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Abstract

This research examines the effective natural lighting in Traditional Malay Houses compared with Modern Houses, focusing on the architectural characteristics that impact light distribution. The aim is to evaluate residences capture daylight, especially through different openings such as windows and doors. The methodology for the research included a careful selection of case studies that focused on traditional Malay houses in comparison to modern houses of comparable sizes and locations, ensuring that variables were controlled for effective analysis. Data gathering included assessments of daylight levels through Lux Meter measurements in both types of housing, specifically in areas such as the living room and kitchen (for traditional houses) and their modern counterparts. The data obtained was analyzed using arithmetic mean calculations and was further corroborated through simulations conducted with Autodesk Revit software to confirm the findings and maintain methodological integrity. In living rooms, traditional homes reached up to 23.67 lux, whereas modern homes only achieved 1-2 lux. The performance of the Daylight Factor indicated that traditional homes exhibited 21% of their floor area within the ideal daylight factor range (2.0-20.0%), compared to just 7% in modern homes. The Average Daylight Factor showed that traditional homes had a value of 1.5%, while modern homes registered 0.8%. Traditional houses effectively provided sufficient daylight to 20 m^2 (21%) of a 95 m^2 floor area, in contrast to modern houses, which only managed 9 m^2 (7%) of a 118 m^2 floor area. Furthermore, 79% of the floor area in traditional houses received some natural light below the required threshold, whereas 93% of the area in modern homes did not meet daylight standards. The findings illustrate that Traditional Malay Houses considerably excel compared to Modern Houses in attaining higher lux levels, primarily due to the design and materials of traditional windows and doors. These results highlight the necessity of incorporating traditional architectural features into modern designs to improve the use of natural light.

1. Introduction

Traditional Malay houses and modern homes exhibit significant differences in their approaches to natural daylighting and environmental adaptability. Structures from the traditional Malay era were created with a focus on responsiveness to climate [1]. These buildings featured aspects that highlighted natural light and airflow. Their elevated construction, generous window placements, and open floor designs allowed daylight to permeate interior spaces while encouraging ventilation [2,3]. This architectural strategy decreased dependence on artificial lighting and cooling methods during the tropical daytime. Traditional Malay architecture incorporated large operable windows and lattice screens that invited light and supported air circulation. The employment of lightweight materials, such as bamboo and wood, in these homes assisted in reflecting sunlight while enhancing ventilation [4] Ventilation is defined as the natural flow of air within a building to ensure cooling and fresh air movement. These materials improved daylight conditions and reduced heat retention.

Modern residential designs, particularly in urban settings, frequently prioritize privacy and energy efficiency, often at the expense of access to natural daylight. Urban developments have increasingly adopted features such as expansive glass facades and sliding doors for visual appeal. However, these designs typically result in increased heat gain, leading to a greater reliance on mechanical cooling systems [5,6]. Mechanical cooling devices refer to artificial systems, such as air conditioners, that use electricity to lower indoor temperatures. The compartmentalized layouts commonly found in contemporary designs generally restrict the flow of natural light and require greater reliance on artificial illumination. Recent studies have shown that integrating elements from traditional architecture, like shading features and cross-ventilation openings typical of Malay homes, could significantly enhance energy efficiency and quality of the indoor environment in modern buildings [3, 7]. Cross-ventilation is the natural airflow created when air enters through one side of a building and exits through another, producing cooling breezes. Implementing vernacular design principles, including overhangs and thermal mass strategies, could foster the construction of modern housing that is more in harmony with its environmental context [8]. Thermal mass refers to materials that can absorb, store, and release heat energy, aiding in the regulation of indoor temperatures.

1.1 Problem Statement

Modern houses architecture encountered difficulties in maximizing daylight access and energy efficiency, particularly when compared to traditional Malay housing styles. Traditional Malay building methods adopted techniques that effectively merged daylight access with thermal comfort through elevated structures, generous overhangs, and strategically placed openings [9,10].

Daylight autonomy indicates the percentage of time that natural daylight delivers adequate illumination without the need for artificial lighting. The research aimed to investigate hybrid techniques that fused innovative modern technologies with the passive principles inherent in traditional Malay architecture. Developments such as dynamic shading systems, high-performance glass, and intelligent lighting controls could strengthen the beneficial interplay between natural daylight and thermal comfort [4]. The main goal was to devise design strategies that enhanced occupant comfort while promoting sustainable energy practices in tropical residential settings.

1.2 Objective

The objectives of this study will be achieved by obtaining the following objectives:

i) To measure natural daylight levels in a Traditional Malay House and a Modern House using a digital lux meter.
ii) To compare the average daylight illuminance between Traditional Malay House and Modern House.
iii) To conduct a natural daylight simulation model using Autodesk REVIT to validate field measurements and assess daylight performance.

2. Methodology

This study utilized a mixed-method approach that integrated both quantitative and qualitative research methods to gain a thorough understanding of the impact of architectural design on daylighting effectiveness. Quantitative information was gathered through Lux Meter measurements from specified areas in both traditional and modern homes, with the results analyzed using arithmetic means and validated via simulations from Autodesk Revit software. Qualitative data were obtained through observations, contextual insights derived from literature reviews, and on-site case studies to help interpret the findings. This integrated approach enabled accurate assessment of daylighting effectiveness while taking into account the unique spatial, cultural, and design characteristics of traditional and contemporary Malay residences, ensuring that the conclusions drawn were both technically robust and contextually applicable for practical design improvements.

2.1 Flowchart

Figure 1 depicts the structured research framework used to assess daylighting performance in both traditional and contemporary Malay residential architecture. The methodology initiated with five essential research components: selecting a title, articulating the problem statement, determining objectives, defining the scope, and establishing significance. After this foundational stage, an extensive literature review was performed to deepen theoretical insights. The research advanced to case study selection, focusing on traditional Malay houses and modern homes of similar sizes and locations to allow for a controlled comparative analysis. Data collection involved measuring daylight with Lux Meter devices in specific areas, such as the Serambi and Rumah Ibu of traditional homes and their modern equivalents. The gathered data were analyzed by calculating the arithmetic mean and validating the results using Autodesk Revit simulation software. A critical evaluation point assessed the adequacy of the results, and unsatisfactory findings led to refinements in methodology and subsequent data gathering. Results deemed satisfactory moved on to in-depth analysis and discussion stages, ultimately resulting in conclusions and recommendations aimed at optimizing daylighting efficiency and enhancing modern architectural design through insights drawn from traditional practices.

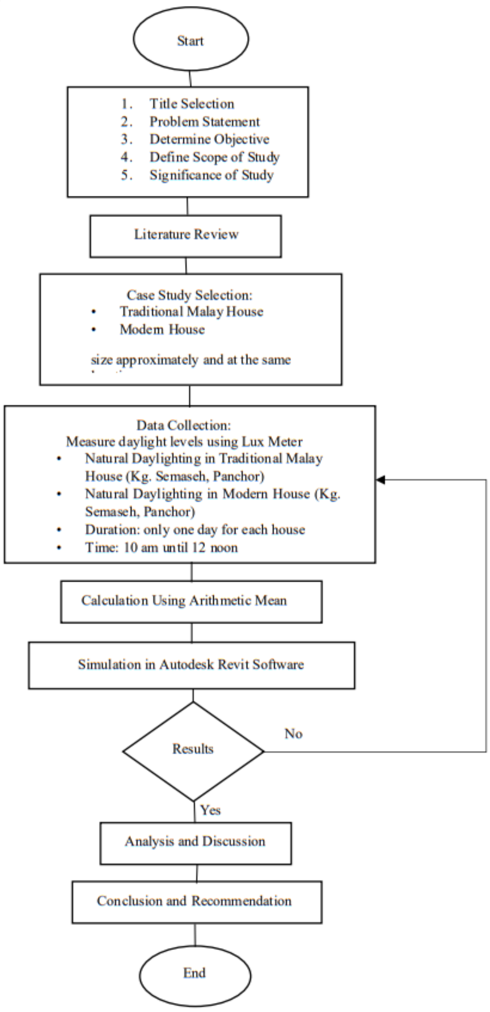

Fig. 1 *Flowchart of Natural Daylighting study*

2.2 Selection of the Study Location

Two homes were selected for this study in order to provide a precise comparison of daylighting performance between traditional and contemporary Malay residential construction. As shown in Figure 2, the traditional Malay house is located at Kg. Semaseh, Panchor, Muar, Johor, about 9 miles from the Universiti Tun Hussein Onn Malaysia, Pagoh Campus. Puan Syarifah and her husband live in this 60-year-old timber building that has been conserved throughout its existence without any renovations or architectural changes.

Fig. 2 *Puan Syarifah's Traditional Malay House*

The modern house was selected in Kampung Jawa, Panchor, Johor, located about 10 km from the university campus, and is occupied by Puan Ramlah, a private pensioner (Figures 3). This brick and concrete building is 2 years old and has not undergone any renovations, ensuring structural integrity for the purpose of comparative analysis. Both houses have similar architectural dimensions, with the traditional house measuring 8m x 17m ($136m^2$) and the modern house measuring 7m x 19m ($133m^2$), both oriented towards the North West, as detailed in Table 1.

Fig. 3 *Puan Ramlah's Traditional Malay House*

Table 1 *Main Characteristics of the Case Study Houses*

Characteristics	Traditional Malay House	Modern House
Location	Kg. Semaseh, Panchor, Muar, Johor	Kg. Jawa, Panchor, Muar, Johor
House Age	60 years	2 years
Size of House	8m x17m $136m^2$ (Area)	7m x 19m $133m^2$ (Area)
Orientation	Facing North West	Facing North West
Renovation	No renovation	No renovation
Material	Timber	Brick and Concrete

The main goal of this study was to ascertain which type of house offered better natural daylighting efficiency for energy savings during daytime hours. Data was collected using a Lux Meter to gauge natural light levels, with the measurement period set between 10:00 AM and 12:00 PM, following previous research by [11], which identified this timeframe as optimal for reliable natural light readings. Measurements were taken at 60-second intervals in all naturally lit areas of both houses to ensure extensive data collection, acknowledging that natural lighting fluctuates due to temporal factors, varying weather conditions, and celestial factors such as solar position and atmospheric disturbances. Environmental variables were meticulously controlled to ensure a fair assessment, with both houses selected within a 1 km radius to experience comparable climatic and solar conditions, a similar North West orientation for equivalent sunlight exposure, and measurements undertaken only in clear sky conditions using the same Lux Meter under natural daylight, without any artificial lighting, to maintain consistency across both structures.

2.3 Data Collection using Lux Meter

This research examines the daylighting efficiency of traditional Malay houses compared to modern houses through digital lux meter readings (Figure 4). A lux meter provides readings in lux, where 1 lux is equivalent to 1 lumen per square meter, which is essential for maintaining appropriate lighting conditions [12,13]. Measurements were conducted between 10:00 AM and 12:00 PM on clear days, with three readings taken at each location at one-minute intervals, utilizing the arithmetic mean formula: Average Lux = (R1 + R2 + R3) ÷ 3.

Fig. 4 *Lux meter*

Two residences were examined Puan Syarifah's traditional Malay house, which is 60 years old, located in Kampung Semaseh, and Puan Ramlah's contemporary terrace house in Kampung Jawa. On May 12, 2025, the traditional house was assessed in four sections: the living room, the central area containing the bedrooms, the family area, and the kitchen, along with outdoor reference measurements. This house includes large windows, lattice designs, ventilation areas, and green mirrors that enhance the flow of natural light [3,1]. Measurements were only done in sunny, clear weather and gloomy or wet conditions were avoided to ensure accuracy. The data collection procedure is summarized in the table 2 below. For Outdoor, Continuous because it is only used as a reference reading, not for an average for each room.

Table 2 *An overview of the conditions and measurement points for daylight Traditional Malay House*

Area	Measurement Points	Readings Point	Total Readings	Calculation Method
Living Room	4	3	12	Arithmetic Mean per point and area
Middle Area	3	3	9	Arithmetic Mean per point and area
Family Area	2	3	6	Arithmetic Mean per point and area
Kitchen	1	3	3	Arithmetic Mean per point and area
Outdoor	1	Continuous	-	Readings per minute in real time

On May 14, 2025, measurements were taken of the modern house, concentrating on the living room and kitchen, along with outdoor reference measurements. Modern terrace houses encounter design obstacles due to restricted side openings resulting from their interconnected nature, and contemporary structures often lead to reduced natural light for occupants due to glare and thermal discomfort [14]. The results indicate that traditional Malay houses naturally incorporate climatic design techniques that efficiently harness natural light, whereas modern designs may necessitate artificial alternatives [2,15]. A comparative analysis was used to compare the data that was collected. The process of gathering data is outlined in Table 3 below. For the Outdoor category, it is recorded continuously since it serves solely as a reference reading rather than an average for each room.

Table 3 *An overview of the conditions and measurement points for daylight Modern house*

Area	Measurement Points	Readings Point	Total Readings	Calculation Method
Living Room	5	3	15	Arithmetic Mean per point and area
Middle Area	1	3	3	Arithmetic Mean per point and area
Kitchen	3	3	9	Arithmetic Mean per point and area
Outdoor	1	Continuous	-	Readings per minute in real time

2.4 Calculation arithmetic mean method

According to [16], the average of the values, or, to put it another way, the sum of the values divided by the total number of values in the data set, is the arithmetic mean of a data collection. The arithmetic mean formula is shown in Equation 1.

$$A = \frac{1}{n}\sum_{i=1}^{n} a_i \quad (1)$$

Assessing a space's natural daylighting is essential to figuring out how efficient the daylighting is. The Arithmetic Mean Method is one of the most widely used techniques for this evaluation. This method determines an average illuminance value (in lux) by taking several lux readings from different spots within an area, adding up the readings, and dividing the total by the number of readings. For instance, equation 2 shows the average illuminance is determined as follows if three lux readings are obtained at the same location: 230 lux, 220 lux, and 240 lux.

$$Average\ Lux = \frac{230+220+240}{3} = 230\ lux \quad (2)$$

2.5 Autodesk Revit Software Simulation of Natural daylighting

Autodesk Revit provides extensive Building Information Modeling (BIM) features that greatly improve architectural modeling and daylighting evaluation by utilizing complex 3D modeling that accounts for environmental aspects. As stated by [17], modeling strategies based on BIM offer significant benefits for building design simulation and retrofitting processes. The software's unified platform reduces the risk of data loss while allowing for iterative design methods to optimize window placement, orientation, and spatial configurations without the necessity of creating new models [18,19,20].

The methodology of the simulation entails crafting detailed floor plans derived from actual architectural designs, placing significant emphasis on geometric characteristics since the positioning, dimensions, and orientation of windows greatly influence daylight access in various areas [21]. Revit allows for two main types of analysis: Illuminance Analysis, which assesses light intensity in lux from all sources during specified times and conditions, and is crucial for determining indoor lighting needs [22,23], and Daylight Factor analysis, represented as a percentage under standard CIE Overcast Sky conditions, which concentrates exclusively on the effectiveness of natural light for sustainable design efforts [10,24]. The procedure employs recorded architectural data to generate precise models, as illustrated in Figures 5,6,7,8,9, which depict the measured Traditional Malay House, Revit-created floor plans for both contemporary and traditional homes, alongside the software configurations for Illuminance Analysis and Daylight Factor settings.

Fig. 5 *Measured Puan Syarifah's Traditional Malay House.*

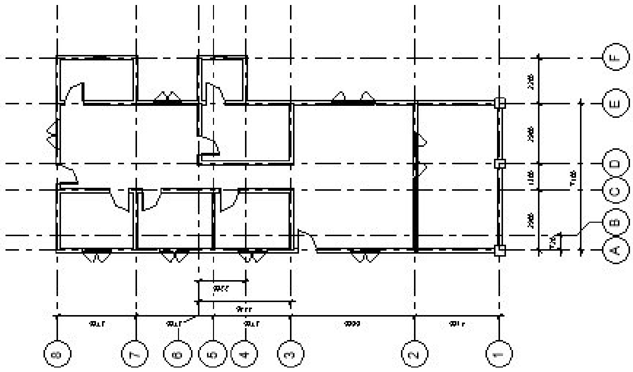

Fig. 6 *The floor plans for the modern house were created using Autodesk Revit.*

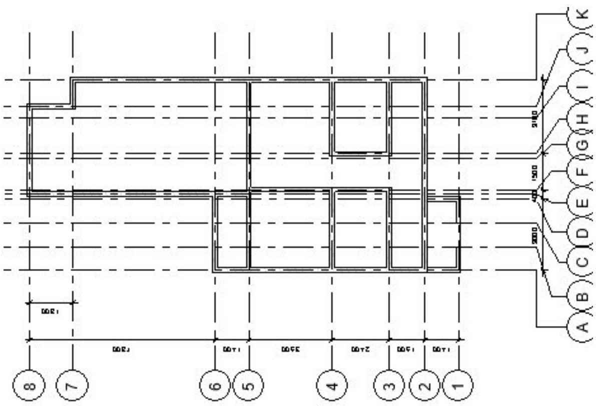

Fig. 7 *The floor plans for the Traditional Malay house were created using Autodesk Revit.*

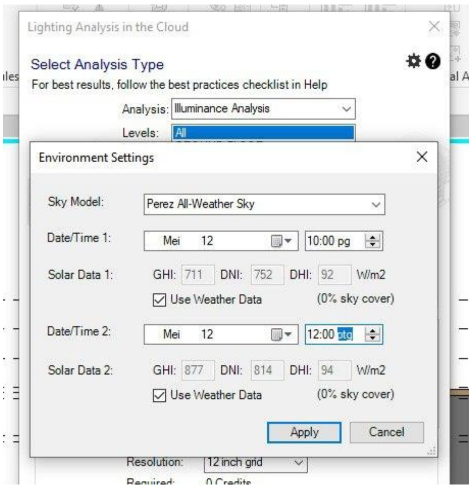

Fig. 8 *Setting Illuminance Analysis in Autodesk Revit*

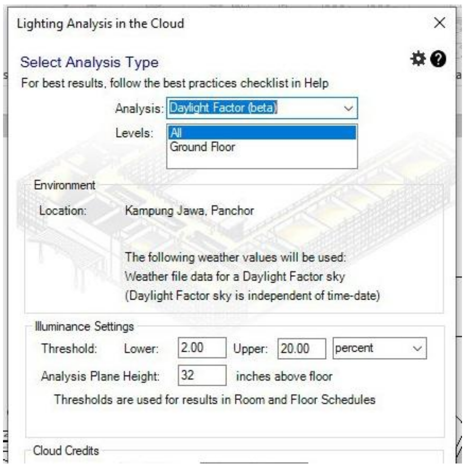

Fig. 9 *Setting Daylight Factor in Autodesk Revit*

2.6 Comparative Analysis method

The method of comparative analysis, particularly qualitative comparative analysis (QCA), has seen a rise in popularity within social science and educational research due to its effectiveness in merging qualitative and quantitative data to explore intricate causal relationships. [25] has noted QCA's strength in handling conjunctural causation, making it especially suitable for medium-N studies. This technique was implemented by developing comparison tables that categorized lux readings based on architectural attributes, including different types of openings, double leaf doors, jalousie windows, louvred windows, and ventilation openings. This was supported by [26], who highlighted the impact of interior layouts on daylight performance and validated the averaging of lux readings at critical points. The methodology was further refined through simulations using Autodesk Revit Illuminance Analysis conducted on May 12 and 14, 2025, between 10:00 a.m. and 12:00 p.m. These simulations revealed a strong correlation with the recorded lux levels and confirmed that larger glazed openings improve daylight penetration, aligning with the findings of [27] regarding how window orientation, shading characteristics, and material reflectance affect indoor lighting. Furthermore, Daylight Factor simulations under overcast sky scenarios provided reliable comparisons across buildings based solely on their architectural features. This aligns with the insights of [28], who emphasized the necessity of integrating qualitative and quantitative evaluations and taking into account architectural elements when calculating daylight metrics for a thorough assessment of spatial daylighting performance.

3. Result and Discussion

This chapter provides an analysis of the natural lighting effectiveness between two categories of homes: Traditional Malay Houses and Modern Houses. The evaluation relies on three primary techniques: (i) direct measurements conducted with lux meters, (ii) Illuminance Analysis simulations, and (iii) Daylight Factor simulations. The assessment concentrates on key areas like the living room and kitchen, in addition to various types of openings, which include windows, doors, and additional apertures.

3.1 Analysis of Lux Meter Measurements Based on Opening Type

Natural daylight measurement data was averaged based on readings taken at each location in both homes. The comparison was made by constructing a table based on the types of windows, doors, and additional openings.

Table 4 *Lux Readings of Traditional Malay Houses by Measurement Point (Between 10 a.m until 12 p.m)*

Measurement Point	Reading 1 (lux)	Reading 2 (lux)	Reading 3 (lux)	Average (Lux)
Living room (Louvre Window 1) with additional opening above.	15	18	13	15.33
Living room (Double Casement Window 1 (wood)) with additional opening above.	11	16	17	14.67
Living room (Double Casement Window 2 (wood)) with additional opening above.	24	25	22	23.67
Living room (Double Casement Window 3 (wood)) with additional opening above.	26	25	19	23.33
Living room (Double-Leaf Timber Door 1) with additional opening above.	11	16	17	14.67
Prayer Section (Single Casement Window 1(wood)) with additional opening above.	22	21	22	21.67
Family area (Louvre Window 2) with additional opening above.	18	5	2	8.33
Family area (Double-Leaf Timber Door 2) with additional opening above.	2	1	1	1.33
Kitchen (Single Casement Window 2 (wood)) with additional opening above.	17	26	20	21
Kitchen (Single door) with additional opening above. (close)	-	-	-	-

Table 4 displays lux measurements taken from different areas of a traditional Malay house, with each site evaluated three times using the Arithmetic Mean Method to determine the levels of natural light. The assessment of the living room indicated that louvre windows allowed relatively limited daylight with an average of 15.33 lux, whereas double casement windows showed better results with averages of 14.67 lux, 23.67 lux, and 23.33

lux respectively, suggesting that Casement Windows 2 and 3 were especially effective when compared to louvre windows. The double-leaf timber door added minimally to the daylight, producing an average of 14.67 lux, which is on par with the lowest-performing windows. In the prayer area, the single casement window yielded a moderate average of 21.67 lux, offering sufficient natural light for reading and religious activities without the need for artificial illumination, while the family area demonstrated considerably poorer results, with the louvre window averaging just 8.33 lux and the double-leaf timber door only achieving a mere 1.33 lux, underscoring the lack of natural lighting in that zone. The kitchen's single casement window recorded a favorable average of 21 lux, indicating effective access to daylight, leading to the overall conclusion that the type and placement of windows significantly affect interior lighting levels, with casement windows being the most efficient among the window types analyzed.

Table 5 *Lux Readings of Modern Houses by Measurement Point (Between 10 a.m until 12 p.m)*

Measurement Point	Reading 1 (lux)	Reading 2 (lux)	Reading 3 (lux)	Average (Lux)
Living room (Double Casement Window 1 (glass))	1	1	1	1
Living room (Single door 1)	3	2	1	2
Living room (Triple Casement Window 1 (glass))	0	2	1	1
Living room (Double Casement Window 2 (glass))	2	2	1	1.67
Living room (Double-leaf door)	3	2	1	2
Kitchen (Double Casement Window 3 (glass))	1	1	1	1
Kitchen (Double Casement Window 4 (glass))	1	1	1	1
Kitchen (Single door 2)	6	5	6	16

Table 5 presents natural light measurements (in lux) from various locations within a contemporary home during the 10 a.m. to 12 p.m. period, typically associated with abundant daylight, yet revealed strikingly low lux readings across most measurement points. In the living area, glass casement windows demonstrated minimal daylight entry with average readings of 1 lux for Double Casement Window 1, 1 lux for Triple Casement Window 1, and 1.67 lux for Double Casement Window 2, suggesting these windows may be heavily tinted, obstructed by shading, or poorly positioned for natural light access, while single and double-leaf doors in the same area recorded equally low readings of 2 lux each. The kitchen showed similarly poor performance with Double Casement Windows 3 and 4 both registering merely 1 lux, with the notable exception of Single Door 2 achieving 16 lux—significantly higher than other openings—indicating this door may be fully glazed or positioned with direct daylight exposure such as facing an open courtyard or backyard. The overall findings demonstrate that modern homes in this study receive severely limited natural lighting through conventional glass windows and doors, potentially due to design features including overhangs, elevated walls, shading devices, or reduced window-to-wall ratios, creating a stark contrast to traditional homes where certain window types facilitated greater daylight penetration into interior spaces.

Table 6 *Comparison of Average Lux: Traditional Malay House and Modern Houses*

Measurement Point	Traditional Malay House (Average lux)	Modern House (Average lux)
Living room (Louvre Window 1)	15.33	-
Living room (Louvre Window 2)	8.33	-

Living room (Double Casement Window 1) (wood/glass)	14.67	1
Living room (Double Casement Window 2) (wood/glass)	23.67	1.67
Living room (Double Casement Window 3)	23.33	-
Living room (Triple Casement Window 1)	-	1
Living room (Double-Leaf Timber Door 1/Double Leaf Door)	14.67	2
Living room (Single door 1)	-	2
Family area (Louvre Window 2)	8.33	-
Family area (Double-Leaf Timber Door 2)	1.33	-
Prayer Section (Single Casement Window 1)	21.67	-
Kitchen (Single Casement Window 2)	21	-
Kitchen (Double Casement Window 3)	-	1
Kitchen (Double Casement Window 4)	-	1
Kitchen (Single door 2)	-	16

Table 6 provides a direct comparison of average lux values between Traditional Malay Houses and Modern Houses, revealing that traditional homes achieve significantly higher natural daylight levels across most measurement points. Traditional Double Casement Window 2 recorded an impressive 23.67 lux compared to only 1.67 lux in the modern equivalent, while traditional Double Casement Window 1 generated 14.67 lux versus merely 1 lux in the modern version, highlighting the effectiveness of traditional wooden window materials and design elements such as overhead openings and broader operable panels that enhance daylight penetration. Double-leaf timber doors also performed better in traditional residences with 14.67 lux compared to just 2 lux in modern counterparts, and areas like the prayer section and kitchen in traditional homes exceeded 21 lux while corresponding spaces in modern houses with enclosed or glass-based windows remained at only 1 lux. The sole exception in modern houses was the kitchen's Single Door 2, which measured 16 lux, presumably due to direct external light exposure or minimal shading, demonstrating the overall superior daylight performance of traditional architectural design compared to contemporary enclosed window systems.

3.2 Ratio of Openings to Floor Area in Compliance with UBBL Standards

The Uniform Building By-Laws (UBBL) 1984, By-Law 39(1)(a) sets forth essential natural lighting standards for residential, commercial, and various other spaces [29]. This rule mandates that every room must have sufficient natural light entering through windows, fixed glass panels, or skylights, with the cumulative opening area totaling at least 10% of the room's usable floor area—for example, a 20 square meter room is required to have a minimum window area of 2 square meters. The main aim is to ensure adequate daylight reaches the interiors throughout the day, which enhances the comfort and well-being of occupants while decreasing dependence on artificial lighting to boost energy efficiency. In contrast to the operable ventilation openings outlined in By-Law 39(1)(b), these natural light openings are not required to be functional, as their primary role is to allow in daylight. Ultimately, this regulation enhances architectural design quality by ensuring sufficient natural illumination in all habitable spaces, which significantly improves the overall indoor environmental condition.

Table 7 *Ratio of Openings to Floor Area in Compliance with UBBL Standards in Modern House*

Place/room Modern House	Area (m^2)	Ratio UBBL (10%) x Area (m^2) (Required Openings Area)	Openings Area (Window) (m^2)	Total Achieved Openings Area (m^2)	Compare result Required and Achieved Area (m^2)
Living room	42	4.2	Triple Casement Window (Glass) 1=1.8 Triple Casement Window (Glass) 2=1.8 Double Casement Window (Glass) 1=1.2	4.8	4.8>4.2 more than UBBL Standard
Kitchen	28	2.8	Double Casement Window (Glass) 2=1.2 Double Casement Window (Glass) 3=1.2	2.4	2.4<4.2 less than UBBL Standard, not have enough openings (window)

Table 7 provides an assessment of window openings in a modern home based on UBBL standards for natural lighting and ventilation, focusing on a 42 m^2 living room and a 28 m^2 kitchen. As per UBBL specifications, the living room is required to have 4.2 m^2 of window openings (10% of the floor area), while the kitchen needs 2.8 m^2. The living room meets the compliance criteria with different window designs, which include triple casement windows (with 1.8 m^2 glass panels) and double casement windows (with 1.2 m^2 glass panels), resulting in a total opening area of 4.8 m^2 that exceeds the mandated 4.2 m^2 threshold, thus ensuring sufficient natural ventilation and lighting. Conversely, the kitchen does not meet compliance, having only double casement windows that provide a total of 2.4 m^2 of opening area, falling short by 0.4 m^2 of the necessary 2.8 m^2 requirement. This shortfall highlights that the kitchen does not have adequate window openings for effective natural ventilation and lighting according to UBBL standards, calling for either additional or larger window designs to resolve this compliance issue and satisfy building code mandates.

Table 8 *Ratio of Openings to Floor Area in Compliance with UBBL Standards in Traditional Malay House*

Place/room Traditional Malay House	Area (m^2)	Ratio UBBL (10%) x Area (m^2) (Required Openings Area)	Openings Area (Window) (m^2)	Total Achieved Openings Area (m^2)	Compare result Required and Achieved Area (m^2)
Living room	12	1.2	Double Casement Window (Wood) 1=0.8 Double Casement Window (Wood) 2=0.8	4.4	4.4>1.2 more than UBBL Standard

			Double Casement Window (Wood) 3=0.8 Double Casement Window (Wood) 4=0.8 Louvre Window 1=1.2		
Kitchen	24	2.4	Single Casement Window (Wood) 1=0.64	0.64	0.64<2.4 less than UBBL Standard, not have enough openings (window)

Table 8 assesses the adherence of window openings in a traditional Malay house to UBBL standards for natural lighting and ventilation, focusing on a living room of 12 m^2 and a kitchen of 24 m^2, which necessitate 1.2 m^2 and 2.4 m^2 of window openings, respectively (10% of the floor area). The living room shows excellent compliance, featuring four double casement wooden windows (each measuring 0.8 m^2) along with one louvre window (1.2 m^2), resulting in a total opening area of 4.4 m^2, which significantly surpasses the necessary 1.2 m^2 standard and provides ample natural ventilation and lighting. Conversely, the kitchen faces a significant compliance challenge with just one casement wooden window that offers 0.64 m^2 of opening area, which is substantially below the required 2.4 m^2 by 1.76 m^2. This notable shortfall underscores a considerable design flaw within the layout of the traditional Malay house, indicating that the kitchen requires either additional or larger windows to satisfy UBBL building code standards for sufficient natural ventilation and lighting, highlighting an essential compliance gap that needs to be addressed.

3.3 Comparison of Illuminance Analysis Simulations

Based on the illuminance analysis comparison, the study conducted simulations using Autodesk Revit software on a Traditional Malay house (May 12, 2025) and a modern house (May 14, 2025) from 10 am to 12 pm, with results closely matching actual measurements and validating the significant influence of opening design on indoor lighting levels. The Traditional Malay house demonstrated superior natural lighting balance through its elevated structure, strategic window positioning, and open floor plan, achieving more uniform light distribution across both floors with moderate lighting levels ranging from 2000-4000+ LUX in well-lit areas and extreme brightness exceeding 6000 LUX near large openings (Figures 10).

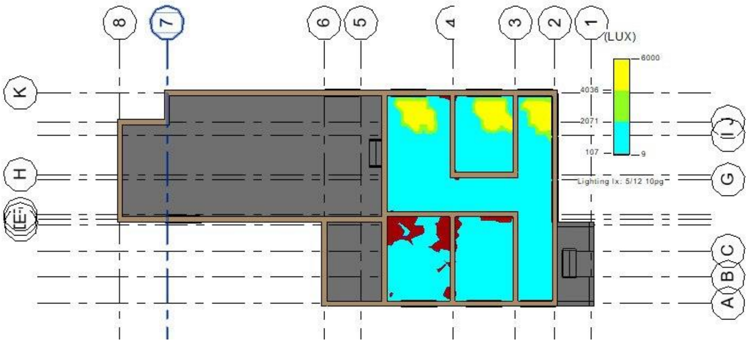

Fig. 10 *First floor plan Illuminance analysis simulation Traditional Malay House*

In contrast, the modern house exhibited more intense and focused lighting patterns with extensive bright yellow zones reaching 6000 LUX due to larger glass elements and floor-to-ceiling windows, but created problematic sharp contrasts between overly illuminated regions and dark red under-lit areas requiring artificial lighting (Figure 11). The comparison revealed that traditional vernacular architecture achieves more sustainable and comfortable lighting conditions through established design principles, while modern architecture requires additional strategies like light shelves or advanced glazing technologies to achieve equivalent lighting quality and distribution throughout the building.

Fig. 11 *Floor plan Illuminance analysis simulation Traditional Malay*

3.4 Comparison of Daylight Factor Simulations

This study analyzed natural light penetration effectiveness by conducting Daylight Factor (DF) simulations under typical overcast sky conditions (CIE Overcast Sky), using globally recognized standards that define acceptable DF values between 1.0% and 3.5%, with a preferred range of 2.0-20.0% according to BS 8206-2:2008 and EN 17037:2018 guidelines for optimal and energy-efficient daylight conditions. The findings highlighted notable differences between the two architectural designs, where the modern house exhibited significant variations in lighting performance—showcasing intense red zones in upper areas and outer sections, signaling excessive brightness and potential glare problems, whereas the central areas revealed deep blue zones with markedly low daylight factors that necessitated artificial lighting (Figure 12).

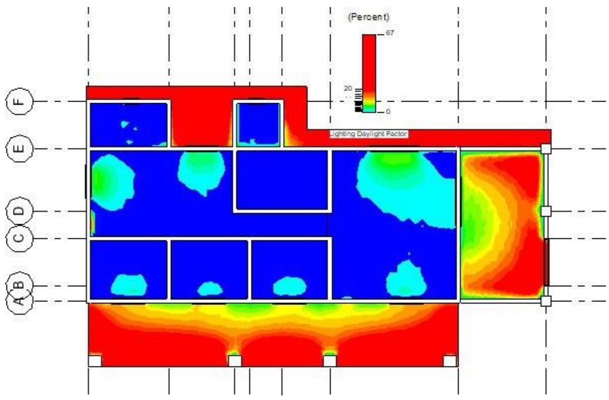

Fig. 12 *Floor plan Daylight Factor simulation Modern house*

On the other hand, the traditional Malay house revealed a more balanced and gradual distribution of daylight factors, predominantly characterized by blue zones indicating moderate daylight levels throughout the internal spaces, with green and yellow zones near openings providing a more even light distribution without drastic fluctuations (Figure 13).

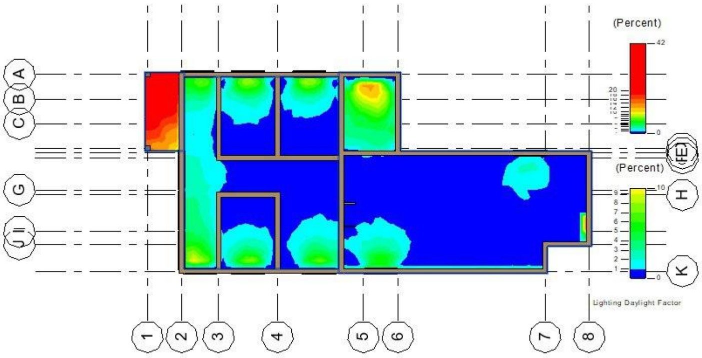

Fig. 13 *Floor plan Daylight Factor simulation Traditional Malay house*

3.5 Summary of Findings Comparative Analysis Simulation using Autodesk Revit BIM

Table 9 *Summary of Findings Comparative Analysis Simulation using Autodesk Revit BIM*

Metric/Parameter	Traditional Malay House	Modern House
	Illuminance Analysis	
Date simulation setting	May 12, 2025	May 14, 2025
Duration	10 am until 12 noon	10 am until 12 noon
Software	Autodesk Revit BIM	Autodesk Revit BIM
Validation	Lux readings that are almost the same as the measurements	Lux readings that are almost the same as the measurements
Pattern of Lighting	Gradual and regulated change	Intensive and concentrated pattern
Bright zone > 6000 lux	Strategic positioning close to wide openings	Significant regions with large, brilliant yellow zones
Well-lit Areas (2000-4000+ lux)	Regular dispersion, areas of light blue and cyan	Focused on the upper and right portions.
Poorly lit Areas <107 lux	Gray, darker areas in enclosed areas	Areas that are dark red and lack natural light
Distribution	More consistent between the two floors	Significant changes in polarized lighting
Ground Floor	Luminous zones close to apertures with moderate lighting	Bright lighting with striking contrasts
First Floor	Uniform lighting and fewer areas of darkness	-
Benefits of Design	Multi-angle light entrance is made possible by the elevated construction.	Large windows to let in as much sunlight as possible
	Daylight Factor Analysis	
Sky Condition Setting	CIE Overcast sky	CIE Overcast sky
Analysis of Floor Area (m^2)	95	118
Average Daylight Factor (ADF) %	1.5	0.8
Sufficient Daylight Area	20 m^2 (21%)	9 m^2 (7%)
Points inside the Desired Range	21%	7%

Table 9 showcases a comparative analysis indicating that traditional Malay homes exhibit better lighting efficiency than contemporary residential designs. The traditional Malay house provides a more balanced and gradual light distribution with fewer extreme brightness challenges, resulting in consistent lighting with minimal variations, while the modern residence displays notable lighting inconsistencies characterized by intense red areas that cause glare and large central blue zones representing significant under-illumination, leading to an uncomfortable polarized lighting situation. The elevated structure of the traditional design and the thoughtfully placed openings contribute to a decreased reliance on artificial lighting and more sustainable lighting conditions, in contrast to the modern home's extensive glazing which, though it maximizes sunlight entry, produces inadequate light distribution that necessitates artificial lighting, causing both glare and dark areas that hinder energy efficiency and occupant comfort. Performance metrics strongly favor traditional design principles, revealing that the traditional Malay house attains an Average Daylight Factor of 1.5% in comparison to the 0.8% of the modern house. Additionally, 21% of the floor area in the traditional house (20 m^2 out of a total of 95 m^2) receives sufficient daylight within the preferred range, whereas only 7% of the modern house's floor area (9 m^2 out of 118 m^2 total) meets this standard, underscoring the traditional design's superior lighting effectiveness even with a smaller overall floor area.

4. Conclusion

This study shows that traditional Malay homes excel in natural daylighting capabilities compared to modern residences, with traditional designs achieving lighting levels that are 10 to 20 times higher, recording up to 23.67 lux in contrast to just 1-2 lux in contemporary houses. The research indicates that 21% of the floor space in traditional homes meets optimal daylight factors (2.0-20.0%), while only 7% of modern homes do, leading to nearly double the Average Daylight Factor (1.5% compared to 0.8%). Features inherent to traditional architecture, such as elevated structures, strategically located wooden windows with overhead openings, and appropriately proportioned room depths, resulted in even light distribution, whereas modern designs experienced uneven lighting due to oversized roof overhangs, compartmentalized layouts, and an excessive reliance on glazing, which caused uncomfortable variations in brightness and shadow. This research confirms the daylight factor criteria set forth by BS 8206-2:2008 and EN 17037:2018 and aligns with findings from [30, 31] that stress the significance of sufficient daylight for human well-being, energy efficiency, and overall building effectiveness, while also underscoring the opportunity to incorporate vernacular architectural concepts into modern sustainable design strategies.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

All authors of this study have complete contribution for data collection, data analysis and manuscript writing.

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