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Integration of Traditional and Modern Materials for Visual Comfort in Bayan Village Weaving House

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Abstract
The Weaving Production Houses in Bayan Village serve as dedicated spaces for weaving activities. Three permanent buildings, Fetung Bayan, Jajaq Bayan, and Belida Bayan, are primary weaving production facilities. Visual comfort is critical in supporting weaving activities from morning until evening. Ensuring optimal lighting conditions is essential to maintaining productivity and minimising visual strain for weavers. This study aims to identify the most effective material combinations to enhance visual comfort within these weaving spaces. A descriptive-quantitative research approach is employed, utilising DIALux simulation software to develop strategies for optimising visual comfort. The findings suggest that combining traditional and modern materials improves lighting conditions. The recommended configuration includes galvalume ceilings with a 78% reflection factor, woven bamboo (bedeg) walls with a 40% reflection factor, and concrete flooring with an 80% reflection factor. Additionally, shading elements and a Window-to-Wall Ratio (WWR) of 40% are proposed to enhance daylight control and reduce glare, ensuring a well-balanced luminous environment for weaving activities.

***Keywords**: daylighting; weaving production house; visual comfort*

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1. INTRODUCTION

Bayan Village is a region rich in cultural diversity and indigenous traditions that have been preserved into the modern era. The unique blend of local customs, religious practices, and wisdom is reflected in various aspects of daily life, particularly in the enduring presence of traditional architecture. The local customary law (*awig-awig*) plays a crucial role in maintaining the authenticity of traditional architectural spaces, as exemplified by the Bayan Timur Traditional House, which retains its original facade incorporating indigenous elements (Suman et al., 2023).

Traditional architecture significantly influences the lives of Bayan Village residents, serving not only as a cultural heritage but also shaping their daily activities and comfort. One of the enduring traditions is the practice of weaving, which has historically been limited to specific community groups. However, the introduction of regional regulations requiring civil servants (ASN) to wear handwoven textiles on Tuesdays has increased demand for woven fabrics, leading to a rise in the village's weavers and weaving production facilities.

The first weaving production house in Bayan, *Fetung Bayan*, was established in 2004.

Initially functioning as a distribution hub for woven textiles, it evolved into an art shop with a semi-outdoor weaving space designed to enhance weaver comfort by reducing monotony and improving environmental quality. The semi-outdoor configuration was selected to create a more engaging workspace, allowing natural ventilation, and visual connection with the surroundings.

This study focuses on the architectural and environmental quality of weaving production houses, mainly about art shops and weaving facilities that support the craft. Weaving is a hereditary skill that traditionally passed down through generations. Weaving particularly among women who were historically required to master it before marriage. The weaving occurs in diverse settings, including agricultural fields and *berugaq*, a semi-open wooden pavilion supported by six timber columns commonly used for social gatherings and receiving guests. Many weaving production houses adopt the *berugaq* concept, featuring low enclosures or open-air spaces, allowing visual access to the outside to reduce eye strain during extended weaving sessions (Widiyantoro et al., 2017), which typically lasting from 09.00 to 17.00.

Currently, 25 weaving production houses exist in Bayan Village, though not all provide permanent workspaces for weavers. Thus, this study selects three art shops with dedicated weaving spaces, *Fetung Bayan*, *Jajaq Bayan*, and *Belida Bayan*, as research samples (Figure 1). Each art shop presents distinct architectural characteristics that reflect diverse spatial designs and comfort strategies for weaving activities.

(a) (b) (c)

Figure 1. Weaving Room in Weaving Production House (a) *Fetung Bayan*, (b) *Jajaq Bayan*, (c) *Belida Bayan*

A significant challenge in weaving production houses is the uneven distribution of natural lighting due to the combination of traditional and modern materials. For instance, measurements at *Jajaq Bayan* art shop reveal significant variations in light intensity, ranging from 150 to 489 lux in the weaving area, whereas the display space records only 28 to 45 lux. Data logger measurements indicate differences between indoor regions (63-65 lux) and semi-outdoor spaces (43 lux). These variations result from shaded spatial layouts, which can lead to visual discomfort and glare (TERI, 2021), affecting the weaving process.

Visual comfort is a critical aspect of designing an optimal workspace for weavers. It is influenced by light quality, luminosity, glare control, and access to outdoor views (TERI, 2021). These parameters are further shaped by the building's orientation and material selection. The primary materials used in weaving production houses include woven bamboo (*bedeg*) for walls and ceilings. At the same time, roofing typically consists of corrugated metal sheets (zinc or galvalume) due to their affordability and lightweight properties. Following the 2018 earthquake, many weaving production houses began transitioning to more durable materials, incorporating concrete slab flooring and brick walls up to 30 cm in height to mitigate moisture accumulation in Bayan's humid climate.

However, adopting modern materials introduces new challenges, such as increased heat retention and glare caused by metal roofing. Therefore, the architectural design of weaving production houses must carefully integrate traditional and modern materials to enhance visual comfort while preserving cultural identity. This study explores design solutions optimizing visual comfort by combining materials, lighting strategies, and spatial orientation in Bayan Village's weaving production houses.

Natural lighting plays a crucial role in daily activities, particularly weaving. Proper light intensity enhances the visual comfort of weavers and directly influences production quality. According to the Indonesian National Standard (SNI) 03-6197-2000, workspaces require an illumination level of 500 lux, while exhibition or display areas should maintain an illumination range of 300-500 lux. Natural lighting is preferred as it reduces eye strain and enhances visual comfort. The lighting quality within a workspace is affected by glare levels regulated by SNI 03-2396-2001. Effective lighting design must consider this factor in creating a comfortable and productive working environment.

Natural lighting and access to outdoor views can support visual comfort in weaving spaces. Several passive design strategies can be implemented, including building orientation, openings, and sun shading. Weaving production houses are typically oriented east or west, exposing them to significant solar radiation. Consequently, an optimal north or south building orientation is recommended to mitigate excessive sunlight exposure (Bhochhibhoya et al., 2017).

The apparent annual movement of the sun influences the duration of sunlight exposure on buildings. From march to september, the sun is positioned north of the equator, peaking in june, while from september to march, it shifts southward, reaching its highest position in december (Suryadi Siregar, 2017). Understanding this pattern allows building design adjustments that optimize natural lighting without increasing indoor temperatures. Visual comfort supported by optimal natural lighting can undoubtedly increase the productivity of activities both indoors and outdoors (Ragilyani & Dewi, 2021).

Sun shading devices can be implemented to regulate natural lighting within weaving spaces. Overhangs and fins combine vertical and horizontal shading elements, effectively reducing glare and improving visual comfort (UN Habitat, 2018). The best opening position is in the south and the east is the opening position to be avoided. Lighting in the south has the deepest light range, the north has the shortest, and the east and west have the shorter ranges (Yusri, 2020)

A room's lighting cannot be achieved using a single lighting system. Both natural and artificial lighting are suitable. Visual comfort through natural lighting is highly beneficial for indoor spaces (TERI, 2021). However, artificial lighting is needed to support natural lighting during cloudy weather or when there are significant differences in illumination near openings, the center, and the back of the room. Artificial lighting can maximize visual comfort in a space. Limited natural light sources due to weather changes and room depth issues result in uneven distribution because not all room areas are exposed to sunlight (Azizah, 2020). The need for artificial lighting to support natural lighting is assessed using the PSALI method. This method calculates the number of lamps needed in a room. The central concept is to increase natural light to normal values under artificial lighting in areas with inadequate natural light (Muraviova et al., 2018).

Integrating traditional and modern materials can enhance visual comfort and energy efficiency. Traditional materials are known for their durability and eco-friendliness, while contemporary materials are often utilized to improve structural strength (Ngowi et al., 2016). The combination of traditional and modern materials can undoubtedly be an environmentally friendly solution (Spišáková & Mačková, 2015). The appropriate specifications of modern materials can provide visual comfort that matches the combination of traditional materials. Material characteristics and albedo can also be considered when selecting environmentally friendly and appropriate materials (Syahriyah, 2017). The texture and color of materials can also affect the visual comfort of a space. Texture can influence how our brains perceive space. Thin, smooth, and light textures create a larger space, while heavy textures create the impression of a smaller space (W. E. Sari et al., 2022).

In Bayan Village, modern materials such as zinc, galvalume, and concrete are increasing due to their affordability and ease of installation. However, these materials can exacerbate glare and create uneven lighting distribution. Therefore, a balanced combination of traditional and modern materials can create a more comfortable environment for weavers Table 2 .

Table 1. Material Reflection

Material	Reflection Factor (%)
Aluminum	70-85
Wood	5-40
Glass	7
Concrete	30-50

Source: Heating, Cooling, and Lighting, 2022 (Andrasik, 2022)

Material texture and color also affect visual comfort. Smooth and light-colored surfaces create a sense of spaciousness, whereas rough textures produce the opposite effect (N. B. Sari, 2017). Selecting materials with appropriate reflectance values can reduce glare and enhance lighting efficiency within weaving spaces.

Optimal visual comfort enhances weaver productivity. Several parameters influence visual comfort (TERI, 2021; see Table 2) .

Table 2. Visual comfort parameter used in research

Parameter	Standard	Function
Uniformity	0.6-0.8	Maintaining visual sharpness and visibility
Illuminance	500 lux	Ensures work is safe and comfortable, light distribution, and determines optimal illumination levels.

Source: TERI (2021)

Weaving spaces can be transformed into more comfortable and productive work environments by optimizing natural lighting, implementing effective passive design strategies, selecting appropriate materials, controlling illumination, and ensuring uniformity. This study aimed to determine the integration between traditional and modern materials to create visual comfort in weaving activities at the Bayan Village weaving production house.

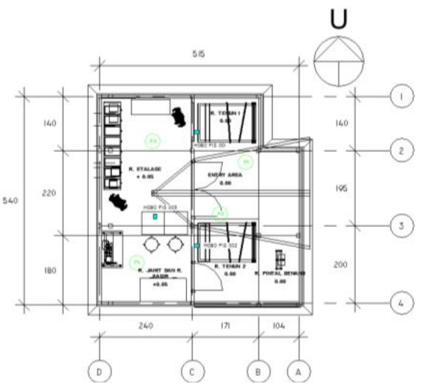
2. METHODS

This study aimed to determine the combination of traditional and modern material integration to optimize lighting in weaving production houses, thus creating visual comfort for weavers. The research is a quantitative descriptive study with the independent variable being the integration of traditional and modern materials, with the indicator of material reflectance level. This research also uses dependent variable being visual comfort, with the indicator of illumination and uniformity.

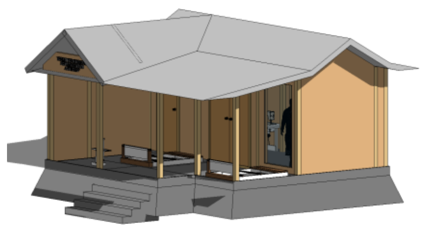
The data processing in this study was conducted using a lighting simulation method through DIALux software, which was utilized for both natural and artificial lighting simulations. The quantitative data obtained were analyzed to determine whether they met the applicable standards, and design recommendations were subsequently developed. These proposed design modifications were then re-simulated using DIALux software to identify optimal lighting design scenarios aligned with workspace lighting standards (Puni et al., 2020).

The analysis considered several key lighting parameters, including illuminance levels, task luminance, background luminance, contrast ratio, and brightness. These factors were evaluated to ensure compliance with ergonomic lighting standards for weaving activities, which require visual precision and prolonged concentration.

This research was conducted in 3 weaving houses, namely *Fetung Bayan* (Figure 2), *Jajaq Bayan* (Figure 3), and *Belida Bayan* (Figure 4).

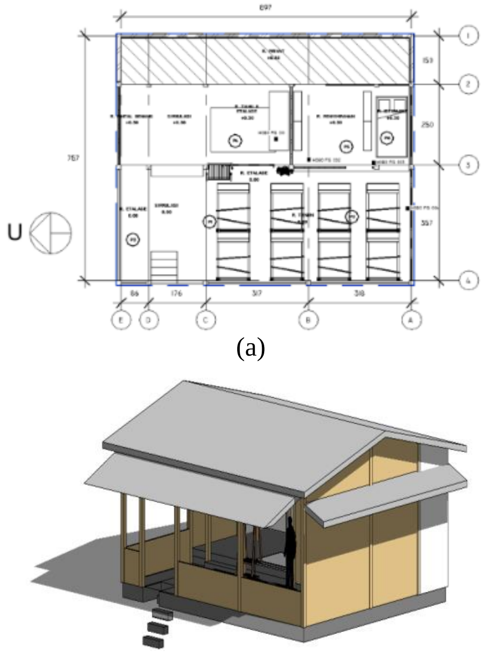


(a)



(b)

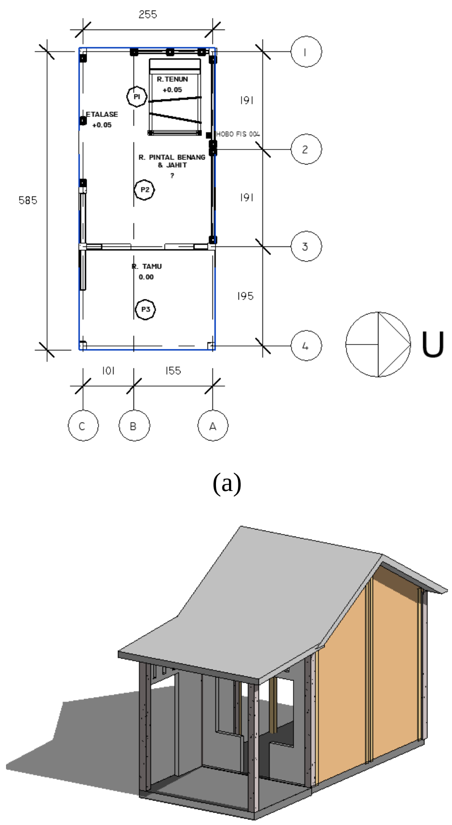
Figure 2. *Fetung Bayan* (a) Floor Plan, (b) 3D Building Visualization



(a)

(b)

Figure 3. *Jajaq Bayan* (a) Floor Plan, (b) 3D Building Visualization



(a)

(b)

Figure 4. *Belida Bayan* (a) Floor Plan, (b) 3D Building Visualization

The analysis and simulation results will be analyzed based on the illuminance and reflectivity standards of the material plane and the uniformity ratio to optimise visual comfort at the Bayan Village Weaving Production House by integrating traditional and modern materials to create a comfortable space.

3. RESULT AND DISCUSSION

Analysis of natural and artificial lighting in the weaving production house in Bayan Village, integrated with modern and traditional materials, was carried out to optimize visual comfort for weavers. Lighting simulation was conducted using DIALux software to determine the lighting distribution in the weaving production house. Integration of traditional and modern materials was carried out by adjusting the reflectance value of the material. Lighting optimization was carried out by providing several alternative combinations of traditional and contemporary material integration in three weaving production houses to achieve lighting standards in the weaving room. Simulations were carried out in March, June, September, and December, according to the pattern of sun movement. The materials used in the weaving room are galvalume on the ceiling, *bedeg* on the wall covering, and concrete slabs.

The improvement scheme carried out is in the form of a strategy to maximize natural lighting by adding shading, replacing the size of the openings, the type of openings, and the elements of the building façade, whether glass or non-glass (Olgyay, 2001), and a combination of traditional and modern material integration based on the reflectance of the materials used.

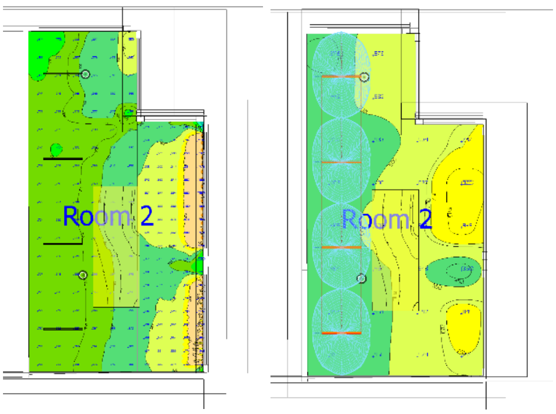
Based on the simulation results in ***Fetung Bayan***, the best material combination is ceiling material using galvalume with a 78% reflection factor, walls using a badge with a 40% reflection factor, and floors using concrete with an 80% reflection factor. The rear area of *Fetung Bayan* has achieved visual comfort standards with a uniformity of 0.62, but the average illuminance level of the entire room is 422 lux. The calculation area to determine the light intensity is divided into the rear and the front. The rear area has an illumination level of 286 lux, while the front has an *illuminance* level of 721 lux. The daylight factor is 1.94%

because the openings are only on one side of the wall, so only the front area gets much natural light. So, it is necessary to add artificial lighting to the rear to achieve the standard illuminance level of 500 lux, and the uniformity and brightness of the room should become even.

Based on the simulation with the addition of artificial lighting, the average illuminance level of the entire room before adding artificial lighting was 424 lux with a uniformity of 0.51. After artificial lighting was added in the back area, the average illuminance level of the entire room was 596 lux with a uniformity of 0.64 (Table 3; Figure 5). So, the scheme achieved the visual comfort standard at an illuminance level of 500 lux and uniformity of 0.6.

Table 3. *Fetung Bayan*'s best scenario for visual comfort

Scenario	Uniformity	Illuminance (lux)
Without Artificial Light	0.51	424
With Artificial Light	0.64	596



(a) (b)

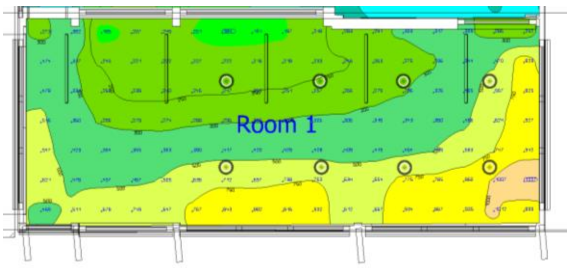
Figure 5. Simulation Result Visualization in *Fetung Bayan* (a) Without Artificial Lighting, (b) With Artificial Lighting

Based on the simulation results in ***Jajaq Bayan***, the best material combination is ceiling material using galvalume with a 78% reflection factor, walls using a badge with a 40% reflection factor, and floors using concrete with an 80% reflection factor. However, it has not reached the visual comfort standard with a uniformity of 0.39, and the average illuminance level of the entire room is 443 lux. The daylight factor is 2.2%, and this is because the openings on the three sides of the north, south, and west walls cannot transmit natural light to the east side of the room. So, it is necessary to add artificial lighting to achieve the illuminance standard at 500 lux and uniformity at 0.6, and the room's brightness becomes even.

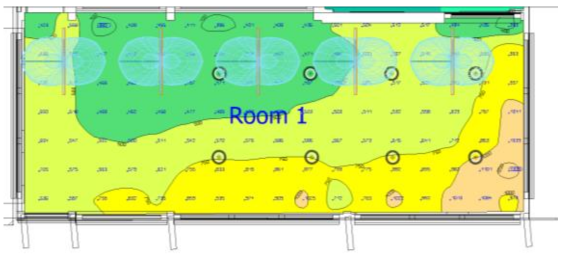
Based on the simulation with the addition of artificial lighting, the average illuminance level of the entire room before adding artificial lighting was 443 lux with a uniformity of 0.39. After artificial lighting was added in the back area, the average illuminance level of the entire room was 603 lux with a uniformity of 0.61 (Table 4; Figure 6). So, it has reached the standard of visual comfort at an illuminance level of 500 lux and uniformity of 0.6.

Table 4. *Jajaq Bayan*'s best scenario for visual comfort

Scenario	Uniformity	Illuminance (lux)
Without Artificial Light	0.39	443
With Artificial Light	0.61	603



(a)



(b)

Figure 6. Simulation Result Visualization in *Jajaq Bayan* (a) Without Artificial Lighting, (b) With Artificial Lighting

Based on the simulation results at ***Belida Bayan***, the best material combination is the ceiling material using galvalume with a 78% reflection factor, the wall using a badge with a 40% reflection factor, and the floor using concrete with an 80% reflection factor. The repair results show that it has reached the visual comfort standard with a uniformity of 0.63, but the average illuminance level of the entire room is 311 lux. The daylight factor is 1.5%, and this is because the openings on the three sides of the north, east, and west walls cannot transmit natural light to the south side of the room. So, it is necessary to add artificial lighting at the back to achieve the illuminance standard of 500 lux, and the uniformity and brightness of the room will become even.

Based on the simulation results of adding artificial lighting, the average illuminance level of the entire room before adding artificial lighting was 313 lux with a uniformity of 0.63. After artificial lighting was added, the average illuminance level of the whole room was 515 lux with a uniformity of 0.71 (Table 5; Figure 7). So, it has reached the visual comfort standard at an illuminance level of 500 lux and uniformity of 0.6.

Table 5. *Belida Bayan*'s best scenario for visual comfort

Scenario	Uniformity	Illuminance (lux)
Without Artificial Light	0.63	313
With Artificial Light	0.71	515

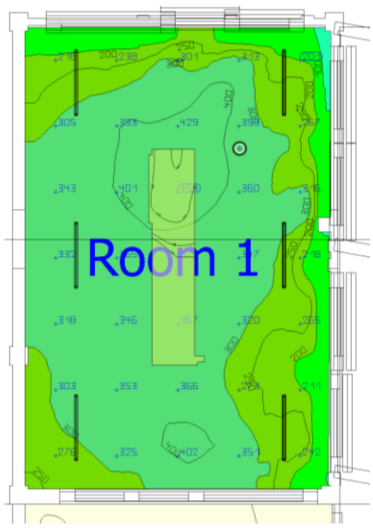


Figure 8. Simulation Result Visualization in *Belida Bayan* without Artificial Lighting

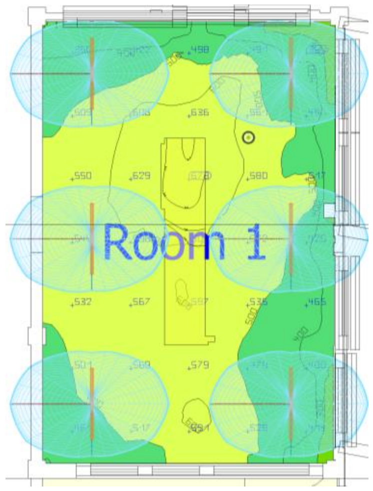


Figure 8. Simulation Result Visualization in *Belida Bayan* with Artificial Lighting

Based on the results of the analysis, traditional and modern materials suitable for the Bayan Village weaving production house have been integrated. The integration with a room height of 2.4 - 3 m is:

1. Ceiling material or ceiling uses galvalume with a 78% reflection factor, the reflectance condition of new galvalume material (modern material).
2. The wall material is woven bamboo with a 40% reflection factor without additional furnishings. The bed used is also in new condition (traditional material).
3. The floor material uses a concrete slab with an 80% reflection factor, which is the condition of the new concrete slab (modern material).

This theory of material reflectance value affects the spread of light in space. The percentage of light reflectance is 80% on the ceiling, 50% on the walls, and 20% on the floor. Ceiling heights of 8 to 16 feet or 2.4 m can distribute light more evenly on the top and sides (Olgyay, 2001).

All Bayan Village weaving production houses use the same type and reflectance of materials. However, several schemes are still needed to create visual comfort in addition to using materials. Three weaving production house buildings have been carried out using scenario schemes.

Reduction of the opening area in *Fetung Bayan* and *Jajaq Bayan* obtained the exact and most optimal opening ratio results at WWR 40% with horizontal openings. In *Belida Bayan*, the most optimal opening ratio results were obtained at WWR 40% with vertical openings. This scenario recommends that the optimal east and west opening orientation uses WWR 30-40% (Goyal et al., 2022). The horizontal or strip opening shape is suitable for entering natural light evenly (Schumann et al., 2003). Vertical openings are ideal for the *Belida Bayan* building because of its high shape. This scenario is based on the theory that the higher the window, the more natural light enters it (Schumann et al., 2003). The type of opening in *Fetung Bayan* is a Standard Window. In *Jajaq Bayan*, the type of opening used is a 3-Wing Window with a Transom and a Rectangular Window with Transom. In *Belida Bayan*, the opening is a Rectangular Window with Transom. The optimal opening facade element criteria is not to use glass (no glass). Through the simulation that has been carried out using the no-glass option, the daylight factor, light intensity, and uniformity ratio results reach the visual comfort standard.

From the results of integrating traditional and modern materials and adding visual comfort schemes in shading and WWR, the best model was obtained from each Bayan Village weaving production house. In *Fetung Bayan*, visual comfort was achieved with an illuminance level in the front area of 721 lux and a rear area of 286 lux with a uniformity of 0.51. In the front area, it is higher than the standard illuminance level of the weaving area. In the rear area, it is lower than the standard illuminance level of the weaving area, which is 500 lux. Therefore, artificial lighting was added to the rear area so that the overall average illuminance level was 596 lux with a uniformity of 0.64. So, it has met the visual comfort standard with a uniformity of 0.6.

In *Jajaq Bayan*, visual comfort is achieved with an illuminance level of 443 lux with a uniformity of 0.39, which is lower than the standard illuminance level of the weaving area of 500 lux and has not reached the uniformity standard of 0.6. Therefore, artificial lighting is added so that the overall average illuminance level is 603 lux, with a uniformity of 0.61. So, it has met the visual comfort standard.

In *Belida Bayan*, visual comfort is achieved with an illuminance level of 313 lux with a uniformity of 0.63, which is lower than the standard illuminance level of the weaving area of 500 lux and has reached the uniformity standard of 0.6. Therefore, artificial lighting is added so that the overall average illuminance level is 515 lux with a uniformity of 0.71. So, it has met the visual comfort standard.

The use of artificial lighting to support natural lighting in areas of space far from openings. This design is achieved through the PSALI method: adding or combining natural lighting to achieve standards with artificial lighting in areas without natural lighting (Muraviova et al., 2018). Artificial lighting uses the LED Tube Lamp type with linear placement.

4. CONCLUSION

Several schemes have been developed based on the analysis and discussion conducted to address integrating traditional and modern materials in achieving visual comfort for weaving activities in the Weaving Production Houses of Bayan Village. The integration of conventional and contemporary materials across all weaving production houses in Bayan Village includes the use of galvalume ceilings with a reflection factor of 78%, woven bamboo (bedeg) walls with a reflection factor of 40%, and concrete slab flooring with a reflection factor of 80%.

In addition to material selection, visual comfort is further enhanced through the implementation of shading strategies. At *Fetung Bayan*, horizontal shading (cantilever), vertical shading with a 5° inclination, and venetian blinds are utilised. *Jajaq Bayan* employs horizontal shading (cantilever), light shelves, vertical shading with a 5° inclination, and venetian blinds. Meanwhile, *Belida Bayan* incorporates horizontal shading (cantilever), vertical shading with a 10° inclination, and venetian blinds.

A no-glass approach is implemented for window design, with horizontal windows featuring a 40% window-to-wall ratio (WWR) in *Fetung Bayan* and *Jajaq Bayan* and vertical windows with a 40% WWR in *Belida Bayan*. Artificial lighting is introduced in areas distant from openings to complement natural lighting. The artificial lighting system utilizes LED tube lamps arranged in a linear configuration to ensure uniform illumination throughout the space.

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CONTRIBUTIONS

Gusti Ayu Putu Selina Dewi contributed to methodology, investigation, formal analysis, data curation, software, and visualization. Nimas Sekarlangit contributed to conceptualization, methodology, formal analysis, investigation, resources, writing–review and editing, and supervision.

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