# The Effect of Shading Devices on OTTV (Overall Thermal Transfer Value) Value of Office Buildings: Case Study of PT Industri Kapal Indonesia (IKI) Building

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## ABSTRACT

One of the passive design strategies that effectively reduce the heat load on the building envelope, especially in areas with a large surface area of glass shading Device. The research aims to measure the design influence of shading devices against the value of Overall Thermal Transfer Value (OTTV) buildings. Research using quantitative methods, research done by trying Shading devices with Vertical Models, Horizontal multiple fins, and Egg crates, which have the length and slope provided by the Indonesian National Standard SNI. It tests each design shading measured on an impairment basis OTTV the best and best under 45 Watt/m². The results of the study show that shading devices affect the impairment of OTTV. The longer the shading device and the higher the slope, the more effective it is in blocking incoming radiation through the glass surface. Impairment OTTV existing buildings without a shading device have an initial value of 69.572 W/m2, decreased by 55% to 31.57 W/m2. Shading an egg crate with length120 cm with a slope of 40° is the best shading based on a comparative analysis between vertical louver shading and horizontal multiple fin shading. This is due to shading egg crates being able to respond to the sun in incoming low and high altitude angles to minimize or block radiation that enters through the glass surface.

**Keywords:** conservation; envelope energy; shading design; OTTV.

## INTRODUCTION

The building facade is the outer shell of a building that functions as a protector of the inner space from the outdoor environment [1] The building envelope is the building element that encloses the building, namely transparent or non-transparent walls and roof, where some of the thermal energy transfers through these elements [2] Research conducted by [3] showed that building facades contribute 50% -60% of the building's total heat gain.

To limit external loads, the building envelope and roof plane are essential building elements that must be taken into account in energy use. Because of its function as an external casing, energy conservation criteria need to be considered in the process of designing a particular building concerned with planning exterior fields concerning the visible appearance of the building. To reduce the external burden, the Indonesian National Standardization Agency determines the criteria design building envelope stated in the Overall Thermal Transfer Price (Overall Thermal Transfer Value, OTTV) which is OTTV ≤ 45 Watt/m² [4]. The case study used is a mid-rise building, namely the PT.IKI (Indonesian Ship Industry) Building. The building has three floors, and the shape of the building mass is a rectangle with a ratio of building length to building width of 1:2. The building envelope consists of a paint composition with colored gray, ceramic walls measuring 40x40cm in gray, windows with 2 types and a curtain wall which has a module 100 x 75 cm. The building is Oriented west and east, and the solar radiation received in the west is directly directed to the curtain wall without any sun Shading attached to the building is the same as the west side of the sun installation Shading, However Of area to the east there is a balcony that forms a corridor that can indirectly protect the glass surface from incoming radiation. The design of the balcony forming a small walkway may not be effective because it has no function for the building. The shape of the balcony is not quite right in preventing minimal radiation from entering the building due to the shape of the shading device horizontally where According to the design of effective shading devices for east and west orientations of shading vertical and Shading Egg Crate. In contrast, one of the design

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principles applied to reduce heat gain through the building envelope is to design the shape of the building orientation to avoid and minimize exposure of the building envelope from a west orientation and reduce heat transmission by providing appropriately designed external shading. This research is one form of effort to save energy in the building by analyzing usage shading efficiency in each orientation.

**Conservation of Envelope Energy**

A building has a cooling load consisting of internal and external loads. Internal loads are loads caused by the addition of indoor heat, such as lighting. In contrast, external loads originate from solar radiation and solar conduction that enter through the building envelope [5]

One energy-saving criterion is the value OTTV according to SNI 03 – 6389 – 2011, which equals 35 watts/m². OTTV includes 3 essential elements: solar radiation through glass, heat conduction through glass, and heat conduction through opaque walls [6]

According to SNI 6389:2020, the energy conservation of the building envelope can be seen from the value overall Thermal Transfer Value (OTTV), namely the determination of the value of the design criteria for the conditioned exterior walls and the glass of the building. OTTV is the heat transfer value of solar radiation received by the building envelope per square meter of area.

**Shading device**

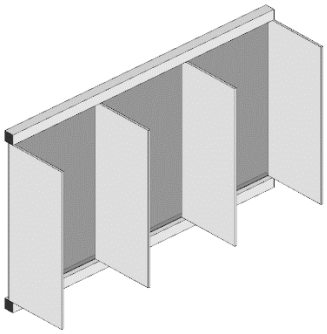
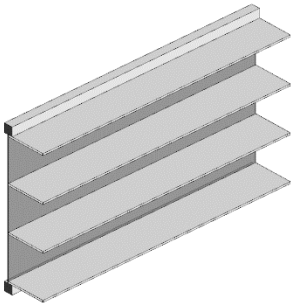
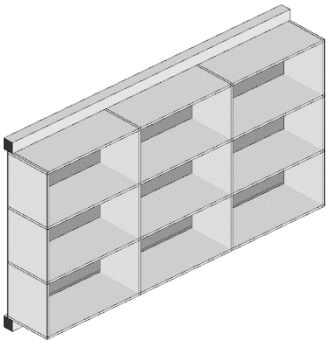
Controlling sunlight entering the building is the primary step in the passive cooling process to get thermal comfort conditions. Sunlight modulation in this setting process can be achieved by paying attention to Orientation and aperture geometry, Shading devices, Property of opaque and transparent surfaces [7] A shading device is a component of the building envelope and has an essential role in positively influencing energy efficiency in buildings. In general, shading devices are used to protect indoor spaces from direct sunlight through openings, windows, and large glass surfaces. Different climate areas require different configurations of shading devices. Buildings in areas with hot-humid climates need to reduce solar radiation and the penetration of sunlight into the building. [8]

Building shading as a means of reducing energy consumption requires careful consideration. Many studies explore the use of shading devices. For example, between 10% and 11.3% energy savings can be expected from the benefits of external shading devices in hot and humid climates [9]and [10].

However, most shading devices are designed for aesthetic purposes rather than their energy-saving potential. Designers need to pay more attention to findings about the importance of shading devices when they leave the analysis late in the design development phase. Shading devices require careful consideration at the initial design stage, especially for facades with high window-to-wall ratios [11]

There are 3 types of Shading devices [12], namely vertical devices, horizontal devices, and egg-crate devices, which are a combination of vertical and horizontal devices. Al-[13] are several researchers who tested the effectiveness of Shading devices compared to buildings that do not use shading devices. His research on high-rise office buildings in Malaysia found that buildings with shading devices have better-cooling energy performance than buildings that do not use shading devices, and egg-crate shading has the best cooling energy performance. Lau et al. (2016) stated that egg-crate shading can save cooling energy up to 3.4%, vertical Shading 2.4%, and horizontal Shading 1,4.

**Table 1.** Type Shading Device

| No | Shading Type | Visual | Best Orientation |
|---|---|---|---|
| 1 | Vertical Shading |  | East, West |
| 2 | Horizontal Shading<br>Multiple Fins |  | East, West |
| 3 | Shading Eggcrate |  | West, East |

**OTTV**

The calculation results, OTTV, can be an input from the performance of the building envelope, the more fragile the value OTTV obtained, the heat that enters the building is also low, and the energy consumption of the building is also low. [14]

In calculations OTTV, building conservation criteria include thermal conditions outside the building, which can affect internal heat [15] Modification Window to Wall Ratio (WWR), type, thickness, and color of outer walls, shading devices, glass conduction, and roof and wall insulation, are modifications that can be used to achieve energy-efficient building qualifications [16] The modification is expected to meet the standard criteria of [17]. In addition, the rating tools published by Green Building Council Indonesia (GBCI) are one of the efforts to support sustainable development, aiming to evaluate the application of the green building concept [18]

Calculation OTTV obtained from the formula [17] is as follows.

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$OTTV = a[U_w \times (1\text{-}WWR)] \times TD_{EK} + (U_F \times WWR \times \Delta T) + (SC \times WWR \times SF)$ (1)

Where:

OTTV= Overall thermal transfer value on the outer wall with a specific direction or orientation (Watt/m²).

α = Absorbance of solar radiation.

Uw = Thermal transmittance of the opaque wall (Watts/m².ºK).

WWR= Comparison of the window area with the area of the entire outer wall at the orientation determined in the study.

SC = Shading coefficient of the fenestration system.

SF = Solar radiation factor (Watt /m²).

Uf = Fenestrated thermal transmittance (Watt/m².ºK)

## RESEARCH METHODS


**Figure 1.** Research Locations

The research location is PT. Indonesian Ship Industry (Persero), whose address is: Galangan Kapal Street No.31, Kaluku Bodoa, Tallo, Makassar City, and South Sulawesi 90212. PT. IKI is a state-owned enterprise engaged in repairs or repairs, new shipbuilding, steel construction & related industries, and Fiberglass.


**Figure 2.** PT.IKI Building Façade

In this study, the research method used is a quantitative research method. This research uses 3 variables in analyzing, namely:

**a. Dependent variable**

Dependent variables are factors that are observed and measured to determine the influence of independent variables. These namely factors appear, do not appear, or change according to what was introduced by the researcher. The dependent variable in this study is OTTV (Overall Thermal Transfer Value) or overall thermal transfer value, which is determined as a design criterion for conditioned exterior walls and glass of buildings. Standard OTTV used in this

study is 35 watts/m² according to SNI 6389 (2011), and the permitted limit is 45 watts/m² [4]

**b. Independent variable**

Independent variables cause or influence, namely factors that are measured, manipulated, or selected by researchers to determine the relationship between observed or observed phenomena. Become independent variables in this study are; Shading device model horizontal, the Shading device Vertical Model, and Shading device the Egg Crate model. The length of each model, the Shading device, is 60cm, 90cm, and 120cm. The slope of each model the Shading device with the tested length.

**c. Variable control**

Control variables are controlled or kept constant so that the relationship between the independent and dependent variables is not influenced by external factors that are not examined. The control variable in this study is the existing condition regarding the physical building, value OTTV.


**Figure 3.** Research flow concept

## RESULTS AND DISCUSSION

### Existing Design Simulation

Calculation simulation OTTV PT.IKI building with value specifications being absorbed solar radiation, the value of the thermal transmittance of the opaque wall (Uw), WWR, SC value, SF value, UF value, WWR.

**Table 2.** Table of Values OTTV Existing

| **Elevation** | **OTTV** |
|---|---|
| | (Watt/m²) |
| North | 74.57 |
| South | 61.32 |
| west | 62.93 |
| East | 79.47 |
| Average | **69.572** |

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Based on the results of the Calculation analysis OTTV existing condition of the building OTTV shows that it has a value of 69,572 W/m². This value is above the limit allowed, i.e., 45 Watts/m².

**Analysis shading device Against Impairment of Value OTTV**

There are three types of Shading devices tested horizontal, vertical, and egg crate. Shading vertical (SV) was tested with 18 samples with a length of 60.90 and 120cm (SV60, SV90, and SV120) with a slope of each sample of 0 °, 10 °, 20 °, 30 °, 40 °, and 50 °. Shading Horizontal (SH) was tested with 18 samples with a length of 60.90 and 120cm (SH60, SH 90, and SH120) with a slope of each sample 0 °, 10 °, 20 °, 30 °, 40 °, and 50 °. Shading Eggcrate (ET) was tested with 15 samples with lengths of 60.90 and 120cm (ET60, ET90, and ET 120) with a slope of each sample of 0 °, 10 °, 20 °, 30 °, and 40 °.

a. Shading device North Orientation

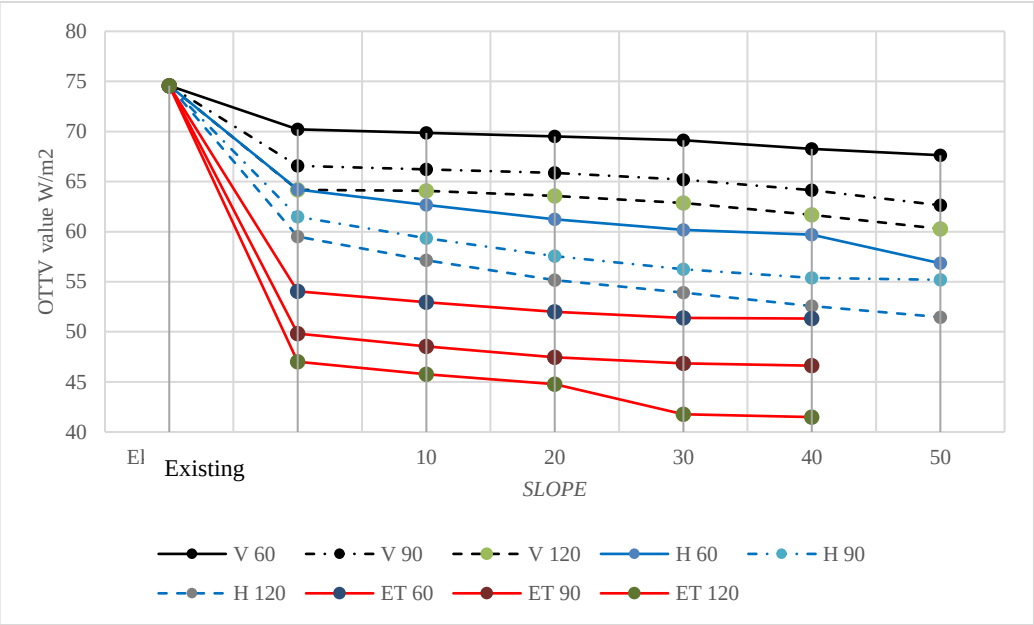


**Figure 5.** Graph of Impairment Variation OTTV North Orientation with Shading Horizontal, Vertical and Eggcrate based on Simulation Ecotect.

Figure 5 shows Shading The vertical with the highest decline is Shading Vertical with a Length of 120 with a slope of 50, a decrease in value of 19% to 60.28 W/m2.Shading Horizontal Length 120 slope 50 decreased 31% to 51.468 W/m2.Shading Egg Crates with a length of 120 slopes 40 experienced the most effective reduction of 44% to 41.49 W/m2. The picture shows that the longer and deeper the slope shading can reduce the value of OTTV because the length and slope of the shading effect are dispelling. Comparison between shading vertically and horizontally in this north orientation, according to figure 5, is effective Shading horizontally, is due to its ability Shading horizontally to receive the high sun altitude angle and while Shading horizontally is less effective at receiving angles altitude high sun. North orientation is more dominant, and the angle of incidence is the high altitude angle. Nevertheless, in comparison Shading vertical and horizontal exist Shading Egg Crate is more effective in lowering Value OTTV. This is due to its affordability Shading Egg Crate receives angle altitude low and high sun until shading can drive away radiation that enters through the glass surface.

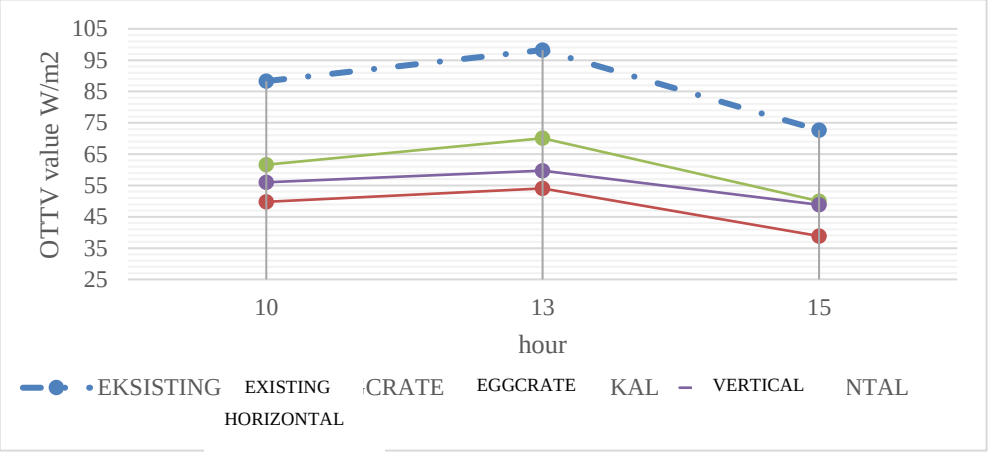


**Figure 6**. Graph of Impairment in Value OTTV North Orientation with Shading Horizontal, Vertical and Eggcrate March 21st.

The existing condition of the building without using a Shading device on March 21 at 10.00 am has a value of OTTV 88.297 W/m2, 13.00 noon 98.251 W/m2, and 3.00 pm has a value of 72.683 W/m2. Decline, shading device vertical at 10:00 am lowered the value OTTV by 30%, at 13.00 noon by 29%, and at 3.00 pm, a decrease of 31%. Shading Horizontal at 10:00 am lowers OTTV by 37%, at 13.00 decreases OTTV by 39%, and at 3.00 pm, a 33% drop. Shading Egg crate has the most efficient reduction compared to shading vertically and horizontally at 10.00 at 44%, at 13.00 noon at 45%, and at 15.00 at 47%. A comparison of the effectiveness of vertical and horizontal shading can be seen in Figure 6 at 13.00, and it can be seen that vertical shading is less efficient in responding to angles altitude high sun. In contrast, horizontal shading efficiently responds to high sun altitude angles. Shading Egg crate is effective in response to high and low sun altitude angles so that the value decreases OTTV can get off regularly maximum.

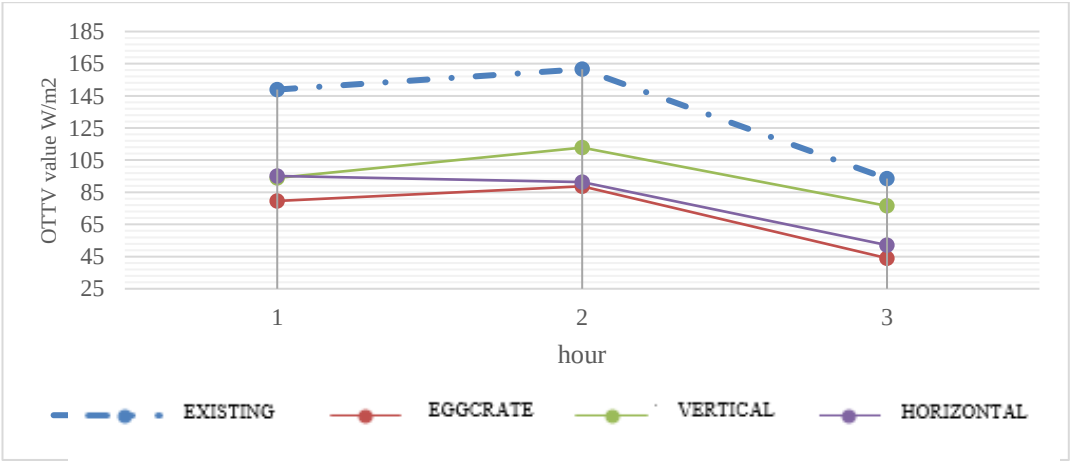


**Figure 7.** Graph of Impairment in Value OTTV North Orientation with Shading Horizontal, Vertical and Eggcrate June 21.

Figure 7 shows the existing condition of the building without the use Shading device on June 21 at 10:00 am has a value of OTTV 148.87 W/m2, 13.00 noon 161.56 W/m2, and 3.00 pm has a value of 93.516 W/m2. Decline, shading device vertical at 10:00 am lowered the value OTTV by 37%, at 13.00 noon by 30%, and at 3.00 pm, a decrease of 18%. Shading horizontally at 10.00 am lowered the value OTTV by 36%. At 13.00 decrease, OTTV was 43%, and at 3.00 pm, a decrease of 18%. Shading the egg crate has the most efficient reduction compared to shading vertically and horizontally at 10.00 at 46%, 13.00 at 45%, and 15.00 at 53%. A comparison of effectiveness

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between Shading Vertical and horizontal can be seen in Figure 7 at 13.00Shading Vertical is less efficient in responding to angles altitude the sun is high while Shading horizontally is efficient in responding to high solar altitude angles. At 10.00 am, the vertical and horizontal shading have almost the same decrease, only differing by 1%. This is because the vertical shading can respond to the angle of the sun's altitude, which comes in June at 10.00 am, so the vertical shading decrease value is superior even though it is only 1%. In contrast, 15.00-noon horizontal shading is more effective at receiving the angle of the sun's altitude. Shading egg crate is effective in response to high and low sun altitude angles so that the value decreases OTTV can get off regular efficiency seen in graphic image 9 at 10.00 am to 15.00 shading egg crate.

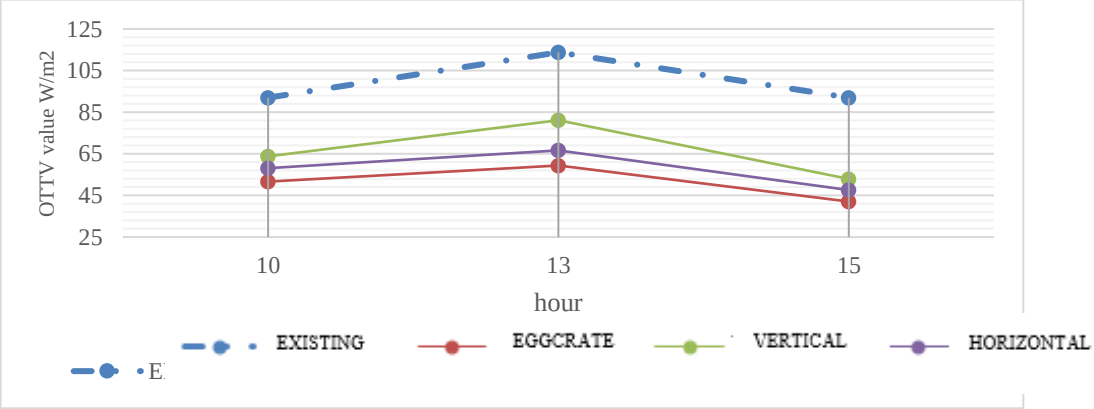


**Figure 8.** Impairment Graph OTTV North Orientation with Shading Horizontal, Vertical and Egg crate September 23.

September 23, Figure 8 shows the existing condition of the building without the use Shading device on September 23 at 10.00 am has a value of OTTV 91.983 W/m2, at 1.00 pm 113.77 W/m2 and 3.00 pm has a value of 91.983 W/m2. Decline, shading device vertical at 10:00 am lowered the value OTTV by 31%, at 13.00 noon by 29%, and at 3.00 pm, a decrease of 42%. Shading horizontally at 10.00 am lowered the value OTTV by 37%. At 13.00, OTTV decreased by 41%, and at 3.00 pm, a 48% drop. Shading egg crate has the most efficient decrease compared to shading vertically and horizontally at 10.00 at 44%, at 13.00 noon at 48%, and at 15.00 at 54%. The ratio of vertical and horizontal shading is the same analysis in the explanation of Figures 7 and 8, which explain the effectiveness of superior horizontal multiple fins shading at high sun angles Shading egg crate is Shading that is effective in responding to high and low sun altitude angles resulting in a decrease in value OTTV can get off regularly efficiency can be seen in the graphic image 10 at 10.00 am to 15.00 is Shading egg crate.

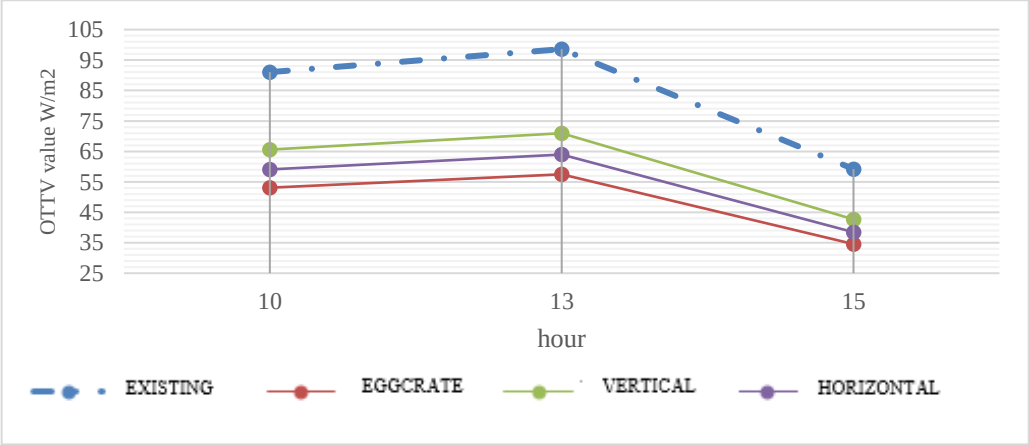


**Figure 9.** Impairment Graph OTTV North Orientation with Shading Horizontal, Vertical and Eggcrate December 22.

December 23 in Figure 9 shows the existing condition of the building without using a Shading device at 10.00 am has a value of OTTV 91.033 W/m2, 1.00 pm 98.577 W/m2, and 3.00 pm has a value of 59.23 W/m2. Decline, Shading device vertical at 10:00 am lowered the value OTTV at 13.00 noon by 28%, and at 3.00 pm, a decrease of 28%.Shading Horizontal at 10.00 am lowered the value OTTV 35%, at 13.00 decrease OTTV 35% and at 3.00 pm, a 35% drop. Shading egg crate has the most efficient decrease compared to Shading vertically and horizontally at 10.00, at 13.00 noon at 42%, and 15.00 at 42%. The ratio of vertical and horizontal shading is the same analysis in the explanation of Figures 8 and 9, which explain the effectiveness of superior horizontal multiple fins shading at high sun angles Shading egg crate is Shading that is effective in responding to high and low sun altitude angles resulting in a decrease in value OTTV can get off regularly efficiency can be seen in the graphic image 10 at 10.00 am to 15.00 is Shading egg crate.

b. Shading device South Orientation

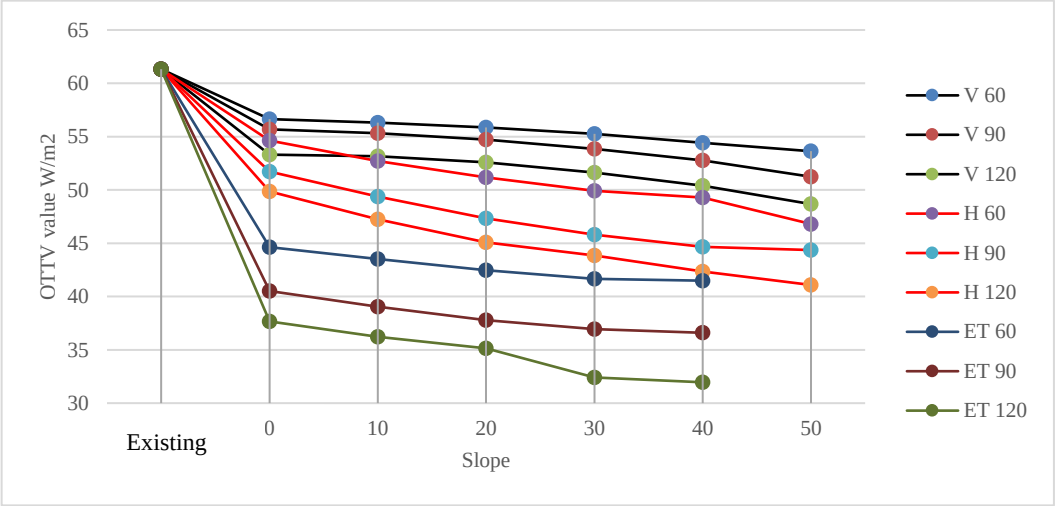


**Figure 10.** Graph of Impairment Variation OTTV North Orientation with Shading Horizontal, Vertical and Eggcrate based on Simulation Ecotect.

Figure 10 shows shading of the vertical with the highest decline is Shading Vertical with a Length of 120 slope of 50 with a 19% reduction value to 48.66W/m2. Shading Horizontal Long 120 slope 50 decreased 31% to 41.086 W/m2. And Shading Egg Crate with a length of 120 slopes 40 experienced the most effective reduction of 44% to 41.086W/m2. The graph in Figure 10 explains that the longer and deeper the slope Shading can reduce value only with the North orientation. It is shading best shading Egg Crate.

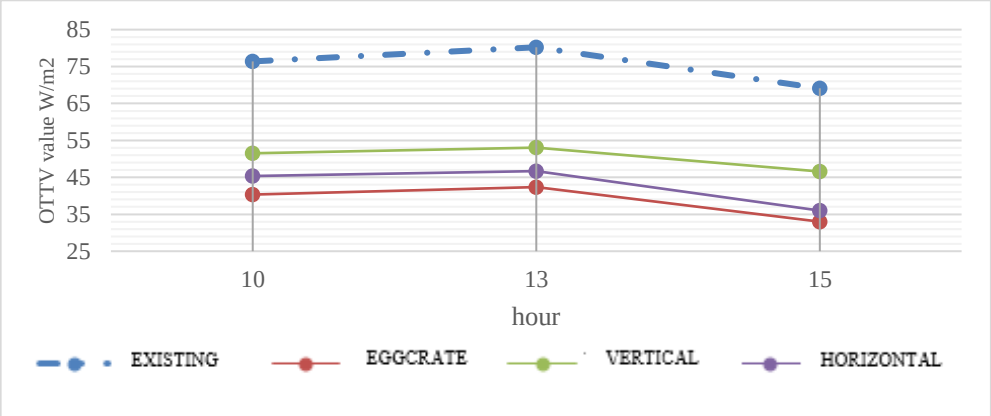


**Figure 11.** Impairment Graph OTTV South Orientation with Shading Horizontal, Vertical and Eggcrate March 21.

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March 21 in Figure 11 shows the existing condition of the building without using a Shading device at 10.00 am has a value of OTTV 76.378 W/m2, 13.00 noon 80.222 W/m2, and 3.00 pm has a value of 69.104 W/m2. Decline, shading device vertical at 10:00 am lowered the value OTTV by 33%, at 13.00 noon by 34%, and at 3.00 pm, a decrease of 33%. Shading horizontally at 10.00 am lowered the value OTTV by 41%. At 13.00 decrease in OTTV was 42%, and at 3.00 pm, a 48% drop. Shading egg crate has the most efficient decrease compared to shading vertically and horizontally at 10.00 at 47%, at 13.00 noon, and at 15.00 at 52%. The comparison of vertical and horizontal shading is the same as the analysis on the explanation of the north orientation, which explains the effectiveness of multiple horizontal fins shading superior at high sun angles Shading egg crate is Shading that is effective in responding to high and low sun altitude angles resulting in a decrease in value OTTV can get off regularly efficiency can be seen in the graphic image 10 at 10.00 am to 15.00 is Shading egg crate.

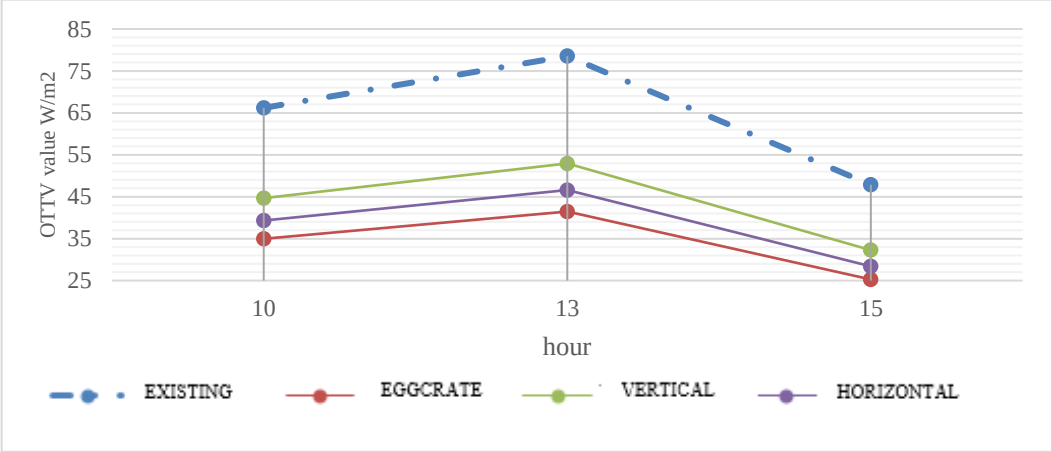


**Figure 12.** Impairment Graph OTTV South Orientation with Shading Horizontal, Vertical and Eggcrate June 21.

The existing condition of the building without the use shading device at 10.00 am has a value of OTTV 66.211 W/m2, at 13.00 noon, 78.528 W/m2, and at 3.00 pm has a value of 47.68 W/m2. Figure 12 shows a decrease in the vertical Shading device at 10.00 am, decreasing the value OTTV at 13.00 noon by 33%, and at 3.00 pm, a decrease of 33%. Shading Horizontal at 10:00 am lowers the value OTTV, at 13.00, decreases OTTV by 41%, and at 3.00 pm, a 41% drop. Shading egg crate has the most efficient reduction compared to vertical and horizontal shading at 10.00 at 41%, 13.00 noon at 41%, and 15.00 at 41%. Furthermore, it was shading the egg crate shows shading efficiency in comparison to shading vertical and horizontal.

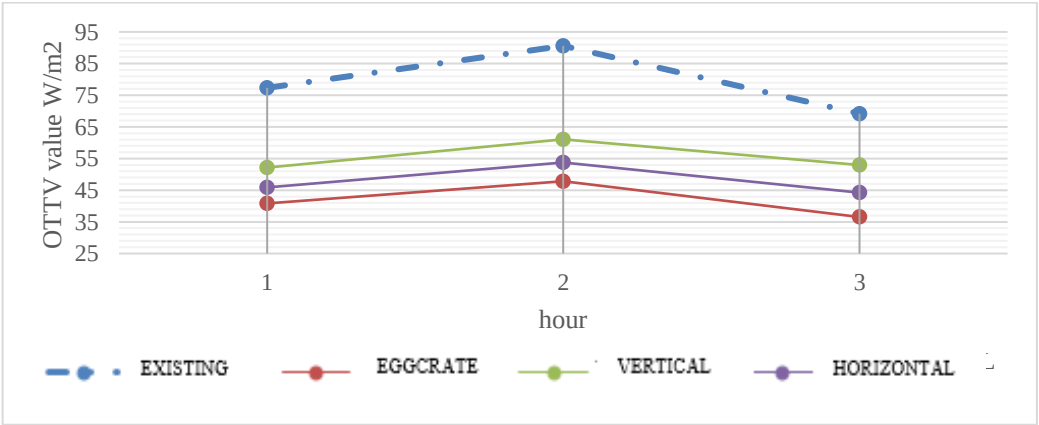


**Figure 13.** Impairment Graph OTTV South Orientation With Shading Horizontal, Vertical and Eggcrate September 23.

The existing condition of the building without the use Shading device at 10.00 am has a value of OTTV 77.37 W/m2, at 13.00 noon 90.596 W/m2, and at 3.00 pm has a value of 69.187 W/m2. Figure 13 shows a decrease in the vertical Shading device at 10.00 am decreasing the value OTTV by 33%, at 13.00 noon, and at 3.00 pm a decrease of 23%. Shading Horizontal at 10:00 am lowers the value OTTV by 41%, at 13.00 decreases OTTV by 41%, and at 3.00 pm a 36% drop. Shading egg crate has the most efficient reduction compared to vertical and horizontal Shading at 10.00 at 47%, at 13.00 noon by 47%, and at 15.00 at 47%. Shading egg crate shows shading efficiency in comparison to Shading vertical and horizontal.

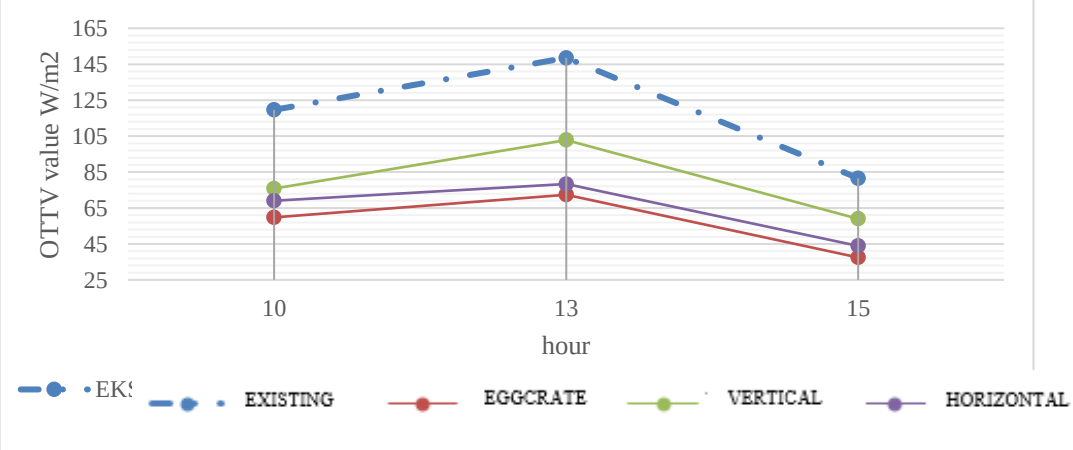


**Figure 14.** Impairment Graph OTTV South Orientation with Shading Horizontal, Vertical and Eggcrate December 22nd.

The existing condition of the building without the use shading device at 10.00 am has a value of OTTV 119.641 W/m2, at 13.00 noon 148.56 W/m2, and at 3.00 pm has a value of 81.586 W/m2. Figure 14 shows a decrease in the vertical Shading device at 10.00 am decreasing the value OTTV by 37%, at 13.00 noon by 31%, and at 3.00 pm a decrease of 28%. Shading Horizontal at 10:00 am lowers the value OTTV by 42%, at 13.00 decreases OTTV by 47%, and at 3.00 pm a 46% drop. Shading egg crate has the most efficient reduction compared to vertical and horizontal Shading at 10.00 at 50%, at 13.00 noon by 51%, and at 15.00 at 54%.Shading egg crate shows shading efficiently in comparison to Shading vertical and horizontal.

c. Shading device Western orientation

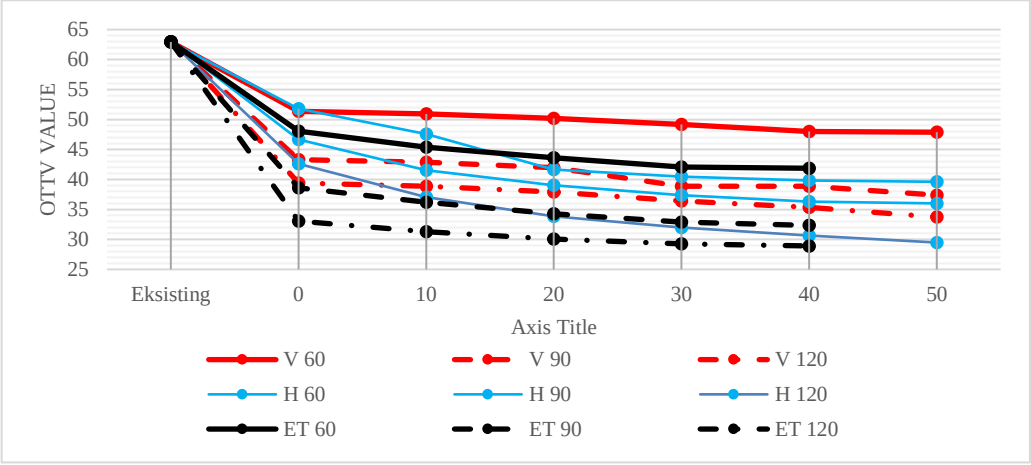


**Figure 15.** Graph of Impairment Variation OTTV Western Orientation with Shading Horizontal, Vertical and Eggcrate based on Simulation Ecotect.

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Ecotect Simulation Results for shading the west orientation in Figure 15 show shading the vertical that has the highest decline is Shading Vertical with a length of 120, a slope of 50 with a value of 46% reduction to 33,724 W/m2.Shading Horizontal Long 120 slope 50 decreased 53% to 29.483 W/m2. And Shading Egg Crate with a length of 120 slopes 40 experienced the most effective decrease of 62% to 28,912W/m2. West orientation effectiveness Shading horizontal multiple fins is superior compared to shading vertically this is due efficient Shading horizontal multiple fins responds to the sun's altitude angle which is high and low order Shading horizontally and tilted reduces the rate of radiation entering through the glass surface.

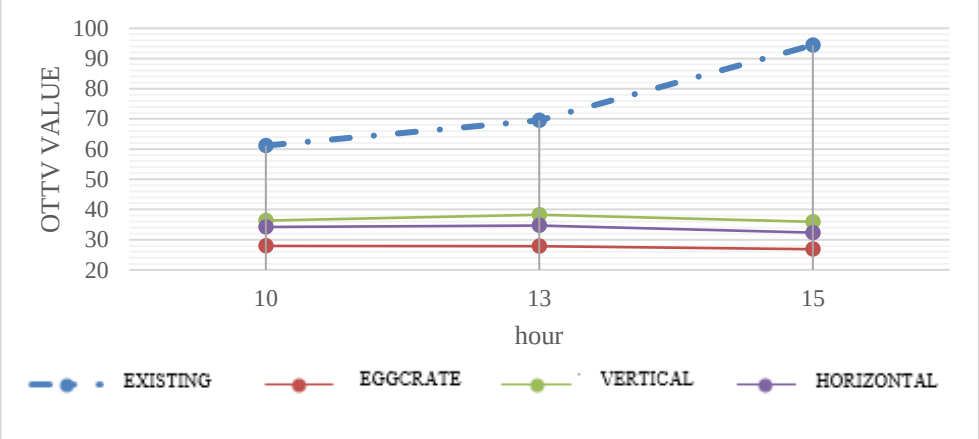


**Figure 16.** Impairment Graph OTTV West Orientation With Horizontal, Vertical and Egg Crate Shading March 21st.

The Impairment of OTTV West orientation on March 21 can be seen in Figure 16. Existing values OTTV at 10.00 am 61.167 W/m2, at 1.00 pm 69.544 W/m2, at 3.00 pm 94.423 W/m2. The vertical shading in the figure shows a decrease that occurred at 10.00 in the morning of 41%, at noon at 13.00 there was a decrease of 45% and in the afternoon a decrease of 62%. Shading Horizontal at 10.00 am decreased by 44%, at 13.00 experienced a decrease of 50%, and at 3.00 pm decreased by 66%. Shading Egg Crate experienced the biggest decrease between vertical and horizontal shading, at 10.00 am it decreased in value OTTV by 52%, at noon at 13.00 a decrease of 60%, and at 15.00 in the afternoon 72%. The comparison of vertical and horizontal shading in Figure 16 shows that horizontal shading is more effective. This is because the Horizontal multiple fin shading can respond to the angle of the sun's altitude which comes at 10.00 am, 13.00 noon, and 3.00 pm. But shading egg crates show the biggest reduction compared to these two types of shading. This is due to the ability to shade egg crates to receive the altitude angle of the sun that comes in a low angle as well as a high angle.

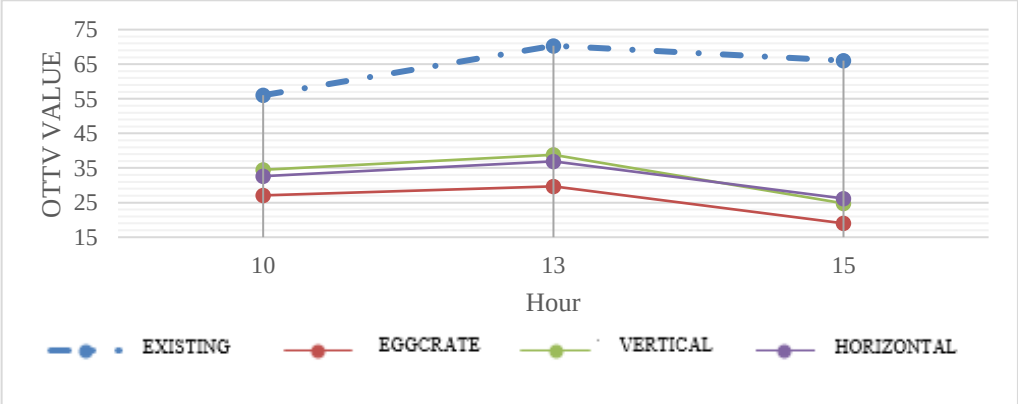


**Figure 17.** Impairment Graph OTTV Western Orientation with Shading Horizontal, Vertical and Eggcrate June 21st.

The Impairment of OTTV West orientation on June 21 can be seen in Figure 17. Existing values OTTV at 10.00 am 56.062 W/m2, at 1.00 pm 70.341 W/m2, at 3.00 pm 66.029 W/m2. The vertical shading in the figure shows a decrease that occurred at 10.00 in the morning of 38%, at noon at 13.00 there was a decrease of 45% and in the afternoon a decrease of 62%. Shading Horizontally at 10.00 am it decreased by 42%, at 13.00 it decreased by 48% and at 3.00 pm it decreased by 60%. In graphic image 14, vertical shading at 15 o'clock is 2% superior to horizontal shading. Shading Egg Crate experienced the largest decrease among shading vertically and horizontally, at 10:00 am markdown OTTV by 52%, at noon at 13.00 a decrease of 58%, and at 15.00 in the afternoon 71%.

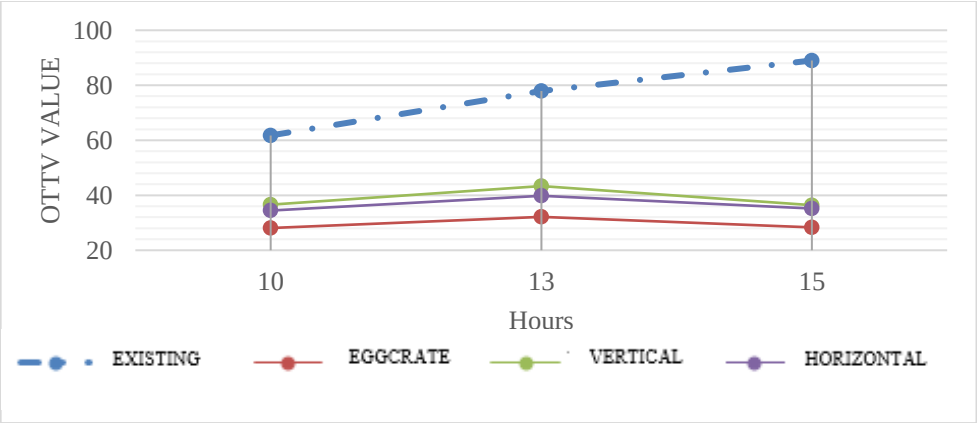


**Figure 18**. Impairment Graph OTTV Western Orientation with Shading Horizontal, Vertical and Eggcrate September 23rd.

The Impairment of OTTV West orientation on September 23 can be seen in Figure 18. Existing values OTTV at 10.00 am 61.757 W/m2, at 1.00 pm 77.941 W/m2, at 3.00 pm 89.008 W/m2.Shading The vertical in the figure shows a decrease that occurred at 10.00 in the morning by 41%, at noon at 13.00 there was a decrease of 44%, and in the afternoon a decrease of 59%.Shading Horizontally at 10.00 am it decreased by 44%, at 13.00 it decreased by 49% and at 3.00 pm it decreased by 60%. In graphic image 15, vertical and horizontal shading have decreasing values that tend to be the same, this is due to effectiveness second the

shading is effective, but horizontal shading is more effective in responding to the angle of the sun's altitude coming at 3.00 pm. Shading Egg Crate experienced the largest decrease among Shading vertically and horizontally, at 10:00 am markdown OTTV by 55%, at noon at 13.00 a decrease of 59%, and at 15.00 in the afternoon 68%.

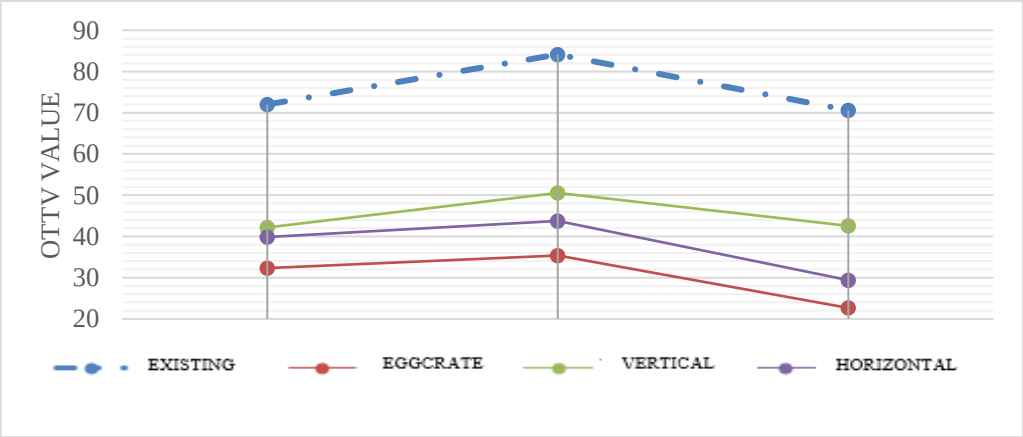


**Figure 19.** Impairment Graph OTTV Western Orientation with Shading Horizontal, Vertical and Eggcrate December 22nd.

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The Impairment of OTTV West orientation on December 22 can be seen in Figure 19. Existing values OTTV at 10.00 am 72.010 W/m2, at 1.00 pm 84.123 W/m2, at 3.00 pm 70.608 W/m2.Shading The vertical in the figure shows a decrease that occurred at 10.00 in the morning by 41%, at noon at 13.00 there was a decrease of 40%, and in the afternoon a decrease of 40%.Shading Horizontally at 10.00 am it decreased by 45%, at 13.00 it decreased by 48% and at 3.00 pm it decreased by 58%. Shading Egg Crate experienced the largest decrease among shading vertically and horizontally, at 10:00 am markdown OTTV by 45%, at noon at 13.00 a decrease of 48%, and at 15.00 in the afternoon 68%.

d. Shading device Eastern Orientation

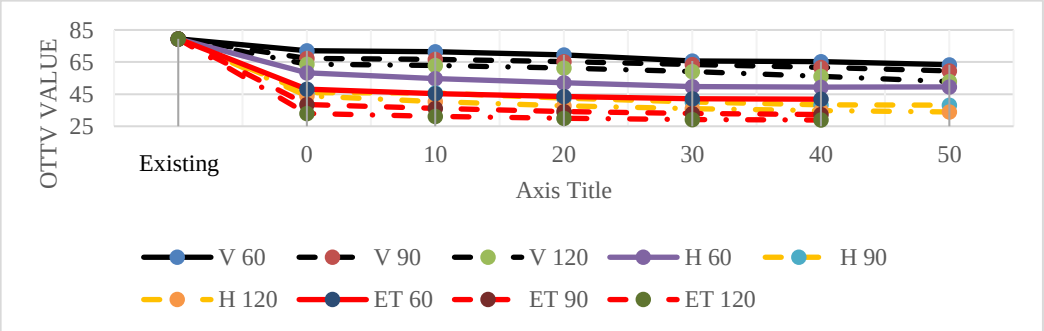


**Figure 20.** Graph of Impairment Variation OTTV Eastern Orientation With Shading Horizontal, Vertical and Eggcrate

Figure 20 shows the simulation results shading the vertical with the highest decline is Shading Vertical with Length 120 slope 50 with a 33% reduction value to 52.872W/m2. Shading Horizontal Long 120 slope 50 decreased 53% to 29.483 W/m2. And Shading Egg Crate with a length of 120 slopes 40 experienced the most effective decrease of 62% to 28,912W/m2. West orientation effectiveness in shading multiple horizontal fins is superior compared to shading vertically. This is due to efficiency. Shading multiple horizontal fins responds to high and low sun altitude angles Shading horizontally and tilted reduces the rate of radiation entering through the glass surface, shading egg crate more effectively because it can drive away incoming radiation and respond altitude angle of the incoming sun.

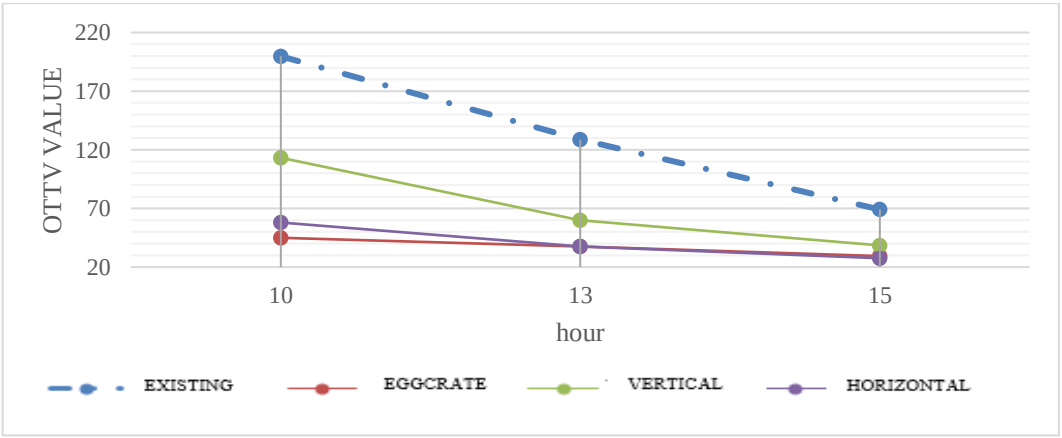


**Figure 21.** Impairment Graph OTTV Eastern Orientation with Horizontal, Vertical, and Egg Crate Shading March 21.

The Impairment of OTTV West orientation on March 21 can be seen in Figure 21. Existing values OTTV at 10.00 am 199.752 W/m2, at 13.00noon 128.627 W/m2, at 3.00 pm 69.092 W/m2. The vertical shading in the figure shows a decrease that occurred at 10.00 in the morning of 43% at noon at 01.00 pm, a decrease of 53%, and a decrease of 44% in the afternoon. Shading Horizontal at 10.00 am decreased by 71%, at 13.00 experienced a decrease of 71%, and at 3.00 pm decreased by 60%.

Shading Egg Crate experienced the most significant decrease between vertical and horizontal shading. At 10.00 am, it decreased in value OTTV by 77%. At noon at 13.00, a decrease of 71%, and at 15.00 in the afternoon by 60%. A comparison of vertical and horizontal shading in Figure 21 shows that horizontal shading is more effective. This is because the Horizontal multiple fin shading can respond to the sun's altitude angle, which comes at 10.00 am, 13.00 noon, and at 3.00 pm. However, shading egg crates show the most significant reduction compared to these two types of shading. This is due to the ability to shade egg crates to receive the altitude angle of the sun that comes in a low angle and a high angle.

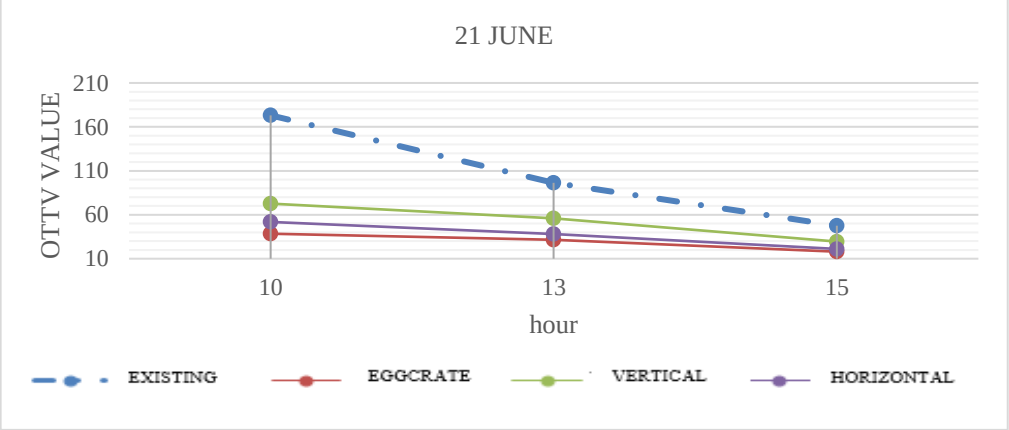


**Figure 22.** Impairment Graph OTTV Eastern Orientation with Horizontal, Vertical, and Egg Crate Shading June 21.

Figure 22 shows Impairment in Value OTTV West orientation on June 21. They were existing value OTTV at 10.00 am 173.124 W/m2, at 1.00 pm 96.260 W/m2, at 3.00 pm 47.582 W/m2. The vertical shading in the figure shows a decrease that occurred at 10.00 in the morning by 58%, at noon at 13.00, it decreased by 42%, and in the afternoon, it decreased by 38%. Shading Horizontal at 10.00 am decreased by 70%, at 13.00 experienced a decrease of 61%, and at 3.00 pm decreased by 56%. Shading Egg Crate experienced the most significant decrease between vertical and horizontal shading. At 10.00 am, it decreased in value OTTV by 78%, at noon at 13.00, at a decrease of 67%, and at 15.00 in the afternoon by 62%.

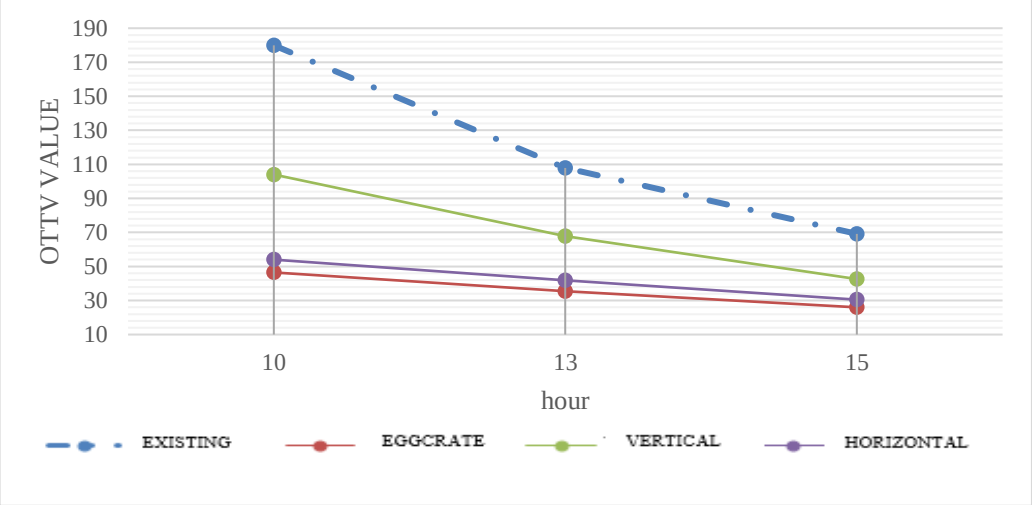


**Figure 23.** Impairment Graph OTTV Eastern Orientation with Horizontal, Vertical, and Egg Crate Shading September 23

Figure 23 shows Impairment in Value OTTV West orientation on June 21. It was existing value OTTV at 10.00 am 179.939 W/m2, at 1.00 pm 107.912 W/m2, at 3.00 pm 69.174 W/m2. The vertical

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shading in the figure shows a decrease that occurred at 10.00 in the morning of 42%, at noon at 01.00 pm, there was a decrease of 37%, and in the afternoon, a decrease of 38%. Shading Horizontal at 10.00 am decreased by 70%, at 13.00 experienced a decrease of 61%, and at 3.00 pm decreased by 56%. Shading Egg Crate experienced the most significant decrease between vertical and horizontal shading. At 10.00 am, it decreased in value OTTV by 74%, at noon at 13.00, at a decrease of 67%, and at 15.00 in the afternoon by 62%.

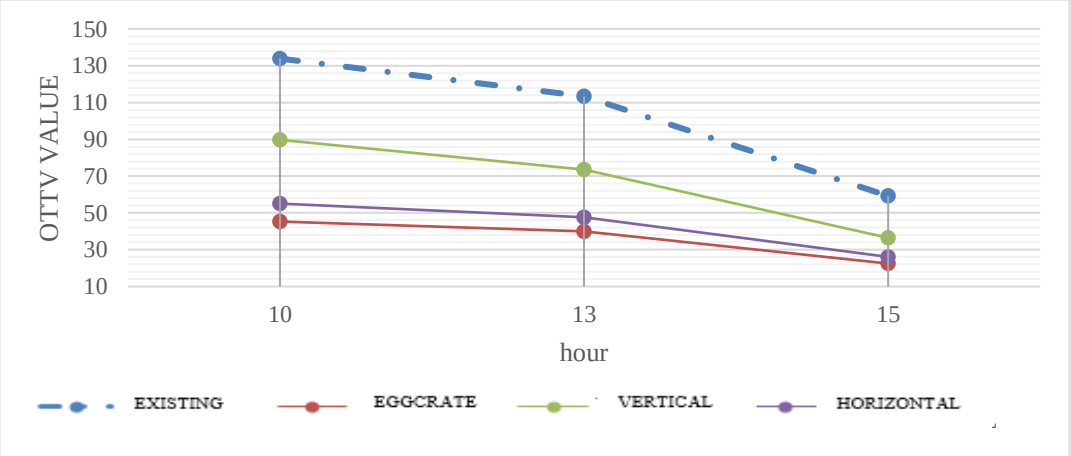


**Figure 24**. Impairment Graph OTTV Eastern Orientation With Horizontal, Vertical, and Egg Crate Shading December 22.

Figure 24 shows Impairment in Value OTTV West orientation on June 21. It was existing value OTTV at 10.00 am 133.888 W/m2, at 1.00 pm 113.319 W/m2, at 3.00 pm 59.257 W/m2. The vertical shading in the figure shows a decrease that occurred at 10.00 in the morning of 33% at noon at 13.00, a decrease of 35%, and a decrease of 38% in the afternoon. Shading Horizontal at 10.00 am decreased by 59%, at 13.00 experienced a decrease of 58%, and at 3.00 pm decreased by 56%. Shading Egg Crate experienced the most significant decrease between vertical and horizontal shading. At 10.00 am, it decreased in value OTTV by 66%, at noon at 13.00, at a decrease of 65%, and at 15.00 in the afternoon by 62%.

**OTTV Summary with Shading Device Modification**

**Table 3.** Table of Values OTTV after Use Shading

| elevation | OTTV Simulation (Watt/m²) | OTTV (Watt/m²) |
|---|---|---|
| North | 74.57 | 41.49 |
| South | 61.32 | 31.95 |
| west | 62.93 | 23.95 |
| East | 79.47 | 28.91 |
| | Average | 31.57 |

The Ecotect simulation results show the value OTTV overall 31.57 W/m2. On the north side has value OTTV which has a value of 74.57 Watt/m² to 41.49 Watt/m² after using Shading Egg Crate, the South side 61.32Watt/m² to 31.95 W/m2 after using Shading Eggcrate, the west side 62.93 Watt/m² becomes 23.95 W/m2 after using Shading Egg Crate and an east side 79.47 W/m2 to be 28.91 W/m2 after use Shading Eggcrate. The OTTV analysis value using the shading device is included in the standard category regulated in SNI, which is 35 W/m2 and does not exceed 45 W/m2.

## CONCLUSION

Shading devices affect the impairment of OTTV. The longer the shading device and the higher the slope, the more effective it is in blocking incoming radiation through the glass surface. This can be seen in the shading response tested at 1 year, tested at the time of the sun's apparent motion on March 21, June 21, September 23, and December 22 at 10.00 am, 1.00 pm and 3.00 pm. seen in impairment OTTV existing buildings without using a shading device have an initial value of 69,572 W/m2 decreased by 55% to 31.57 W/m2. Shading an egg crate with length120 cm with a slope of 40° is the best shading based on a comparative analysis between vertical louver shading and horizontal multiple fin shading. This is due to shading egg crates being able to respond to the incoming low and high sun altitude angles to minimize or obstruct radiation that enters through the glass surface.

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