Smart window design in commercial building in Jakarta

by Muhammad Syarif Hidayat

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M. Syarif Hidayat [1)] , **Rizka Nurfitri** [2)]

[1)] Mercu Buana Univercity Jalan. Meruya Selatan No. 1, Jakarta, Indonesia
[2)] Aaron Purbo Architecture, Komplek Duta Mas Fatmawati Blok B2, Jakarta 12150, Indonesia

Corresponding author : syarifh5@mail.com

Abstract. The current issue of Indonesian building is about the energy saving. The efficiency of the building can be implemented by reducing the cooling load and the use of the correct control air system. Smart window design aims at reducing consuming energy used in building. To reduce the external load, National Standardization Authority of Indonesia through the standard of SNI 03-6389-2011 about Overall Thermal Transfer Value (OTTV) to determine the design of the building envelope criteria of 35 W/m^2. Building envelope should have reduced heat energy from outside coming into inside. The objective of the study is to calculate the Overall Thermal Transfer Value (OTTV) of the building and compared to the standard. The value of 35 W/m2 is fairly low compared with other countries. This study is carried out on the buildings facades of Amaris Juanda Hotel in Jakarta. The parameters involved in these simulations such as Windows to Wall Ratio (WWR), wall materials and wall colour. To verify the calculation, is also carried out the measurements of thermal environments inside the building, that is guest room and meeting room. The study shows that the whole building envelope has the value OTTV of 32.47 and 32.36 if the colour of external finishes uses medium / blue and medium yellow colour. The lowest of OTTV value is achieved by the white colour.

1. Introduction

Energy usage has grown in the last 30 years along with population and economic growth. The energy crisis that struck the world including Indonesia requires energy saving efforts in all sectors. The building sector plays a major role in consuming electricity for lighting purposes, room conditioning and equipment operational. According to Silaban [1] for the tropics, energy use of fuel oil and electricity is generally lower than in sub-tropical countries that can reach 60 per cent of total energy consumption. This is due to the need for space heaters in most buildings during winter. While in the tropics, cooling space (Air Conditioned) is only used on a small number of buildings. Nevertheless, energy savings in the construction sector in tropical regions such as Indonesia will continue to contribute substantially to the decline in national energy consumption.

Building experts who take part in the creation of an artificial environment (built environment) have a great responsibility to participate in reducing energy use through building designs that can minimize energy use. This is a challenge for the designers of the built environment in this era of global warming as it is now, because of the longer issues that must be considered in the design decisions. The results of the design is no longer just beauty in its form and functional in its use. But it must also pay attention to the level of efficiency in the use of energy which in this case is to reduce the level of electricity consumption without ignoring the beauty, functionality and comfort [2]. The application of energy saving concepts from the building sector will have a significant impact on the sustainability of energy availability.

One way to reduce energy use in buildings is to reduce the burden of incoming heat from the outside. Therefore, the Indonesian National Standardization Body specifies the design criteria for building envelope as expressed in Overall Thermal Transfer Value (OTTV), OTTV≤ 45 Watt / m² [3]. The OTTV concept includes three basic elements of heat transfer through an outer building sheath that is heat conduction through a translucent wall, solar radiation through glass, and heat conduction through glass. The external heat load is caused by heat coming through conduction (walls, ceiling, glass, partition, and floor), radiation (glass), and convection (ventilation and infiltration). The internal heat load is caused by heat generated by people / occupants, lamps, and equipment / machinery.

To achieve the qualification of energy-efficient buildings required a series of energy analysis parameters. Criteria for energy conservation of building envelope include the ratio of window glass to wall or Window to Wall Ratio (WWR), type, thickness and colour of outer wall, shielding, conductance of glass, roof and wall insulation, roof and wall absorption, face- other. According to Yasmin [4], among the many parameters that can affect energy consumption in buildings especially high buildings, window to wall ratio (WWR), solar heat gain coefficient (SHGC) and light transmittance (LT) have an important role in the number heat and sunlight enter the room and have a significant effect on electricity usage in buildings. [4, 5]

According to Zain-Ahmed et al in Malaysia the window size is 25% WWR [5] for buildings without fins, while research in Hong Kong shows that the optimal WWR for buildings with fins is 36%. [6, 7, 8]. WWR is related to the size of the wall and also directly affects the facade of the building. [9]

While, Indonesian National Standard (SNI) "Energy Conservation of Building Enclosure on Building" 03-6389-2000 shows that the maximum limit of the OTTV value of a building is 45 W / m2. In 2011 the maximum limit of OTTV SNI is changed to 35 W / m2. This indicates that performance on the building envelope may have an impact on energy consumption. [10]

The result of Loekita [11] study indicates that WWR is smaller or equal to 0.40 gives the OTTV value fulfilling the requirement determined by SNI 03-6389-2000 (45 watt / m2). It is also pointed out that the OTTV value is not the only limitation that ensures energy efficient buildings (Loekita, Sandra). Planning of building envelope should use WWR = 0,40, selection of reflective sheath material and high-grade glass or canopy material.

In this study the building under study is a commercial building / hotel because the building in Indonesia is still quite wasteful (Palembang.tribunnews.com). Aspects to be studied how much the value of glass window OTTV in guest room at Hotel X on Juanda Street, Central Jakarta. The building is attractive because it includes a hotel that is quite selling and has a unique appearance, which is black. As is known black color absorbs heat of solar radiation. The purpose of this research is to know the value of OTTV on the facade of Amaris Hotel Juanda building in Central Jakarta; Is the value of OTTV on the facade of the Amaris Hotel Juanda building in Central Jakarta meets the SNI standard or not.

2. Materials and methods

2.1 Materials

The object selected in this research is Amaris Hotel Juanda building which is located at Ir. H. Juanda Street, No. 3, in the Central of Jakarta. This hotel includes a two-star business hotel. Amaris Hotel is owned by one of hotel group in Indonesia and managed by Grahawita Santika Pte. Ltd, business unit of Kompas Gramedia Group. The Amaris Hotel building is surrounded by: Settlement, Ir. H. Juanda IA Street in the North side:, Offices in the East side, Ir. H Juanda in the South side:, while in the West side are Offices. The Amaris Juanda Hotel Building consists of seven floors, has eighty guest rooms and two meeting rooms. Front desk, meeting room and management room are located on the ground floor. Guest room is located on the second until fifth floor. Equipment is located on the 6^{th} floor. The ground water tank and the fuel tank are located on the basement floor.

The facade of the Amaris Hotel Juanda building uses a brick wall with stucco and paint finishes. Aperture on the facade of the ground floor using tempered glass with a 12 mm thick and coated with sandblasted stickers whereas in the guest room using a 5 mm thick glass window. The main structure on the facade of Hotel Amaris building in Juanda in Central Jakarta uses reinforced concrete. The window opening uses a 5 mm thick glass material and concrete roof.

Figure 2: Material On Facade Overview

Figure 1: Glass Window In Guest room Amaris Hotel Juanda Building

2.2 Methods

In this study the authors use a quantitative approach, using OTTV formula of the Indonesian National Standard (SNI). It is implemented in guest rooms and meeting rooms. The first step is to collect data of materials used in the building and their thermal or physical specific value. After that, calculate the area of wall and window to obtain Window Wall Ratio (WWR). It is one of the important things in determining OTTV value. All materials characteristics and specifications together with WWR are calculated with OTTV formula. The result will show whether the building's OTTV values are in accordance with the standards SNI or not. If the value of OTTV is not in accordance with the standard, then it is simulated with other important parameters. The value of OTTV also means how much heat enter the room.

After the calculation of OTTV finished, observation and field measurement is carried out to find out the actual condition of heat transfer from outside to inside. This experiment is carried out by measuring indoor air temperature and humidity with and without air conditioning. The purpose of measuring air temperature in the room without air conditioning is to find out the effects of heat coming into the room. Temperature measurements are made in guest room as well as in meeting rooms. Room temperature is an indicator of the presence of heat in the room.

These two methods are then connected and compared. If the value of OTTV is in accordance with the standard then the temperature in the room slightly low concluded that the heat is less enter the room. Conversely, if the air temperature is high, means that much heat enter the room.

3. Results and discussions

3.1 The value of existing OTTV

Based on SNI-03-6389-2000 on Energy Conservation of Building enclosure, it is explained that OTTV (Overall Thermal Transfer Value) is the total thermal displacement value on the outer wall having a specific orientation (Watt / m2). According to SNI 03-6389-2011, buildings are said to be energy efficient if the value of OTTV (Overall Thermal Transfer Value) and RTTV (Roof Thermal Transfer Value) does not exceed 35 Watt / m². The value of OTTV building becomes the basis for determining thermal comfort factor in principle.

The total thermal transfer value or OTTV for each area of the outer wall of a building with such an orientation shall be calculated by equation.

$$OTTV = \alpha [(Uw \times (1 - WWR)] \times TDEk + (Uf \times WWR \times \Delta T) + (SC \times WWR \times SF)$$

Where:

OTTV = thermal displacement value on the outer wall having a certain direction or orientation (Watt / m2)
A = absorbance of solar radiation
Uw = Thin transparent wall transmittance (Watt / m2.K)
WWR = the ratio of the window area to the area of the entire outer wall at the specified orientation
TDEk = the equivalent temperature difference (K)
SC = shielding coefficient of the fenestration system
SF = solar radiation factor (W / m2)
Uf = thermal transmittance of fenestration (W / m2.K)
ΔT = different planning temperature between outer and inner part (taken 5K)

To calculate the OTTV value of the entire outer wall then used the following equation:

$$OTTVi = \frac{(A1\,.\,OTTV) + (A02\,.\,OTTV2) + \cdots + (A01\,.\,OTTVi)}{A01 + A02 + \cdots + A0i}$$

A01 = wall area on the outside I (m2). This total area includes all transparent wall surfaces and the surface area of the window on the wall.
OTTVi = Total thermal displacement value at part I (Watt / m2) as the result of calculation using equation of OTTV formula.

Material Specification

The main structure of Amaris Hotel Juanda uses reinforced concrete. On the facade of Amaris Hotel Juanda in Central Jakarta using brick walls with stucco and paint finishing, so the wall thickness to 15cm. At openings on the ground floor use a tempered glass window with 12mm thick coated with a sandblasted sticker. Openings on floors 2,3,4, and 5 are using glass windows with 5mm thick with UPVC frame. Here is a picture of the floor plan and the Amaris Hotel Juanda building in Central Jakarta.

Following are the data for OTTV calculation

Table 1. The value of the parameters

	Parameters and Value
a.	the absorbance value of solar radiation : 0.89
b.	the absorbance value of black colour : 0.95
c.	The solar absorbance value (α) of the red with the black paint plaster paint layer : 0.92
d.	The Wall transmittance value (Uw) for the red brick : 2.857 W / m2.K
e.	Density of the red brick material : 176 kg / m2
f.	The equivalent temperature difference (TDEk) of brick (126 <x <195 kg / m2) is 12 K
g.	The value of thermal transmittance (Uf) for 5mm sheet glass : 5,927 W / m2.K
h.	The North WWR value (0,024), East WWR (0.068), South WWR (0.101), West WWR (0.044).
i.	The shading coefficient of fenestration (SC) in the direction of North and South (1), while for East and West direction (0,8144).
j.	The value solar radiation factor (SF) in the North direction (130), east direction (112), south direction (97), west direction (243).

k.	Temperature Different between the outside and the inside (ΔT) are captured 5° K

Based on the above calculation, it can be obtained OTTV value of building facades from various sides. Here is a description of the calculations.
OTTV for the North direction as follows = 34.616 W / m2
OTTV for the East = 37.612 W / m2
OTTV for the South = 41.142 W / m2
OTTV for the West = 40,163 W / m2
Total OTTV = 38.607 W / m2

From these results it can be concluded that almost the overall orientation exceeds the standard except OTTV which faces north. The largest OTTV value faces south. From the results of this calculation can be concluded that the value of OTTV as a whole pass the standards set by SNI 2011. Therefore, efforts need to be able to reduce this excess.

3.2 The value of simulated OTTV

After the calculation of existing OTTV, it would conduct the next calculation in order to obtain new value of OTTV that match with the standard. Generally, the material specification and data are similar with the first calculation. Some alteration is made in the value of absorbance because the WWR is small enough in terms of daylight and design consideration.
The following table indicates the simulation results OTTV calculations with other colour paint.

Tabel 1 : The simulation of OTTV with other colour paint

External wall finishes	North side (W/m^2)	East side (W/m^2)	South side (W/m^2)	West side (W/m^2)	Total (W/m^2)
White finish	23,74	27,22	31,125	29,511	28,106
Dark blue /green	33,444	36,495	40,063	39,061	37,477
Medium green/ blue	28,257	31,542	35,286	33,936	32,47
Medium yellow	28,424	31,702	35,44	34,099	32,361

These results are graphically as follows:

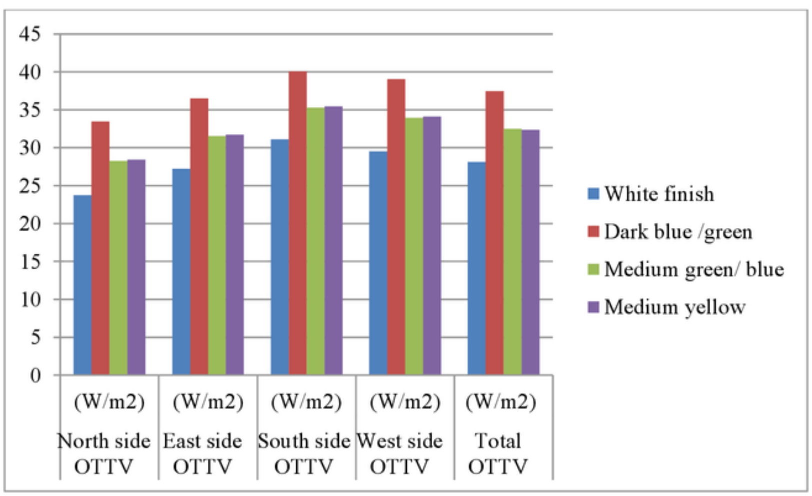

Figure 2. The results of the OTTV simulations using various colour external finish.

Following is a graph of difference OTTV calculation results with black paint compared with white paint semi glossy, blue / dark green, medium green / blue, yellow medium.

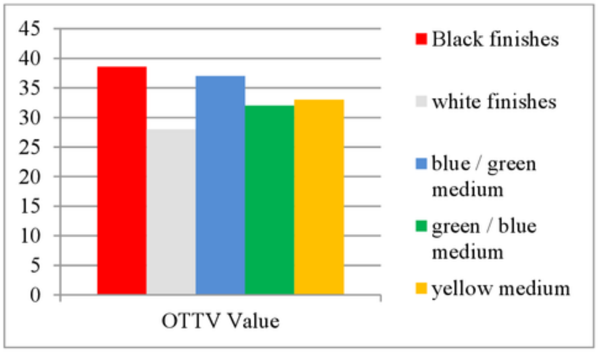

Figure 3: Comparison diagram of total OTTV value of black with other colour paint

From the graph above it can be seen that in general the use of white colour causes the value of OTTV decrease and in accordance with the standard of SNI 2011. Similarly, the use of green / blue medium and yellow medium can produce the value of OTTV in accordance with the standard. However, the use of green / dark blue colour causes OTTV values above the standard.

In terms of building orientation, the north side produces the lowest OTTV value compared to other orientations. This is due to the position of the sun being in the south in October 2015. So the south side OTTV has the highest value compared to the other side.

From the calculation of total OTTV we get the appropriate OTTV values for white, green / blue medium and yellow medium. As for the color green / dark blue produce OTTV value exceeding SNI 2011 standard

3.3 Observation and measurement results

In addition to OTTV calculations based on the formula, it is also conducted measurements of temperature and humidity of the space directly on the object of research. Measurements are made at the meeting room and guest room with and without air conditioned. Measurements were made for six days. Following graphs are the measurement results.

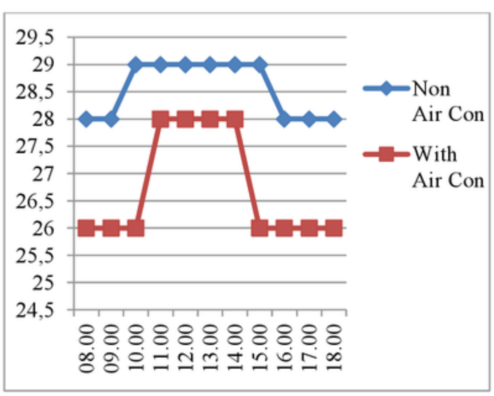

Figure 4: The measurement of temperature in guest room

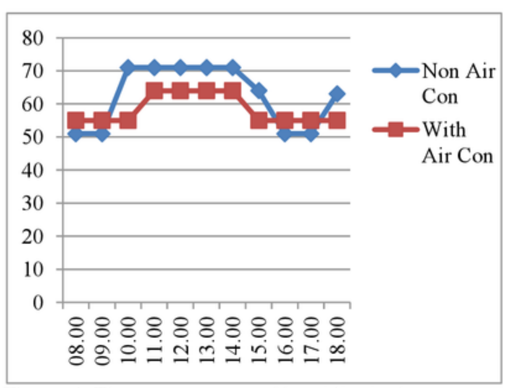

Figure 4: The measurement of humidity in the same room

From the air temperature measurements, it can be seen that the air temperature without using air conditioning has a maximum temperature of 29 C. while the maximum air temperature by using AC is 29 C. this indicates that the air temperature without air conditioning (eg Ac die) is still within the temperature range convenient for non AC room. This situation occurs from 10:00 am to 15:00 pm.

On the other hand, the humidity in the living room, showing humidity is 70%. Humidity of this size indicates a slightly moist level. This is due to the number of occupants in the hotel when making the measurements. When using Ac, the value of moisture achieved by 62% indicates a value that is also higher than the humidity for air-conditioned seeds are between 45-55%.

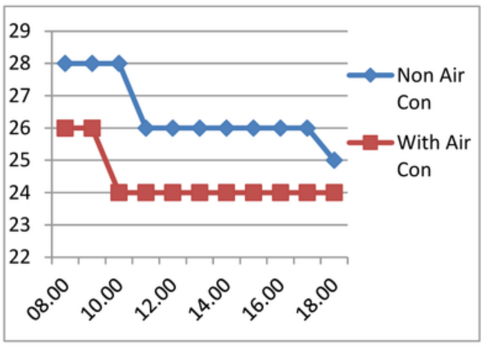

Figure 2: The measurement of temperature in meeting room

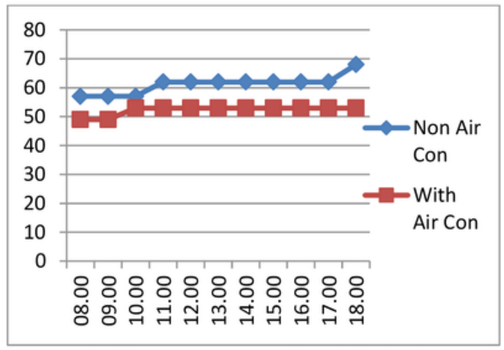

Figure 3: The measurement of humidity in the same room

In the meeting room, there is different environment with the living room. In this space the air temperature is 26 C from 11 am to 5 pm. the air temperature of this size is low enough for a non-AC room. This is because it is surrounded by another room. So, the radiation from outside is not reach the room. Humidity is also obtained 60% from 11 to 17:00 hours. This is because this room is in the central area of the hotel. This is different from the guest room that intersect with outside air.

Table 2: Simulation result of OTTV calculation with other colour paint

External wall colour finish	The North side OTTV value (W/m^2)	The East side OTTV value (W/m^2)	The South side OTTV value (W/m^2)	The West OTTV value (W/m^2)	The total OTTV (W/m^2)
White finish	23,74	27,22	31,125	29,511	28,106
Dark blue /green	33,444	36,495	40,063	39,061	37,477
Medium green / blue	28,257	31,542	35,286	33,936	32,47
Medium yellow	28,424	31,702	35,44	34,099	32,361

From the calculation of OTTV values for different outer wall paint colours obtained that the value of OTTV decreased. This is because the absorbance value of solar radiation for paint colours other than black is smaller in value. The colour of the wall paint on the facade also affects the value of the OTTV of the building. On the facade of the building Amaris Hotel Juanda almost entirely using black. At Indonesian National Standard (SNI) the absorbance value of solar radiation to paint the outer wall surface for black paint evenly is 0.95. The black colour represents the highest value for the absorbance value of solar radiation. Characteristics of black colour is faster to absorb heat and longer to release heat.

3.4 Discussions

In the earliest computation, the lowest value of OTTV is facing to the north. And the highest is the south. OTTV east and west also exceed standard. After simulation, all results show a low value below 35 watt / m2 for all colours i.e. white, blue / dark green, blue / light green and medium yellow. While the south side was the highest, two were the results. For dark blue / green colour is above the light, while medium / medium green medium, yellow medium and white are equal or below standard values. For dark blue / dark colours almost all orientation exceeds the standard, except the south.

Researcher Priandini conducted research at Novotel Hotel Yogyakarta [10]. The colour change of this paint also occurs at this hotel in Yogyakarta where when the change of paint colour in the building is replaced with blue which has a higher absorption, the value of OTTV becomes 37.07 W / m2. In addition to experimenting with colour change the paint was also performed by a long canopy experiment. Based on the simulation with the assumptions given and with the actual condition approach, the OTTV value of Novotel Hotel building on the first floor was 24.69 W / m2. When the shading factor was eliminated from the calculation, the OTTV value of the hotel increased to 28.35 W / m2. Thus it can be concluded that the factors that affect the OTTV value of the hotel are the coefficient of shade and the absorbtance value (α) of the paint colour.

4. Conclusion & Recommendations

4.1 Conclusion

Based on the calculations, the OTTV value of Amaris Hotel Juanda is 34,616 W / m2, the east is 37,612 W / m2, the south is 41,143 W / m2 west is 40,163 W / m2 while OTTV is 38,607. Based on the calculation result, the value of OTTV building facade of Amaris Hotel Juanda in Central Jakarta exceeded 35 W / m2 which is issued by Indonesia National Standard Body.

At the guest room openings or windows are on the west and east side which are the most exposed side of the sun's radiation. However, the direction of the window is tilted towards the northwest and northeast so that the sun's rays go down. At the front of the window there is a roof that when seen from the outside resembles the balcony but actually is the place to put out the door unit. The roof also serves as a wall shade underneath which can reduce the radiation of the sun. On the north and south sides are used as main lobby, managerial, and corridors. In the main lobby which using glass doors and windows almost the whole facade. While in corridor, the use glass window with size 1100 mm x 1400 mm without canopy on it. On the north and south side the openings are not too much. On the south side is the highest OTTV value compared to the other side.

4.2 Recommendations

The value of OTTV in the building facade of the Amaris Hotel Juanda exceeds the standard set by the SNI Board. To reduce the value of the OTTV facade of the building, Amaris Hotel Juanda advised the external walls to use non-black colours, such as white, medium / medium blue, or medium cum. The smaller OTTV value will reduce the external load of the building so that the Air Conditioning (AC) load also decreases. The positive impact is the reduction of energy use inside the building

REFERENCES

[1] Silaban (2004), Energy Efficient Building. Active and Passive Design, http://silaban.net/2004

[2] Handayani, Teti. 2010. Energy efficiency in building design (Energy Efficiency in Building Design). Civil Spectrum, ISSN 1858-4896, Vol. 1, No. 2: 102 - 108, August 2010.

[3] National Standardization Agency (2000). Energy Conservation Building envelope on buildings, SNI 03 - 6389 - 2000.

[4] Nikpour, Mansour.et al (2011), Study of the Effectiveness of Solar Heat Gain and Day Light Factors on Minimizing Electricity Use in High-rise Buildings, World Academy of Science, Engineering and Technology, Vol. 73, p73-77 .

[5] Suriansyah, Yasmin. (2011). Natural Lighting Quality at Six Flats in Bandung, Cimahi, Soreang, and Baleendah.Prosiding, National Seminar and Exhibition of Procurement Policies and Strategies for Sustainable Housing in Indonesia. Bandung 22-23 November 2011.

[6] Ahmed, A.Z. (2002), Daylighting as a Passive Design Strategy in Tropical Buildings: a Case Study of Malaysia, Energy Conversion and Management, Vol. 43, pp 1725-1736.

[7] Nikpour, Mansour.et al (2011), Investigating the Effectiveness of Self-Shading Strategy on Overall Thermal Transfer Value and Window Size in High Rise Buildings, International Journal of Civil and Environmental EngineeringVol 3: 2 2011, pp 111-116 .

[8] Suriansyah, Yasmin (2011). Natural Lighting Quality at Six Flats in Bandung, Cimahi, Soreang, and Baleendah.Prosiding, National Seminar and Exhibition of Procurement Policies and Strategies for Sustainable Housing in Indonesia. Bandung 22-23 November 2011.

[9] Suriansyah, Yasmin (2011). Natural Lighting Quality at Six Flats in Bandung, Cimahi, Soreang, and Baleendah.Prosiding, National Seminar and Exhibition of Procurement Policies and Strategies for Sustainable Housing in Indonesia. Bandung 22-23 November 2011.

[10] Priandini Umi Kulsum Maharani. (2013) Building Veil Performance Analysis with reference to OTTV Value (Case study of Novotel Hotel, Yogyakarta, Indonesia). Thesis Bachelor Degree S-1 Program of Engineering Physics. not published. Downloaded on March 7, 2018.

[11] Sandra Loekita (2006). Analysis of Energy Conservation through Building Coverage. Civil Engineering Dimension, Vol. 8, No. 2, 93-98, September 2006 ISSN 1410-9530. http://puslit.petra.ac.id/journals/ civil

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