**The Influence of Overall Thermal Transfer Value (OTTV) on Building Energy Consumption**

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**Abstract.** Air Conditioning (AC) system is one form of energy consumption which heavily load the total energy usage. It is essential to find relation between power used by AC to design factor of a building. Numerous countries have been using Overall Thermal Transfer Value (OTTV) as consideration in designing energy efficient buildings. Indonesia regulated it on SNI 03-6389 2011 on energy conservation of building envelope. In this paper we will discuss how OTTV derived from façade measurements and find its correlation to power of those air conditioners spent.

1. **Introduction**

The nation’ awareness towards sustainable development has been gradually increasing for the last two decades. It is encouraged by Indonesia Government in Law No. 30/2007 on Energy and Government Regulation No. 79/2014 on National Energy Policy Direction. Consequently, provincial governments regulated their green building plan such as the Capital Jakarta as one of the lead with its Jakarta Building User Guide [1].

 The guidance induces construction companies to implement certain approaches as mentioned in it. Two of the main measurements are Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV). OTTV is an average value of heat transferred into a building through the building envelope [2] while RTTV an average value of heat transferred into a building through the building roof [3]. Both measures are often used to design energy efficient buildings.

 The relation between OTTV and energy consumption has been investigated with four approaches which are (1) the equations derived by Chow and Chan through extensive energy simulations, (2) the ASHRAE 90A-80 method, (3) the one recommended in the Hong Kong Code of Practice (HKCOP) published by the HKSAR Government, and (4) the basic definition of OTTV using data generated from computer simulations by TRACE 600 [4].

 It is highly important to know the relation between OTTV and building energy consumption to be able to design buildings that not only eco-friendly but is also sustainable as well as green.

 The remain of this paper are organised as follows: the latest works done by other researchers are presented in Section 2 followed by method and analysis used in Section 3. Results are discussed in Section 4 ended with Conclusions and Future Works in the last section.

1. **Related Works**

Every country has different standards of OTTV. Malaysia and Hongkong are among those often using OTTV as consideration when designing buildings. Among parameters determining OTTV thermal transmittance (U) value and absorptivity (α) are considered the most influential factors [5].

1. **Method**

It is a research and development study which obtained data by taking façade measurements then calculate it to find OTTV. The office buildings where data taken were several buildings at Department of Electrical Engineering Education, Yogyakarta State University including 5 classrooms and a laboratory. The calculation of OTTV was in accordance with Indonesia National Standards SNI 03-6389 2011 on Building Envelope and How to Calculate OTTV.

This study used qualitative approach. The data analysis was carried out based on Pearson Product Moment correlation technique. The results were plotted on a Scatter Graph.

1. **Results and Discussion**

In order to be able to calculate Overall Thermal Transfer Value (OTTV), a number of other measurement has to be computed first namely absorptivity of sun radiation (α), window wall ratio (WWR), equivalent temperature difference (TDeq), shading coefficient (SC), solar factor (SF), wall surface thermal transmittance (Uw), surface thermal transmittance for fenestration (Uf), and temperature difference between indoor and outdoor conditions (∆T).

Table 1. Pre-Calculated / Pre-Determined Values to Calculate OTTV.

|  |  |  |
| --- | --- | --- |
| **No** | **Measurements** | **Calculated / Determined Values** |
| 1 | absorptivity of sun radiation (α) | 0.58 |
| 2 | window wall ratio (WWR) | Based on orientation |
| 3 | equivalent temperature difference (TDeq) | 10 K |
| 4 | shading coefficient (SC) | Based on orientation |
| 5 | solar factor (SF), | 147 Wm-2 (average value) |
| 6 | wall surface thermal transmittance (Uw) | 2,0085 Wm-2K-1 |
| 7 | surface thermal transmittance for fenestration (Uf) | 3,587 Wm-2K-1 |
| 8 | temperature difference between indoor and outdoor conditions (∆T). | 5 K |

The OTTV for each orientation of every room (OTTVo) then computed using the following Equation 1 as mentioned in SNI 03-6389 2011 and the results are appeared in Table 2.

|  |  |
| --- | --- |
| $$OTTV\_{o}=\left(α\left[U\_{w}×\left(1-WWR\right)\right]\right)×TD\_{eq}) +\left(SC×WWR×SF\right)+ \left(U\_{f}×WWR×∆T\right)$$ | Eq. 1 |

Table 2. OTTV for Each Orientation on Each Room

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Room** | **Orientation** | **α** | **Uw** | **WWR** | **TDeq** | **SC** | **SF** | **Uf** | **∆T** | **OTTV** |
| 1 | RE 3 | North | 0.58 | 2,0085 | 0,285 | 10 | 0,526 | 130 | 3,587 | 5 | 32,928 |
| East | 0.58 | 2,0085 | 0,000 | 10 | 0,749 | 112 | 3,587 | 5 | 11,650 |
| South | 0.58 | 2,0085 | 0,588 | 10 | 0,750 | 97 | 3,587 | 5 | 58,119 |
| West | 0,58 | 2,0085 | 0,000 | 10 | 0,749 | 243 | 3,587 | 5 | 11,650 |
| 2 | RF 1 | North | 0,58 | 2,0085 | 0,157 | 10 | 0,634 | 130 | 3,587 | 5 | 25,587 |
| East | 0,58 | 2,0085 | 0,000 | 10 | 0,784 | 112 | 3,587 | 5 | 11,650 |
| South | 0,58 | 2,0085 | 0,233 | 10 | 0,750 | 97 | 3,587 | 5 | 30,101 |
| West | 0,58 | 2,0085 | 0,000 | 10 | 0,784 | 243 | 3,587 | 5 | 11,650 |
| 3 | RF 4 | North | 0,58 | 2,0085 | 0,157 | 10 | 0,634 | 130 | 3,587 | 5 | 25,587 |
| East | 0,58 | 2,0085 | 0,000 | 10 | 0,784 | 112 | 3,587 | 5 | 11,650 |
| South | 0,58 | 2,0085 | 0,233 | 10 | 0,750 | 97 | 3,587 | 5 | 30,101 |
| West | 0,58 | 2,0085 | 0,000 | 10 | 0,784 | 243 | 3,587 | 5 | 11,650 |
| 4 | RE 1 | North | 0,58 | 2,0085 | 0,138 | 10 | 0,634 | 130 | 3,587 | 5 | 23,854 |
| East | 0,58 | 2,0085 | 0 | 10 | 0,784 | 112 | 3,587 | 5 | 11,650 |
| South | 0,58 | 2,0085 | 0,588 | 10 | 0,750 | 97 | 3,587 | 5 | 58,119 |
| West | 0,58 | 2,0085 | 0 | 10 | 0,784 | 243 | 3,587 | 5 | 11,650 |
| 5 | RF 9 | North | 0,58 | 2,0085 | 0,157 | 10 | 0,634 | 130 | 3,587 | 5 | 25,587 |
| East | 0,58 | 2,0085 | 0,000 | 10 | 0,784 | 112 | 3,587 | 5 | 11,650 |
| South | 0,58 | 2,0085 | 0,233 | 10 | 0,750 | 97 | 3,587 | 5 | 30,101 |
| West | 0,58 | 2,0085 | 0 | 10 | 0,784 | 243 | 3,587 | 5 | 11,650 |
| 6 | Automa-tion Lab | North | 0,58 | 2,0085 | 0 | 10 | 0,786 | 130 | 3,587 | 5 | 11,650 |
| East | 0,58 | 2,0085 | 0,117 | 10 | 0,526 | 112 | 3,587 | 5 | 19,287 |
| South | 0,58 | 2,0085 | 0,072 | 10 | 0,786 | 97 | 3,587 | 5 | 17,613 |
| West | 0,58 | 2,0085 | 0,200 | 10 | 0,742 | 243 | 3,587 | 5 | 49,030 |

We then calculated OTTV for each room using Equation 2.

|  |  |
| --- | --- |
| $$OTTV=\frac{\sum\_{i=1}^{n}A\_{i}×OTTV\_{i}}{\sum\_{i=1}^{n}A\_{i}}$$ | Eq. 2 |

Table 3. OTTV on Each Room

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Room** | **Orientation** | **OTTVp** | **A** | **AxOTTVp** | **OTTV** | **Range on SNI** | **State** |
| 1 | RE 3 | North | 32,928 | 25,50 | 839,676 | 32,928 | 35 | Approved |
| East | 11,650 | 18,00 | 209,692 |
| South | 58,119 | 25,50 | 1482,026 |
| West | 11,650 | 18,00 | 209,692 |
| 2 | RF 1 | North | 25,587 | 28,50 | 729,236 | 20,441 | 35 | Approved |
| East | 11,650 | 24,00 | 279,589 |
| South | 30,101 | 28,50 | 857,871 |
| West | 11,650 | 24,00 | 279,589 |
| 3 | RF 4 | North | 25,587 | 28,50 | 729,236 | 20,441 | 35 | Approved |
| East | 11,650 | 24,00 | 279,589 |
| South | 30,101 | 28,50 | 857,871 |
| West | 11,650 | 24,00 | 279,589 |
| 4 | RE 1 | North | 23,854 | 25,50 | 608,282 | 28,847 | 35 | Approved |
| East | 11,650 | 18,00 | 209,692 |
| South | 58,119 | 25,50 | 1482,026 |
| West | 11,650 | 18,00 | 209,692 |
| 5 | RF 9 | North | 25,587 | 28,50 | 729,236 | 20,441 | 35 | Approved |
| East | 11,650 | 24,00 | 279,589 |
| South | 30,101 | 28,50 | 857,871 |
| West | 11,650 | 24,00 | 279,589 |
| 6 | Automa-tion Lab | North | 11,650 | 25,20 | 293,568 | 24,731 | 35 | Approved |
| East | 19,287 | 27,00 | 520,739 |
| South | 17,613 | 25,20 | 443,843 |
| West | 49,030 | 27,00 | 1323,800 |

Based on Table 3, we could conclude that all rooms are within SNI OTTV Value which is 35 Watt/m2.

The data of energy spent on air conditioning system was taken by measuring the current flowing on each air conditioner (AC). The power consumed on all the ACs was then calculated. The relation between OTTV and AC Power is shown on Table 4 and Figure 1.

Table 4. Relation between OTTV and Air Conditioning Power Consumption

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No** | **Room** | **OTTV** | **P AC 1** | **P AC 2** |
| 1 | RE 3 | 31,507 W/m2 | 534,6 Watt | 541,2 Watt |
| 2 | RF 1 | 20,441 W/m2 | 422,4 Watt | 426,8 Watt |
| 3 | RF 4 | 20,441 W/m2 | 426,8 Watt | 429,0 Watt |
| 4 | RE 1 | 28,847 W/m2 | 506,0 Watt | 499,4 Watt |
| 5 | RF 9 | 20,441 W/m2 | 431,2 Watt | 433,4 Watt |
| 6 | Automation Lab | 24,731 W/m2 | 459,8 Watt | 468,6 Watt |

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**Figure 1.** Scatter Graph of Relation between OTTV and Air Conditioning Power Consumption

1. **Conclusion and Future Works**

It is clear to see that the relation of OTTV and power consumption of air conditioning system is linear positive. The more OTTV increases the more energy used.

Our future works will be comparing the RTTV and OTTV in affecting decisions make on designing energy efficient buildings.

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1. **References**

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