

Energy Efficiency Towards Building Envelope An Analysis Study Between Main Library of University Malaya Building and Library of UiTM Perak Building

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Abstract—Energy is a very important thing to elaborate, therefore this research will discuss about energy efficiency for the building envelope based on Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Building MS 1525: 2007. This research was conducted for the building envelope at Library of UiTM Perak and Main Library of UM. The objective of this paper is to compare the capacity of two educational buildings and how far it fulfills the requirements in the guideline. It will focus on energy conservation that provides a comfortable environment for its occupants. To illustrate the function of building envelope as an important aspect to focus on building surface design achievement and then to evaluate how far the potential of the building envelope that could fulfill the building criteria that is prescribed by the requirements in the guideline based on U Value and OTTV Value. This research will also look at the energy efficiency management based on the guideline by producing the use of effective and continuous energy and to evaluate the quality of energy usage by creating energy efficient environment that gives a better impact for the National Energy Sector in the future

Index Terms— Building envelope, “Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings” MS 1525:2007, University Malaya Main Library Building, UiTM Perak Library.

I. INTRODUCTION

With the researches, many parties will be aware whether they are engaged directly or indirectly in the building industry. All parties involved should realize and understand the concept of efficient energy management before a construction starts. This is vital to energy usage which will give huge impact to the effect of high energy consumption in a building. The importance and understanding must be

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focused to design a building that meets the needs of efficient energy in a building and not just to view the cost of the building and its aesthetic values. This efforts is done to develop the understanding of all parties to increase the usage of energy efficiently to create the flow of energy usage intensity that is rising and to avoid wastage of energy usage. The utilization of efficient energy in a building is important as one of the main divisions in the total usage of energy which comprises of 14% of national energy usage. So, this manual is required as the main reference to produce a building that meets the potential of a building which uses energy efficiently. This research covers research building for the Library Building at UiTM Perak and Universiti Malaya(UM) Main Library Building to study one of the aspects of efficient energy that is Building Envelope and to assess how far the needs of the buildings meet the minimum standard of efficient energy in educational buildings. The factors of high energy consumption and also the rising cost are on a part with the increase of electrical appliances like air-conditioning, lamps, visual equipment and others. UiTM Perak is now upgrading its structure and infrastructure which will drive towards a higher energy consumption if energy usage is not managed efficiently. Thus, researches on the efficient usage of energy in educational buildings is very vital to look at the potential of a building whether the construction meets the guideline that has been regulated.

II. DESIGN CRITERIA

For enclosed space building, building envelope is usually used for the need of Overall Thermal Transfer Value (OTTV) only for air-conditioning building, targeted to enclosed design space building to reduce the absorption of external heat and ultimately reduce the cooling load of air-conditioning system. It is verified that this criterion is known as Overall Thermal Transfer Value (OTTV). The need of OTTV is targeted to achieve the design of enclosed space structure to minimize the absorption of external heat and also to reduce the cooling load of air-conditioning system.

$$OTTV = \frac{A_{o1} \times OTTV1 + A_{o2} \times OTTV2 + \dots + A_{on} \times OTTVn}{A_{o1} + A_{o2} + \dots + A_{on}} \quad (1)$$

Where :

A_{oi} = Gross exterior wall area for orientation i

OTTV_i = OTTV value for orientation i from equation (2)

For a fenestration at given orientation

$$OTTV_i = 19.1\alpha (1 - WWR) U_w + (194 \times CF \times WWR \times SC)$$
 (2)

Where :

WWR = Window-to-gross exterior wall area ratio for the orientation under consideration

α = Solar absorptivity of opaque wall

U_w = Thermal transmittance of opaque wall (W/m² K)

CF = Solar correction factor for the orientation of the fenestration under consideration as given by Table 1 Assume nearest predominant orientation (Table 1)

SC = Shading Coefficient

TABLE 1: SOLAR CORRECTION FACTORS (SOURCE: CODE OF PRACTICE ON ENERGY EFFICIENCY MS 1525:2007)

Orientation	Factor
N	0.83
NE	1.01
E	1.15
SE	1.02
S	0.85
SW	1.02
W	1.14

Shading Coefficient (SC)

The shading coefficient of the fenestration system is defined as the ratio of solar heat gain through the fenestration system having combination of glazing and shading device to the solar heat gain through an unshaded 3mm clear glass. This ratio is a unique characteristic of each type of fenestration system and is represented by the equation (3).

$$SC = \frac{\text{Solar heat gain of any glass and shading combination}}{\text{Solar heat gain through a 3mm unshaded clear glass}}$$
 (3)

In general the shading coefficient of any fenestration system can be obtained by multiplying the shading coefficient of the external sun-shading device as follows:

$$SC = SC_1 \times SC_2$$

SC = Shading coefficient of the fenestration system

SC₁ = Shading coefficient of glass

SC₂ = Effective shading coefficient of external shading Devices

The shading coefficient of glass shall be based on the manufacturer's recommended value assessed at an incident angle of 45 to the normal. The effective shading coefficient of external shading devices can be obtained from table 2, table 3 and table 4.

TABLE 2: EFFECTIVE SHADING COEFFICIENT OF HORIZONTAL PROJECTIONS (SOURCE: CODE OF PRACTICE ON ENERGY EFFICIENCY MS 1525:2007)

Ratio	Orientation			
	North, South	East, West	NE, NW	SE, SW
0.3 – 0.4	0.8	0.8	0.8	0.8
0.5 – 0.7	0.7	0.7	0.7	0.65
0.8 – 1.2	0.7	0.6	0.6	0.58
1.32 – 2.0	0.66	0.5	0.54	0.5

TABLE 3: EFFECTIVE SHADING COEFFICIENT OF VERTICAL PROJECTIONS (SOURCE: CODE OF PRACTICE ON ENERGY EFFICIENCY MS 1525:2007)

Ratio	Orientation			
	North, South	East, West	NE, NW	SE, SW
0.3 – 0.4	0.8	0.9	0.85	0.85
0.5 – 0.7	0.7	0.9	0.75	0.75
0.8 – 1.2	0.7	0.8	0.65	0.65
1.32 – 2.0	0.66	0.75	0.6	0.6

TABLE 4: EFFECTIVE SHADING COEFFICIENTS OF EGG-CRATE LOUVRES (SOURCE: CODE OF PRACTICE ON ENERGY EFFICIENCY MS 1525:2007)

R1	R2	N, S	E, W	NE, NW	SE, SW
0.2	0.2	0.8	0.8	0.8	0.8
	0.4 – 0.6	0.75	0.8	0.7	0.7
	0.6 – 1.8	0.7	0.7	0.6	0.6
0.4	0.2 – 0.4	0.7	0.75	0.7	0.7
	0.6 – 1.2	0.66	0.7	0.6	0.6
	1.4 – 1.8	0.66	0.6	0.5	0.5
0.6	0.2 – 0.6	0.66	0.66	0.6	0.6
	0.8 – 1.8	0.66	0.6	0.5	0.5
0.8	0.2 – 0.6	0.66	0.6	0.6	0.6
	0.8 – 1.8	0.66	0.55	0.5	0.5
1.0	0.2 – 0.4	0.66	0.55	0.6	0.5
	0.6 – 1.2	0.66	0.55	0.5	0.5
	1.4 – 1.8	0.66	0.5	0.5	0.5
1.2 – 1.8	0.2 – 1.8	0.66	0.5	0.5	0.5

III. RESEARCH ANALYSIS

Overall OTTV of UiTM Perak Library Building.

$$(572 \times 59.81) + (141 \times 57.09) + (487 \times 61.26) + (120 \times 61.26)$$

$$\frac{\quad}{(572 + 141 + 487 + 120)}$$

$$= \mathbf{60.19 \text{ W / m}^2}$$

Overall OTTV of Universiti Malaya Main Library Building.

$$(935.5 \times 27.15) + (1140 \times 47.97) + (1075 \times 23.88) + (464.5 \times 29.73)$$

$$\frac{\quad}{(935.5 + 1140 + 1075 + 464.5)}$$

$$= \mathbf{33.07 \text{ W / m}^2}$$

The value of Overall Thermal Transfer Value or OTTV of UiTM Perak Library Building is 60.19 W / m² and this is higher than the value set by the guideline in MS 1525:2007. This shows that efficient energy usage in the assessment of building envelope aspect of UiTM Perak Library Building is inefficient because the value of OTTV of the building exceeds the set value which is 50 W / m². As for the Main Library Building of Universiti Malaya, the OTTV value is 33.07 W / m² and this value is lower than the value set by the guideline. Thus, this finding reveals that the usage of energy in Universiti Malaya Main Library Building from the aspect of building envelope is more efficient than UiTM Perak Library Building as the value is less than 50 W / m². The difference can be seen in Chart 1:

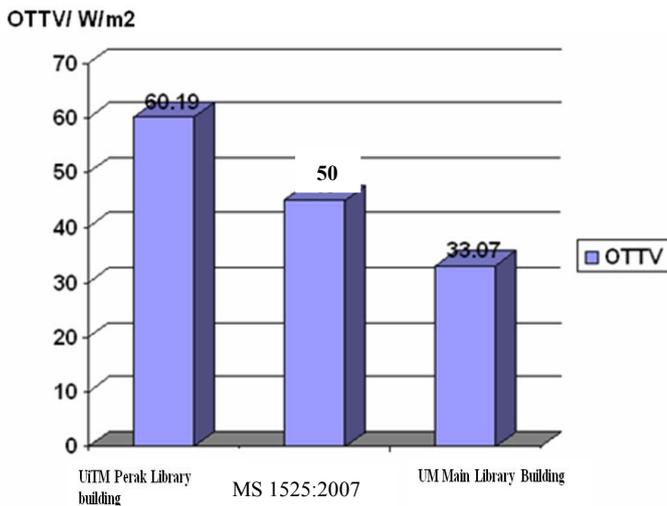
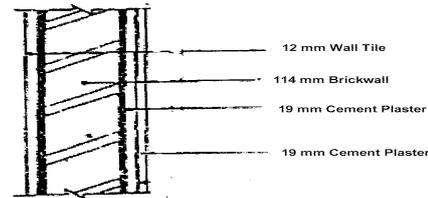


Chart 1: The Difference Between UiTM Perak Library Building and UM Main Library Building with the Guideline

IV. CONSTRUCTION MATERIALS AND U-VALUE

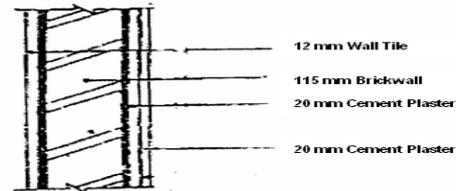
A good wall is a wall that can prevent the entry of excess heat into the building. Materials that are used to build the wall also influence the heat entry rate into a building. Construction materials and U-Value are two matters which are closely related, a thicker material will yield a lower U-Value of a certain material. The lower the U-Value of certain construction materials, the better the value of insulation and its quality of heat absorption prevention. Looking at the construction materials that are used by UM Main Library and UiTM Perak Library buildings, are the usage of conventional building materials like concrete, plaster, brickwall and also wall tiles as wall foundation. This conventional construction may reduce the cost of construction materials of a building without considering the factor of efficient energy usage. Although we are looking at the short term effect of the cost, with the usage of conventional construction materials it has contributed to high rate of heat intensity inside a building especially the UiTM Perak Library building. Consequently, the energy capacity that will be used increases together with the increase usage of air-conditioning in the building. If we look at the usage of concrete where the natural characteristic of concrete wall is absorbing heat at a high rate during the day and releasing high heat at night. Therefore, the heat that absorbs through building wall element will give impact to the temperature in the building. Conventional usage of concrete will effect the rising usage of energy in the building. Another factor that is the source of increase internal temperature which is also important, is the choice of the building colour component. White resemble colours are the best because they absorb less heat compare to other dark colours. Thus, an external wall that is painted with white colour will help to reduce the heat absorption that will be stored and channelled to the space in the building. Looking at UM Main Library building, the construction materials are not influenced by the low value of OTTV of the building. Looking deeper, the thickness of the construction materials in the building of UM Main Library building may cause the reduction of the U-Value of the building. See Figure 1 and 2 about the low usage of the U-Value. The U-Value of the construction

materials of UM Main Library is lower than the U-Value of UiTM Perak Library building although the difference is not very obvious.



U-Value = 2.59 W/ m² K

Fig 1: Brickwall of UiTM Perak Library Building



U-Value = 2.55 W/ m² K

Fig 2: Brickwall of UM Main Library Building

The overall wall of UiTM Perak Library building and Universiti Malaya Main Library building are not using heat insulation at the wall building which is necessary to prevent the entry of a great deal of heat into the buildings. Heat insulation is very much needed to coat the external wall to minimize the impact of heat absorption. We can see here that many existing buildings do not install the heat insulation material. Although, there is no usage of heat insulation in UM Main Library building, the value of OTTV of the building is still low. This is due to the correct building orientation that has been applied during the construction of this building. Correct orientation application is the main factor in the reduction of OTTV value without the need to comply with other factors. If we look at the value of the U-Value where the maximum value is 2.0W/m², it can be said that the level of insulation is good. The low U-Value will be achieved by providing enough insulation at the wall building. However, both libraries, at UM and UiTM Perak are not using insulation materials in their walls. U-Value for the wall building has exceeded the maximum value that has been set. Without the preparation of insulation material at wall building, it may increase the U-Value quite a lot. As Seri Iskandar and Lembah Pantai are situated at a hot and humid area, the effect of ray into buildings is greatly influenced by building orientation. Thus, wall insulation is very important to reduce U-Value. The lower the U-Value of certain materials and constructions, the better the insulation value and the quality of the heat entry prevention will also be improving. Generally, UiTM Perak Library and UM Main Library buildings are using conventional method. Therefore, insulation material is a must in wall building to reduce the excessive flow of heat and gradually improving the U-Value. U-Value will be reduced if suitable insulation material is used in wall and roof of a building. The sensitivity of building architect is vital in understanding the need of insulation material in a building. It is important to reduce massive absorption in a building. Here is a suitable

suggestion to replace conventional construction materials which are being used nowadays to a better quality material. Among the material that can be used is aerated concrete wall as shown in Figure 3 based on their thickness. Meanwhile, Chart 2 shows the difference between the suggested construction materials and materials that are used in UM Main Library Building and UiTM Perak Library Building.

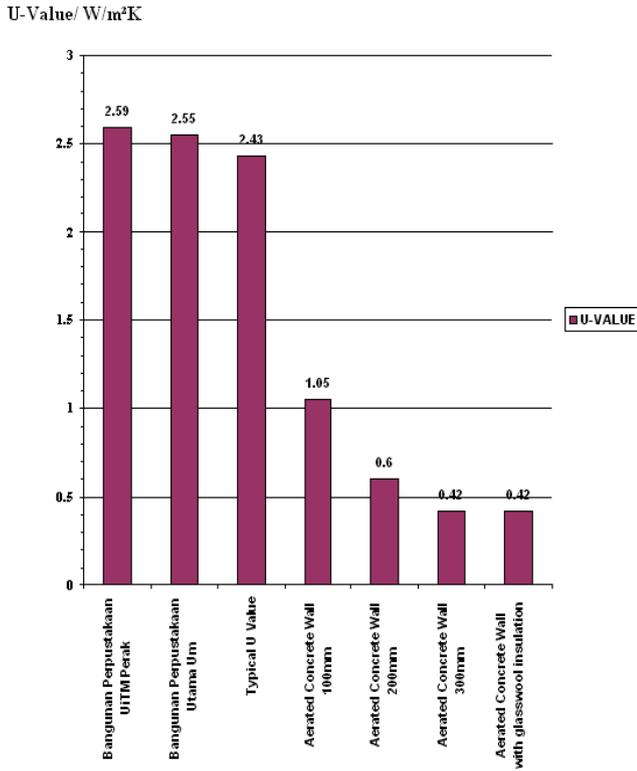
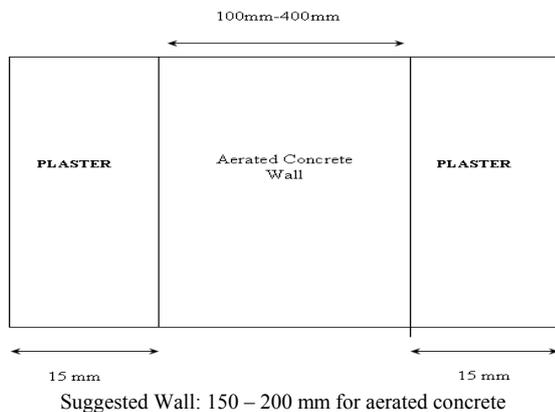


Chart 2: Difference between U-Value



Case Studies :

- 100 mm : U-Value = 1.05 W/m²K
- 200 mm : U-Value = 0.60 W/m²K
- 300 mm : U-Value = 0.42 W/m²K
- 400 mm : U-Value = 0.32W/m²K

Fig 3: Suggested Material Insulation in Wall Building

V. ORIENTATION

Maximum wastage through design, location and building arrangement taking into consideration the building orientation factor enables the reduction of energy

consumption for the purpose of building cooling and direct lighting of sun heat into a building. The usage of air-conditioning in a building certainly will reduce the effect of heat and the production of comfortable dry air. However, if the rate of direct sun light penetration can be reduced through good orientation effect. Heat production effect from sun energy will effect the rate of energy consumption in the building. The ray heat effect a wall building and no wind movement will drive the heat to accumulate in the building. The revolving of the sun and wind has a regular path. It has been considered from the level of planning. Design features are like an arrangement and building orientation needs the reduction of sun heat exposure. The guideline requires buildings in hot and humid tropical climate like our country to build a longer facade towards south north is applicable especially for skyscrapers.

UM Main Library building has applied the right orientation where a long facade is directed towards north and south while the short facade is directed towards east and west. Excess heat from east and west with the short facade will enable only low entry of heat into the building because only a small part of the facade is exposed to sunlight heat. UM Main Library building is equipped with glass window at the east side only meanwhile the west is covered completely with brick wall. So, only the east side will absorb energy without fail. Furthermore, no window is facing the west side because it is covered by brick wall and only the east side is using glass window and the heat effect can only be felt in the morning because the sun rises from the east. Looking at UiTM Perak Library building, it has vast surface that is facing the west side compare to the north and south side. The design of the building has breached the principle of building orientation to reduce the heat volume that hit the wall building. The designer of the library building should lengthen the main core towards east and west as significant wall exposure can be directed towards south and north. Using this method, the total rate of wall surface that is exposed to sun heat can be reduced. Apart from that, this method will also reduce the total cooling load of the air-conditioning system in the building. Thus, the objective to efficient energy saving into the building can be suited with the building orientation effect with the total heat rate that goes into the building through sun passageway.

VI. SHADING DESIGN ASPECT

There are few aspects of design that should be controlled by designers including from the aspect of shading. Shading is very important to prevent direct light from entering a building. It is one of the ways to reduce cooling load which will eventually reduce the usage of energy by the air-conditioning. So, to prevent hot light from entering the building interior, the need of shading tools should be arranged. In addition, the design of the accurate shading tools is intended to produce shadow effect in the building. The presence of high humidity of air and windy rain require an effective shading design building. The projection on the window not only to block rain but also to obstruct sun heat from its direct ray from entering the interior of a building that will increase the internal temperature. The best shading has

the capability to protect the entire wall to prevent from rising wall heat and reduce the climate negative effect such as obsolete and decay element or wall finishing. UiTM Perak Library building is not using external shading tool maybe because it is difficult to be adapted as the building is high. Shading tool not only limited to the window side, there are also various structural shapes that can be used as shading tool. If we look at Picture 1, there is no shading tool at the window of UiTM Perak Library building. This enables heat to directly entering the building through the window of the building. As for UM Main Library building, there is a good shading tool because most of the windows of the building have a shading tool with the shape of a panel that is made of concrete or also known as Vertical Shading Tool that prevent the heat and light from entering directly into the building. Moreover, UM Main Library Building also has a shading tool called "Hung Louvers" at the west side of the building like what is shown in Picture 2 below. The intense heat from the sun in the afternoon is facing the west to suit the usage of the shading tool at the research building. The shading tools are important because the fierce sun ray takes place on the east and west sides.



Pic 1: There is no Shading Tool at the Window of UiTM Perak Library Building



Pic 2: Hung Louvers a Shading Tool at the West Side of UM Main Library Building

VII. LANDSCAPE USAGE

The environment of a building can boost to create thermal comfortness that is much needed by a building to support the usage of air-conditioning system. Quality landscape design will prevent heat from sunlight and heat rebound that is produced from earth surface. It is found that the wall of the east and west sides accept sunlight ray directly and expand on wall building. Looking at UiTM Perak library building, it can be seen that there is a lot of heat absorption at the southwest and northwest. In the morning, sunlight hits the wall at the southwest and northeast while in the afternoon, the density of

sunlight is more towards the northwest and southwest of the wall building. Furthermore, the planting of unsuitable trees and disorganize plantation have caused the presence of landscape not giving positive impact to the landscape protection of the building. Thus, the function of existing landscape does not contribute to the reduction of heat entry rate into the building. Looking at the landscape at the southwest side as shown in Picture 3, we could see unorganized arrangement and the usage of tree is not protecting the wall building where the effectiveness of the plants to be the natural shading is limited to the maturity height. This can be seen as there is no small plants that is being used as effective natural shading to the wall building. Thus, the rate of sunlight ray penetration is direct towards the wall building. Now, looking at UM Main Library Building, the landscape usage has been adapted effectively at every part whether the north, south, east and west. Picture 4 below shows the usage of landscape at UM Main Library Building. The type of trees are also suitable with the building height. With the presence of big size trees, this enables the prevention of direct and excess heat into the building because there are obstacles for the heat to enter. In addition, the choosing of types of trees and their arrangement give effective natural shading to the building and consequently have solved part of the problems of rising heat in the building.



Pic 3: Landscape at the Southwest of UiTM Perak Library Building



Pic 4: Landscape at the entire view of UM Main Library Building.

VIII. PROPOSAL TO MONITOR THERMAL COMFORTNESS

- i. Correct orientation before designing a building
- ii. Suitable usage of construction materials and low U value
- iii. The usage of heat absorption glass
- iv. The usage of landscape around the building.
- v. Shading of the building

vi. The usage of opening in building design

IX. CONCLUSION

From the analysis, it is found that Overall Thermal Transfer Value or OTTV value of UiTM Perak Library Building is 60.19 W / m^2 and this is higher than the value set in MS 1525:2007 guideline. For Universiti Malaya Main Library Building the OTTV value is 33.07 W / m^2 and this value is lower than the value set by the guideline. This finding shows that the usage of energy in Universiti Malaya Main Library Building from the aspect of building envelope is more efficient than UiTM Perak Library Building because the value is less than 50 W / m^2 . From the analysis, there are few factors that influence efficient energy usage in both buildings, among the factors that have been discussed earlier are:

- 1) Orientation
- 2) Construction Materials and U Value
- 3) Building Design From The Aspect Of Shading
- 4) Surrounding Landscape

Based on the analysis on the above factors, it can be concluded that UiTM Perak Library Building does not meet the requirement of the above factor and this is the reason why the OTTV value of the building exceeds the value set by the guideline. Whereas, Universiti Malaya Main Library Building is able to apply the factors efficiently. Thus, building envelope is an important aspect that needs to be considered by any building designer to gain efficient energy usage of a building before looking at other aspects. The choices of building envelope and the achievement of good usage of building envelope will lead to positive impact on the aspect of air-conditioning choices, operation in the building and finally continuous maintenance will create efficient energy usage in a building. Therefore, something has to be done to make sure all future buildings meet the criteria that have been set by the guideline by emphasizing the aspects of design, construction materials, U-Value, building orientation and others that strongly influence the rate of heat absorption into any building.

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