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A Study of Overall Thermal Transfer Value (OTTV) in Healthcare Building in Perak Tengah District

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Abstract: Overall Thermal Transfer Value (OTTV) is a design parameter that indicates the solar thermal load transmitted through the building envelope excluding the roof. Temperature readings were taken for both research healthcare to prove that the internal temperature of the building is still not cool enough even though air conditioning has been installed. Thus, this study was carried out to identify and calculate the Overall Thermal Transfer Value (OTTV) in Klinik Desa Kota Setia (KDKS) and Klinik Kesihatan Ulu Dedap (KSUD) starting in July until September 2022 the value of the OTTV was recorded, and the data intended to analyze based on Malaysian Standard 1525:2019. Accordingly, the data collection methods through site visits, interviews, and measurement of each parameter before implementing into the formula of OTTV. The measurements were used in a 4-in-1 Meter Kit for an environmental parameter for 5 weeks from July to September. The study finds out 7 parameters calculated such as wall area, solar absorption factor, window-to-wall ratio, wall construction U-value, orientation value, glass shading coefficient, and device shading coefficient. Then, the OTTV result for KDKS and KSUD was 72.04 W/m^2 and 39.7 W/m^2, respectively. For improvement 3 consideration factors, the selection of building materials, the use of shading components, and the installation of thermal insulation play a very important role in achieving good thermal and energy use of air conditioners as well as energy efficiency can be applied to KDKS healthcare.

Keywords: Overall Thermal Transfer Value, Healthcare, U-Value

1. Introduction

The OTTV value in a building is affected by the size of the opening in the structure. The amount of energy load created by a building is proportional to the size of the aperture in the translucent wall [1]. Discomfort to the occupants of the building due to the accumulation of heat in the building. The increase in heat from outside into the building is also one of the discomfort factors for occupants inside

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the building. This often happens to structures exposed to hot weather outside the building and have a building design that does not help in heat reduction [2].

The Overall Thermal Transfer Value (OTTV) focuses on the three basic components of heat gain due to the windows and the external walls of the building. The research was carried out at Klinik Desa Kota Setia (KDKS) and Klinik Kesihatan Ulu Dedap (KSUD) located in Perak to determine the Overall Thermal Transfer Value (OTTV) based on calculation and through field measurement. Both buildings typically have high transient heat loads in nature, with patients coming and going, from the lighting, and are generally full of occupancy and internal medical equipment. Thus, this may cause overheating due to excessive heat gain and lead to dissatisfaction patient and energy waste.

The objectives of this study are to identify the OTTV parameters at KDKS and KKUD in Perak, calculate data OTTV at KDKS and KKUD from July until September 2022 and analyze data based on Malaysian Standard 1525:2019 Code of Practice on Energy Efficiency and Use of Renewable Energy for Residential Buildings.

Scope of the study mainly focused on the thermal transfer of both healthcare building with an area of around 121.5 m^2 and 259.2 m^2 and both are single-story building structure. The measurement is carried out by using 4 in 1 Meter Kit as well as equipment with applications such as building orientation methods other than that site visit and interview. All the data were analyzed and calculated was done using the equation refer from Malaysian Standard 1525:2019 that had been interpreted in tabular form by using Microsoft Excel Spreadsheet software.

2. Literature Review

OTTV definition is the design parameter that indicates the solar thermal load transmitted through the building envelope excluding the roof [3].

2.1 Building Envelope

The building envelope refers to the contact between the building's interior and its surroundings, including the foundation, roof, walls, doors, and windows [4]. The primary function of the building envelope is to prevent heat gain through conduction and solar radiation. The Building Energy Simulation Method enables designers to demonstrate compliance using the same procedure that was utilized to establish the OTTV constants. Clause 10 further applies the notion of whole-building energy efficiency and accepts credits for on-site renewable energy sources, better ACMV, and daylighting. This proves the need in emphasizing OTTV in balancing thermal comfort so that the occupants of the building are in a productive state. The aim of OTTV is to balance the thermal comfort of a building without affecting energy consumption [5].

2.2 Building Orientation

Building orientation is the process of turning a building so that its front face is oriented in such a way as to maximize certain characteristics of its surroundings, such as its street appeal, its ability to capture a scenic vista, its ability to accommodate drainage concerns, and so on [6].

2.3 Thermal Comfort

Comfort is a personal interpretation based on human opinions, whereas thermal comfort is objective and typical heat dissipation rates by persons for different activities in diverse applications refer to Figure 1 [7]. Usually, heat transfer always occurs in three main categories either acting alone or in some combinations like conduction, convection, and radiation.

TABLE 8

Heat gain from people in conditioned spaces (from ASHRAE *Handbook of Fundamentals*, Chap. 26, Table 3)

		Total heat, W*			
Degree of activity	Typical application	Adult male	Adjusted M/F/C[1]	Sensible heat, W*	Latent heat, W*
Seated at theater	Theater—matinee	115	95	65	30
Seated at theater, night	Theater—evening	115	105	70	35
Seated, very light work	Offices, hotels, apartments	130	115	70	45
Moderately active office work	Offices, hotels, apartments	140	130	75	55
Standing, light work; walking	Department or retail store	160	130	75	55
Walking, standing	Drug store, bank	160	145	75	70
Sedentary work	Restaurant[2]	145	160	80	80
Light bench work	Factory	235	220	80	80
Moderate dancing	Dance hall	265	250	90	90
Walking 4.8 km/h (3 mph); light machine work	Factory	295	295	110	110
Bowling[3]	Bowling alley	440	425	170	255
Heavy work	Factory	440	425	170	255
Heavy machine work; lifting	Factory	470	470	185	285
Athletics	Gymnasium	585	525	210	315

Figure 1: Heat Gain from People in Conditioned Spaces (ASHRAE, 2007)

The high energy consumption in the building occurred was one of the factors affecting thermal comfort. This part of the process by which chemical or electrical energy is converted to thermal energy within a structure is referred to as internal heat gain or internal load.

2.3 Fundamental and Formulation of Overall Thermal Transfer Value (OTTV)

The overall thermal transfer value (OTTV) requires that the building envelope be completely enclosed and located within an area that is air-conditioned as a fundamental need. Because the heat gains from the sun coming in through the building envelope accounts for a sizeable portion of the total cooling load, employing OTTV assessment will allow for a reduction in the heat gain from the outside, which will, in turn, result in a lower total cooling load for the air conditioning system. The OTTV comprises three major factors in their formula such as heat conduction through walls and windows and solar heat gain through the window. The equations are referred to in Malaysian Standards 1525:2019 as the in Eq. 1.

$$OTTV = [15\ \alpha\ (1 - WWR)Uw] + [6\ (WWR)Uf] + [194\ x\ CF\ x\ WWR\ x\ SC] \quad Eq.1$$

3. Methodology

The methodology is described as a set of rules from which specific methods or procedures can be constructed to understand or solve various problems within the scope of specific disciplines. Figure 2 depicts a flow chart depicting the experimental activities of the study that was used.

The main material for the building walls for KDKS is made of wood while KSUD is made of bricks. Next, the facing for KDKS is facing north while KSUD is west. The building orientation factor is important when linked to the Window-to-Wall Ratio (WWR) parameter where the WWR value for KDKS is relatively high on the facing side.

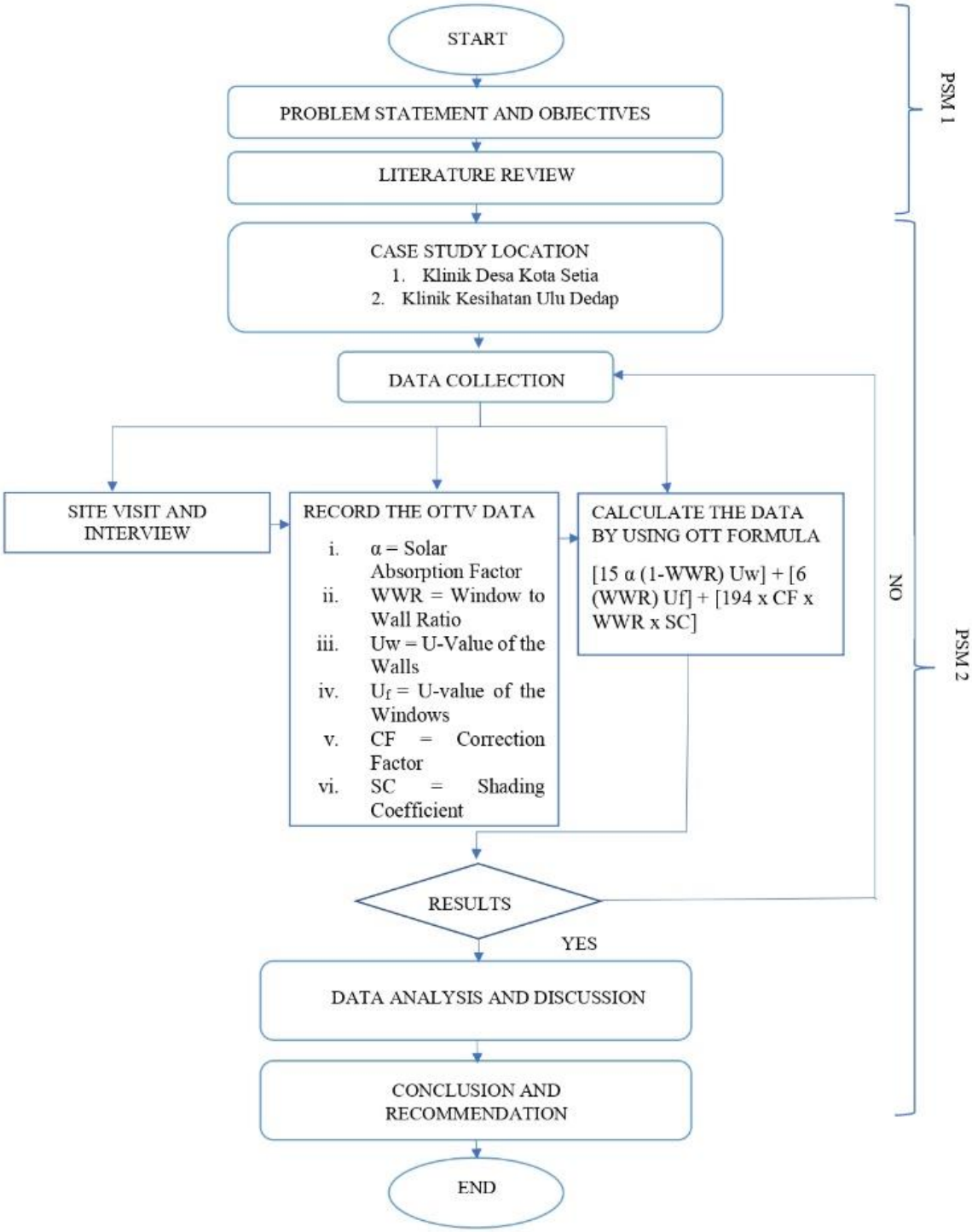

Figure 2: Methodology Chart

Figure 3: The building of KDKS

Figure 4: The building of KSUD

4. Results and Discussion

Data were collected from July until September 2022 and this study takes into account 7 important parameters for OTTV calculation:

i. Wall Area
ii. Solar Absorption Factor
iii. Window-to-Wall Ratio
iv. Wall Construction U-Value
v. Orientation Factor
vi. Glass Shading Coefficient
vii. Device Shading Coefficient

4.1 Factor affecting Overall Thermal Transfer Value (OTTV)

A good wall is one that can preserve excessive heat from entering the building. The materials used to construct the walls also have an impact on the rate of heat entering the building. Building materials and U-value are inextricably linked where the thicker material, the lower its U-value. By means of the lower a building material's U-value, the greater its insulating value and heat protection quality. The KDKS are using wood as the main building material for the wall structure compared to the other three buildings apart from KSUD where the building uses conventional building materials such as concrete, plaster, and brick wall as the basic material for the walls. As evidence, the U-value of

wooden walls is higher when compared to bricks wall. Therefore, energy consumption also increased in line with the increased use of air conditioning in the Klinik Desa Kota Setia.

The most significant aspect apart from the wall construction material for this two healthcare, the thickness of the wall also plays an important role in terms of heat absorption on the walls of this healthcare buildings. In addition, the wall thickness of the Klinik Desa Kota Setia's building, which is wooden boards, is thinner compared to the Klinik Kesihatan Ulu Dedap's building, which is brick. It is different from Klinik Desa Kota Setia's walls where only wooden construction materials are used on the walls and there are no other components that help to be thermal insulation. Here it can be seen that the thickness of a wall affects it, when the U-value can be reduced then it affects the rate of heat entry in the building.

Thermal conductivity values vary widely between materials and are highly dependent on the structure of each material. Some materials will have different thermal conductivity values depending on the direction of heat transfer because they are anisotropic materials. In these cases, heat moves more easily in a certain direction due to the structural layout. Generally, thermal conductivity is affected by its own parameters which can be seen in its formula which is the amount of heat transferred.

4.2 Summary of Parameter.

There are various factors that affect the value of the OTTV and the following table shows the parameters that contribute to differences between KDKS and KSUD.

Table 1: The difference in the value of the parameters involved between KDKS and KSUD

Details	Klinik Desa Kota Setia	Klinik Kesihatan Ulu Dedap
Location	Jalan Parit, Kampung Gajah, Perak Tengah, 36000 Teluk Intan, Perak	Jalan Seberang Perak, Kampung Ulu Dedap 36000 Teluk Intan, Perak
Floor area	135 m^2	295.2 m^2
Materials	Wall: a) Elements: Wood and Paint b) U-value: 8.55 W/m^2 K	Wall: a) Elements: Concrete, Plaster, Brick wall, Wall Tiles and Plaster. b) U-value: 0.015 W/m^2 K
	Windows: a) Elements: Single glazed and tinted b) U-value: 5.80 W/m^2 K	Windows: a) Elements: Single glazed and tinted b) U-value: 5.80 W/m^2 K
Total of Shading Coefficient (SC)	North Window: 0.96	North Window: 0.96
	South Window: 0.64	South Window: 0.7008
	East Window: 0.96	East Window: 0.96
	West Window: 0.62	West Window: 0.96
Solar Absorption Factor	Paint: Cream Value: 0.40	Paint: White Value: 0.40

Solar Orientation Factor (Based on MS1525:2019)	North: 0.90 South: 0.92 East: 1.23 West: 0.94	
OTTV (W/m^2) (50 W/m^2)	72.04	39.7

4.3 Comparison

From the analysis that has been carried out, it was found that the OTTV of Klinik Kesihatan Ulu Dedap is 39.7 W / m² meanwhile Klinik Desa Kota Setia is 72.04 W / m² and it is higher than the value set by the guidelines in MS 1525:2019 refer to Figure 5. This shows that the efficient use of energy in the evaluation of the building envelope aspect of Klinik Desa Kota Setia is inefficient.

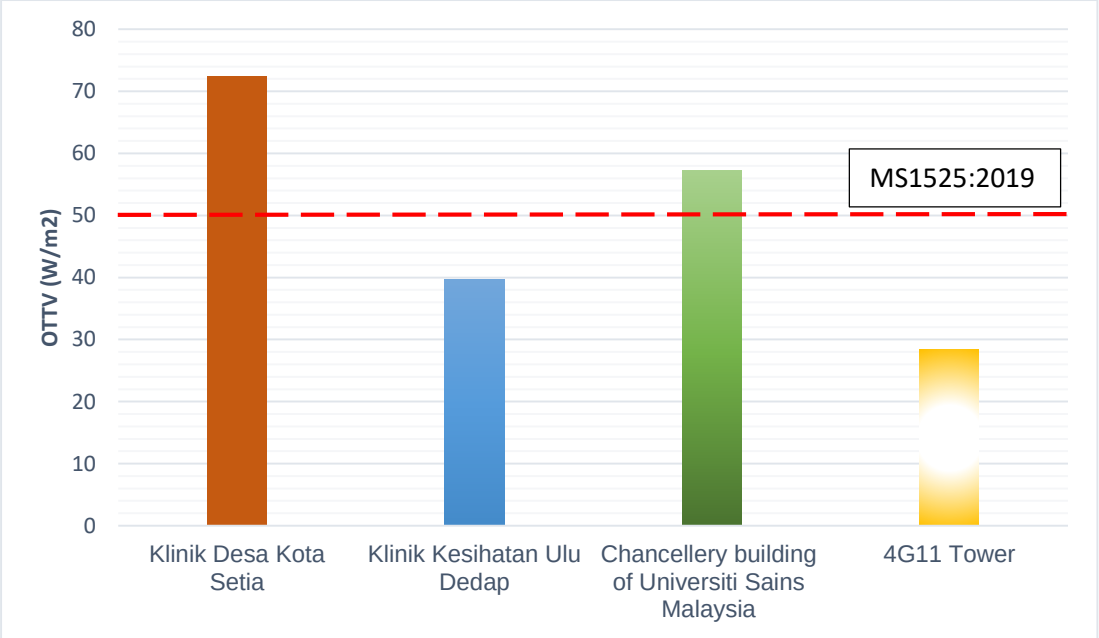

Figure 5: OTTV's value at selected Healthcare Building and past building study compared with MS 1525:2019.

4.4 Discussion to reduce OTTV value

Maximizing waste through building design, location, and arrangement that considers the building's orientation factor can reduce energy consumption for cooling and direct lighting of the sun's heat into the structure. However, if the rate of direct sunlight can be minimized, the rate of cooling energy consumption can be reduced as a result of proper orientation [8]. Therefore, by installing a sun shading device, it can indirectly produce a shaded area that can reduce the amount of sunlight that enters the clinic building.

At the preliminary design stage, the design should start to prioritize daylighting. Classical and reducing daylighting techniques that gather, transmit, and distribute light into structures with in-depth planning and systems to lessen the need for artificial lighting without increasing solar heat gain [9]. Therefore, focusing on the type of glass on the windows can assist a little to control the amount of excessive sunlight.

Improvements on wall insulation can be a significant factor in lowering the energy requirements for active cooling of a building's interior while also reducing solar heat gain for passive cooling. Therefore, adding a layer of wall insulation which consists of materials such as mineral wool and polyurethane foam to the Klinik Desa Kota Setia's wall, can help in reducing the waste of using air conditioners in this building.

Table 2: Differentiation value of heat transfer for each material insulation

Material of Insulation	Existing Wall	Mineral Wall Insulation	Polyurethane Foam Insulation
Heat Transfer's Value (J)	2012.9	16.54	13.47

5. Conclusion

All objectives of this study are achieved. According to the study and discussions that have been conducted, 7 parameters including orientation, building materials, U-value, and building design, which is in terms of shading, are examined in detail as elements that affect the effective use of energy in this building. As a result of the analysis of the factors mentioned, the OTTV of KSUD is 39.7 W / m² meanwhile KDKS is 72.04 W / m², the selection of building materials, the use of shading components, and the installation of thermal insulation play a very important role in achieving good use of air conditioners, as well as efficient energy efficiency, can be applied. Therefore, it is necessary to ensure that the buildings that were constructed in the future were able to meet the guidelines' requirements by placing an emphasis on design, material selection, U-value, and building orientation, and further lowering the value of OTTV to support efficient energy use in buildings.

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