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Strategy of Energy for Commercial Building

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Abstract-Presently, the average temperature in Thailand is tended to be increasing every year. Many organizations, therefore, create energy-saving campaigns to decrease energy consumption in buildings, for example, reduce unnecessary energy use, turn off all lights and switch off all electrical appliances when not in use, and reduce heat transfer in buildings. Reducing heat transfer in buildings is one of the energy-saving strategies that can decrease energy consumption. To study energy reduction by this strategy, this research aims to analyze Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV) of a two-story commercial building. Construction materials data of the commercial building, such as walls and roofs, including temperature inside and outside of the commercial building, are collected to examine the study. According to the research, averages of OTTV and RTTV are 80.36 W/m^2 and 59.18 W/m^2 subsequently, which are higher than the standard values specified by the Ministry of Energy. By this, the commercial building would be needed for renovation in order to meet the standards. Adding insulation and gypsum board to wall, applying window tinted film, and attaching insulation and insulated ceiling to the roof can help to decrease the averages of OTTV and RTTV about 57% and 80% respectively. The outcomes from this research could be applied for the energy-efficient renovation of buildings in the future.

Keywords: OTTV, RTTV, energy saving, renovation, commercial building

1. Introduction

Due to the average temperature in Thailand is tended to increase every year. As a result, energy-saving campaigns are created from many organizations in order to reduce energy consumption in buildings, including reduce unnecessary energy use, turn off all lights and switch off all electrical appliances when not in use, and reduce heat transfer in buildings. The reduction of heat transfer in buildings is one of the strategies that are applied for energy-efficient use. It is found that existing or being constructed commercial buildings are both designed to save energy. However, most of the building envelopes used in construction are cheap, easy to install, and are low thermal resistant materials, due to the budget.

Walls and roofs, for example, have effects on energy consumption in buildings. That is to say, building envelopes with high heat transfer will conduct heat to the air-conditioning systems and cause a high cooling load (Department of Alternative Energy Development and Efficiency, 2019), resulting in the increase of energy use in the air-conditioning system. The study of the averages of Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV) could help re-consider renovating the buildings. For commercial buildings, there is Building Energy Code (BEC) B.E. 2552 (2009) contained within Ministerial Regulations set up by the Ministry of Energy, prescribing Types or Size of Buildings and Standards, Rules and Procedures for Designing Energy Conservative Buildings, as shown in Table 1.

Table 1. Standard value of heat transfer through building envelopes of each type of buildings (Sripaded, 2008).

Unit: W/m^2

Building type	OTTV	RTTV
Office, Institute	≤ 50	≤ 15
Theater, Assemble Building, Department Store, Shopping Mall	≤ 40	≤ 12
Hospital, Hotel, Condominium	≤ 30	≤ 10

As stated above, this research has analyzed the values of OTTV and RTTV of one commercial building. The data analysis could be used to select materials which help prevent exceeding heat transfer through building envelopes. At the same time, the analysis would be beneficial to calculate energy savings.

2. Principles and Related Theories

The calculation of total heat transfer of the building consists of OTTV and RTTV. By this, the value of total heat transfer indicates heat value transferred from outside and solar radiation transfer into the building. The theory of heat transfer is applied for calculating the value of total heat transfer. It is found that heat transfer through building envelopes consists of three elements:

1. Heat conduction through the opaque wall

2. Heat conduction through the glass

3. The heat from solar radiation through glass

These three heat factors are brought to share the area average which results in the value of total heat transfer (Patcharaprakiti & Saelao, 2012).

OTTV of each wall ($OTTV_i$) could be calculated as Equation (1).

$$OTTV_i = \frac{\left(A_w \times U_w \times T_{eq}\right) + \left(A_f \times U_f \times \Delta T\right) + \left(A_f \times SC \times SF\right)}{A_i} \quad (1)$$

OTTV is the weighted average of Overall Thermal Transfer Value of each wall ($OTTV_i$), as calculated in Equation (2).

$$OTTV = \frac{\sum\left(OTTV_i \times A_i\right)}{\sum A_i} \quad (2)$$

From Equation (1), the window-to-wall ratio (WWR) could be described as presented:

$$OTTV_i = (1 - WWR) \cdot TD_{eq} \cdot U_w + WWR \cdot \Delta T \cdot U_f + WWR \cdot SC \cdot SF \quad (3)$$

Meanwhile, RTTV could be calculated as Equation (4).

$$RTTV = \left(U_f\right)(1 - RSR)\left(TD_{eq}\right) + U_{rf} \cdot RSR \cdot \Delta T + SC \cdot RSR \cdot SF \quad (4)$$

U_w = Overall heat transfer coefficient through the opaque wall ($W/m^2 \times °C$)

U_f = Overall heat transfer coefficient through glass ($W/m^2 \times °C$)

TD_{eq} = Equivalent temperature difference between indoor space of a building and outdoor ambient (°C)

ΔT = Temperature difference between indoor space of a building and outdoor ambient (°C)

A_W = Area of wall (m^2)

A_f = Area of window (m^2)

A_i = Total area of the wall includes wall and window (m^2)

SC = Shading coefficient

SF = Solar factor (W/m^2)

WWR = Window to Wall Ratio

RSR = Skylight ration of roof (skylight area/gross area of the roof)

3. Delimitation of the Study

Three rooms of a two-story commercial building located at 13.720140, 100.325279 of the geographic coordinate, with an area of 27.21 m^2 in Sampran District, Nakhon Pathom Province.

4. Research Procedures

1. Collect data of the commercial building, such as location and surroundings. However, the 1st floor of this building is located between other commercial buildings. Hence, this floor is not examined. Details of the building are displayed in (Figure 1).

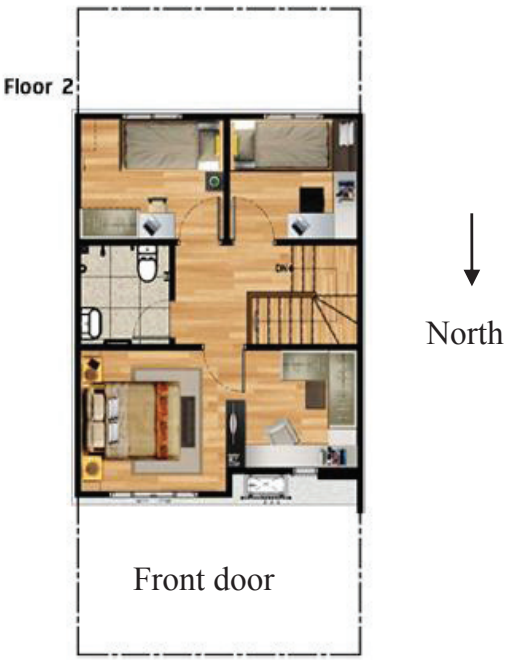

Figure 1. Plan of 2nd floor of the commercial building.

2. Collect all materials information, for example, types of concrete and glass, including living spaces

3. Calculate the values of OTTV and RTTV with Building Energy Code (BEC) program

4. Collect data about qualifications of materials as a guideline for energy conservative renovation, such as insulation, energy-efficient glass, window film, etc.

5. Results

According to (Figure 2) which shows the averages of OTTV and RTTV of three rooms of the commercial building on the 2nd floor, it presents that the first room has the highest OTTV since it was received sunlight all afternoon. For RTTV value, the research has examined the value from both the ceiling and roof. When examining both OTTV and RTTV, the results show that the averages of OTTV and RTTV of the three rooms all exceed the standards of heat transfer for the office building. In order to reduce the averages, there are several effective procedures as follow:

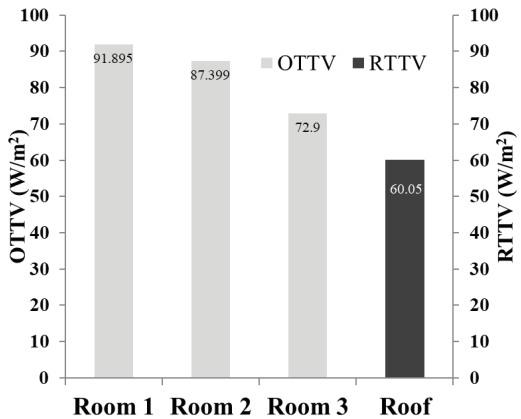

Figure 2. Results of OTTV and RTTV of the commercial building.

5.1 Window Film and Insulated Gypsum Board

As shown in (Figure 3), the OTTV of each room is decreased. The results show that attaching insulated gypsum board to the wall helps reduce OTTV about three times. Applying window film to glass also reduces the average of OTTV.

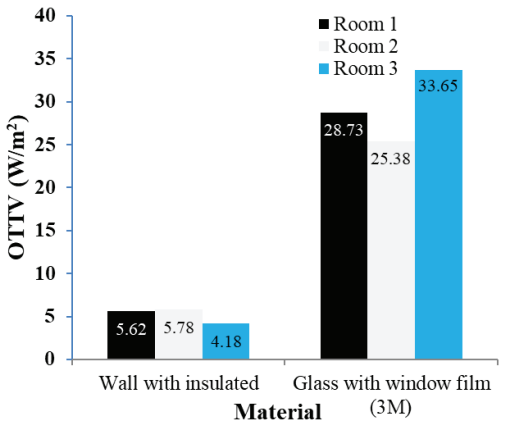

Figure 3. Averages of OTTV when adding insulation materials.

5.2 Insulated Ceiling and Insulated Roof

The results describe that installing an insulated roof could decrease a higher average of RTTV than the insulated ceiling, as presented in (Figure 4).

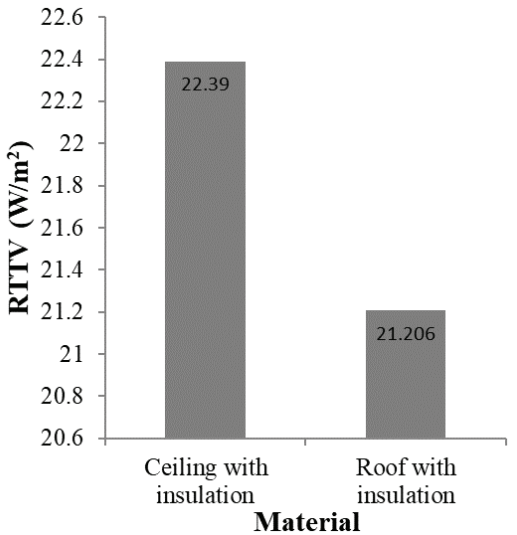

Figure 4. Averages of RTTV when adding insulation materials.

5.3 Average Comparison of OTTV and RTTV Before and After Adding Insulation Materials

According to (Figure 5), the results present that OTTV and RTTV could be decreased after adding insulation materials. With this application, the decreased averages of OTTV and RTTV are lower than the standards specified by the Ministry of Energy in the category of Office Building, which is $\leq$ 50 W/m^2 and $\leq$ 15 W/m^2 respectively. As shown in the graph, fiberglass insulation and gypsum board are the best materials to help to decrease the average of OTTV, while the average of RTTV is highest reduced when applying insulation.

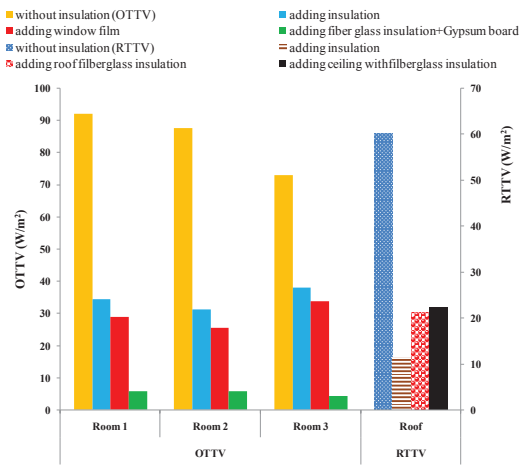

Figure 5. Average comparison of OTTV and RTTV before and after adding insulation materials.

6. Conclusion and Suggestion

Building envelopes renovation with the application of Building Energy Code (BEC) program presents that the examined commercial building has OTTV and RTTV higher than the standards of the Ministry of Energy, in the category of Office

Building. In order to reduce heat transfer value, applying insulation materials to building envelopes could be a resolvable way. These effective procedures include adding fiberglass insulation and gypsum board to wall, applying window tinted film or attaching sunscreen curtains to windows, insulating fiberglass to ceiling, and adding fiberglass insulation to the roof. However, this research does not examine the payback period if insulation materials are equipped.

7. Acknowledgement

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