The Study of Using the Opaque Wall Material to Manage Overall Thermal Transfer for the Heritage Hospital Façade in Bangkok

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Abstract
Many hospitals in Bangkok metropolitan districts are awaken to the global warming crisis. It results that the temperature in the winter is closed to the summer. The following effect is that the old hospital buildings, are confronting the energy over consumption than ever. In particular, the old facades are needed renovation to preserve comfortable condition. However, there has a limited renovation for a heritage building such the demolition in a façade component realized the maintenance of historical building character and district conservation. This article concentrates on the study the suitable opaque material finishing for the heritage hospital façade renovation. The aim is to reduce overall thermal transfer value (OTTV) of the façade related to Thailand standard requirement of Pollution Control Department (PCD). The research scope emphasizes in the opaque material of the hospital façade. Here the ward of Sirinthorn building, within Rajavithi hospital in Bangkok is selected as a paradigm. The study method is divided in 3 phases: defining a suitable format of material installation for building conservation for the paradigm, investigating opaque materials for construction following Thai Industrial Standard, and considering material character by a trail & error method. The result is the guideline of material selection presented in 3 characters. This article offers the sample opaque material to apply for the case study in practical later.

Keywords: An opaque wall, Heat transfer, Heritage hospital façade, Energy management

Introduction

OTTV in heritage hospital building

Many hospitals in Bangkok metropolitan districts are awaken to the global warming crisis. It results that the urban temperature is hot from the winter to the summer. The following effect is that energy performance of the heritage hospital buildings in Bangkok metropolitan districts are confronting the overconsumption than ever.

After the overview of heritage state hospitals, it found their actual building lifetime to serve people is frequently over 30 years. During this period it will be renovated many times due to the shorter life of technical equipment, the development of new types of equipment, new regulations, new energy-saving technologies and the ageing of the building itself (CADDET, 1997).

The primary evaluation of Hospital building in Bangkok by Department of Alternative Energy Department and Efficiency (2008.), it founds that buildings remain potential to proceed further in energy conservation. Meanwhile hospitals are ready to promote this issue seriously.

One significant issue is the obsolescence of the existing façade material design which happen in the heritage building. The old heritage facade always malfunction in the present Bangkok climatic characteristics, especially in the Thailand summer season. The existing facade designs cannot reduce higher external heat gain from solar radiation in Bangkok zone as protected in the last decades.

In particular, the opaque wall are major area of the old hospital facades need heat transfer management between outdoor and all interior air-conditioning zones. So the façade, redefined as a special share component between in-and-out, is to practice energy conservation and the comfort condition for users in the old hospital buildings.

Similar in typical buildings, hospital facade design promotes not only the balance of heat transfer between inside and outside, but creating a comfortable zone. The overall Thermal transfer value (OTTV) concept can calculate by heat transfer via the facades. (Hui, 1991.) OTTV standard is applicable to mechanically cooled buildings, especially air-conditioning zone. OTTV is a measure of heat transfer into the building through its envelope in the unit of watts per square meters (Jeyasingh, 2010.).

Objective

This article concentrates on the study of using the suitable opaque material finishing for the heritage hospital façade renovation. The expected aim is to reduce overall thermal transfer in building by adaptive use of opaque material in facades. The design output is under Thailand OTTV code. Also the new renovation remain maintaining outstanding existing Building Character of the façade to public sight.

Methodology

The assumption of this article is based on that selecting suitable materials and its façade setup method can manage energy efficiency in heat transfer in a heritage hospital building. The heritage case differs from the new construction project by restricting to conserve some existing architectural components following DOCOMOMO guideline (Rattanamart, 2018), consequently the research variables are categorized by dependent variables (material type and its installation method), control (Coordinating Center for Energy Conservation Building Design., 2016.) variables (site, a historic building conservation, existing components, area function and façade area), and independent variables (opaque wall characters, OTTV status and a type of wall installation).

The typical principle of façade design solution for thermal transfer management in a building is divided in 3 formats: solid (a single-layered masonry), framing studs (such a partition) and composite wall (combine techniques between material kinds) (Coordinating Center for Energy Conservation Building Design., 2016.). The highest level of the resistant value (R-Value) is the setup type of composite wall with the insulation, flexibly designed in materials (Buranasompob, 1996). The potential is assigned by the OTTV value from calculation from material character. It can be implemented by measuring the size and a characters of building façades to proceed the OTTV formula (A.L.S.Chan, 2014). Its output offers a numeric value (in the unit of watts per a square meter) to consider in the façade material selection based on the industry foundation class (IFC).

In this project methodology, energy software is selected as an optional tool for calculation higher potential than the other choices (such manual calculation). Refer to the precedent study of software for OTTV calculation compared to the manual style by Charoensuttiyotin (2017), it found that the distinct advantage of software application is proceeding in a limited time, less revenue and able to present various analysis solution. It can work for the project time management. The selected software to calculate, analysis and report the OTTV status referred to the code OTTV and its status after calculation, is the standard software BEC (Building Energy Code) designed by DEDE (Department of Alternative Energy Development and Energy Conservation, 2016.) as followed in Figure 1.

The paradigm of this research area is selected by considering in the hospital executive committee policy which is desired to develop the building conservation together with energy efficiency. The research methodology for this project is discussed in 2 aspects-energy efficiency (via OTTV) and heritage conservation as shown in Figure 2.

Data

Sirinthorn building, the hexagon shape building in Rajavithi hospital, is the outstanding architecture in Victory monument in Bangkok metropolitan. The research scope emphasizes in the opaque façade material of the fourth to tenth floor of the building, its function is an inpatient ward. Refer to the report on October 2nd, 2017 by the Sirinthorn Building renovation committee, it agrees that renovating building facades must preserve the existing façade characteristic.

Prior to analysis, the facade character and its area is surveyed to calculate (Figure 3). The scope of building façade renovation is concluded in the Sirinthorn Building renovation committees' previous report. Also according to the previous building survey, it founds that the opaque materials for existing hospital façade is the 10-centimeters thickness brick walls with white render. Its values of the opaque specifications are 1.069 W/M•K for thermal conductivity, 1700 KG/M3 for density, and 0.79 J/Kelvin. All database from Figure 3 and its specification is inserted in BEC program in the part of database and evaluated the OTTV status.

Result and Discussion

The calculation result for the existing opaque wall is presented by the report compared to the building code OTTV. It founds that the building OTTV status is failed. Its value is 91.659 watts per a square meter, which is higher than the code, 30 watts per a square meter (Coordinating Center for Energy Conservation Building Design, 2009). The trail-and-error method (Muthuri, 2009) is applied for this project by BEC program practice to meet the building OTTV code. The required result from process is to achieve building OTTV code and heritage characters conservation.
Typical heritage conservation can practice in 2 different methods: Revitalization and Preservation. The revitalization is mainly reconstruction with adaptive use, but the preservation is defined maintaining the existing historic character (Architecture Department of the University of Hong Kong, 2012.). The Sirinthorn renovation plan is limited to work 3-4 months as shown in Figure 2. For this reason, the preservation of the historic building facades by maintain the existing facade is a more appropriated option than the revitalization. This research selects the technique of adding panel structure on the existing wall rather than masonry reconstruction to practice trail-and-error with materials. After the test, it founds that the OTTV status result is pass the test as shown in Figure 4.

Refer to the building OTTV status report, the insulation material which is recommended for this case is the 3 inches of Thickness of Fiberglass insulation with high performance label. (Or called Stay Cool 3" Super Save). Its material character specification contains the maximum values of 1) heat insulation: 0.39 W/m•K in Thermal conductivity, 2) 12 Kg/m^3 in density, and 3) 96 kJ/kg•K for specific heat (Figure 5). This research also discovers that material performance in heat transfer guideline is depended on 3 characters: Thermal Conductivity, Density and Specific heat capacity. The characters is the insulation material, this research offers “Fiberglass insulation with high performance label” as an alternative material for adding to the existing masonry material (a brick wall).

The critical consideration after use of insulation is that the whole façade thickness is increase from the existing depth in an opaque wall part (as Figure 5). It effects on the detail of and opening components such windows and doors is deeper (> 10 centimeter), the material cost of window or doors is higher.

Conclusion

In conclusion, the frame of Sirinthorn building renovation is realized that 1) selected materials should be harmony and orderly the whole building envelope. The research also recommend the three significant material characters which is influential to heat transference. And 2) respecting the heritage conservation principle by preserving the exterior façade and adapting the interior. Here adding the insulation and create more layer inside the building is an alternative solution to protect heat transfer cross the façade, meanwhile to maintain out skins of heritage building character. Also outside materials can be kept the same exterior elevation character as the previous design.

Finally the research outcome is considered in practical for Sirinthorn renovation project. Materials itself and its installation technique may be adaptive, in the term and condition that the values of material specification and design details must support building OTTV status pass.

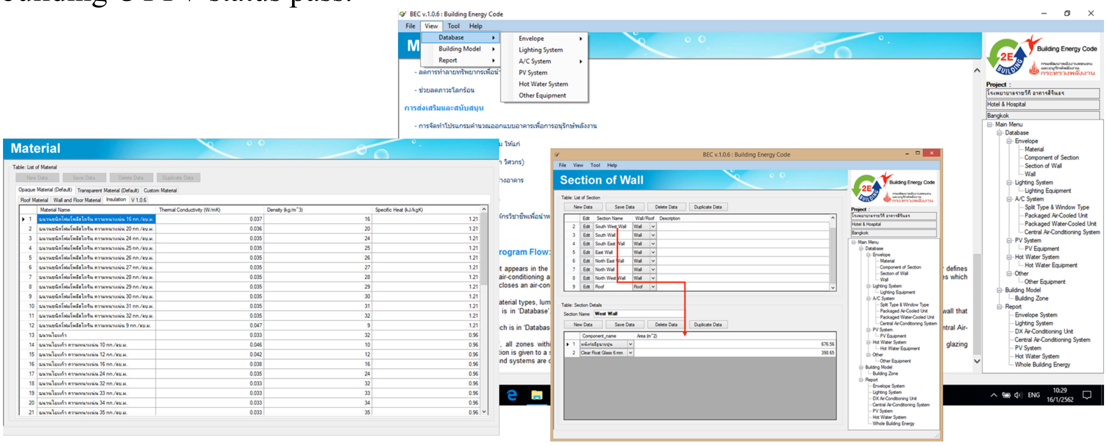


Figure 1 : BEC interface.

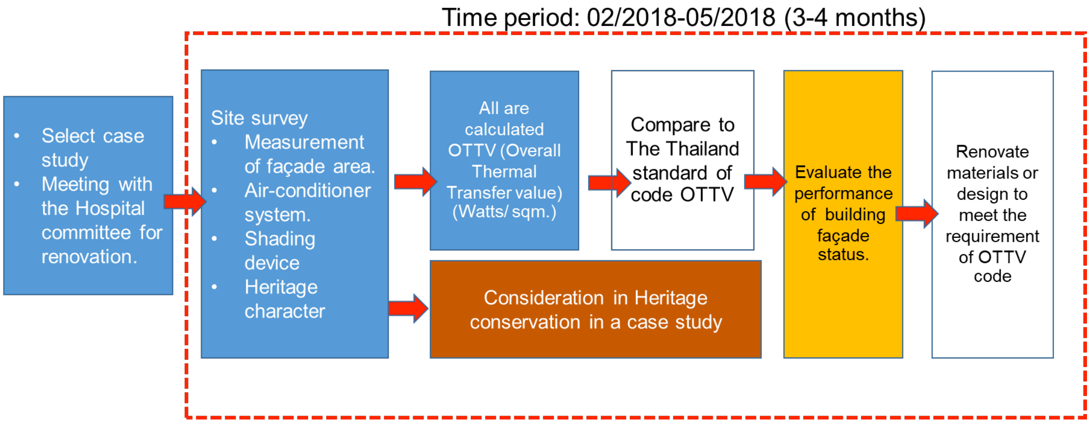
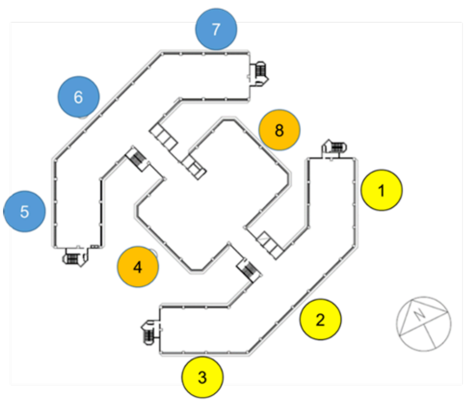


Figure 2 : Research methodology diagram.



Direction	Number	Opaque area (Sqms.)
West	4	676.56
South-West	3	479.1
South	2	856.2
East-West	1	479.1
East	8	673.14
North-East	7	501.24
North	6	856.2
North-West	5	501.24
Total	all	5040.78

Figure 3: Diagram of direction and building façade area.

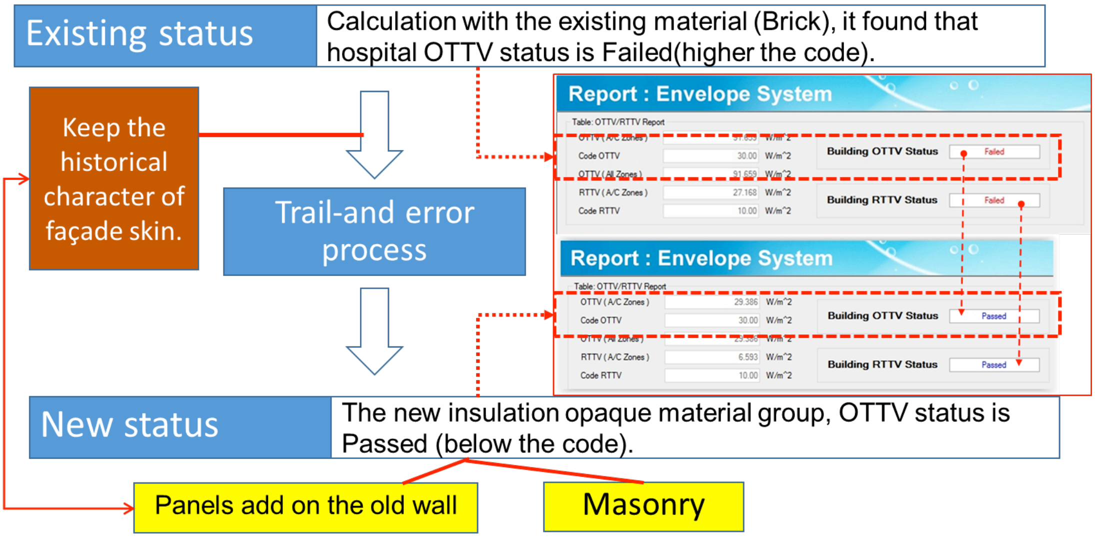


Figure 4 : Frame of result and discussion.

Material name	***Thermal Conductivity (W/m·K)***	***Density (kg/m^3)***	***Specific Heat capacity (kJ/kg·K)***
3 inches. Thickness of Fiberglass insulation with high performance label. (Stay Cool 3'Super Save)	*0.039*	*12*	*0.96*

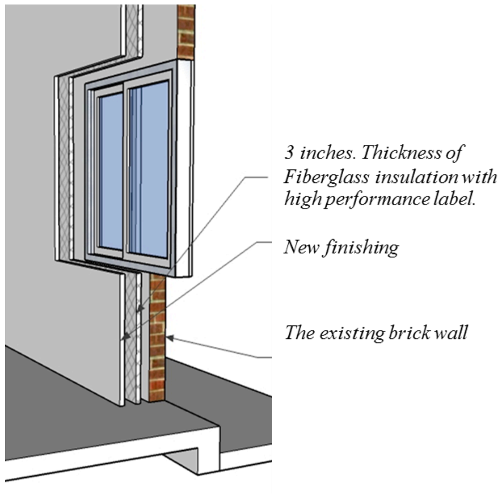


Figure 5 : The recommended optional principle solution.

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