Study of facade design method to improve the energy consumption performance of buildings

(Research period: FY 2017–2019)

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Keywords: Energy conservation, facade, heat environment, light and visual environment

1. Background and objective

An important point in improving the energy conservation of a building is to reduce the load on devices, such as the air-conditioning load and lighting load, using arrangement plans and façade designs (plans for outer shells such as outer walls, windows, and roofs) that are in the upstream side of an architectural design process.

Also, façade designs have large effects on the heat environment and the light and visual environment, such as that low insulation performance creates an uncomfortable environment, such as cold temperatures near the floor and high temperatures near people' heads while using heaters. Meanwhile, the evaluation of the energy consumption performance of a building requires the forecasting of energy consumption that keeps changing with weather conditions and how devices are used. Thus, the presumptions of the indoor environment are now being limited, such as assuming that the indoor temperature remains homogeneous and constant while using air conditioning.

Based on the above, this study aims to develop methods to evaluate how façades affect building energy consumption performance and methods to design buildings (design guidelines) to increase the number of energy efficient buildings that realize high energy efficiency and a comfortable indoor environment at the same time.

2. Details of the study

In FY 2017, the authors examined regulations and past studies inside and outside of Japan in regard to the aspect stated in 1 in table 1 and organized methods to calculate individual performances based on the types of façade (insulation and sunlight blocking performances, lighting and light guiding performances), as well as indexes and standards of the indoor environment (heat environment and light and visual environment).

The authors also simulated the indoor environment based on different types of façades. Figure 1 is the example of the computational fluid dynamics (CFD) of the heat environment while using heaters based on insulation performance. In addition to insulation performance, it examines the rate of airflow from an air-conditioning unit and its temperature. This examination found that improved insulation performance reduces vertical temperature differences (improved heat environment) even when the temperature setup is lowered with the same airflow rate or when the airflow rate is reduced with the same setup temperature (energy efficiency is improved in either case). The result was expressed in a figure so that designers could instinctively understand it.

Table 1: Main aspects of the study

1.	Development of methods to calculate individual performances of façades (redevelopment) and indexes and standards of indoor environments
2.	Development of methods to evaluate the energy consumption performance of buildings that takes into account the combined effects of arrangement plans and facades on air conditioning and lighting
3.	Development of facade design methods to improve energy consumption performance and the maintenance of proper indoor environments

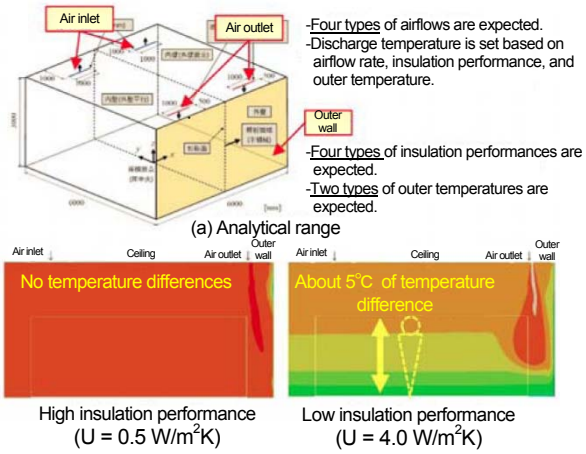

Figure 1: The CFD of the heat environment based on insulation performance

3. Future plans

The authors are going to mainly examine table 1-2 in the next fiscal year, and test the developed evaluation methods in the final fiscal year to prepare a façade design method (design guideline) reflecting the outcomes of the study.