

Principal Research Results

Practical application of design tool for indoor thermal environments for houses – Calculation method of load associated with air-conditioning and thermal comfort of multiple rooms –

Background

The Central Research Institute of Electric Power Industry (CRIEPI) has been developing a design tool called “Amenity,”*¹ which enables the quantitative evaluation of the thermal comfort of a residence and the load associated with the air-conditioning (hereafter, air-conditioning load) by simulating the three-dimensional heat transfer phenomenon due to indoor radiation, convection and the conduction of heat to simultaneously pursue energy savings and improve the thermal comfort of home environments. The merit of Amenity is that it can calculate the heat transfer caused by radiation with high precision, while this has been dealt with only roughly by the conventional method despite having a significant effect on thermal comfort. In addition, the results calculated using Amenity can directly be used in the already developed airflow analysis tool “Airflow”*² to precisely calculate airflows such as those from an air conditioner. To put Amenity to practical use, it is indispensable to expand the area that Amenity can handle from a single room to the entire house (multiple rooms).

Purpose

The purpose of this study is to improve Amenity so that the thermal comfort index*³ and air-conditioning load can be calculated for multiple rooms. Furthermore, the improved Amenity is applied to a house to verify the feasibility of Amenity for the calculation of air-conditioning load.

Main achievements

1. Improvement of functions of Amenity

- Amenity was improved to enable simultaneous evaluation of various parameters in a house consisting of multiple rooms. The thermal comfort index and air-conditioning load for each room are simultaneously calculated considering the three-dimensional location of the residents, the effects of insolation and outdoor air temperature, which affect each room, and the mutual thermal effects between neighboring rooms owing to thermal flow through the indoor walls (Figs.1 and 2).
- The Windows graphical user interface (GUI) was developed to easily prepare the data required for calculations on a computer, significantly improving the convenience of Amenity (Fig.3).

2. Verification of feasibility of improved Amenity for calculating air-conditioning load

- The air-conditioning load of an average-sized house in Tokyo, calculated using the improved Amenity, was compared with those obtained using two commercially available software packages*⁴ with the evaluation certification for the calculation of air-conditioning load*⁵ (hereafter, called accredited software).
- As shown in Fig.4, the results of monthly load calculated using Amenity are between those of the two accredited software packages; the yearly results (total sum of each month) obtained using Amenity and the accredited software agree well. On the basis of this finding, it was considered that the accuracy of the air-conditioning load, calculated using Amenity, was valid for practical use.

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References

- 1) “Numerical evaluation method of radiant heat environment in radiantly cooled space,” CRIEPI Report T62 (April 2000).
- 2) “Practical application of design tool for indoor thermal environments for houses, Part 1: Simultaneous calculation method of air-conditioning load and thermal comfort index of multiple rooms,” CRIEPI Report R06016 (June 2007).

*¹ : Analysis Method of indoor thermal ENvIronmenT and energy (Amenity): Amenity is a tool for calculating the air-conditioning load and thermal comfort index by simulating heat transfer induced by radiation, airflow and conduction three-dimensionally (airflow is simplified).

*² : Airflow: Airflow is a tool for simulating heat transfer caused by airflow three-dimensionally. Airflow was developed under the assumption that it would be used with Amenity.

*³ : Predicted mean vote (PMV) is an index calculated using room temperature, humidity, airflow velocity, radiation temperature, and the amount of clothes and the activity of the resident. PMV range: -3 (cold) ~ 0 (medium) ~ +3 (hot); the resident feels less discomfort as the number approaches 0.

*⁴ : (1) AE-Sim/Heat (Yamauchi Planning Inc.) and (2) TRNSYS-J (Quattro Corporate Design Co., Ltd.) Neither software package can simulate the difference in heat radiated to residents from the environment, such as the walls, depending on the location of the residents.

*⁵ : House Performance Indication Standards (calculation of annual air-conditioning load: IBEC test number: SN-0007), an evaluation certification provided by the Ministry of Land, Infrastructure and Transport.

3. Energy Services for Customer - Optimum energy application technology

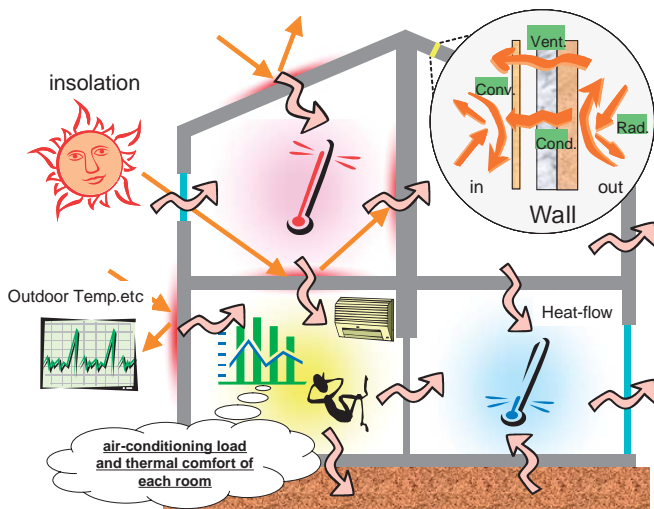


Fig.1 Schematic of calculation in which mutual thermal effects between the outdoors and/or neighboring rooms are taken into consideration.

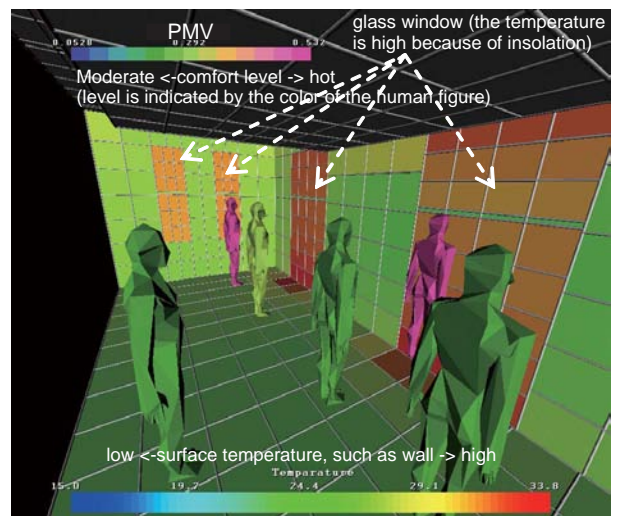


Fig.2 Concept of indoor thermal comfort evaluation. (thermal comfort can be evaluated considering the location of the residents. Those who are closer to windows, where the temperature is high due to insolation, feel hotter.)

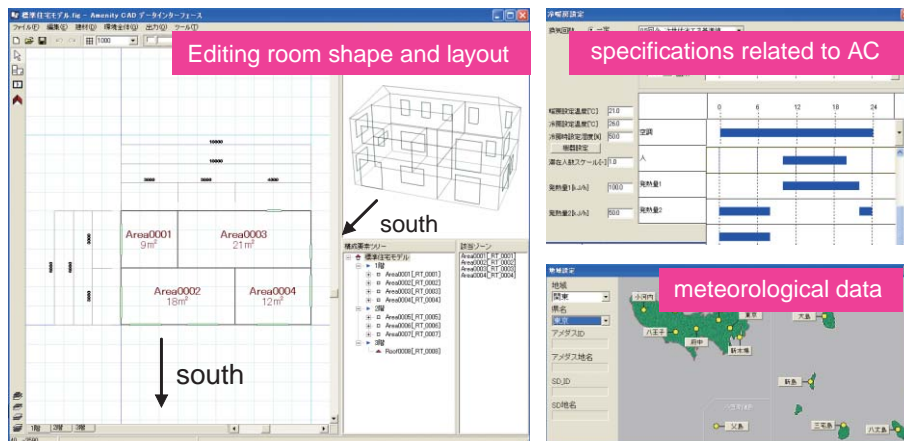


Fig.3 Example of GUI window of developed CAD data interface.

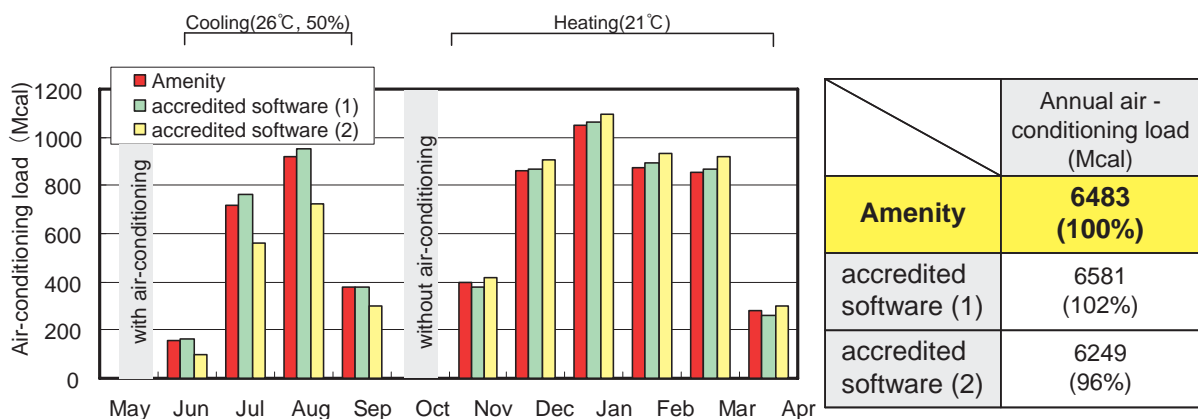


Fig.4 Example of calculation of air-conditioning load for the entire house (Fig.3) (in Tokyo; left: monthly; right: annually)

Air-conditioning load is calculated for each room, and the obtained values are summed to calculate the load for the entire house.)