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VALIDATION OF A SIMULATION PROGRAM FOR THE ESTIMATION OF THERMAL PERFORMANCE OF RESIDENTIAL HOUSES USING THE DATA FROM THE YEAR ROUND MONITORING

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Introduction

As the computer simulation is a very accurate method for estimating the thermal performance of residential houses, a generalized simulation program, MALTEP 2.0 has been developing for the prediction of the heat loads and room thermal environment of residential houses. However, the validation of the program had not been sufficiently made especially for a long period as throughout winter season or year-round. In order to examine the agreement between the simulation and the measurement, the computer simulation was carried out using the data obtained from the monitoring of three experimental houses for the six months winter.

Simulation Program

The algorithms used in the program are based on the multi-room concept (1), since a residential house generally consist of conditioned and unconditioned spaces. The implicit finite difference method is applied for calculating the heat transfer of walls, roofs and floors. The simulation program is able to apply to any type of ordinary residential houses for the estimating the thermal performance for a year.

Three Experimental Houses

Three full scale experimental houses called PSH1, PSH2 and STD had been built in the suburbs of Tokyo, in March 1983 in order to validate the predicted performance by the simulation for the development a standard type of the passive solar house. The each house has 123m2 of floor area and the same floor plan with wooden-framed construction as shown in Fig. 1. PSH1 is a well insulated house with 150mm thick insulation and double glazed windows with the night insulation. The concrete floor slab and the brick interior wall are used as the thermal storage elements. PSH2 is the same as PSH1 but heating and cooling were not used throughout a year. STD is a typically insulated house with 50mm thick insulation and single glazed windows without specific thermal storage elements. Heat pump air-conditioners were installed in the living room, the children's room and the bed room of both PSH1 and STD for heating and cooling.

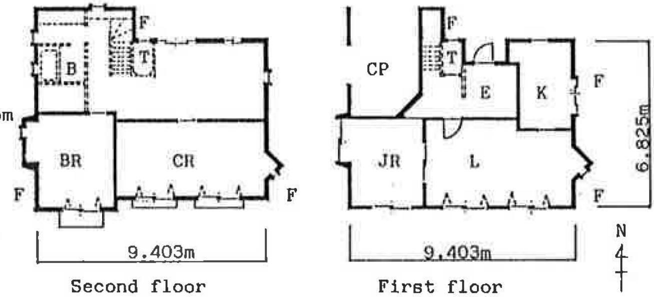
The experimental houses were designed to simulate the occupation by the program timers which controlled the heat generation by lamps, domestic appliances, human bodies, and cooking.

If the experimental houses are built in a city area, solar radiation may be shaded by houses located in the south. Therefor, 5m tall wall was set up in front of the experimental houses in order to simulate the shadows.

Fig. 1 Floor plan of the experimental houses

L : Living room
BR: Bed room
CR: Children's room
JR: Japanese room
K : Kitchen
E : Entrance
CP: Car port
T : Toilet
B : Bathe room

F : Exhaust fan



Input Data for the Program

The input data used to validate the program are as follow;

1) Measured weather data with this experiment at 30 minute interval from October 1983 through March 1984.

2) Schedule of the internal heat generation of the experimental houses.

3) Using the measured values, the input ventilation rates were 0.3 air change per hour when exhaust fans in the kitchen and the toilet were not used and 1.0 air change per hour when the fans were used.

Results of the Comparison

Hourly Profile

Figure 2 shows the temperatures and the heating loads of the living room and the bed room in PSH1 on the typical clear days in January. The room temperatures were measured at 1.5m above the floor at the center of the room. The measured heating loads were estimated from the air flow rate through the air-conditioners and the temperature differences between the inlet air and the outlet air. The temperature profile of the simulation and

Fig.2 The Temperatures and the heating loads of the living room and the bed room in PSH1.

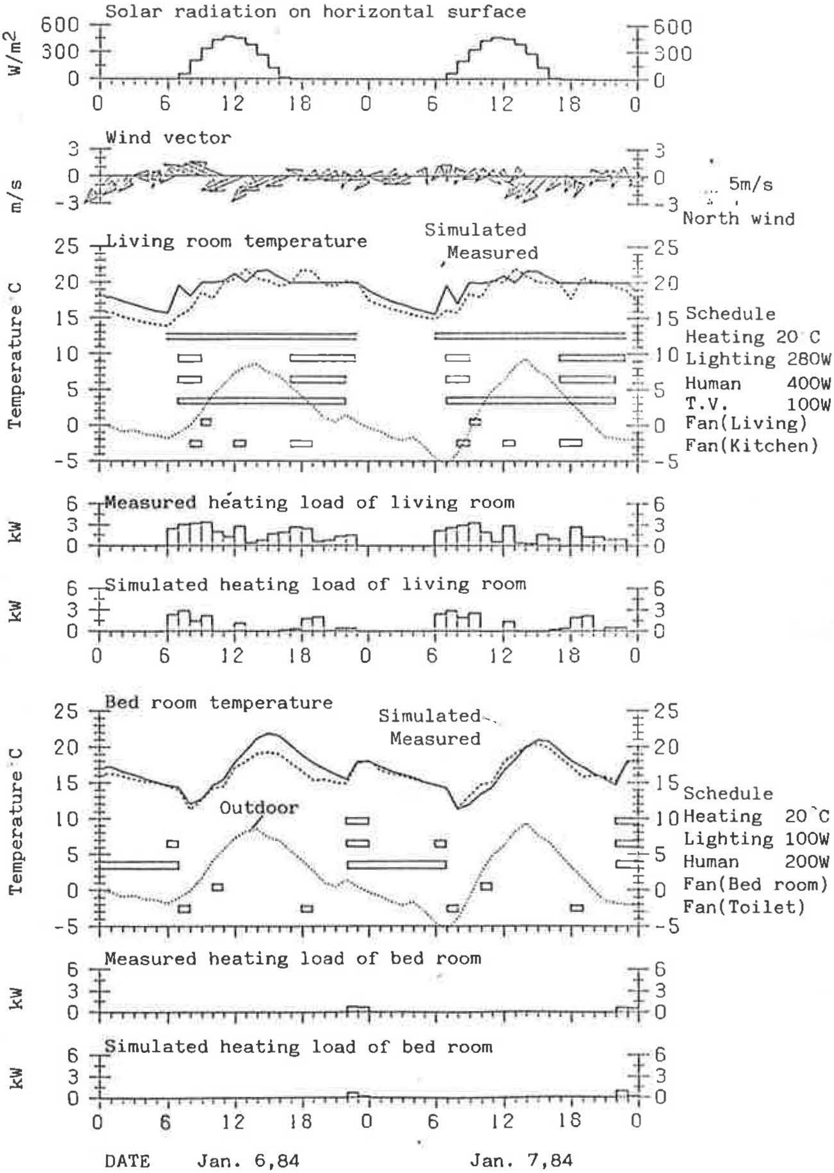


Table 1. The monthly and the seasonal heating loads of PSH1

Room		Heating Load 1983 Nov.*	Dec.	1984 Jan.	Feb.	Mar.	Seasonal**
Living room	Simulated	602	1804	2210	1792	1561	7970
	Measured	489	2696	3286	3198	2352	12022
Bed room	Simulated	42	184	259	239	184	908
	Measured	33	155	205	280	226	899
Children's room	Simulated	46	218	331	343	293	1231
	Measured	38	155	171	389	372	1125
Total	Simulated	690	2206	2800	2374	2038	10109
	Measured	560	3006	3662	3867	2950	13821

Table 2. The monthly and the seasonal heating loads of STD

Room		Heating Load 1983 Nov.*	Dec.	1984 Jan.	Feb.	Mar.	Seasonal**
Living room	Simulated	1997	4140	4944	4211	3959	19151
	Measured	2331	5756	6224	6061	4692	25064
Bed room	Simulated	343	536	598	540	532	2549
	Measured	285	527	565	532	515	2424
Children's room	Simulated	460	933	1130	1025	917	4465
	Measured	126	883	1147	1234	850	4240
Total	Simulated	2800	5609	6672	5776	5308	26165
	Measured	2742	7166	7936	7827	6057	31728

*The monthly heating loads are MJ/month
**The seasonal heating loads are MJ/season

the measurement are very similar except the followings;

1) When the air-conditioner were operated, the disagreement occur in the living rooms, since the room air temperature swung and was not kept the constant temperature.

2) When strong wind blows, the simulated temperatures are higher than the measured temperature, because the ventilation rates increase by the strong wind, however, ventilation rates in the simulation are not changed with wind velocity.

In the bed room, the simulated heating loads and the measured heating loads show good agreement, however, in the living room, the simulated heating load is about 30% less than the measured heating load.

The Monthly and the Seasonal Heating Loads

Tables 1,2 show the monthly and the seasonal heating loads of PSH1 and STD. The seasonal heating loads are the total of the monthly heating load from November 1983 to March 1984, since the heating started in November in the experimental houses. In the bed room and the children's room, the simulated monthly heating loads are larger than the measured monthly heating loads in early winter, but the simulated loads become smaller in mid winter.

For the seasonal heating load of the bed room and the children's room, the disagreement between the simulation and the measurement are very small, but simulated heating load of living room are 20-30% less than the measured heating load.

Conclusions

This first attempt to validate the simulation program with the long term measurement of the experimental houses shows that this program is able to reproduce the room temperature profile and the heating load of the bed room and the children's room with small error. However, the heating load of the living rooms were smaller than the measured heating load, since shading by the wall located in the south were not sufficiently estimated and ventilation rates were constant. However, the difference is small enough to use the program for the practical design.

References

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SUMMARY

K. Ishida, M. Udagawa : Validation of a Simulation Program for the Estimation of Thermal Performance of Residential Houses Using the Data from the Year Round Monitoring. The purpose of this paper is to validate the simulation program using the data obtained with the long term measurement of the three experimental houses. The computer simulation were carried out with measured weather data from October 1983 to March 1984. The results of the comparison between the simulation and the measurement showed the following: The profiles of the temperatures are quite similar. Although the heating loads by the simulation and the measurement showed good agreement for the bedrooms, the simulated heating loads of the living rooms were smaller than the measured load. However, the difference was small enough to use the program for the practical design.

RESUME

K. Ishida, M. Udagawa : Validation d'un Programme de Simulation pour Performances Thermiques d'Habitations Résidentielles avec l'Aide des Données Annuelles de Contrôle. Le but de cette étude est de valider le programme de simulation à láide des données measurées à long terme sur les trois habitations expérimentales. La simulation sur ordinateur a été effectuée avec des données météorologiques allant d'Octobre 1983 à Mars 1984. Les résultats de la compaeation entre la simulation et les measure effectives ont montré ceci: les profils des températures sont à peu prés semblables. Bien que les charges de chauffage simulées et measurées aient montré un accord pour les chambres à coucher, les charges de chauffage simulées des salles de séjour étaient plus petites que les charges measurées. Toutefois, la différence était suffisamment petite pour que le programme puisse être utilisé dans un but pratique.

ZUSAMMENFASSUNG

K. Ishida, M. Udagawa : Gültigkeitsprüfung eines Simulations-programms für die Schätzung der Wärmeleistung von Wohnhäusern unter Verwendung der Daten aus der das ganze Jahr hindurch durchgeführten Uberwachung. Der Zweck dieser Abhandlung ist die Bestätigung des Simulations-programms unter Benutzung der Daten, welche bei der langfristigen Messung von drei Versuchshäusern gewonnen wurden. Die Computer-simulation wurde mit gemessenen Wetterdaten vom Oktober 1983 bis zum März 1984 durchgeführt. chgeführt. Die Resultate des Vergleichs zwischen der Simulation und der Messung zeigten folgendes: Die Profile der Temperaturen sind sehr ähnlich. Obwohl die Heizlasten durch die Simulation und die Messungen gute Übereinstimmung für die Schlafzimmer zeigten, waren die simulierten Heizlasten für die Wohnzimmer kleiner als die gemessenen Lasten. Der Unterschied war jedoch klein genug, um das Programm für die prak-tische Konstruktion zu verwenden.