THE INDOOR THERMAL COMFORT RESEARCH—COMPARISON OF SIMULATED DATA WITH ACTUAL MEASUREMENT DATA

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Abstract- With the advanced development of science and technology, the mechanization of society and the increasing degree of industrialization, people tends to spend longer time in room, approximately accounted for more than 80% of their total life time.Improving the indoor environment, especially the indoor thermal and humid environment, is one of the main ways to improve the quality of life. People pay great attention to the indoor thermal comfort and realized the importance of indoor environment quality, such as sound, indoor light condition, hot and humid environment and indoor air quality, which will have a direct impact on people's physical and mental health. Indoor environment refers to all the parameters of the room; these parameters can affect the heat transfer and indoor ventilation to affect the human body's thermal comfort. This paper mainly through the actual measurement data and simulation data are compared to the study of indoor thermal environment.

Index Terms- Temperature;Humidity; Simulation; thermal comfort

I. INTRODUCTION

With the improvement of people's living standard, indoor air quality, energy saving and environmental protection come into people's attention. The indoor thermal comfort has become an important research issue.

The purpose of this experiment is to study thermal comfort in the room of the international student house of The University of Kitakyushu.The indoor thermal environment is studied by comparing actual measurements with simulated data.

II. STUDY PURPOSES

A. Actual measurements experiment

In the cold winter, the outdoor temperature and temperature of flanking room of the objective room have effect on the temperature in the room that affect the thermal comfort. In the case of closing the door, closing the air conditioning and closing the window, the temperature and humidity of the room are measured under the above conditions.

B. Simulation experiment

I made the building model through the design builder software. The model is imported into actual measured outdoor temperatures, and Indoor temperature data are simulated, and the feasibility of the model is proved by comparing with the actual measured indoor temperature.

III. RESEARCH METHOD

C. Building target

In the experiment, we chose the rooms of International student house. The building consists of four stories. The first floor functions as an office and living room. The other floors function as the room for international student dormitory. Amount of rooms in this dormitory are 54 rooms, with 18 rooms on each floor. The room area is about 19m2 with furniture are bookshelves, desks, cabinets, kitchen, toilet, bed, and equipped with air circulation natural ventilation and air conditioning (AC).



Fig.1. International student house

D. Introduction of experimental sites

I chose 413, 414 and 415 rooms in the building, as an experimental room for measuring temperature and humidity. The 413 and 415 rooms are inhabited; the 414 room is empty in these rooms. This is showed in Figure 2.

401	402	403	404	405	406	407	408		409	410	411	412	413	414			418
301	302	303	304	305	306	307	308		309	310	311	312	313	314	315	316	317	318
201	202	203	204	205	206	207	208		209	210	211	212	213	214	215	216	217	218

Fig.2. Experimental site selection

E. Experimental device placement

We measure the temperature and humidity of the equipment in the same place in the specified room. Each room is provided 5 devices, one point placed outdoors (balcony), 2 points placed close the window, and two points are placed close to the entrance of the room.

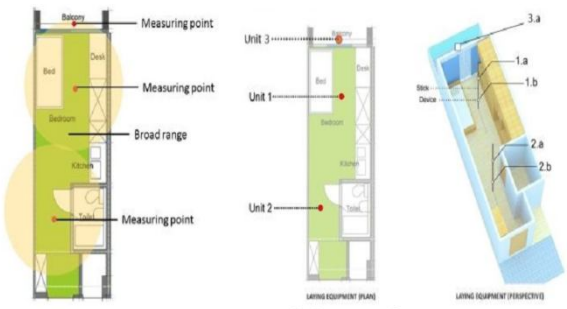


Fig.3. Experimental device placement

Position height of measuring equipment, adapted to all human activities in the room as sleep and seat down, the height is 60cm and standup the height is 150cm. High measuring tools taken from the International standard height of Asians, in order to get the data in accordance with the activities of thermal comfort in the room.

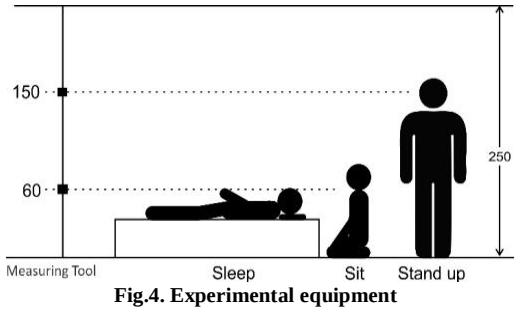


Fig.4. Experimental equipment

We use temperature recorder tr-72wf as a measure of the temperature and humidity of the room. Tools can gather data with a sensor coupled with the tool. In recording the data, the tool can be set from 1 minute to 1 hour, for retrieval of data in this study using per-10 minutes.



Fig.5. Experimental equipment

F. Measurement plan

The main subject of this experiment is the 414 room, 413 and 415 room's temperature and humidity used as a reference. The test data of all measurements are drawn under natural conditions, without air conditioning and humidifier. The experiment was conducted in December 1, 2016,the experiment took 24 hours. In the course of the experiment, the windows and doors were closed. The purpose of this experiment is to understand the change of indoor temperature under the condition of natural ventilation.

G. Model introduction

I made the building model through the design builder software. I use CAD software to make the floor plan, and then import it into the design builder software. My object in the design builder software is the 414 room, because the room temperature in other rooms will affect the 414 room, so the414 room and its surrounding rooms are all made by software.

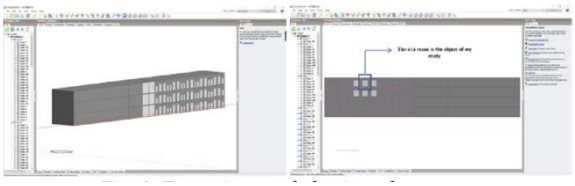


Fig.6. Experimental device placement

In design builder software, set the underlying properties, including Layout, Activity, Construction, Openings, Lighting and HVAC. All the settings of the model are based on the building drawings and the current rules of daily life of the occupants.

H. Model setting

Because the 414room is in the experimental stage under an uninhabited condition, when setting up "Activity", set up in the case of being unoccupied.
When setting "Construction", I need to set 3 sections, namely the exterior wall, the internal partitions and the flat roof.

1. The exterior wall: Gypsum Plastering+ Cement/plaster/mortar - cement plaster+ Concrete, Reinforced (with 1% steel)
2. The internal partitions: Glass fibre/ wool - fibre slab
3. The flat roof: Sand and gravel+ Asphalt - roofing, mastic+ Concrete, Reinforced (with 1% steel)

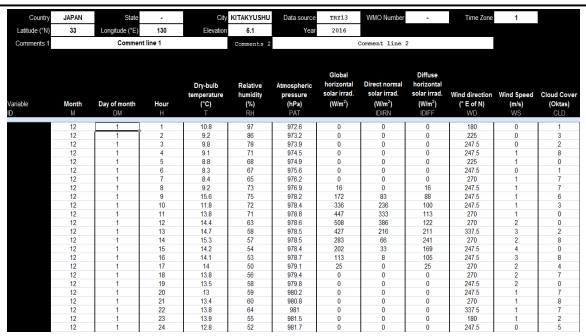
When setting "Openings ",I set it according to the size of the actual window.

1. Window width (m): 2.18
2. Window height (m): 1.83
3. Window spacing (m): 0.52
4. Sill height (0.01)

When setting "Lighting ",I didn't set it up because the room was unoccupied.

When setting "HVAC ", the experimental conditions for the natural ventilation state, so I did not set up.
There are some other parameters, it includes the dry-bulb temperature, relative humidity, global horizontal solar irradiate, direct normal solar irradiate, diffuse horizontal solar irradiate, wind direction, wind speed and cloud cover. All parameter settings are set up on the same day, data found by the Japan Meteorological agency. The "Dry-bulb temperature" is based on the actual measurement data set.
When I find the Japan Meteorological hall "Global horizontal solar irradiate, direct normal solar irradiate, diffuse horizontal solar irradiate", Found that the units between them are not the same. There is a time factor between the two units. MJ/m2： Represents the solar radiation energy per unit area, it's the unit of solar radiation. W/m2： the amount of radiation projected to the said unit receiving area is the unit of illumination radiation.

Their conversion methods are as follows:
1 MJ/m2 = 10^6 * 1s * 1 w/m2
This is the basic data of the model:



Country	JAPAN	State	-	City	KITAKYUSHU	Data source	TRY13	WMO Number	-	Time Zone	1
Latitude (°N)	33	Longitude (°E)	130	Elevation	6.1	Year	2016				
Comments 1	Comment line 1			Comments 2		Comment line 2					

Variable ID	Month M	Day of month DM	Hour H	Dry-bulb temperature (°C) T	Relative humidity (%) RH	Atmospheric pressure (hPa) PAT	Global horizontal solar irrad. (W/m²)	Direct normal solar irrad. (W/m²) IDRN	Diffuse horizontal solar irrad. (W/m²) IDIFF	Wind direction (° E of N) WD	Wind Speed (m/s) WS	Cloud Cover (Oktas) CLD
	12	1	1	10.8	97	972.6	0	0	0	180	0	1
	12	1	2	9.2	86	973.2	0	0	0	225	0	3
	12	1	3	9.8	78	973.9	0	0	0	247.5	0	2
	12	1	4	9.1	71	974.5	0	0	0	247.5	1	8
	12	1	5	8.8	68	974.9	0	0	0	225	1	0
	12	1	6	8.3	67	975.6	0	0	0	247.5	0	1
	12	1	7	8.4	65	976.2	0	0	0	270	1	7
	12	1	8	9.2	73	976.9	16	0	16	247.5	1	7
	12	1	9	15.6	75	978.2	172	83	88	247.5	1	6
	12	1	10	11.8	72	978.4	336	236	100	247.5	1	3
	12	1	11	13.8	71	978.8	447	333	113	270	1	0
	12	1	12	14.4	63	978.6	508	386	122	270	2	0
	12	1	13	14.7	58	978.5	427	216	211	337.5	3	2
	12	1	14	15.3	57	978.5	283	66	241	270	2	8
	12	1	15	14.2	54	978.4	202	33	169	247.5	4	0
	12	1	16	14.1	53	978.7	113	8	105	247.5	3	8
	12	1	17	14	50	979.1	25	0	25	270	2	4
	12	1	18	13.8	56	979.4	0	0	0	270	2	7
	12	1	19	13.5	58	979.8	0	0	0	247.5	2	0
	12	1	20	13	59	980.2	0	0	0	247.5	1	7
	12	1	21	13.4	60	980.8	0	0	0	270	1	8
	12	1	22	13.8	64	981	0	0	0	337.5	1	7
	12	1	23	13.9	55	981.5	0	0	0	180	1	2
	12	1	24	12.8	52	981.7	0	0	0	247.5	0	5

Fig.7. Property settings

IV. RESEARCH RESULT

I. Experimental data

This is the actual measurement data, this experiment was in December 1st.In design builder software, the model calculates a temperature value every 30 minutes depending on the conditions you set. In order to compare the temperature with the simulated temperature, the temperature is also measured by 30 minutes.

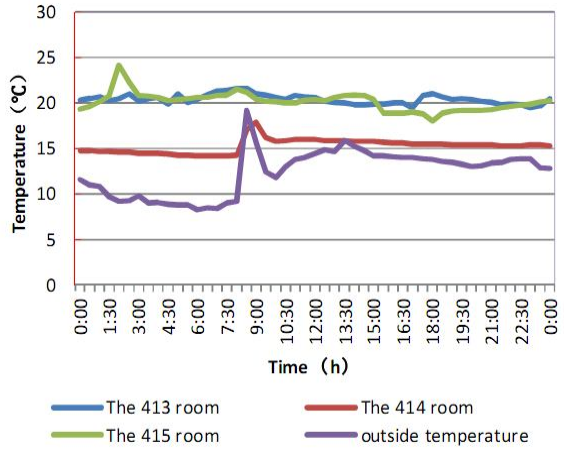


Fig.8. Temperature measurement

The above chart shows the temperature of the three rooms and the outside. The temperature in the 413 room and the 415 room about 20 degrees. Because they are inhabited, the air conditioner will be in open condition for a certain period of time. So the room temperature is relatively stable, not too big fluctuations, and the temperature is relatively high. The 414 Room is unoccupied and has no air-conditioning system; the temperature in the room is affected by the outside temperature and the temperature in the next room. Because the walls have heat insulation, these two effects on the 414 room temperature rise is not great, so the room temperature of the 414 room is relatively low.

J. Simulation

This is the simulation data. Before I calculate the simulation data; I'll first check the location and time. In design builder software, a closed space is a whole; each time the temperature is calculated, only one whole can be counted.



Fig.9. Temperature measurement

The above chart shows the temperature of the 414 room and the outside. There are 4 color lines in the chart above. They represent 4 kinds of temperature respectively:

1. Light blue line: Air Temperature
2. Red lines: Radiant Temperature
3. Green lines: Operative Temperature
4. Dark blue lines: Outside Dry-Bulb Temperature

I use the "Air Temperature" as an experimental result of the simulation experiment. It represents the simulated indoor temperature.

K. Compare

The purpose of this study is to compare the two experimental data to prove the feasibility of the model. At the same time, to understand the temperature of the room under the condition of natural ventilation.

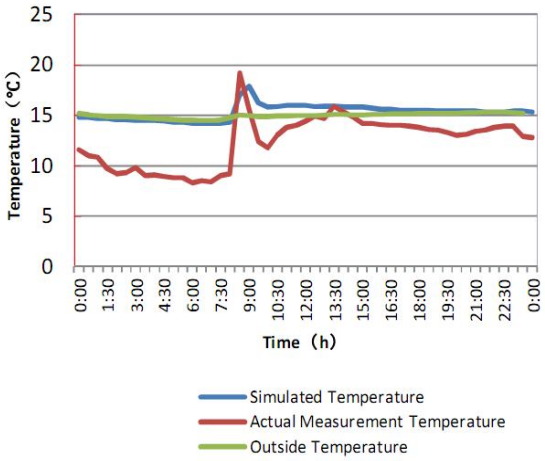


Fig.10. Comparison of temperature

The chart above shows measured temperature and the simulated temperature of room 414. It can be seen that although there are differences between them, they are similar in general. At 0 o'clock in the morning to 6 o'clock in the morning, the simulated temperature is almost the same as the measured temperature. The simulated temperature rise is not measured and the temperature rises considerably at 8 o'clock in the morning to 9 o'clock in the morning. This is because the window of the room is facing the sun, and during this time period, the solar direct measurement instrument produces high heat, which makes the experiment temperature deviated. From 9 o'clock a.m. to 6 o'clock p.m., the difference between the simulated temperature and the measured temperature is obvious, but the error is less than ten percent.

Through the above experimental data and data

analysis, the feasibility of the model is proved. It also proves that my model is correct and can be applied to the next research.

Throwing wall insulation performance, we can see through the two experimental data, indoor thermal comfort of buildings. In the cold December, indoor temperatures were relatively low in the absence of air-conditioning systems. The room temperature is 15 degrees, which is not up to the standard of thermal comfort. The room temperature is limited by the natural lighting and the influence of the surrounding rooms. The air conditioning system must be used.

CONCLUSION

The purpose of this study is to compare the two experimental data to prove the feasibility of the model and understand the indoor temperature, and provide an effective model for how to improve indoor thermal comfort. First of all, I complete the temperature measurement of the 414 room in the building from International student house to learn about indoor temperatures in December 1, 2016.Secondly, through the design Builder software, we design the same model as the building from International student house, we compare these two experimental data to find that their experimental results are relatively close and within the allowable error. The feasibility of the model is proved at the same time point. It laid the foundation for my next study of indoor thermal comfort.

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