Indoor air condition in narrow living spaces (Part 2)

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Abstract

Purpose - It is rather easy to control thermal air conditions in narrow-air tight living spaces. However, it is not so easy to keep good air quality in the spaces. Indoor air condition is especially important to keep the health condition of the people. We researched the environmental condition of the temporary houses.

Methodology - We carried out a survey regarding housing conditions, families and so on, measuring indoor air conditions, room air temperature, humidity in summer and winter, and carbon dioxide (CO_2) in winter.

Results - In August, average air temperatures were near 28℃ in living rooms and in bed room. Humidity was near 70% in both rooms. Discomfort index was about 78 in both rooms. In January, average air temperature was 14.3℃. Humidity was near 60% and Wind-chill index was about 320kcal/m^2/hr. Mean of average CO_2 concentration was 1240ppm. Max CO_2 concentration was 2182ppm.

Key Findings - The thermal condition in indoor housing is hot and humid: not so comfortable in summer. Wind-chill index 300 ~500kcal/m^2/hr. is cool and wind-chill index 150 ~300 kcal/m^2/hr. is comfortable according to the evaluation of thermal conditions. Inside the housing is not so uncomfortable for the activities and daily life of people. CO_2 levels became to be high. Poor air quality occurs frequently inside air tight and narrow spaces. Therefore, adequate ventilation in rooms is needed to keep good air quality.

Originality - In practice, carbon dioxide (CO_2) is an easy index of air quality in living spaces. Discomfort index (DI) in hot and humid environments and, wind-chill index (WCI) in cold environments are better indices.

Keywords - narrow living spaces, carbon dioxide, thermal air conditions, summer, winter

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1. Introduction

It is rather easy to control thermal air conditions in narrow-air tight living spaces. However it is not so easy to keep good air quality in the spaces. Carbon dioxide (CO_2) is an easy index of air quality in living spaces. On the Japanese standard levels of CO_2, a concentration of less than 700 ppm is excellent, 1000 ppm is generally permitted, 1500 ppm is permitted in the space with a ventilator, 2000~5000 ppm is not so good, and a level of over 5000 ppm is considered to be bad for daily life.

After the earthquake on 11th March 2011 in North-East area of Japan, temporary houses were built in the area. In Fukushima, temporary houses were built further inland especially due to the nuclear evacuation zones, and evacuees are living in them. There are many elderly people in the housing. Indoor air condition is especially important to keep the health condition of the people. We researched the environmental condition of the housing.

2. Methods

We carried out a survey regarding housing conditions, families and so on, measuring indoor air conditions; room air temperature, humidity in summer and winter, and Carbon dioxide (CO_2) in winter. We researched some temporary housing estates in Fukushima city. 10 houses were selected as the housing for this research at each estate, totaling 30 houses.

Room air temperature and humidity were measured and recorded in the living room and bed room at 30 minute intervals. Thermal recorders were set up at a height of 0.5~1.5m from the floor for each room. In winter, the CO_2 was measured and recorded in the kitchen at 10 minute intervals also.

The measuring devices were a Thermo-Recorder and CO_2 Recorder, with automatic recording system (T&D Corporation, Japan).

3. Results

3.1 In summer

Summer season is from June to August in Japan. August is the hottest month. The basic material of the structure of the temporary housing is light-weight steel. Room air temperatures using air conditioners in each housing were set up from 19 to 32℃. Setting room air temperature at 28℃ comprised the highest frequency at 45%, and the next setting of room air temperature at 25℃ was 15%. Rooms were comfortable with the use of the air conditioner, but uncomfortable with no use. Natural ventilation was not satisfactory.

As an example, in the living room of temporary housing with air conditioner in August, the air temperature level was 24~25℃ and humidity was rather high at night. During the daytime, the air temperature level was 26~27℃. Humidity level was 40~50% and Discomfort index (DI) was 70~75 level.

Table 1: Room air temperature, humidity, and Discomfort Index (ID) in living room and bed room

	Average air temp. (℃)		Average humidity (%)		Discomfort index (DI)	
	living room	bed room	living room	bed room	living room	bed room
Mean	27.8	2	69.5	69.0	77.	78.1
SD	0.94	0.	3.17	3.08	1.5	1.20
Max	29.6	2	74.5	75.3	80.	80.2
Min	24.6	2	59.8	60.8	72.	73.8

Table 1 shows average values of room air temperature, humidity, and Discomfort index in living rooms and bed rooms of the temporary housing in August. Average air temperature were 27.8℃ in living rooms and 28.1 ℃ in bed room. Humidity was near 70% in both rooms. Discomfort index was about 78 in both rooms.

3.2 In winter

Winter season is from December to February. January is the coldest month. In many temporary houses, air conditioners and double windows were added to prevent coldness in winter.

Room air temperatures using air conditioners in the housing were set up from 14 to 30℃. Setting room air temperature at 25℃ comprised the highest frequency at 35%.

Figure 1 shows CO_2 concentration, air temperature and humidity using an oil heater in the kitchen of one house in January as an example. At night, the CO_2 level was 600 ppm. During the daytime the CO_2 was sometimes high; over 2000ppm. The air temperature level was 18~20℃ at night, and the air temperature level was 20~25℃ during the daytime. Humidity level was 40~50%.

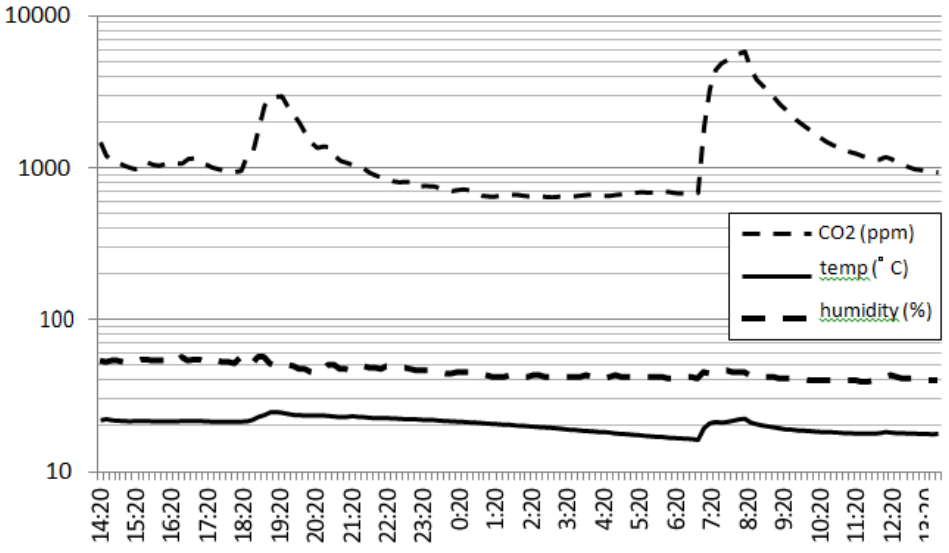

Figure 1 CO_2 concentration, air temperature, humidity in the kitchen of one house in January

CO2 concentration in the kitchen of each was was measured for one week in winter season. Mean average CO2 concentration was 1240ppm and standard deviation (SD) was 663ppm. Max CO2 concentration (±SD) was 2182±653ppm.

Table 2: Room air temp, humidity, and wind-chill index in living room in winter

	Room air temp. (℃)			Room humidity (%)			Wind-chill index (kcal/m^2/hr.)		
	average	max.	min.	average	max.	min.	average	max.	min.
Mean	14.3	25.0	5.6	59.3	84.7	31.2	317.7	464.3	135.3
SD	3.3	3.4	3.6	9.8	10.6	7.5	58.1	63.4	58.5
Max	19.2	33.3	10.6	79.5	99.0	51.0	487.7	583.8	220.2
Min	4.43	20.1	-1.2	42.1	66.0	14.0	235.2	382.4	-5.1

Table 2 shows the average mean values of room air temperature, humidity, and Wind-chill index in living rooms of the temporary housing in January. Average air temperature was 14.3℃. Humidity was near 60% and Wind-chill index was about 320kcal/m2/hr.

4. Conclusion

In summer, room air temperatures in living rooms and bed rooms were similar; max average temperature over 29℃. Humidity was rather high; about 75%. Discomfort index (DI) was about 80. Therefore the thermal condition in indoor housing is hot and humid: not so comfortable in summer.

In winter, wind-chill index was 320kcal/m^2/hr. Wind-chill index 300 ~500kcal/m^2/hr. is cool and wind-chill index 150 ~300 kcal/m^2/hr. is comfortable according to the evaluation of thermal conditions. Inside the housing are not so uncomfortable for the activity and daily life of people.

But CO_2 levels became to be high. Poor air quality occurs frequently inside air tight and narrow spaces; therefore adequate ventilation in the room is needed to keep good air quality. The thermal condition of living spaces and healthy air must be seriously considered.

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