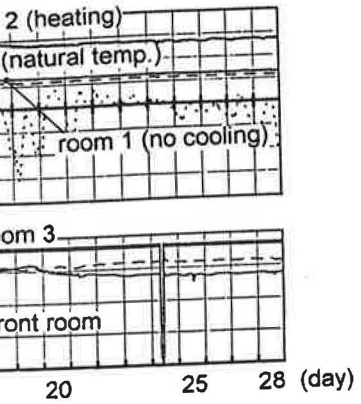

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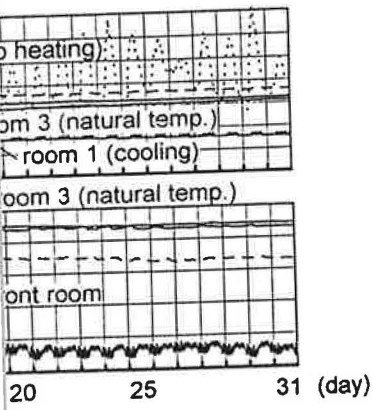

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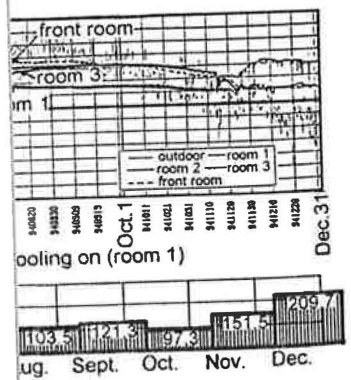

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THERMAL ENVIRONMENTS IN AN ATRIUM SPACE AS AN INSTITUTION FOR THE ELDERLY IN A WINTER CITY

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ABSTRACT This paper presents a method for the dynamic numerical analysis in calculating the thermal environment in the atrium space of an institution for the elderly. The analysis is carried out and using BASIC. In Kushiro, it is very foggy, cool and highly humid in Summer. On the other hand, it has little snow with clear skies while still being cold in Winter. In Winter, the atrium space is heated by satisfactory solar radiation in the daytime, so outdoor air flowing into the atrium space is warmed. Usually, Wards are directly ventilated by cool outdoor air, but when taking in the fresh outdoor air warmed through the atrium space, we can decrease heating load. When the room air temperature in the atrium space decreases to under 10 degrees Celsius, it is difficult to use the atrium space for a rehabilitation or as a lounge space. In this situation, the floor is heated by the remnant heat from neighboring buildings. By this pre-heating system through the atrium space, the decrease of total heating load is 30%. Even if the roof-top openings are opened in Summer and the atrium space is ventilated, humidity in the atrium space will decrease because of the solar radiation through glazed roofs. Then it is possible to cool by exhausting warm air at the ceiling level. In addition to the buoyant convection, the floor is cooled by using cool well water the same temperature as the dew point temperature of the room air. The temperature decrease in an occupied space is 10 degrees.

1. INTRODUCTION

Recently, as the aged are advancing faster, more institutions for the elderly are being built. In Hokkaido, they are built at a rate of 10 places per year. Particularly, in Winter, it is so difficult for the aged who stay at an institution for the elderly to get around. Because the outside is covered with snow and the footpaths are frozen, it is so dangerous for the old and disabled to go out. If old people don't go out, they tend to be weakened, not able to experience the stimuli of nature. Also any institution for the elderly needs restorative training rooms. For the above reasons we propose that an atrium space should be annexed as an active space for daily life.

In this report, the thermal environments in an atrium space to an institution for the elderly are numerically calculated. As the atrium space is annexed in an institution for the elderly, in such numerical analyses, the below subjects are studied. The first is how to reduce the energy consumption (sensible heat) and how to improve the thermal amenity in occupied spaces when pre-heating the fresh outdoor air through the atrium space in Winter. The second is how to improve the thermal environments of occupied spaces when opening the roof-top and cooling by buoyant ventilation in Summer.

2. ANALYSIS METHOD & MODELS

This analysis uses the successive integration method and is numerically calculated by using BASIC language software. The heat transfer with respect to the constituent wall in the subject space was separated into the convection component and the radiation component. It has been proved from some actual measurements in large spaces that dry-bulb temperature is horizontally contoured. Thus this stratification could be assumed in a large space. The space is divided into the upper, the middle and the lower zones (i.e. occupied space) as imaginary divisions. Changes of the temperature distribution in the atrium space and of the thermal load for the building can easily be calculated.
Fig. 1 shows a floor plan and a cross section of the model, which is located as an institution for the elderly in Kushiro. There are 45 persons(i.e. elderly people) in both the East and West wards. The atrium has roof-top openings (i.e. exhaust openings for the fire smoke) which proved 40m^2 of opening space in both sides. Outdoor air inlets of 6m^2 are provided in the middle of both the South and North glazed walls. Using the standard weather data in Kushiro, hourly data of the ambient climate condition in Winter for the analysis is made up showing a 2-week average as the coldest period and hourly data in Summer is made up showing a 2-week average as the hottest period.

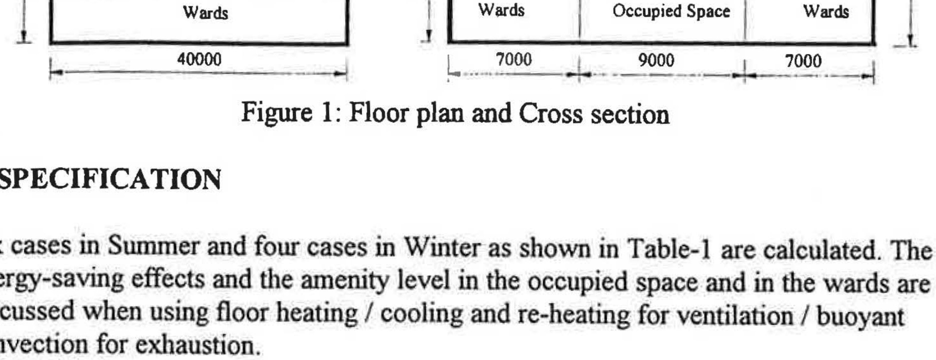

Figure 1: Floor plan and Cross section

3. SPECIFICATION

Six cases in Summer and four cases in Winter as shown in Table-1 are calculated. The energy-saving effects and the amenity level in the occupied space and in the wards are discussed when using floor heating / cooling and re-heating for ventilation / buoyant convection for exhaustion.

Table-1

Winter		
Cases	Floor heating	Ventilatic
Case A	No	Typ
Case B	No	Typ
Case C	Yes	Typ
Case D	Yes	Typ

Type 1: The way to ventilate d
Type 2: The way to ventilate u
Type 3: Exhaust only openings
Type 4: Exhaust only openings

3-1. OPERATION IN WINT

Every ward is heated to mainta
Celsius. The difference betwee
The next difference is adopting
each difference, changes o the
temperature and of the quantity

3-2. OPERATION IN SUMI

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Therefore, Case E becomes th
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4. RESULTS & DISCUSSIO

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Fig. 3 shows the peak of the
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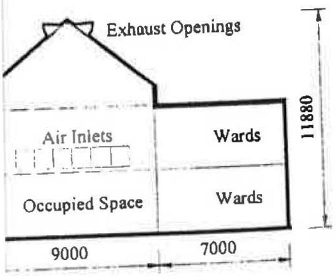

section

in Table-1 are calculated. The
pied space and in the wards are
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Table-1 : Specification for the calculations

Winter			Summer			
Cases	Floor heating	Ventilation system	Cases	Sunshade	Floor cooling	Air flow systems
Case A	No	Type 1	Case E	No	No	No
Case B	No	Type 2	Case F	No	Yes	Type 3
Case C	Yes	Type 1	Case G	Yes	Yes	Type 3
Case D	Yes	Type 2	Case H	No	No	Type 4
			Case I	Yes	Yes	Type 4

Type 1: The way to ventilate directly supplying the cool outdoor air into wards
Type 2: The way to ventilate using a pre-heating system through the atrium space
Type 3: Exhaust only openings in the roof
Type 4: Exhaust only openings in the roof and supply only inlets on the glazed walls

3-1. OPERATION IN WINTER

Every ward is heated to maintain the roof air temperature uniformly at 20 degrees Celsius. The difference between Type 1 and Type 2 is the air flow paths for ventilation. The next difference is adopting the floor heating in the atrium space or not. To compare each difference, changes o the occupied space temperature, of the operative temperature and of the quantity of heat supply are evaluated.

3-2. OPERATION IN SUMMER

Case E doesn't adopt the sunshade, the floor cooling system and the air flow system. Therefore, Case E becomes the starting point or control, when comparing each case. As compared with the adopted scheme, changes of the occupied space temperature, of the operative temperature and of the heat extraction are evaluated.

4. RESULTS & DISCUSSION

In the case of Winter, Fig. 2 shows the air temperature and the operative temperature at the center portion in the occupied space. As compared with Case A, daytime's average air temperature in the occupied space and the operative temperature of Case B becomes 2 degrees lower than in Case A. These temperatures shown are maintained in the range between 13 degrees Celsius and 16 degrees Celsius. But the minimum air temperature during daytime becomes 5 degree Celsius, so it is difficult to use the atrium space for a rehabilitation or as a lounge. Therefore, the atrium is heated by floor heating which is maintained uniformly at 32 degrees Celsius. The heat source is the remnant heat from wards or neighboring buildings. As compared with the case not to adopt the floor heating, the air temperature becomes 2 or 3 degrees higher than in that case.

Fig. 3 shows the peak of the thermal load in the atrium space (floor heating) and in the wards (panel heating). Fig. 4 shows the day consumption of the thermal load. When comparing Case A and Case B, the peak load of Case B is smaller than that of Case A, and the reduce ratio between both peaks becomes 33.6%. The reduce ratio of the day consumption between Case A and Case B becomes 41.7%, and the same ratio between Case C and Case D becomes 39.3%.

Even if the air temperature in the occupied area of the atrium space becomes a few degrees lower, it has been found that the sensible heat load decreases when using the pre-heating system through the atrium space. Usually, as the atrium space is designed as a semi-outdoor space, in which the air temperature fluctuates moderately in the daytime, it is reasonable that the air temperature is made up a little less level than 10 degrees Celsius.

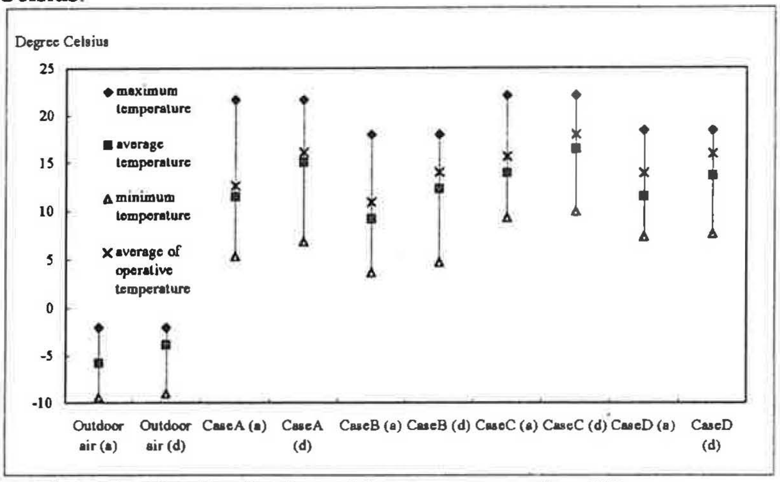
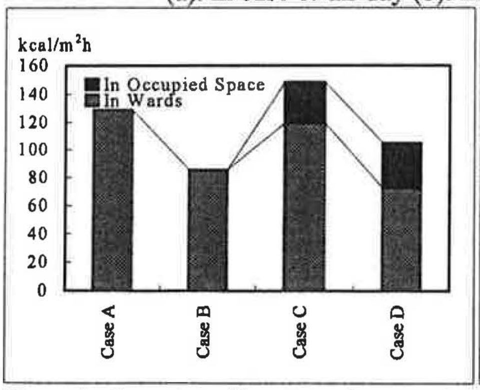


Figure 2: The distribution of the temperature for different cases
(a): In case of all-day (b): In case of daytime (8:00-20:00)



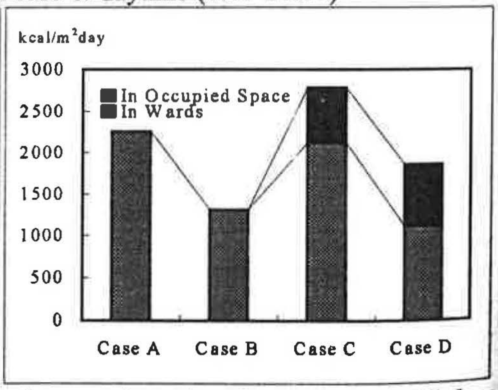


Figure 3: Quantity of heat supply at peak Figure 4: Quantity of heat supply in all-day

In the case of Summer, Fig. 5 shows the air temperature in the occupied zone and the operative temperature at the center portion in the occupied space. Fig. 6 shows the excluded heat when using the buoyant convection and the floor cooling. Fig. 7 shows the quantity of outdoor air exhausted through the space. If the cool outdoor air isn't taken into the atrium space, the average air temperature and the average operative

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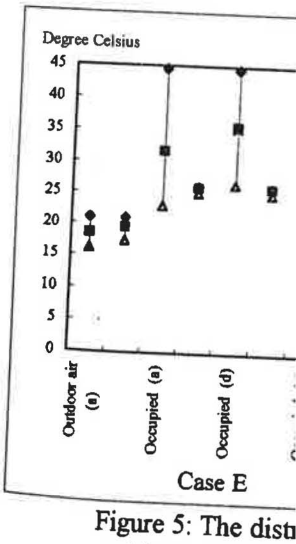


Figure 5: The distr
(a): In case of a

temperature in the occupied space reach 35 degrees Celsius and it is usually necessary to cool. The maximum temperature in Summer in Kushiro is a little over 20 degrees Celsius. When taking a lot of cool outdoor air into the occupied spaces, it is possible to improve the thermal environment. That concept for design of the Summer amenity is very important.

When comparing Case G and Case I as shown in Fig. 7, Case I (exhaust only openings in the roof and supply only inlets on the wall) can take a 1.5 times greater quantity than Case G (exhaust only openings). In such a case, the air temperature in the occupied space decrease and is about 10 degree less than that of Case E. If the transmitted rate of the direct solar radiation is assumed as 70% when using shield cloths, the air temperature is 1 degree less than that when not using the shield cloths. Of course, we can hope to achieve more lowering of the air temperature in the atrium space if the transmitted rate is increased. However, the transparent feeling in the atrium space is lost when the glazed roof is almost covered with shield cloths. So, the thermal environment of the atrium space is planned, it is important to strictly control the use of shield cloths.

In Winter, the floor heating system is adopted to recover the remnant heat. Such a floor system can be used as the floor cooling. When the atrium space is cooled by supplying the cool well water at 22 degrees Celsius, the air temperature is 1 degree less than when not adopting the floor cooling system. Maximum excluded heat by the floor cooling becomes 12 kcal/m^{2}h. So a lowering of 1 degree is reasonable to expect in such a case. The air temperature in the wards changes moderately around the level of 25 degrees Celsius. When the outdoor air is taken into the atrium space, the cool and highly humid air in Summer in Kushiro becomes desirably warm with low humidity because of solar radiation. It looks like a comfortable environment.

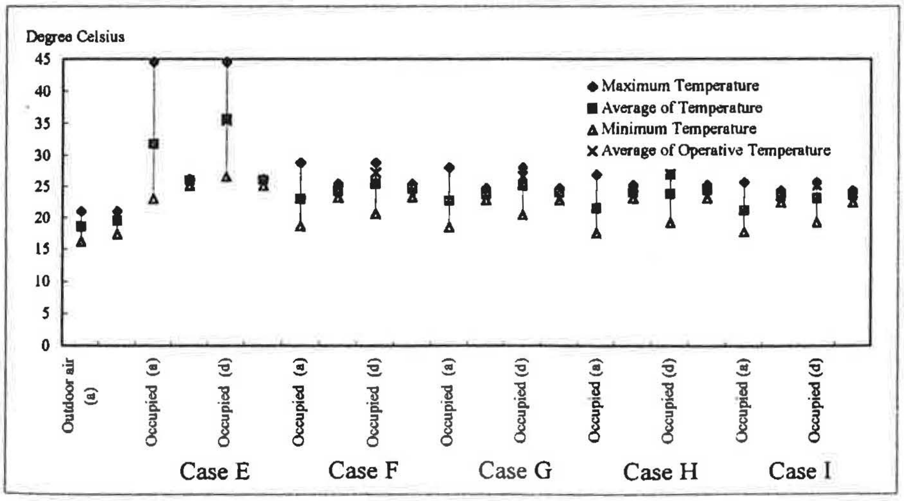
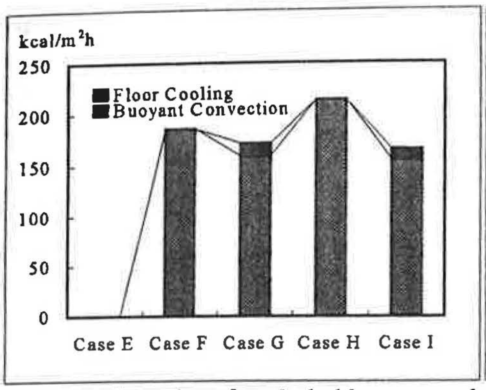


Figure 5: The distribution of the temperature for different cases
(a): In case of all-day (b): In case of daytime (7:00-20:00)



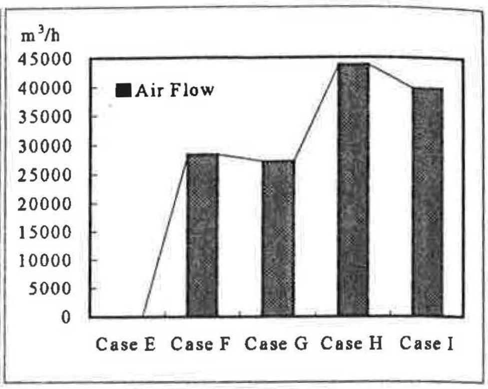


Figure 6: Quantity of excluded heat at peak

Figure 7: Quantity of air flow at peak

5. CONCLUSIONS

1) It has been found that the atrium space heats the outdoor air and is used as a pre-heating space. Even if air temperature in the occupied space of the atrium space becomes a little lower, it has been found that the sensible heat load decreases when using the pre-heating system through the atrium space.

2)The floor heating using the remnant heat from wards or neighboring buildings was found to make an increase of 2 degrees to 4 as it supplied a maximum of 30 kcal/m^{2}h of heat.

3)The ways to exclude heat are the sunshade, the floor cooling system and the air flow system. The most quantity of heat can be excluded by using buoyant convention. So when the exhaust openings are provided in the atrium space, they should be used not only for emergencies but also for the daily ventilation and should occupy large openings.

4)Using the floor cooling shows a decrease of only 1 degree with regard to the temperature in an occupied space, but it shows a decrease of 2 degrees for the operative temperature. It has been found that the floor cooling affects more lowering of the sensory temperature than of the air temperature.

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THE INDOOR T
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ABSTRACT The purpose of this st
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1. INTRODUCTION

In recent years consumed energ
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to find new energy that get safely