STUDY ON THE EVALUATION OF NATURAL CROSS VENTILATED DETACHED HOUSE USING MICRO/MACRO ANALYSIS

Shin-ichi AKABAYASHI, Niigata University, 8050, 2nocho, Igarashi, Niigata-city, JAPAN, Phone +81-25-262-7266, Fax +81-25-262-7268, Email akabayas@cc.niigata-u.ac.jp
Jun Sakaguchi, Niigata Women's College, 471 Ebigase, Niigata-city, JAPAN, Phone&Fax +81-25-270-0321, E-mail sakaj@hes.nicol.ac.jp
Yoshitaka SASAKI, Niigata University, 8050, 2nocho, Igarashi, Niigata-city, JAPAN, Phone +81-25-262-7266, Fax +81-25-262-7268, Email sasaki@tkkankyo.eng.niigata-u.ac.jp

Summary
In this study, we evaluate cross ventilation by the multi zone network airflow simulation and the CFD. Cross-ventilated detached house is evaluated. Quantitative evaluation of the effect of cross ventilation is carried out.
The analytic object is a standard residence model. The k-e turbulence model simulates the flow. The purpose of this simulation is to calculate indoor airflow velocity distribution.
The multi-zone airflow network model analysis using TRNSYS-COMIS simulates the indoor temperature. Two different analyses are coupled, so that the long-term simulation is realized.
This paper proposes to report on the outline of the evaluation index of natural cross ventilation performance. This paper has the point to (1) locality, (2) location, (3) building performance as factors which influenced indoor wind velocity, and show the outline of the evaluation method for natural cross ventilation performance.

1. Introduction
Cross ventilation is very popular research subject in the field of building environment engineering. One of the effects of cross ventilation is to decrease sensible temperature due to the airflow velocity. So that, the effect of cross ventilation cannot be evaluated only by air change rate.
It is very important to evaluate indoor airflow characteristics precisely in planning the layout of windows. The study on evaluation of natural cross ventilation must analyze heat load and CFD in every house. However, because this calculation requires so much time, this analysis is difficult. So, this study proposes the evaluation of the natural cross ventilation performance using CFD and the multi zone airflow model network analysis (micro/macro analysis). Figure 1 shows the influence of cross ventilation. The distribution of indoor wind velocity by cross ventilation is influenced by the weather condition, the location of the building and form of the building. This paper considers these three indexes, and proposes new evaluation method of natural cross ventilation performance.

2. The outline of local index
Figure 2 shows the outline of local index. It assumes that the human "weather sense" can be evaluated by the thermal comfort index. It is assumed that there is an imaginary roof above the human body (the roof is a

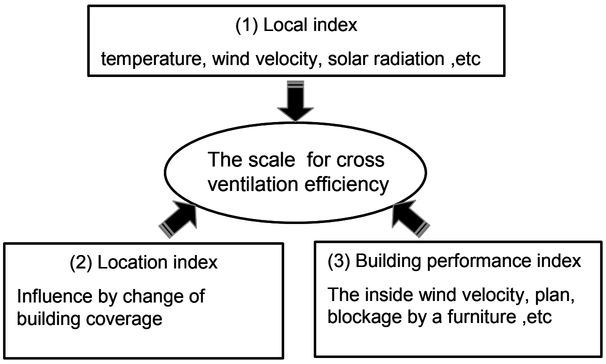


Figure 1 The influence of cross ventilation

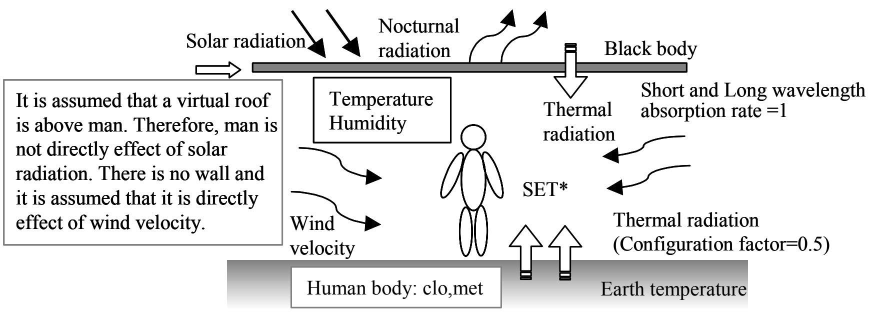


Figure 2 The outline of local index

perfect black body with a long and short wavelength absorption rate of 1.0). The human body is also assumed to receive no direct influence of solar radiation. It assumes no wall around the human, and the human body is affected by the influence of the outside wind velocity directly.

2.1 The weather data used

The weather data used was the "Expanded AMeDAS Weather Data in Japan" by AIJ. In this paper, some of this weather data that is necessary to calculate the SET* was used, (temperature, humidity, wind velocity, solar radiation, nocturnal radiation, the ground temperature).

2.2 Evaluation index of comfort

SET* by the ASHRAE is used for the evaluation index of indoor comfort. The wind velocity which is necessary for the calculation of SET* is given by isothermal CFD. And, the room temperature and the wall surface temperature are given by the multi zone airflow network model analysis.

2.3 Definition of Cross Ventilation Degree Hour

We propose Cross Ventilation Degree Hour (CVDH) for the location index in this study. Figure 3 shows outline of CVDH. We decide the wind velocity for SET* which is from a low of 0.3 m/s to a high of 3.0 m/s from the view point of the heat convection around the human body.

CVDH is defined as follows:

if SET*> 26 degrees centigrade

CVDH=(SET1*-SET2*) x T

if SET*=< 26 degrees centigrade

CVDH=0

Where

CVDH: Cross Ventilation Degree Hour [Kh]

SET1*: SET* on wind velocity that is 0.3m/s or higher. [K]

SET2*: SET* on wind velocity that is 3.0m/s or lower. [K]

T: Time, SET* beyond 26 degrees centigrade. [h]

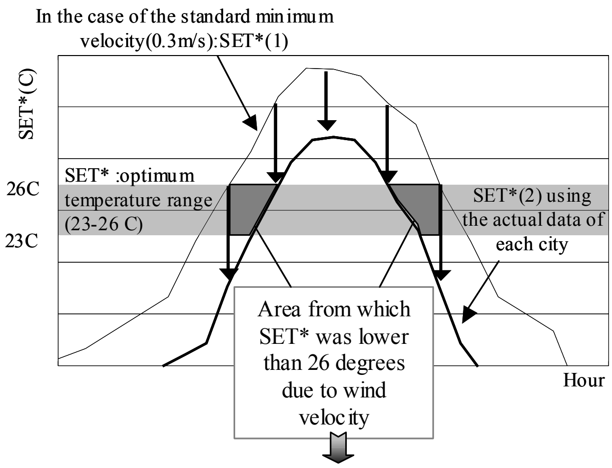
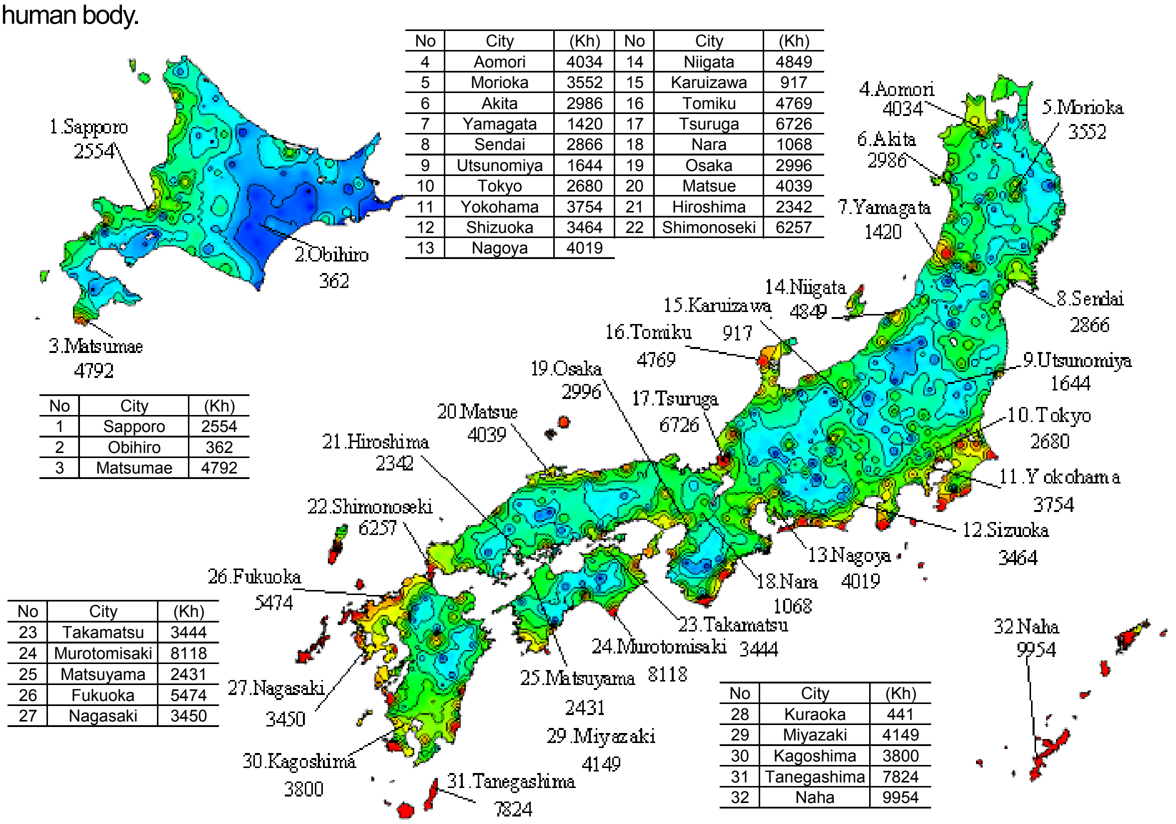


Figure 3 The outline of CVDH



No	City	(Kh)
1	Sapporo	2554
2	Obihiro	362
3	Matsumae	4792

No	City	(Kh)	No	City	(Kh)
4	Aomori	4034	14	Niigata	4849
5	Morioka	3552	15	Karuizawa	917
6	Akita	2986	16	Tomiku	4769
7	Yamagata	1420	17	Tsuruga	6726
8	Sendai	2866	18	Nara	1068
9	Utsunomiya	1644	19	Osaka	2996
10	Tokyo	2680	20	Matsue	4039
11	Yokohama	3754	21	Hiroshima	2342
12	Shizuoka	3464	22	Shimonoseki	6257
13	Nagoya	4019			

No	City	(Kh)
23	Takamatsu	3444
24	Murotomisaki	8118
25	Matsuyama	2431
26	Fukuoka	5474
27	Nagasaki	3450

No	City	(Kh)
28	Kuraoka	441
29	Miyazaki	4149
30	Kagoshima	3800
31	Tanegashima	7824
32	Naha	9954

Figure 4 Results of the Cross Ventilation Degree Hour (CVDH) Map in Japan

CVDH is the index which assumes the effect of reducing effective temperature by the influence of the wind velocity when SET* exceeds 26 degrees centigrade in every area.
Figure 4 shows results of the map of CVDH in JAPAN.

3. The outline of location index

The natural cross ventilation of the residence is strongly influenced by the building coverage. In past research, the prediction of the cross ventilation is done by the field survey on the pressure coefficient on the wall, airtight performance of the house, effect of building coverage, and experimental study in a wind tunnel. The influence which building coverage rate exerts on the ventilation performance is defined as the location index by this paper.

3.1 Distribution of wind velocity by the difference in building coverage rate

Figure 5 shows distribution of wind velocity when building coverage is 0% and 40%. This paper shows one of the results of detached house using micro/macro analysis. If the building coverage rate changes, the exfoliation flow and distribution of indoor wind velocity change greatly.

3.2 The analysis of the amount of cross ventilation due to the change in building coverage rate

Figure 6 shows the analysis of the amount of cross ventilation due to the change in building coverage rate. This paper describes the analysis of cross ventilation performance due to the change of building coverage for the house model which is shown by figure 5. The flow analysis uses CFD that is the k-e turbulence model. The purpose of this simulation is to calculate indoor airflow velocity distribution. The calculated amount of cross ventilation is divided into grades, and these grades assume a location index.

4. Building performance index

Figure 7 shows the flowchart of the building performance index.

4.1 Results of the indoor wind velocity analysis

The indoor wind velocity analyzes 16 wind directions, and the indoor wind velocity distribution is

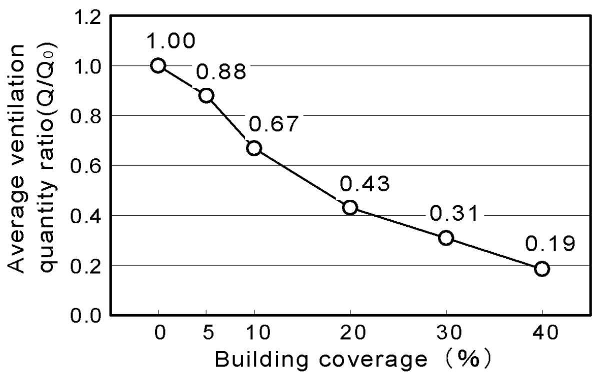


Figure 6 The ratio of cross ventilation quantity to building coverage

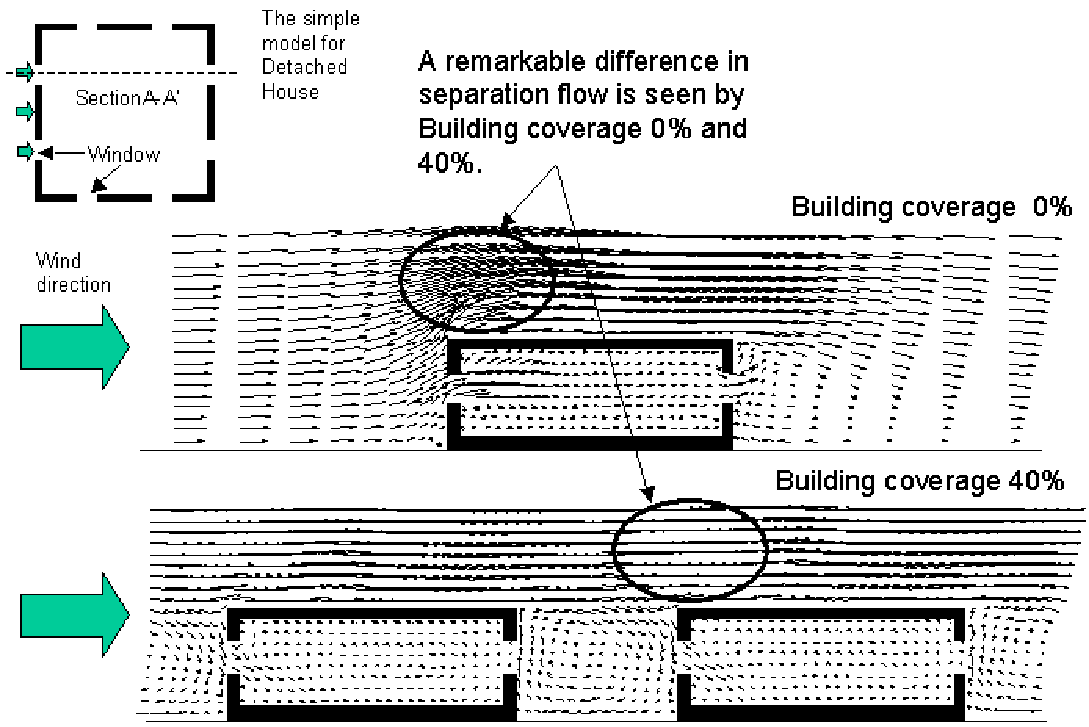


Figure 5 Distribution of wind velocity when building coverage is 0% and 40%

calculated for this result of CFD and the weather data of Tokyo (The wind velocity and wind direction in period when heating systems are not in use). Figure 8 shows section of object house and results of indoor wind velocity. It can get uniform cross ventilation by the installation of a skylight in the house in the urban area. The house has a well in the center of the house, and a skylight above the top of the well. The outdoor air which flows in from the south-facing windows of the first and second floors passes through the well and exits through the skylight.

4.2 The evaluation index of the building performance

The rate of the room volume of the indoor wind velocity of over 0.3m/s is calculated by results of CFD. Then the rates of room volume change due to indoor wind velocity we grouped into several grades, the result of which becomes an index of building performance.

5. Conclusion

This paper reports the outline of the evaluation index of natural cross ventilation performance. This paper points to (1) locality, (2) location, and (3) building performance as factors which influenced indoor wind velocity, and show the outline of the evaluation method for natural cross ventilation performance. The influence of the decrease in the effective temperature by cross ventilation is evaluated by the evaluation index of (1), (2), (3). Finally, this paper makes the evaluation index of cross ventilation performance. It is shown in figure 8. In the future, We will continue the calculation for several houses, and the synthetic evaluation method for the cross ventilation will be established.

References

[1] S. Kato, S. Murakami, H. Kobayashi, New scales for evaluating ventilation efficiency as affected by supply and exhaust openings based on spatial distribution of contaminant, International Symposium on Room Air Convection and Ventilation Effectiveness, pp.321-332, (1992)

[2] Q.Zhang, T. Katayama et. al., Energy saving of apartment houses by natural ventilation, Journal of architecture, Planning and environmental engineering (Transaction of AIJ), Vol 381, pp.1-10, Architectural Institute of Japan, (1987)

(1) The CFD analysis results of the object building, using Tokyo weather data (wind velocity and wind direction for the period when heating systems are not in use)→Indoor air distribution is computed.

↓

(2) Capacity where indoor wind velocity is more than 0.3 m/s divided by scope of human activity

↓

(3) "Capacity where indoor wind velocity is more than 0.3 m/s divided by scope of human activity" is defined as "The index of a building performance".
The grade of each object building is divided from this index.

Figure 7 The flowchart of the building performance index

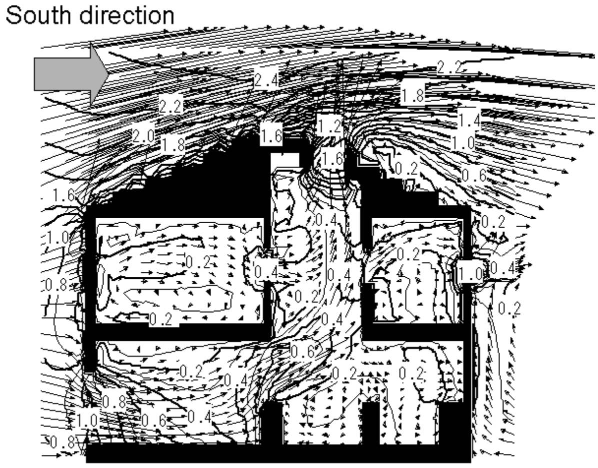


Figure 8 Section of object house and results of indoor wind velocity

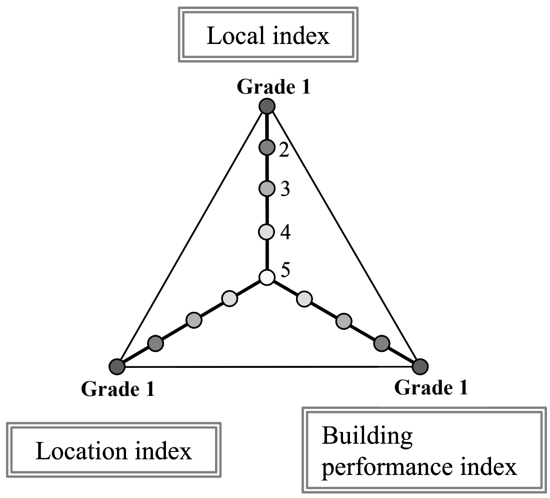


Figure 9 The concept of the evaluation index of cross ventilation