PERFORMANCE EVALATION OF THE HYBRID VENTILATION SYSTEM CONTROLLED BY A PRESSURE DIFFERENCE SENSOR

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ABSTRACT

A hybrid ventilation system controlled by a pressure difference sensor was installed on a detached test house. Performance of this ventilation system was evaluated through the field measurement taken into account the different conditions of the air supply and the exhaust systems. The results of the measurement revealed that the exhaust airflow rate was relatively stable while the indoor-outdoor temperature difference varied and the wind velocity changed. The exhaust airflow rate met the target airflow rate of 64% during the whole measuring period. From the comparison about the air supply systems, the crawl space air supply system showed better result than the passive air supply system not only for the balance of air supply in the first floor and the second floor but also for the stability against various outdoor condition.

KEYWORDS

Hybrid ventilation system, Control strategy, Pressure difference sensor,
Crawl space air supply system, Balance of infiltration airflow rate

INTRODUCTION

Hybrid ventilation systems utilize not only the mechanical force but also the natural forces such as buoyancy and wind effects. The mechanical system can stabilize the irregular natural forces such as buoyancy and wind effect instead of consuming energy. It has to be taken into account seriously, therefore, how these different systems should be combined and controlled[1].

From the previous research[2] about the performance of hybrid ventilation system installed on a two-storey building, the followings were reported that the hybrid ventilation system controlled by the temperature difference between indoor and outdoor cannot deal with the influence of outdoor wind on the ventilation airflow rate while the supplemental fan is off. Moreover, the infiltration airflow rate was very insufficient in the second floor by the influence of buoyancy effect under the condition of heating.

To make an alternative for such problems, a hybrid ventilation system using the pressure difference sensor for controlling the airflow rate with supplemental fan and damper was introduced in this study. The crawl space air supply system was adopted for maintaining the balance of infiltration airflow rate in the first floor and the second floor and compared with the passive air supply system.

ABSTRACT OF THE HYBRID VENTIATION SYSTEM AND THE TEST HOUSE

Hybrid ventilation system

Figure 1 shows the conceptual drawing of the control strategy of the hybrid ventilation system. The airflow rate passing the vertical exhaust duct is monitored by a pressure difference sensor stored in the system unit. A supplemental fan and a damper are controlled automatically according to the monitored results to meet the target airflow rate. The fan has 35 stages of rotation speed and the damper has 7 stages of angle.

Test house

Figure 2 shows the floor plans and sectional view of the test house used for the measurement. Total floor area of the house is 78.9m^2 and the volume is 163.9m^3. The equivalent leakage area of the building envelope per unit floor area is 2.8cm^2/m^2 obtained by the measurement of the fan pressurization method. A stairwell in the hall connects the first floor with the second

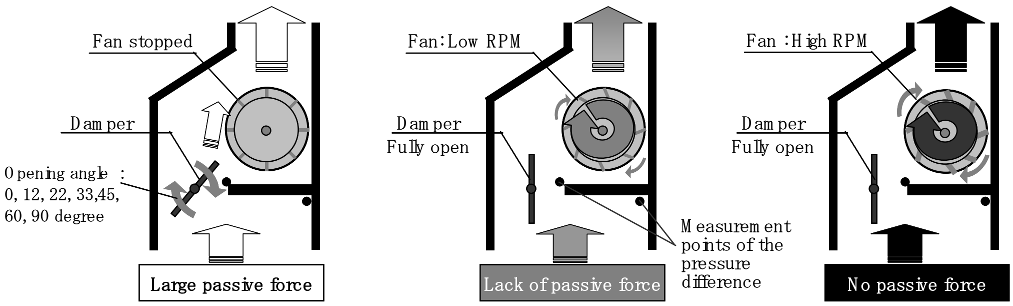


Figure 1. The control strategy of the hybrid ventilation system

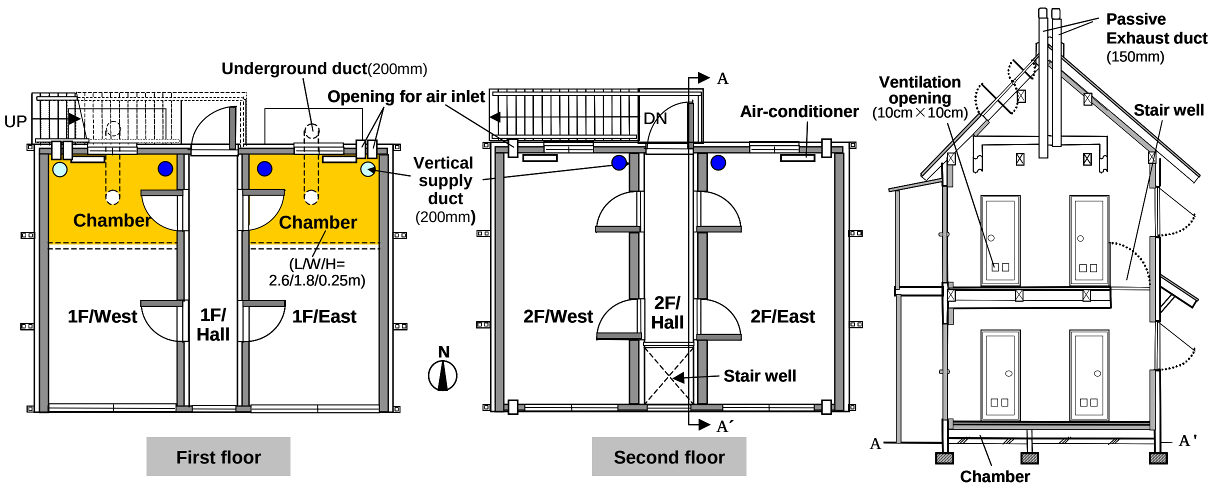


Figure 2. Floor plans and sectional view

floor and two openings are set on every internal doors for ventilation. Openings for air inlet are installed on the external wall of each room except halls which could be used as the passive air supply system. As well as, underground ducts, chambers installed in the crawl space and vertical supply ducts can be used as the crawl space air supply system. The hybrid ventilation system is installed at the top of the second floor hall and it is connected via ducts to each rooms and outdoor space.

METHODS AND CONDITIONS OF MEASUREMENT

The infiltration airflow rates of each room were measured by the constant concentration method with SF_6 gas as a tracer. The airflow rate of the exhaust duct was measured by the constant injection method using CO_2 gas. The operating conditions of the supplemental fan and the damper of hybrid ventilation system were monitored. Indoor-outdoor temperature difference, indoor-outdoor pressure difference and outdoor wind speed and direction were measured. Table 1 shows the measurement cases for comparing the influences of the air supply system and the difference of places where the exhaust executed. Figure 3 shows the conceptual drawings of Case A and Case B. The exhaust airflow rate of ventilation system was set to 95～125m^3/h for satisfying 0.6～0.75ACH.

RESULTS & DISCUSSIOIN

Variation of each measurement item

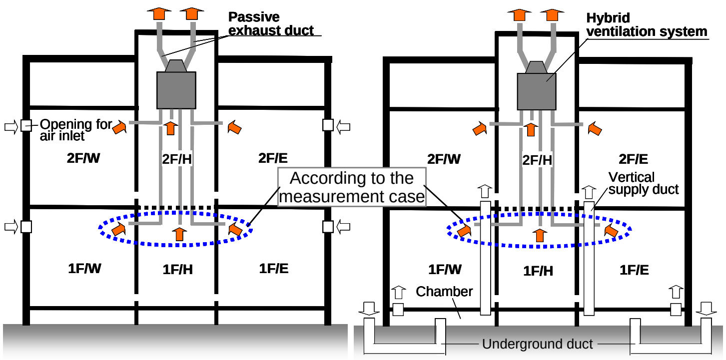
Figure 4 shows a part of the measurement result from Case A-1 and Case B-2, including the infiltration airflow rate and exhaust airflow rate, outdoor wind velocity and direction, indoor-outdoor temperature difference and pressure difference, operating conditions of the fan and the damper, respectively.

The total infiltration airflow rate and the airflow rate of the exhaust duct were generally stable while the indoor-outdoor temperature difference varied and the wind velocity changed. But the operating conditions of the fan and the damper of Case A-1 and Case B-2 are varied under the same direction of wind from the northwest at 0:00-6:00 in the day of January 24th and 19th, respectively. This caused by the different influences of wind on each cases where the air supply systems of different feature are introduced.

Table1. Case of measurement

	Place of exhaust	Air supply system	Period (Jan)	Time (hr)
CaseA-1	2nd Floor	Passive	20～25th	117
CaseA-2	All rooms		25～29th	88
CaseB-1	2nd Floor	Crawl space	5～12th	160
CaseB-2	All rooms		17～20th	66

※Set temperature : 30℃ (Crawl space : free floating temp.)
※Opening area of vertical supply duct in the 1st floor adjusted to 1/4



(1) Case A (2) Case B

Figure 3. Conceptual drawing of Case A, Case B

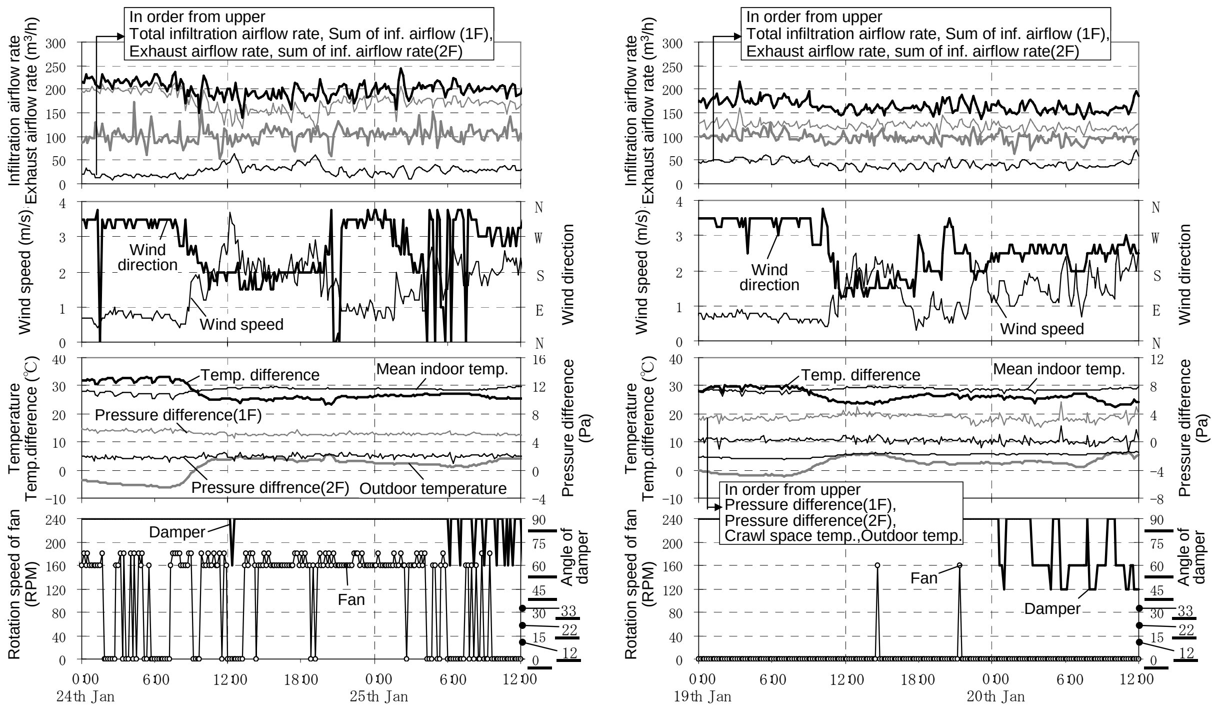


Figure 4. Measurement results of Case A-1(left), Case B-2(right)

Table 2. Operating modes and mean value of each measurement item (Case A)

Operating mode	Rotation speed of fan (RPM)	Opening angle of damper (degree)	Total time (hr)	Total infiltration airflow rate (m³/h)	Exhaust airflow rate (m³/h)	Temp. difference (℃)	Pressure difference(1F) (Pa)	Pressure difference(2F) (Pa)	Wind speed (m/s)
1		45	1	206	97	28.0	5.6	2.0	2.5
2	0	60	6	205	103	27.9	5.4	1.8	2.3
3			134	200	96	28.6	5.7	1.9	1.1
4	160	90	45	203	106	28.1	5.6	2.0	1.1
5	180		20	204	106	28.4	5.6	2.0	1.0

Table 3. Operating modes and mean value of each measurement item (Case B)

Operating mode	Rotation speed of fan (RPM)	Opening angle of damper (degree)	Total time (hr)	Total infiltration airflow rate (m³/h)	Exhaust airflow rate (m³/h)	Temp. difference (℃)	Pressure difference(1F) (Pa)	Pressure difference(2F) (Pa)	Wind speed (m/s)
1		45	7	158	89	26.8	3.6	0.2	1.3
2	0	60	15	160	93	26.9	3.6	0.3	1.3
3			196	167	97	28.8	3.4	0.3	0.8
4	160	90	7	162	105	25.1	3.8	0.7	1.0
(5)	180		0.3	163	113	25.0	4.1	0.8	0.6

Comparison about the operating conditions

The operating conditions of the supplemental fan and the damper appeared in Case A and Case B (206 hours, 225.3 hours in total respectively) could be divided into five modes. Table 2 and Table 3 shows the mean value of the infiltration airflow rate and exhaust airflow rate, indoor-outdoor temperature difference and pressure difference with outdoor wind speed for each operating mode. The mean exhaust airflow rate almost met the target airflow rate (95～125m^3/h). But the total infiltration airflow rates of Case B show lower value than Case A because of the large resistance of the air supply system by using the underground ducts and crawl spaces. No relationships are found between the operating modes and indoor-outdoor temperature difference, and pressure difference.

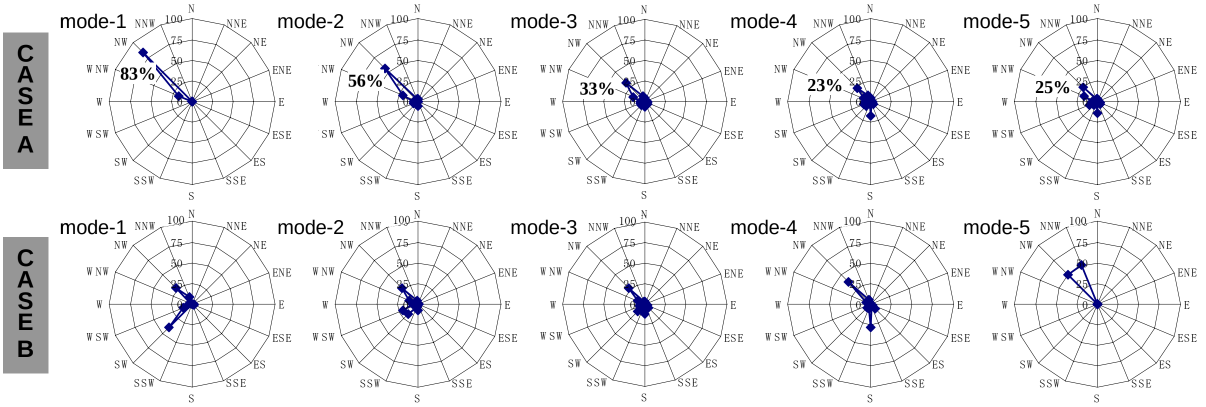


Figure 5. Wind rose for each operating mode

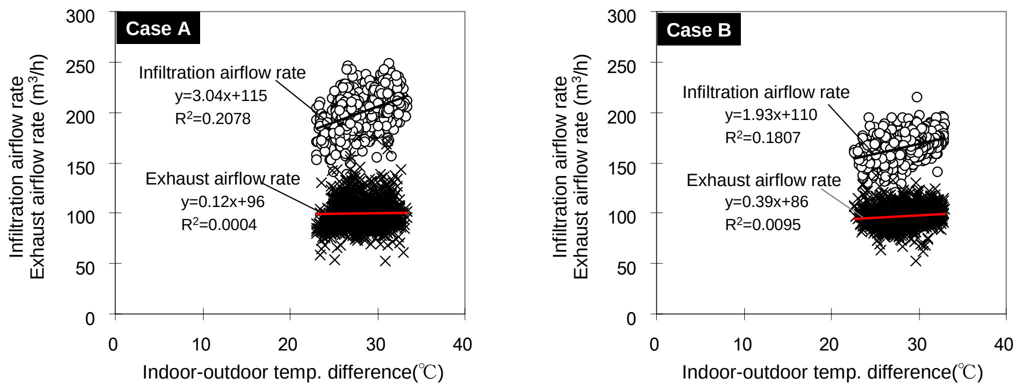


Figure 6. Relationship between temp. difference and ventilation airflow rate in Case A(left), Case B(right)

Influence of the wind on the ventilation airflow rate

Figure 5 shows the wind rose for each operating mode of Case A and Case B. In Case A, the proportion of wind from the northwest becomes the higher from mode-5 to mode-1 with increase of the mean value of wind speed(reference Table 2). In Case B, on the other hands, there are no correlation between the operating modes and outdoor wind. This reveals that the crawl space air supply system provides more stability for system control than the passive air supply system against the influence of outdoor wind.

Influence of the indoor-outdoor temperature difference on the ventilation airflow rate

Figure 6 shows the relationship between the indoor-outdoor temperature difference and the total infiltration airflow rate, and the exhaust airflow rate about Case A and Case B. The airflow rate of passive exhaust duct was maintained by the control of hybrid ventilation system even the indoor-outdoor temperature difference changed. But the total infiltration airflow rate increases according to the rise of temperature difference, especially in Case A.

Proportion of the target airflow rate

Figure 7 shows the histogram of each operating mode. Figure 8 shows that the proportions of target airflow rate are occupying about 60% and 70% for whole periods in Case A and Case B, respectively.

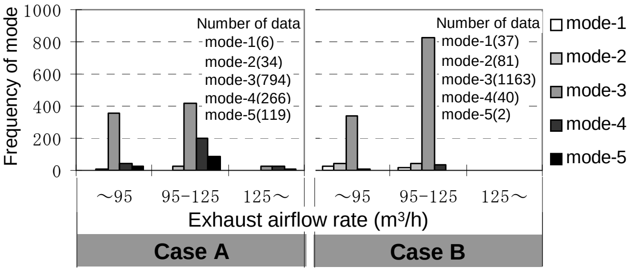


Figure 7. Histogram of each operating mode

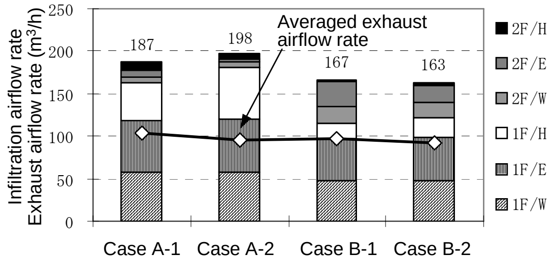


Figure 9. Distribution of infiltration airflow rate

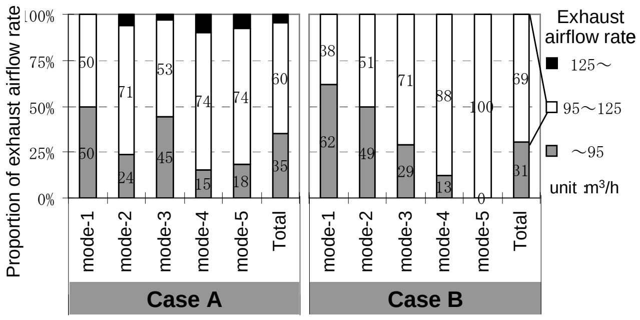


Figure 8. Proportion of exhaust airflow rate

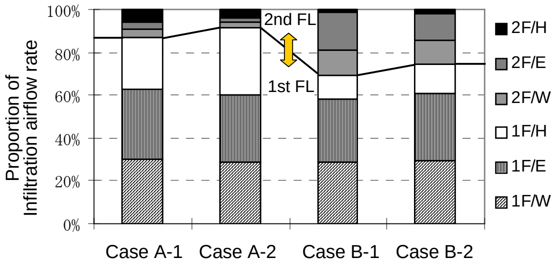


Figure 10. Proportion of infiltration airflow rate

Balance of the infiltration airflow rate for the first floor and the second floor

Figure 9, Figure 10 shows the distribution of averaged infiltration airflow rate and its proportion respectively. Mean value of the exhaust airflow rate has been added as well and it met the target airflow rate in any cases. The infiltration airflow rate on the second floor increased to 30% in Case B while it reached only 10% in Case A. From the comparison about the place of exhaust, Case A-1 and Case B-1 in which the second floor has been exhausted showed better balance of the infiltration airflow rate than Case A-2 and Case B-2.

CONCLUSION

The exhaust airflow rate was generally stable and met the target airflow rate in average under the condition of varying indoor-outdoor temperature difference and outdoor wind. The crawl space air supply system showed higher proportion of target airflow rate than the passive air supply system. Combination of the crawl space air supply system with the exhaust from the second floor is recommended for getting the balance of infiltration airflow rate in the first floor and the second floor.

Acknowledgement

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