Correlation analysis between ACH50 and Air permeability considering the floor area of a residential buildings

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ABSTRACT

Airtightness is presented through various expression according to the standards and measurement methods of each country. To compare the airtightness of buildings of different sizes, ACH50 and air permeability are mainly used to express the airtightness.
ACH50 and air permeability are airtightness expression methods calculated by dividing air flow into volume and surface area, respectively. As the size of a building increases, the airtightness value tends to decrease. However, the rate of change of ACH50 and air permeability according to the size of the building appears different, and it is necessary to compare the airtightness with an appropriate expression considering the characteristics of the building.
In this study, to analyze the correlation between ACH50 and air permeability according to the characteristics of the building, airtightness measurement data in multi-unit residential buildings were analyzed. The measurement target was a residential building built with the same construction method, and it was divided into three cases of small, medium, and large sizes, and 24 units were measured for each case.
As a result, the s/v ratio of the large floor area was 1, but the s/v ratio of the small floor area was 1.1. The S/V ratio tends to decrease as the floor area increases, and the area of the target building showed an s/v ratio close to 1, ranging from 1.02 to 1.11. This means that the larger the floor area, the smaller the effect of the airtightness expression. In the case of a small floor area, since the change in the value of ACH50 is relatively large, it is necessary to consider setting detailed standard for ACH50 according to the floor area. When the area is decreased to less than 100 m^2 or increased to more than 200 m^2, the change rate value is significantly different from 0.8 to 1.5, so it is necessary to evaluate the airtightness results considering the s/v ratio change rate by floor area.

KEYWORDS

ACH50, Air permeability, floor area, s/v ratio, Correlation

1 INTRODUCTION

Airtightness are presented through various expressions according to the standards and measurement methods of each country to compare the airtightness of buildings of different sizes.
Airtightness in a building is expressed as the air leakage rate for the area and volume of a building at a reference pressure difference, and is mainly expressed as ACH50, air permeability. ACH50 and air permeability are airtightness expressions calculated by dividing the air leakage rate by the volume and the envelope area, respectively. They are values calculated using dimensions such as airflow rate, volume, area, they can be converted to each other.
Due to the characteristics of the area and volume used in the two expressions, the rate of change of ACH50 and air permeability according to the size of the building appears different. In particular, the larger the size of the building, the larger the difference occurs. In small-sized buildings, ACH50 and air permeability are almost the same (AIRAH, 2017; Kyung-Hwan, J

et al., 2016), but in large-sized buildings, ACH50 expressed by volume is lower than air permeability, which seems to indicate tighter air tightness.
In this study, to analyze the correlation between ACH50 and air permeability, airtightness measurements were conducted on residential houses with the same construction technique in Korea, and correlations were derived by analyzing airtightness measurement data according to floor area.

2 AIRTIGHTNESS EXPRESSION

2.1 Airtightness expression according to the building geometry

Airtightness is expressed in various ways depending on the reference pressure difference and building geometry. To compare airtightness in buildings of different shapes and sizes, the airflow rate is divided into envelope area, volume, and floor area.
ACH50 and air permeability are commonly used airtightness expressions around the world. Air change rate (ACH50) is the air leakage rate (m^3/h) at 50Pa divided by the volume (m^3) of the building. Air permeability is the air leakage rate (m^3/h) at 50Pa divided by the envelope area (m^2) of the building. ACH50 indicates how many times the air in a room is leak out when a pressure of 50 Pa is applied to the building envelope, also expressed as n50. Air Permeability refers to the amount of leakage through the building envelope and is also represented by q50 (ISO9972, 2015).

2.2 Features of ACH50 and Air permeability

ACH50 and air permeability are expressed as volume and envelope area divided by the same airflow rate, respectively. Due to the characteristics of area increasing as a square and volume increasing as a cube, differences occur as the size of the building increases (Figure 1). Figure 2 shows the variation of the s/v ratio as dimension increases. For example, if the shape of a building is assumed to be a cube, a cube with a length of 1 has an s/v ratio of 6, which means that the area is much larger than the volume, but at a length of 6, the envelope area and the volume become equal, and exceeds 6, the s/v ratio becomes less than 1, which means that the volume appears larger. The envelope area and volume of a small building are approximately the same, so the s/v ratio for small building appears to be close to 1 (AIRAH, 2017; Kyung-Hwan, J et al., 2016). However, since the s/v ratio decreases as the size of the building increases, converting ACH50 and air permeability to the same ratio will cause a difference from the actual value, so it is necessary to evaluate the result by considering the correlation between the two expressions.

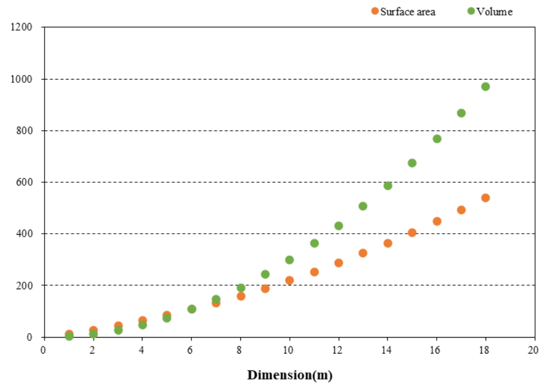

Figure 1: Area and volume change with dimensions

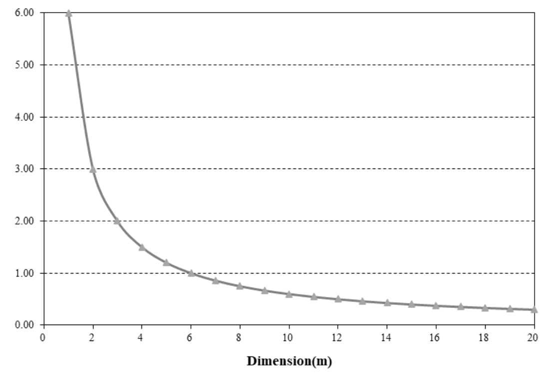

Figure 2: S/V ratio by dimension

3 FIELD MEASUREMENT OF AIRTIGHTNESS IN RESIDENTIAL BUILDINGS

3.1 Descriptions of residential buildings

The target building is a residential building in South Korea, constructed of reinforced concrete and completed in 2017. 274 units were measured and classified into small, medium, and large types according to floor area for analysis. To utilize the same number of data, we used 24 data points determined by random sampling. An overview of the target building is shown in Table 1.

Table 1: Descriptions of residential buildings

Classification	Small type	Medium type	Large type
Building site		Incheon, South Korea	
Construction		Reinforced concrete structure, Flat slab	
Building use		Multi-unit dwelling	
Number of stories		2 Basements, 42~44 stories	
Number of test unit	24	24	24
Floor area(m^2)	101.76 ~ 102.21	134.56 ~ 137.56	173.18

3.2 Airtightness results according to the floor area

Airtightness is measured according to ISO 9972, and ACH50 and air permeability are calculated from the airflow rate (Q) at 50Pa, the volume (V) of the unit, and the envelope area (S) of the unit. As shown in Figure 3, the ACH50(1/h) for the small type ranged from 1.49 to 3.32, with an average of 2.42. The ACH50 for the medium type ranged from 1.31 to 2.77, with an average of 1.79. The ACH50 of large type ranged from 0.87 to 2.37, with an average of 1.58. As shown in Figure 4, the air permeability($m^3/h{\cdot}m^2$) of the small type was measured between 1.32 and 3.07, with an average of 2.19. The air permeability of the medium type ranged from 1.24 to 2.63, with an average of 1.70. The air permeability of the large type ranged from 0.86 to 2.33, with an average of 1.56.

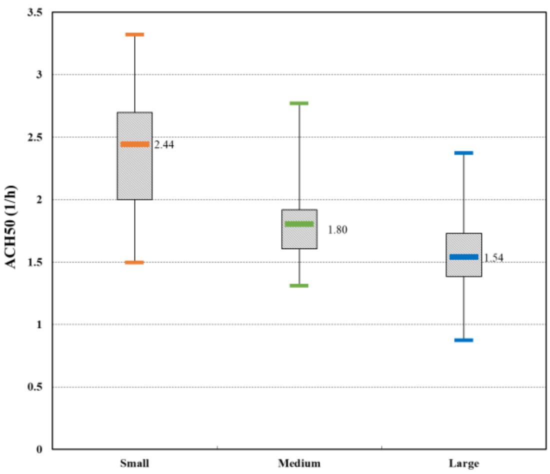

Figure 3: ACH50 by floor area

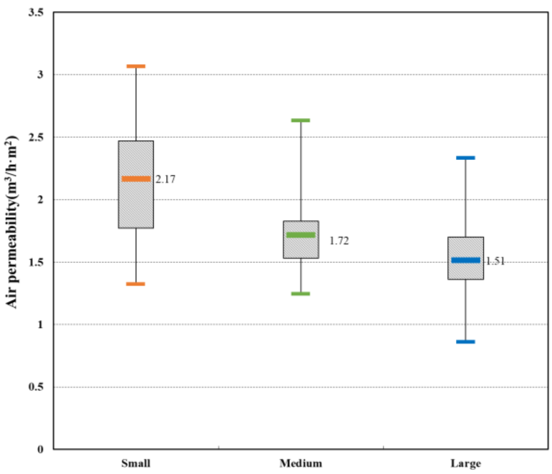

Figure 4: Air permeability by floor area

For both ACH50 and air permeability, the large type had the lowest values, with values decreasing as the floor area increased (Figure 5). When comparing the rate of change of ACH50 and air permeability according to floor area, the change of ACH50 is more rapid, and the difference is more noticeable for small. The difference between AHC50 and air permeability for each floor area was 11% for the small type, 5% for the medium type, and 2% for the large type. The small type has a higher airtightness value than the other two types, which is due to the relatively small volume and envelope area of the small type, although the Q of the small and medium types are similar.

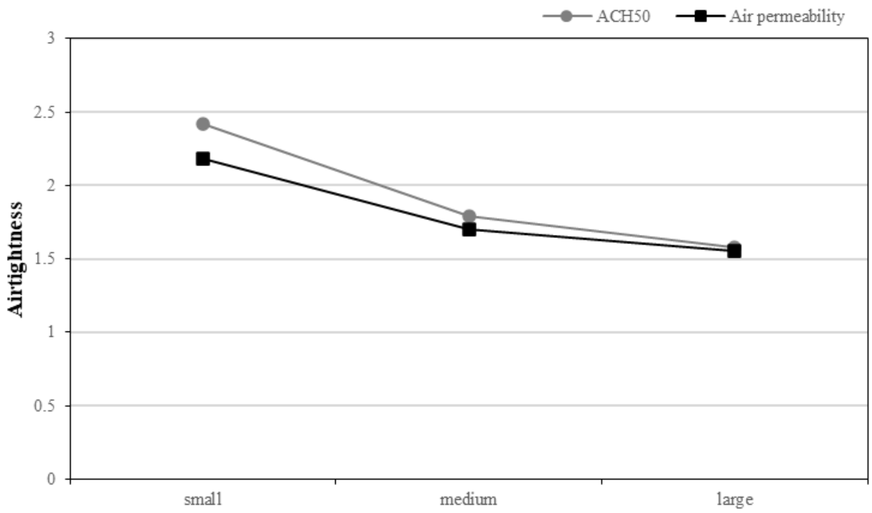

Figure 5: Change rate of ACH50 and air permeability by floor area

4 CORRELATION ANALYSIS BETWEEN ACH50 AND AIR PERMEABILITY

4.1 Correlation of ACH50 and Air permeability

To analyze the correlation between the two variables, ACH50 and air permeability, a scatter plot was used to analyze the correlation. ACH50 and air permeability are linearly related, with correlation coefficients of 0.99 for small type, 1.00 for medium type, and 1.00 for large type, indicating a strong positive correlation (Figure 6).

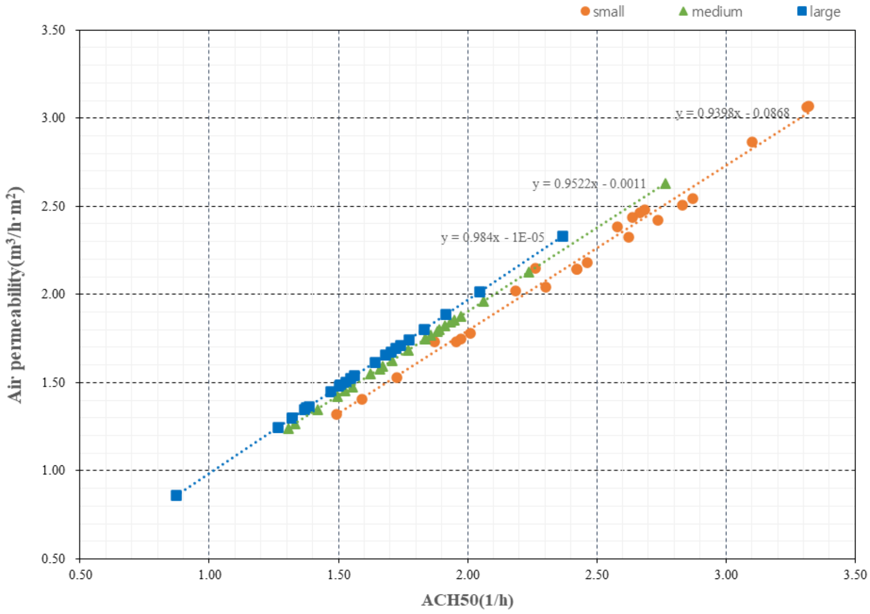

Figure 6: Correlation of ACH50 and air permeability

4.2 Analysis of ACH50 and Air permeability by floor area

ACH50 and air permeability are calculated as airflow rate divided by volume and envelope area, and the ratio of ACH50 to air permeability is equivalent to the s/v ratio, which is surface area divided by volume. As the floor area increases, the floor area ratio tends to decrease, which is shown in Figure 2 because the volume increases more rapidly than the area above a certain dimension. The average s/v ratio for small is 1.11, medium is 1.05, and large is 1.02, with ratios closer to 1 as the floor area increases (Figure 7).

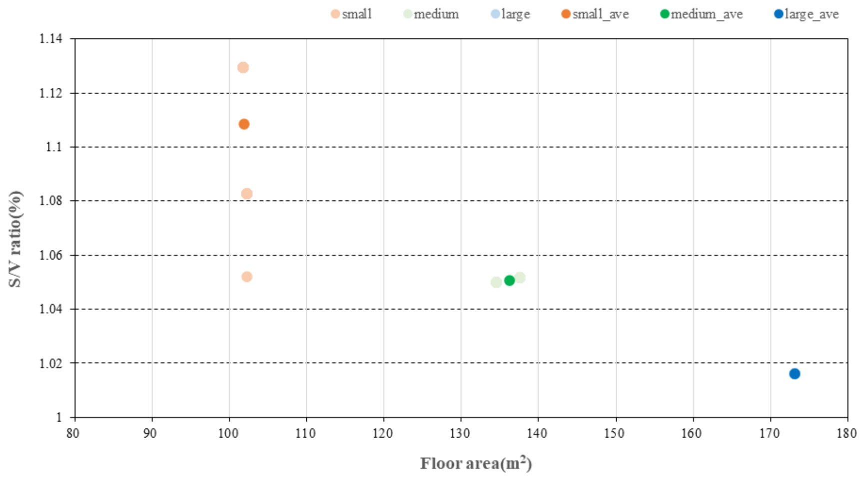

Figure 7: s/v ratio by floor area

To identify the changes in ACH50 and air permeability according to the floor area, we analyzed the s/v ratio according to the floor area (Figure 8). Assuming a hexahedron, the height was fixed at 3 meters for residential buildings, and the floor area ranged from 50m^2 to 1000m^2. We considered three different floor types: 1:1, 1:2, and 1:5.

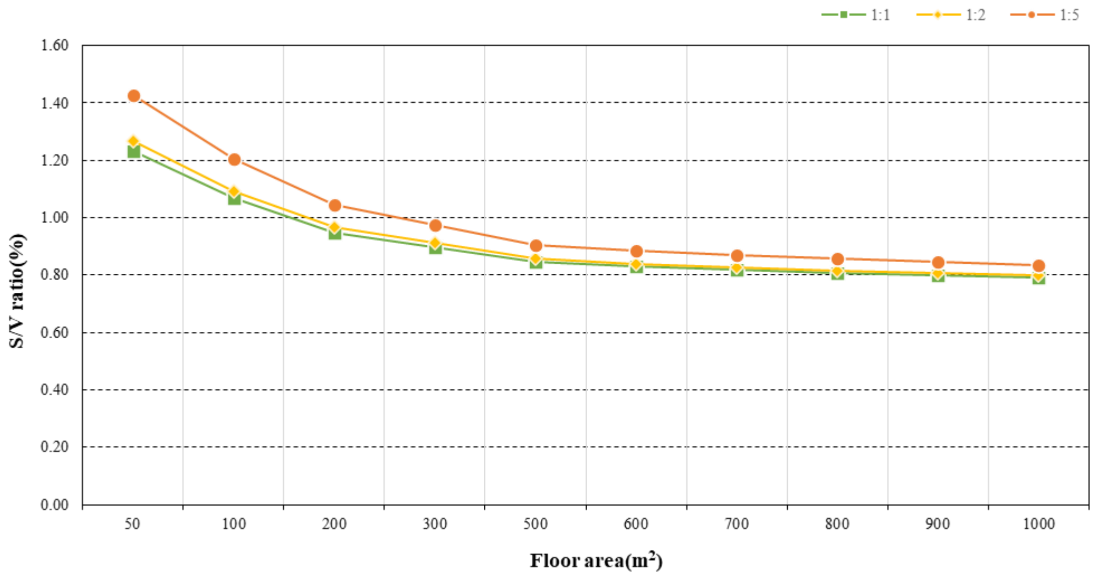

Figure 8: Change rate of s/v ratio by floor area

The s/v ratio tended to decrease as the floor area increased, with the closer to square the lower the ratio. The s/v ratio ranged from 1.23 to 1.43 for 50m^2 and 0.79 to 0.84 for 1000m^2, with a ratio of 1 between 100m^2 and 200m^2. The data applied to the residential building does not have a wide range of floor area, so the change of ACH50 and air permeability ratio, which have the same meaning as s/v ratio, shows a value like 1. When the area is decreased to less than 100 m^2 or increased to more than 200 m^2, the change rate value is significantly different from 0.8 to 1.5, so it is necessary to evaluate the airtightness results considering the s/v ratio change rate by floor area.

5 CONCLUSIONS

This study analyzed the correlation between ACH50 and air permeability, which is used to compare the airtightness of buildings of different sizes. ACH50 and air permeability were analyzed by classifying the measured data of residential buildings into small, medium, and large according to floor area. ACH50 and air permeability showed a strong positive correlation with the s/v ratio tending to decrease as the floor area increased, with the closer to the square shape showing a lower ratio.

The s/v ratio will have a value greater than 1 when the floor area is less than 100 m^2 and a value less than 1 when it is greater than 200 m^2. The area range in the target building is between 100m^2 and 200m^2, and the s/v ratio of the large type is closer to 1, but this is due to the small floor area of the target building, and it is necessary to consider the relationship between floor area and s/v ratio when converting the two expressions to evaluate the actual airtightness.

ACH50 is an expression of airtightness expressed by volume, and as the size of the building increases, it is more affected by volume, and the airtightness value changes more rapidly compared to air permeability and seems to have a better quality of airtightness. However, since airtightness is related to the flow of leakage rate through the envelope, the openings caused by each component present in the envelope must be considered. Therefore, it is more reasonable to evaluate the airtightness by air permeability, which has a smoother change in airtightness value and can consider the effect of leakage rate through the envelope. In this study, the correlation between envelope area and volume was considered to evaluate the airtightness according to the floor area, and further consideration of each component that affects the airflow rate required for airtightness evaluation is needed.

6 ACKNOWLEDGEMENTS

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