Design pressure difference for self adjusting air inlets

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Synopsis

At present the design pressure difference for air inlets in The Netherlands is 1 Pascal. This paper investigates the question whether or not this value is still appropriate.

In recent years the airtightness of dwellings has improved remarkably. Self adjusting air inlets have been introduced on the market. What is the effect of these changing building features on the pressure difference over the building envelope? To answer this question more insight is needed in the pressure differences that appear in reality during the year, and on the way they depend on building features.

A mulitizone air flow model has been used to calculate the pressure differences during a reference year. Building types are: a) an existing dwelling with conventional air inlets and b) a new built dwelling with improved airtightness and self adjusting air inlets. This type of dwelling will be built in large numbers for the following years in the Netherlands.

The calculations allow for the following conclusions:

- The design air pressure difference increases as a result of improved airtightness and the application of self adjusting air inlets.
- For new built dwellings in the center of the country the design pressure difference can be raised to 2 Pascal.
- Other building locations (near coast) and better building airtightness may lead to still higher design pressure differences. These will have to be calculated separately.

The advantages of working with higher design pressure differences, applicable to the situation:

- Ventilation energy losses decrease
- Deviations from the ideal ventilation pattern will decrease, which will improve indoor air quality
- Less or smaller air inlets will be needed, which saves costs

Introduction

The Dutch ventilation standard [1] assumes a design pressure difference of 1 Pa. This pressure difference is supposed to be available across the facade, to drive fresh external air into the building. The design pressure difference is used to determine the proper size of air inlets. The 1 Pa value of the design pressure difference has been established decades ago. At that time buildings were relatively leaky, used openable windows for air inlet and were equipped with natural ventilation exhaust shafts that are nowadays considered much too narrow.

The airtightness of buildings has improved remarkably during recent years [2]. Self adjusting air inlets, introduced on the market some 5 years ago, are applied in increasing numbers. Air exhaust is guaranteed by mechanical ventilation or well-sized natural outlets. It is expected that all these developments lead to a higher pressure difference being available across the facade. A case study of the ventilation in modern airtight dwellings with self adjusting air inlets is reported in [4].

Using the right pressure difference is important to decrease ventilation losses. Using the right pressure difference will also promote the desired ventilation patterns within the building.

This paper reports a simulation study which investigates the question whether or not an adjustment of the design pressure difference, used in the ventilation standard, is justified.

The study focuses on dwellings. In this paper the term self adjusting air inlets is used. These devices are also known as constant flow inlets. This paper is devoted to pressure controlled inlets, where a constant inflow is maintained irrespective of pressure difference.

Calculations

Calculations were performed with the multizone ventilation model MVRM97 [3]. This model incorporates wind speed, wind direction, external pressure coefficients, external and internal temperature, building airtightness, air inlets, interzonal openings and exhausts into the calculation of interzonal air balances.

The external climate was simulated using the Test Reference Year (TRY) for de Bilt, Netherlands. To limit the number of calculations, a limited number of combinations of wind speed and external temperature has been used (tables 1 and 2). The distiguished wind directions were: perpendicular to the facade, parallel along the facade and at an angle of 45 degrees with the facade. The distribution of wind directions is supposed to be flat, which means that no predominant wind direction exists. Wind pressure coefficients acting on the facade are presented in table 3.

Table 1 Combinations of windspeed and external temperature; the given percentages represent the amount of time this combination of speed and temperature occurs in the Test Reference Year.

windspeed	external temperature	
	< 10 °C	> 10 °C
< 2,5 m/s	20%	17%
2,5…4,5 m/s	19%	20%
4,5…6,5 m/s	10%	8%
> 6,5 m/s	4%	2%

Table 2 Mean values for the windspeed and external temperature classes given in table 1; mean values determined from Test Reference Year

temperature class	mean value
< 10 °C	4,3 °C
> 10 °C	15,4 °C

windspeed class	mean value
< 2,5 m/s	1,5 m/s
2,5…4,5 m/s	3,5 m/s
4,5…6,5 m/s	5,5 m/s
> 6,5 m/s	8,0 m/s

Table 3 wind pressure coefficients

	Wind direction, relative to facade:		
surface	perpendicular	parallel	45 degr.
floor	0,1	-0,1	0
front facade	0,9	-0,35	0,6
back facade	-0,4	-0,45	-0,4
roof	-0,7	-0,6	-0,7

The building model represents a common new built single-family dwelling, situated in a row of similar dwellings. The average building height in the surroundings is supposed to be about equal to the dwelling simulated. This represents the actual situation the Netherlands with large new housing areas.

The ventilation need of the dwelling is 42 l/s, relating to a dwelling with combined living room / kitchen and separate bathroom and toilet. Fresh air enters through air inlets, evenly distributed on the front and back facade and the ground and first floor. Air is removed from locations in kitchen, bathroom and toilet with a fan operating at 42 l/s.

Two alternative dwelling models have been studied: traditional and modern.

Traditional dwelling: air inlets (not self adjusting); airtightness 150 l/s at 10 Pa
Modern dwelling: self adjusting air inlets; airtightness 100 l/s at 10 Pa

The traditional model represents a dwelling on which the design pressure difference of 1 Pa is applicable. The modern model represents the type of dwellings that are built nowadays. In both cases closed internal doors have been assumed.

Note: the airtightness of the dwellings is determined at a pressure difference of 10 Pa, as is usual in the Netherlands. The cracks in the building surfaces occur in the roof (50%), facades (30%) and floor (20%).

Results and discussion

The calculations were used to establish the pressure difference across the facade for all combinations of external climate and wind direction. If all pressure data is taken together, the distribution curves of figure 1 are obtained.

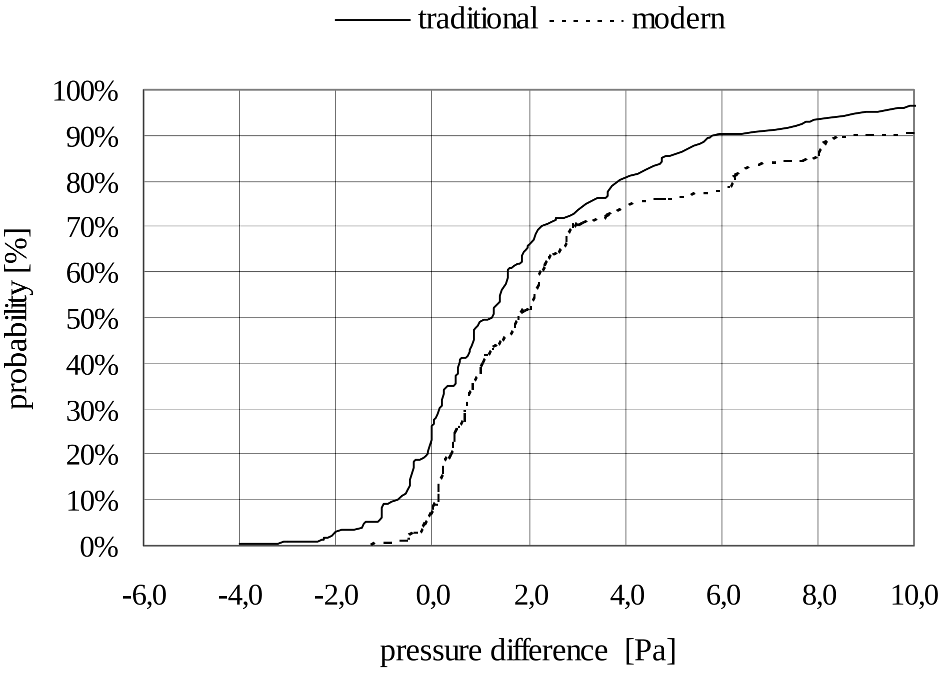

Figure 1 Pressure difference distribution. Shown is the probability that a certain pressure difference is not exceeded.

Figure 1 shows a clear difference between the traditional and modern dwelling. Improved airtightness and the application of self adjusting air inlets result in a shift of the pressure difference curve of about 1 Pa. This shift towards higher pressure differences is even more, about 3 Pa, near the tails of the curve. The probability for negative pressure differences (resulting in outflow while inflow is desired) to occur decreases from 26% to 8%. The value of the most negative pressure difference decreases from –4 Pa to –1,3 Pa.

So, in a modern dwelling with self adjusting air inlets the outflow of air through inlets occurs considerably less often. And íf it occurs, it is at a lower (negative) pressure difference. This reduces energy losses due to ventilation and infiltration. The desired ventilation pattern is realised much better in the modern dwelling. Occupant comfort and indoor air quality will improve. Poor quality air, coming from the kitchen or bathroom, is much less likely to follow undesired air flow paths to bedrooms or livingroom.

The calculations have shown that the pressure difference is increased by 1 Pa for modern dwellings with self adjusting air inlets. It is therefore recommended to increase the design pressure difference by 1 Pa to 2 Pa. The effect of this increase (in fact, a doubling) will be that air inlets will be better sized for the desired ventilation rates. It will be possible to use less or smaller inlets, resulting in cost reductions.

Conclusion

The pressure differences, occurring across the facade of a representative dwelling have been simulated. The simulation for a common traditional dwelling clearly shows the occurrance of undesired outflow of air for 26% of the time.

The simulation of a modern airtight dwelling with self adjusting air inlets shows that the pressure difference increases by about 1 Pa, relative to the pressure difference for a traditional dwelling. Undesired outflow of air occurs only for 8% of the time.

The improved airtightness and self adjusting air inlets will likely result in a decrease of energy losses, a better ventilation pattern, improved indoor air quality and occupant comfort.

The simulation results confirm the desirability to increase the design pressure difference, that is used in the standard to size air inlets in The Netherlands, by 1 Pa to 2 Pa. This paper is intended to initiaze such a adjustment. Reduced energy losses and improved occupant comfort and IAQ are expected.

A next step is to quantify the advantages of self adjusting air inlets, sized at a higher pressure difference.

The simulation study was performed using data relavant for the center of the Country, and assuming a low rise building and low rise surroundings. Higher design pressure differences may be expected for higher buildings, buildings near the coast and buildings with further improved airtightness. The design pressure difference of 2 Pa, determined in this study, should be regarded a minimum value in this respect.

References

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