MARKET OPPORTUNITIES FOR ADVANCED VENTILATION TECHNOLOGY

22nd ANNUAL AIVC CONFERENCE
BATH, UNITED KINGDOM, 11-14 SEPTEMBER 2001

MONOZONE MODELISATION OF NATURAL VENTILATION WITH DUCTS

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SYNOPSIS

European project pr EN13465 from CEN TC 156/WG2/AH4 gives a monozone model for airflows calculations in dwellings. In order to apply it to natural ventilation systems with adjacent ducts used in dwellings in France, we need to address several issues.

First, in adjacent ducts, airflows at each level depends on pressions in the different dwellings. We have to solve by iteration the balanced equation proposed in AH4. Then, cowls and roof outlet performances as well as the wind-pressure coefficient on the roof must be known. Finally, for dimensioning purpose, airflows must be calculated including the air transfer between rooms. As the dwelling is considered in monozone, taking it directly into account is impossible and the study considered it as an additionnal pressure drop.

1- INTRODUCTION

In France, natural ventilation with ducts is often used for dwellings ventilation. In order to use the same duct for several dwellings exhausts, specific shunts systems are used (see figure 1). The aim of this study was to determine if the monozone calculation model given in pr EN 13465 from CEN TC156/WG2/AH4 can be applied to these systems (for dimensioning, IAQ and energy calculations). We also maint to focus on main parameters in order to help design rules.

2- APPLICATION OF pr EN 13465

2.1 Multi-iterative approach

The pr EN 13465 model is an iterative monozone model calculating airflows though all openings (air inlet, outlet and air-hightness) in given conditions (wind pressure, stack effect …).

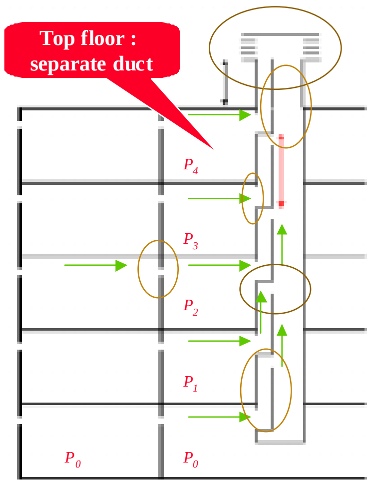


Figure 1 : Shunt duct for dwellings ventilation

We can consider each flat as a single zone model. In this case, we can solve by a multi-iteration the equation proposed in pr EN 13465 : airflows extracted from each dwelling via the shunt depends on the internal pressure of the dwelling. This multi-iteration has been programmed on Excel 97 Visual Basic and converge correctly for a limited number of floors (4 to 5 maximum). Yet, to achieve correct results, some parameters have to be known correctly :

- pressure drop in ducts
- performances of cowls

2.2 Pressure drop in ducts

Calculation of the total pressure drop can be easily done by adding singularities and linear pressure drops. Yet, the pressure drop in the take-off is badly known. Generally, designers use the Idel'cik formula for a 45 ° take-off. Yet, an old campaign of measurements in 1962 have shown different values. As in natural ventilation, the driving force can be low, we need to estimate correctly this pressure drop.

Some CFD calculations (figure 2) have been run in the range of airflows common for these systems.

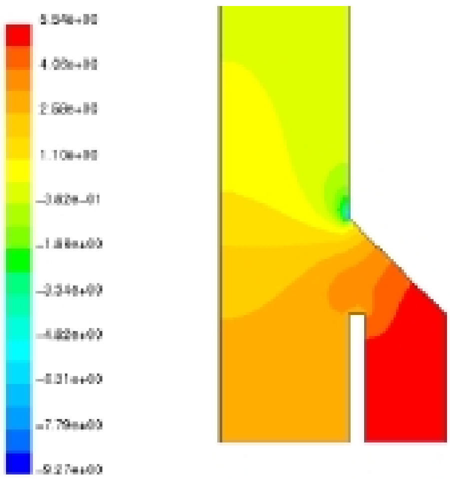


Figure 2 : CFD simulations

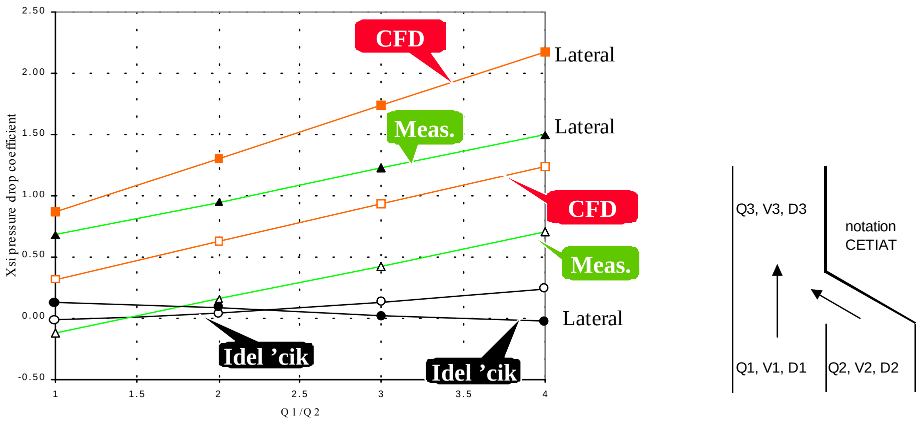


Figure 3 : Comparison of results – pressure drop coefficient (lateral and straight branches)

Figure 3 shows a comparison of these results. We can note that the Idel'cik formula is not appropriate. CFD calculations and measurements show a good similarity and an increase of the lateral pressure drop coefficient when the ratio main airflow out of the lateral airflow increases, while the Idel'cik formula tends to slightly decrease.

2.3 Simulation of cowls

Similitude laws allow calculation of the cowl coefficient in function of the velocity in duct (airflow) for several wind velocities from the cowl's tests.

In order not to take into account twice the wind effect, we have corrected the wind velocity acting on the cowl and decreased it from the wind pressure coefficient (Cp) on the roof :

$$V_{wind\_corrected} = \sqrt{1-|Cpk|}.V_{wind}$$

This proposal, although logical, has not been tested.

3- BUILDING SIMULATION AND PARAMETRIC STUDY

3.1 Configurations

We have simulated a 4 floors building with 4 identical dwellings of 61 m^2. The building is situated near Paris, is half shielded by surroundings and situated in a sub-urban area.

Each dwelling is ventilated through passive air-inlets in bedrooms and living rooms and two exhaust shunts, one in the kitchen, one for both bathroom and toilet.

Calculations are runned for outside temperature between – 10 °C and + 15 °C, wind velocities from 0 m/s to 5 m/s (average wind velocity in France is 4 m/s) and two wind directions (0 ° = North and 270 ° = South/West). In order to study dimensioning, three hypothesis have been made for inlets and outlets.

3.2 Main results

The method proposed can be applied and a good convergeance is obtained. Some examples of results are given in figure 4.

As predictable, they show that airflows depend on outdoor temperature, wind velocity and direction. Dimensioning of inlets and outlets must be adapted to obtain the minimum hygienic airflows required by french regulation.

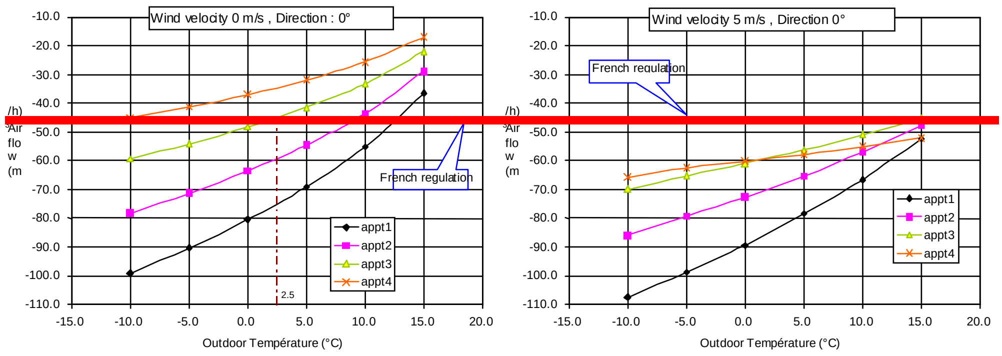
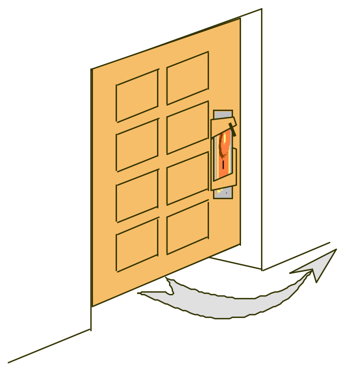


Figure 4 : Example of resulting airflows in the kitchen

We also note that the wind reduction (reduced by 60 % from meteo due to the sub urban zone, shield and roof correction hypothesis) induce that cowls have mainly worked in resistive conditions.

3.3 Influence of air transfer

Air transfer from rooms to kitchen or bathroom are generally realised below doors.



As the pr EN 13465 method is mono zone, it can't take this into account. Without going to a multi-zone model, we have simulated the influence of this air-transfer by adding its pressure drop to the outlet pressure drop (equivalent area).

Results (figure 5) on our building show that this additional pressure drop reduces automatically airflows (up to 17 %), mainly of course when inlet and outlet dimensioning is large.

Dimensioning : low.

	Difference (with/without) %				
	Pressure	Total Airflow	Ventilation Loss	Airflow in kitchen shunt	Airflow in bathroom shunt
Maximum	5.20	5.67	5.67	5.31	6.78
Minimum	0.21	1.19	1.19	4.10	4.95

Dimensioning : high.

	Difference (with/without) %				
	Pressure	Total Airflow	Ventilation Loss	Airflow in kitchen shunt	Airflow in bathroom shunt
Maximum	**16.26**	**17.77**	**17.77**	**23.80**	**15.73**
Minimum	1.17	4.33	4.33	12.86	9.85

Figure 5 : Influence of air transfer for several dimensioning, minimum and maximum for several outdoor conditions

4- CONCLUSIONS

We can use pr EN 13465 to calculate airflows in dwellings naturally ventilated with shunts however some complements are necessary :

- Adding pressure drop calculations in ducts
- Adding pressure drop corrections for air transfer
- Checking the best way to take into account cowls

- Using a multi-iteration on a several floors building where each dwelling is considered as a zone

Fast and simple dimensioning methods and rules are needed by designers for natural ventilation (IAQ, energy …) and must be developed and standardized. Hypothesis and proposals from this study still need to be checked but adapting the pr EN 13465 should reach our aim of an easy design method.