"ADAPTIVE VENTILATION WINDOWS"

E. Panzhauser, A. Fail, A. Mahdavi
Technical University of Vienna
Vienna, Austria

ABSTRACT

Ventilation windows must be designed and installed in a way that inhabitants can to fullfill their needs for fresh air (triggered by indoor pollution, overheating or personal state of well-being) under nearly any outdoor (weather) condition. This can not be maintained with the widely used "tilt & turn" windows because of poor ventilation which causes indoor pollution, surface condensation or excessive ventilation which causes heat loss increasing, high air velocities, etc. This means that "adaptive ventilation windows" are needed which should be specified by product declaration, describing the range of adaptability of effective ventilation for typical design and outdoor conditions.
Experimental data and simulation results on the efficiency of "adaptive ventilation windows" for a variety of indoor, outdoor and design conditions are given.

INTRODUCTION

Long term indoor air humidity depends primaraly on the strengh of moisture sources and on average ventilation rates. Both factors are determined by the user in a wide range. But the infiltration/exfiltration wich is a function of the airtightness of building envelope, cannot be influenced by the user.

As far as consumer behavior is concerned, window airing is the most important factor for the accessable average ventilation rate. Window airing is the eldest, by user most accepted and (if correctly designed) most effective kind of ventilation for space cooling and elliminating pollutants.

In the last two decades, the development of extremly tight windows and the adaption of the most widely used "tilt and turn"-technique has resulted in a substantial loss in the ventilation efficiency of windows:

- as a result of tight window joints (and cracks) the contribution of infiltration/exfiltration to basic ventilation was eliminated
- oversizing of the wings made them unusable for window airing
- the number of possible wing positions was reduced to "closed" or "tilt".

The present study points out which properties of ventilation-windows must be recovered to fullfill the fundamental tasks of window airing shown in following table:

season	indoor climate factor	main ventil. task	width of opening [m]	technical element	protection from	protection through
winter	air humidity	drying (dehumitization)	10^{-3} ... 10^{-2}	slot, slit overflow-opening	snow-storm	handle
all seasons	pollutants	diluting	10^{-2} ... 10^{-1}	ventilat. wing	rain	window shade, venetian blinds
summer	room temp.	cooling	10^{-1} ... 10^{0}	ventilat. wing	storm, undesir. entry	handle

TABLE 1. Scheme of "Adaptive Ventilation".

CALCULATION OF WINDOW AIRING

There are some simple methods to calculate air infiltration through leakages in building fabrics (/1/, /2/, /3/). Widely known is the LBL-model introduced by M.SHERMAN (/4/). This method is based on the assumption of leakages evenly distributed over the surface areas of exterior walls of the room/building under consideration. Corrections can be introduced, if the fraction R of total leakage area in the floor and ceiling and the difference in ceiling/floor fractional leakage area are known.

The total effective leakage area L_o of the envelope is defined as the average of the effective leakage area from pressurization and depressurization.
Mearured wind speed at the height of the wind tower, but no effect of wind direction is taken into account in the LBL-model.
Wind induced and stack induced infiltration are calculated independently. Air flow being proportional to the square root of the pressure, both components of infiltration are added in quadrature:

$$Q_{tot} = \sqrt{Q_w^2 + Q_s^2}$$

The envelope leakage is grouped into 3 catagories:

Floor, wall and ceiling leakage area.

So 3 parameters describe the leaks:

L_o the total leakage area
R the fraction of total leakage area in the floor and ceiling
X the difference between floor and ceiling leakage areas divided by the total leakage area.

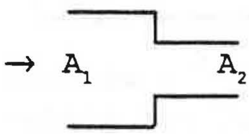
Driving forces for wind infiltration, namely pressure differences are proportional to the local wind speed and the degree of shielding of the building. Two terrain parameters are used to describe the wind profile.

According to our experiences, the LBL-model is applicable for the calculation of infiltration/exfiltration through slots (and cracks) which are distributed in a way typical for slots of windows and doors.

In case of larger window (wing) openings the calculation procedure must be extended. The transformation from the geometrical cross-section into a flow cross-section by a coefficient of contraction is possible.

$$L_o = \varepsilon \cdot A_L$$

ε = coefficient of contraction
A_L = geometrical leakage area



For $A_2/A_1 = 0$ (e.g. windows in external walls), the coefficient of contraction becomes 0.59

In this case, the influence of wind direction must be take into consideration. An example for this influence is shown in fig.1. Appropriate pressure coefficients c_{pe} of the building surface must be used to calculate air infiltration. These pressure coefficients are to be derived from wind tunnel measurements (see /5/).

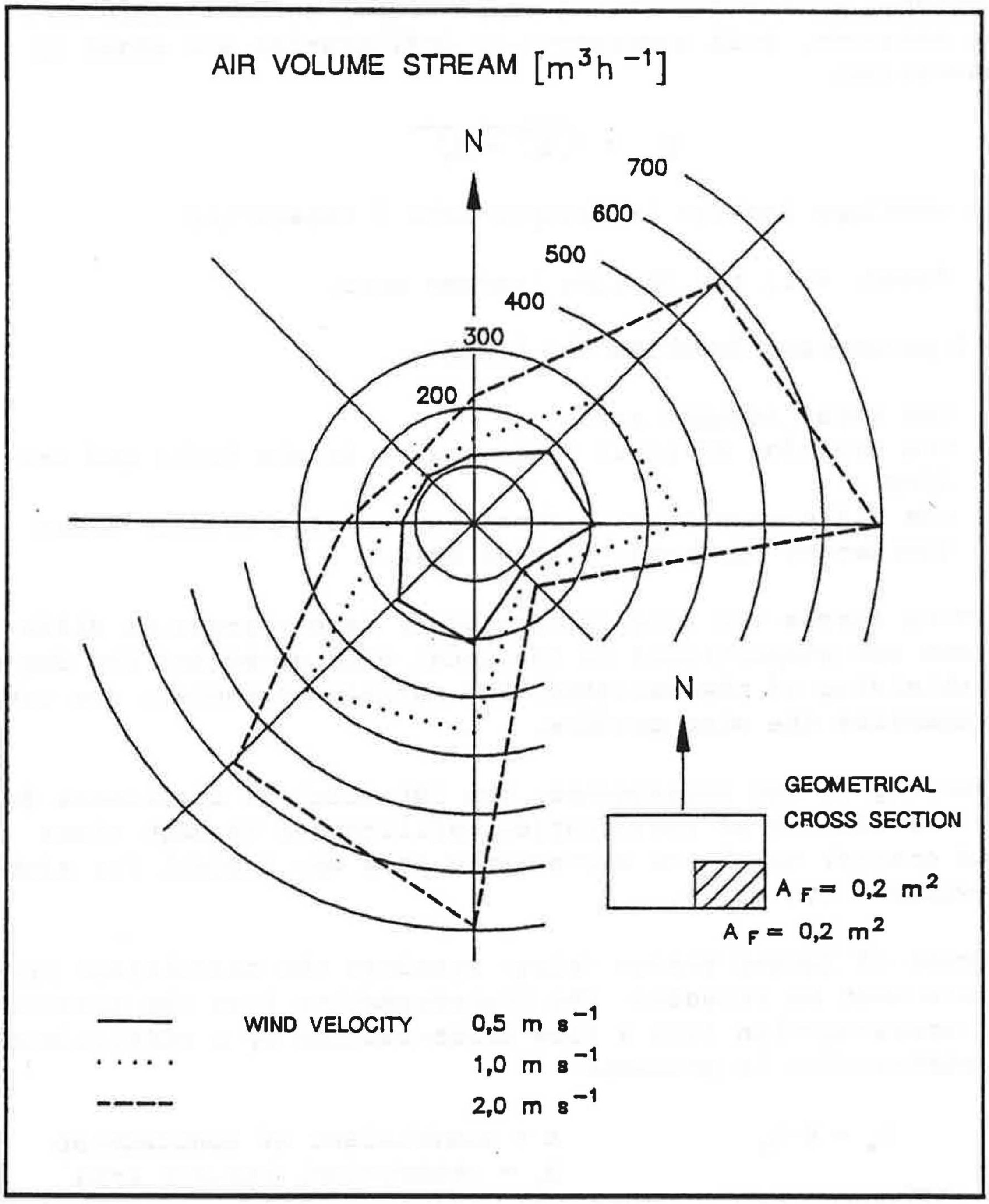


FIGURE 1. Calculated air volume stream through 2 tilt windows (each facade 1 window) depending on wind direction and different wind velocities.

MEASUREMENTS AND CALCULATION RESULTS

Ventilation Properties of "tilt & turn" Windows

From fig. 2 the result of calculation of airflow (V) depending on the cross section (A) have been shown for typical ventilation cases with tilt and turn windows (calculated for winter conditions for temperatur differences 10 to 30 K, summer conditions for a wind velocity of $1\ m \cdot s^{-1}$). As it can be seen from this figure, sufficient fresh air for cooling can be provided with "one facade ventilation" neither with tilt nor with fully opened position. Concerning "two facade ventilation" in summer and "one facade ventilation" in winter it must be said, that this kind of window offers a limited flexibility regarding the available air flow (only two possibilities).

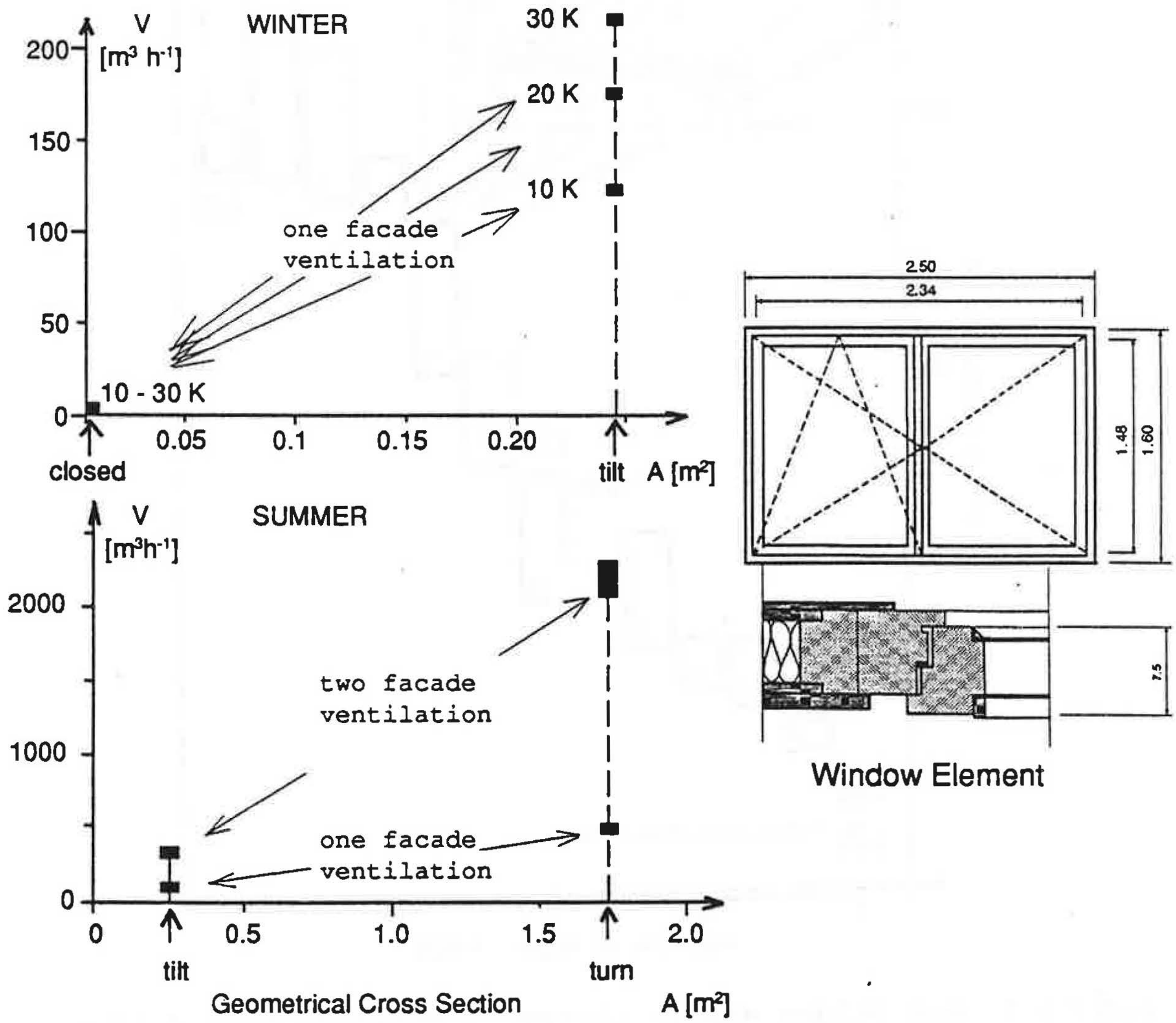


FIGURE 2. Air volume stream (V) through a tilt & turn window under winter and summer conditions.

Ventilation Properties of Adaptive Windows

The simplest way to change a tilt & turn window into an adaptive window is to install a mechanism for arrestable opening positions (window fixing device) in the tilt or turn modus of the window.
Fig. 3 shows the measured air volume flow (measured with tracergas technique) through a window with a fixing device depending on the opening position (measurements under winter conditions with no wind influence in a room with one window). As it can been seen from fig.3, the volume stream can be regulated with the aid of the fixing device.

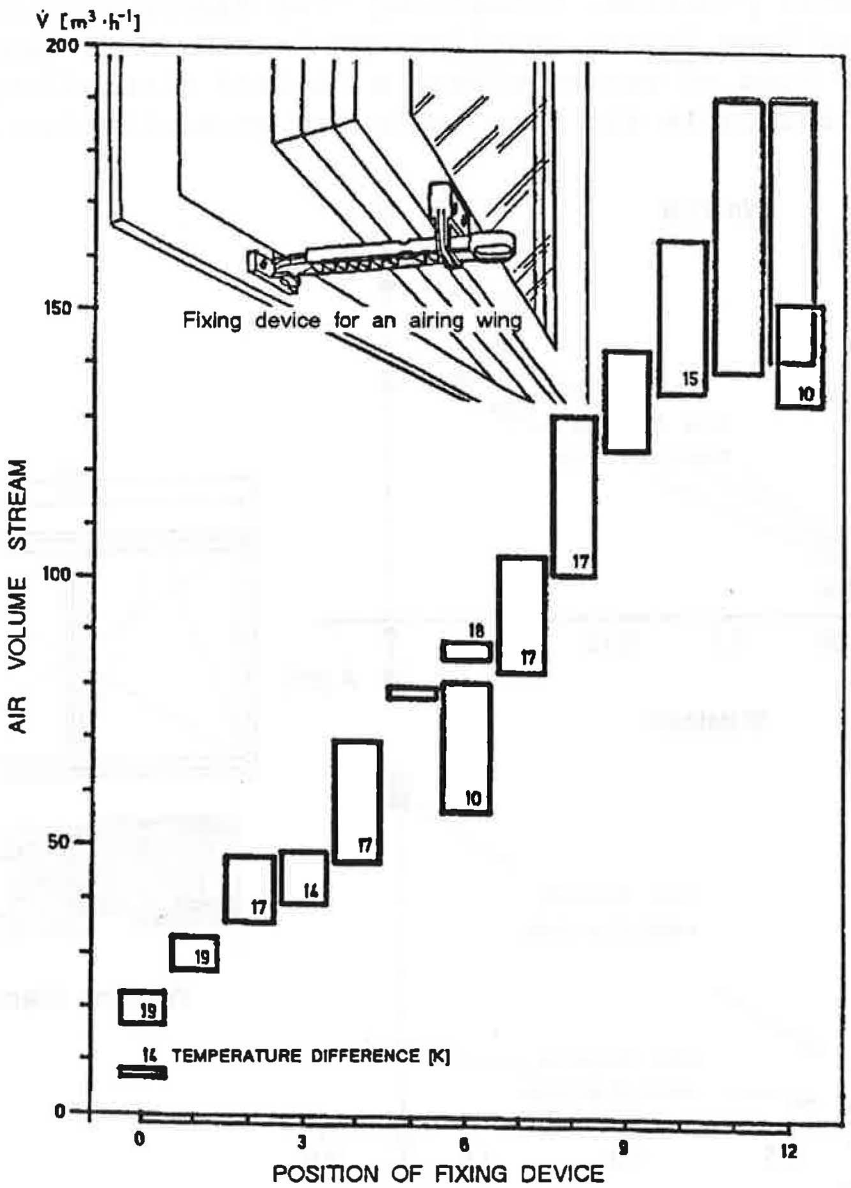


FIGURE 3. Air volume stream through a modified tilt & turn window depending on the position of the added fixing device.

A much better form of adaptive window includes a ventilating slot field in a separate frame next to the window element in a horizontal or vertical position. In this case, the flow opening is better protected and easier to handle.

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