PAPER 5

A SIMPLE METHOD FOR REPRESENTING THE TOTAL VENTILATION BEHAVIOUR OF AN APARTMENT BUILDING

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1. INTRODUCTION

The method, described below, may be applied for the determination of air leakage characteristics and for the assessment of energy saving measures. It was developed for four-storey apartment buildings with either natural ventilation (see Figure 1a) or mechanical extract ventilation (see Figure 1b). These building types are common in Sweden.

The air flow circuit for e.g. a second-storey apartment is represented in Figure 1c. It can be approximated by two resistances coupled in series.

The air flows through the two resistances must be the same and the sum of the pressures across the two resistances must equal the total driving pressure.

Since the flow through a resistance depends on its leakage characteristic, the total flow for the system can be represented graphically by plotting the leakage (n/p) curves "back-to-back" with a common axis for the flow rate (n) (see Figure 2).

2. THE DETERMINATION OF THE AIR INFILTRATION CHARACTERISTICS OF A BLOCK OF FLATS UNDER OPERATIONAL CONDITIONS

Pressurization tests in Sweden today are carried out at 50 Pa. This is well outside the normal range of operational conditions for a building.

When calculating air infiltration rates, the leakage characteristics for pressures within the normal range must be used.

This problem may be approached in one of two ways:

a) Extrapolate the leakage curve determined at high pressures to lower pressures.

b) Determine the leakage using operational pressures.

Accuracy is lost in both cases.

A method has been developed for estimating the leakage characteristics for an apartment in a four-storey residential building with natural ventilation. Each apartment may have 2, 3 or 4 ventilation channels running through a common stack to a vent above roof level (Figure 1a).

The resistance of the outside wall is high and, when the door and windows are closed and taped, forms a "bottle-neck" in the flow so that most of the pressure difference is developed across it. The total driving pressure is the stack pressure. The pressure difference across the outside wall is measured and the outflows through the open exhaust vents are summed. This value is plotted on an n/p diagram, i.e. point A on Figure 3.

By sealing one or more of the exhaust openings with plastic film, the pressure differences across the outer walls is reduced. The outflow through the remaining open exhaust vents gives a new point B.

The characteristics of the ventilation shafts can be arrived at by carrying out a similar exercise with the shafts open and a door or window open to varying degrees. A partially open window yields point C. A fully open window or door yields point D for which the total driving pressure acts across the ventilation shaft alone.

The resulting curves can then be used in the manner of Figure 2 to find the air change rate for any given stack pressure.

The method was tested for several apartments during April-May 1981 as part of a larger research project involving measurements in 500 apartments. At this time, the weather became too warm for the method to be effective. The method has been employed and found very useful during the winter 1981/1982.

3. WHAT ABOUT THE WIND EFFECT ?

It can be demonstrated theoretically and in practice that for buildings with tight construction, and for the stack dominated weather conditions suited to this test, the wind effect is important for the flow through the walls.

However, wind does still affect the top of the ventilation shafts. The magnitude of this effect is not well known, and will be investigated as part of the current research programme with a view to modifying the design of the outlet to minimise the effects of wind.

4. CONTROLLING THE VENTILATION RATE IN NATURALLY VENTILATED FLATS

Some of the apartments in the project have been, or soon will be, fitted with a thermostatically controlled ventilation inlet valve for which the open area decreases as the outside temperature decreases. This provides an almost constant flow rate across the outside walls of the flat.

The flow for a range of outside temperatures normalised to the flow at $0^{o}C$ is illustrated in Figure 4.

5. ASSESSMENT OF ENERGY SAVING BY SEALING THE ENVELOPE

The presentation of leakage data in the "back-to-back" form of Figure 2 can also be used if the natural ventilation channels are replaced by a mechanical extract system (see Figure 1b).

Thus the method can be used to investigate the effects of such practices as sealing the external walls of naturally ventilated and exhaust ventilated buildings.

The leakage characteristics for outside walls with an air change rate (at 50 Pa) of 1.5 and 0.75 air changes per hour are illustrated in Figure 5a.

The corresponding curves for the ventilation exhaust shafts for natural and extract ventilation systems are given in Figures 5b and 5c respectively. Figures 6a and 6b represent the effects of placing 5a "back-to-back" with 5b and 5c respectively. (Note the change of pressure scale).

It will be observed from Figure 6a that for the natural ventilation system, with the same total pressure difference (9 Pa), that there is a substantially reduced air change rate from 0.6 ach (air changes per hour) to 0.3 ach after sealing.

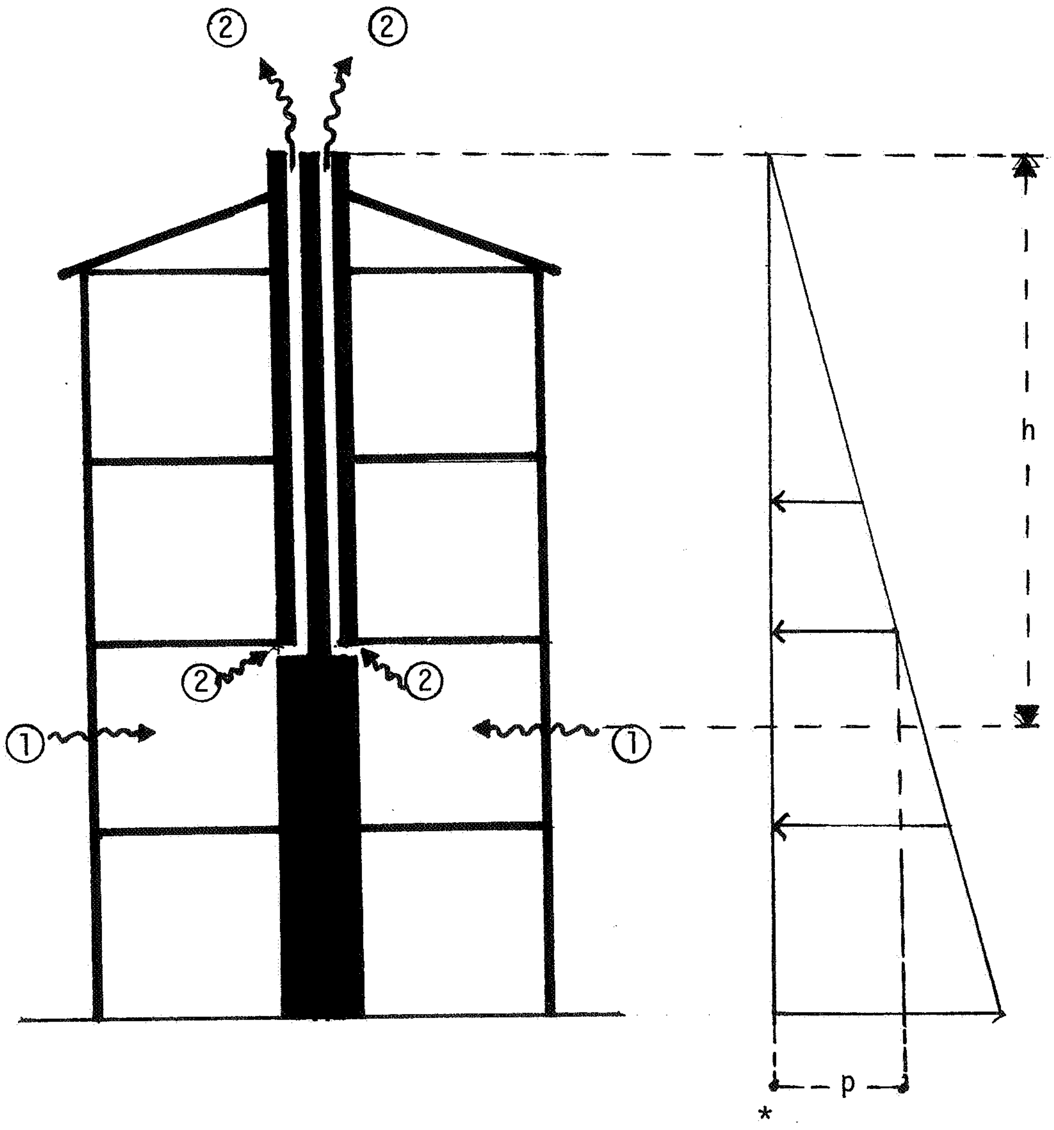
For the mechanical system, Figure 6b, the total driving pressure is 300 Pa. The effect of the exhaust fan predominates and the reduction in air change rate is very small or negligible.

6. COMMENTS

The above examples show that the air flow characteristics of a building and of its ventilation system must be regarded as an organic whole.

Lack of understanding of the effects of the interactions between the various parts of the total system on the functioning of the system poses a severe problem when seeking effective strategies for energy saving in buildings.

Figure 1(a) Naturally ventilated building



* $p \simeq 0.04.h.(T_i - T_o)$

Figure 1(b) Mechanically ventilated building

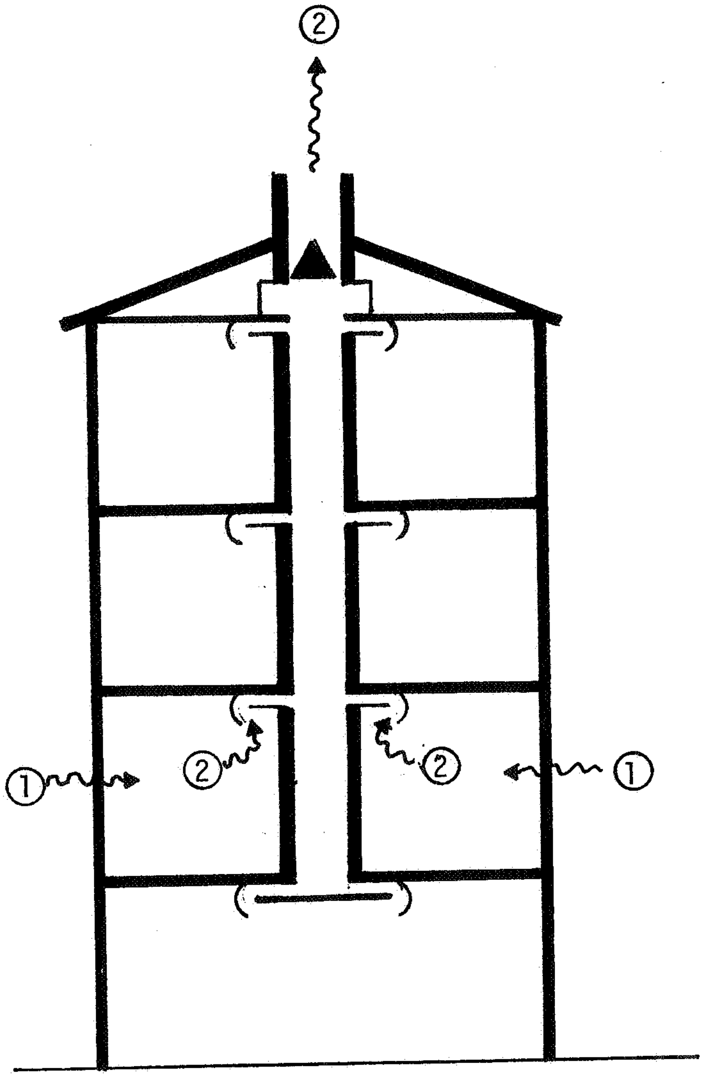
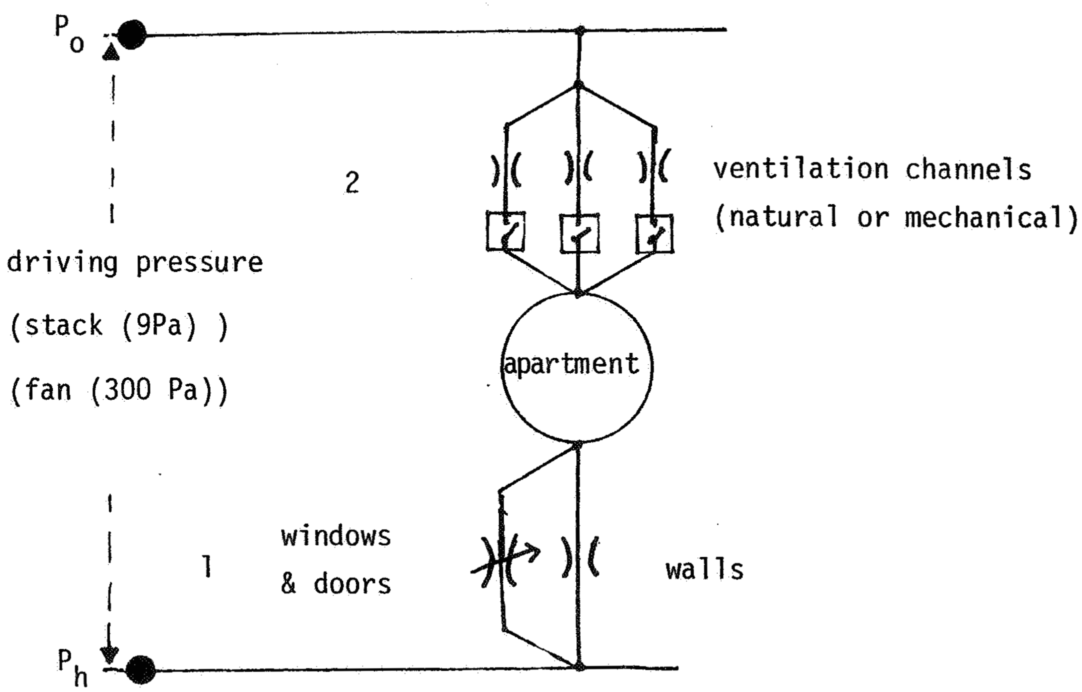


Figure 1c Schematic diagram of the air flow circuit for the flat



- fixed resistances (e.g. wall)
- variable resistances (e.g. openable window)
- closure (e.g. damper, plastic sheet sealing an opening)

Figure 2 Graphical description of air exchange by total pressure difference

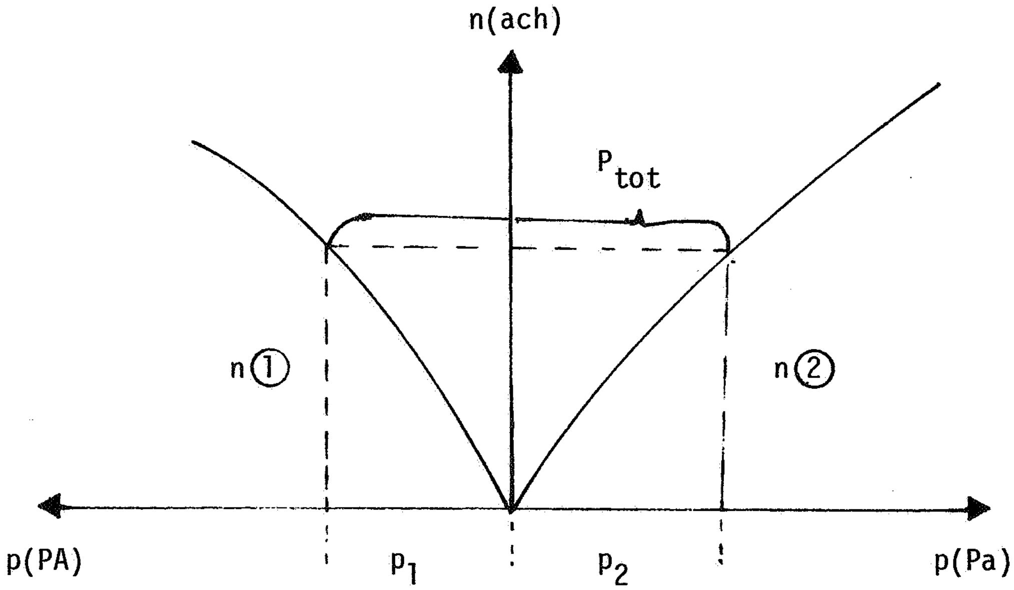


Figure 3 Leakage graphs of outer walls ① and ventilation channels ②

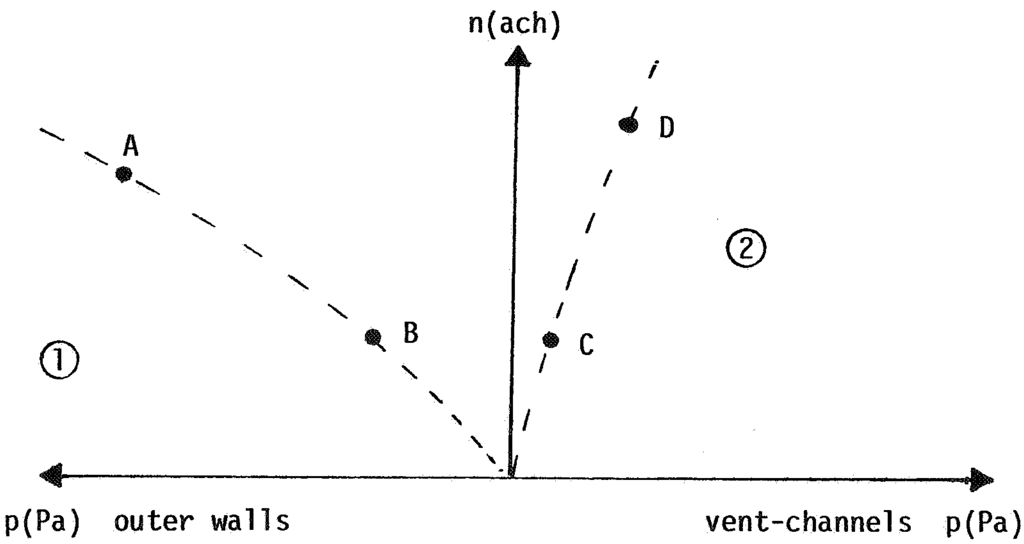
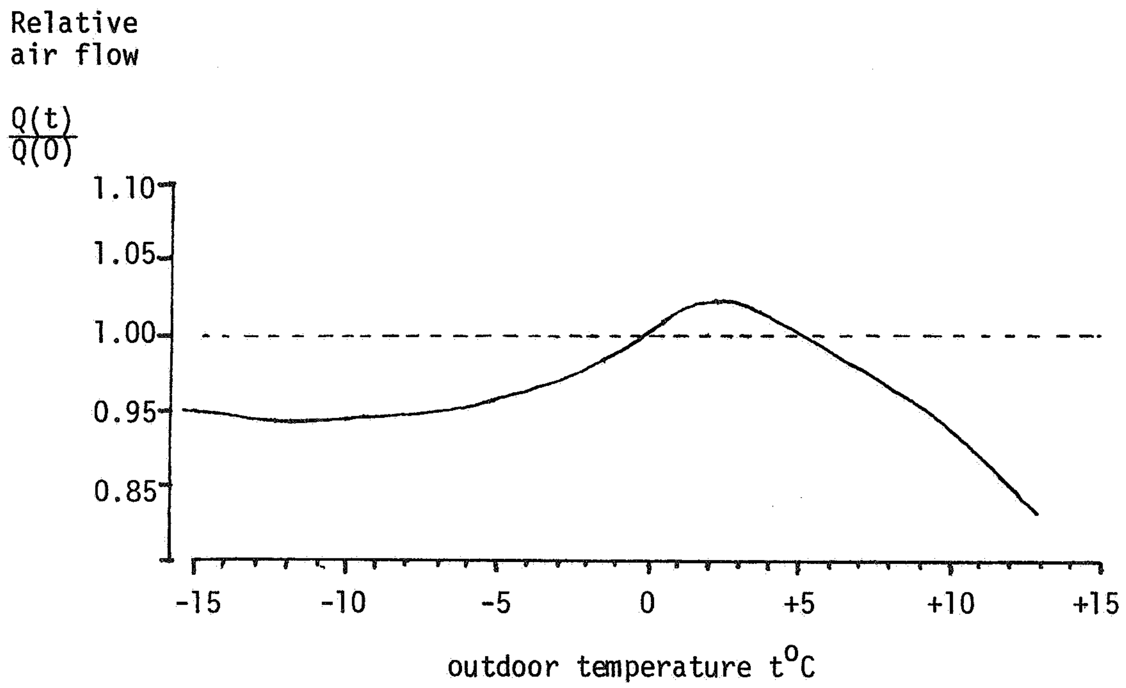
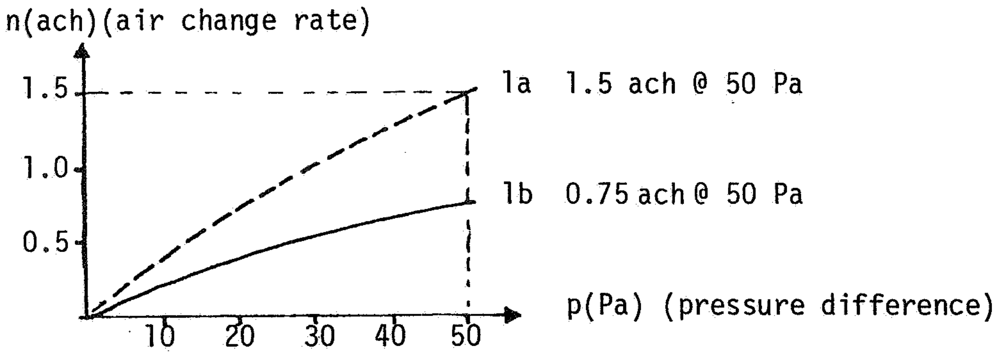


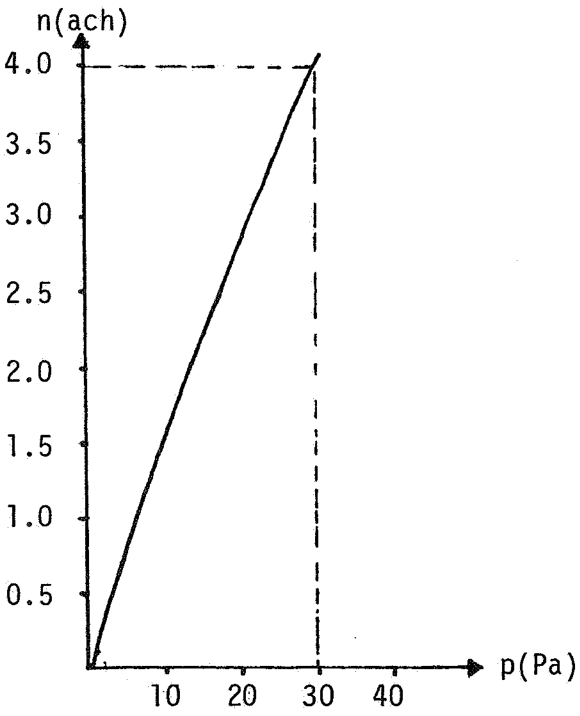
Figure 4 Temperature dependent flow characteristic of inlet valve



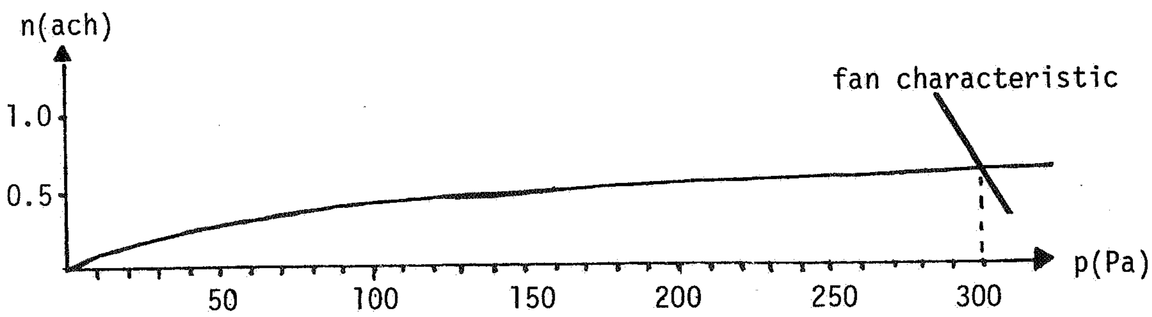
5a Walls



5b Natural ventilation system



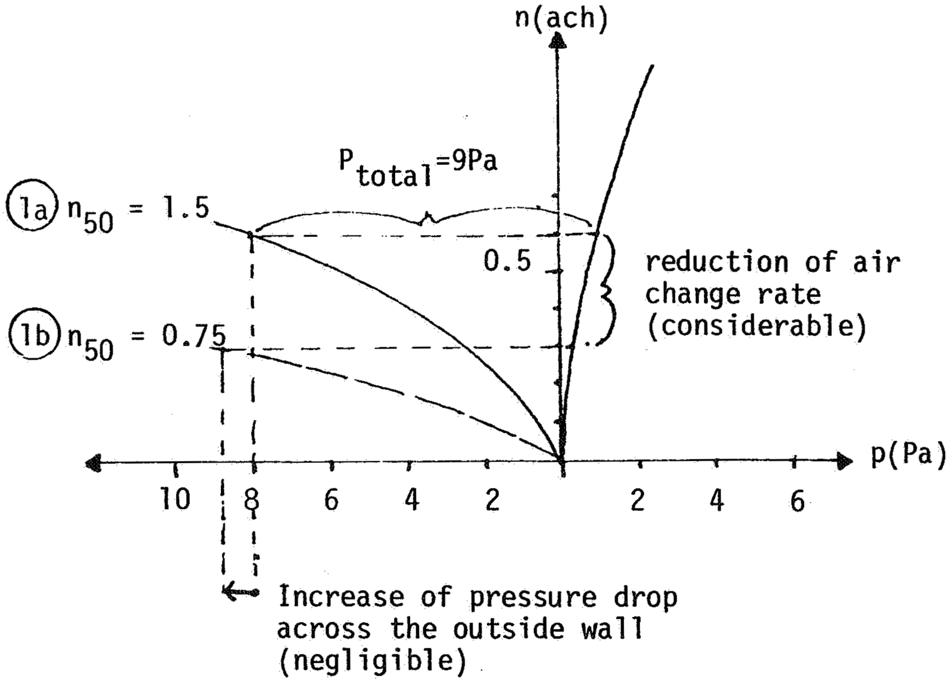
5c Mechanical ventilation system



*Note change of scale

Figure 6 Diagrams to demonstrate the effect of sealing the outside walls

a) Natural ventilation system



b) Mechanical ventilation system