PAPER 13

CHANGING THE VENTILATION PATTERN OF A HOUSE

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1. Introduction

Two series of pressurisation and ventilation measurements have been made in a low-energy house. One of the objectives of the work was to assess the extent to which the ventilation pattern of the house could be improved by modifying its leakage distribution. The first series of measurements was interpreted to understand the ventilation pattern and to make recommendations for the modifications. The second series was used to find out the effects of the modifications.

Throughout this paper the term ventilation rate is used to denote the volume flow rate of air entering a room (or the whole house) directly from outside, divided by the volume of the room i.e. the ventilation rate of the room is the fresh air change rate.

The term stack effect denotes the temperature difference between the inside and the outside of the house.

2. Description of the House and the Measurement Methods

The house, built on split levels on a hillside, is part of a long terrace within an estate. It has a brick outer wall and an insulating block inner wall, with an insulated dry lining. The design heat loss is 5kW and the house is centrally heated by a gas-fired boiler. A plan of the house and its spatial orientation are given in Fig.1. The lowest level contained a utility room and entrance hall. Stairs led to the first landing, the kitchen and lounge; further stairs reached the second landing and the bathroom and toilet, these being directly above the utility room and entrance hall. A third set of stairs extended to the top landing and 3 bedrooms, these being above the kitchen and lounge. There were two separate attic spaces accessible from the bathroom and bedroom 2 respectively. The house was at the end of the terrace and was exposed, in varying degrees, to winds from the East, South and West. The volume of the house, excluding the utility room and internal cupboards which were kept shut, was 160 m^3. The windows were adequately weatherstripped but that on the doors had deteriorated.

Pressurisation measurements were made on the whole house and on individual rooms using a technique described previously (1). Ventilation rate measurements for the whole house and individual rooms were made using Autovent, the automatic monitoring equipment developed by British Gas for ventilation studies in dwellings (1).

The Autovent apparatus provides detailed information on the volume of fresh air entering each room of the house. By studying this data as a function of measured wind conditions and stack effect and using our knowledge of the leakage of the house and the rooms, we built up a picture of the ventilation pattern. We had precise knowledge of the entry points for fresh air, but exit routes were inferred. The results are described below.

3. Before Modification

3.1. Leakages

The leakage distribution is shown on the left hand side of Fig.2. It can be seen that the biggest measured leakages are in the bathroom, hall and bedroom 1, but the biggest actual leakage was due to the stairwells and landings which was determined by subraction of the measured room leakages from the total.

Smoke flow visualisation was performed during the tests to indicate large sources of leakages. The major leakages in the bathroom were at floor level and around the bath and those in the hall were around the door and door frame.

3.2. Ventilation rates

In all there were 132 separate half-hourly average ventilation rates determined. Of these 122 were for wind directions lying in the range $230^{o}C$ through North to 180^{o}. For this range it was found that stack effect was a very important determinant of the whole house ventilation rate R_H. A regression analysis of the results showed that R_H was seven times more sensitive to $\sqrt{\Delta T}$ (ΔT is the internal/ external temperature difference, ^{o}C) than to wind speed U (m/s).

However, for the small range of wind directions from 180^{o} to 230^{o} R_H showed an almost equal dependence on wind and stack effects, and this manifested itself in relatively higher ventilation rates for a given $\sqrt{\Delta T}$. This directional effect is shown in Figure 2 where R_H is plotted against wind directions for a fairly narrow band of wind speeds and a roughly constant stack effect.

Additional information on the ventilation pattern of the house came from an anlysis of the room ventilation rates. The mean ventilation rates of the hall and bathroom were by far the largest (expressed in room volumes per hour). They were roughly ten times larger than those of the kitchen, living room and toilet. The mean rates in the bedrooms were very low (less than 0.1 h^{-1}). In many instances the bedrooms had no fresh air entry i.e. only air from other parts of the house entered the bedrooms.

4. Modification to leakage distribution

From the results of the first series of tests it was decided that the average of the whole house ventilation rate was probably satisfactory, but the pattern of ventilation was open to improvement. Briefly summarised, the objectives were

(i) to maintain the average whole house ventilation rate,

(ii) to increase the ventilation rates in the living room and the bedrooms,

and (iii) to decrease the ventilation rates in the hall and bathroom.

With these aims in view, the following modifications were carried out.

(a) All of the rooms and the landing were fitted with (closeable) strip ventilators.

(b) Gaps in the joins between floors, walls and ceilings in the hall, bathroom and toilet were sealed with tape. The hall door was weatherstripped with durable material.

5. After modification

5.1. Leakages

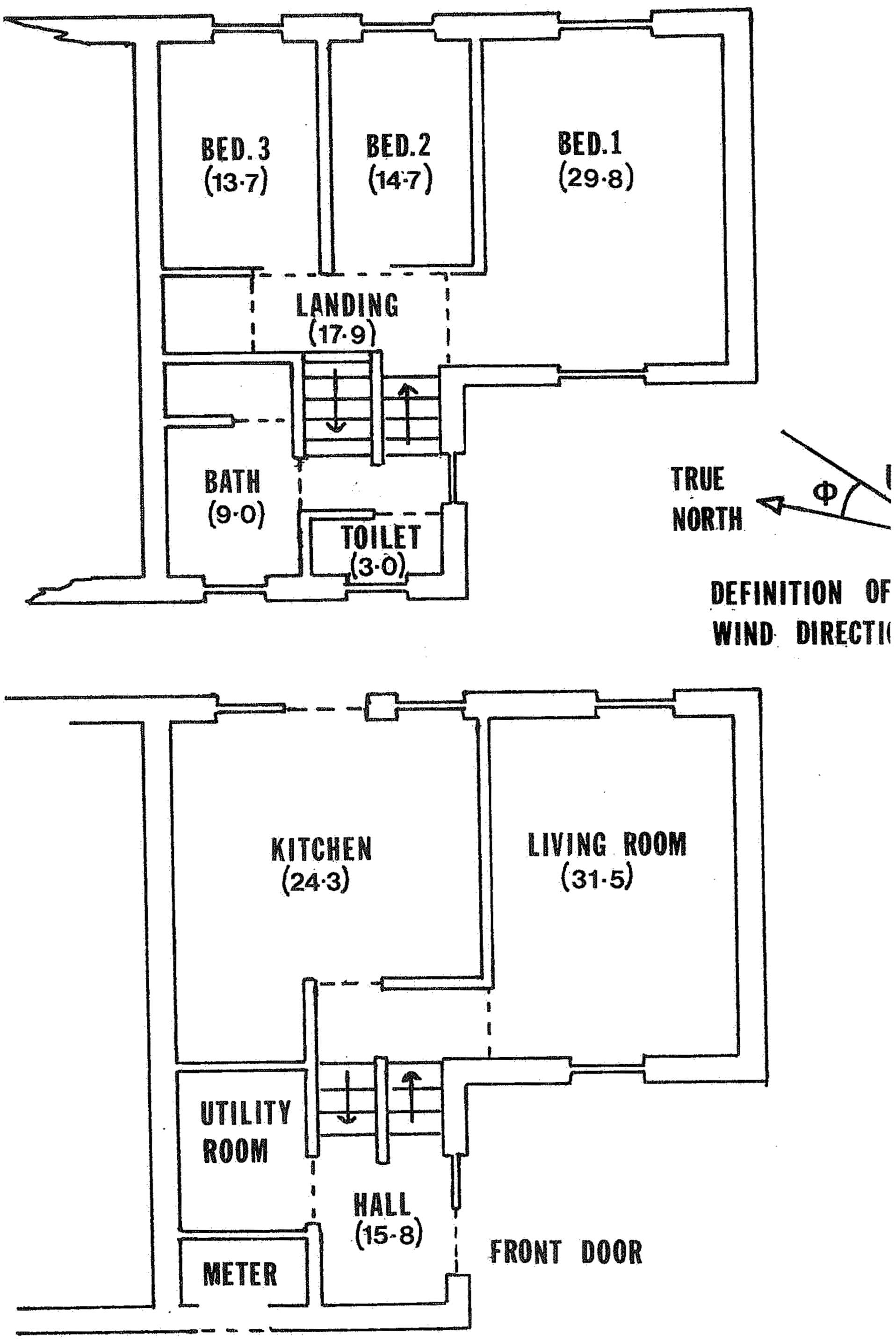
Figure 2 compares the leakage distribution measured after the modification with that measured before. It can be seen that the total leakage after modification is about 10% less than that measured before. The leakages of the hall, bathroom and toilet have been substantially decreased, whereas the leakages of the kitchen, living room and the three bedrooms have been increased, presumably due to the installation of the strip vents. In the hall, bathroom and toilet the sealing measures were sufficiently effective to more than compensate for the installation of the vents.

5.2. Whole House ventilation rates

Figure 4 compares the values of R_H before and after modification, plotted against wind speed. For clarity, no distinction has been made between different wind directions, or between those results which have different arrangements of open vents and open internal doors. These differences are the main reasons for the apparent scatter in the results. All of the results however correspond to the range of stack parameter indicated in Figure 4.

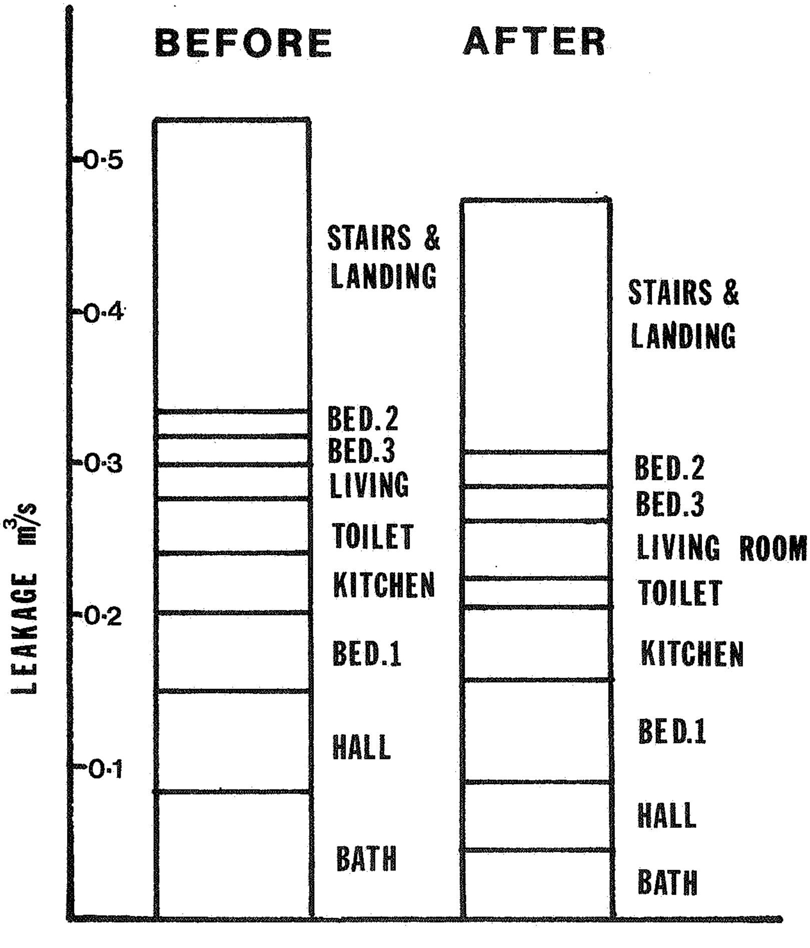
It can be seen that, despite the greater leakage before modification, the whole house ventilation rates have generally been increased by the modifications. These increases are however relatively small when compared to the changes observed for some of the rooms.

FIGURE 1 PLAN OF THE HOUSE SHOWING ROOM VOLUMES



not to scale

FIGURE 2. LEAKAGE DISTRIBUTION BEFORE AND AFTER MODIFICATION



LEAKAGE AT ΔP=20Pa

Fig.3 VARIATION IN WHOLE-HOUSE VENTILATION RATE WITH WIND DIRECTION

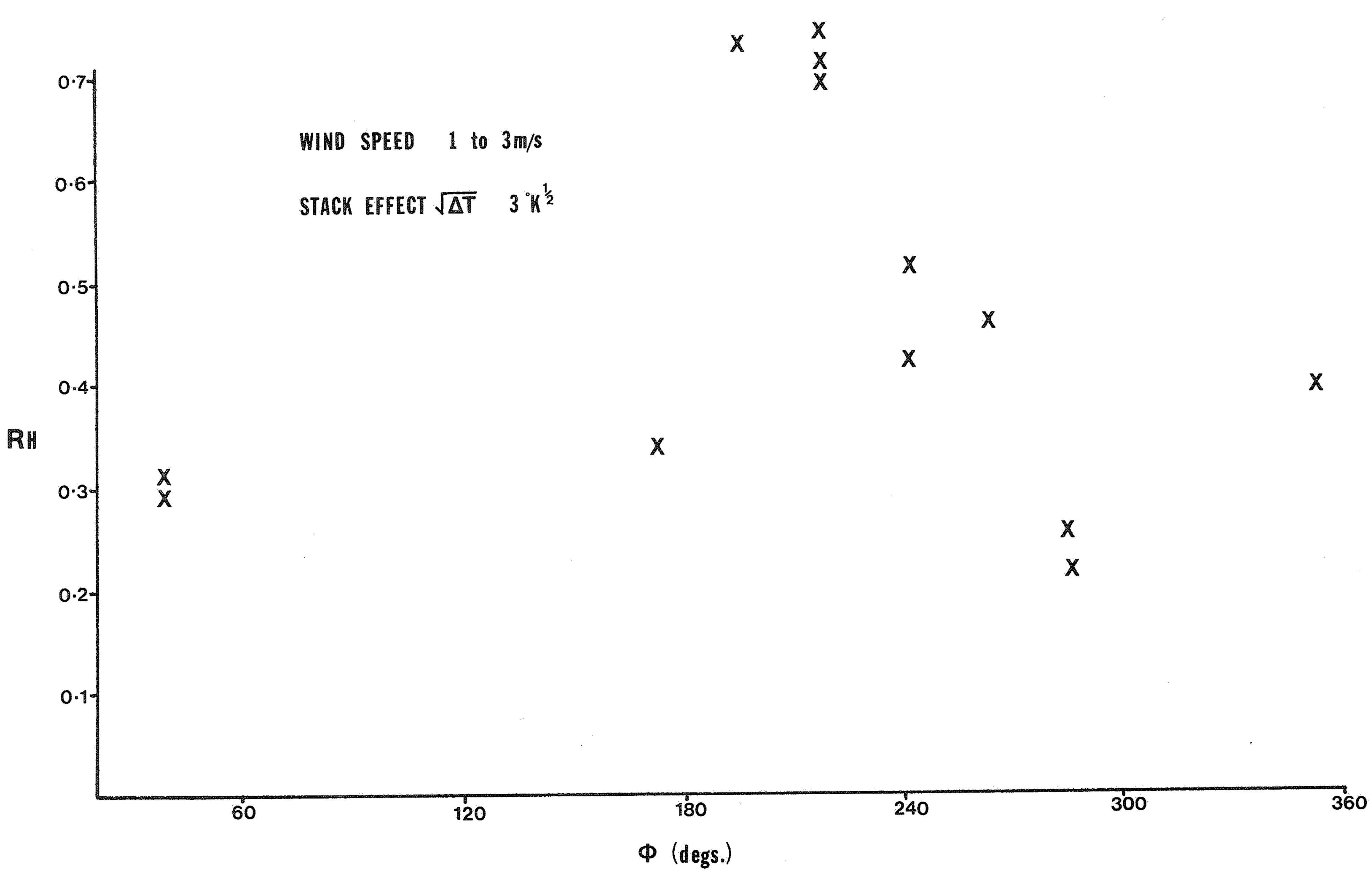


Fig.4 COMPARISON OF WHOLE-HOUSE VENTILATION RATES

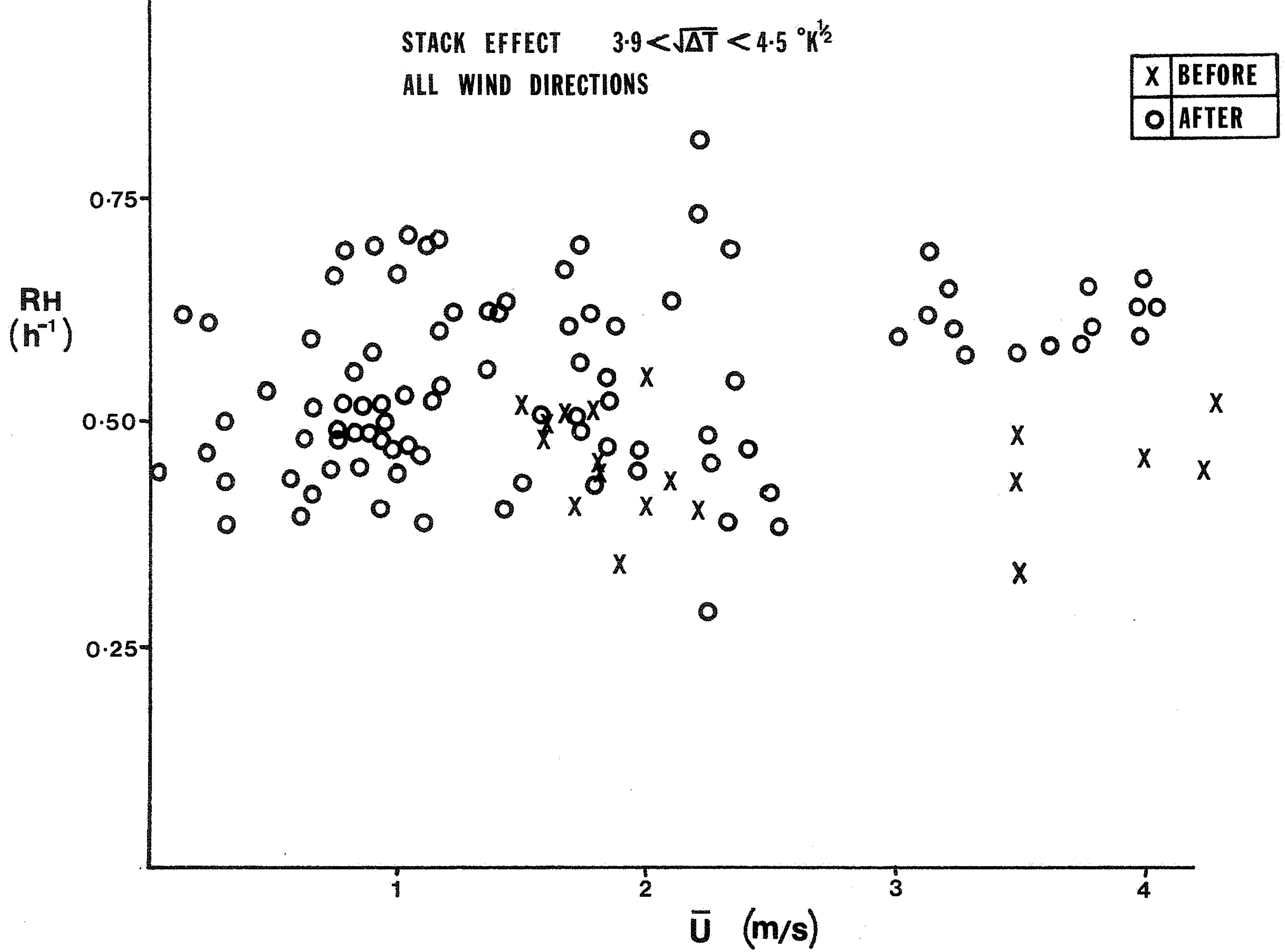


Fig.5 COMPARISON OF BATHROOM VENTILATION RATES

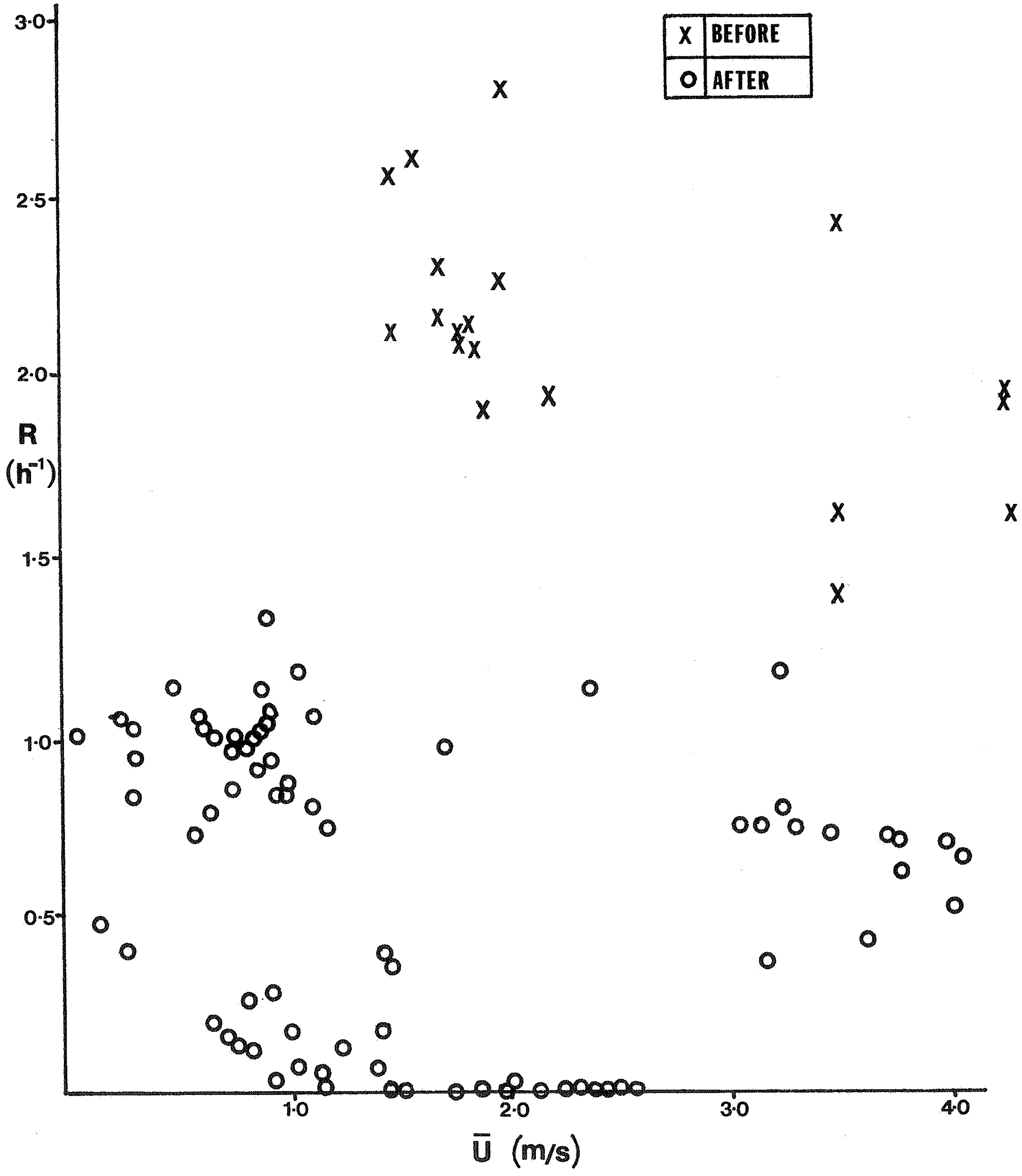


Fig.6 COMPARISON OF HALL VENTILATION RATES