F 2180

Short report on research project.
"Relationships between energy-saving and interior humidity
"Business reference: B I 5 - 80 01 86 - 202

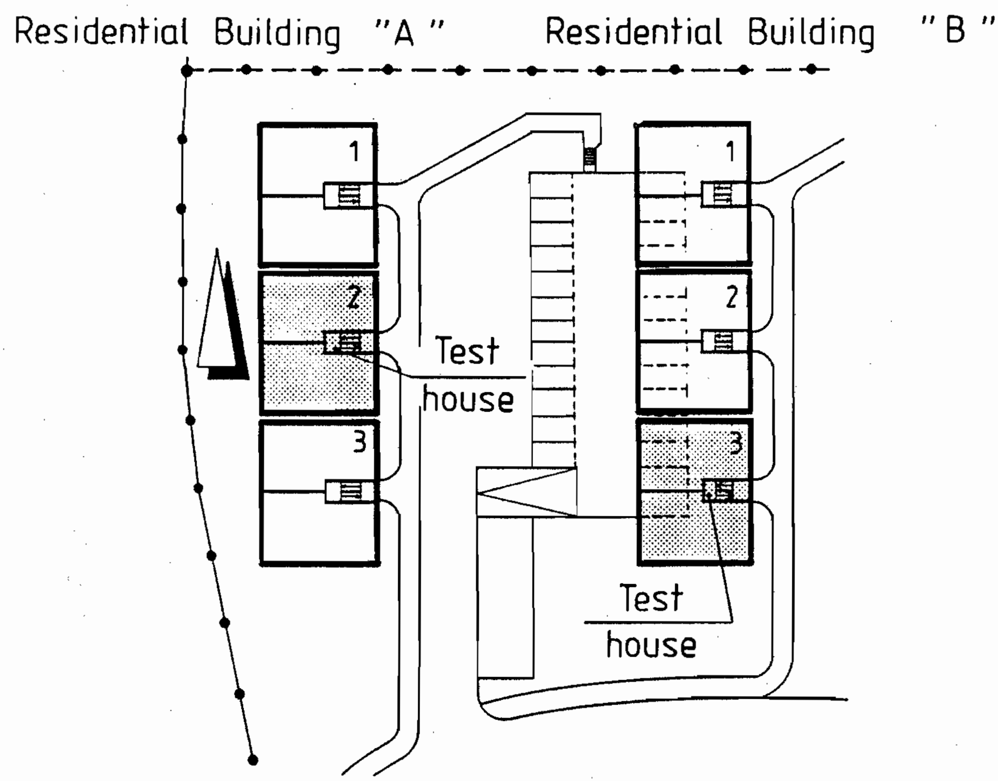
Aim of research project

The aim of the work is to investigate the temperature, humidity and energy consumption of flats with different ventilation systems.
A new aspect is the application of a type of graphic representation that readily enables the investigation of factors such as temperature, humidity and ventilation system with only a few diagrams.
The data appear in a raster which is embedded in a system of coordinates. In order to enable comparisons between experimental curves, hourly or daily rasters are set up. The temperature and humidity axes are of importance only in their mutual relationship; they enable ready recognition of what is warmer or more humid or both.
The representation of the experimental data in Mollier's h,x-diagram furthermore allows differences between individual flats as well as seasonal variations in the behaviour of the occupants to be displayed.

Implementation of research project

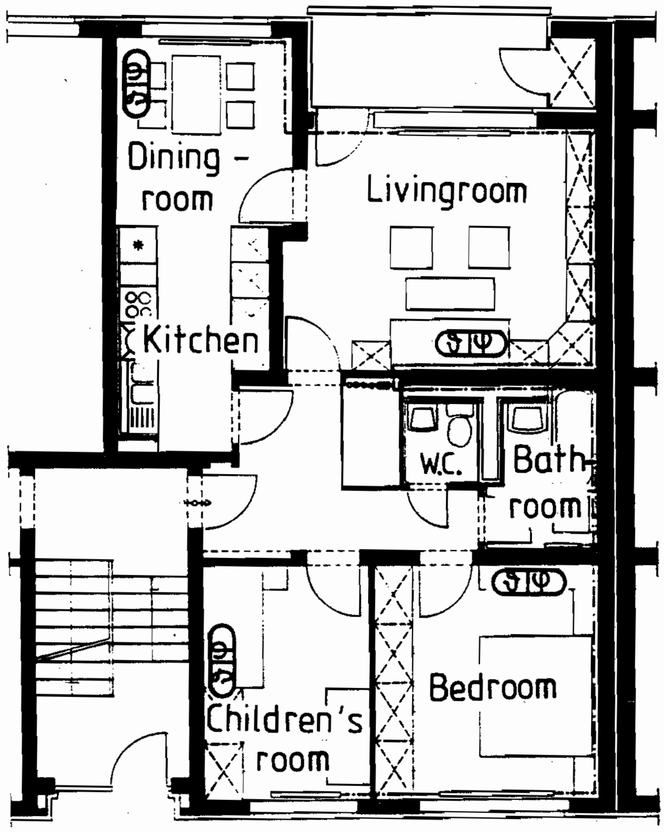
The object under research consists of a total of 4 housing blocks (Fig. 1). The housing blocks are labelled Block A to Block D. Each housing block consists of 3 houses each containing 8 flats. The houses are numbered from 1 to 3 (e.g. A1, A2, A3). Each house has 4 floors, upon each of which 2 flats are built symmetrically around the staircase. The housing estate was built within the scope of the building of social housing, and allows research of the domestic behaviour of the tenants as concerns the interior climate. There were previously almost no investigations of temperature and humidity in occupied flats as in the present case and to this extent, so that at the end of this project, a large body of data on occupied flats was available for the first time, and it was no longer necessary to be satisfied with purely theoretical considerations.

Fig. 1: Plan view of object under research



The plan view of one flat is represented in Fig. 2. This is identical for all flats, so that different experimental results must be attributed to constructional differences (ventilation systems) or to differences in dwelling behaviour.
Exact measurements were made on the centre house of block A (Block A, House 2) and on Block B, House 3; these are represented with hatching in Fig. 1. In each flat of these houses, the temperature and relative humidity were recorded at 4 measuring points (Fig. 2), as well as the heating and electrical consumption in Block A. Data on the outdoor weather was likewise recorded.

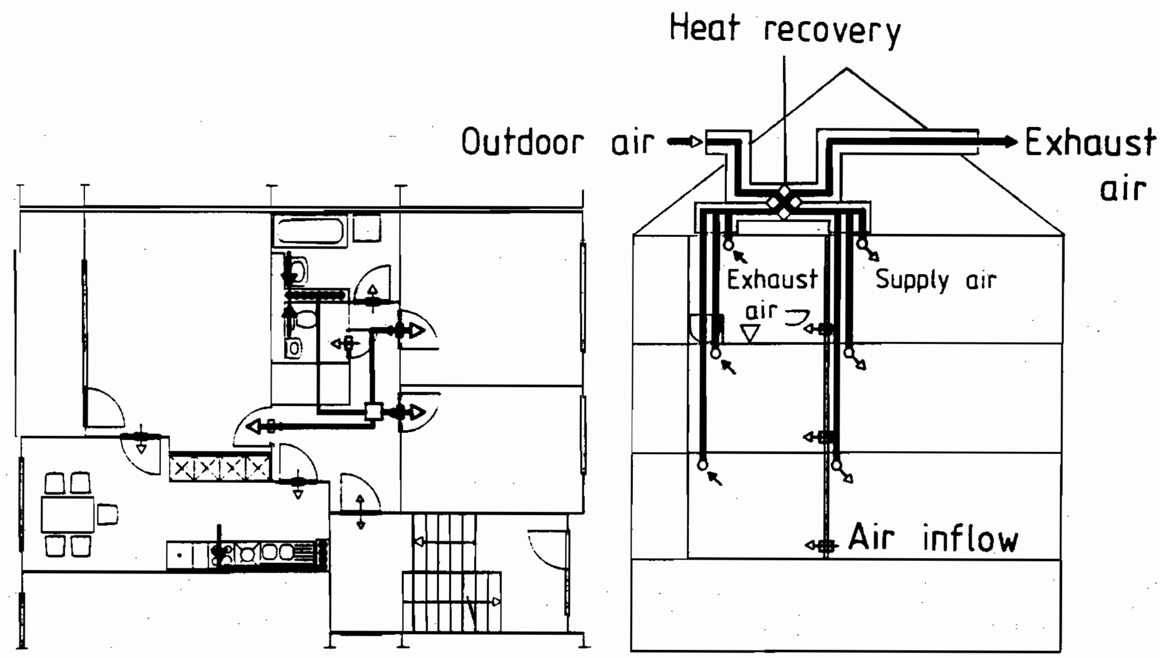
Fig. 2: Ground plan of an experimental flat and position of the measuring sensors in the flats



The experimental data were evaluated on University computers and on PCs (personal computers). The house occupants were informed of the installation of the measuring sensors, but had no exact knowledge of the functioning of the technical installations. It was gratifying to find that the tenants were able to live "normally" despite the visibly-installed sensors. They did not allow their behaviour to be influenced, as indicated by sample questioning.

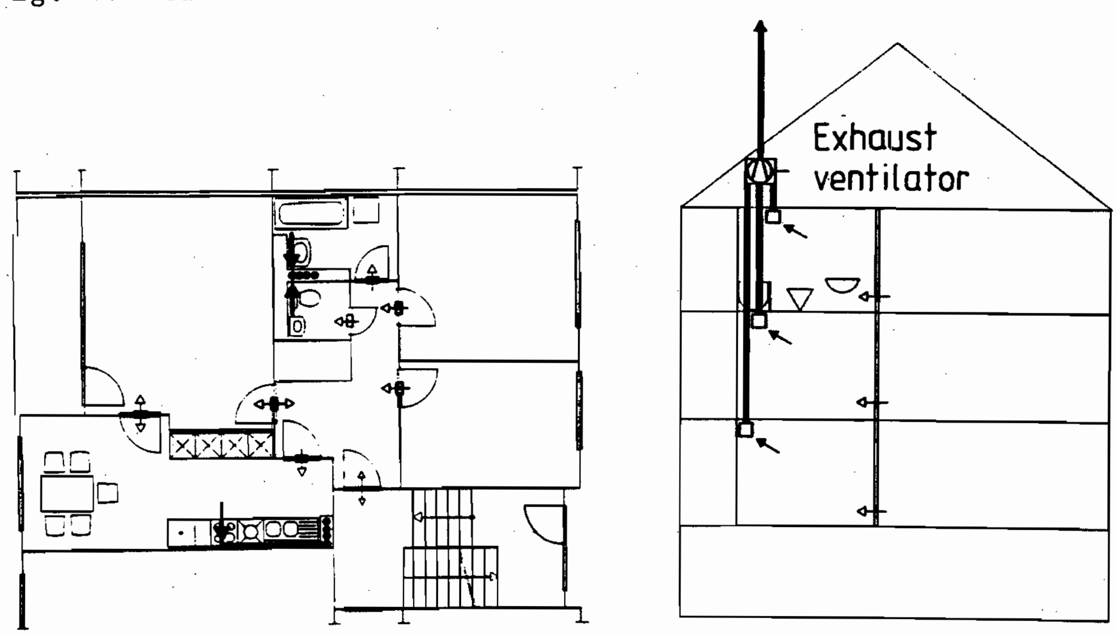
Some of the flats in Block A were provided with a mechanical, central air-conditioning plant with heat recovery (Fig. 3) in the attic. Part of the energy from the exit air was returned to the inlet air via a plate heat-exchanger. The air was distributed via a network of dicts on the hallway ceiling. Air is introduced into the living area (parents', children's and living rooms), and is extracted from the bath, WC and kitchen.

Fig. 3: Flat with mechanical ventilation



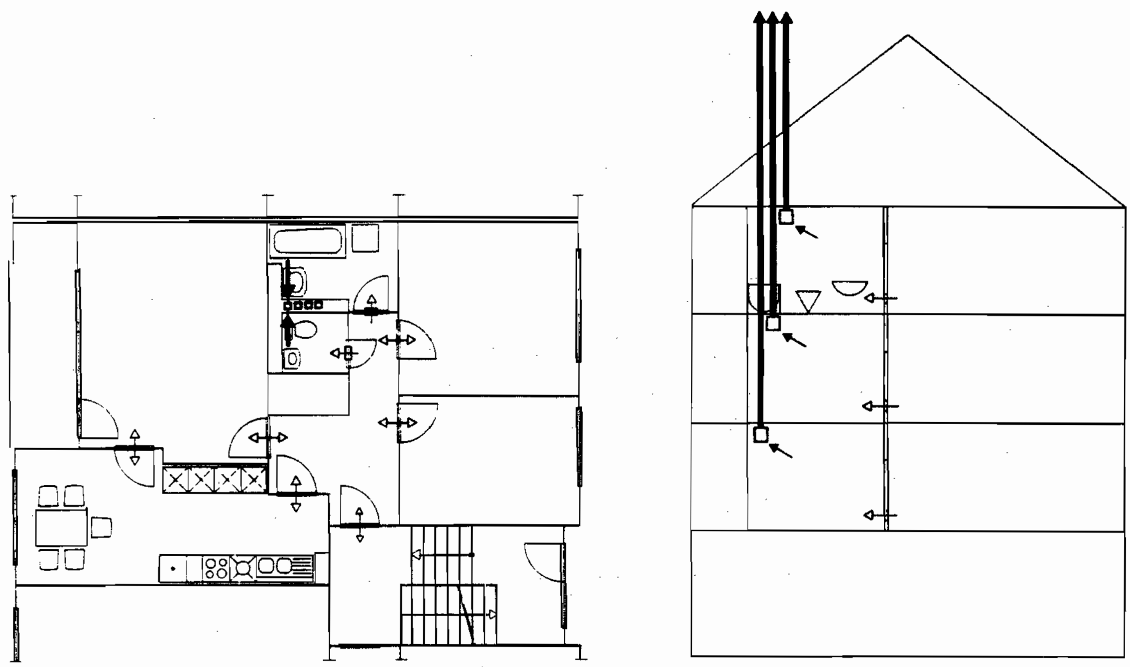
In order to investigate a mechanical ventilation system (Fig. 4) in House 2, the air input to one flat was switched off, so that air was still extracted, but outdoor air had to flow in through windows and doors.

Fig. 4: Flat with mechanical air extraction



A second research house was available on the same housing estate: this was an equivalent dwelling house, labelled Block B3; this had a natural ventilation system (Fig. 5): a ventilation shaft system which is also known as "Berlin ventilation". Air inlet is possible only via the cracks around the windows or around the door to the staircase. In order to achieve adequate air inlet, the windows must additionally be opened.

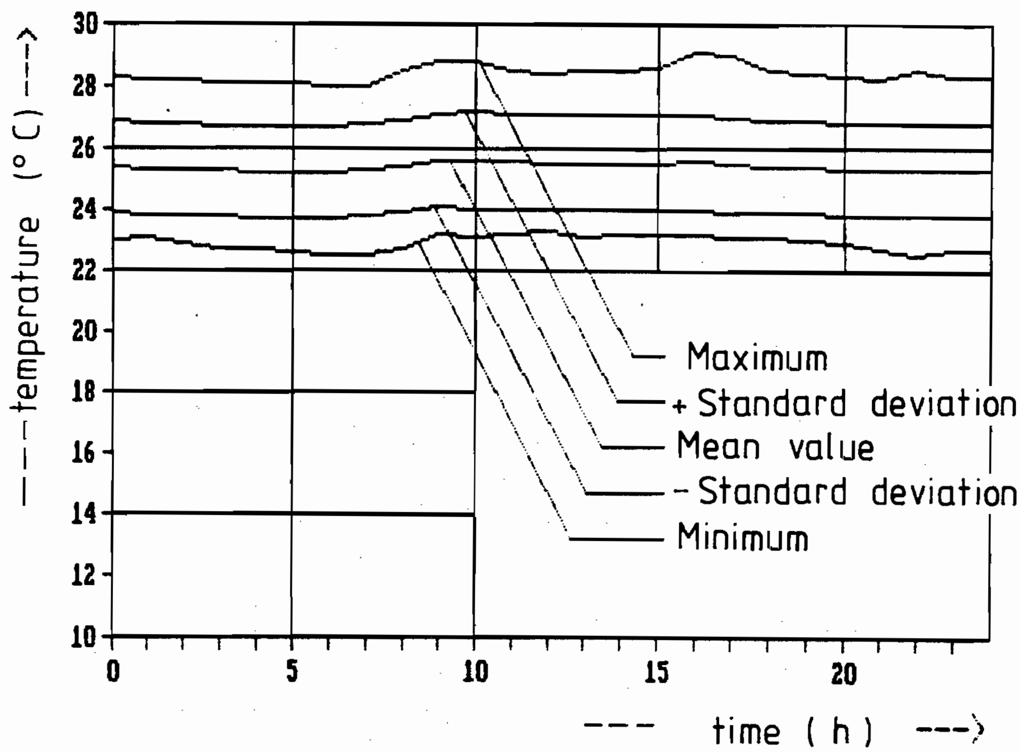
Fig. 5: Flat with conventional shaft ventilation



Curves of the mean temperature and of the mean and relative humidities are displayed for the flats described above. Initially, half-annual curves were investigated, and then monthly curves for July, October, January and March, representative for each of the seasons summer, autumn, winter and spring.

A further very interesting form of representing temperature and humidity results when the mean values for each hour of a day are calculated for a month. When the pertaining hourly standard deviations are plotted, the band either side of the curve of mean values shows how the occupants in general live. When the curve of maxima and minima is additionally included, indications of occasional extreme lifestyle are obtained.

Fig. 6: Example of a daily curve

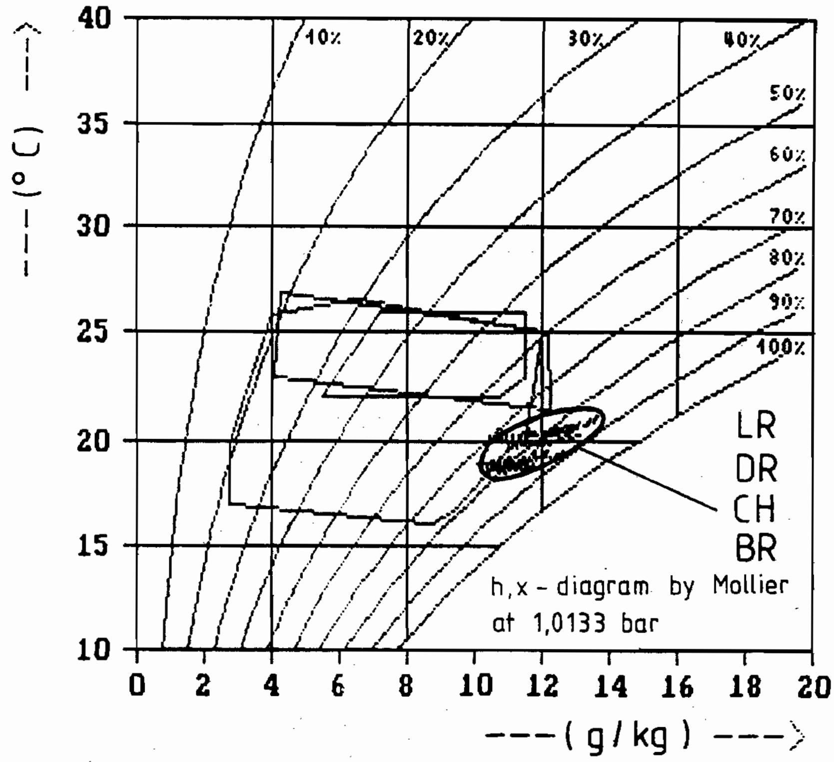


A new representation of the experimental values is obtained in combination with the h,x-diagram according to Mollier. This is achieved by plotting the measurements of temperature and relative humidity in the h,x diagram. This results in experimentally-measured comfort fields which are compared to the comfort fields of Ashrae, DIN 1946 and of Leudsen-Freymark.

Fig. 7 shows for the example of the children's room in October the manner in which the overall representation of a flat is built up from the measuring points of the individual rooms (children's, parents', living and dining rooms).

The seasonal and annual representations of the various flats with their different ventilation systems were represented and compared.

Fig. 7: Example of children's room 10/86 Block B gf



Summary of results

Temperature, air humidity, data of outdoor weather, heatingenergy consumption and electrical consumption are graphically represented and evaluated for different ventilation systems in the living and residential areas in occupied dwellings.

A new method results from an application of Mollier's h,x-diagram. Previous graphic methods are improved by point fields.

The following individual for results were obtained:

Evaluation of the graphic representation of the experimental data in curve form permits a rapid visual impression of the experimental results.

Dwelling behaviour is mainly influenced by the following three factors:

a. Outdoor climate b. Lifestyle c. Ventilation system

The influence of these three factors in this order increases as winter approaches, i.e. though the weighting of the factors changes, the influence of none of them disappears.
The influence of the outdoor climate cannot be completely "switched off" by ventilation and heating.
Flats with mechanical inlet and extraction ventilation are drier, and approach the outdoor climate more nearly than do flats ventilated by natural ventilation.
As the investigations have shown, the subjective comfort of the occupants is more important with respect to the room temperature than with respect to the air humidity. The occupants therefore regulate the temperature via the room heater, but they do not influence the humidity.
Plotting the experimental measurements in Mollier's h,x-diagram (point fields) permits comparison with the comfort fields represented in the literature.
The advantage of this method of representation is that all important data of the flat investigated are contained in a single diagram:
Temperature, relative humidity, absolute humidity, risk of condensation formation, as well as particular forms of lifestyle, or how one flat behaves in comparison to others.
All investigations show that, in flats, much depends on the spontaneous, "unconscious" lifestyle of the inhabitants, and thus the outdoor climate influences the interior climate.