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Influence of Air Infiltration on Heat Losses in Multi-Family Dwelling Houses

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SYNOPSIS

The paper presents a proposal of numerical procedure for air flow simulation in multi-zone buildings (up to 100 zones). This procedure can work with 1 hour time-step according to requirement of TRNSYS - a well-known modular system simulation programme. Co-operation between TRNSYS and my own programme is analysed, taking a typical Polish 5 - storey dwelling house as an object of simulation.

The proposed numerical procedure can also be run as an independent programme calculating the ventilation air flow, air change rate and heat losses due to infiltration. Simulation results for typical Polish heat season climate conditions are presented, analysing results coming from TRNSYS and my own programme.

1. INTRODUCTION

Air change is one of the most important elements that form the flat microclimate. The process of ventilating flats in multi-family dwelling-houses (particularly in low, up-to-five-storeyed ones) is often still realized by natural (gravity) ventilation system. The air change then takes place through the effect of air infiltration from the outside of a building. The influence of infiltration on the process of ventilating flats is not usually estimated properly. This has bad consequences both in inaccurate predicting energy consumption required to cover the infiltration - resulted heat losses of a building and in disensuring the air change to be suitable from the hygienic point of view.

2. AIR INFILTRATION IN RELATION TO THE HEAT LOAD OF A BUILDING

The calculating of a heat building requirement balance is significant both to minimize energy input by optimum choice of heating and ventilation systems and to ensure the suitable thermal comfort to the flat user. One of the more useful simulation programmes that can be applied in such calculations is the numerical module programme TRNSYS [1], which enables to make simulating calculations of required heat input a determined building structure. In the case of natural ventilation system, the calculations are made with some error since the TRNSYS package is not provided with the possibility to calculate air infiltration. This quantity, however, may be declared for individual zones as an hourly air change rate. This possibility is quite sufficient for the rooms or spaces with mechanical ventilation systems in which air flows are organized in a determined degree and in a determined way. In the case of natural ventilation, infiltration is formed spontaneously, owing to the variation of the factors that force it. What is particularly important here is wind action, the velocity and direction of wind being changed randomly.

In order to determine the real infiltration rate it is convenient to use the numerical programme that enables to make simulating calculations of ventilating air flows in the examined building. The calculations are carried out for steady, chosen parameters of ambient climate, what makes the results should be treated as "accidental state" ones, i.e. concerning a given, instantaneous disturbance [2] . Without doubt, the more accurate image of the phenomenon can be obtained when the time variation of infiltration is available for given zones of a building.

To achieve the run of variation of air flows in a multi-family dwelling-house the numerical programme TRANSVEN was constructed, which makes it possible to simulate the process of natural ventilation. The calculations are carried out in the quasi-dynamic course with time step being declared and with the use of ambient climate generator. The programme enables to make calculations in the object divided into 100 zones (e.g. the flats). The calculations are based on the classical balance equations for individual zones but the solution of systems of non-linear equations is reached differently that it is done in other similar programms [3]. Here, a methode from the field of optimization theory was applied that consists in searching the minimum value of specific target function created. One of the results of the calculations is the run of variation of air streams infiltrating each calculation zone. It is transformed into an hourly air change rate and makes the TRNSYS input data set describing the infiltration.

3. SIMULATION CONDITIONS AND EXAMPLE RESULTS

The most interesting season from the point of view of the heat load of a building is the heat season. In Poland, it comprises the period from October till April. For this period, a climate gemerator was constructed that gives the values of velocity and direction of wind and ambient temperature as well. Fig.1 presents the run of variation of wind direction and air temperature in the period of approx. 2 weeks of January, which period is that one the further presented results reffer to.

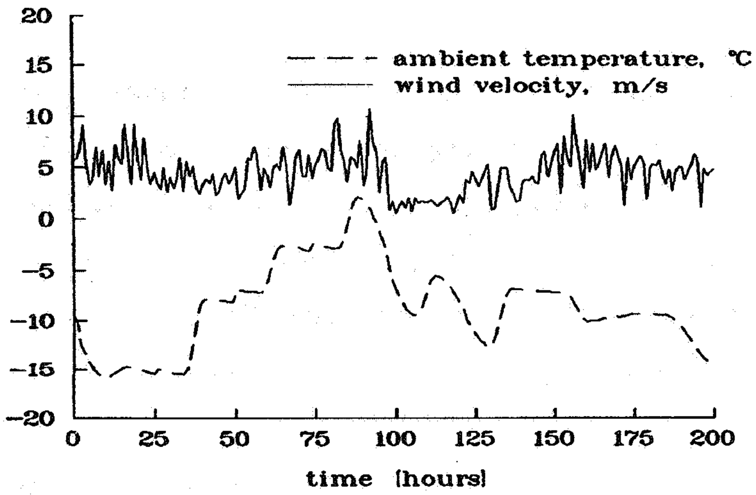

Fig. 1. Ambient climate parameters in a given calculation period.

The object of the simulating calculation was a standard five-storeyed multi-family building. The calculation were made for 10 flats, i.e. 10 separated calculation zones.

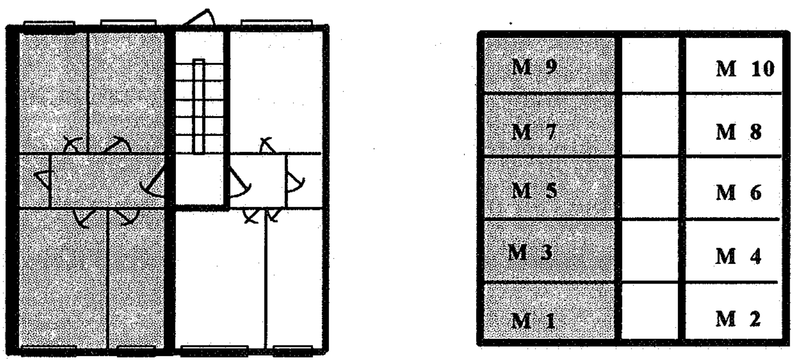

Fig. 2. Inside structure of a building (floor plane and sciagraph)

One of the results the TRANSVEN calculations yielded was the run of variation of air infiltration for individual flats. Fig.3 shows the time-variable air streams that flow into the flats on the 1st and 5th floor. The averaged values of the air flow rates give 0.8 and 0.3 air changes per hour, respectively, that means less that it is provided by Polish standards.

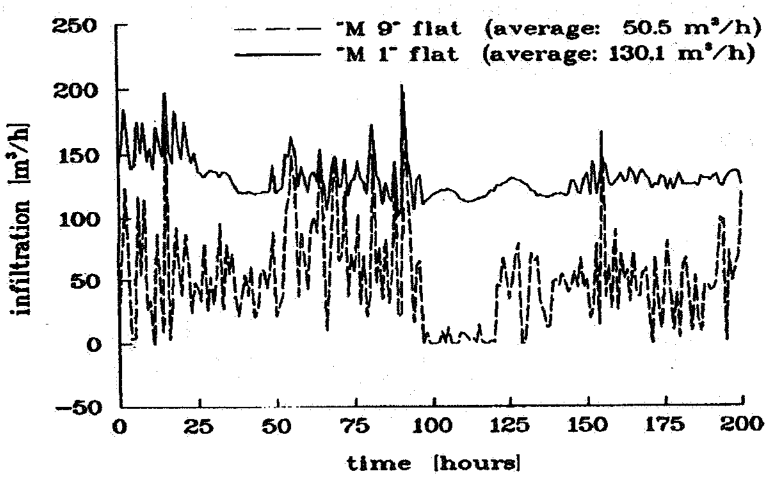

Fig. 3. Run of infiltration variation in chosen zones of building.

The TRANSVEN-calculated values of infiltrating flow rates in individual flats formed an input data set for TRNSYS for calculating total energy requirement. Chosen results of these calculations are illustrated in Fig.4, which presents an hourly run of variation of heat requirement in the flat on the 1st floor and also the heat (the lower curve) necessary to heat the air infiltrating this flat.

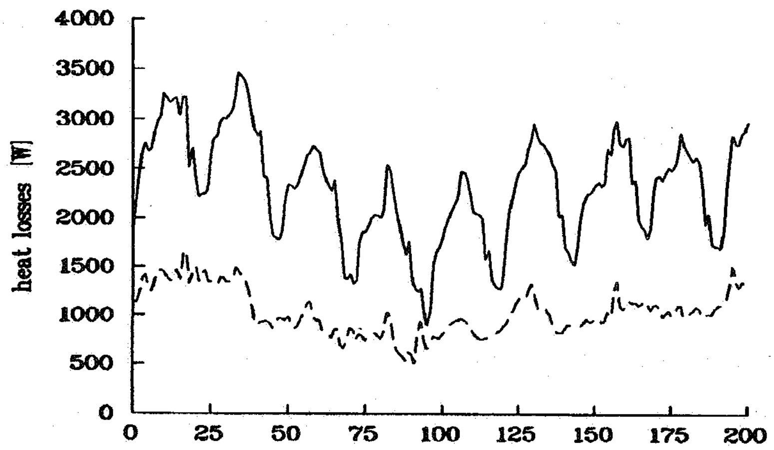

Fig. 4. Comparison between total heat losses (solid line) and heat losses due to infiltration (dashed line).

It can be easily noted that infiltration takes the significant part (nearly a 50 per cent one) in forming total heat load. Such an unfavourable result is connected with low ambient temperature that occurs in this period - here -9 °C an average. In the result of analogous calculations made for heat season average ambient temperature equal to + 2.5 °C (for the region of Silesia, Poland), the heat consumption for infiltration decreases to about 20-30 per cent of total heat requirement of a building.

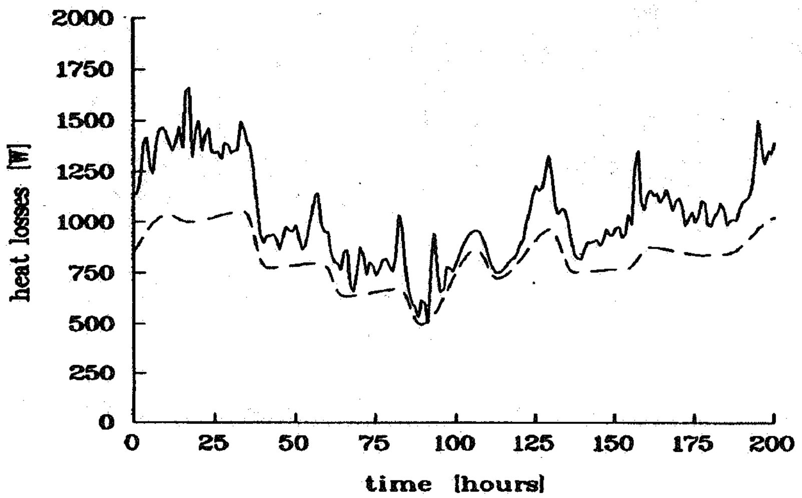

Fig. 5. Comparison of heat losses for infiltration in zone 'M1' : for constant air change rate (dashed line) and for varying infiltration (solid line).

The usefulness of calculation of air infiltration was confirmed in a simulating cycle that was made with the use of TRNSYS for constant air change declared, identical for each zone. The absolute minimum air change rate of 0.5 h^{-1} was assumed.

Fig.5 shows the comparison between the infiltration-resulted heat losses due to the infiltration calculated in a cycle of an hour and those due to the constant infiltration. The average difference in energy input amouts 20 per cent.

4. CONCLUSIONS

The effect of infiltration in buildings with natural ventilation systems is unavoidable and also desired. The tendency that occurs to tighten walls and window openings to a maximum leads without doubt to decreasing heat losses of a building but on the other hand it produces the unfavourable consequences, i.e. limits the necessary air change.

Natural ventilation is still the most conveninet way the air is changed, particulary in singleor multi - family low detached houses. The results presented suggest that it is necessary to seek a comparison between building coating tightness and transmitting the necessary amount of ventilating air from the outside. It seems essential to apply new construction designes of window woodwork and walls as well. They would allow, to a certain extent, to control the process of infiltration, which is, by its nature, in large measure random.

The recognition of the extent of infiltration, which phenomenon varies with climate conditions and which also greatly depends on location of a flat in the complex structure of a building, can result in more accurate predicting energy input necessary to cover the building heat reguirement, thus can be profitable in saving energy and money as well as in improving the thermal comfort of flats [4].

What seem suitable for the above-mentioned purposes are calculations of dynamic variation of ventilating air as well as climate gemeretors, which simulate the specific character of a given geographical region and which are constructed on the base of statistically important data coming from many years' observations made by weather stations.

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