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Current Research at Lawrence Berkeley Laboratory

on Multizone Infiltration

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Abstract

Many computer programmes have been developed in order to calculate infiltration in buildings. Those, which treat the true complexity of flows in a multizone building, and therefore recognize the effects of internal flow resistance, require extensive information about flow characteristics and pressure distribution. Therefore, simplified models have been developed to simulate weather driven air infiltration of singlecell structures, such as single-family houses. Many of the existing buildings, however, have floor plans that characterize them more accurately as multizone structures, which cannot be treated by singlecell models. Most multizone models presently in use are either not available to the public or are written as research tools, rather than for the use of professional engineers or architects. Therefore, a simplified multizone infiltration model capable of providing the same accuracy as the established singlecell models is being developed at LBL.

Current Research at Lawrence Berkeley Laboratory on Multizone Infiltration

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Introduction

Many computer programmes have been developed in order to calculate infiltration. Those, which treat the true complexity of flows in a multizone building, and therefore recognize the effects of internal flow resistance, require extensive information about flow characteristics and pressure distribution. Therefore, simplified models have been developed to simulate weather driven air infiltration of singlecell structures, such as single-family houses (see for example the LBL model [1]). Many of the existing buildings, however, have floor plans that characterize them more accurately as multizone structures, which cannot be treated by singlecell models. Most multizone models presently in use are either not available to the public or are written as research tools, rather than for the use of professional engineers or architects [2]. Therefore, a simplified multizone infiltration model capable of providing the same accuracy as the established singlecell models is being developed at LBL. Figure 1 shows a comparison between the different modelling strategies.

Multizone Models

The air flow distribution for a given building is caused by pressure differences, whether evoked by wind, thermal buoyancy, mechanical ventilation systems or a combination of those. The distribution of openings in the building shell and the inner paths also influence the air flow. The openings can be varied by the occupants, which can cause significant differences in the pressure distribution inside the building.

In terms of air flow, buildings are complicated interlaced systems of flow paths [3]. In this grid system the joints are the rooms of the buildings and the connections between the joints simulate the flow paths and include the flow resistances caused by open or closed doors and windows or air leakage through the walls. The boundary conditions for the pressure can be described by the grid points outside the building. Differences in density of air, due to differences between outside and inside air temperatures, cause further pressures in the vertical direction, again influencing the air flow.

The duct system for mechanical ventilation systems can be treated like the other flow paths in the building. In case of mechanical ventilation systems the fan can be described as a source of pressure differences, lifting the pressure level between two joints according to the characteristic curve of the fan.

Multizone Infiltration Studies at LBL

In order to validate a simplified multizone infiltration model we have developed a multi-gas tracer measurement system, using Freons as tracer gases. Air from different zones is sampled for a ten minute period in sampling bags and then immediately analyzed using a gas chromatograph with an electron capture detector. The tracer gases are injected in the different zones using the constant flow method for each sampling period. Weather data is recorded during infiltration measurements. For the recorded wind data, surface pressure coefficients are measured on scale models in a boundary layer wind tunnel. These pressure coefficients, together with the weather data and the house leakage data obtained by blower door measurements, are used as input for a detailed multizone model. Whereas the measured infiltration data will mainly be used as a validation of the model, the predicted infiltration data will be used to learn about the mechanisms that cause infiltration (See Figure 2).

To simplify the description of the complex air flow distribution in buildings, similarity parameters --like those used to describe other physical phenomena-- have to be found. With these parameters, the infiltration for a given building can be predicted. These parameters will be obtained by using a detailed computer model for simulating a large number of different floor plans. The variation of the flow resistance distribution inside a building will show a few significant combinations which determine the flow.

A study by Krischer and Beck [4] gave the first hint, that such similarity parameters may exist. In order to calculate the maximum infiltration heat loss for a building (at design conditions for the heating system) they distinguished between terrace houses and detached houses. The differences are expressed by the ratio of the permeabilities of the leeward side and the windward side of the building envelope. In the latest issue of the German standard DIN 4701 [5] a further distinction was made between shaft type and storey type houses, which differ in their vertical inside permeability between floors.

While existing parameters are used to calculate the maximum air flow for the whole building, we have started to investigate parameters which describe the different zones of a building and the effect of the location of the building[6]. This preliminary study showes a strong relationship between the air flow distribution in a building and the ratio of the permeabilities of the envelope and the interior partitions. Depending on the permeability distribution, a zone might be stack dominated, wind dominated, or not be effected by the weather at all. Further studies will give more detailed information on the ventilation behavior of different zones.

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