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Wind tunnel investigation of natural ventilation through multiple stacks. Part 2: Instantaneous values

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ABSTRACT

Wind tunnel experiments have been performed on a scale model to study unsteady natural ventilation through multiple stacks. Part 1 of the paper [1] concentrated on the characteristics of the mean flows. Part 2 concentrates on the instantaneous characteristics of the flows, both in terms of the experimental measurements and in terms of an unsteady envelope flow model.

Further investigations into the experimental measurement techniques are described. These relate to improving the hot-wire calibration, to the instantaneous flow balance with multiple stacks (and the importance of model rigidity) and to the increased importance of internal air motion with the higher flow rates associated with multiple openings.

The experimental measurements of stack reversal percentage are examined in some detail, regarding the effects of wind direction and Reynolds number and how the reversal percentage relates to a simple pressure parameter.

Following on from Part 1, the effect of opening configuration on the instantaneous properties of the external wind pressures is investigated by examining their correlations. As with the mean values it is found that the correlations are not entirely independent of opening configuration.

The experimental data is used to assess the performance of an unsteady envelope flow model, both in terms of calculating instantaneous values and mean values such as reversal percentage. The model is shown to perform well with multiple stacks. It is then used to estimate the effect of Reynolds number on the reversal percentage at model-scale and full-scale.

1. Introduction

Part 1 [1] of the companion paper dealt with mean flow properties such as mean pressure coefficient and mean flow rate. As mentioned in Part 1, the special feature of the experimental technique is that measurements of the instantaneous flow and pressure in multiple stacks can be made simultaneously. In Part 2, the emphasis is on instantaneous values. The objectives are:

(i) to describe further work that has been done on the experimental technique, namely improving the hot-wire calibration technique (Section 2.1), investigating the instantaneous flow balance (Section 2.2) and improving the measurement of internal pressure (Section 4.1).
(ii) to present the observed effects of Reynolds number, wind direction and stack geometry on instantaneous flow properties (Sections 3 and 4).
(iii) to compare the instantaneous measurements with a theoretical unsteady model (Section 5.l). Again the underlying philosophy is to use the wind tunnel results to assess the theoretical model. If the model performs well at low Reynolds numbers, there is reason to be optimistic about its performance at full-scale.

2. Experimental techniques

2.1. Unsteady calibration of hot-wires

The calibration procedure for the hot-wires has been described in earlier papers [2,3],. Basically each wire is calibrated in terms of volume flow rate rather than velocity. It is recognized that the relation between the local velocity and the volume flow rate will depend on the instantaneous velocity profile in the stack, due to unsteady effects, and for this reason each wire is calibrated with steady and unsteady flow. Both the steady and unsteady calibrations are carried out *in-situ*, using different devices: a fan with a flow meter for steady calibration; a specially designed piston

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