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Wind tunnel investigation of natural ventilation through multiple stacks. Part 1: Mean values

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ABSTRACT

Wind tunnel experiments have been performed on a scale model to study unsteady natural ventilation through multiple stacks. A previously developed hot-wire technique was used to obtain both mean and instantaneous flow characteristics. The work is described in two Parts.

Part 1 concentrates on the mean flows, since it is these that are usually used for design purposes. Stacks are a potential means of ensuring that the required flow pattern is obtained over a range of conditions, so that flow direction (rather than just magnitude) is an important issue. Two distinct ways in which a wind tunnel can be used for design are considered. The first is to measure surface wind pressures, from which flow directions can be inferred or calculated. The second way is to carry out direct measurements of the stack flows (magnitude and direction). Both of these ways are examined using the measured data and their advantages and disadvantages are discussed.

The accuracy of the hot-wire technique was examined on the basis of the mass balance when only stacks are present. The effects of Reynolds number and wind direction on flows and pressures are presented. An investigation of the effect of opening configuration on wind pressure coefficients surprisingly revealed that in some cases the coefficients were affected. The effect of external flow on the discharge coefficients of the stacks was found to be consistent with earlier results on single stacks. There is evidence that the effect on the orifice coefficients is more important for envelope flow modeling.

1. Introduction

1.1. Background

Ventilation stacks are becoming increasingly common in the design of naturally ventilated buildings. They offer a method for achieving a fixed flow pattern irrespective of internal and external conditions e.g. upward stack flow should be maintained under all wind conditions and opening configurations, at least with positive buoyancy, by positioning the stack outlet at high level in a region of relatively low wind pressure. The paper describes an experimental investigation of unsteady natural ventilation in an environmental wind tunnel. The model was equipped with four identical stacks and four sharp-edged orifices and various combinations of these were tested. The investigation is a continuation of the work reported in Refs. [1–3]. In those investigations a single stack and orifice were tested. The technique was subsequently used to investigate flow reversal in a single ventilation stack of a real building [4]. Apart from this work and that described in Ref. [5], there seem to have been few studies of wind effects on ventilation stacks using environmental wind tunnels.

An important and probably unique feature of this investigation is that *simultaneous* measurements were made of *instantaneous* flows and pressure differences in up to four stacks. Such measurements are rare, yet they provide a greater insight into the flows than can be obtained from measurements of time-averages alone. In particular, the phenomenon of intermittent flow reversal can be investigated. This is important, because the change from purely upward flow to purely downward flow is not abrupt. Furthermore, the effects of correlations between the wind pressures and the stack flows can be determined. These phenomena become more complex as the number of stacks is increased. However, time-averaged (mean) values are used for design purposes. Part 1 of this paper therefore concentrates on mean values and the relevance of the results to design. In accordance with this, a conventional steady envelope flow model is used to calculate mean flow rates for comparison with the measured values. Part 2 of the paper deals with instantaneous flow rates and pressures and comparisons with an unsteady envelope flow model.

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