Natural Ventilation of Enclosures Driven by Sources of Buoyancy at Different Elevations

by

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Abstract

This thesis describes the results of laboratory and theoretical modelling of the steady airflows and thermal stratifications in naturally ventilated enclosures that are established by multiple localised sources of buoyancy at different elevations within the space. Previous research has largely been limited to sources located at a single level, however, there are many practical situations where buoyancy sources are located at different elevations, for example, inside tiered lecture theatres and auditoria. Understanding the dynamics of the airflows in these spaces, so that effective low-energy designs can be identified, provided the motivation for the present work.

Experimental observations at small scale, using water as the working fluid and brine to create density differences, show that, in general, a steady three-layer flow is established by two localised sources of buoyancy. This basic structure is maintained for a broad range of source elevations and strength ratios. Measurements of interface heights revealed a sensitive dependence on the ventilation opening area and a less sensitive dependence on the relative source strengths and elevations. The predictions of a mathematical model, developed to provide further insight into these flows and estimates of the bulk flow properties, showed good agreement with experimental observations.

A key design requirement for comfort in tiered auditoria is that occupants are located within the cooler region of the stratification. It is shown that the minimum height of the thermal interface separating the warm upper and cooler lower regions is closely predicted by assuming that all sources are located on the floor. Additionally, increasing the incline of the floor generally requires an increase in the ventilation rate to maintain comfortable displacement ventilation conditions for all occupants. Further implications of this research to the design of naturally ventilated enclosures are discussed.