Overview

Airflow in buildings has been a topic of interest since people began to build shelters. One of the earliest issues was orientation with respect to the wind, including both augmentation and reduction of indoor air motion. The issues of interest expanded to include thermal buoyancy effects, as well as the provision of air for ventilation and combustion as building shells became more airtight. The issues of current interest encompass natural and mechanical ventilation systems, pressure control, control and dilution of air pollutants, control of the thermal environment (including distribution of ventilation air, heat and cooling), and control of airflow through leaks in the building envelope. As the numerous types of airflow in buildings have been studied over the years, the level of detail of the knowledge available and required relative to those types has continued to increase.

ASTM Subcommittee E06.41 (Infiltration Performances) began writing consensus standards on measurement techniques for air infiltration in 1975, focusing on measuring the airflow through building envelopes with tracer gases (current version: E 741-93, Test Method for Determining Air Change in a Single Zone by Means of Tracer Gas Dilution), and the air leakage characteristics of building envelopes (current version: E 779-87, Test Method for Determining Air Leakage Rate by Fan Pressurization). Since 1975, ASTM Subcommittee E06.41 has written a number of additional standards addressing more of the details associated with understanding airflow and air leakage in buildings (E 1186-87, Practice for Air Leakage Site Detection in Building Envelopes; E 1258-88, Test Method for Airflow Calibration of Fan Pressurization Devices; E 1465-92, Guide for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings; and E 1554-94, Test Method for Determining the External Air Leakage of Air Distribution Systems by Fan Pressurization).

In parallel with the efforts of E06.41, ASTM Subcommittee E06.51 (Component Performance of Windows, Curtain Walls, and Doors), has been addressing the airflow performance of various building components, starting with the performance of various building shell components in the laboratory (E 283-91, Test Method for Determining the Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors under Specified Pressure Differences Across the Specimen; and E 1424-91, Test Method for Determining the Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors under Specified Pressure and Temperature Differences Across the Specimen), and extending to the installed performance of those components (E 783-93, Test Method for Field Measurement of Air Leakage through Installed Exterior Windows and Doors).

To aid in the consensus standards process, as well as to provide concentrated documentation of progress in the area of building airflow and air leakage, ASTM Subcommittee E06.41 has sponsored a technical symposium (and subsequent Special Technical Publication) approximately once every five years. The first of these, Building Air Change Rate and Infiltration Measurements (*ASTM STP 719*), held in 1978, was focused principally on measurement techniques, with some limited data taken by researchers. The 1984 symposium, Measured Air Leakage of Buildings (*ASTM STP 904*) was focused on relatively large sets of field data. The third symposium, Air Change Rate and Airtightness in Buildings (*ASTM STP 1067*) was held in 1989 and was divided fairly evenly between analyses of measurement techniques and compilations of field measurement results.

The symposium that forms the basis of this book attempted to document current research efforts for and knowledge of airflow through the building envelope as a whole, a topic that has been the focus of the earlier symposia put together by ASTM Subcommittee E06.41, as well as to address the growing interest and concerns associated with airrflow through the various components that make up that building envelope (e.g., windows), and the systems that serve to distribute air (and heat or cooling) within a building. Like the 1989 symposium, this symposium was split between analyses of measurement techniques and summaries/analyses of field data, with somewhat more emphasis on the latter. This symposium served to bring together the expertise within at least two ASTM subcommittees: E06.41 and E06.51.

The symposium was divided into four sessions, each session focusing on a particular aspect of building airflow. These four sessions included, in order of presentation: (1) Air Movement, Ventilation, and Indoor Air Quality, (2) Window Air Leakage, (3) Envelope Heat and Mass Transfer, and (4) Envelope and Distribution System Leakage.

The first symposium session, Air Movement, Ventilation, and Indoor Air Quality, was chaired by Andy Persily, and included five papers. The major focus of this session was building airflows under more complex circumstances, in particular larger buildings with multiple zones, and pollutant entry from soil gases. The Palmiter et al. paper provided one of the few published sets of simultaneous measurements of airflow through all pathways in a multifamily building. The Dols and Persily paper compared and contrasted ventilation measurement results obtained for a large office building with several different techniques, whereas the Shaw and Reardon paper reports on changes in the airtightness of six office buildings over a period of about 20 years. The Kozik et al. and Williamson et al. papers explored two aspects of soil gas entry and dilution in the field, the Kozik paper focusing on the impacts of duct leakage and resulting house pressurization/depressurization on radon entry and dilution, and the Williamson paper focusing on whether or not slab flooring provides an effective barrier to soil-gas entry.

The Window Air Leakage session, chaired by Mark Modera, was comprised of four papers addressing the airtightness of window systems. The papers in this session focused on the various issues associated with understanding how windows will leak in the field as opposed to under ideal conditions in a laboratory. The first of the Kehrli papers described the relatively recently-approved ASTM standard for window air leakage, E 1424, which includes the impacts of temperature differentials in laboratory measurements of window air leakage. The second Kehrli paper was a simulation-based analysis of the energy implications of window air leakage for several window products placed in four different building designs in various U.S. climates. The Louis and Nelson paper outlined an approach for quantifying window perimeter leakage, which is not accounted for in current ASTM standards. The Proskiw paper addressed the issue of perimeter leakage for the particular case of residential construction, including cost data for various types of rough opening seals.

The third session, Envelope Heat and Mass Transfer, was chaired by William Brown, and consisted of four papers. In particular, two of the papers addressed airflow and moisture in the envelopes of manufactured housing, and two papers addressed the interactions between conduction heat flows and airflows in the building envelope. The Tenwolde et al. paper addressed the impacts of airflow on moisture accumulation in the walls of manufactured homes, and the Burch paper addressed the same problem for the roof cavities of those structures by means of computer simulation. The Claridge et al. and Jones et al. papers dealt with the important issue of how airflow through building walls interacts with fourier conduction within those walls.

The final session, Envelope and Distribution System Leakage, was chaired by David Saum. This session contained three papers analyzing measurement techniques, and one paper focusing on field measurement results. The Levin et al. paper presented comparisons of various

air leakage standards, focusing on the impacts of different test pressures and variations in flow exponents. The Proskiw paper presented field data on variations in whole building airtightness over a three-year period. The Sherman and Palmiter paper presented an error analysis of various single-zone fan pressurization measurement protocols and analysis procedures. The Modera paper compared and contrasted the performance of two alternative techniques for measuring duct system leakage that were recently incorporated into a new ASTM test method (E 1554).

As was the case with earlier ASTM symposia on building airflow, the papers presented and published herein serve both to enlighten us on the progress that has been made in our understanding of building airflows, as well as to point out where that understanding is lacking. This is true both for our ability to predict those flows and their impacts by means of computer modeling, as well as for our ability to standardize measurement techniques that can provide accurate airflow characterization data in a minimum amount of time. This symposium represents a small step forward in our continuing quests to improve our understanding of building airflow, and to use that understanding to provide the building community with standards that can provide accurate data as cost-effectively as possible.

The publication of this book was made possible by the efforts of a large number of individuals. We, as the editors and organizers of this symposium, would like to thank all of those individuals, starting with the authors, who provided the substance upon which this book is based. We would also like to thank the ASTM editorial and conference organization staff who took on the thankless task of assuring that the symposium and the publication of this book actually came to pass. Finally, we would also like to thank the session chairmen for their efforts.

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