RESEARCH HIGHLIGHTS

Technical Series 99-118

FIELD TESTING TO CHARACTERIZE SUITE VENTILATION IN RECENTLY CONSTRUCTED MID- AND HIGH-RISE RESIDENTIAL BUILDINGS

Introduction

Mechanical ventilation systems in multi-unit residential buildings typically consist of central corridor air supply systems and central, or individual, suite exhaust systems. This approach has not significantly changed over the past 30 years despite evidence that such systems are neither effective nor efficient. Occupant's complaints regarding indoor air quality and comfort are well documented. The energy consumption attributable to conventional mechanical ventilation systems in buildings is not insignificant. Despite the number of problems associated with ventilation systems that can be experienced in buildings, little research has been performed to assess ventilation system performance to identify shortcomings in system design, installation, operation, and maintenance, and to develop solutions.

CMHC conducted a research study of 10 mid- and high-rise residential buildings to assess the performance of the mechanical ventilation systems and to identify influencing design, installation, operational, and environmental factors. The study provides many useful insights as to why conventional ventilation strategies are unable to meet the ventilation requirements of multi-unit residential buildings.

Research Program

Ten recently constructed (post-1990) mid- and high-rise residential buildings were selected for testing. The buildings selected were deemed to be representative of conventional building practices in each of the regions where buildings were located (Quebec, Toronto, Winnipeg, Vancouver). A research protocol was established to characterize the as-found performance of the corridor air and suite exhaust systems. The protocol also provided for the assessment of the background indoor-outdoor environmental conditions and building-specific features that could influence the performance of ventilation systems.

Six series of field tests were conducted in each building:

1. Determination of Environmental Driving Forces
2. Determination of the Pressure and Airflow Capabilities of the Suite Exhaust Systems
3. Determination of Corridor Air System Supply Airflow Rates
4. Assessment of the Air Leakage Characteristics of Suite Access Doors
5. Determination of Suite and Room Air-change Rates
6. Estimation of Inter-suite Transfer Air Fraction.

The tests were conducted at each building site during the winter in order to evaluate the performance of the systems during potentially worst-case conditions. The tests can only be considered as "snapshots" of the performance of the ventilation systems, as no long-term monitoring was undertaken. Nevertheless, the observations of system performance from building to building had much in common allowing the research team to identify general trends.

Findings

The design specifications for both corridor air and suite exhaust systems vary widely from building to building. The field tests showed that measured flows for both the corridor and exhaust systems were consistently less than the design capacities. In some of the buildings, as outdoor temperatures changed the corridor supply airflows varied over the course of a day. Corridor supply airflow was also found to be affected by the

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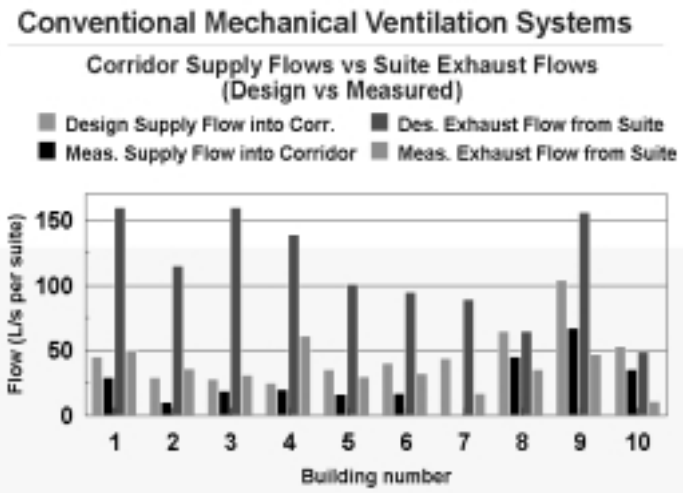
airtightness of the building envelope and internal zonal partitions. The designed suite exhaust capacities were usually far greater than the designed suite corridor supply airflow.

Informal discussions with the system designers revealed that little consideration was given to ensure that there would be sufficient leakage between the corridor and suite for the transfer of air.

Additionally, designers assume that additional makeup air for exhaust systems would be provided by infiltration from outdoors. Figure 1 demonstrates the differences in designed and measured flows and provides a comparison of corridor supply airflows and suite exhaust capacities:

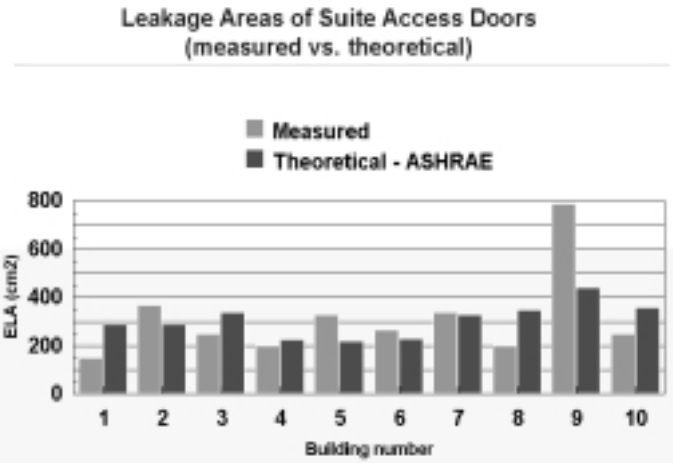
Figure 1:
Corridor Air and Suite Exhaust Air System Performance in 10 High-rise Apartment Buildings



When comparing design and measured corridor supply airflows to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) requirements, it was observed that the designed corridor supply airflows on a per-suite basis usually significantly exceeded the ASHRAE requirements while the measured airflows often were closer to the ASHRAE requirements. The comparison to the CAN/CSA - F326 M91 "Residential Mechanical Ventilation Systems" requirements showed that the designed corridor airflows on a per-suite basis often significantly exceeded the CSA requirements while the measured airflows were often significantly less than the CSA requirements. The designed exhaust capacities always exceeded ASHRAE and CSA minimum exhaust requirements, but measured values were significantly lower than both standards.

Another factor that influences suite ventilation is the leakage area around suite access doors. The measured areas of suite access doors were large and highly variable. They were usually within allowable National Fire Protection Association (NFPA)

Figure 2:
Leakage Areas of Suite Access Doors (measured vs. theoretical)

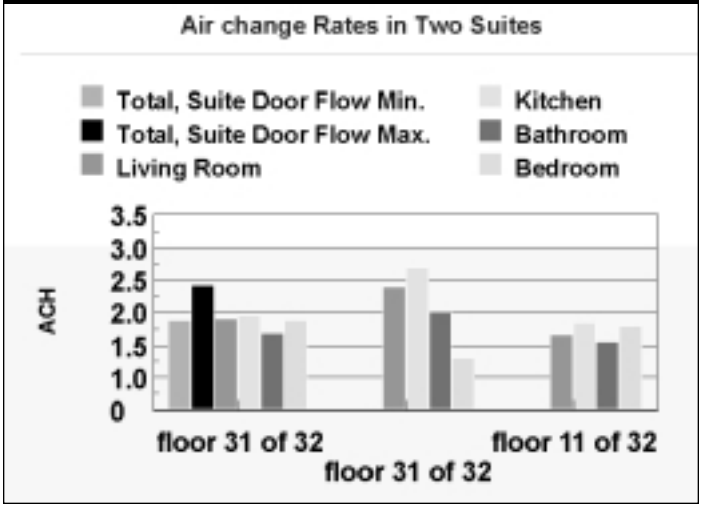


limits for fire doors, but always greater than allowable National Building Code of Canada (NBC) limits for fire doors and greater than allowable NFPA limits for smoke-control doors. Some buildings had considerable differences between theoretical and measured door leakage areas, as shown in Figure 2.

In general, most rooms of the test suites were well ventilated compared to existing ventilation standards. However, some suites were underventilated. The air exchange in most of the test suites is due to airflows from the corridor through the suite access door, but the test showed that some suites had reversed airflows into corridors, while others were largely ventilated by air coming from other locations in the building.

Tests also compared two suites in the same building to help characterize suite ventilation. The main findings are shown in Figure 3:

Figure 3:
Air Change Rates in Two Typical Suites



Generally, closing interior doors within the test suite can have complex effects, including reducing the suite volume that is directly open to flows from the suite access door and increasing the apparent airtightness of these open volumes. For example, the air change rate for the open living room and kitchen increased due to the reduced open volume of the suite; the bathroom air change rate increased when its door was closed; and the bedroom air change rate decreased when its door was closed. The study found that most of the test suites had air flowing into them that comes from other suites.

The field tests showed that suite ventilation was mainly influenced by three major factors: weather, suite location within the building, and treatment of both interior and corridor access doors. The tests showed that there are substantial amounts of transfer air entering the test suites. However, ventilation within a suite was difficult to predict at any given moment.

Most buildings had varying design specifications for ventilation systems. To ensure that suite ventilation is both controlled and adequate under normal operating conditions, the building industry will need to develop and follow a strict set of ventilation design practices, more in keeping with those currently used for low-rise single-family dwellings.

Implications for the Housing Industry

The results of this research project challenge the idea that conventional corridor air systems can act as a ventilation system for individual apartments. Environmental conditions and building physical and operational parameters can undermine the ability of corridor air systems to deliver outdoor air to individual apartments. The findings imply that other approaches to ventilating apartments will have to be developed in order to meet growing demands for healthy, safe, durable, and energy-efficient buildings.

Project Manager: Duncan Hill

Research Report: Field Testing to Characterize Suite Ventilation in Recently Constructed Mid- and High-Rise Residential Buildings, 1999: English only

Research Consultant: Sheltair Scientific

A full report on this project is available from the Canadian Housing Information Centre at the address below.

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Under Part IX of the National Housing Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, ON K1A 0P7

Telephone: 1 800 668-2642
FAX: 1 800 245-9274

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