RESEARCH HIGHLIGHT

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Field Testing of Positive Pressure Ventilation for Smoke Control in a High-Rise Apartment Building

INTRODUCTION

Positive pressure ventilation (PPV) is used by fire departments as a means to clear smoke during and after fire emergencies. A positive pressure ventilation system typically consists of a portable high volume axial fan that can be used in open areas to clear smoke or in closed areas to clear smoke and generate pressure differences between zones to prevent further smoke proliferation.

As most testing and use of PPV systems has been done in low-rise residential and commercial buildings, CMHC initiated a research project to establish the pressure generation capabilities of PPV systems in a stairwell of a high-rise residential building under different set-up configurations. The purpose of the project was to determine the magnitude of pressure that the PPV system could generate between the stairwell and adjacent corridors at all floor levels under various operating conditions. This information will be useful in determining the ability of PPV systems to prevent smoke proliferation into exit stairways during fire emergencies.

RESEARCH PROGRAM

The test building was a 22-storey, 250 unit apartment building located in Ottawa, Ontario, Canada. The building was tested under normal operating conditions that included continuous operation of the corridor air supply fan and occupants being free to come and go and use windows and doors as needed (except in the stairwell being tested). The West side stairwell was selected for testing as it was connected directly to outdoors via a ground floor exit door. On the test day, outdoor temperatures ranged from 7.2°C to 10.6°C and wind speeds varied between 3.6 km/h to 14.8 km/h in a direction that placed the stairwell on the leeward side of the building.

The PPV fan tested was an electricity powered, axial fan with a free flow capacity of 6,096 L/s. The fan was tested in a "free flow" condition where it was set up to blow outdoor air through the open ground floor stairwell exit doorway from a distance of 2 metres away. The fan was later tested mounted in a plywood frame in the ground floor exit doorway to the stairwell. This set up is referred to as the "sealed door" configuration. This was done to determine if the fan could develop better pressure differentials in the stairwell when all outdoor airflow produced by the fan was contained and directed into the stairwell with little or no losses to outdoors. Both tests are compared with a "no flow" stairwell condition where the PPV system was not operating and all the stairwell doors and hatches were closed.

The corridor-stairwell pressure regimes were recorded under several different conditions.

1. Corridor-stairwell doors closed, stairwell roof vent shut, PPV system operating free flow mode;
2. Corridor-stairwell doors closed, stairwell roof vent shut, PPV system operating sealed door mode;
3. 12th floor corridor-stairwell door open, all other doors shut, roof vent shut, PPV system operating free flow mode;
4. Corridor-stairwell doors closed, stairwell roof vent open, PPV system operating in free flow mode;
5. 21st storey corridor-stairwell door open, all other doors closed, roof vent shut, PPV system operating sealed door mode;
6. 21st and 2nd storey corridor-stairwell doors open, all other doors closed, roof vent shut, PPV system operating sealed door mode.

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TEST MEASUREMENTS

Measurements of stairwell to corridor differential pressures under each test condition were made with a digital micromanometer. Test results for several test regimes are shown below in Figures 1 - 3.

Figure 1 Stairwell-Corridor Pressurization

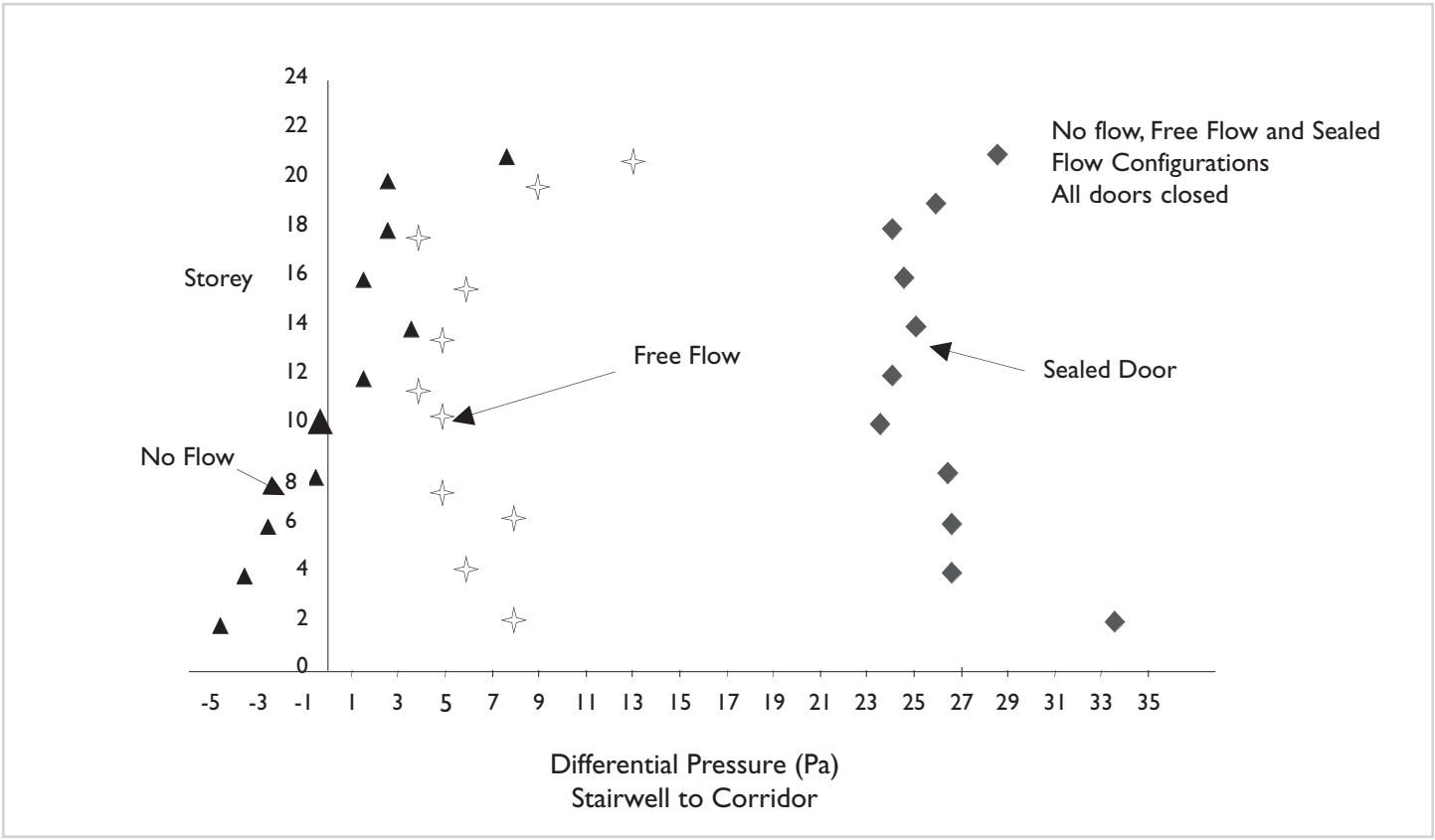


Figure 2 Stairwell-Corridor Pressurization

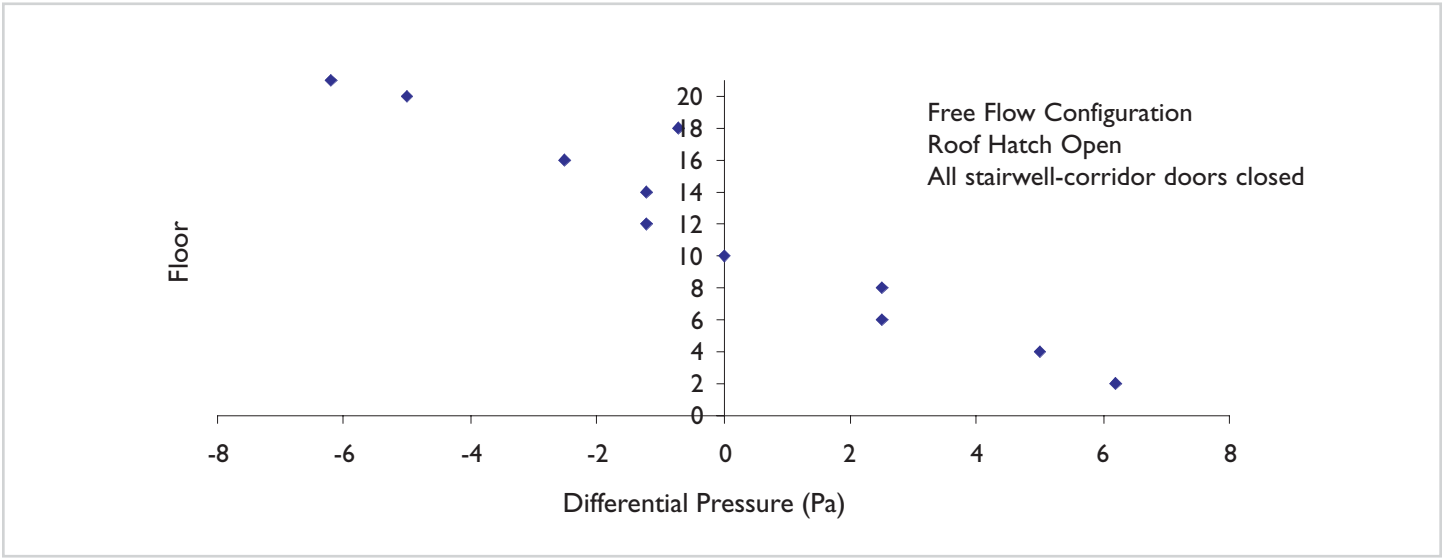
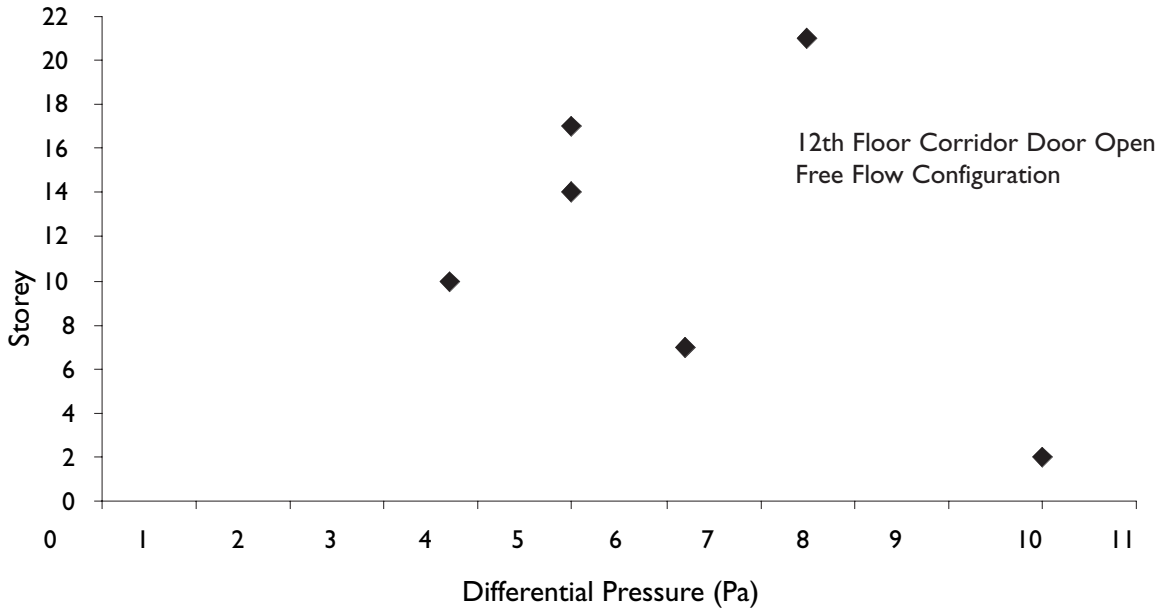


Figure 3 Stairwell-Corridor Pressurization



FINDINGS

Some of the major findings of the PPV Stairwell Pressurization tests were as follows:

1. The PPV system was effective in pressurizing a closed stairwell under free flow and sealed flow conditions. Figure 1 shows the impact of the use of the PPV system on the stairwell-corridor pressure regimes. Before the PPV system was activated (the "No flow condition"), the lower floor corridors were positively pressurized relative to the stairwell. Upon activation of the PPV system, the stairwell became pressurized relative to the adjacent corridors on every floor.
2. Figure 1 also shows that the PPV system was capable of generating significantly greater stairwell pressurization when operating in the "sealed flow" mode (i.e. the fan sealed into the exterior stairwell doorway). The pressure and flow losses in the conventional free flow configuration are significant.
3. Figure 2 shows that the PPV system could not maintain positive stairwell pressurization relative to the corridors on the top half of the building when the stairwell roof hatch was opened. However, positive stairwell pressurization relative to the adjacent corridors was maintained on the lower storeys.
4. Figure 3 demonstrates that the PPV system, operating in free flow mode, was capable of maintaining positive stairwell pressurization when a corridor-stairwell doorway was opened.
5. The PPV system, operating in sealed door mode, with the 21st storey stairwell-corridor door open, was able to maintain a positive pressure in the stairwell at all floor levels (test results not shown).
6. The PPV system, operating again in sealed door mode, with the 21st and 2nd floor stairwell-corridor doors open, was able to maintain positive pressure in the stairwell at all floor levels (test results not shown).

In general, the research indicated that the PPV system was effective in pressurizing a stairwell in a 22-storey apartment building. Based on the test measurements, the sealed flow configuration was the most successful at maintaining a positive pressure in the stairwells relative to the corridors. If the PPV system were to be modified to operate in such a configuration, it would be better able to prevent smoke proliferation into a stairwell during a fire emergency. However, the configuration would have to be designed to allow for occupant egress and firefighter access around the PPV system through the stairwell exit door.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The PPV system tested was capable of positively pressurizing a stairwell in a 22-storey apartment building. This finding demonstrates that portable PPV systems could be a useful tool for fire departments when dealing with fire emergencies in apartment buildings not equipped with stairwell smoke control systems. The PPV fan system may protect stairwells from smoke proliferation thereby easing occupant evacuation from the building and fire fighter access to the fire scene. This can enhance the safety of occupants of multi-unit residential buildings.

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Housing Research at CMHC

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.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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