RESEARCH HIGHLIGHTS

Technical Series 00-104

CORRIDOR AIR VENTILATION SYSTEM ENERGY USE IN MULTI-UNIT RESIDENTIAL BUILDINGS

Introduction

Many multi-unit residential buildings (MURBs) in Canada have corridor ventilation systems. It is commonly assumed that the corridor ventilation systems can displace space heating by pressurizing the building, thus counteracting air infiltration. However, the extent to which this occurs has never been assessed.

Canada Mortgage and Housing Corporation (CMHC) initiated a project to develop a protocol to assess the impact of operating building corridor ventilation systems on energy consumption in MURBs. The protocol was then used to characterize the relative impacts of corridor ventilation on energy consumption in five buildings during mid-winter conditions.

Two approaches were developed to study the effect of corridor ventilation on overall building energy usage. The first involved monitoring building energy use during a series of corridor ventilation system fan-on/fan-off tests. The fan-on/fan-off tests provided real data on the energy impact of operating corridor ventilation in the study building. The second method involved the use of a computer model to estimate the impact of corridor ventilation on building energy use. An effective computer model was expected to offer a faster and less costly alternative to field monitoring and its application would not be weather dependent.

Description of Publication

The research report describes the protocols developed and documents the results obtained from the five case study MURBs. The report includes detailed documentation of the field testing protocol and all the building and occupancy parameters that were considered in the assessment.

The protocol is only applicable in cold weather. Estimating the impact of operating corridor ventilation systems on air-conditioning energy use was beyond the scope of the study.

The protocols were evaluated using a two-phase process. Phase one involved the field testing of the protocol on one building and a comparison of the field results with the predictions of the computer model. In phase two, the field testing protocol was applied to four other buildings.

Results

The primary intent of this project was to develop a method to estimate the impact of operating corridor ventilation systems on net building air change rates and, hence, on annual heating costs.

Energy consumption data was gathered in winter during the time periods between midnight and early morning. This avoided or minimized the impact of extraneous factors, such as solar gain and occupant activities including

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cooking, cleaning, clothes drying, on energy usage. The corridor air systems were turned "on" or "off" on consecutive nights when the outdoor temperatures were relatively constant.

Energy use with the corridor ventilation system operating and with the corridor ventilation system turned off was plotted against outdoor temperature to determine an appropriate upper limit for outdoor temperature in the study. It was found that balance point temperatures occur between +5°C and +10°C. At warmer outdoor temperatures, building energy use was not related to outdoor temperature. Linear regression analysis was used on the data below this temperature range to identify the relationships between energy use and outdoor temperature with the corridor ventilation system operating and with the corridor ventilation system off. Equations were developed to estimate the impact of corridor air system operation on annual building energy use.

Data was gathered manually and by computer-based monitoring systems. Manually reading the energy meters was determined to be an adequate and inexpensive way to conduct the protocol.

Figure 1: Average Overnight Electric Demand in an Electrically Heated Building

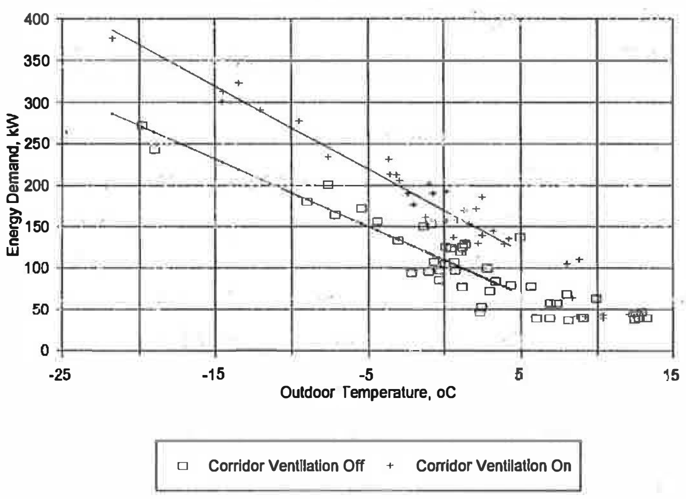

Figure 1 illustrates the relationship between total building energy use with the corridor ventilation system operating and turned off for the first building studied. The building was an "all electric" (space heating and domestic hot water) seniors' apartment building.

The monitoring and data assessment revealed that operating the corridor air system increased the building's electric demand by 100 kW at -20°C and had an estimated annual cost of $7,531.

Computer modelling of the first building involved applying a simple air leakage model developed to estimate the energy benefit of improving air barriers in buildings. Input included building height, width, length, number of storeys, envelope air leakage characteristics, resistance to air flow between floors, annual temperature distribution, windspeed and wind angle. The model was calibrated and the energy estimates from the simulations were compared with field test results.

The results predicted by the computer model were significantly different to the measured results obtained during the field testing. It was concluded that the model required multi-zone capabilities and sophisticated inputs and calibration to accurately model the impact of corridor ventilation in multi-zone buildings. The model was not applied to the second phase of the project.

The results of the other four buildings investigated under phase two were consistent with the observations from phase one.

Figure 2: Average Overnight Gas Consumption in an Electrically Heated Building with a Gas-fired Corridor Air System

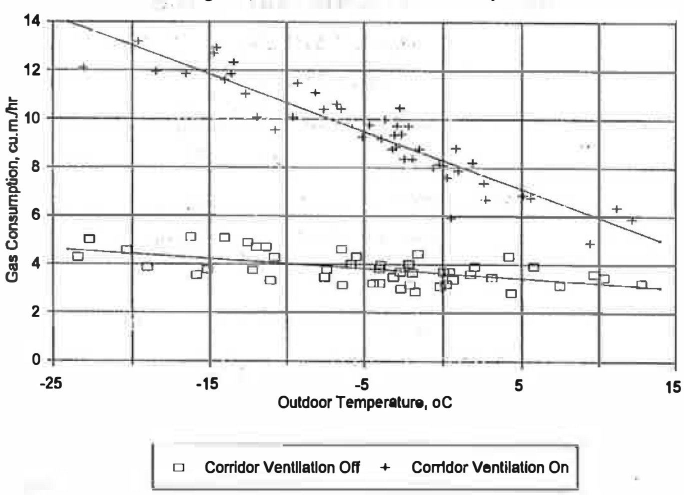

Figure 2 shows the relationship between energy use with the corridor ventilation system operating and turned off for an apartment building with a gas-fired corridor ventilation system and electrically heated suites.

Figure 3: Average Overnight Gas Consumption in a Natural Gas Heated Building

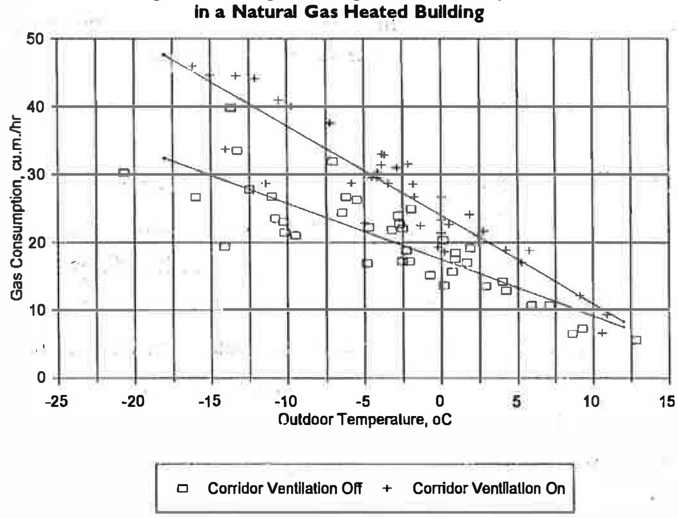

Figure 3 provides the same information for an all gas-heated apartment building (gas-fired corridor ventilation system and gas-fired space heating).

In all cases, the data clearly indicated the operation of the corridor ventilation system had a significant impact on whole-building energy use. There was good correlation between outdoor temperature and energy use. As well, the results demonstrated that, in all five buildings, operating the corridor ventilation system did not displace significant amounts of infiltration or space heating load.

The observed increase in whole building energy use when the corridor ventilation system was operated in the five buildings ranged from 60% to 90% of the energy that would be required to condition the air flowing through the corridor ventilation system. This increase in energy was much greater than expected based on previous assumptions of how buildings worked. In the past it was assumed that operating a corridor ventilation system that introduced tempered air into a building would displace a greater portion of the other heating loads in the building.

The researchers concluded that the heated air from the corridor air systems was finding direct routes to the outside, bypassing most areas in the building envelope. Consequently, it was concluded that the corridor ventilation air systems did not significantly impact air leakage across the exterior walls of the suites. Since suite walls dominate the surface area of the building envelope, the impact of corridor ventilation on overall building infiltration is small, especially where there is good air tightness between the corridor and the suites or where bypass routes exist.

In all five buildings in the study, operating the corridor ventilation systems increased heating season energy consumption. The estimated cost of operating the corridor ventilation systems in the buildings ranged from $5,500 to $20,000 per year.

These estimates of energy impact from the use of corridor ventilation systems are considered conservative. During winter days when solar and internal heat gains contribute to the overheating of the suites, there are no energy savings associated with any reduction in infiltration caused by the corridor ventilation systems.

Implications for the Housing Industry

This five building field investigation indicates that in high-rise residential buildings corridor ventilation air can flow out of buildings through more direct leakage paths than through the suites. Only modest amounts of infiltration may be displaced while exfiltration is increased significantly. It cannot be assumed that the energy used to condition the building's corridors will offset the energy needed to condition the suites in the building. Consequently, corridor ventilation systems significantly add to the energy consumed in the building.

The implications of this research are twofold. First, in existing buildings, corridor air systems represent a reasonable target for energy conservation efforts due to their impact on building energy use. Second, for new buildings, the functionality of corridor air systems should be questioned since significant amounts of the air provided do not flow as intended.

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Research Report: *Corridor Air Ventilation System Energy Use in Multi-Unit Residential Buildings, 1999*

Research Consultants: UNIES Ltd., Winnipeg, Manitoba

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

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