Comprehensive Retrofit of an Existing Multi-Unit Residential Building

Impacts on Indoor Environmental Conditions

INTRODUCTION

A comprehensive retrofit was completed of a four-storey 1970s rental apartment building located in Victoria, B.C., which included building enclosure insulation and mechanical system upgrades to reduce energy use and improve indoor conditions. Two research projects were initiated to understand the impacts that the retrofit had on energy consumption and indoor environmental conditions within the building. This research project investigated the impact of the retrofit work on indoor environmental conditions. Energy retrofits can adversely impact indoor conditions if they reduce indoor-outdoor air exchange to the point where indoor pollutants accumulate and resultant moisture conditions give rise to condensation, mould growth and the deterioration of interior materials and finishes and the building envelope system. Accordingly, the retrofit project included the installation of a continuously operating, energy-efficient exhaust fan in each dwelling unit to mitigate these risks.

To understand the effectiveness of the approach, research was undertaken to characterize the post-retrofit interior environmental conditions in comparison with industry benchmarks and the occupants' experience prior to the retrofit. It also examined the effectiveness of the post-retrofit ventilation strategy and the impacts that occupant behaviour and interactions had on the retrofitted ventilation system performance.

FINDINGS

Improvements to the continuity of the exterior air barrier combined with the addition of exterior insulation in the building enclosure and the installation of the continuously running exhaust fans in the dwelling units resulted in the following impacts on indoor environmental conditions:

- The upgraded building insulation and airtightness helped to moderate indoor temperatures (that is, reduced problematic temperature swings and maintained more consistent and comfortable conditions) during the winter/shoulder season.
- Relative humidity (RH) conditions within the monitored suites indicated levels were well within the typical comfort range (between 25% and 60%) recommended by several American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) documents and Health Canada *Exposure Guidelines for Residential Indoor Air Quality*.
- The higher thermal insulation installed on the exterior of the wall system sheathing board and controlled interior temperature and RH levels significantly reduced or eliminated condensation (and the potential for condensation) on windows and within the exterior wall assembly.
- Carbon dioxide (CO_2) levels within the monitored dwelling units, a proxy for indoor air quality, were within acceptable ranges most of the time. According to ASHRAE Standard 62.1, levels under 1000 ppm indicate adequate air ventilation and circulation for indoor environments. A pattern of increased CO_2 levels (>1000 ppm) was observed in bedrooms overnight suggesting insufficient fresh air to these rooms when windows were closed and interior doors were shut.
- A survey of the building occupants indicated that the building envelope insulation and airtightness retrofit led to a considerable reduction in exterior (outdoor) noise. However, the noise and vibration of the continuous operation of the newly installed bathroom exhaust fans annoyed some residents, resulting in the fans being disconnected.
- The continuous exhaust ventilation approach was not balanced (that is, in-unit pressures were continually changing based on exterior wind pressure conditions, window operation, fan operation and stack effect), resulting in uncontrolled smell and odour migration between adjacent suites.
- In general, the use of a simple, low-cost continuous operating bathroom exhaust fan strategy, in combination with the use of operable windows, appeared to provide adequate indoor environmental conditions in this retrofitted building located in a temperate climate region. However, when rooms were isolated from the exhaust fans for extended periods of time (for example, the closing of bedroom doors during the night), it resulted in a reduction in occupant comfort levels and indoor environmental conditions. Similar outcomes can be expected in colder climate regions where windows remain closed for extended periods of time during the winter months. A balanced ventilation system with ducted supply to bedrooms and living areas (for example, via heat recovery ventilators) would be a more effective strategy but more difficult, disruptive and costly to implement.

IMPLICATIONS FOR THE HOUSING INDUSTRY

Much of the existing residential building stock in Canada has reached an age whereby significant renewal is required to preserve, and improve, energy performance. However, upgrading the thermal and airtightness performance of building envelope assemblies can mean that additional measures will be needed to provide acceptable indoor environmental conditions. This study showed that the installation of a simple ventilation system as a part of the overall retrofit strategy can help maintain post-retrofit indoor environmental conditions but it may not provide uniform and adequate benefits in all the rooms of dwelling units at all times of the year. This illustrated the need to consider ventilation approaches that can deliver and circulate fresh outdoor air in all habitable rooms to meet the indoor environmental needs of the occupants as an integral part of energy efficiency retrofit projects.

FURTHER READING

Full report – *Comprehensive Retrofit of an Existing Multi-Unit Rental Building – Impacts on Indoor Environmental Conditions* (https://eppdscrmssa01.blob.core.windows.net/cmhcprodcontainer/sf/project/archive/research_2/comprehensive_retrofit_murb_impacts_indoor_env_conditions.pdf)

Related research – *Comprehensive Retrofit of an Existing Multi-Unit Rental Building – Impacts on Energy Performance and Greenhouse Gas Emissions* (https://eppdscrmssa01.blob.core.windows.net/cmhcprodcontainer/sf/project/archive/research_2/comprehensive_retrofit_murb_impacts_energy_performance_greenhouse_gas.pdf)

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