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Assessment of Natural Ventilation for Canadian Residential Buildings

INTRODUCTION

The objective of this research project was to determine the frequency and duration of periods where natural ventilation in dwellings in Canada can be expected to be inadequate. Supplemental mechanical ventilation could be needed in these periods, depending upon the occupancy of the house and the degree of underventilation. The project was supported by the Policy and Research group of the Canada Mortgage and Housing Corporation (CMHC) and the National Research Council of Canada (NRC).

Project Methodology

Task 1 – to establish an acceptable and useful definition of adequate residential ventilation for Canadian housing.

Task 2 – to review available data, from previous NRC projects and elsewhere in Canada, from which a wide range of ventilation-related house characteristics could be developed to represent Canadian housing.

Task 3 – to review existing models of residential ventilation, compare their input data requirements, computational complexity and output information, and identify the model(s) that can be used in this assessment.

Task 4 – to review the available datasets suitable for input to the selected model(s), including house characteristics and weather data, and identify those for analysis.

Task 5 – to apply the simulation model to the range of house characteristics and weather conditions based on the available data sets to calculate the estimates of air infiltration / natural ventilation and to determine the statistics of frequency and duration of periods of inadequate natural ventilation in Canadian dwellings. Initially this analysis was to focus on the cities of Ottawa and Vancouver, but later the city of Saskatoon was added to the analysis.

Task 6 – to prepare the final report describing the work and the conclusions and recommendations drawn from the analysis.

Results

There are various definitions of "adequate ventilation" for Canadian houses, including the standard CAN/CSA F326 M91, "Residential Mechanical Ventilation Systems", and its ASHRAE counterpart Standard 62.2-2004 "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings". While standards differ amongst themselves and will change over time, there is some consensus that the combined total of infiltration and mechanical ventilation should be in the range of 0.3 air changes per hour for houses of reasonable occupancy (e.g. four residents in a three-bedroom house).

There has been some research into the airtightness of new and existing houses, with the most comprehensive data collection by Natural Resources Canada as part of their EnerGuide program (now the ecoENERGY retrofit program). They provided an airtightness test data set of over 100,000 Canadian houses to the NRC project officer (the database has since expanded to 300,000 houses). The database could be separated into house age and house type (e.g. bungalow, 1 1/2 storey, etc.), with specific heating system information.

There is far less data available on residential natural air change rates, and little data on pressure distributions in Canadian houses. Despite these shortcomings, the research team had sufficient direction to simulate house air change rates. The simulation program that they chose, the Shaw model, has been shown more or less equivalent to more complex simulation software and uses fewer inputs.

Three Canadian cities were simulated: Vancouver, B.C. as the mild, coastal example; Ottawa, Ontario as a typical Canadian urban climate; and Saskatoon, Saskatchewan as a city with significantly colder winters than most. Weather data for the simulations was obtained from Environment Canada. A new metric for under-ventilation, “under supply”, was developed. It is defined as the integrated total number of air changes less than those that would have been supplied by a constant ventilation rate meeting the 0.3 air changes per hour requirement. The total number of hours where the ventilation exceeds 0.3 ac/h has not been named or calculated, and has not been used to offset periods of under supply.

There is a great deal of data in the main report, breaking down the simulations according to house location, house age, etc. For brevity, Table 1 below shows the simulation results for only two cities: Saskatoon and Ottawa. The table shows the aggregated data from simulations on all individual houses. While the mean and maximum air change rates often exceed 0.3 ac/h, especially in the older houses, there is a column of total hours during the year when the ventilation rate falls below 0.3. The Ottawa collected data shows that almost half the year is under the 0.3 ac/h threshold. Looking at the last row, in the airtight, new Saskatoon homes, you can see that 8,565 hours out of a year of 8,760 hours are below the criteria, and the under supply for that group of houses is almost 60%. Note that most houses had their highest air change rates in winter, and their lowest rates in summer where the houses were simulated as having closed windows and air conditioning. Houses with large window openings through summer will not see the same low infiltration rates.

Table 1

Period built	**No. of houses**	**% of pop’n.**	**Max [ac/h]**	**Min [ac/h]**	**Mean [ac/h]**	**Under-ventilation**				
						No. of hrs	**No. of periods**	**Longest period [h]**	**Under supply [ac]**	**Under supply [%]**
Ottawa	3848	100.00	0.8071	0	0.3904	4073	209	1457.7	446.2	16.98
pre-1945	1015	26.38	1.2420	0.0000	0.6140	1486	209	145.2	134.9	5.13
1945	45	1.17	0.9465	0.0000	0.4670	2228	253	240.5	201.6	7.67
1946-1960	832	21.62	0.7588	0.0000	0.3715	3716	245	859.5	370.4	14.09
1961-1980	1228	31.91	0.6251	0.0000	0.3050	5030	221	1631.9	533.2	20.29
1981-1995	571	14.84	0.5113	0.0000	0.2463	6473	151	3514.0	801.2	30.49
1996-2004	157	4.08	0.4483	0.0000	0.2164	7014	122	4620.2	958.7	36.48
Saskatoon	4162	100.00	0.4962	0.0064	0.2536	6423	149	3056.3	754.4	28.71
pre-1945	487	11.70	0.8930	0.0128	0.4608	2247	237	297.6	182.6	6.95
1945	21	0.50	0.7814	0.0107	0.4024	3159	229	589.2	283.5	10.79
1946-1960	840	20.18	0.5509	0.0071	0.2816	5589	206	1743.7	565.8	21.53
1961-1980	1872	44.98	0.4404	0.0054	0.2242	7117	141	3081.9	797.5	30.35
1981-1995	803	19.29	0.3645	0.0045	0.1858	7924	74	5216.9	1068.7	40.66
1996-2004	139	3.34	0.2439	0.0031	0.1243	8565	13	8201.5	1572.6	59.84

IMPLICATIONS

There are several implications of this research and analysis.

1. Canadian houses have been built more and more airtight in the decades since the Second World War.

2. Natural ventilation, at least due to air infiltration, cannot be relied upon to provide all the ventilation needs in Canadian houses. There will always exist periods of the year when natural driving forces will be insufficient to cause enough air movement in and out through leaks in realistic building envelopes of houses to meet a continuous 0.3 ac/h ventilation requirement.

3. During the colder periods of the year, natural ventilation due to air infiltration may in fact be sufficient to meet the 0.3 ac/h ventilation requirement. In the leakier houses, air infiltration can create excess ventilation that can increase energy consumption wastefully.

4. Mechanical ventilation in some form is required in most Canadian houses to ensure adequate year-round ventilation air supply. Better controls and consumer education are required to optimize mechanical ventilation usage. While some of the leakiest houses in Canada (e.g., older homes in Vancouver) can be made more airtight to conserve energy, they will likely also require mechanical ventilation to ensure their adequate ventilation during milder parts of the year.

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Housing Research at CMHC

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