REMEDIAL MEASURES FOR HOUSING ON HAZARDOUS LANDS

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In the mid-1970's, an 81 unit townhouse complex was built in Kitchener, Ontario on an old municipal garbage dump and adjacent to a major landfill site. The combination of odours and dangerous levels of methane soon caused the householders to leave. The complex has been largely vacant for ten years.

CMHC and CH2M Hill Engineering explored ways to reduce the levels of methane concentration in the houses. A radon remedial measure, subslab ventilation, proved very effective in keeping indoor methane concentrations below 100 ppm, even in the townhouses with the previously recorded levels up to 30,000 ppm. Researchers are now investigating the ambient air impact of the subslab venting, the soil pressures required for effective venting, and the regulatory maze that needs to be traversed before the units can be reoccupied.

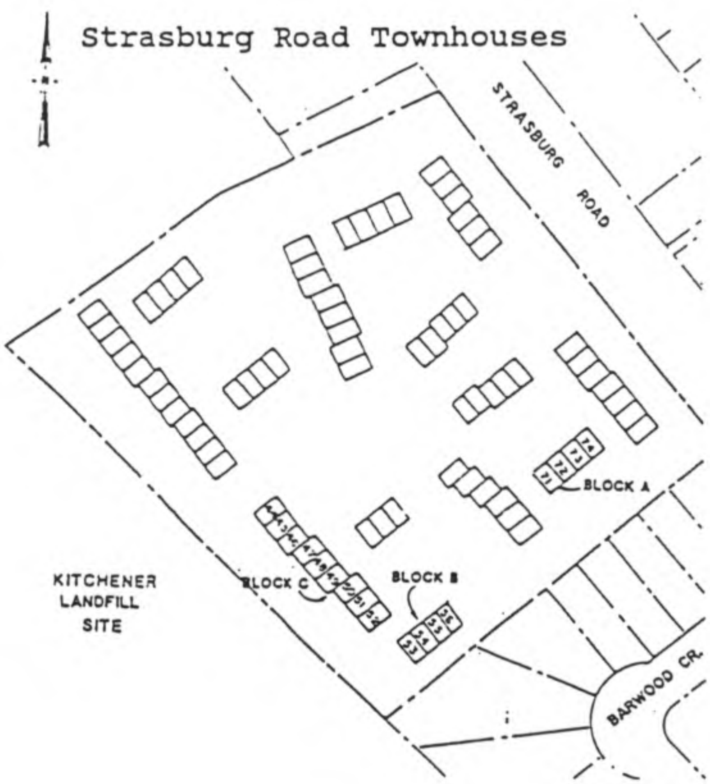
INTRODUCTION

In the mid-1970's, an 81 unit townhouse project was built in Kitchener, Ontario. The units were all two storey with full basements. Figure 1 shows a plan of the project. As the site had been a municipal garbage dump, closed in the early 1950's, precautions were taken to avoid garbage gas entry. The buried refuse was, in theory, excavated from all the foundations, but not from the adjacent green areas, parking lots, and playground. (Note on Figure 1 that a municipal landfill is also adjacent to the project, sloping down into the back yards of the houses on the landfill perimeter.) A passive soil gas collection system was installed, consisting of 150 mm plastic drain tile around the perimeter of the foundation (located above the actual foundation drainage tile), and connected to 100 mm plastic risers that were spaced roughly every three units. Despite these precautions, odours and high methane levels plagued the occupants, and the townhouse project was largely deserted by 1980.

Canada Mortgage and Housing Corporation (CMHC) is the federal agency responsible for housing policy. It also provides mortgage insurance. Through mortgage default, it assumed possession of the majority of the units. Studies for CMHC, culminating in 1987 (1), recommended that all onsite refuse be removed and protective wells be established on the border of the property. The estimated cost was in the order of $1,000,000 for these remedial measures. The CMHC Research Division, asked to review the studies, suggested that house-related measures would be less expensive and more effective. Recent research into the exclusion of radon, another soil gas, showed that soil gas ventilation around the foundation had most often reduced house radon levels to minimal concentrations. Researchers proposed trying a similar system to reduce methane levels in the townhouses. CMHC purchased the remaining five occupied units and arranged for their evacuation, prior to commencing the testing of remedial measures.

Contracts were issued to Arthur Scott and Associates, radon experts, for initial assessment of the measures (2), and to CH2M Hill Engineering for field testing and analysis (3). A multi-disciplinary advisory committee was set up, including regional officials, representatives from various affected provincial and federal ministries, and concerned local citizens.

Figure 1



MATERIALS AND METHODS

Testing was performed on a sample of the townhouses. Block A, in Figure 1, had the highest recorded concentrations of indoor methane. Block C had variable levels of methane and was adjacent to the municipal landfill site. Units in Block B had measurable levels of methane and would remain unmodified during the tests to act as controls. Methane emissions from the soil vary over time. Controls were critical to ensure that any methane reductions observed during monitoring could be properly attributed to either the remedial measures in place or to soil gas methane reductions.

The original intent was to attach a fan to the existing passive venting system, in order to have a guaranteed exhaust flow from around the foundation perimeter. The planned research followed the traditional approach of:

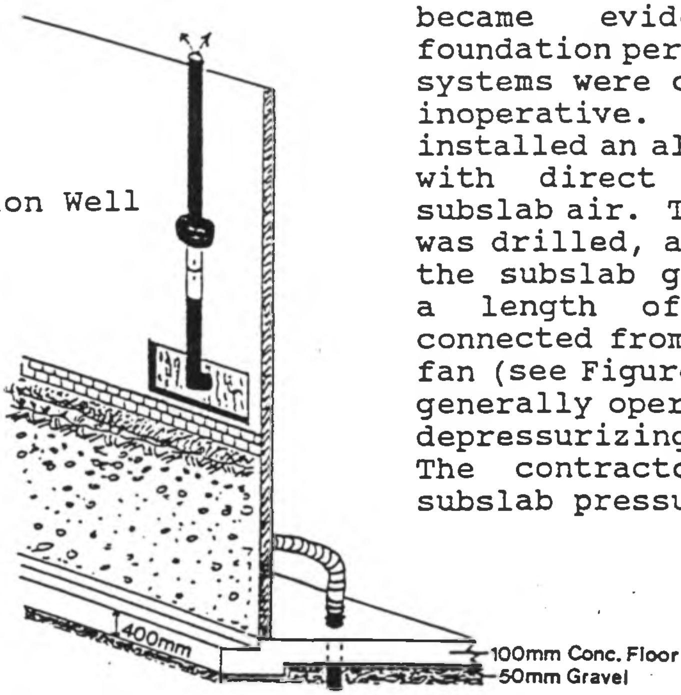
- establishment of baseline methane levels in the townhouses;
- installation and commissioning of the remedial measures; and
- retesting of the methane levels during operation of the exhaust fans.

The contractors took both spot and continuous methane samples, using flame ionization samplers and a Heath GMI Methane Detector, respectively. The contractors measured indoor air concentrations in the basement, using a fan to mix the basement air prior to sampling. The exhaust fan used in the remedial measures was a Kanalflakt K-6, which is not certified for explosive environments, and was issued a temporary permit for this research project. Requests from advisory committee members and others resulted in a number of secondary tests including:

- carbon monoxide testing in the soil gases and houses;
- volatile organic compound (VOC) testing in indoor air, ambient air, and vent stacks (for modelling purposes);
- basement wall and subslab pressure monitoring; and
- simulated fan failure events, to observe the rate of methane concentration rise during power outages.

Figure 2

Soil Gas Extraction Well



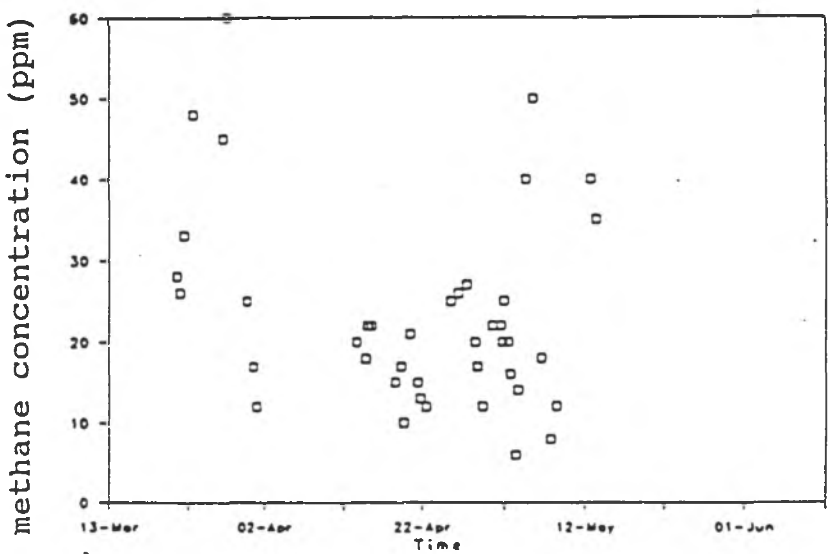
As the testing proceeded, it became evident that the foundation perimeter collection systems were often plugged and inoperative. The contractors installed an alternative system, with direct access to the subslab air. The basement floor was drilled, a pipe inserted to the subslab gravel layer, and a length of flexible duct connected from this pipe to the fan (see Figure 2). This system generally operated with the fan depressurizing the subslab air. The contractors also tested subslab pressurization.

RESULTS AND DISCUSSION

The concentrations of methane within the townhouses varied widely. Of the seventeen units monitored, all but two units had indoor levels less than 125 ppm, whether the remedial measures were in place or not. Methane concentrations in the control block declined slightly through the main period of testing (March - May, 1989), but remained adequately high for evaluation of the remedial measures. Measurements at soil probes around the site showed that high methane concentrations occurred throughout the test period, peaking usually after heavy rain. Figure 3 displays the type of variation observed in a single house in the control block, presumably due to fluctuating methane emission rates, changing house air infiltration patterns, and varying soil porosity following rainfall.

The methane levels in units 71 and 72 were considerably higher. These two townhouses were in the block with historically higher levels, and the monitoring confirmed the problem. Unit 72 peaked at 4650 ppm; unit 71 at 27,500 ppm. This latter peak is over 50% of the lower explosive limit (LEL) for methane. It is unlikely that the indoor air ever exceeded the LEL, as the standing pilot of the gas furnace would have ensured that such an event would not pass unnoticed.

Figure 3: Methane in Unit 55



The contractors examined the existing passive venting system, initially by using fans to characterize the flow resistance of the perimeter collection system. Unfortunately, the junction of the 150 mm diameter collection pipe and the 100 mm plastic riser had never been effectively sealed, and silt entered and plugged the pipes. Other blockages were due to dead birds and animals. Some of the perimeter piping in Block C was opened up with mechanical snakes, other sections were replaced. Remedial measures on Block C consisted of attaching fans to the rehabilitated perimeter pipe. In Block A, the perimeter system was clogged or partially absent; contractors used the alternative system, the hole through the basement floor.

When the fans were activated on Block C, there were no appreciable changes in the indoor methane levels. In part, this is due to low baseline levels of 1 - 50 ppm, with most of Block C having less than 10 ppm. Another factor was that the perimeter system may not have connected well to the subslab granular layer, due to wet soil conditions around the footings. Pressure testing around the foundation showed that the radius of influence of depressurization was limited, with the perimeter system more strongly affecting the walls than the floor, as would be expected if the footings had originally been placed on undisturbed ground.

The subslab depressurization system in Block A caused a striking reduction in indoor methane levels. See Figure 4 which shows spot methane concentrations before and during subslab venting. Abrupt changes in basement methane concentrations were evident upon the activation of the venting operation. As venting was halted on May 3, methane concentrations increased again. All other Block A units had similar results.

Figure 4: Methane in Unit 71 (early testing)

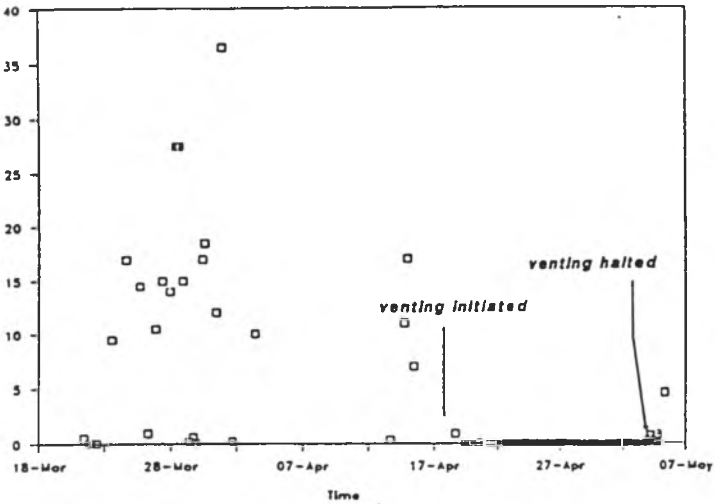
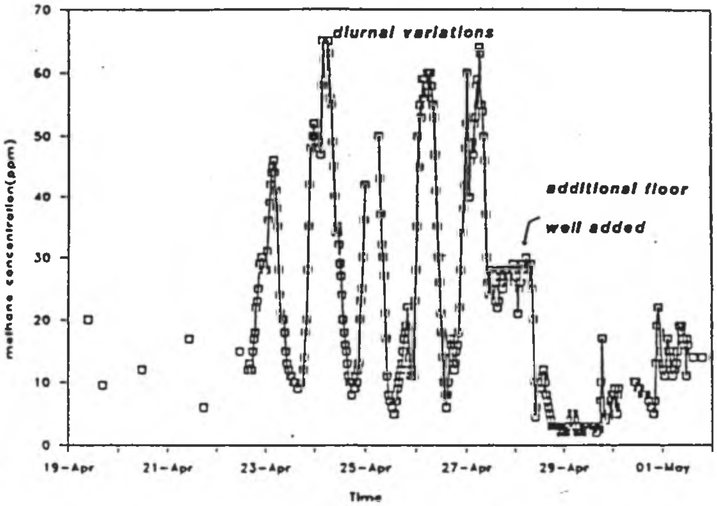


Figure 5: Methane in Unit 71 (testing with two wells)



During the initial stages of subslab venting, some significant diurnal methane variations were still observed in unit 71, up to 70 ppm (see Figure 5). The occurrance of higher methane levels during the early morning hours may be due to house stack effect, which is more pronounced during the colder outdoor temperatures of early morning. With the addition of another floor well, subslab depressurization increased and minimized the diurnal variations.

When the advisory committee reviewed these findings, they suggested some additional testing. One of the major concerns was the possibility of ambient air pollution through the process of active venting. An alternative solution, attempted in radon remedial measures, is to actively pressurize the subslab. If this system was applied to the townhouses, it would probably be forcing as much soil gas into the atmosphere as the vented subslab system. However, the gases would be modified to some extent by their passage through soil to the surface, and would avoid possible regulatory restraints by that circuitous path. The pressurization attempts were not immediately successful in reducing indoor methane concentrations, and were deemed too developmental for implementation in the Kitchener townhouses.

The contractor simulated fan failures or power outages by halting the fans and observing the resultant rises in indoor methane. Levels in problem houses such as unit 71 peaked quite quickly after the fan was shut off, though never to dangerously explosive concentrations. In the event of an extended power outage, or fan failure, some alternative system should be specified for any permanent remedial measure. An indoor methane alarm may be sufficient.

The contractor measured levels of methane and VOC's in a number of vent stacks to help assess the contribution of vented soil gases to the ambient air. The cannisters were supplied and analyzed by

Environment Canada. It is difficult to compare the recorded levels with environmental standards, as there are few ambient standards set for individual VOC's. Furthermore, the most pertinent regulatory agency, the Ontario Ministry of Environment, had, at the time of this writing, only "point of impingement" standards, which are difficult to translate to straight vent exhaust concentrations. The levels of most compounds were far below any recommended limits, with a few exceptions. One vent pipe sample had a vinyl chloride concentration of 2.2 micrograms/cubic metre which is greater than the newly set vinyl chloride ambient limit of 1.0 micrograms/cubic meter. A formal application has been made to the Ontario Ministry of Environment for permission to vent, in conjunction with additional sampling and monitoring taking place in the winter and spring of 1990. This should prompt a thorough regulatory evaluation of the concentrations in the vented gases.

CONCLUSIONS AND RECOMMENDATIONS

1) The levels of methane in the indoor air of the townhouses varied widely from house to house, and over time. Within the seventeen houses monitored, fifteen showed methane concentrations under 125 ppm.

2) The existing perimeter venting systems were largely ineffective, even when they were rehabilitated to match their designed condition. Any future installed system might avoid these problems through a thorough commissioning, regular maintenance, and a periodic retesting.

3) The subslab venting system proved to be an effective measure for reducing indoor methane levels. There are further details on the fan and system design that would have to be worked out prior to any permanent installation.

4) Implementation of remedial measures, to allow reoccupation of the townhouses, depends upon their acceptance by various regulatory agencies and governmental groups. Many of these agencies have stated their reluctance to approve any reoccupation, even if extensive technical proof of the remedial measure effectiveness are submitted.

ACKNOWLEDGMENTS

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