Crawl Space Construction

Sebastian Moffatt

Passive crawl space vents have long been seen as an effective defence against moisture build-up in crawl spaces. But because these vents are often left open in the winter and have inoperable or loosely fitting covers, they cause excessive cold air movement through the crawl space. Despite the use of crawl space vents as required by building codes, crawl spaces often have high moisture levels which can result in high humidity and condensation in living areas.

Passive crawl space vents are a major source of heat loss especially when the crawl space contains forced air heating ducts. Ambiguous wording in the Building Code and uneven enforcement of ventilation requirements by municipal inspectors manes that in some municipalities builders are required to install exterior wall vents whether or not crawl spaces are heated. In non-forced air houses some inspectors require builders to install and operate electric baseboard heaters in the crawl space all winter - even if it is meant to be unheated! This has lead to frustration and complaints from builders, and a continuing series of appeals to the B.C. Building Standards Branch.

Crawl spaces are not unique to B.C., so the basics apply wherever they are part of a building design.

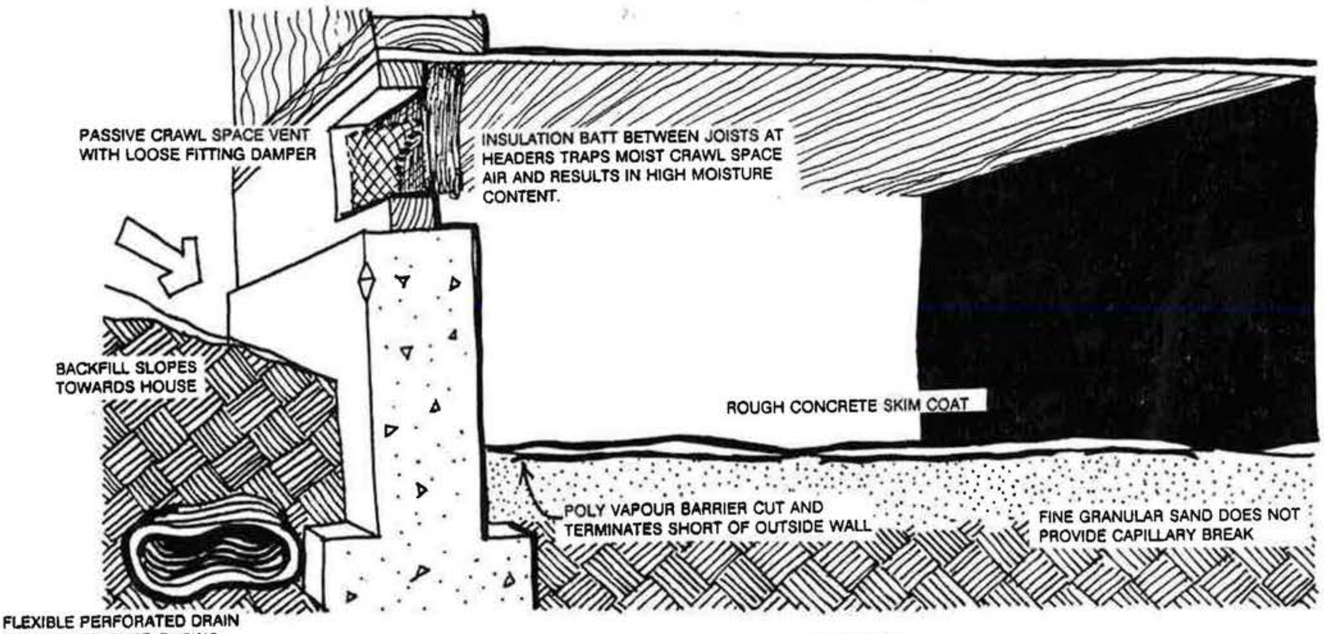
Part of the problem lies with builders who want the best of both worlds. To lower insulating and plumbing costs they choose to treat the crawl space like a shallow basement, insulating the walls and not the slab or floor (this also creates useful storage area). But for heating and ventilation purposes it is easier to treat the crawl space like wall or attic cavities, and simply ignore any distribution or delivery of heat and air. This means high heat loss as from piping, forced air ducting and through ground floors.

A study to investigate the nature of the problems has just been completed by Sheltair Scientific.Ten Vancouver area houses were studied. They included similar types of crawl space construction with different types of heating and crawl space ventilation systems (ie. vented or non-vented, forced-air or radiant heated). 3 of the problem houses had inadequate moisture barriers. Moisture was directly attributable to the lack of an effective moisture barrier, despite the presence of a 50 mm concrete slab.

Test results showed that crawl space air leakage, excluding installed ventilation, was high enough to assure a natural air change of 0.35 air changes per hour with only a small temperature difference and light wind. It was also discovered that none of the vented crawl spaces had enough vents to meet the code requirements for installed vent area (0.1 m^2/50 m^2 of plan area).

Extensive cracking of the concrete skim coat was found in all houses. The cracks did not damage the polyethylene moisture barrier where it was present. Even though the skim coat was often cracked, the poly protects the crawl and kept it dry. High wood moisture content was also measured in areas behind the joist header insulation.

The use of crawl space vents has been an attempt to compensate for inadequate or



TYPICAL PROBLEMS SEEN IN CRAWL SPACES

ineffective drainage systems and moisture barriers. A better approach may be to eliminate the vents in heated crawl spaces, and apply the cost saving towards improving drainage systems and moisture barriers.

Perimeter drainage tiles should be designed for easy testing, clean-out, and should be connected to the floor area through drains installed in the footings. Fine granular sand commonly used under slabs does not provide an effective capillary break and should be substituted with a coarse granular fill at no additional cost. Better application of insulation materials on the interior wall surfaces of crawl spaces is needed to raise thermal efficiency and reduce surface condensation. Heat radiation and air leakage from ducts in a typical forced-air crawl space should be taken into account when calculating heating requirements.

The main reason for vents in a heated crawl space is to ensure adequate drying during the non-heating season. A number of recent research reports have indicated that passive ventilation may often be unnecessary or ineffective. Ground-level air moving through passive vents in the summertime may supply little heat and drying and on cool days and nights may actually contribute to condensation in crawl spaces.

Most householders have never been informed that passive vents are to be opened in spring and closed each fall, if they're even aware of them in the first place. Vents are frequently inoperable (due to distortion by sunlight, poor installation, or settlement of structural members), or permanently plugged with insulating material.

Problems found elsewhere

Crawl space moisture problems are not just a temperate climate condition. A study in Norway House, Manitoba, found many moisture problems inside crawl spaces were caused by inappropriate construction practices. Opening vents in the spring to dry out the crawl space actually increased crawl space moisture levels as the outdoor air is moist and crawl space walls cold. This was a limited study of cold climate bungalows but, it points out the problem is not exclusive to mild coastal B.C..

A crawl space study by Lawrence Berkeley Labs in California also found that as much as 50% of the Radon gas released into the crawl space, will enter the living space. While the focus was on radon infiltration, the results are also valid for some aspects of moisture entry and for other types of soil gases.

Another study, sponsored by the USDA forest products lab found that a reasonably effective moisture barrier was adequate to control moisture, without any crawl space ventilation.

Research by Dow Chemical to develop the Perimeter Insulated Raised Floors (PIRF) system for crawl space insulation and ventilation found that the use of an effective barrier allowed builders to reduce to 1/10th of the ventilation requirements in the California Uniform Building Code. The PIRF system uses an extremely effective moisture barrier sealed to Styrofoam SM R5 board insulation.

Current Construction Practices

Foundation drainage systems were similar in the Vancouver houses. They were generally a single 100 mm plastic flexible perforated drain tile (big O) placed at or below footing height, terminating at a collection box or sump. No special measures were taken to avoid potential drainage problems. None had clean outs or risers located to easily test or service foundation drains.

Four of the houses had no poly vapour barrier under the concrete. Not surprisingly, these were 4 of the 6 houses with problems. In two of the houses, concrete was observed to have thinned to nothing in some locations, exposing poly and sand. In the house with no poly the area where the thinning was observed was noticeably wet compared to other areas.

The minimum requirements are for insulation to extend to below the frost line. Poorly applied rigid insulation can actually create condensation along concrete walls above grade, especially if humidity is high.

Air tightness testing of the crawl spaces was done on 9 houses with a door fan. The average vented crawl space leakage area was 1920 cm^2 including the installed vent leakage area and the accidental leakage area around the sill plate. The biggest leakage area was 15% more than the code required (.1 m2/50 m^2) even through the installed ventilation area was only 67% of the code requirement. All other houses measured well below the code requirements (even when accidental leakage was taken into account).

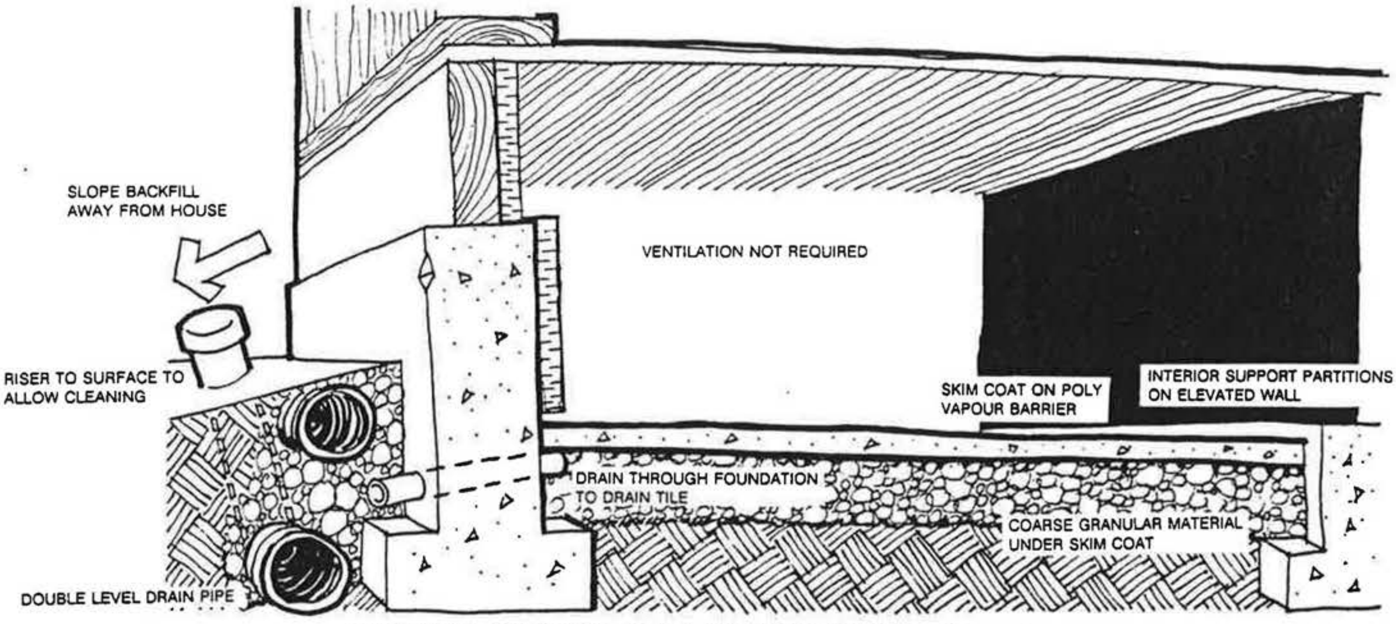
On average, forced air houses had a leakage area 510% larger than the radiant houses on the floor separating the house from crawl space. Duct leakage and supply air outlets make up most this difference.

How to build trouble-free crawlspaces?

What has to be considered for a problem free crawlspace? Some sites require a comprehensively designed moisture control system to control ground water levels that may be above the level of the crawl space floor.

Where water tables are known to be high site conditions should be investigated to assess drainage requirements. This may only be economical for multi-unit projects (or in new subdivisions as they are being laid out).

Backfills should be graded so that rain run-off is diverted away from the foundations - always grade backfill to create a small slope away from the house. Foundation drainage systems should have clean-outs to provide easy maintenance. If silting happens, this will make it easier to clean. Flexible foundation drains (big 'O') is cheap but has low strength and is easily blocked, which is why some municipalities are already refusing to allow the use of big O.



EFFECTIVE MOISTURE CONTROL SYSTEM FOR HEATED CRAWL SPACES (mild climates such as B.C. some additional heat may be required in colder climates).

Fine granular sand used under slabs (common in the lower mainland of B.C.) does not provide an effective capillary break. Coarse gravel does a much better job.

A drain through the footing to the foundation drain tile should be provided in combination with a coarse granular layer beneath the slab. This allows any water that may accumulate to drain into the perimeter drain system.

As a moisture barrier system, it is not crucial that the poly be overlapped or sealed at the edge, or that it be free of puncture holes. However, the poly should not be punctured on purpose. Lapping the poly around the slab-edge to the inside of foundation walls is impractical. But dampproofing of the inside of crawl space foundation walls would reduce crawl moisture production.

Dampproofing the top of foundation walls is important because of capillary water rising through the unprotected footing. This is why sill plate gaskets are important.

Proper application of insulation materials to the interior wall surfaces of crawl spaces will reduce the amount of moisture moved into the crawl space.

Interior support walls resting on crawl space floor at slab level absorb high amounts of moisture at the sill plate if they are not properly protected. When the walls sit on a curb above the skim coat level, they are protected better and the problem disappears.

Crawl space vents are an inappropriate moisture control system compared to an effective poly vapour barrier. Operable crawl space vents are not always properly used. Accidental air leakage into crawl spaces provides enough ventilation through infiltration and wind pressure. (a most louvred vents are poorly made, when dampers are closed the open area is reduced by only 60 - 70%.

Crawl spaces used as warm-air plenums are rare and code references to them have caused unnecessary confusion among builders and inspectors. Crawl spaces with forced air duct systems are different than crawl spaces in radiant heated houses, due to the additional air change and heat loss caused by ducting.

Heat radiation and leakage from duct work in a typical forced-air heated house crawl space are enough to keep the crawl space at 15°C (Vancouver design temperature). In colder climates some additional heat may have to be supplied.

In a radiant heated home without vents, a floor grille(s) or a duct could be installed in the ground floor to ensure adequate mixing of air in the crawl space with air in the rest of the house. Extra heat to crawl spaces in radiant heated homes does not appear to be essential based on the limited testing undertaken in this project.

The use of crawl space vents has been an attempt to compensate for inadequate or ineffective drainage systems and moisture barriers. Field surveys and test results indicate that the crawl space vents are not being installed and operated in a manner consistent with building codes, and that even where vents have been used correctly they are ineffective as a moisture control strategy. A better approach would be to eliminate the vents, and use the money to improve drainage systems and moisture barriers.

From: "Investigation of Crawl Space Ventilation and Moisture Control Strategies for B.C. Houses" prepared for CMHC by Sheltair Scientific, Vancouver.