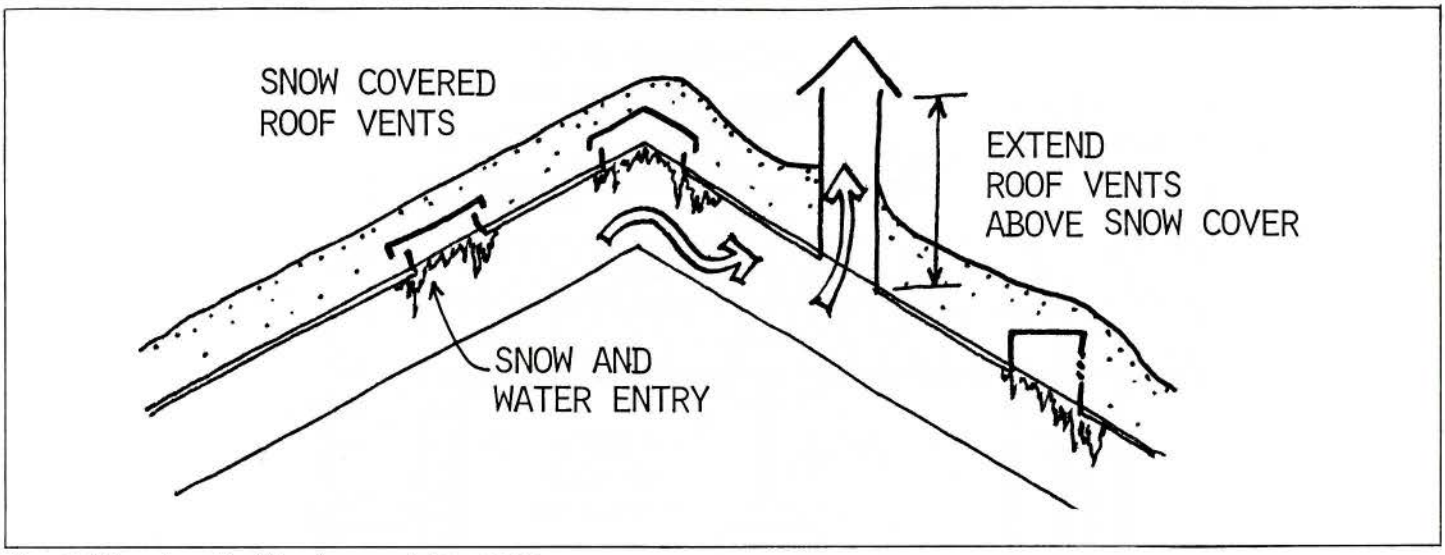

Figure 1. Attic vents must be higher than expected snow cover.

Condensation Problems in Northern Rural Houses A Case Study

by Tang G. Lee

Condensation problems cannot be blamed on any one cause but a combination of construction details, workmanship, occupant lifestyles, and a lack of home maintenance. It is also apparent that there is a need deterioration of the building structure and finishes. Evident throughout these houses are water stains, rotting materials, and growth of molds and mildew.

The houses investigated were built with financial and technical assistance from the province. Most were one to five years old and generally house families of four to ten people. These are wood frame, three bedroom, 90m² bungalows. All houses have an oil fired furnace but many homes also have wood burning stoves or other types of supplementary heaters. Every house had rough-in plumbing but none were completed as the occupants could neither afford to have water supplied to their dwelling nor a waste water septic system. The incomplete plumbing and septic system have contributed to the condensation problem.

Condensation proglems cannot be blamed on any one cause but a combination of construction details, workmanship, occupant lifestyles, and a lack of home maintenance. It is also apparent that there is a need to re-examine the house details and the construction process. While the existing house design is simple and easily constructed, it has difficulty performing under such severe climatic conditions.

This article identifies the condensation problem in rural northern houses. The causes of condensation and measures to mitigate its damaging consequences to the houses are also discussed.

Observations

The major concern in all the houses examined was the build up of condensation within the house and the resulting deterioration. These houses have very musty and stale odours. An air sampling in these houses revealed very high relative humidities of over 50% during the winter. Among the causes of high indoor humidities are:

- no kitchen exhaust hoods and fans,
- inoperative or unused bathroom exhaust fans,
- bathroom and clothes dryer exhaust vents were clogged by dirt, snow and debris,
- missing or inadequately sized crawl space vents,
- missing or damaged gable vents,
- snow covered roof vents,
- no fresh air supplied to the furnace for combustion purpose nor fresh air supply to the house,
- furnace filters were clogged with dust thus reducing air circulation throughout the house, and
- wet crawl spaces.

Condensation and the resulting water stains, molds and dust markings were evident throughout the building but particularly on windows, doors, baseboards and on wall and ceiling junctions.

Siting and Construction

To determine the cause or causes of condensation in buildings one must examine closely the use and occupancy of the building, its location, workmanship and whether the house meets relevant building standards. The houses inspected for this project were located in remote areas. Being isolated from other houses and from urban centres can result in several problems that will affect the severity of condensation problems. The six main problems attributed to the remote location of these houses are, siting, inspection, building supplies, workmanship, building standards and condensation.

Improper Siting

Some of the houses examined for this study were built on a swale or on a lower part of the site. Houses located in these areas exhibited wet foundation walls and crawl spaces due to surface runoff and high water table levels. Moisture can migrate into the house from wet crawl spaces.

Inadequate Building Inspection

The scattered location of these houses made periodic inspection during construction difficult, costly and time consuming. As a result, some methods of construction and workmanship may not achieve normally acceptable building standards. For example, inadequately sealed ceilings allowed vapour to migrate into the attic.

Access to Building Supplies

Restricted access to building materials and supplies hinders the speed and overall efficiency of construction. While some builders may be resourceful in substituting materials and components which are missing or damaged, other builders may use unacceptable materials or not bother to make up the deficiencies during construction. Damaged or poorly installed bathroom fans for example were unused by the occupants as the noise was unacceptable. Ventilating grilles for the roof and crawl space were easily bent which reduced their effective vent opening area resulting in humid attics and crawl spaces. To obtain a replacement part may require a three hour trip to the nearest building supplier.

Owning a house requires periodic maintenance. The furnace filter and weatherstripping on windows and doors need replacing regularly. Owners who are able, willing and capable of maintaining their home are discouraged by the availability and cost of obtaining building supplies. As a result, the owners are reluctant to make the necessary repairs to extend the service life of their houses.

Construction and Workmanship

One of the requirements of the provincial building assistance programme is to leave a small amount of the construction for the home owner

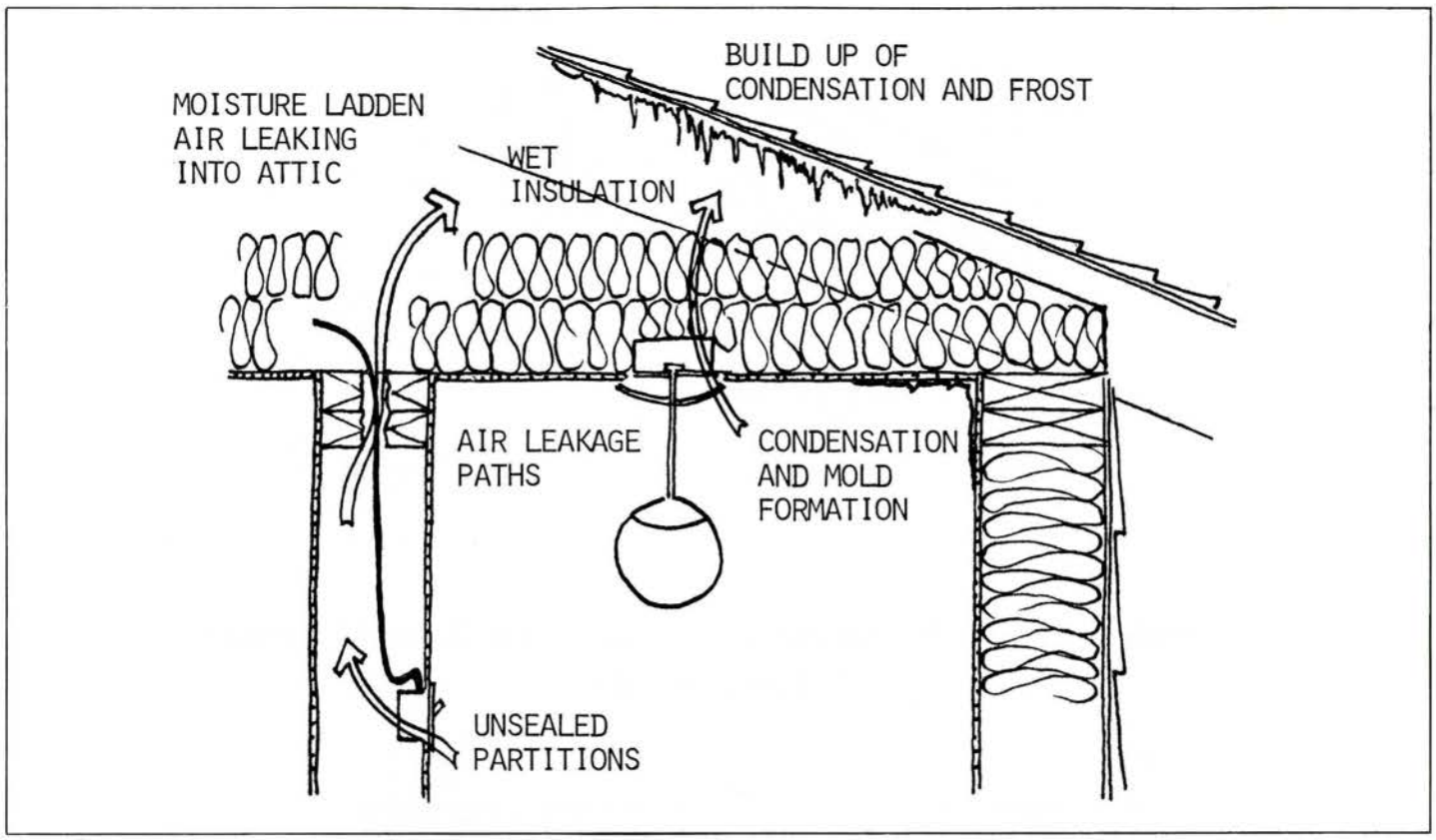

Figure 2. Attic consensation resulting from air leakage through the ceiling.

to undertake. Painting of wood trims around doors and windows, and of the interior was expected. Unfortunately many of the houses examined did not have the exterior window trims painted. As a result, the wood had deteriorated, some with cracks which allowed rain and snow to enter the house, thus adding moisture to the air. While most interior walls were painted, some owners did not use the proper type of paint, or diluted the paint to the extent that it cannot provide adequate vapour seal. Concealed moisture can form inside or behind the drywall owing to improper painting and from water dripping down the wall.

Building Standards

The Alberta Building Code requires the attic and crawl spaces to be vented with an unobstructed opening of at least 1/300th of the insulated ceiling area.[2] Unfortunately some of the roof type vents used in northern Alberta can easily be covered by snow as shown in Figure 1.

Crawl space venting in these houses involved four 200 x 400 mm vents installed with insect screens and frille. The effective unobstructed opening required is 0.29 m^2 (450 in^2) but the insect screen and grille reduced its opening to approximately 50% or 0.16 m^2 opening.[3] Furthermore, the crawl space venting was often obstructed with snow, dirt and other debris piled against the wall. The building code requires 1/300th of the crawl space area be vented. In a 90 m^2 crawl space, the venting area should be at least 0.30 m^2. The amount of venting in these crawl spaces was therefore quite inadequate.

Attic condensation

It was originally thought that diffusion was the most influential mode of water vapour movement. However, water vapour migration through air leakage is of greater importance to the problem of interstitial condensation.[4] This refers to the water vapour transported with the air as it migrates into the assembly. To minimize the amount of moisture laden air carried into the attic space, the ceiling must be air-tight. Penetrations abound in the houses examined due to electrical wiring, plumbing and gaps in the construction. (Fig. 2). Builders of these houses have not sealed the polyethylene with caulking thus providing another path for air leakage. Obviously one solution is to seal leaks in the ceiling by caulking or spraying any openings.

Occupant Lifestyle

The houses in question here were owned by people with low incomes or on social assistance. For most of these residents this was the first home they have lived in which had central heating. It was also by far the first home they had lived in which comes close to being air-tight.

The majority of the occupants have maintained a lifestyle which differs from usual urban dwellers. Some of the major differences in lifestyles and conditions which affected the amount of condensation problems in these houses are outlined below.

Domestic Water

As part of the provincial assistance programme, all roughed in plumbing and drainage were installed in the houses with the intent that the owners would complete the installation. In practice, the water and drainage were often not completed owing to high cost, lack of priority and availability of water supply. As a result, the houses examined do not have operating water and sewage systems. Water or snow must be brought into the house and stored in water containers, typically in a 45 gallon steel drum. The water containers were not always covered which resulted in additional moisture in the house by evaporation.

Water for laundry, bathing and washing floors was heated on an electric stove. Heating and boiling such water adds further moisture to the air.

Waste water was disposed of by pouring it out the door. Unless the door faces a grade which slopes away from the house, the discarded water can migrate back into the house via the crawl space. When the crawl space becomes wet, the humid air can migrate into the house through openings in the floor. (Fig. 3).

Cooking

Much of the food in these houses was cooked by boiling or using water based methods. Baking, and the use of microwave ovens which do not generate as much moisture were not common. The general style of cooking and washing up per meal releases roughly 18 litres (4 gallons) of water into the house.

Space Heating

Many oil fired furnaces in these houses were never used once the initial tank of oil was depleted. The oil tanks were rarely refilled owing to the cost and inconvenience of delivering oil to these remote locations. As a result, the occupants installed a wood burning stove or a portable oil heater. Since the stove and heater were generally located in the living room, the heat did not readily reach the bedrooms because there was no forced air circulation. To counteract cold bedrooms, the living room must be overheated in an attempt to warm the bedrooms. (Fig. 4). Without air circulation the humid air concentrated in the bathroom and kitchen and caused the worst condesation damges there. (Fig. 5).

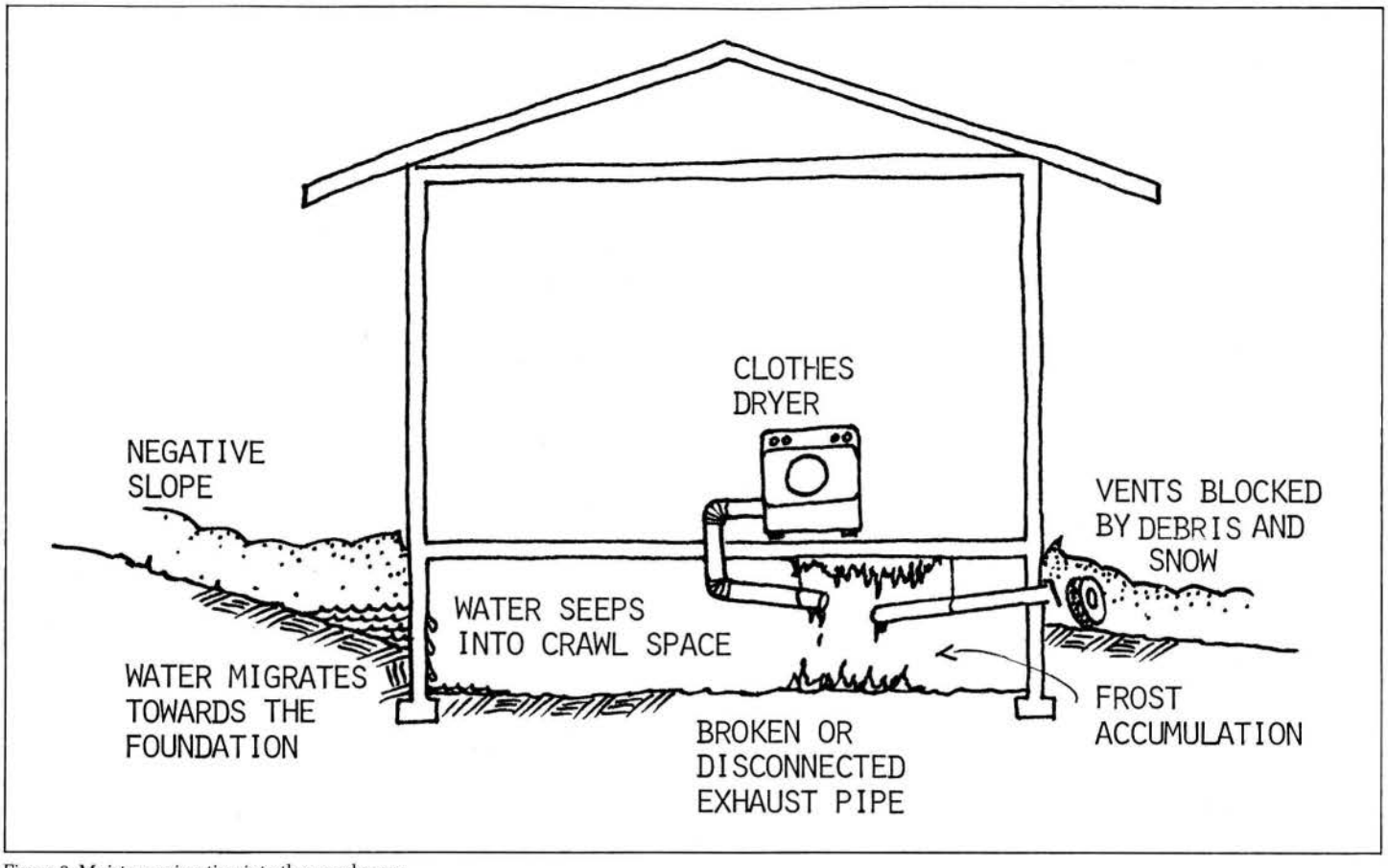

Figure 3. Moisture migration into the crawl space.

Food Storage

The crawl space was often used for food storage since it is cooler than the house. The unfinished crawl space became dirty and humid. As a result, growth of fungi and molds leading to deterioration of food stored in this space was common. The storage of food in the crawl space increased the amount of humidity dissipated into the house through floor cracks and the loosely fitted and frequently opened hatch.

The effect of the occupant's lifestyles is the generation of high humidity levels in the houses. The lack of adequate ventilation in these houses further contributes to the build-up of high indoor humidities.

Remedial Measures to Existing Houses

1) Reduce moisture generating sources.

It is without doubt that high indoor water vapour levels increase the rish of condensation damage to the building enclosure. The obvious strategy therefore is to ensure the indoor relative humidity does not exceed a certain level which would limit the condensation to a tolerable level. Some authorities suggest the maximum tolerable relative humidity in a building is reached when a small amount of condensation is present on a double glazed window.[5] The indoor relative humidity must be between 15% and 20% before condensation will occur on a double glazed window when the outdoor temperature is -30°C. This is a typical moderately severe winter condition in northern Alberta. If a higher relative humidity level is necessary or desirable, triple glazing can tolerate 40% relative humidity before condensation is noticeable on the windows.[6]

Rising ground moisture in the crawl space increases the water vapour level in the house above. Moist air migrates into the house from openings into the crawl space. The openings occur at the trap door and where plumbing, ducting and electrical wires penetrate through the floor and walls. Since it is inappropriate to use the crawl space as a root cellar or workshop, the floor access hatch should be sealed. For maintenance purpose, the crawl space access hatch can be located in the foundation wall accessible from the exterior.

Raising the 45 gallon water cistern above the floor and installing a hose bib and lid as shown in Figure 6 will reduce evaporation and avoid contamination.

Standing waste water also evaporates into the house, increasing the relative humidity level. A simple drain which discharges out to the lower side of the site will encourage the occupants to discard used water immediately. Laundry water can also be discarded through this one outlet. Pouring the occasional pot of hot water into the drain will keep the pipes free from ice blockage. While discarding waste water onto the ground is not desirable, this solution is no different from current practices in these remote locations. If possible all drains should discharge into a drywell.

2) Ventilate the attic.

Moist indoor air which leaks from the house to the attic through the inevitable openings will condense into water droplets on the rafters and roof sheathing. Proper attic ventilation can carry much of this vapour to the outside before the amount of moisture exceeds the tolerable limits of the building materials in the attic. Where the roof slope is less than 1:6, or the roof incorporates no attic space, the unobstructed vent area must be not less than 1/150 of the insulated ceiling area.[7] In all cases where venting of the roof is required, there must be a clear passage of at least 25 mm between the top of the ceiling insulation and below the top of the roof joist.[8]

3) Ventilate the crawl space.

The crawl spaces examined were very humid and the ground was often wet indicating rising dampness from groundwater. Furthermore, some clothes dryer vents exhausted directly into the crawl space, either from unconnected or separated ducts. (Fig. 3). Ventilation is the most effective way to reduce the humidity in the crawl space. Unfortunately the foundation wall was insulated and venting the crawl space to remove moisture would also increase heat loss from the house. Furthermore, the foundation wall insulation had very little thermal resistance because it was often wet owing to rising dampness and melting snow. It is better to insulate the floor and not the foundation wall.

In many instances the existing vents were not very effective. Many vents were damaged and the grilles were sometimes blocked by snow, dirt or debris. A black painted metal duct positioned on the south side of the house can create an updraft when the sun is shining. If this duct is connected to one of the ven openings in the crawl space it will draw air through the house creating a drying effect. The solar chimney would only draw air when the air is warmed on a sunny day. At night the solar chimney would not create a stack effect, thus eliminating heat loss in the crawl space. An opening on the opposite (north) side of the house is needed to replace the air vented by the solar chimney. This intake

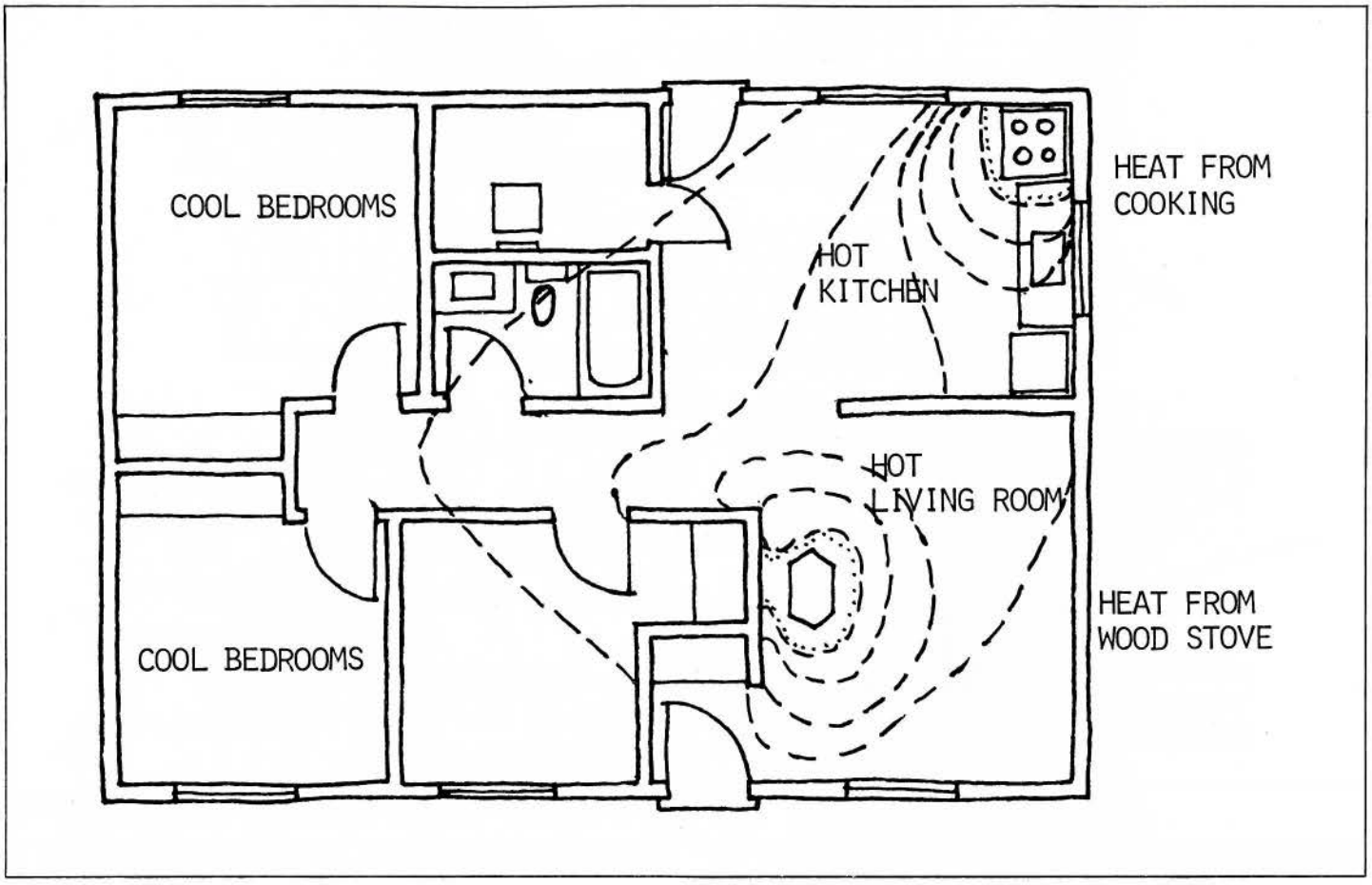

Figure 4. Concentrated area of heat.

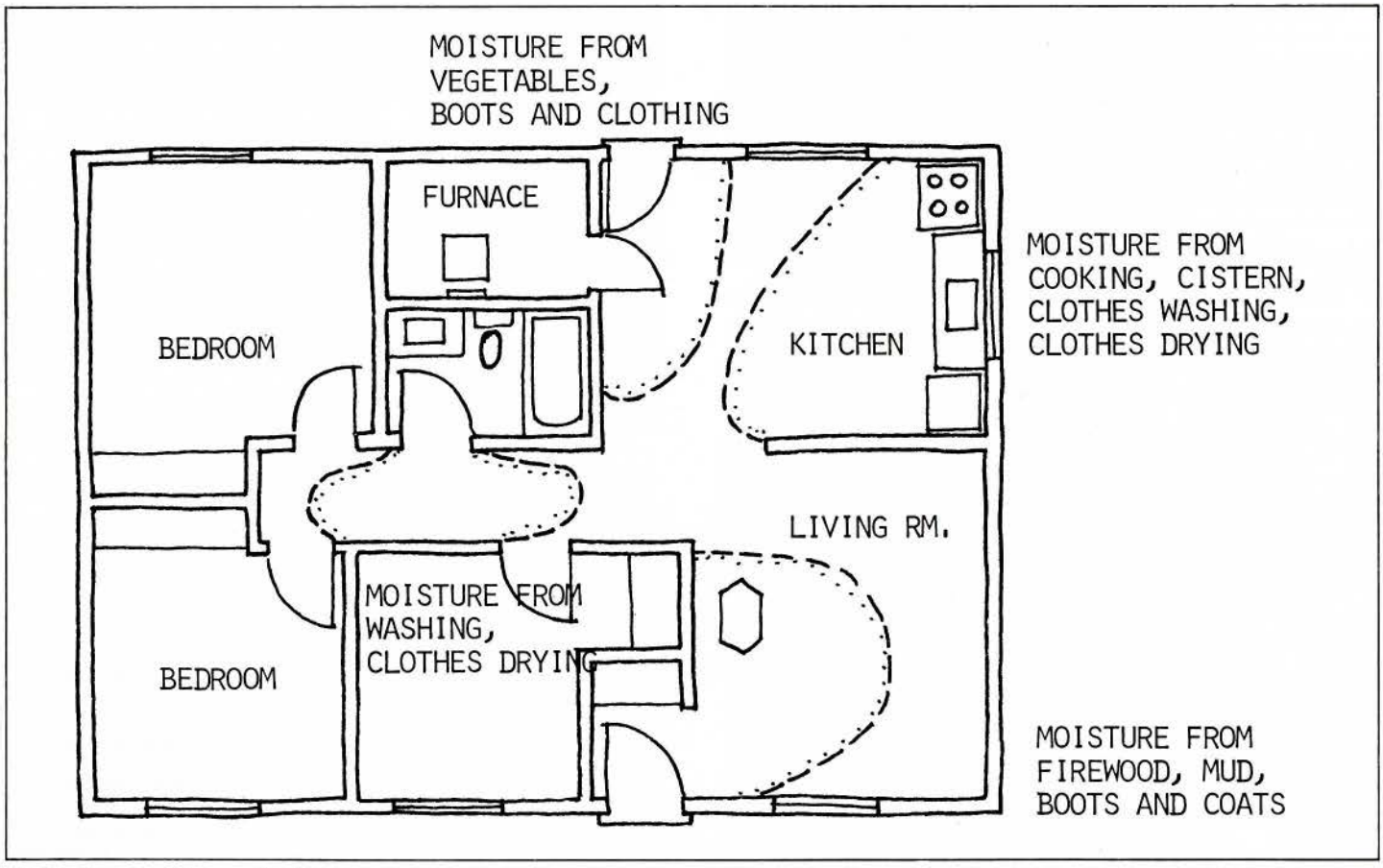

Figure 5. Concentrated areas of moisture.

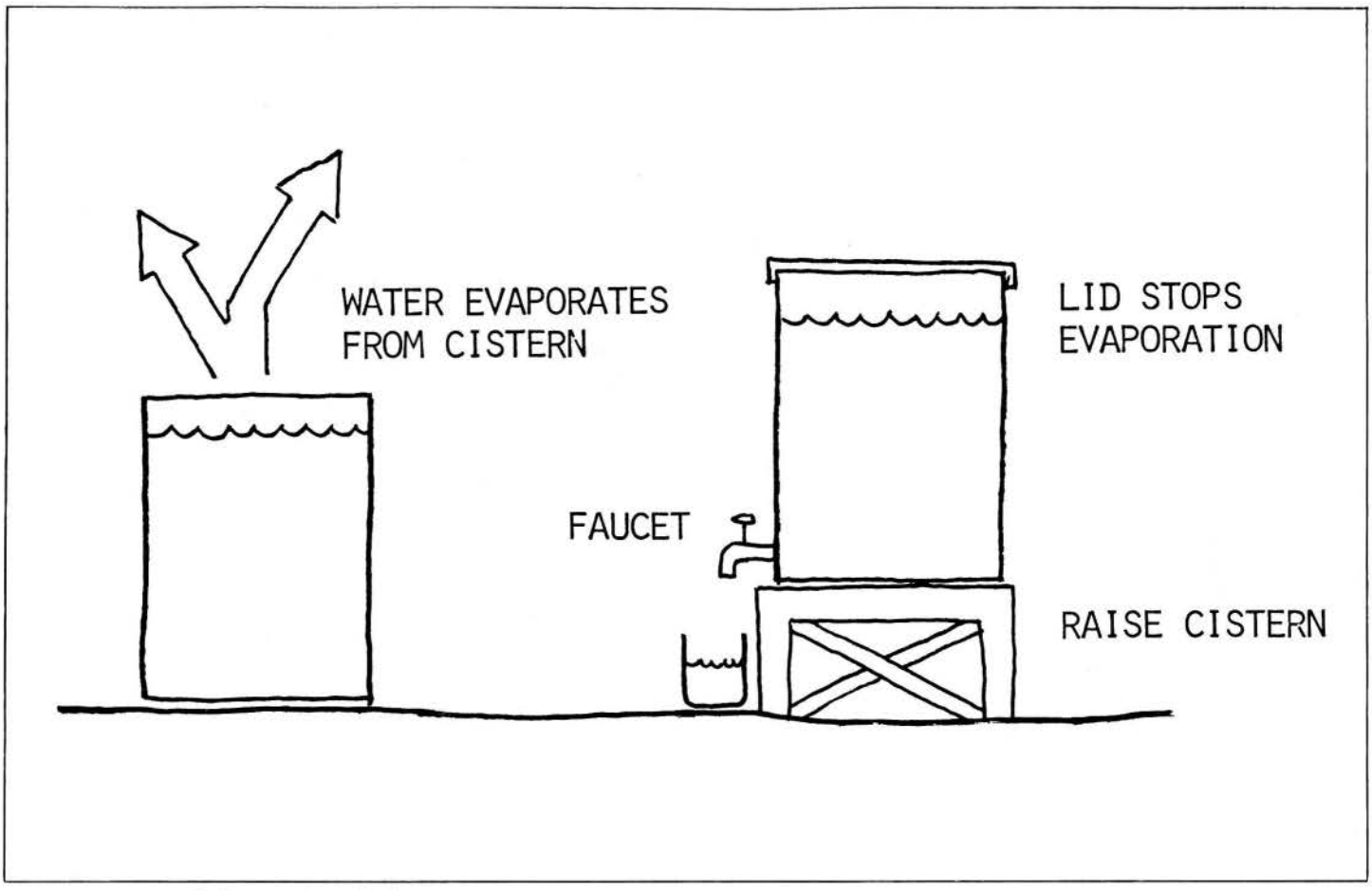

Figure 6. Water cistern for houses without plumbing.

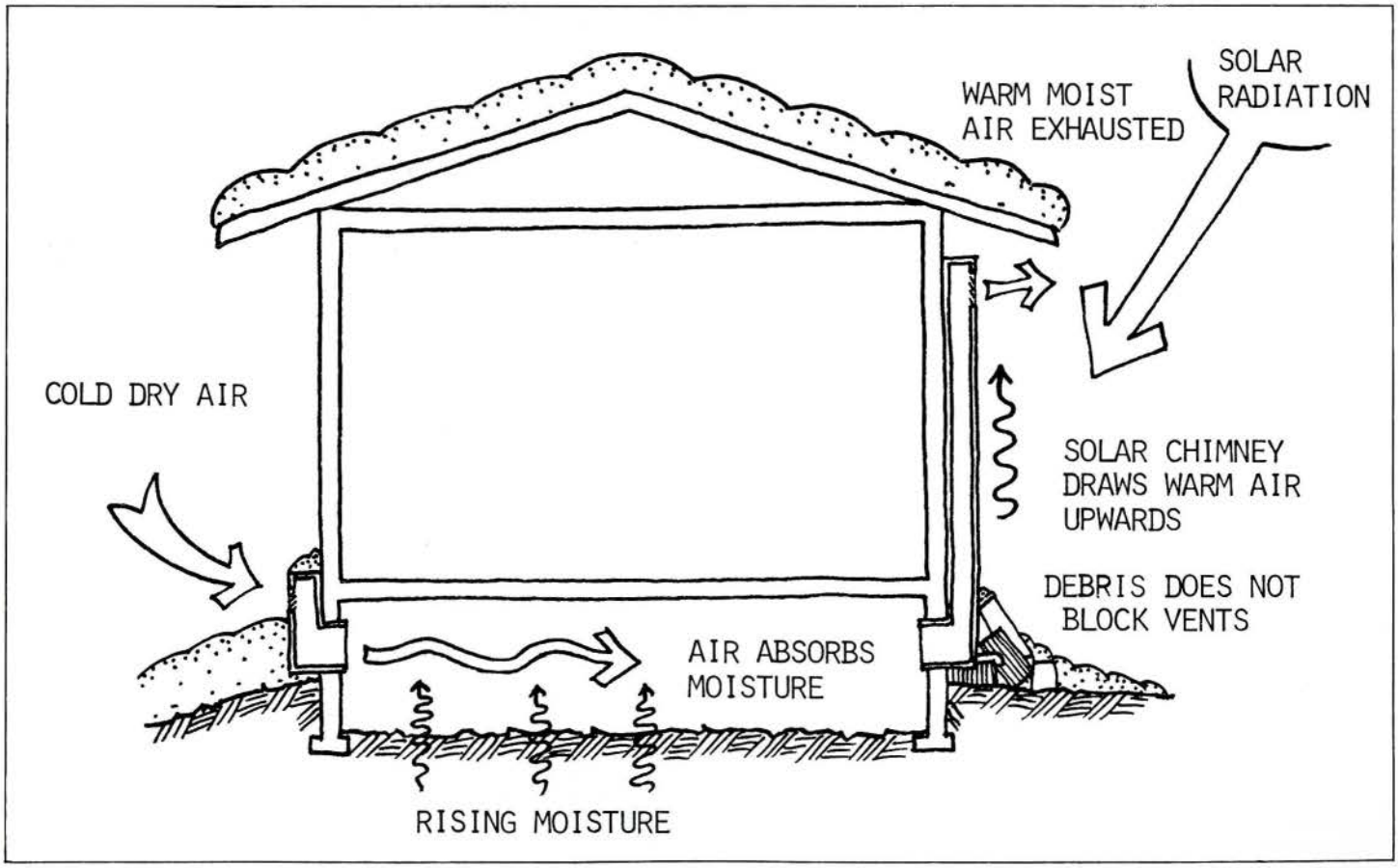

Figure 7. Proposed crawl space venting using a solar chimney.

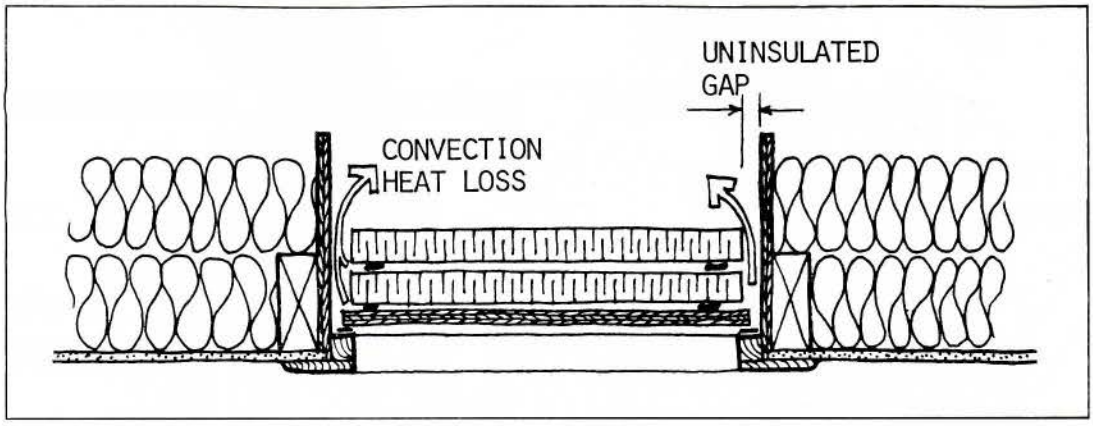

Figure 8. Typical insulated attic access hatch.

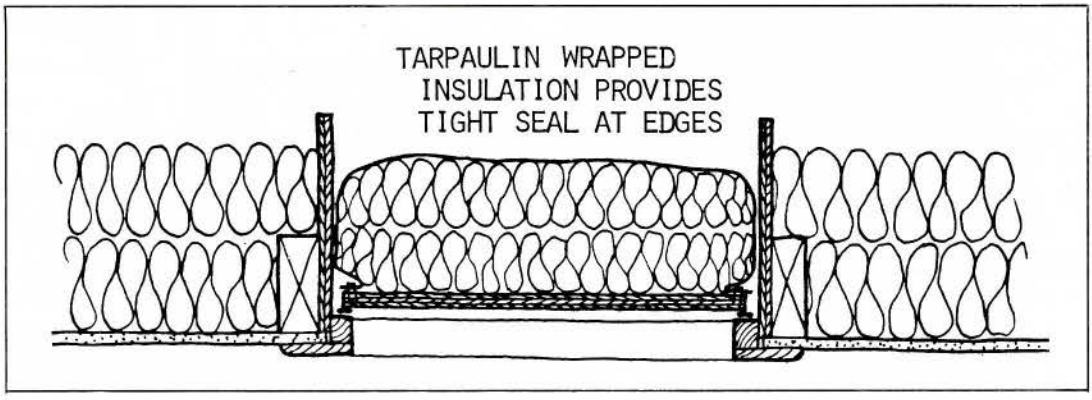

Figure 9. Proposed attic access hatch with good insulation and air seal.

vent should also be ducted upward to avoid blockage by snow or other materials (Fig. 7).

With a solar chimney it is possible to keep the insulation on the foundation walls instead of under the floor. Insulating the floor is difficult because the ducts and other utilities in the floor have to be covered. Heat loss from the house is minimized because the ventilation only occurs during warmer days.

4) Ventilate the house.

In the Canadian prairies, the most effective means of reducing high humidity levels in houses is through ventilation. Outdoor air in the winter may have a very high relative humidity level but its actual moisture content is low. When this cold air is brought to the inside and heated the capacity to carry more water vapour increases. As a result, the warmed outdoor air mixes with the indoor air to lower the indoor relative humidity level.

The problem with uncontrolled ventilation is that excess building heat loss results in very high heating fuel cost. The ideal situation therefore is to ventilate only those areas of high moisture generating sources in the house such as the bathrooms and kitchen.

Controlling the indoor relative humidity with ventilation requires detecting humidity levels. Simple but quiet kitchen and bathroom exhaust fans will help alleviate the amount of moisture build-up. The occupant would turn on the exhaust fan when condensation appears on the window and turn it off when the condensation disappears to reduce heat loss. Alternatively, an additional exhausting fan strictly for the control of condensation can be installed. This fan is operated by a humidistat which turns on the ventilating fan to lower the humidity to a preset level. This humidistat controlled exhaust fan has been successfully tested by the province on one of the houses examined.

5) Attic access hatches.

In the houses examined the attic access hatch was not insulated or was inadequately insulated. No hatches had good air seals. Many hatches were insulated with rigid insulation and a gap between the insulation and hatch opening was thermally weak causing cold conditions around the frames. (Fig. 8). A tarpaulin covered glass fibre insulation attached to the hatch, (Fig. 9), can provide a snug fit.[9] Unsealed hatches permit moist air into the attic, causing a build-up of condensation and frost. These hatches must be weatherstripped to alleviate the condensation problem.

It is rarely needed to access the attic from inside the house. It would be better to position the access on the outside. Although less convenient to access the attic from the exterior the need to do so is rare. This would result in a continuous air-tight ceiling uninterrupted by the attic hatch.

Conclusion

The major causes of condensation problems in houses located in northern Alberta are; lifestyles which generate much indoor humidity, lack of water supply and sewage disposal and a lack of ventilation. Owing to the remote rural location of these houses, servicing, inspection and repairs were particularly difficult and costly.

Appropriate maintenance free housing suitable for the needs, desires and ability of the low income dwellers is needed. A number of solutions are proposed ranging from consumer awareness and participation, to the installation of humidity controlled ventilating fans and a solar chimney to ventilate the crawl space.□

Notes

1. Lee, T.G. "Investigation of condensation problems in rural home assistance program units." Unpublished report for the Rural Housing Division, Alberta Housing, March 24, 1986.
2. Alberta Building Code 1985, Article 9.19.1.1. Building Standards Branch, Alberta Labour.
3. ASHRAE Handbook 1985 Fundamental, Chapter 19.
4. Rousseau, M.Z. "Control of surface and concealed condensation." Proceeding of seminar, Humidity, Condensation and Ventilation in Houses, Building Science Insight '83, Division of Building Research, National Research Council, Canada, Edmonton, November 8, 1983, NRCC 23293, May 1984.
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6. "Condensation Concerns." Booklet, ENR I/17 - No. 9, Energy Conservation Branch, Alberta Energy, 1987.
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8. Standata #85-DR-001R, Director's ruling, January 1986, Alberta Building Code 1985.
9. Lee, T.G., "Condensation in Manufactured Housing." Alberta Municipal Affairs, February, 1987, Edmonton, Alberta.