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Introduction

Many inquiries concerning rain penetration of exterior walls are received by the B.C. Regional Station of the Division of Building Research, National Research Council of Canada. Much of the damage that has been investigated consisted of staining and deterioration of interior finishes of the walls around windows. In severe cases wetting of carpets and floors near windows was also encountered. This report discusses wood window frames in relation to the principles of water penetration, and the watershedding function of flashings, sheathing paper and window details. It also discusses flange-mounted metal windows and their installation details, particularly in regard to the application of sheathing paper around window openings.

Causes of Rain leakage

Rain leakage occurs as a result of three factors: water on a wall, paths for the water to penetrate the wall surface and forces to drive water inward. These three factors are described below.

Presence of water on a wall surface

It is almost certain that at some time there will be water on a wall surface. Earlier houses had large roof overhangs that protected the walls from wetting, except when rain was accompanied by high winds. At wind speeds of less than 20 km/h, rain will drip almost vertically from the edge of an overhang if a reasonable drip edge is provided. Much current residential construction in the lower mainland of British Columbia, however, is characterized by a lack of roof overhangs or projections above openings. Flashings that are designed to act as a drip edge can be ineffective when they are cut back flush to or behind the surface. (This is frequently done to make them inconspicuous.) Water migrating down a wall surface can be driven across a building face by the wind to concentrate at vertical obstructions such as projecting window jambs. This is usually evident by the staining that appears below the bottom corners of windows, although part of this may be due to rain runoff from sills that slope to one corner.

Water leakage paths

There will almost always be paths for water to penetrate at the joints around window and door openings, unless great care is taken in design and construction. The junction between the rough framing of a window opening and the window frame, and between the frame and the exterior wall finish is seldom sealed completely. Even when achieved initially, water tightness and airtightness can be difficult to maintain.

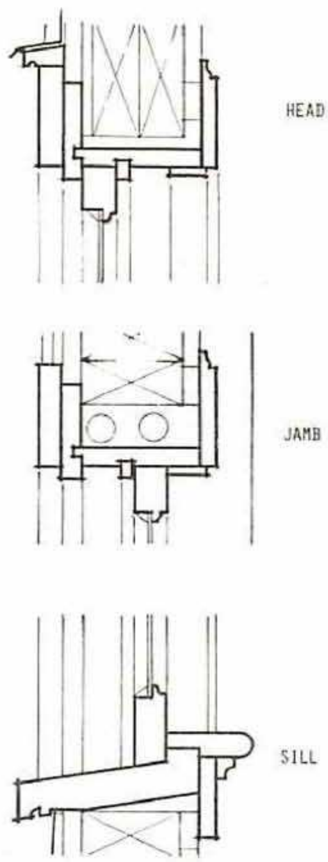

FIGURE 1 DETAIL OF EARLIER WOOD WINDOW

In an attempt to simplify details and produce less expensive windows, designers and manufacturers sometimes ignore design details that evolved over hundreds of years of building practice. An earlier wood window design shown in Figure 1 shows a drip cap and flashing at the head of the window, properly sloped to control water. The sill is steeply sloped to drain water away. In addition, this design has a barrier to rain penetration behind the bottom of the sash, a groove to stop water flowing back under the sill, and a notch in the sill at the wall to deter water from entering under the sill. Experience showed this, along with the window head, to be an area with a high risk of water entry. At the window head a wood drip cap is used in addition to the flashing. Although the possibility of leakage at the jamb is not as great as at the head or sill, in some older window designs the safeguards against water penetration at the jamb were also quite carefully detailed.

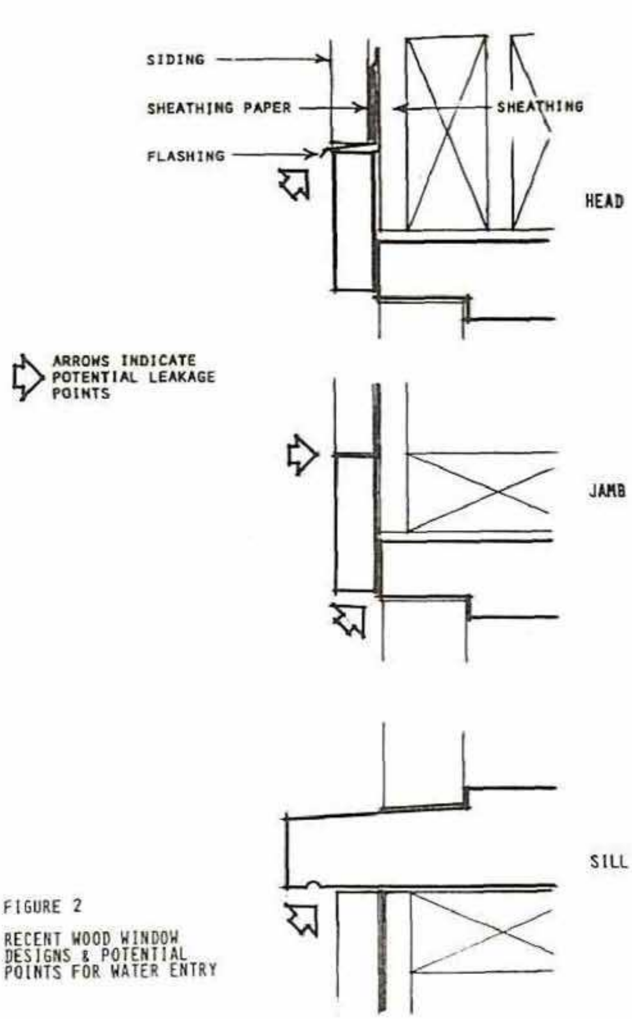

FIGURE 2

RECENT WOOD WINDOW DESIGNS & POTENTIAL POINTS FOR WATER ENTRY

The wood windows of a recently built project are shown in Figure 2. The design details at the sill, head and jambs have been greatly simplified. The sill has a small slope only on the top surface. There is a shallow groove to deter the flow along the underside of the sill, but it obviously would not be as effective as the sloped underside in Figure 1. Also, this design has no deterrent against rain entry at the wall, so that water flowing along the underside of the sill can penetrate the wall or the building. Caulking between the sill and exterior cladding might be effective for a short time, but with a proper design the detail should work even without caulking. The flashing at the head of this window was not sloped to the exterior when installed, and it was cut back so close to the casing that water could run under it and behind the casing. Any building movement causing wracking forces on the casings will also quite likely open up water paths. Effective caulking at the jamb is difficult and water can easily penetrate behind the casing. Simplifying joinery details by using only butted joints allows easy water penetration from outside to inside and also creates air leakage paths for heat loss.

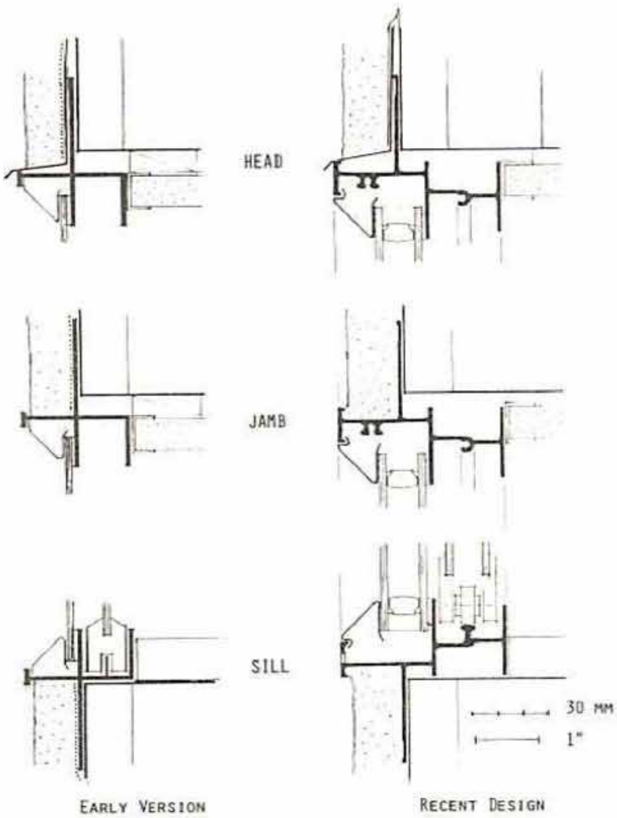

FIGURE 3 FLANGE MOUNTED METAL WINDOWS

Earlier metal window frames were often simplified even more than wood frames in the interest of producing a single extrusion for head, jamb and sill members. A flange as part of the extrusion simplifies the installation and attachment in the opening. The early version shown in Figure 3 is typical of the designs used for metal window frames in this area. For reasons of economy the exposed edges of the frame are almost flush with the exterior finish. The edge of the sill does not extend far enough to allow water to drip clear of the joint and the wall. This creates a potential for leakage behind the exterior finish, as there is usually a crack between the finish and the frame. The situation at the jambs and head is similar and the potential for problems at the head may even be greater than at the sill, particularly if flashing is not used.

The section of a more modern frame, also shown in Figure 3, illustrates advances in design over earlier types. Even this design, however, has potential for leakage if improperly installed. Drain holes are provided in the upturned lip of the sill, but the sill itself will not direct water away from the joint at the exterior wall finish. The large upstanding lip at the head detail will create a water trap if the flashing is inadequate, or if no flashing is used.

Forces that drive water inwards

The forces that cause water penetration at openings are the kinetic energy of the rain as it is driven by wind, the difference in air pressure across the opening from outside to inside, and gravity and capillary forces acting on water bridging an opening. Since these forces are normally always present together, water penetration will almost certainly take place if there are also leakage paths.

Sheathing paper

Sheathing paper is used on the walls of frame buildings to prevent air leakage from wind, and as a water barrier behind the exterior cladding. A frame building is generally considered secure from the weather when the roof, doors and windows are in place, and the sheathing paper is installed. Unless the sheathing paper is damaged from wind or construction operations it does provide good short-term protection even without the exterior wall finish. It is usually installed horizontally starting from the bottom of the wall, and is lapped in shingle-fashion to shed water. Vertical applications may also be used in some cases. Sheathing paper is intended to restrict water penetration to the exterior cladding and carry the leakage harmlessly to the outside. If improperly installed, however, it may actually encourage water to penetrate the wall, even through to interior surfaces.

At one time, it was required that sheathing paper be wrapped back (or returned) around the rough framing of window and door openings. This made it necessary to apply the sheathing paper before installing the windows. This is most desirable if a complete air barrier is to be achieved, but it is also necessary to assure that, when the window is installed, the head flashing goes up behind the sheathing paper to achieve proper shedding of any water that penetrates the exterior finish above the window. This does not usually pose a problem for wood windows, but may be a problem for flange-mounted metal windows.

Metal windows generally have a continuous flange all around with close fitting mitered corners that are not sealed or welded. When the window is positioned in the opening it is fastened by nails or screws through the flanges and sheathing to the rough frame (Figure 4). Some manufacturers recommend that nails not penetrate the flanges but be driven at the outer edge and then bent back over the flange. This is to minimize stress transfer to the window in case of structural movement of the building frame. For water control the sheathing paper needs to overlap the flange at the head and jambs, but the flange must overlap the paper at the sill. If the sheathing paper is applied before the windows are installed this will not occur (Figure 4a). Most often in current practice the windows are installed before the sheathing paper is applied (Figure 4b) and this will not prevent rain leakage if the paper is on top of the sill flange.

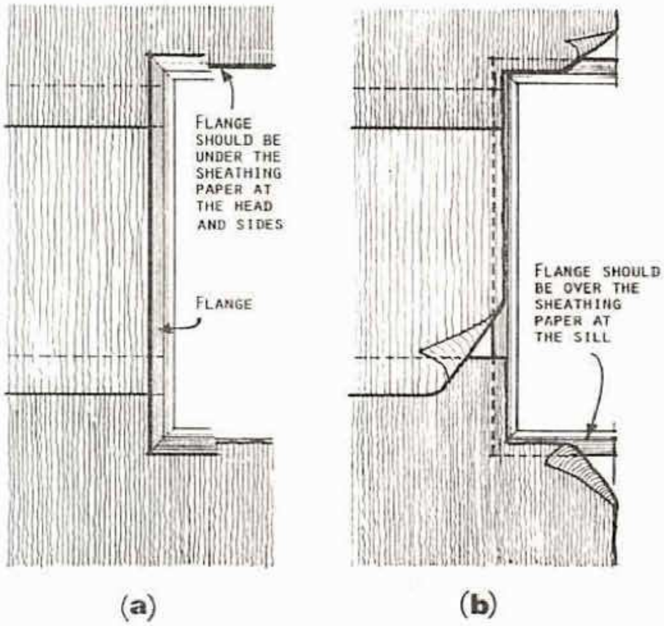

FIGURE 4 FLANGE MOUNTED METAL WINDOWS
(a) MOUNTED AFTER THE SHEATHING PAPER IS IN PLACE
(b) CURRENT PRACTICE. MOUNTED BEFORE THE SHEATHING PAPER IS IN PLACE.

A method for overcoming this problem is suggested in Figure 5. The sheathing paper is applied after windows have been installed, but a separate piece of sheathing paper or other watershedding membrane is applied over the sill of the rough opening before the installation of the window (Figure 5a). The window frame is set over this membrane (Figure 5b), and when the sheathing paper is applied it can be tucked under the sill protection and carried up over the jamb flange (Figure 5c). A spot of caulking at the intersection of the membranes at the flange will assure a seal. The sill membrane must be temporarily fastened during construction to prevent it from being torn away or damaged by wind.

Some window manufacturers have recognized this problem, and attach a built-in membrane flashing to the window frame. In this case the membrane flashing should be under the sheathing paper at the head and jambs of the window, and over the sheathing paper at the sill.

Flashing

Flashing is required at the heads of all openings, unless the roof overhang projects from the wall to a distance equal to at least four times the distance between the fascia and the top of the window trim. The flashing must extend not less than 50 mm behind the building paper. When the building paper is installed after the window and flashing are in place this would be the normal result, but if the building paper is installed before the windows and flashing it would be necessary to slit the paper in order to slide the flashing behind it.

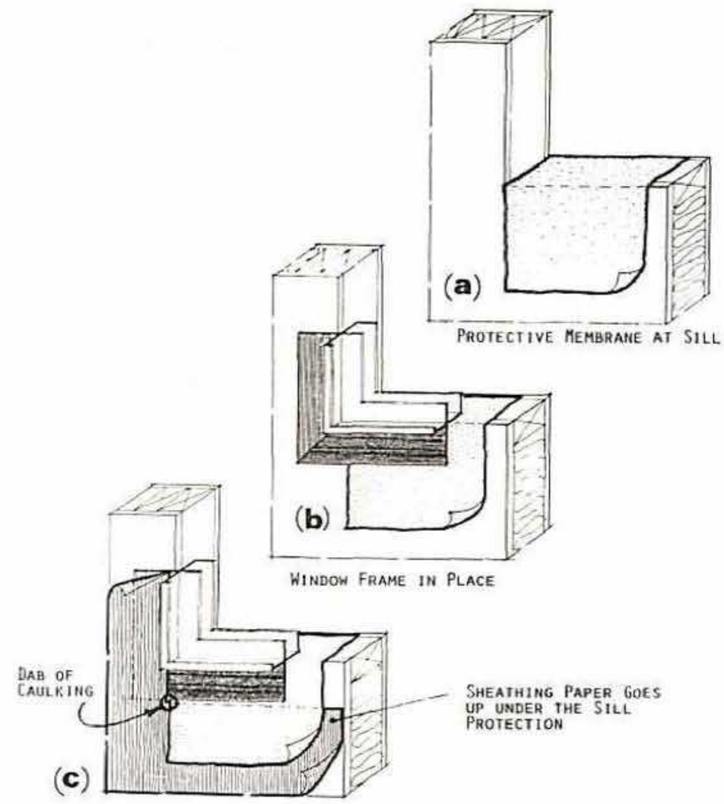

FIGURE 5

SUGGESTED METHOD OF PREVENTING WATER ENTRY AT THE SILL

In the case of flanged metal windows, flashing is not used over the tops of openings when the flanges are imbedded in caulking, and screwed to the wall to form a waterproof joint. If this is done for the frames shown in Figure 3, the top of the frames will collect water flowing down the wall. The water will then flow to the jambs and could penetrate at a lower level. For the type of frames shown, which are common in this area, this is not good practice. The flange should extend up under the sheathing paper, since the top of the frame acts as a flashing, but it is preferable to use proper flashing at the window head even when the flanges are caulked and screwed to the wall.

Caulking

Caulking is normally provided between masonry, siding or stucco and the adjacent door and window frames or trim, including sills unless these locations are completely protected from the entry of rain. Caulking has limited life, however, especially when exposed to weather. Narrow spaces are hard to caulk effectively and do not perform well. Therefore, it may not always be very effective in preventing water penetration for a long period of time.

Manufacturers usually recommend, for flange-mounted metal windows, that a bead of caulking be placed on the underside of the flanges prior to mounting. The caulking is not always used in practice, because of insulation difficulties. The window frame usually fits loosely in the rough opening, and has to be held in place against the sheathing and then slid around until properly located. This action will frequently displace the bead of caulking. The practice of caulking, however, should be encouraged, to provide a proper seal between the flange and the sheathing.

As already indicated in the discussion on flashing, metal frames with flanges are sometimes considered to be self-flashing at the head despite the turned-up exterior edge. They have to be set in caulking as noted, but it may be very difficult with some frames to achieve a good watertight or watershedding detail. If it is not achieved, water penetration is inevitable.

Concluding remarks

Most windows seem to function satisfactorily when they are protected by eaves or other overhangs, or are in sheltered locations. Windows with current details will have leakage problems when they are exposed to wind and rain, unless a good deal of care is taken in relation to rain control and airtightness. Where rain penetration does take place there is usually staining and deterioration of interior wall finishes around windows, peeling of paint, staining of drapes, and in the worst cases, wetting of floor finishes and growth of mold on walls. This also occurs in other parts of Canada and is also related to the window details (BRN No. 210).

Small amounts of rain leakage may be tolerated without any serious deterioration taking place if there is an opportunity for drying between the periodic wetting. The potential for drying may be reduced in highly insulated energy-efficient walls, and this in fact could produce an additional risk of rain penetration. Some forms of insulation may be wetted, and this could lead to wood rot in the walls.

It is desirable to maintain good principles of water control around windows to achieve long service life. The watershedding function of building paper and flashings must be insured. Caulking may also be essential to eliminate problems. When problems do occur they are usually serious and result from ignoring the simple facts about water penetration.