



EXTERIOR VENTILATED CLADDING

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Introduction

This publication is one of nine that has been translated from Norwegian. They are taken from a series of publications produced by the Norwegian Building Research Institute (NBI) series, "Byggedetaljer," which literally translated means "building details." It is hoped that Alaskan builders will be able to glean useful ideas from these publications. The translations were done by Dr. Nils Johanson and Richard D. Seifert of the University of Alaska Fairbanks with the cooperation and permission of NBI, Oslo, Norway. The financial support for the translations and printing came through the Alaska Department of Community and Regional Affairs, from USDOE Grant DE-FG06-80CS6908. The publications use the original index code of the Norwegian "Byggedetaljer" series so that specific translations can be directly cited. All questions on these translations should be directed to Richard D. Seifert, Alaska Cooperative Extension, P.O. Box 756180, University of Alaska Fairbanks, Fairbanks, Alaska 99775-6180. Phone: 907-474-7201

- 01 This publication deals with principles for ventilated claddings on exterior walls. This is a general survey and pertains to various types of cladding material and wood framing construction techniques. Details of the construction of ventilated cladding are given in this paper, particularly in the photographs.
- 02 It is the purpose of this pamphlet to show the general performance and mechanics of the cladding system and also to give the necessary background for the construction and use of ventilated cladding.
- 03 Ventilated cladding has been used in Norway for hundreds of years and mainly consisted of wood paneling that was not watertight. The panels themselves were often loose, and abundant ventilation occurred through cracks and joints in the paneling. This provided for a satisfactory wall cladding. External cladding used in connection with modern exterior wall construction has led to greater demands on the cladding due to increasing amounts of thermal insulation and air tightness requirements (tightness against air penetration). This has led in turn to a two-tiered approach to tightening the wall, and has furthered the understanding of the dynamics of ventilated claddings. The two surfaces on the exterior wall each have a different purpose: one protects against rain and the other against wind.
- 04 It is wind and rain that create the greatest problems in deterioration of exterior walls. If rain occurs simultaneously with strong wind, we get driving rain against the wall. This driving rain is often the cause for leakage. Causes of inward water movement are: capillary action, the force of gravity, and kinetic energy. Strong wind creates a pressure over the wall which can be extremely high. With a single barrier against both rain and wind the water film which is formed on the outside of the wall will be very strongly influenced by the pressure over the outermost layer of the wall. This is the main reason that walls with a single layer barrier are so often damaged by driving rain.
- 05 In the ventilated wall system, the rain and wind barriers are separated from each other by an air space which is ventilated outward as in Figure 05. This column of air has many functions. It evens out the pressure in such a way that no pressure drop is created over the rain barrier. It also can drain away water which has come

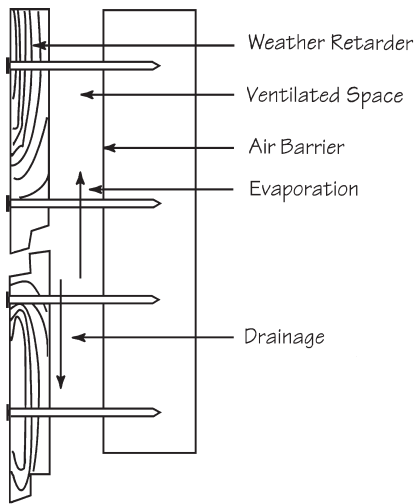


Figure 05. Design schematic for ventilated cladding on exterior walls.

through the barrier and direct it out of the wall. It can allow the escape of moisture which has found its way from the inner parts of the wall and allow it to evaporate in the ambient air.

1 FUNCTION

In addition to giving the wall the desired appearance, the cladding must withstand the stresses to which it is exposed, and also must protect the enclosed structure against the local climate. These functions include: stopping rain which is driven against the facade and to direct it downward and away from the underlying construction. It must endure the wind stresses and be able to take up and absorb the changes in expansion and contraction which can occur because of temperature and moisture changes without causing damage to the cladding. Deformations due to these stresses must not exceed the expansion and contraction allowable with the fastening mechanisms. It must withstand shock and abuse, and chemical attack from possible air pollution, salt air, or unusually bad weather. Be very attentive to potential for corrosion of hardware mountings and fastenings associated with the cladding. They must endure solar radiation without discoloration, bleaching or other damage. And the cladding must also limit the spread of fire (meet code requirements).

2 DRIVING RAIN

21 Cladding as Rain Protection

211 Rain is first halted at the wall's outermost surface. If the surface is porous, water penetrates straight inward and can, in massive construction (concrete) penetrate deep inward and eventually to the inner wall surface. In compressed walls with many layers of material, one surface can direct water and carry it laterally a long distance both into and from the outer wall. In walls with loose cladding such as walls with an air space behind the outer layer of surface material, water which has been absorbed will run down along the cladding's backside and can be directed out again, such as in Figure 05. The surface of the backwall (the wind barrier) can thereby be kept free of water. That surface must consist of permeable material such that humidity which needs to get from within this wall to the outside through the air barrier surface can be ventilated away. It is important that there is some air change between the outside air and the air space behind the cladding.

212 Rainwater not absorbed into the wall will stream down the wall. Over holes, cracks or faults larger than 5 millimeters in diameter, hanging water drops would create a bridge or a film of water which can be blown in against the back wall. The pressure difference over the cladding in turn causes air movement through this opening which eventually pushes and bursts the film as shown in Figure 212.

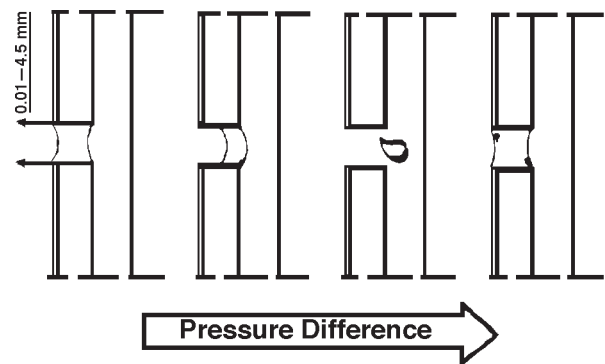


Figure 212. Water penetration in small openings and cracks is caused by pressure differences over the cladding.

213 Ventilation of the air space behind the cladding contributes to the elimination of any pressure difference present. This is especially necessary during wind storms and high wind events when the wall must prevent the air stream from carrying water into the wall. This is a great advantage of covered joints.

214 The back of the wall, especially its outer surface, must be airtight. If there are breaks or perforations in the wall it is possible to get powerful local airflow into the walls and water drops could be carried into them, such as in Figure 214. Concentrated air leakage can often convey water leakage and distribute it over a large area. For this back wall surface an air barrier material such as Tyvek® or equivalent is highly recommended.

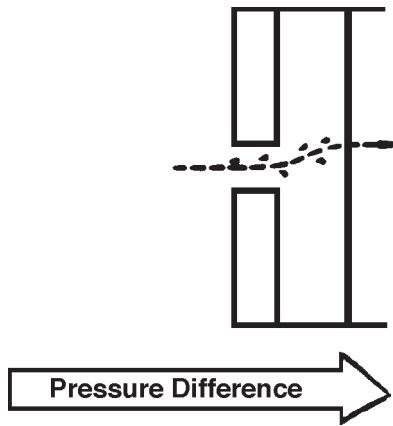
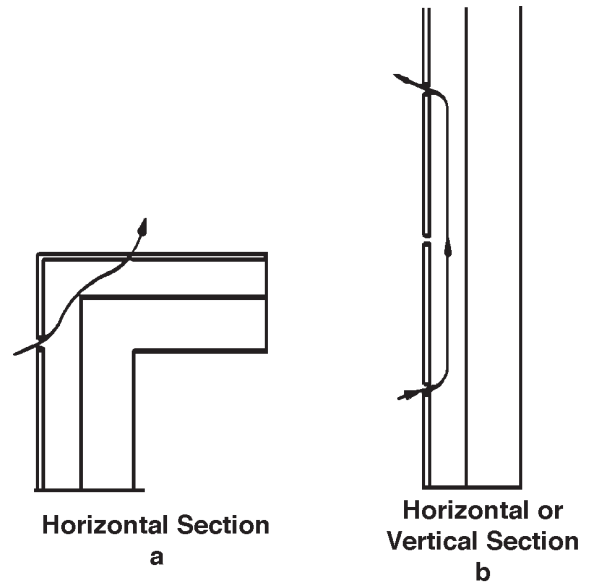


Figure 214. Water penetration due to leaky cladding and faulty construction.

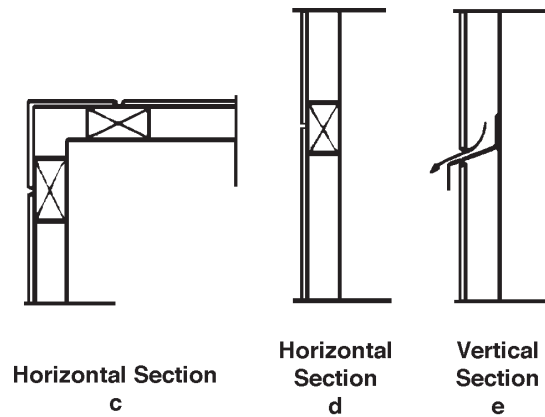
215 Wind always yields an uneven pressure on a wall. Pressure variations in the plane of the wall can create lively air movements behind the cladding, such as in Figure 215 a and b. Air movement through the cladding can move water into the wall. On large facades the air space is divided up into compartments. It is important to seal the air space at the corners of the house such as in Figure 215 c, d, and e. See also Figures 218 - 223.

216 During driving rain the kinetic energy of water droplets can be large enough so that they can penetrate through open joints in walls. The width of the joints, the thickness of the cladding



WRONG DESIGN!

Figure 215 a and b
a. Airflow in the airspace around the corner.
b. Vertical or horizontal airflow in the airspace.



CORRECT DESIGN!

Figure 215 c, d and e
c. Barrier to airflow around corner.
d. Air is blocked in stud spaces.
e. Drainage with horizontal air blocks.

and the direction of the drops all combine such that they can pass through whole or split up against the side of the joint, such as in Figure 216. Whether or not water reaches the back wall is dependent upon the air space thickness.

217 Much water can run into the wall if the joints have an inward slant such as in Figure 217. How much depends upon the amount of driving

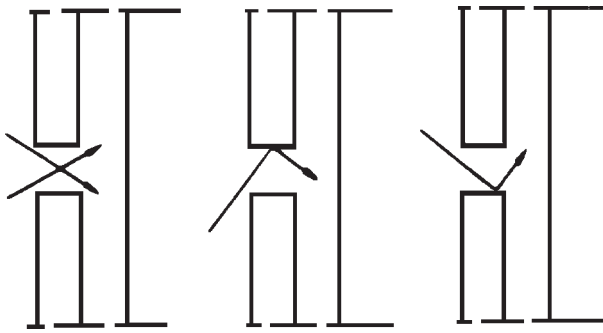


Figure 216. Water spray reaches the backside (air barrier) if joint openings are too large.

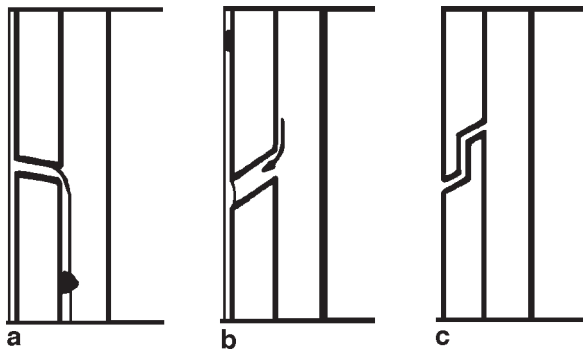


Figure 217 a, b and c

- a. Joints with inward sloping drainage. Water will pass through badly constructed joints in the claddings.
 b-c. Joints with an outward sloping drain. This method provides drainage and protection from rain penetration simultaneously.

rain and the height of the wall. If the climate isn't too rigorous, one can use horizontal joint surfaces, but the surfaces must have an outward slant. However, when there's a large wind pressure against the facade and especially when the wind is blowing water upward, such joints will allow water to penetrate the exterior cladding.

22 Principle recommendations for types of joints.

- 221 There are in principle two types of joints, an open joint: a joint without a rain protection; and a closed joint: a joint with rain protection.
- 222 The joints can also be classified as to how they allow for movement of the cladding.
- Butt joints: In these joints the stresses, due to compression and tension, are handled by the fastening mechanisms.
 - Lap joints: in which the fastening hardware is

mostly provided for countervailing the shear stresses.

- Open joints: in cladding which is not leak tight. These provide no stress function on the surface of the back wall because of movements in the joints.

- 223 Basically a joint system between the elements of the wall can be divided into three parts: the vertical joints, the horizontal joints and the cross joints. Because weather stresses are different on different parts of the joints, they often deform in different ways simultaneously, such that one must take great care in the structure and design of those areas where the joints meet each other.

23 Vertical Joints

Water which runs downward over the facade collects in back along the vertical joint, and in inlaid joints and at connections with pilastres, or columns. Strains on the joints at these particular points are very great but can be curtailed at the ribs and thereby limit the passage of water from the sides.

- 231 Closed joints are made according to the same principle as ventilated cladding. It consists of the outermost rain shield, then a pressure equalization chamber (with drainage), then bounded on the inward side by an air barrier. An opening is provided in the back of the rain protection for pressure equalization and a drain in each cross joint. Cover the top of the drainage channel on the back side. During episodes of wind pressure the stresses on the rain shield can be reduced with the help of small holes or drainage channels in the sides of the joints.

- 232 When using open joints, only the best fastening hardware must be used because of the great stresses from the sun, humidity, cleaning materials, environmental weathering and general movement. This type of joint must not be used in areas of extreme weather or where they can be destroyed by vandalism. Stresses can be reduced by utilizing narrow joint openings on the outside. Three millimeter joint openings can prevent water from reaching the air barrier if that barrier lies at least 45 millimeters behind the surface.



Air Barrier
Backing
the Air
Vent Space

Screened Bottom
Air Vent Opening

2 7/8" Wide 1/2" A WW
Plywood Nailers

Figure 218. A framed example of backing side of exterior ventilated cladding.



Figure 219. Shows the installation of insect-proof mesh vent screening installed over the bottom opening of the ventilated wall. This allows air and water drainage to easily occur behind the exterior rain-shield sheathing.



Figure 220. This figure indicates a sequential step from figure 218. The battens have been carried up to the soffit. As the finished siding approaches the top of the wall a single or double vent can be used. The choice is only determined by the desired "look" and/or performance. Only experience will tell how much ventilation is necessary or appropriate. Cut a strip of fiberglass insect screen to be stapled to the top leading edge for the last "common" siding course above the reveal line of the existing course of siding. This sequence is then followed by using cutoffs of the furring material. Use 1/2 inch pressure treated plywood, ripped to a width of 2 7/8 inches. A wide strip is used to increase the width of the nailing base. Keep the nails at least 1 inch away from any end of a board to decrease the likelihood of splitting the siding.



Figure 221. The stand-off furring blocks are attached over the sandwiched screen and original furring. The corner boards have only the original furring underneath them. This gives a nailing base for the corner board and the siding that will butt into the corner board. As the stand-off blocks at the top of the wall are installed, do not install a furring block where the siding is going to marry to the corner board, as this will result in the siding standing out proud of the corner board. The siding is formed, faired, and bent from the corner board plane to the next stud-furring spacer so the air space goes from nothing to the ½ inch space depending on the stud spacing. This holds true when a deck or other mid-wall penetration occurs. Visually it is quite undetectable.



Figure 222. This is similar to figure 221. The top-most spacer is cut to not lay on the siding, but over the existing furring and insect screen. One stand-off is probably more than adequate.



Figure 223. This figure is a view of a finish exterior cladding wall. Note that it is difficult to see that the wall is vented, and it is esthetically pleasing. The biggest problem with a ventilated wall is probably a correct flashing detail over the top of the windows. A two-piece flashing system has been used by Marquam George in Juneau. The first goes on before the furring is attached and the windows have been installed. The final goes on after the window has been installed. This creates a counter-flashed system.

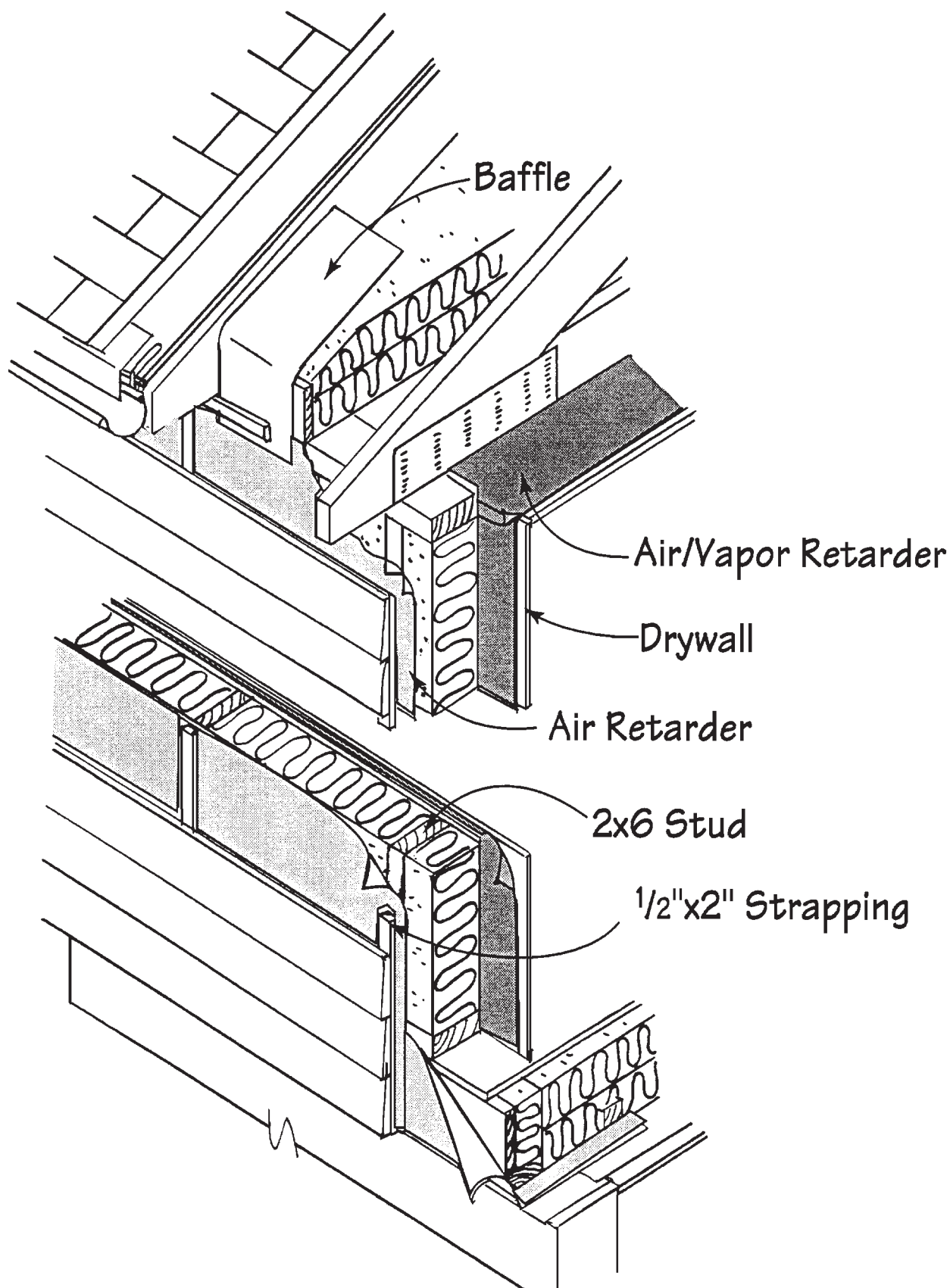


Figure 224. A full cut-away cross section of a wall and roof assembly showing integration of exterior ventilated cladding with stud framing. Graphic from Norwegian Building Research Institute. The strapping shown could easily be substituted by the 3/4 inch thick, 2 inch wide, A WW material used in the example in the photographs (Figures 218 through 223).

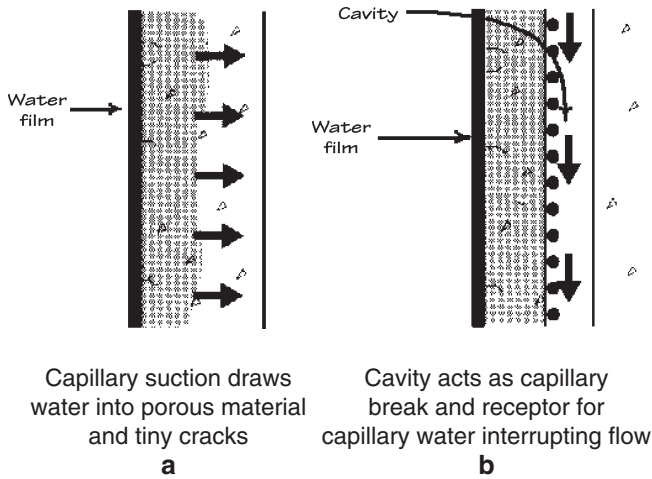


Figure 225 a and b. Capillarity effects in exterior cladding. This effect provides the "strategy" for design of a ventilated wall to stop water penetration. The air cavity in figure 225b is backed by Tyvek or equivalent providing a drainage path, drying and limiting water penetration into the wall.

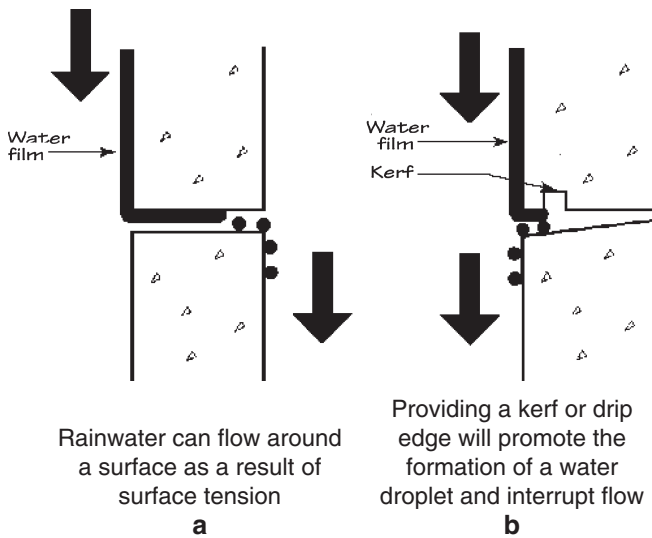


Figure 226 a and b. Flashing to eliminate water penetration around an edge. Some crucial flashing details and kerfs should be made to ensure droplet formation and drainage to the exterior.

233 Open joints in loose cladding must be as narrow as possible, at the most not over 3 millimeters. The back wall (air barrier) must be able to withstand water and wetting. The vertical joints are covered on the back side with lathwork. This must be done in locations where the weather is severe.

Figures 225-227 are from the EEBA Manual by Joe Lstiburek, Cold Climate Version, Appendix I: Rain and Drainage Planes.

3 STRESSES

31 Rain

The amount of rain which is allowed to impact against the wall is dependent, among other things, upon the intensity of precipitation and the simultaneous wind strength and direction. From measurements it is desirable to find out where the most precipitation will occur on the wall. Conditions are complicated by the fact that driving rain's effect is influenced strongly by the size of the building, the orientation and condition with respect to the predominant wind direction and the width and height conditions, building shell responses to rain, neighborhood buildings and so forth. Small changes in the environment can cause marked changes in the effects of driving rain on a building. The same conditions also apply to precipitation and wind conditions in general, such that the data from a meteorological station is not relevant for other than measurements in the general vicinity. Experience and measurements show that areas near corners and high on top of walls get more driving rain on the facade under most conditions. Tall houses are much more exposed than low houses. Water has a tendency to collect itself along vertical cracks or openings in facades. Stresses are especially great where the cladding is smooth because wind can cause the water film to be driven sideways. Joints with vertical openings must always be covered. Along coastal areas driving rain occurs more

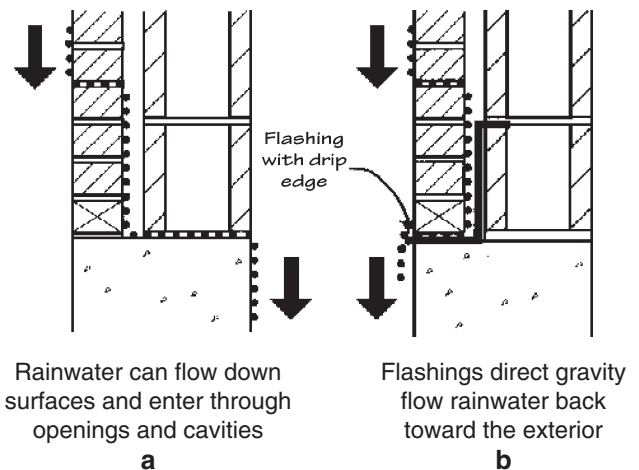


Figure 227 a and b. Rainwater flow down surfaces and flashing with drip edge. Two additional flashing details also ensure drainage to the outside away from wall.

often. Conditions are generally more difficult and severe than inland. The following are estimates of maximum rain intensity. One can estimate the maximum rain intensity as the following: one to two liters per meter squared per ten minutes in the general coast areas of Norway¹, rain can achieve rates of 5 to 6 liters per meter squared per ten minutes or about 30 to 36 liters per meter squared per hour (8-10 gals/hr).

32 Wind

321 Wind pressure operates on walls as a pressure or a suction. Wind pressure varies with the wind's velocity and the height over the terrain and the stresses on a building are therefore dependent on the site and form.

322 It is somewhat unclear just exactly how a ventilated cladding transfers the power of the wind to the other construction. With complete pressure equalization the wind pressure is transmitted to the surface behind the air space and the cladding will be unloaded. In practice the cladding always must absorb some loading. The wind must not be allowed to set the building elements or cladding into vibration.

323 The cladding must be fastened such that its own weight and the loads it is designed for can be transmitted to the bearing portions of the building. Placing of the fastening points must be related to the size of the deformations of the building elements and to what extent vibrations will occur. The fastening points must be designed such that the minimum deformation in the building is anticipated and such that the cladding will not suffer damage because of deformation.

33 Temperature Changes

All materials change dimensions with variations in humidity. Cladding and the underlying construction to a lesser degree deforms such that the movements can be significant normal

to the plane of the wall. Simple materials will become bent or bowed. Wall design must take this into consideration. For example, the sealing materials in joints must be appropriate to handle the stresses they will be exposed to. Tremco® acoustical sealant or its equivalent should be used to seal the air barrier on the backside of the ventilated space.

34 Shocks

The cladding, especially the lower part of the facade, will be exposed to shocks and general rough treatment. Fragile or delicate materials must not be used where they can contact the terrain. If these materials are in fact desired for use, it is appropriate, especially in exposed places, to provide framing which is stronger and more supportive than normal. One can also limit the rough handling of claddings through the use of excavation of terrain, with forethought as to how it will affect the exposure of the cladding. Clever and well thought out use of shrubbery can also be effective. Openings through joints can also enable damage to the back wall, for example through the use of a knife. It is especially important to cover the joint's exposed parts, by providing a backwall that is robust enough to handle any shocks. Parts of the jointing system can be damaged if it can come in contact with the backing material.

35 Chemical Action and Corrosion

Practically all the chemical action which strongly affects materials is associated with water. This makes it imperative that rain water must be carried away from the facade as fast as possible to avoid any possibility that stagnant water can come in contact with the structural materials. Strong chemical attack can occur because of air pollution in industrial regions and because of salt in the coastal regions. This is especially the case for some types of acids which attack materials. It is doubtful you will be able to determine which pollutants are present in the local air. Material suppliers are required to give information on dangers from chemical attack for materials. Nearly all metals corrode when they come into contact with other metals. This can be a serious problem, and also a security problem with cladding and

¹Comparisons of these areas correspond roughly to the outer coasts of Kodiak Island, Yakobi, Chichagof, Baranof, and Prince of Wales Island in Alaska

curtain walls. Many unlike metals are used in construction. Corrosion can be prevented in building by isolating materials from one another or by choosing metals which corrode very little in contact with one another. Corrosion products, rust, etc. can discolor facades when water carries them with it. Impregnation materials can be found for wood which can be used to keep corrosion from occurring on simple metals.

36 Sunlight

Cladding materials are exposed to the physical action from the sunlight, especially ultraviolet and thermal radiation. Materials which from experience have been shown to age rapidly must (if it's necessary to use them) be mounted in such a way that they are easy to replace. Sealing materials age more rapidly when they are exposed to solar radiation and therefore require as much shielding and shading as possible.

37 Fire Protection and Considerations

371 The demands of fire protection vary with the building's size and type. They can also vary from place to place dependent upon the local fire protection equipment available. Regulations require that the outer wall in large buildings must be constructed for the most part of fire proof materials. Lath made of wood can be

used, but protection against the spread of fire must be provided because of the presence of tiers of beams and burnable wall materials.

372 Nonbearing outer walls can be made of wood with a fire authority's permission. However, the exterior cladding must be of fireproof materials (in buildings with a maximum of 8 floors, a smaller portion of the cladding can be burnable). Internal wood construction must be protected by a fire proof cladding. Outer walls must be provided with a barrier such that the tiers of beams and burnable walls can be protected from the spread of fire.

373 The air space behind the cladding must be blocked at each beam and at each burnable wall interface. One can construct the wall such that the beam or the burnable wall portion can penetrate the facade cladding. If a smooth or sheer facade is desired, it is possible to satisfy the necessity for protection of the burnable section of the wall or the beams with fire protective cladding. If it is not possible to place fittings and mountings outside the layer which is ventilated, they can be mounted vertically, as long as they are bounded by a fireproof flat strip. This is adequate if there is ventilation of the ventilated surface downward when the building the wall surface does not exceed one floor in height.

The information given herein is supplied with the understanding that no discrimination is intended and no endorsement by Cooperative Extension is implied.

Credit: This publication was greatly assisted by the experience and photographic documentation provided by Marquam George of Blu Spruce Construction, a member of the Alaska Building Science Network, who works and lives in Southeast Alaska on Douglas Island in the Juneau area.

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