Technical Note No. 17
WEATHERTIGHTNESS AND DRAINAGE

CENTRE FOR WINDOW AND CLADDING TECHNOLOGY

Introduction

This Technical Note describes requirements for weathertight construction and how this can be achieved in the design of windows and cladding systems. In this context weathertightness is concerned with the penetration of the building envelope by air and water. Thermal transmission, either in the form of heat gain resulting from solar radiation or heat loss in cold weather, is not included.

Effects of weather penetration

Water ingress through a cladding system and into a building can lead to:

- Damage to internal finishes;
- Degradation of seals (e.g. at the perimeter of glass units or between mullions and transoms);
- Corrosion of elements (e.g. fixings or steelwork),
- Reduced levels of thermal insulation.

High rates of air leakage will increase heat loss and lead to discomfort of the occupants of the building.

Rainwater wetting

Designing against water penetration requires an understanding of the theory of rainwater wetting and subsequent leakage mechanisms.

Rain and wind usually occur concurrently so that raindrops fall at an angle, which depends on the size of drops and speed of the wind. Due to water's greater inertia, abrupt changes in wind direction caused, for example, by the flow over the top and around the sides of a building, leads to the rainwater separating from the air stream and being deposited near that part of the facade. If rainfall continues for long enough, rainwater will begin to flow across the whole facade, causing heavy wetting of the mid regions of the windward face, particularly on walls of impervious materials. Impervious cladding materials, such as metals and glass, encourage water to run off, rather than be absorbed, so that much more water accumulates and covers the façade. Any projections (e.g. framing members of curtain walling) may serve to direct water towards joints which are points of vulnerability, requiring good joint design, construction and sealing to prevent water penetration.

Shelter from any adjacent buildings or an overhang will affect the pattern and degree of wetting.

Leakage mechanisms

For water ingress to occur there must be, simultaneously:

- presence of water ;
- a path (e.g. a joint between components or connecting cells in a porous material), and
- a force (e.g. gravity, wind pressure or capillarity).

There are six mechanisms of water leakage as shown in Figure 1:

- Gravity - gravity causes water to flow downwards. Joint surfaces which slope downwards into the structure therefore allow the ingress of water. This can be prevented by sloping surfaces upwards or lapping panels over the one below;
- Kinetic energy - wind-driven raindrops can be carried through an opening by their own momentum. The incidence of water drops directly hitting (narrow) joints is low and penetration of the joint can only

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occur where there is a straight path through the joint. Provision of a baffle or a tortuous path through the joint will therefore prevent the passage of water;

- Surface tension - surface tension allows water to flow sideways along an overhanging joint surface. This can be prevented by providing drip grooves or nibs along the edges of horizontal surfaces;
- Capillary action - capillary suction makes water fill the gap between two closely-spaced elements. Capillary action will not on its own cause penetration of free water but will hold water in gaps where it can be forced through by air pressure. In porous materials capillary action may lead to dampness on internal surfaces;
- Air currents – a fast moving airflow may carry water droplets through a joint. Slowing the airflow will allow the droplets to settle out of the air stream under the action of gravity;
- Pressure differential – pressure differences across a body of water cause movement of the water. Water in the pores of permeable materials or filling gaps or joints in impermeable materials will be subject to pressure differences as a result of wind pressure. Differential air pressure across a joint is the primary cause of leakage and the most difficult to overcome.

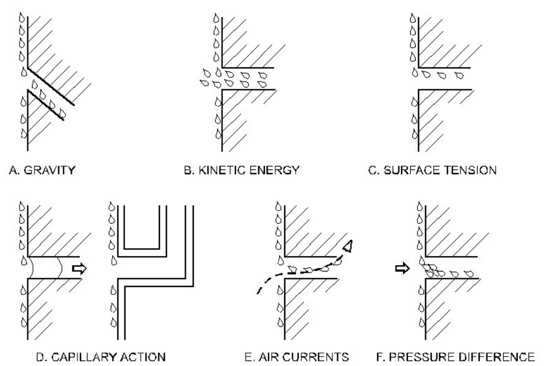

Figure 1 Leakage mechanisms

Ways of achieving Weathertightness

Porous materials

For permeable cladding materials water can flow through the bulk of the material under the action of capillarity and air pressure.

The most common form of construction using permeable material is masonry. Buildings with solid masonry walls keep the rain out by virtue of the wall's thickness and low permeability. Rain driven onto the wall during rainstorms is absorbed into the pores of the brick, concrete or stone units but subsequently dries out. Provided that the wall is sufficiently thick and the permeability is low water will not penetrate to the inner surface.

The presence of internal plaster may improve the resistance to air penetration, particularly where there are voids and cracks in the masonry and hence improve resistance to rain penetration. The wall's resistance to weather can be further enhanced by the use of external renders. Strong renders have a lower permeability than weaker materials however there is a danger that the render will crack allowing water to penetrate the crack and become trapped. Weaker more porous renders may perform better as there will be less immediate run-off and less cracking.

To be watertight, solid masonry walls need to be thick and they are not suitable in severe exposure conditions. In modern construction, a cavity is normally incorporated into masonry walls to provide an additional barrier to the passage of water. Provision should also be made for drainage of any water passing through the external masonry leaf.

Sealed construction

For impermeable materials, water penetration can only occur through joints.

Water movement through joints can be minimised by sensible joint design. The use of slopes, baffles, steps, drips, projections and wide joints can limit the mechanisms by which water can move through an opening, as described above.

The use of an impermeable cladding material together with sealed joints may appear to be a simple solution to providing weathertight construction however obtaining joints that will remain watertight when exposed to weather and the inevitable movements of the joint is very difficult.

Rainscreens

Ventilated rainscreen walls are used either for new-build or refurbishment/repair cladding solutions. Their fundamental features are

- an outermost arrangement of rainscreen panels designed to shed water effectively and to provide the finished appearance.
- a cavity at least 25mm deep
- an insulated airtight backing wall

The air gap is the primary feature of a rain screen system. Many other types of cladding system either do not have an extensive air gap or rely on an air gap only to vent moisture from the wall and reduce condensation risk.

Although some of the joints between the rainscreen panels may be sealed some are left unsealed to allow air to enter the cavity. The air gap may be treated as 'drained and ventilated' or 'pressure equalised'.

In a drained and ventilated wall the cavity is left continuous except for discontinuities at firestops and closers round penetrations. Any water that gets past the outer rainscreen panels is drained downward and outward and ventilation is encouraged to dry out any water remaining in the air gap. To provide this ventilation the rainscreen may have all joints left unsealed or may only have unsealed joints at the top and bottom of the air gap.

In a pressure-equalised wall the air gap is divided into cavities and at least one joint at the perimeter of each cavity is left unsealed to allow the pressure within the cavity to follow that of the external air. The pressure difference across the rainscreen is therefore reduced, preventing water penetration. A rainscreen may be considered to be pressure-equalised if the following conditions are met:

- The air permeability of the rainscreen is ten times greater than the air permeability of the air barrier.
- Each compartment is vented with openings of adequate area. Current guidance within *Standard for Walls With Ventilated Rainscreens* (CWCT, 1998) states that to obtain pressure-equalisation the vent opening (m^2) should be greater that 1/80 times the cavity volume (m^3). For example, for a typical panel measuring 0.5m by 1m with a cavity depth of 0.2m, an opening width of 2.5mm across the 0.5m span of the panel would be required to achieve pressure-equalisation.
- The cavity should be compartmented both horizontally and vertically. Current guidance states that horizontal cavity closers should be used at each floor level and vertical cavity closers at up to 6.0m centres (CWCT, 1998).
- At the corners of the building the compartments should be reduced in size (to 1.5m wide) because of the larger negative pressures present in these zones.

Ventilation of the air-gap between the insulation and the outer rainscreen panel is required for a number of reasons:

- To promote the rapid evaporation of residual water and any condensation which has formed on the reverse face of the cladding assembly;
- To promote the rapid evaporation of any water which is deposited on the insulation;
- To evacuate any water vapour which migrates through the inner leaf;
- To promote the rapid evaporation of any condensation which may form within the cold outer layers of thermal insulation.

A through-flow of air is achieved by exploiting the stack effect, in which a current of air enters at the base of the cladding and leaves at the top; wind action creates additional beneficial air movement.

The backing wall is critical to the performance of rainscreen systems. It must provide an air barrier either by itself or by an associated layer such as a polythene sheet. It follows that the backing wall will be subject to wind load and should be designed to withstand the full wind loading on the façade. It may also be necessary to incorporate a breather membrane to protect the insulation against water that passes the outer rainscreen.

Drainage

Some of the techniques for achieving weathertightness rely on drainage to ensure their effectiveness, however even where this is not the case a means of draining any leakage which gets past the water barrier should be provided.

Curtain walling/windows

In the last section, the principles which may be used to create a weather proof façade have been described in relation to a two dimensional wall of a single construction type. This section shows how these principles may be applied to the joint between a glass or infill panel and the surrounding frame.

In curtain walling and windows it is necessary to seal the joint between the glass or infill panel and the surrounding frame. Four basic techniques may be used:

1. Fully bedded (applies to windows only);
2. Single, front-sealed;
3. Drained-and-ventilated;
4. Pressure-equalised.

Fully bedded

Fully bedded glazing is a ‘sealed system’ relying on the glazing rebate being completely filled with glazing compound to prevent the passage of water. No drainage is incorporated since the seal is assumed to be 100 per cent effective at excluding water. Any voids in the bed will attract water, which may penetrate to the edge of the glass unit, become trapped and degrade the unit edge seal if insulated glazing units have been used. Fully bedded glazing systems are not recommended due to the difficulties of ensuring that a full bedding is achieved and due to the risk of water penetration if regular inspection and maintenance by the building user are not sufficiently rigorous.

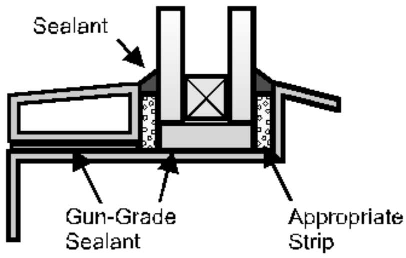

Figure 2 Fully bedded glazing

Single front-sealed systems

Face-sealed glazing/sealing systems rely on a weatherproof outer seal to prevent water penetrating into the rebate and thence the interior. This seal must remain completely free of defects to prevent leakage paths occurring. Any water that bypasses the outer seal can drain away only within the framing system.

Face sealed glazing systems may let some water through into the glazing rebate from time to time. Therefore, provision must be incorporated in the design to allow this water to either evaporate or drain away.

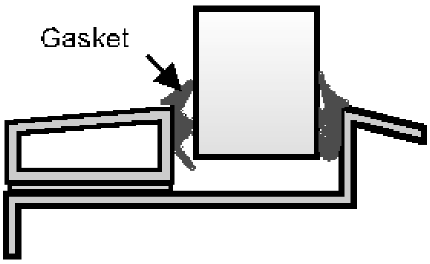

Figure 3 Single front sealed glazing

Drained-and-ventilated systems

In drained-and-ventilated systems, the front gaskets provide an initial barrier. The rebates and cavities are drained and ventilated to the exterior to prevent the accumulation of any water that bypasses the outer seals. Drainage is usually via small holes or slots in the underside of transoms or via sloping glazing platforms that drain water to the mullion and down to the exterior every two to three floors. Any obstruction of the glazing rebates should be avoided since this may reduce the drainage performance.

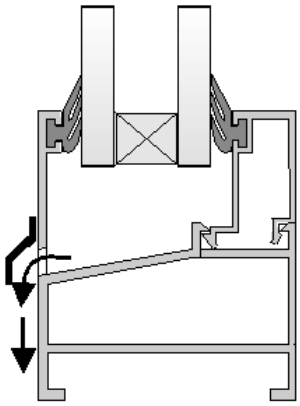

Figure 4 Drained and ventilated glazing

With any drained or pressure-equalised system (see below), water may not always flow through the drainage outlet because the volume of water is not sufficient to overcome surface tension. Therefore, such systems often incorporate ventilation holes/slots in the underside of the upper transom to assist ventilation so that moisture can evaporate away helping to maintain the glazing rebate and seals in a dry condition.

Pressure-equalised systems

The ventilation openings of pressure-equalised systems are of an increased size to permit rapid equalisation of pressure in the glazing cavities with the external pressure, thereby preventing water penetration of the outer face. Effective pressure-equalisation requires the following features:

- Outer face is sealed as tight as possible against rainwater;
- Inner face is sealed as tight as possible against air flow;
- Cavities are made into compartments by sealing mullion/transom joints;
- Each compartment is connected to the exterior by protected openings.

To ensure that the inner gasket is airtight, all corners must be diligently sealed. However, this is not a fundamental requirement for the outer gasket.

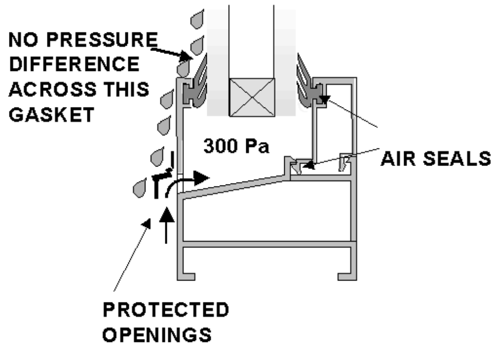

Figure 5 Pressure equalised glazing

Drainage

Drainage provision is incorporated within a glazing system as a precautionary measure, based on the principle that some water will penetrate into the glazing space. Drainage is normally achieved by machining holes at a suitable low point in the system to allow water to flow out under gravity. The action of a number of forces will, however, conspire to inhibit drainage under normal conditions:

- Surface tension will tend to keep the water in contact with the metal surfaces and the perimeter of the drainage hole. The sooner this hold is broken the more readily will the water drain away. An increase in volume and thus weight of water will eventually overcome surface tension, but increasing the size of drainage hole is equally important. A good workable minimum drainage slot is 20mm or 25mm by 5mm, and for holes a minimum diameter of 8mm is recommended.
- External wind pressure will hold water back until either the wind pressure falls or the water builds up to a level sufficient to overcome the pressure. Drainage slots at the sill, which are covered by a film of water, cannot assist in the process of pressure-equalisation. Indeed, a number of systems, which purport to be pressure-equalised, fail to perform owing to their reliance on a single level of drainage holes. Holes should, ideally, be introduced at other locations in order to assist in maintaining an equalisation of pressure and drainage of water.
- Obstructions to the drainage paths will also prevent the escape of water from within the system. These obstructions can occur through the accumulation of debris leading to the blockage of drainage holes or the use of unsuitable setting blocks placed across the drain slot. Weep hole covers will help to avoid the accumulation of debris and will act as a baffle to limit the effects of external wind pressure described in ‘2’.
- Insufficient clearance between the edge of the glass and the glazing frame will encourage the retention of water by surface tension forces. A minimum clearance of 5mm in general, and 6mm at the sill, will be sufficient to prevent bridging by water.
- Insufficient slope of the glazing sill/platform can prevent water from flowing to the drainage holes or to the ends of the transom and down the mullion. The dead load deflections of transoms should be limited so as not to impair drainage of the system.

Construction details

Joints in curtain wall frames for example at mullion/transom intersections and splice joints in mullions are potential weak points for water leakage and require careful design to ensure all the requirements of the joint are met as described in Technical Note 16 *Joints in the building envelope*. Continuity of drainage at joints must also be considered.

Construction interfaces, for example, between different cladding types or building elements, are areas of unusual complexity and may be designed and constructed by different people or companies. Problems on complex construction projects become concentrated around the interfaces, which contractual arrangements exacerbate by virtue of the number of separate contractors who must co-ordinate with unfamiliar trades having different cultures, standards, responsibilities and requirements.

Unless interfaces can be ‘designed out’ they should be tested. Concentrating efforts on construction interfaces during the design development and testing phases should reduce the number of problems experienced during the construction phase.

CIRIA Report R178 gives examples of how various construction interfaces can be detailed to give weathertight joints.

Summary

The external envelope of a building is required to be weathertight to ensure the durability of the fabric and the comfort of the occupants.

Weathertightness requires barriers to both air and water penetration, which can be provided separately or by a single seal.

Weathertightness may be achieved in three ways:

- Porous materials such as brickwork utilise a combination of factors including low permeability, an ability to absorb water during rainstorms and subsequently dry out and discontinuities in the form of cavities and dpcs,
- Impermeable cladding material with sealed joints,
- Ventilated rainscreens which may be drained and ventilated or pressure equalised.

References

CWCT, 1998, Standard for walls with ventilated rainscreens, Centre for Window and Cladding Technology, University of Bath.

CIRIA, 1998, *Sealant joints in the external envelope of buildings. A guide to design, specification and construction*, Report 178, Construction Industry Research and Information Association.

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