QUANTITATIVELY EVALUATING THE EFFECTIVENESS OF DIFFERENT DRIP EDGE PROFILES

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ABSTRACT

Proper rainwater management is one of the key factors ensuring long-term durability of a building. Drip edges should be specified in key locations on nearly every building to help deflect water from the exterior surface of a wall assembly, thereby reducing moisture-related issues such as freeze thaw of masonry, staining of the cladding, and potential long term erosion of historical materials. For these reasons, it is important to understand the effectiveness of different drip edge geometries at minimizing concentrated water deposition on the cladding.

An experimental test apparatus and program was designed to compare the effectiveness of different drip edge materials, profiles and overhang distances with respect to the distribution of water on the wall below the drip edge. Following the testing it was clear that increasing the protruding distance of the drip edge from the surface of the wall does generally decrease the concentration of water on the wall, but the most significant reductions in water on the surface of the wall was a result of the angle of the drip edge and the geometry of the drip edge. Vertical drip edges are often specified because of the aesthetic quality but can result in the highest concentration of water on the wall, even at distances thought to minimize the water shed to the wall surface.

INTRODUCTION

Control of rain water is a primary function of the building enclosure (Straube and Burnett 2005). Water penetrating the building's roof, wall, and foundation can cause deterioration of the building's structure, cause damage to property, and lead to mould growth and potential human health concerns. Water on the surface or penetrating the outer layers of the building enclosure can cause corrosion and decay of sheathing and cladding attachment systems, as well as staining and discolouration of cladding systems. Most importantly, local concentrations of water can cause freeze-thaw damage to masonry materials (Litvan 1980, Ritchie 1968) and rapid deterioration of other exterior finishes.

These traditional concerns have been addressed in older buildings by surface detailing to manage rain water flowing over the exterior surface of the building and by the use of heavy stone and masonry wall assemblies that can store and then dry the absorbed water without major structural or aesthetic damage. However, the importance of rain water control is greater for modern light-weight and hollow enclosures. New building are built using materials that are more sensitive to water and they have more control over heat and water vapour movement, which results in less ability to remove water by drying than old, uninsulated building assemblies using traditional materials (Straube 2006, Lstiburek 2010).

To offset the increased risk of moisture-related problems, a multiple step approach for control of rain water is recommended for modern construction. Building enclosures should be designed to minimize the rain water load and protect openings and penetrations by controlling the flow of water on the surface of the building ("deflection"); provide a means of removing water that has leaked into the enclosure ("drainage"); and dry residual water that cannot be drained by gravity ("drying").

A drip edge is a common water management detail that assists in both deflection and drainage of water from a building enclosure. However, there has been little research on the effectiveness of different drip edge designs. This study investigated several possible factors that could influence effectiveness, including materials, profiles and overhang distances.

BACKGROUND

The drip edge is the leading edge of a flashing, sill, overhang or other linear, horizontal building element designed to shed water from surfaces above away from the surfaces below. Common drip edge locations include window sills; window head flashing; parapet, post, or railing cap flashing; through-wall flashing at masonry relieving angles; and the edges of roofs, balconies, and other projecting building elements. In older buildings, drip edges were often integrated with architectural details in these locations.

There are two primary functional requirements of the drip edge. The first requirement is that water is collected from surfaces above, or at a horizontal edge, and that this water is then directed outwards, away from the building enclosure – i.e., the water is shed off of the building surface. Water may be collected and shed from an exterior surface such as the exterior face of a stone veneer, or from a surface within the wall assembly such as a drainage plane behind a brick veneer. This function is particularly important at vulnerable points such as windows and mechanical penetrations, which are more susceptible to rain water penetration because of joints and exposed horizontal surfaces.

The second requirement is that the water be shed evenly along the horizontal edge to avoid concentration of running water on surfaces below. In many cases the drip edge needs to disperse a concentrated flow of water. Localized concentrations of water on surfaces below can lead to discolouration, staining, and rapid deterioration of cladding materials. A commonly observed location for this type of issue is below windows where a non-absorptive surface (the glazing) collects and concentrates driving rain down onto the window sill where the sill flashing drip edge drains this concentrated water onto the wall surface.

FUNCTIONAL REQUIREMENTS OF A DRIP EDGE ELEMENT

Regardless of material or profile (see FIGURE 1 below), a sharp leading edge allows gravity to overcome the surface tension that would otherwise allow water to adhere to horizontal surfaces and remain in contact with the building.

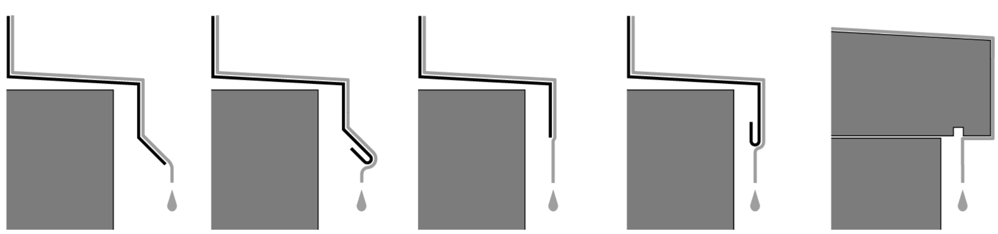

FIGURE 1: COMMON DRIP EDGE PROFILES: (LEFT TO RIGHT) METAL FLASHING WITH 45^{O} KICK-OUT, METAL FLASHING WITH 45^{O} KICK-OUT WITH HEMMED EDGE, METAL FLASHING WITH 90^{O} BEND, METAL FLASHING WITH 90^{O} BEND AND HEMMED EDGE, AND TYPICAL CONCRETE OR STONE SILL OR CAP WITH THROATING.

Water flowing on a roof or vertical surface (like a cladding, a drainage plane, or a window unit) tends to concentrate in streams, either where the flow is interrupted by surface texture or projections. Therefore, streams of water are collected on a horizontal surface that is sloped to the exterior and then drained over the drip edge (see FIGURE 2 below), ideally resulting in an even distribution (an "even drip") of falling water.

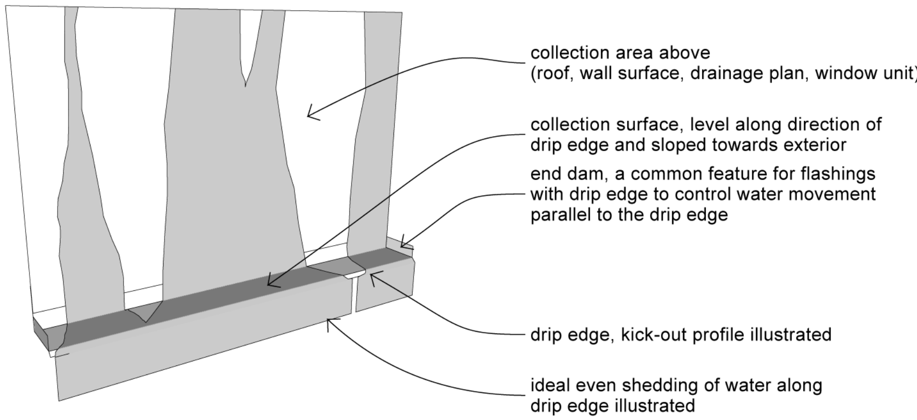

FIGURE 2: THREE-DIMENSIONAL ILLUSTRATION OF SURFACE WATER COLLECTION AND DRIP EDGE SHEDDING

The angle of the collection area towards the exterior ("α" in FIGURE 3), the shape of the drip edge profile, and the distance of the drip edge from the vertical face of the wall below ("O" in FIGURE 3) are all assumed to affect the water shedding and even distribution of the water in the plane of the wall.

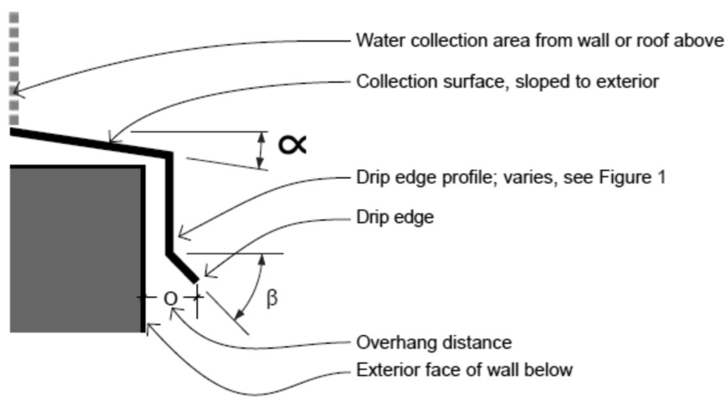

FIGURE 3: PARTS OF A DRIP EDGE

In addition, the drip edge must be strong and stiff enough to hold its shape in wind, rain, and cold weather exposure. The material must be able to resist standing water, environmental exposure (UV and solar heat), and the physical impact that might affect a projecting surface at or near ground level.

Non-functional factors influencing drip edge design

Drip edges, because of their horizontal projection from the façade and their location near architectural elements such as windows and parapets, are also significant visual objects and therefore designed with aesthetic concerns in mind. Architectural decisions that influence drip edge design include:

- Integration into architectural trim detail for window, doors, parapets, balconies
- Depth and profile of projection chosen to emphasize light and shadow on the elevation
- Projection may be chosen to emphasize or deemphasize horizontal lines in the elevation
- Drip edges are often scaled back or eliminated entirely to maintain a “clean” modern look
- Material and material thickness chosen for straightness, colour, ability to hold a shape, and visual match with cladding material

Factors that affect the long-term aesthetics of the building, including water concentrations that lead to cladding deterioration, freeze-thaw damage, discoloration, and staining, may also be considered. However, the prevalence of these problems indicates that any such consideration is done without good information on what factors affect long-term performance.

OBJECTIVE

This study was conducted to address the lack of information about the functional performance of different drip edge designs. It was designed to determine the effectiveness of five different drip edge profiles (FIGURE 1) with additional testing variables such as overhang distance, and metal gauge.

The objective of this paper is to demonstrate which variables affect the distribution of water and therefore performance of the drip edge. With this knowledge, it will be possible to consider some functional factors of the drip edge in the initial design of the enclosure. All of the test variables are discussed in the Scope and Approach.

SCOPE AND APPROACH

This study consisted of four different metal profiles and one stone profile tested under the following variable test conditions.

1. Hemmed or straight edge
2. 45° kickout or 90° vertical edge
3. Overhang distance of 20mm and 45mm from the surface of the wall
4. Different gauges of metal
5. Different drip edge materials – metal and stone

This study is not meant to be exhaustive but rather a preliminary investigation of some of the functional considerations for performance in drip edge design.

The test apparatus is capable of measuring only the vertical distribution of water below the drip edge. Observations of horizontal distribution (i.e., patterns of drips from the edge along the length of the drip edge) will be made qualitatively for this study.

Beyond the tests reported in this analysis, other tests have been conducted including higher (less realistic) flows of 45 L/h (11.9 Gal/h), and medium gauge thickness (17 gauge) for some drip edge profiles. These tests were not included in the analysis for this report.

Apparatus

A 1.2 m (4 ft) wide and 1.2 m (4 ft) tall "wall" was constructed to accept different window sill and flashing details in the Building Science Labs (BSL) laboratory. Below the drip edge detail being tested, a special cladding of sheet metal was installed to allow any water deposited from the drip edge onto the "cladding" to be collected and measured. Five metal troughs of 6.8 cm (2-2/3 in) in height followed by three of 20.3 cm (8 in) in height (equivalent to about one course and three courses of brickwork respectively) were positioned directly below the window sill, such that the front of each trough made up a section of the face of the cladding. As water was deposited on the face, it was caught by the troughs. The water from each trough was then directed to a collection container and the quantity was gravimetrically determined (weighed on a laboratory scale) at the end of each test. A horizontal copper pipe with evenly spaced holes was used to supply and distribute water to the 122 cm (48 in) wide test section. Sealant was applied to the edges of the metal flashing to prevent lateral flow of water off the side edges. A vertical section schematic and a photo of the test setup are shown in FIGURE 4 and FIGURE 5 respectively.

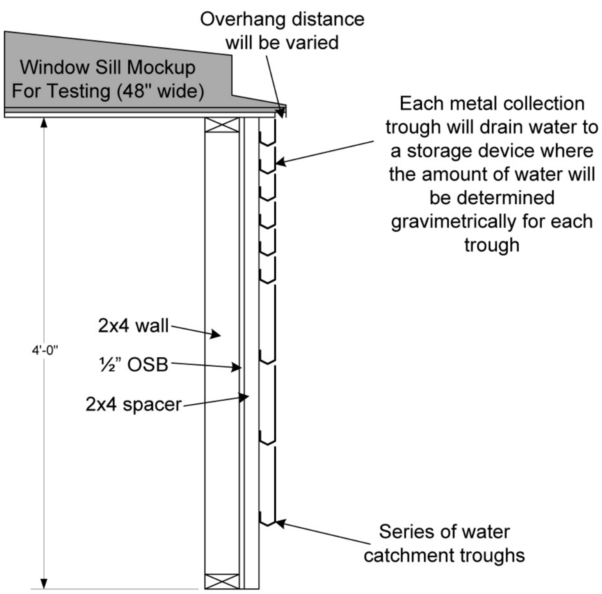

FIGURE 4: SCHEMATIC OF TESTING APPARATUS

FIGURE 5: PHOTOGRAPH OF TESTING APPARATUS

Water application rate

For this study, a rainfall rate of approximately 15 L/h (3.9 Gal/h) was used. To put this rate into context, some driving rain analysis was conducted.

Rainfall analysis was conducted for Toronto, Ontario using hourly climate files for the years 1965 to 1989, measured at the Toronto International Airport (now Pearson) (Straube and Schumacher 2005). The data was analyzed and rainfall figures calculated on an hourly basis (8760 hours, for 25 years), with most results reported as annual averages (e.g., the total over 25 years divided by 25 years).

For the understanding of wall performance, it is driving rain hitting the vertical enclosure surface (i.e., wind-driven rain) not simply rainfall on a horizontal surface that is of interest. In most locations, driving rain occurs predominantly from one direction, so one orientation of the building will experience a larger quantity of driving rain while the others will experience much less. The frequency distribution of driving rain intensity for the orientation that receives the most driving rain over the year in Toronto was calculated and is shown below in TABLE 1. It can be seen that 94% of the driving rain occurs in events with an intensity of less than 3 mm/h (0.1 in/h). Fully 71% of hours with driving rain on the worst orientation occurs at an intensity of 0-1 mm/h (0-0.04 in/h) and 23% occurs at intensities of 1-3 mm/h (0.04-0.1 in/hr).

(mm/h)	Cumulative Driving Rain Distribution, Worst Orientation (average hrs/year)
0-1	281.8
1-3	90.5
3-5	18.3
5-7	5
7-10	2
>10	0.5

TABLE 1: DRIVING RAIN DISTRIBUTION FROM 25 YEARS OF MEASURED DATA IN TORONTO, ONTARIO

To determine a realistic flow rate for testing, the investigators assumed a 3 m (9.8 ft) tall window, as wide as the drip edge testing apparatus (1.2 m [3.9 ft]), and a Rain Deposition Factor (RDF) (Straube and Burnett 2005) of 1.0, meaning that all of the driving rain was deposited on the enclosure. With a driving rain intensity of 3 mm/h (0.1 in/h) (94% of rainy hours are less intense on the worst orientation), then the rate of water application to the window sill would be 3m x 1.2m x 0.003m = 11L/h (9.8 ft x 3.9 ft = 2.4 Gal/h) once the window was completely wetted and the water was running down. During the commissioning of the testing it was found that reliably achieving flow rates less than 15 L/h (3.9 Gal/h) was challenging, so a rate of 15 L/h (3.9 Gal/h) was used for this testing. Different building geometries, cladding types, and window sill depths would also affect the amount of water that drained from the drip edge.

OBSERVATIONS AND DATA ANALYSIS

The testing results using a water application rate of 15L/h (3.9 Gal/h) are presented below for a 90° vertical drip edge (TABLE 2) and 45° kick-out drip edge (TABLE 3). The water collected in each trough is shown as a percentage of the total amount of water applied during the test. The total amount of water collected and shed is also included in the data analysis tables. Because of the somewhat unpredictable behaviour of water flow, the test repeats do show some variation, but only one repeat was done for each. Even with test results that varied somewhat between repeated tests, the trends are the same and conclusions can be made regarding the effectiveness in different variables.

TABLE 3 shows that for each of the gauge thicknesses (12 and 20 gauge) there were two drip edges, a hemmed edge, and an unhemmed edge (see FIGURE 1 for drawings). Each of the hemmed and unhemmed drip edges were tested with an overhang of 20 mm (0.8 in) and 45 mm (1.8 in) from the surface of the simulated cladding. For each overhang distance there were two trials conducted to determine the repeatability (T1 and T2) at the flow rate of 15 L/h (3.9 Gal/h).

In the analysis spreadsheet, the height of the data cell represents the relative height of the collection troughs. Troughs 1-5 were 6.8 cm (2-2/3 in) in height representing one masonry unit, and troughs 6-8 were 20.3 cm

(8 in) in height representing 3 masonry units each. Reported in the bottom two rows of each table is the total water collected as a percentage of the total applied and the total amount shed off the wall.

	12 gauge (thick)								20 gauge (thin)							
	90° hemmed				90° (no hem)				90° hemmed				90° (no hem)			
	20 mm		45 mm		20 mm		45 mm		20 mm		45 mm		20 mm		45 mm	
Trough	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	13.1	29.0	0.0	0.0	0.2	0	0	0	1.8	1.7	0.0	0.0	0.0	0.0	0	0
2	11.6	4.0	11.0	32.0	12.2	1.1	0.2	0	15.9	19.0	0.3	0.0	0.0	0.1	0	0
3	0.4	0.1	48.0	36.0	5.9	4.3	0.1	0	2.2	6.3	1.0	1.3	0.8	0.1	0	0
4	0.1	0.0	24.0	7.0	1.9	5.9	0.2	0	1.1	2.2	3.4	16.9	3.9	0.3	0	0
5	0.0	0.0	4.0	0.0	0.6	1	0	0.2	0.0	0.4	2.4	11.3	1.3	0.6	0	0
6	0.0	0.0	2.0	0.0	0.3	0.3	0.1	0.6	0.3	0.1	1.1	4.1	0.5	0.7	0	0
7	0.1	0.0	1.0	0.0	0.5	0.3	0.3	1.5	0.1	0.3	1.7	4.0	0.7	0.9	0	0
8	0.4	0.0	0.0	0.0	0.9	1	2.2	4.3	0.2	0.7	1.5	1.2	2.4	2.3	0	0
Total Collected	**25.7**	**33.2**	**90.0**	**76.0**	**22.3**	**14**	**3.1**	**6.6**	**21.6**	**30.7**	**11.2**	**38.9**	**9.7**	**4.9**	**0**	**0**
Total Shed	**74.3**	**66.8**	**10**	**24**	**77.7**	**86**	**96.9**	**93.4**	**78.4**	**69.3**	**88.8**	**61.1**	**90.3**	**95.1**	**100**	**100**

48.0 - red shading with white text indicates a single trough collection greater than 10% of total water applied

95.1 - green shading with black text indicates a total water shed greater than 90% of the total water applied

TABLE 2: COMPARISON OF 90° VERTICAL FLASHING RESULTS.

	12 gauge (thick)								20 gauge (thin)							
	45° hemmed kickout				45° kickout (no hem)				45° hemmed kickout				45° kickout (no hem)			
	20 mm		45 mm		20 mm		45 mm		20 mm		45 mm		20 mm		45 mm	
Trough	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	15.8	10.5	0.0	0.1	0.1	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
2	16.4	12.4	0.0	0.2	1.3	8.8	0	0	0.7	0.3	0.2	0.0	0.3	0.1	0	0
3	2.5	0.5	0.7	0.9	0.8	3.2	0	0	0.8	0.7	0.0	0.1	0.1	0.0	0	0
4	0.6	0.1	4.1	9.9	0.8	0.9	0.2	0	0.9	0.9	0.1	0.2	0.3	0.5	0	0
5	0.6	0.2	2.3	3.2	0.7	1	0.5	0.1	2.2	1.0	0.0	0.0	0.8	1.5	0	0
6	2.6	3.6	5.0	5.0	5.7	5.6	1.7	6.4	3.4	3.7	0.0	0.2	4.9	2.0	0	0
7	0.9	0.7	0.4	1.1	1.9	1.5	1.6	2.6	2.0	1.8	0.0	0.1	0.7	0.6	0	0
8	0.7	0.1	2.0	0.3	0.7	0.6	9.9	9.2	0.9	0.8	0.2	0.2	0.6	0.2	0	0
Total Collected	**40.1**	**28.2**	**14.5**	**20.8**	**12.1**	**21.6**	**13.8**	**18.3**	**11.0**	**9.2**	**0.6**	**0.7**	**7.6**	**5.0**	**0**	**0**
Total Shed	**59.9**	**71.8**	**85.5**	**79.2**	**87.9**	**78.4**	**86.2**	**81.7**	**89.0**	**90.8**	**99.4**	**99.3**	**92.4**	**95**	**100**	**100**

16.4 - red shading with white text indicates a single trough collection greater than 10% of total water applied

92.4 - green shading with black text indicates a total water shed greater than 90% of the total water applied

TABLE 3: COMPARISON OF 45° KICKOUT FLASHING RESULTS

Only one research study could be found (Saneinejad and Doshi) that evaluated drip edge profiles based on the amount of water shed from the wall, but this study did not measure the vertical distribution of the water as it contacted the wall. This previous study only tested the overhang distance of the flashing, and the angle of the kickout at the edge of the flashing. No previous testing is known to have been conducted measuring the vertical distribution of water on the wall surface, so the evaluation criteria for this testing was determined based on the relative results of this testing.

High collected amounts correlate to high concentrations. Any trough that collected more than 10% of the total water applied in one or both of the trials was coloured red with white text, to identify the relative highest collected amounts. Any drip edge tests where 90% or greater of the water was shed (not collected in any of the troughs) are highlighted in green with black text. This does not mean that drip edges where less water was shed would not have acceptable performance but rather, that there is a greater risk of staining of the cladding and of elevated moisture contents of storage cladding, when more water is drained onto the surface of the cladding.

90° DRIP EDGE ANALYSIS

TABLE 2 shows that of all the 90° drip edge tests, the specific drip edges that collected the most water were a 12 gauge 90° hemmed at both 20 mm (0.8) and 45 mm (1.8) overhang distances. A drip edge of 12 gauge metal, with a 90° angle, with an unhemmed edge showed reduced wetting as compared to the same profile with a hem.

The hemmed edge test collects more water in the troughs than an unhemmed edge because of the curved radius caused by bending the metal drip edge. This means that water traveling down the metal flashing, follows the radius towards the wall, and has enough momentum when it leaves the drip edge that it flows towards the wall instead of straight down parallel to the wall surface. This observed flow pattern during testing is shown in the drawing in FIGURE 6. FIGURE 7 shows the side profile of the thick 12 gauge metal hemmed drip edge. Because of the thickness of the metal, it makes a large radius at the bottom edge.

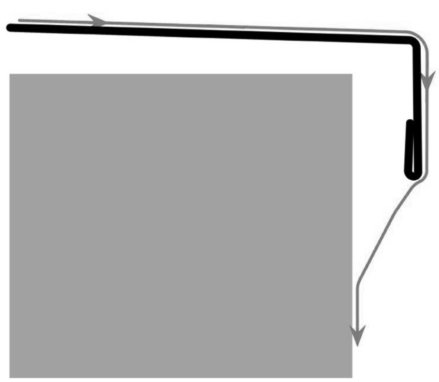

FIGURE 6 : DRAWING OF OBSERVED DRAINAGE

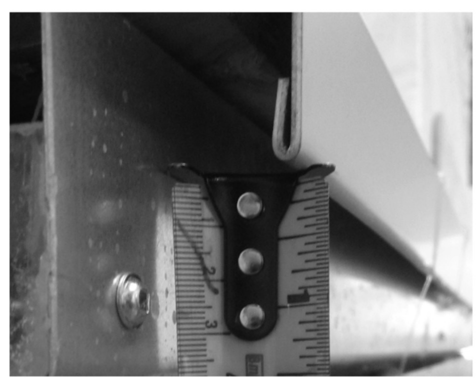

FIGURE 7 : SIDE PROFILE OF 12 GAUGE HEMMED DRIP EDGE

The data shows that typically a 45 mm (1.8 in) overhang distance performed better than a 20 mm (0.8 in) overhang distance. The only exception to this trend during testing was the 90° hemmed 12 gauge drip edge. It is unclear why the 45 mm (1.8 in) overhang had significantly more water collected than the

20 mm (0.8 in) overhang. The 45 mm (1.8 in) overhang did not have any water collected in the first trough, meaning the distribution of water beneath this overhang was lower down the wall than the distribution beneath the 20 mm (0.8 in) overhang. This result is expected with a larger overhang. However, a significant amount of water was still collected in troughs 2, 3, and 4.

When the 20 gauge metal (thin) drip edge was hemmed, it produced a tighter radius on the curve than the 12 gauge metal because the metal is thinner. This means that on the 20 gauge drip edge less water is projected toward the cladding and the water falls more vertically than the 12 gauge hemmed metal drip edge.

When comparing the thin 20 gauge 90° drip edge, only the hemmed profile at a 20 mm (0.8 in) overhang had a measured water collection greater than 10% of the total applied. The 90° hemmed at 45 mm (1.8 in) was improved over the 20 mm (0.8 in) in terms of distribution but still did not shed more than 90%. Both of the thin 20 gauge 90° drip edges without a hem had greater than 90% shedding.

It is unlikely that a 20 gauge drip edge would be specified without a hemmed edge, because the metal requires the hemmed edge for the added strength and rigidity.

45° drip edge analysis

The testing data for the thick 12 gauge, and thin 20 gauge flashings with a 45° kickout is shown in TABLE 3. Compared to TABLE 2, TABLE 3 has fewer instances where 10% or greater of the total water applied was collected in a single trough, indicating that overall, there's an improved vertical distribution on the surface of the wall below the drip edge. The data in TABLE 3 shows that all of the thin 20 gauge drip edges with a 45° kickout shed more than 90% of the water applied in the first four feet of collection.

In every case in TABLE 3 the 45 mm (1.8 in) overhang performed similarly or better than the 20 mm (0.8 in) overhang of the same design. All of the drip edges without a hemmed edge shed more water than the identical comparison drip edge with a hemmed edge.

The only drip edge with a 45° kickout that collected more than 10% of the water in a single trough was the 20 gauge hemmed edge at 20 mm (0.8 in). The water drains down the drip edge, and follows the radius towards the wall as shown in FIGURE 6.

Stone sill

Both vertical and horizontal distribution is necessary to avoid concentrations of rainwater. During the testing of the metal drip edges, it was observed that for the metal profiles, the water tended to flow over the edge in streams, and not distribute evenly along the width of the drip edge. This was observed at both lower and higher flows. The water tended to accumulate on the surface and drain in a few single streams (FIGURE 6). It was also observed that between tests these localized streams were not always in the same location, but when a stream formed, it was consistent for the entire test. These streams of water that were typical for all metal drip edge testing mean that the water is not always well distributed horizontally along the wall, and concentrations could form in a vertical line, even if the test results show that there is good vertical distribution and no trough collects more than 10% of the total water.

Following the tests on metal drip edges, a slightly sloped (8°) stone window sill was tested. It was observed that the water flowing over the stone drip edge tended to be distributed more evenly, as drips rather than streams, over the length of the drip edge (FIGURE 7). The lack of individual streams means the velocity of the water was lower for the stone sill, and that the distribution horizontally was more even distributed, minimizing the drip concentrations on the cladding. During the test of the stone window sill drip edge, no water was collected in any troughs at the 20 mm (0.8 in) overhang length.

The stone sill was not tested at 45mm (1.8") because no water was collected at the smaller 20mm (0.8") overhang with a slight slope (8°).

FIGURE 8: INDIVIDUAL WATER STREAMS ON THE METAL DRIP EDGE

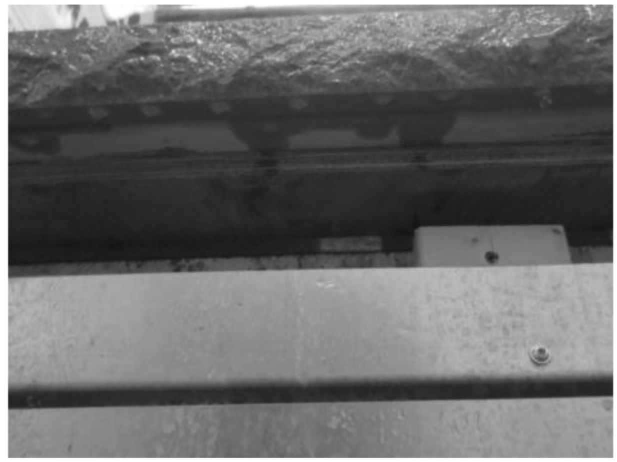

FIGURE 9: ENTIRE FRONT SURFACE OF STONE SILL IS WETTED; MANY DRIP LOCATIONS INDICATE IMPROVED HORIZONTAL DISTRIBUTION

CONCLUSIONS

- An experimental test apparatus and program was designed to compare the effectiveness of different drip edge materials, profiles and overhang distances with respect to the vertical distribution of water on the wall below the drip edge. Key findings were:
- Whether or not the edge of the drip edge was hemmed had the greatest impact on the shedding of water from the surface of the wall. This impact was greater for the thick 12 gauge drip edge than for the thinner 20 gauge drip edge.
- The larger 45 mm (1.8 in) overhang had greater measured water shedding capability when compared to the 20 mm (0.8 in) overhang, in every test but one.
- Adding a 45° kickout also increased the percentage of water shed from the apparatus compared to the 90° vertical drip edge.
- The thinner 20 gauge drip edge generally had improved vertical distribution compared to the 12 gauge, but 20 gauge is thin enough that it would require a hemmed edge to provide strength and rigidity to the drip edge profile on a building.
- There was no water collected in any of the troughs during the test of the stone sill with a small (8°) slope at 20mm (0.8") overhang distance. The water was more distributed horizontally with the stone sill, meaning the water had less velocity over the drip edge than the metal drip edge profiles, and there was a reduced concentration horizontally on the cladding.

- One practical conclusion suggested by this study is that better drip edge performance can be achieved by increasing the thickness of the metal drip edge so that it does not require a hemmed edge. For example, it would be better to use 12 gauge without a hemmed edge, compared to a 20 gauge with a hemmed edge, especially when the overhang distance is small.

REFERENCES

Straube, J.F, and Schumacher, C.J. 2005. Driving rain loads for Canadian building design. External Research Program Report, Canada Mortgage and Housing Corporation, Ottawa, ON.

Litvan, G.G. 1980. Freeze-thaw durability of porous building materials. In Durability of building materials and components, selected technical papers vol. 691. ASTM, Philadelphia, PA, pp 455-463.

Ritchie, T. 1968. Factors affecting frost damage to clay bricks. Building Research Note No.62, Division of Building Research, National Research Council Canada.

Saneinejad, S. and Doshi, H. 2006. Testing of metal flashing for water-shedding effectiveness. Interface Journal [trade publication]. Available at http://www.rci-online.org/interface-articles-2006.html.

Straube, J. and Burnett, E. 2005. Building science for building enclosures. Buildings Science Press, Somerville, MA.

Straube, J. 2006. Rain control in buildings. Building Science 013. Available from http://www.buildingscience.com/ documents/digests/bsd-013-rain-control-in-buildings.

Lstiburek, J. 2010. Five Things. Building Science Insight 039. Available from http://www.buildingscience.com/documents/insights/bsi-039-five-things.