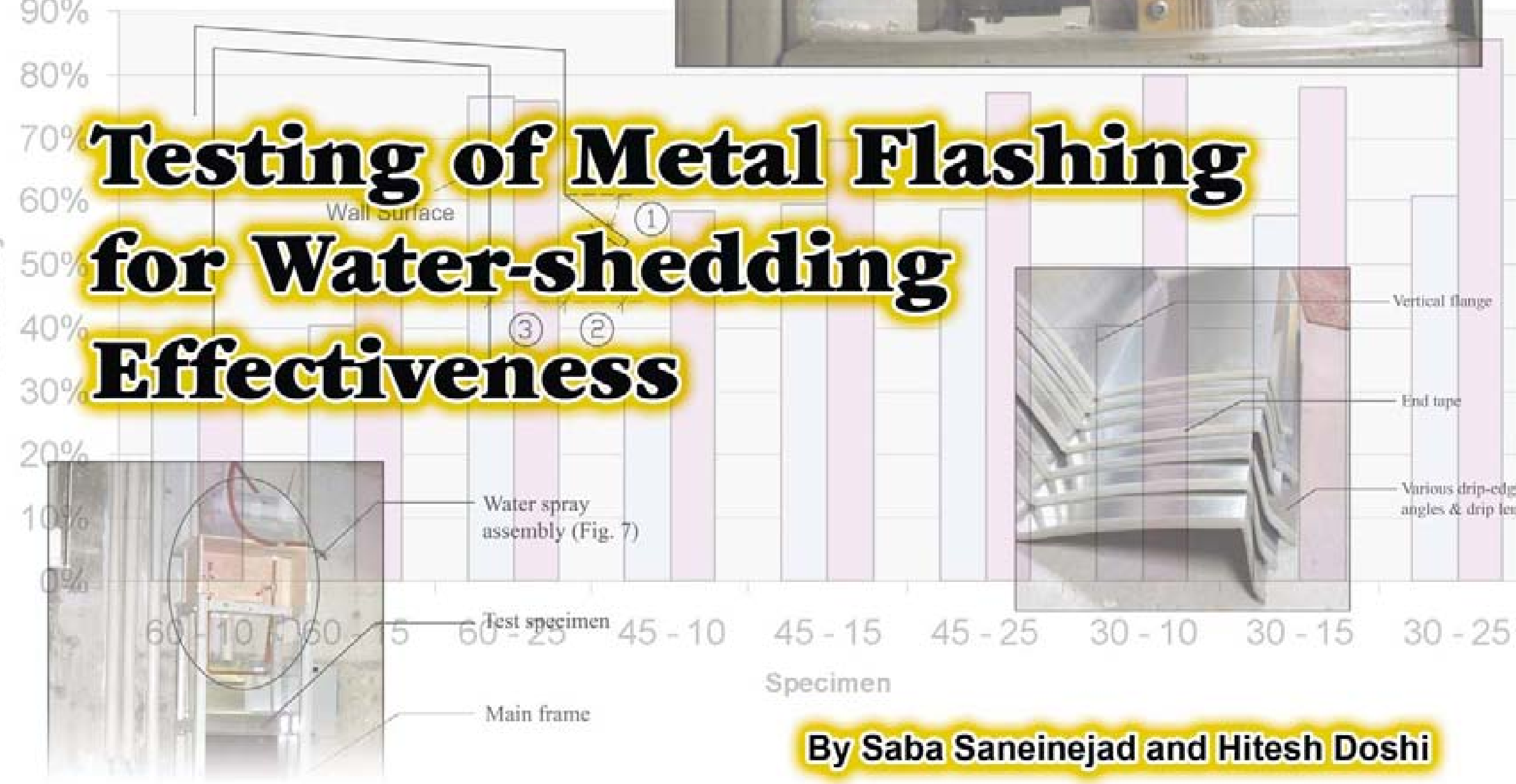
Testing of Metal Flashing for Water-shedding Effectiveness



By Saba Saneinejad and Hitesh Doshi

INTRODUCTION

Metal flashings are commonly used in buildings as parapet caps, at the windowsills and heads, and at horizontal junctions of building components. Water flow over vertical cladding is greatly affected by small changes in the geometry of horizontal projections. *Figure 1* shows the water flow pattern at two different horizontal projections on the cladding of a building in downtown Toronto. Water staining can be seen below the parapet coping.

At windowsill locations, a metal flashing with different drip geometry prevents this phenomenon by more effectively shedding water. Although the presence of water can be noted at two ends of the windowsill, there is no water below the drip, indicating that it is effectively shedding water. In two case studies reported by Doshi (2005), the rainwater flowing over cladding was greater than could be predicted by the effect of wind-driven rain deposition only. This was attributed to water flow over buildings due to ineffective shedding at horizontal projections. Maurenbrecher (1998) reports on water-shedding details that improve masonry and emphasizes the key role played by metal flashing.

This paper details a test method that was developed to quantify the water-shedding effectiveness of metal flashing used in buildings. The test apparatus and the testing procedure developed for this purpose, as well as the parameters which impact the effectiveness of flashing, are described.

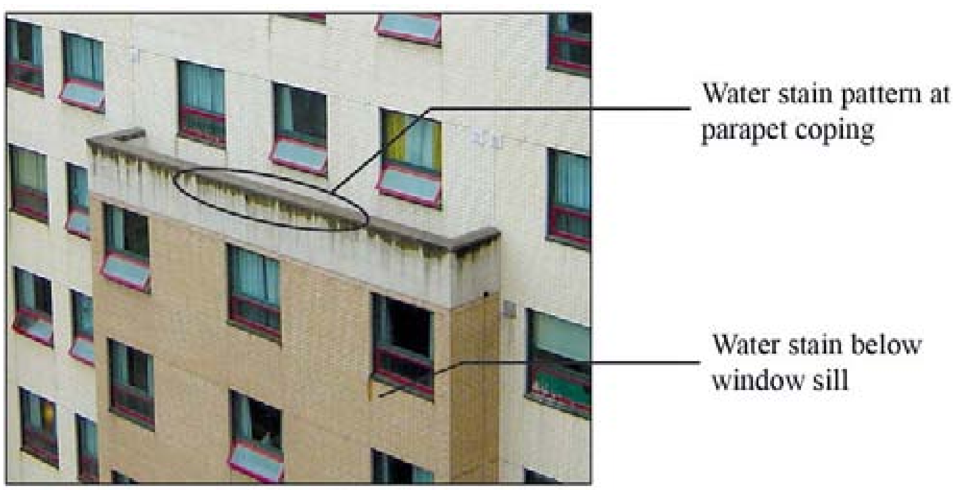


Figure 1 – the effect of small changes in geometry of horizontal projections on water flow over cladding.

BACKGROUND

Literature Review

Despite the importance of metal flashing in building construction, a literature search revealed that there are no consistent guidelines for the design of a metal flashing. Practice guides and building codes include some prescriptive information on metal flashing. This provides details about the material and thickness of flashing, but very little or no information on aspects that affect its water-shedding ability.

The included information varies in content and detail. The Sheet Metal and Air Conditioning Contractors National Association (SMACNA, 1993), the National Roofing Contractors Association (NRCA, 2001), and the Canadian Roofing Contractors' Association (CRCA, 1997) are examples of trade association whose manuals are frequently referenced by designers for components and installation specification details. These manuals include general information about the shape and size of metal flashing used for parapets, but they do not provide any particular information on the design of the water-shedding aspect of the flashing.

The Aluminum Association (2000) manual also provides general information on metal flashing. Again, it does not provide any detailed information about the requirement pertaining to the geometry of the drip edge.

Building codes (IRC, 1995) used in Canada contain information on sheet metal flashing. This information pertains predominantly to the type of materials used for flashings and their applicable thicknesses. Very little information is available that relates to the drip geometry.

Recently, the Canadian Mortgage Housing Corporation (CMHC, 1997a, b) produced practice manuals that provide some prescriptive information pertaining to the design of drip. This information is not consistent among different cases.

The literature survey was limited to North American sources. It has been brought to the attention of the authors that there might be some emerging ideas from Europe. The authors were unable to source the documents from Europe through many of the publicly available databases in Canada. It is expected that a review of these European practices will be conducted in future versions of this work.

Review of existing practices

In addition to the published information, the authors reviewed the practices of design offices and of contractors as it relates to the geometrical considerations of the drip edge of metal flashing. Both new construction and retrofit construction projects were examined (Construction Control Inc., 2004a and b; Quadrangle Architects Limited, 2004; and Young and Wright Architects Inc., 2004). For each of these cases, the drawings, the specifications, and the field practices were examined.

It was noted that the drawing and specifications referenced some of the abovementioned trade publications for the flashing requirements. Discussion with the contractors revealed that the girth of the flashings, the angle of the drip, and the length of the drip were considered in forming the metal flashings. The actual value of these parameters was determined by the shops forming the metal, rather than the designers.

Summary of Findings from Literature Review and Review of Existing Practices

Test method to determine water-shedding effectiveness of flashing

The literature survey revealed that there is a lack of information on testing the water-shedding effectiveness of different configurations of metal flashing. The authors did not find any test method applicable to the measure of the performance of the drip edge of flashing.

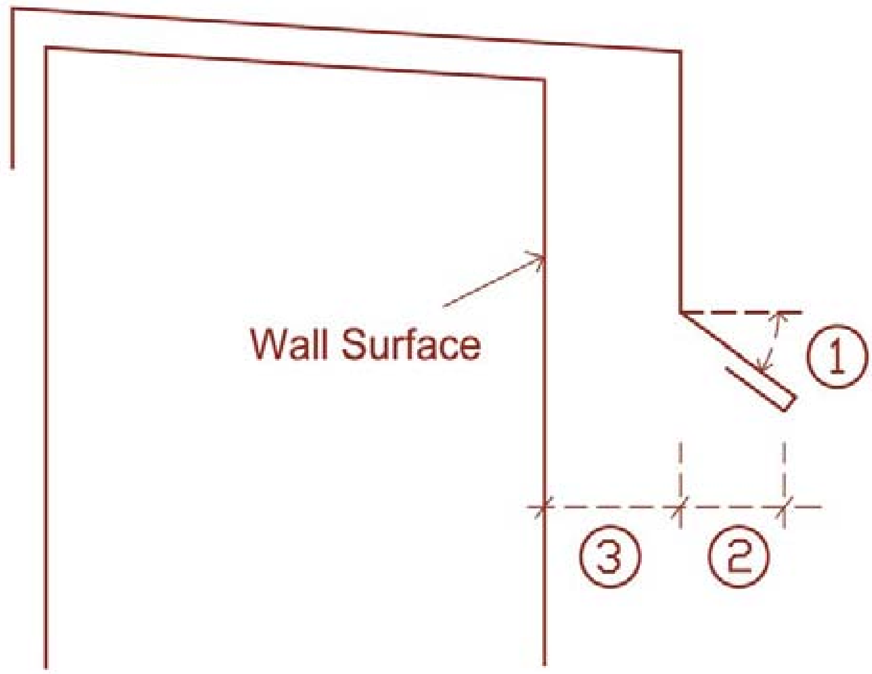


Figure 2 – Flashing design parameters.

Variables affecting water-shedding performance of metal flashing

Three parameters that impact the water-shedding effecttiveness of metal flashing that can be controlled by designers and fabricators were identified in reviewing the existing information. They are shown in *Figure 2*:

1. The angle of the drip-edge.
2. The length of the drip-edge or its horizontal projection from the wall.
3. The gap between the face of flashing and the vertical surface of the wall.

PARAMETER (OUT OF 17 SOURCES)	SPECIFIED	RANGE
Angle of drip edge	4	45°
Horizontal projection	9	13.5mm - 35.8mm
Gap	0	-

Table 1. Reported parapet flashing requirements.

PARAMETER	SPECIFIED (OUT OF 3 SOURCES)	RANGE
Angle of drip edge	0	-
Horizontal projection	3	5mm - 10mm
Gap	0	-

Table 2. Reported through-wall flashing requirements.

PARAMETER	SPECIFIED (OUT OF 3 SOURCES)	RANGE
Angle of drip edge	0	-
Horizontal projection	3	10mm - 25mm
Gap	2	25mm

Table 3. Reported window sill flashing requirements.

Other factors will impact the performance of the flashing that cannot be controlled by designers and fabricators. These include parameters related to the nature of wind-driven rain such as the quantity of rain and the spatial and temporal nature of wind. The focus of this work is on studying the impact of controllable factors.

Figure 3 – Tested flashing profiles.

Values for variables affecting water-shedding performance

Based on a review of published information and a review of practices, values for the parameters affecting water-shedding performance were found to be as shown in *Tables 1* to *3*. The column titled "Parameter" lists the variables of interest as explained above. The next column, titled "Specified," lists the number of sources reporting a value for the respective variable. The total number of sources reporting the particular flashing configuration is shown in the column heading. The last column provides a summary of the range of values.

As can be seen from *Tables 1* through *3*, there is a wide variation among the existing requirements and practices of the three variables that impact the water-shedding effectiveness of metal flashing. In the following section, a test method is presented which attempts to study this effectiveness.

Figure 4 – Water being sprayed at the test specimen (flashing flatness in the test assembly was ensured during installation by fastening).

PROPOSED TEST METHOD

A test method was developed to study the impact of the three mentioned variables on the water-shedding effectiveness of a metal flashing. In order to do this, the following issues were considered.

Test Considerations

Efficiency measure

Water flowing over a flashing should ideally be directed away from the building face. Some of it will flow back toward the building and run down the wall cladding below the flashing. The efficiency of a flashing profile is directly proportional to the amount of water that drips away from the drip-edge without coming in contact with the vertical wall surface below it. The greater this amount, the better the performance of the flashing. *Equation 1* expresses the water-shedding efficiency of a flashing profile as a percentage:

$$E = 100 \times \left(\frac{O - D_w}{O} \right)$$

Equation 1

where E = the efficiency of a profile; O = the original amount of water flowing on the flashing; and Dw = the amount of water dripped back on the wall surface.

The method by which the original amount of water (O) is introduced over the flashing, and manner in which the water that flows back on the wall surface (Dw) is collected and measured, is explained in subsequent sections.

Flow rate

The rate of water flow will affect the water-shedding performance of flashing. A higher rate of flow will direct more water away from the flashing than a lower rate of flow. This should be a control variable in the test. Test results reported in this paper were done using only one rate of flow of water. However, the test method can be easily adapted to include a flow rate control mechanism.

Wind pressure

Wind will have a considerable impact on the water deposition on the wall and the subsequent flow over the cladding. This paper focuses on the study of water flow over different flashing profiles and evaluating the profiles based on their water-shedding effectiveness. It does not take into account the impact of wind on the water flow. In relative comparisons between different flashing profiles, wind will likely have the same effect on tested specimens and will change the test results equally. It is for this reason that ignoring the effect of wind is not expected to change the relative effectiveness of different flashing profiles.

Surface flow considerations

Test specimens are 500-mm-wide galvanized sheet steel profiles. This width is considered to be reasonable in order to achieve the desirable test results. Profiles are designed with a 300-mm-tall vertical flange at the top end. Water is sprayed at this surface first to create a uniform water flow at the top of the flashing. Two sides of the flashing specimens are treated with a strip of foam tape to prevent water run-off at the ends (*Figures 3* and *4*).

Height of fall of water from drip edge

Profiles to be tested are placed in the test assembly at a height of 1 meter from the water collection assembly. This is a common distance from a windowsill flashing to the ground or a parapet flashing to a window head. Field observations showed that water dripping from a flashing hits the wall surface at a distance of approximately 0.5 meters from the flashing; therefore, a

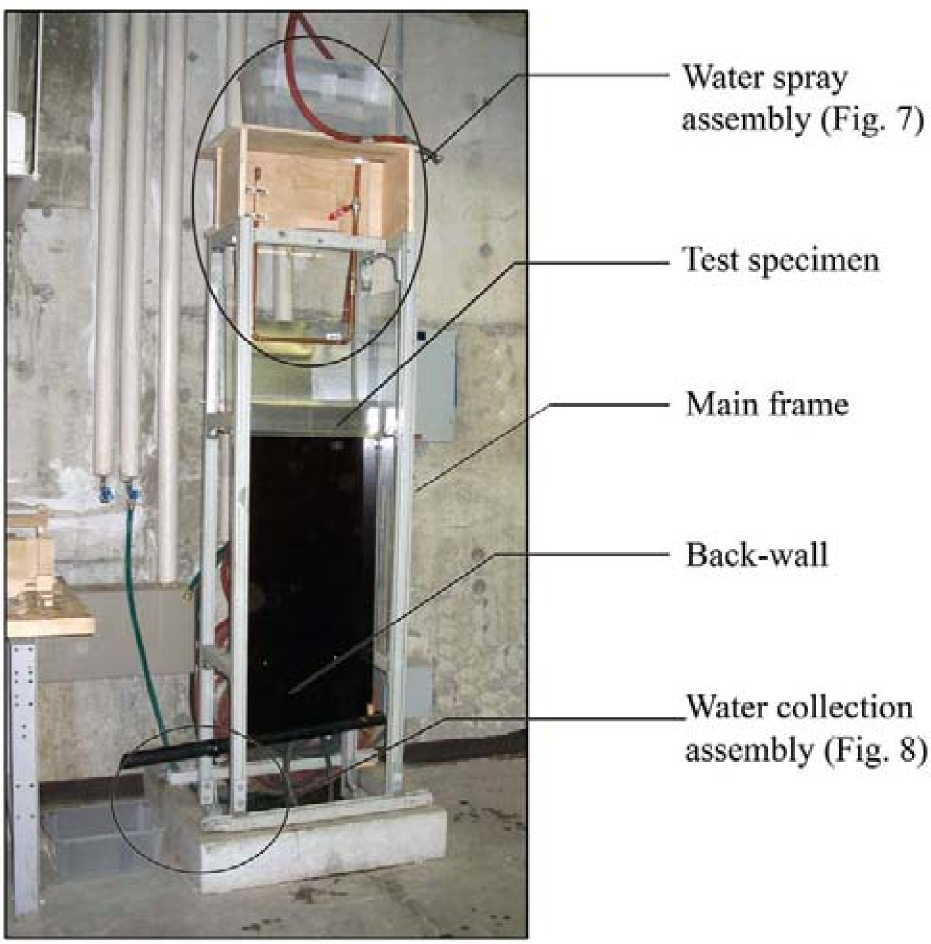


Figure 5 – Test frame of assembly (approximate size of assembly = 300mm deep x 500mm wide x 1600mm high).

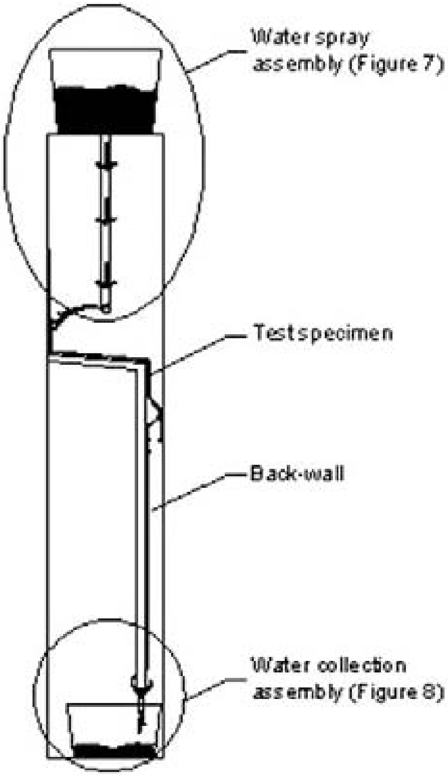


Figure 6

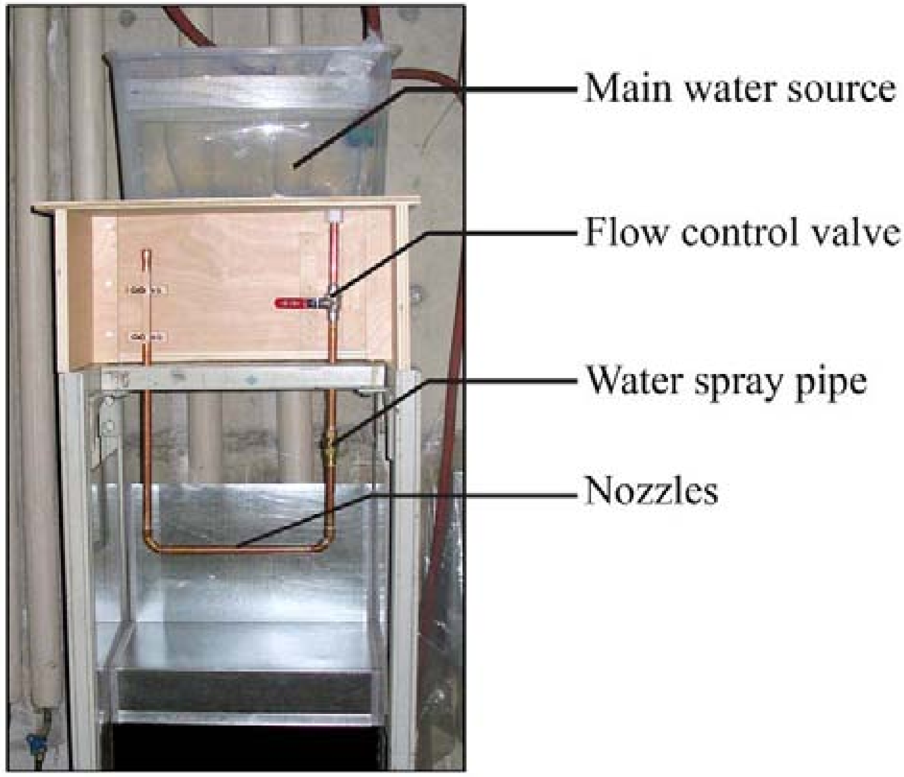


Figure 7 – Water spray assembly.

height of 1 meter will provide enough distance for water to either drip away or hit the wall surface.

Other consideration

The metal flashing test specimen is held in place by using two magnets. These magnets are powerful enough to keep the flashing in place while being tested and enable the researcher to change the position of the profile in order to create different gap sizes between the flashing and wall face.

Design of Test Apparatus

Test frame

The test assembly is made of a 300mm x 500mm x 1600mm steel frame that contains the flashing profile to be tested, as well as water spray and water collection assemblies.

A piece of plywood connected to the front side of the frame performs as the surface of the building. This is referred to as the "back-wall" in the test assembly. The plywood is protected with a waterproof layer that provides a non-absorbent surface over which water can flow without loss due to surface absorption (*Figures 5* and *6*).

Water spray assembly

The flashing profile is sprayed with water dispersed from the water spray apparatus. A 400 x 200mm bucket filled with 14 liters of water is placed on top of the test assembly at a height of 700mm from the test specimens. Water is sprayed to the vertical flange of the flashing through the nozzles placed on a copper pipe. The copper pipe is connected to the bucket of water. A valve is placed at the end of the loop to control the water flow. Once this valve is open, water flows until all the water in the bucket has drained. The results in this paper are for a flow that was timed to last for ten minutes.

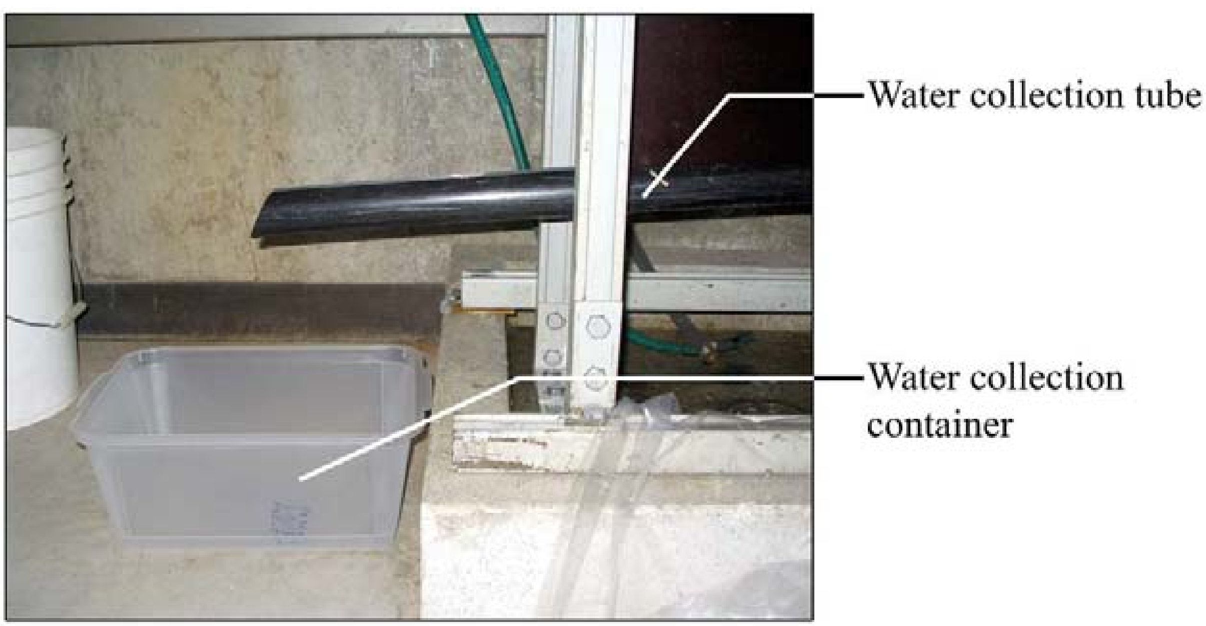


Figure 8 – Water collection assembly.

Sprayed water flows over the flashing and either drips away from the drip-edge, or drips back and runs down the back wall (*Figure 7*).

Water collection assembly

To collect the water runoff, a plastic tube is placed at the bottom end of the back wall. This is placed in such a way so as to minimize any extraneous water except for the amount to be collected. The tube is inclined in order to direct the runoff water to a container placed at the end of the tube. The amount of collected water is measured (*Figure 8*). The efficiency of a flashing profile is calculated by substituting this amount in *Equation 1*.

Description of test specimen

Flashing profiles are constructed of galvanized sheet steel. Tested flashing profiles are constructed based on the design parameters explained previously. Combinations of three sizes of angle (30˚, 45˚, and 60˚), three sizes of horizontal projection (10mm, 15mm, and 25mm), and two sizes of gap between the face of the flashing and the vertical surface of the wall (0 and 25mm), were used. This made 18 different flashing profiles that were tested. These sizes were chosen because they were seen more frequently in the reviewed design guidelines.

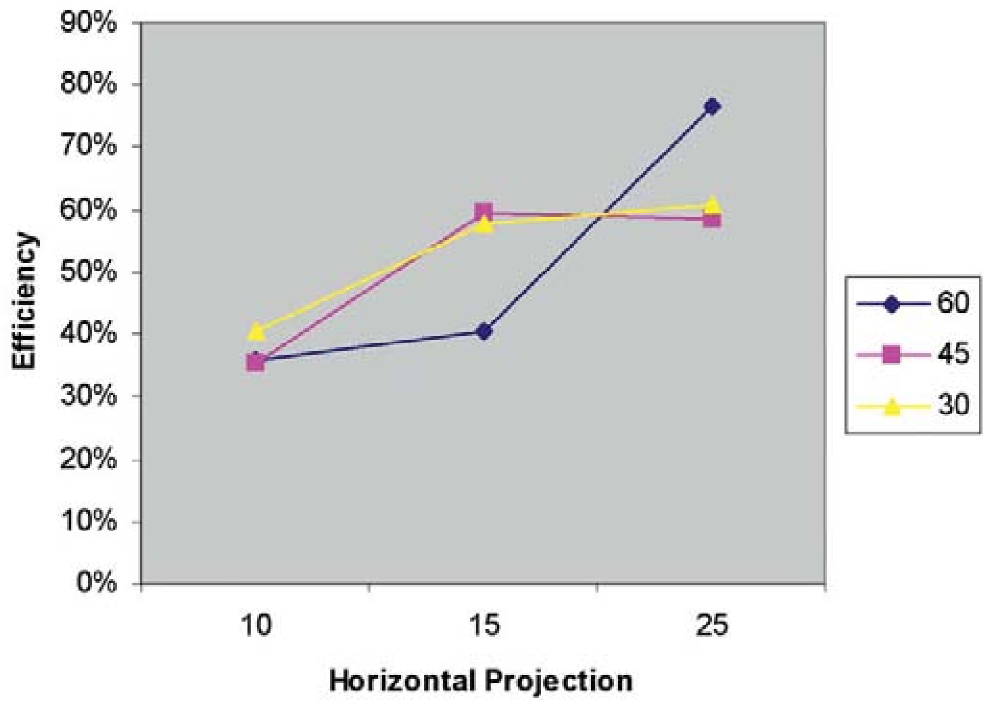


Figure 9 – Effect of horizontal projection on efficiency for angles shown.

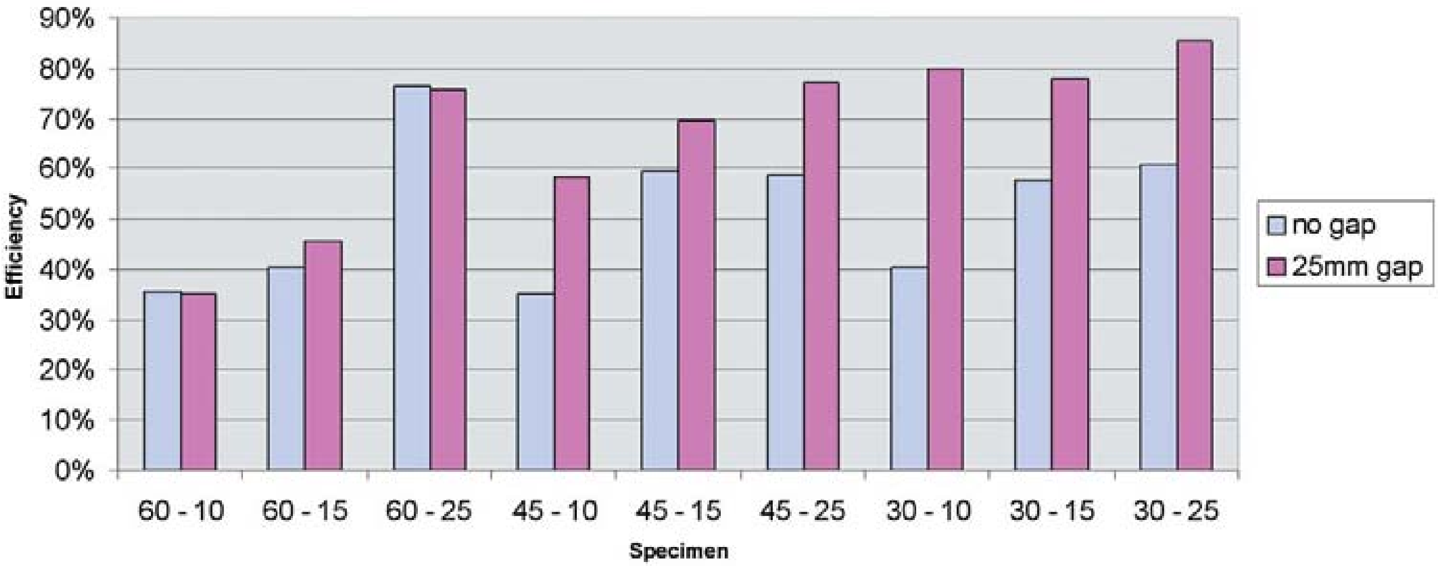


Figure 10 – Effect of increasing gap size on efficiency.

TEST RESULTS

A series of tests was conducted on the fabricated flashing profiles. The results reveal that a change in the design parameters of a flashing has a definite effect on its performance in water shedding.

Using the test assembly described in this paper, 18 different flashing profiles were tested. Each test was repeated three times and the average was calculated for the results reported in this paper. The results from each repetition did not show any significant variation. The efficiency of each profile was calculated as described above. The following observations could be made from the results:

As the horizontal projection of a drip-edge increases, the size of the angle (and consequently the size of the drip-edge itself) should be larger for that profile to have a better performance. This relationship is shown in *Figure 9*. When testing profiles with 10mm horizontal projection, a profile with a 30˚ angle has the best efficiency. By increasing the size of the horizontal projection to 15mm, the profile with a 45˚ angle has the best efficiency. Finally, with a 25mm horizontal projection, the 60˚ angle profile performs the best.

Increasing the size of the horizontal projection (drip-edge) of a profile will improve its performance for a given angle of drip edge. Also seen in *Figure 9* (as the lines representing performance of each angle move higher in the graph, showing a better efficiency), the size of the horizontal projection increases toward the right side of the graph.

Increasing the size of the gap between the flashing and the vertical face of the wall will increase the efficiency of the flashing. This relationship can be noted for the majority of tested profiles, except for those with a 60˚ drip-edge angle, in *Figure 10*. In this figure, each two joined bars represents a specific profile and the numbers below it explain the specification of that profile. For example, profile 60-10 is a flashing with 60˚ angle and 10mm horizontal projection. The bar with lighter color represents the efficiency of the profile with no gap between the flashing and the face of the wall. The bar with darker color represents its efficiency with a 25mm gap. The results indicate that at larger drip-edge angles, the impact of gap is reduced.

POSSIBLE FUTURE IMPROVEMENTS

Further improvements can be applied to the proposed test assembly to more fully discern the impacts of the variables tested and to test the effect of additional variables.

Keeping the same duration of water flow over the specimen was a challenge in these tests. This problem was due to an inconsistent water spray pattern. Small holes in the copper pipe get plugged with particles in the water, which results in increasing the duration of water flow over the specimen. Using a more accurate water spray apparatus could eliminate this problem.

Due to unavailability of an accurate flow meter at this stage, tests were conducted using no particular flow, although the amount of water and duration of spray were kept consistent for each test. We attempted to use a flow meter at the early stages of the design; however, a very high flow was required for the apparatus to show the flow rate. Use of a sensitive flow meter to accurately show the rate of flow will be a significant improvement to this test method. Also, the effect of various rates of flow on water-shedding effectiveness of metal flashing could be studied in the future.

Metal flashing specimens used for testing were fabricated from unpainted galvanized sheet steel. This material was chosen because it was readily available at the time and could be easily bent to the required profiles. The unpainted nature of the surfaces seemed to impact the flow. Water did not seem to flow uniformly over the unpainted metal surface and it tended to form random streams of water that splashed away from the edge. Further testing can be conducted on painted metal flashing specimens. This might give a more representative result.

CONCLUSION

This paper has described the need to study the water-shedding performance of metal flashing and one test method to serve this purpose.

Conducting a literature survey on current design guidelines revealed that there are no consistent design requirements for the drip-edge portion of a metal flashing. Also, studying some construction practices revealed that the drip portion of the metal flashing varies among projects.

A test method was developed to study the water-shedding performance of metal flashing. The test assembly consisted of a frame, which allows the testing of various flashing profiles one at a time, as well as water spray and water collection assemblies.

Different flashing profiles were constructed based on the variables that were identified to impact drip-edge performance. These flashing profiles were placed in the test assembly and were sprayed with water. The efficiency of each tested profile was calculated based on the collected water run-off and the results were compared. Test results revealed that small variations in the geometry of the drip can have a significant impact on the water-shedding characteristics of the flashing.

Improving this test method by using a more accurate water spray apparatus and a sensitive flow meter has the potential for use as a standard for comparing the performance of flashings used in modern cladding systems.

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