Impact of Sealant on the Water Shedding Performance of Metal Flashing

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ABSTRACT

Rain wetting pattern on buildings revealed that horizontal projections have a major impact on the wetting and staining of building faces. Metal flashing is typically used at these locations to shed water away from building surfaces. Guideline manuals such as building codes, CMHC best practice guides and other technical documents do not provide any specific requirements for the flashing design. Neither do they provide any guidelines for flashing implementation, in particular the sealant application below the drip-edge of the metal flashing. Observation of buildings during rain-events revealed that buildings with excessive wetting and staining below the wall/flashing interface had no standard procedures for the design and/or the implementation of the flashing. Further, the extent of sealant application varied between projects. In some instances sealant was applied flush with the drip-edge, directing water on the building face.

Previous studies have shown that the geometry of horizontal projection affects the water flow over building faces. Previous investigators have also studied the importance of variables such as the angle and length of the drip, in the performance of the drip-edge. However, the impact of sealant application on the effectiveness of profiles has not been studied. The current research attempts to build on the study of water shedding effectiveness of metal flashing by studying other dominant factors influencing its efficiency. The extent of sealant changes the geometry of the drip-edge, which may significantly impact the water flow over cladding.

The effect of these variations on the water shedding performance of flashing was determined by conducting an experimental study. A test method was developed and a test apparatus was constructed. Specimens of various drip-edge profiles were tested under low, medium and high water flow rates. Results on water shedding effectiveness for different drip-edge profiles with and without sealant are presented and the effectiveness of different details is highlighted.

1 INTRODUCTION

Rain wetting on building surfaces is a serious issue for buildings with minimum overhangs. These buildings have greater exposure to elements and weather poorly when compared to traditional buildings designed with large cornices and overhangs. Moisture in porous building materials, from rain events, is a significant cause of deterioration. Long term contact with rainwater causes saturation of cladding material, dimensional change, corrosion, leaching efflorescence and leads to freeze/thaw damages and consequently premature deterioration of cladding.

The rainwater impact on building envelope can be controlled through appropriate design and detailing. A good building detail avoids concentrated flows of water over building faces and

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thus reduces the amount of wetting from run-off. In modern buildings, design and performance of flashing details play a very important role in shedding water from the vertical surfaces. Maurenbrecher [1], after observing rain wetting on a number of masonry buildings, showed the importance of metal flashing and provided qualitative guidelines for avoiding wetting problems. Doshi [2] observed water distribution on two buildings from rain and showed that horizontal projections act as significant catchment areas which then can direct water to vertical surfaces as concentrated flows. However, regulations and other practice guidelines have not provided any clear design details and/or implementation procedures for the water shedding details of flashing.

The National Building Code of Canada [3] provides prescriptive information concerning the material. However, design and installation requirements that impact the water shedding ability of flashing are not provided.

In many instances sealant is applied at the joint between the metal flashing and the vertical surface. However there is no precise consideration pertaining to application of sealant material. The distance of sealant from the drip-edge is not explained by any of the literature examined. The impact of sealant application on the performance of drip-edge is not examined in any of the sources.

CMHC's 'Best Practice Guide: Flashing' [4] specifies required metal thicknesses and sealant material properties. Preparation of the sealant for its application is also provided. But there is no indication of the relationship between the sealant and the drip portion of the flashing.

Manuals produced by BIA [5], CRCA [6] and CSA [7] also provide guidelines on the selection of materials but do not provide all the specific information relating to the geometry of the flashing. For instance, the Canadian Standard A440.4-98 [7] specifies exact details for the installation of windows and doors, but merely requires a minimum slope of 6% for flashing and capping. This 6% pertains to the "horizontal" portion of the flashing and not to the drip-edge. There is no specific information on the geometry of the drip-edge.

The lack of information relating to the geometry of the flashing in literature, standards and design and practice guides, manifests itself in the wide variety of inconsistent practices in the field. This is corroborated by field observation of ten buildings across the Greater Toronto Area which revealed extensive wetting and staining along vertical walls exposed to rainfall [8]. Observations showing severe wetting are presented in Figures 1 and 2.

Figure 1. Rain wetting pattern on building cladding

Figure 2. Flashing/wall interface

Extensive wetting and staining below the flashing were common in all of the ten buildings. Sealant was generally applied under the drip-edge. It was evident that rainwater was directed from the drip-edge to the surface of the masonry wall immediately below and that there was ineffective shedding of water.

Horizontal projection, angle and length of the drip-edge were measured and compared. Site observation and detailed analysis revealed that there was no consistent practice among these ten buildings. The flashing angle and the length of the drip-edge varied from building to building. In most cases sealant material was applied flush with the drip-edge. The drip-edge angle and horizontal projection did not seem to have any effect in preventing concentrated flows of water immediately below the flashing [8].

Metal flashing is commonly used at window sills and as cap flashing at top of parapets, and has a significant role in controlling rainwater flow over building faces. The influence of metal flashing parameters such as its drip-edge, horizontal projection, and nature of sealant application below the drip edge on water shedding needs to be understood.

Gyuro [9] carried out experiments to study the effectiveness of the drip-edge of metal flashing. A total of 18 drip-edge profiles were tested under simulated rain condition. Different profiles included various drip-edge angles, projections and configurations. It was concluded that profiles with angles shed water more efficiently. The results showed that drip-edge angles between 30˚ and 60˚ performed well.

The experiments conducted by Gyuro were not controlled and did not help in developing specific relationships amongst the different geometrical aspects of the metal flashing. Saneinejad [10] extended the work by Gyuro. A test method was developed that would permit reproducibility of results and a total of 18 different metal flashing configurations were tested. Saneinejad found a relationship between the size of the horizontal projection, angle of the drip-edge and the efficiency of the profile. Saneinejad's results showed that a flashing profile with large horizontal projection and larger angle had the best performance in removing rainwater away from the wall surface. However, if the angle is small, then flashing with short horizontal projection provided the best performance. This relationship was impacted by changing the distance between the vertical surface of the wall and the vertical downward leg of the flashing. The greater the distance the greater was the efficiency of the flashing.

The experiments of Gyuro and Saneinejad, described above, did not include varying flow rates of sprayed water. Thus the impact of actual rain conditions was not simulated. Also their tests did not apply any sealant to the metal flashing. The impact of sealant application was not studied.

The study whose results are reported in this paper has attempted to fill the gap in this area and also build on the earlier studies by looking closely at other dominant factors affecting the performance of the drip-edge. This study has investigated the impact of sealant application on the efficiency of drip-edge. The results of the experimental study are presented in this paper.

It is intuitive that wind-driven rain would have a significant contribution to the wetting phenomenon. However, Doshi's [2] observations showed that horizontal projections act as strong catchment areas and their contribution to the wetting of the wall is more significant than the impingement by wind-driven rain alone. The current study has not included the effect of wind-driven rain. The main aim, of the results presented, is to isolate the effects of the horizontal projections in preventing water from wetting the wall surfaces immediately below them.

2 DESCRIPTION OF THE EXPERIMENT

The investigation of current practices and construction revealed that the design and construction of the drip-edge portion of metal flashing varied between projects. Various drip angles, drip lengths and projections as well as different sealant extensions were observed.

An experiment was designed to determine the impact of these parameters on the performance of metal flashing. The current test set-up is an extension of the apparatus designed by Saneinejad et. al. [11]. The objectives of the current experiment are to examine the performance of specimens under different flow rates and to determine the impact of sealant application on the efficiency of the drip-edge.

2.1 TEST APPARATUS

An overview image of the test apparatus is shown in Figure 3 and schematic details are shown in Figure 4. The apparatus consists of a test chamber that contains the flashing specimen. The specimen is sprayed with water simulating a rain event. The amount of water that is not deflected and impinges on the surface of the back wall is collected and measured. The experimental set-up is built from a 500 x 400 x 1900 mm steel frame and the test chamber is constructed of plywood. Plywood is coated with a waterproof layer to prevent absorption. Four magnets, on the front and bottom walls of the chamber, are used to hold the specimens in place. Side walls are made of clear plexiglass to control water runoff and to prevent deflected water to run into the catch container.

A waterproof panel is attached below the chamber representing the building's exterior wall. The back wall is one meter high. One meter is an average distance from a window sill flashing to the ground or window head on lower floor, or a parapet flashing to a window head flashing in a typical building. The height of one meter will provide enough distance for water to either drip away or hit the wall surface.

The water-spray system consists of a copper pipe with uniformly spaced nozzles to spray the test specimen evenly. A sensitive flow meter and a control valve are in line with the spray system. Water that runs off the back wall gets into a narrow opening of a plastic tube. The plastic tube is attached to the bottom of the back wall in a sloped position to direct the collected water into the catch container.

Figure 3. Test Apparatus

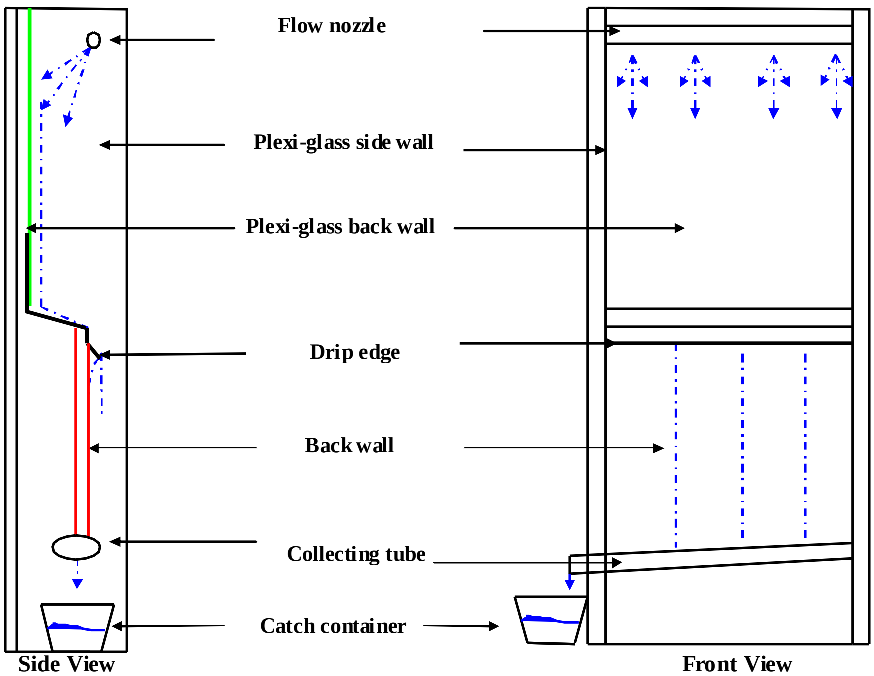


Figure 4. Schematic Details of the Test Apparatus

2.2 PROCEDURE

Specimens are placed inside the test chamber against the back wall; water is sprayed on the specimens at a constant flow rate and pressure. The spray system delivers water uniformly against the vertical flange of test specimen. Flow rates used for the purpose of this test method are 0.7 L/min., 1.5 L/min. and 2.5 L/min. Flow rates used were based on the requirements of the ASTM Standard E 547-00 [12].

As shown in Figure 4, the amount of water that flows down the back wall is collected in the catch container. Collected water was used to calculate the efficiency of the flashing profile. The least amount collected represents the most effective profile. At the second phase of testing, 10 mm backer rod and two beads of strippable sealant material was applied below the drip-edge of each specimen, sealing the flashing to the back wall. Specimens are sprayed and the collected water is measured.

Efficiency of a profile is calculated using the following equation:

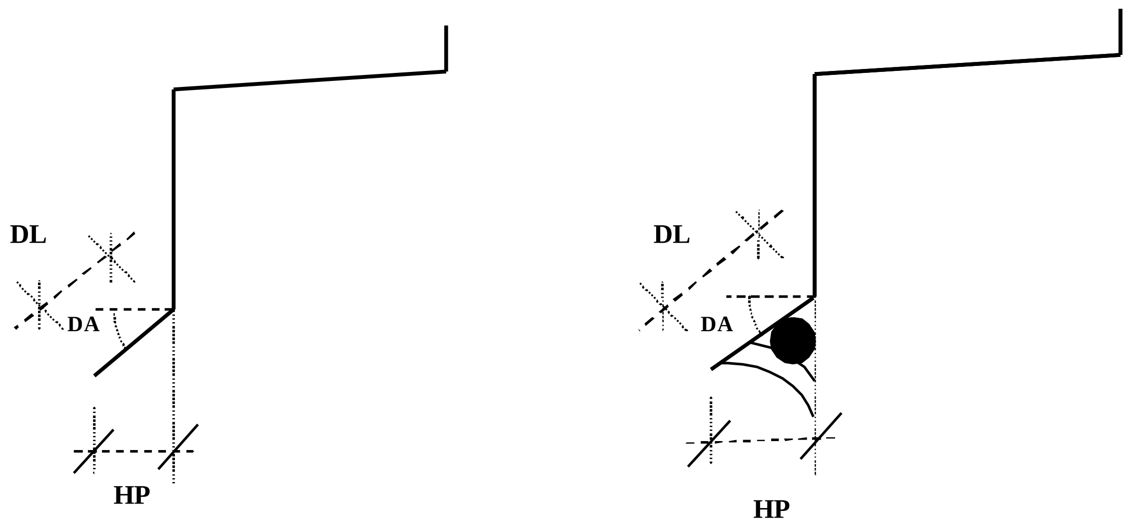
$$\mathbf{E = (SW - CW)/ SW \times 100} \qquad (1)$$

where,

E is the efficiency (%), **SW** is the amount of sprayed water (L) and **CW** is the amount of collected water (L).

2.3 TEST SPECIMENS

Test specimens were 500 mm wide galvanized sheet metal with a 300 mm vertical flange. Drip-edge profiles of the specimens were a combination of 30˚, 45˚ and 60˚ with 10 mm, 15 mm and 25 mm horizontal projections. A total of nine (9) specimens, illustrated in Figure 5 and 6 were tested. Medium density foam strip was applied to the sides of specimens to eliminate water runoff from sides. Specimens were tested with and without sealant application. Metal flashing with sealant is illustrated in Figure 6. Each specimen is tested with low, medium and high flow rates. A total of 54 different conditions were tested in the current study. The details of the nine (9) profiles are summarized in Table 1. The test specimens are shown in Figure 7. The drip-edge of the nine flashing samples used in the study were all hemmed in.



DL is Drip Length; DA is the Drip Angle and HP is the Horizontal Projection

Figure 5. Profile without sealant **Figure 6. Profile with sealant**

Table 1 – Test Specimens

Profile	DA (Drip Angle)	DL (Drip Length)	HP (Horizontal Projection)
A	60º	20mm	10mm
B	60º	30mm	15mm
C	60º	50mm	25mm
D	45º	14.14mm	10mm
E	45º	21.2mm	15mm
F	45º	35.3mm	25mm
G	30º	11.5mm	10mm
H	30º	17.3mm	15mm
I	30º	28.8mm	25mm

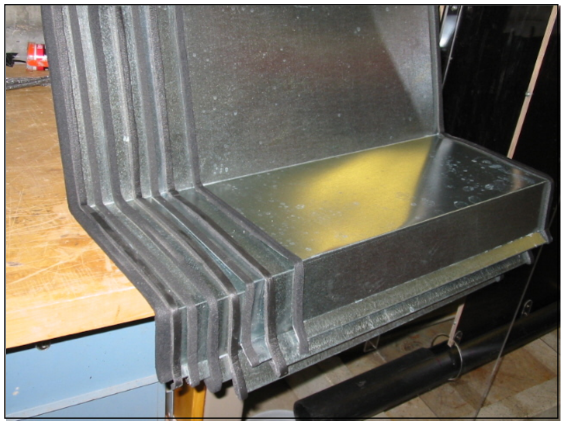


Figure 7. Test Specimens

3 RESULTS AND DISCUSSION

The efficiency of each profile is controlled by drip-edge angle, drip-edge length and horizontal projection. The results also include flashing with and without sealant.

The results of the 54 tests are summarized in Figures 8 and 9. The results without sealant applications are reported in Figure 8. For profiles without sealant applications the efficiency is seen to get better as the horizontal projection gets longer; however, the efficiency is seen to decrease with increasing flow rates. These trends hold true on an average although the variations are not strictly consistent.

The results with sealant applications are reported in Figure 9. The results for profiles with sealant are similar to those without the sealant. The general observations for profiles with sealant applications are: the efficiency is seen to get better as the horizontal projection gets longer; the efficiency is seen to decrease with increasing flow rates; and sealant reduces the efficiency for short horizontal projections. These trends hold true on an average although the variations are not strictly consistent.

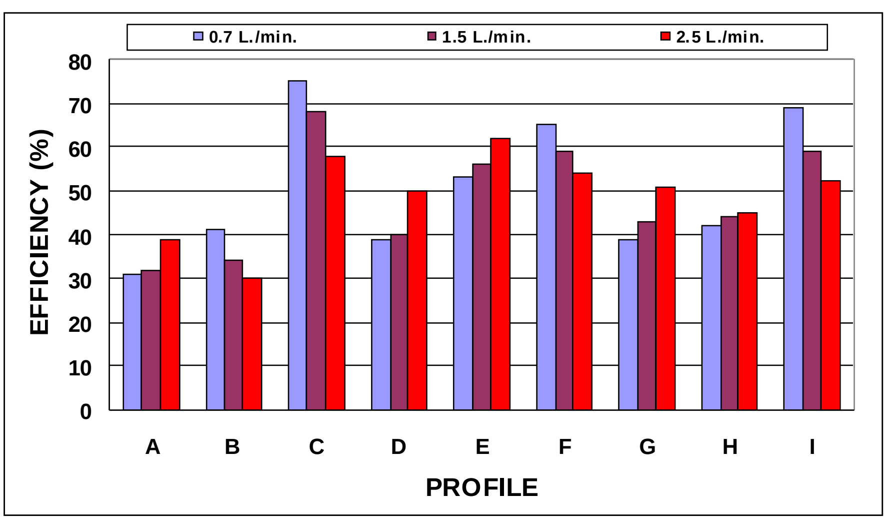


Figure 8. Metal Flashing Performance (without sealant)

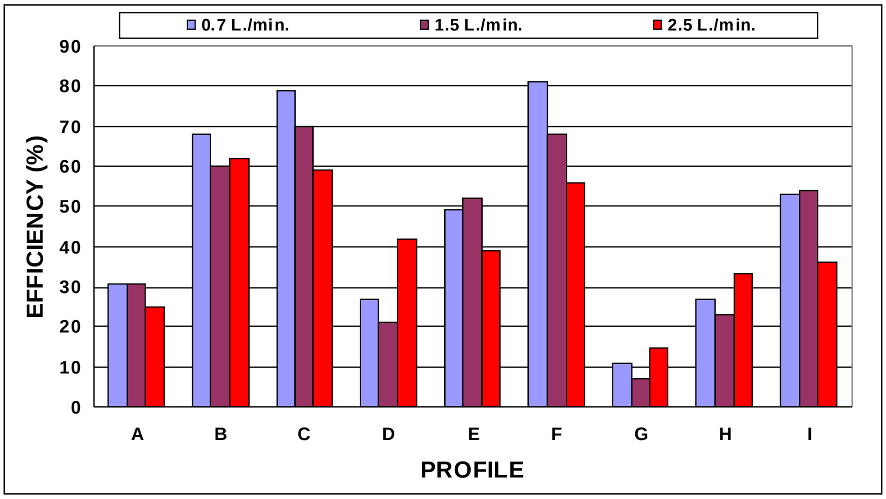


Figure 9. Metal Flashing Performance (with sealant)

3.1 COMPARISONS OF THE RESULTS FROM PREVIOUS EXPERIMENTS

Gyuro [9] and Saneinejad [10] conducted experiments for a single flow rate without sealant application. Their results are compared to the current results in this section. A result summary for the best performance of flashing is shown in Table 2. (Please refer to Figure 8 for detailed results.)

Table 2 – Comparison of current Results with Previous Experiments

	Gyuro [9]		**Saneinaejad [10]**		**Maleki [8]**	
	Condition	E %	Condition	E %	Condition	E %
Horizontal Projection	-NA-	-NA-	25 mm	77%	25 mm	75%
Drip Angle	30º	92%	30º	61%	30º	69%
Horizontal Projection - Sealant	-NA-	-NA-	-NA-	-NA-	25 mm	81%
Drip Angle - Sealant	-NA-	-NA-	-NA-	-NA-	45º	81%

Gyuro concluded that the most effective drip-edge angle is 30˚ [9]. However, he also found that angled profiles between 30˚ and 60˚ performed reasonably well. Similar results for performance were realized in the current study.

Saneinaejad concluded that there is a relationship between the size of the horizontal projection, angle of the drip-edge and the efficiency of the profile [10]. The larger the horizontal projection is, the bigger the angle and therefore the size of drip-edge should be for that profile to have the best performance. The current study also confirms the mentioned correlation.

In the current study first, the profiles have been sorted according to the length of the horizontal projection. Among Profiles A, D and G with 10 mm horizontal projection, Profile G has a slightly better performance compared to the other two in this group as shown in Figure 8. It is seen that among the profiles with 10 mm horizontal projection the profile with 30˚ drip angle, performs most efficiently. Profile E with 45˚ angle performs best for profiles with 15 mm horizontal projection. Profile C with 60˚ angle performs best for profiles with 15 mm horizontal projection.

3.2 IMPACT OF HORIZONTAL PROJECTION

Profiles have been grouped and studied according to the angle of the drip-edge. It is evident that in general the efficiency increases with the increase of horizontal projection and length of drip-edge. Profiles A, B and C have 60˚ drip angle. The most efficient profile in this group is Profile C which has a 25 mm projection. Profile C has an efficiency of 75%, 68% and 58% with low, medium and high flow rates respectively; while Profile A has efficiency of 32%, 31% and 30%; and Profile B has efficiency of 41%, 34%, and 30%. The above results are for profiles with no sealant; however the same trend is seen for profiles with sealant.

The same relationship exists among Profiles D, E and F having 45˚ drip angle; as well as between Profiles G, H and I having 30˚ drip angle as shown in Figures 8 and 9.

3.3 IMPACT OF WATER FLOW RATE

The performance of metal flashing with varying flow rate is seen to be heavily dependant on the horizontal projection. Profiles C, F and I have the efficiency rate of 50% or more for all flow rates. These profiles have a horizontal projection of 25 mm. The other six profiles have efficiencies less than 50 %, except Profile E. Profile E, due to the combination of horizontal projection and angle, had enough distance away from the back wall to drive the water away from the back wall. Further, as expected increasing flow rate decreases the performance of these three efficient profiles (Profile C, F and I).

Sealant is seen to degrade the performance of flashing as discussed below.

3.4 IMPACT OF SEALANT APPLICATION

Performance of profiles with and without sealant for low and high flow rates is presented in Figures 10 and 11.

Studying the impact of sealant on the efficiency of profiles revealed that the performance of the profiles having a drip length of less than 30 mm is negatively impacted by the application of sealant. Profile G having the smallest drip length (11.5 mm) has the largest reduction of efficiency with sealant.

Presence of sealant changes the profile of the drip-edge. With smaller drips the sealant is either flush or very close to the edge. Sealant material directs water flow onto the face of the back wall by surface tension, while the same profile performs better without sealant because the drip-edge breaks the surface tension.

The main design detail, with the sealant, is to allow enough distance from the drip-edge to the sealant. For example, with a single bead of sealant (approximately 10 mm thick), the 30 mm drip length flashing provides at least 15 mm space. And hence, the 30 mm flashing performed best with efficiency more than 75%.

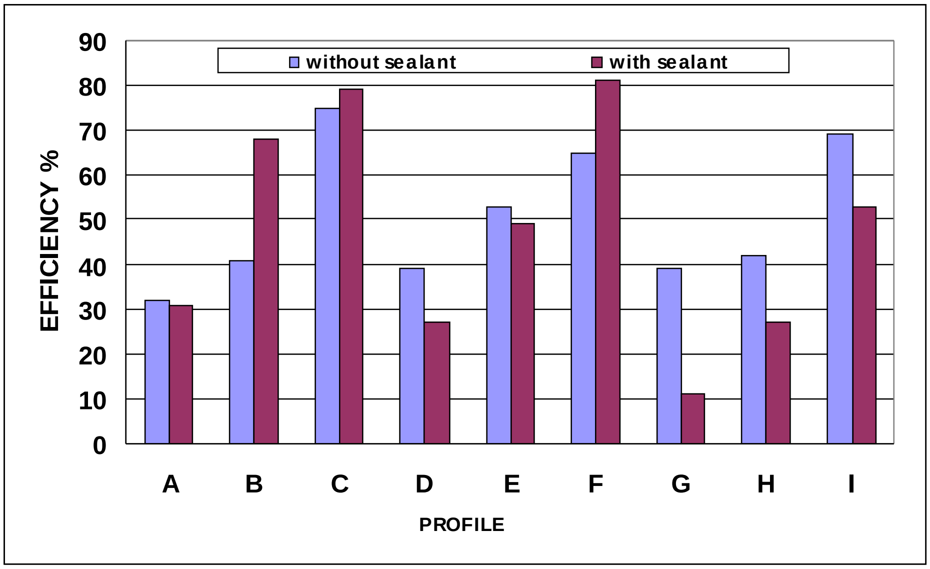


Figure 10 - Profiles with and without sealant with 0.7L/min. flow rate

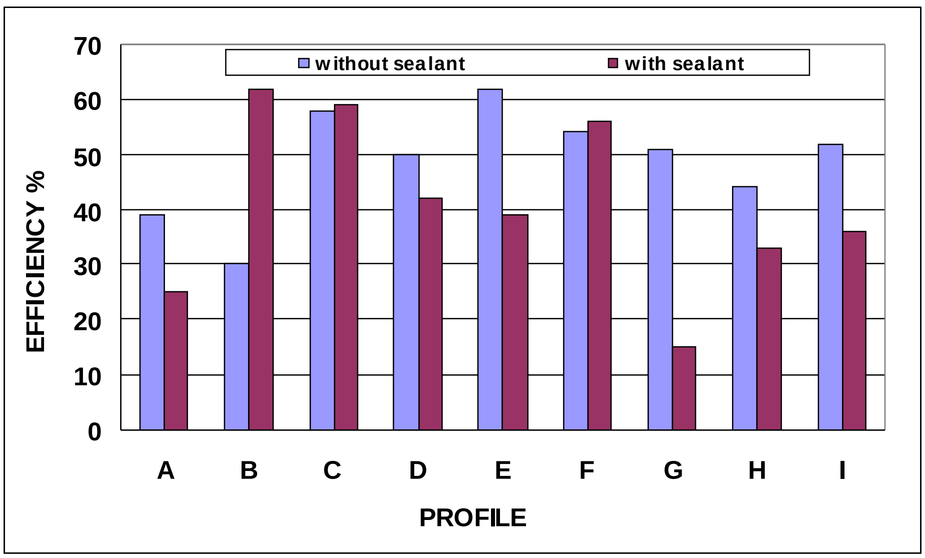


Figure 11 – Profiles with and without sealant with 2.5L/min. flow rate

The efficiency of Profiles B, C and F, which have a drip length of 30 mm or higher, has improved slightly with sealant application. Presence of sealant under the drip-edge may cause a small increase in the horizontal projection of these profiles, and therefore improving their performance. The presence of sealant with large drips increases the distance of the drip-edge to the back wall, and therefore deflects more water away from the wall surface.

The main effect of sealant is to reduce the efficiency. Profiles C, F and I, as discussed in Section 3.4, were found to have efficiencies greater than 50%. The presence of sealant didn't degrade their performance greatly except for Profile I with a flow rate of 2.5 L/min. The combination of high flow rate and sealant has reduced the efficiency to less than 50%.

4 CONCLUSIONS

A test method was developed and a test apparatus constructed to determine the impact of different variables on the efficiency of metal flashing. Samples of different profiles were tested and their water shedding ability was compared. Drip-edge of the test samples was then treated with a sealant at the joint between the flashing and the wall and the efficiency was examined.

Profiles with horizontal projection of 15 mm or less have efficiencies less than 50%. Good detail therefore should have horizontal projections more than 15 mm.

The main conclusion of the current study is that metal flashing, to perform efficiently, must have horizontal projections of 25 mm or more and the drip-edge angle must be between 30˚ and 60˚.

The application of sealant can reduce the efficiency of the flashing. Where sealant is to be applied behind the flashing, the profiles having a drip-edge length of 30 mm or greater can be expected to perform more efficiently.

In summary, metal flashing without sealant, must have a horizontal projection of 25 mm to shed the water efficiently. If sealant is applied, metal flashing must have a drip length of 30 mm to shed water efficiently. The drip angle, however, is not a dominant parameter. As long as the horizontal projection is 25 mm and the drip length is 30 mm or more, the flashing sheds water efficiently.

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