Final Report

d-Rain Validation Testing

P16-0028

Prepared for: Bio-Microbics INC

By

Kansas State University

Advanced Manufacturing Institute

May 2016

Matthew Campbell

Mechanical Engineer

Table of Contents

Introduction

Bio-Microbics Inc. has developed a rainwater management solution for pavement applications. The d-Rain Joint is installed into pavement and allows for passage of water through otherwise impervious surfaces. The flow capacity of the joint is required for proper use and design of this rainwater management solution.

Purpose

The purpose of this project is to independently verify the flow capacity of the *d-Rain Joint* drain device.

Methods

A controlled physical test that simulates field installation is conducted to verify the flow capacity of the d-Rain Joint Drain. This test will consist of a trough with a *d-Rain Joint* installed in a gap in the trough, similar to a field installation. A one-foot-wide section is used to test the device. Water is introduced and allowed to develop sheet type flow as it would develop on impervious pavement during heavy rain. The test is conducted at a low slope (1/40) and a high slope (1/8) to represent different pavement grades. The flow rate is controlled with a mechanical flow meter, as well as, measured by weight over a period of time. The test is run at increasing flow rates until the capacity of the joint is reached, characterized by liquid build-up or overrun. The capacity of the device is reported in gallons per minute per linear foot of drain (GPM/ft).

The flow meter is calibrated using the time and weight method. It is found the device is accurate within ~5-10% but reports readings that are slightly higher than the actual flow rate. The flow meter is used to set the flow rate 'in-the-ballpark' at the desired level. The time and weight method was then used for more accurate flow rate measurement. Once steady state flow is achieved a bucket is used to capture the water that passes in 1 minute of time. The volume of water is then weighed (lbs) and divided by the density (8.316 lb/gal) resulting in a GPM measurement.

This test does not include the effects of sub-grade conditions OR build of debris. It is assumed the sub-surface water retention area is adequately designed, in proper working order and in new condition. Also, this test assumes the joint is clean and free of debris. While these are important aspects of the rainwater management system this test is intended to isolate the d-Rain product from the site specific details.

Setup

To test the device a trough is constructed from steel sheet. A gap is cut in the trough to allow for installation of the d-Rain drain device. The drain is secured to the trough with industrial adhesive and sealed with silicone sealant to ensure water can pass only through the d-Rain device. A manifold is constructed from PVC by drilling a series of holes to distribute flow evenly on the trough surface. The water is introduced to the trough approximately 66" upstream of the drain. Due to the high velocity of water at the manifold ports a filter pad is installed to dampen the jets without affecting the net flow rate of the device. This allows for the water to distribute evenly over the surface and develop a natural sheet type flow.

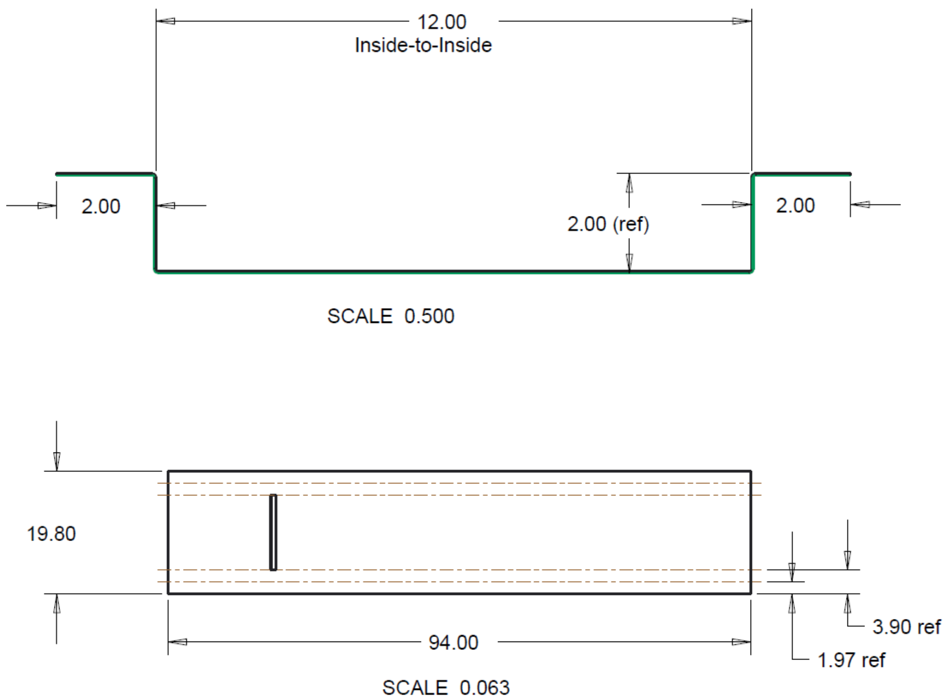

Figure 1: Trough Design

Figure 2: Test Set-up

Figure 3: Manifold Flow

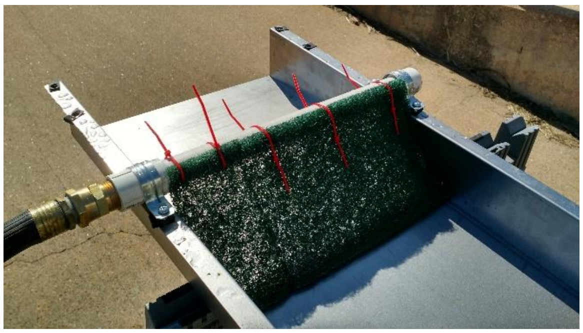

Figure 4: Manifold Porous Dampening

Figure 5: Drain Capturing 100% of Flow

Figure 6: Drain With Overflow

Results

The testing shows good performance of the d-Rain device. The maximum flow rate of the drain is determined by increasing the flow rate until a portion of the water passed over the d-Rain device. The maximum capacity at 1/40 grade is found to be 6 GPM/linear foot while the maximum capacity at 1/8 grade is found to be 5 GPM/linear foot. Additional testing is conducted at flow rates above the maximum capacity to investigate the performance when the flow rate exceeds the maximum capacity. For the 1/40 grade case a significant amount of the flow, 85%, is captured by the drain at flow rates as high as 11 GPM. For the 1/8 grade case the performance is lower, only 51% of the flow is captured by the drain at 9.5 GPM. The table below contains the test results, quantified by the percent of flow the drain captured.

Table 1: Test Results

		Grade	
		1/40	1/8
Flow Rate (GPM)	1	100%	100%
	2	100%	100%
	3	100%	100%
	4	100%	100%
	5	100%	100%
	6	100%	85%
	9.5	-	51%
	11	85%	-

Figure 7: Drain at 1/8 grade, 5 GPM

Figure 8: Drain at 1/8 grade, 9.5 GPM

Figure 9: Flow at 1/8 grade, 9.5 GPM

Figure 10: Drain at 1/40 grade, 6 GPM

Figure 11: Drain at 1/40 grade, 11 GPM

Figure 12: Flow at 1/40 grade, 11 GPM

Observations

In general, the device operated as expected. While the capacity of the drain is rated by the volumetric flow capacity, in GPM, two primary fluid behaviors limit the design. With sufficient velocity the water can overrun or 'jump' the 13/16" gap that the drain creates. Additionally, at lower velocities the porous media (filter) restricts the free flow of water and fluid build-up occurs until a portion runs over the device. The velocity is controlled by the slope and run up distance of the surface. With the flow rate held constant the velocity increases as the slope increases. It is found that the capacity of the drain at higher slopes is lower than the capacity at lower slopes. This indicates that the velocity induced 'jump' mechanism limits the design, not the porosity of the filter.

It is found that a slight side-slope significantly affects the capacity of the drain. In this situation the water accumulates on a small portion of the drain. This causes the local flow rate to greatly exceed the nominal flow rate. For instance, 2 GPM distributed over 12" becomes 8 GPM locally when distributed over 3". This causes the device to be over capacity locally and unused away from that location. This phenomenon will occur in field installations but is very difficult to quantify accurately. For rating purposes, it is assumed there is negligible side-slope and the water is evenly distributed across the device.

Conclusion

There is no known standard to control or govern this test. As such, the procedure, documentation, and results is subject to interpretation. The proposed test is designed to clearly demonstrate the product capacity in an isolated, controlled manner.

The maximum flow rate is found to be **5 GPM/linear foot** of drain.

The d-Rain device is capable of the flow rate reported in this report. However, this was determined in an ideal laboratory setting. The sheet type flow is sensitive to disturbances which could affect the capacity of the drain. It is expected that actual field installations will show a performance drop due to various disturbances such as; side-slope, debris, uneven flow pattern, run-up distance, etc. To address these effects, it is recommended that a safety factor be applied during the design of the system. This will be the responsibility of the design engineer and can vary depending on the situation.