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Via email: pblundell@ultrablock.com

Peter Blundell, President
815 NE 172nd Avenue
Vancouver, WA 98684

Re: Professional Opinion of the Runoff Coefficient for Xeripave® Super Pervious Pavers when using the Rational Method

Dear Mr. Blundell:

At your request Wright Water Engineers, Inc. (WWE) has prepared this letter report which summarizes our independent review and professional opinion of the Xeripave Super Pervious Paver system, and its appropriate runoff coefficient for use with the Rational Method. Based on our review of data from Young et al. (2008), independent laboratory falling head tests, and review of other permeable pavement literature, the runoff coefficient for the Xeripave system is effectively zero (0.00) when the system is maintained on a regular basis to prevent clogging, and when the system is designed with enough storage volume to infiltrate the full design rainfall depth.

BASIS FOR OPINION

According to Young et al. (2008) the Xeripave system (formerly known as Permapave) was subject to a laboratory study in which the system was subjected to a total of 17 years' worth of simulated direct precipitation, which contained concentrations of Total Suspended Solids characteristic of urban stormwater (150 mg/L), at rates of 0.02 inches/hour (0.6 mm/hour) and 0.043 inches/hour (1.1 mm/hour) characteristic of both Melbourne and Brisbane, Australia average annual rainfall rates, respectively. Additionally, at simulated years 6, 10, and 17 years (approximately) the system was subject to a 5 minute duration storm of 7.5 inches/hour (191 mm/hour), during which the Xeripave system fully infiltrated all of the simulated rainfall. Both of the other permeable pavement systems tested in this study exhibited signs of ponding during the 7.5 inches/hour rainfall event during simulated year 17.

Laboratory falling head test, were performed on the Xeripave system in September, 2006 by Mallen (2006) to calculate the hydraulic conductivity of the system. Three samples, with aggregate grades of 0.4 to 0.5 inches (10-12 mm) (sample 1), 0.6 inches (14 mm) (sample 2) and 0.6 to 0.8 inches (16-20 mm) (sample 3), were each tested five times and the average hydraulic conductivity for each sample was calculated. The results of these tests are shown in Table 1.

Table 1. Average Hydraulic Conductivity 'K' of Three Xeripave Aggregate Systems Based on Laboratory Falling Head Tests

Sample 1 Average 'K' (Aggregate Grade 0.4 to 0.5 inches)		Sample 2 Average 'K' (Aggregate Grade 0.6 inches)		Sample 3 Average 'K' (Aggregate Grade 0.6 to 0.8 inches)	
inches/second	inches/hour	inches/second	inches/hour	inches/second	inches/hour
1.48	5,328	1.79	6,444	1.68	6,048

For comparison purposes WWE examined various literature review documents which provided data on surface infiltration rates of other types of permeable pavements. The data from this limited literature review is provided in Table 2.

Table 2. Reported Surface Infiltration Rates of Permeable Pavements

Permeable Pavement System	Average surface infiltration rate (inches/hour)	Reference
Permeable Interlocking Concrete Pavers (PICP) (no fines)	900	Bean et al. (2004)
PICP (with fines)	1.6	Bean et al. (2004)
Concrete Grid Pavers (CGP) (maintained)	3.5	Bean et al. (2004)
Permeable Concrete	1,835	Collins et al. (2007)
Permeable Interlocking Concrete Pavers with pea gravel (No. 78 Stone)	450	Collins et al. (2007)
Concrete grid pavers filled with sand	36	Collins et al. (2007)
Permeable Interlocking Concrete Pavers with pea gravel (No. 78 Stone)	125	Collins et al. (2007)

Xeripave Super Pervious Pavers reportedly have a void ratio of 35%, and allow for infiltration over the entire surface area of the paver. Traditional permeable pavement systems utilize impervious concrete blocks or grids for structural integrity, and the void spaces between the concrete are filled with pervious sand or gravel, limiting the effective void capacity of the system on a unit area basis. Permeable concrete systems typically have void capacities in the range of 15 to 35% (EPA, 2009). As a result, the infiltration rate for the Xeripave system demonstrates a significantly higher infiltration rate than many traditional permeable pavement systems.

PROFESSIONAL OPINION OF THE RUNOFF COEFFICIENT FOR XERIPAVE SYSTEMS FOR USE WITH THE RATIONAL METHOD

The Rational Method is one of the simplest formulas to estimate peak flow rates from small urban watersheds, and it is most commonly used to design local drainage systems for peak flow capacity, such as inlets, storm sewers, culverts, and swales. The basis of the calculation assumes that a uniform rainfall rate across the watershed will produce a maximum runoff rate when all parts or areas of the watershed are contributing to the outflow. The amount of time it takes for this to occur is referred to as the time of concentration (T_c).

Considering that Xeripave systems are typically installed in highly urbanized and relatively small watersheds where the T_c is typically on the order of 5 to 10 minutes, the infiltration rate of a maintained Xeripave system will be greater than the intensity of any rainfall event for which the local drainage systems will be designed, typically a 25 to 50 year event maximum. For example, a small urban watershed in Tallahassee Florida with an 8 minute T_c will experience a rainfall rate of approximately 8.5 inches per hour during a 25-year event (based on Florida DOT Intensity Duration Frequency Curves). Assuming that the Xeripave system is maintained to prevent clogging, and the storage depth of the system is equal to or greater than the total design rainfall event depth, the infiltration rate of the Xeripave system would greatly exceed the rainfall rate, and therefore would not contribute to the peak flow rate calculated by the Rational Method. In effect the runoff coefficient for the Xeripave area is zero (0.00), assuming it is maintained on a regular basis, and sufficient storage is provided.

In summary, it is WWE's professional opinion that the infiltration rate of a well maintained Xeripave system will far exceed the rainfall rate of any typical design storm used for sizing peak flow rates with the Rational Method, and using a runoff coefficient of zero (0.00), for Xeripaved areas, is reasonable assuming the following conditions are met:

1. The system is subject to regular maintenance which prevents clogging.
2. The structural integrity of the Xeripave system is maintained over its service life and it is repaired or rehabilitated as needed.
3. The system is designed with enough storage capacity to capture the depth of rainfall that would fall during the design rainfall event duration.
4. There is not a significant source of solids in the watershed which would cause clogging of the Xeripave system during a storm event.

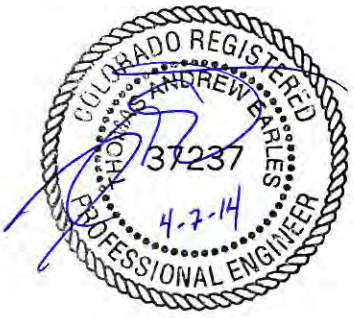
Sincerely,

WRIGHT WATER ENGINEERS, INC.

By _____
Andrew Earles, Ph.D., P.E., D.WRE
Vice President

Attachments

References



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