

# BOWSER-MORNER, INC.

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**AASHTO/ISO 17025 Accredited**

## LABORATORY REPORT

**Report To:** Whitacre-Greer  
Attn: Mr. Colby Dehoff  
1400 South Mahoning Avenue  
Alliance, Ohio 44601

**Report Date:** November 18, 2009  
**Job No.:** 149057  
**Report No.:** 104303  
**No. of Pages:** 5

**Report On:** Laboratory Determination of the Hydraulic Conductivity (Permeability) of a Fired-Clay Paver Unit Placement System

On October 15, 2009, two sets of fired-clay paver units were submitted for laboratory determination of the hydraulic conductivity (coefficient of permeability) of an installation system using six inches of No. 57 crushed limestone as the base course and one inch of No. 9 crushed limestone for the bedding layer.

The permeameter was fabricated in-house based upon the US Army Corps of Engineers design (EM 1110-2-1906, Appendix VII). The schematic for the permeameter is shown in figure 1. The setup of the permeameter was as follows: Wire screens were placed over the four circular outlets at the base of the permeameter to prevent loss of fines. Each outlet was 1.5-in. in diameter. Rubber stoppers were inserted into the outlets. A six inch base course of No. 57 crushed limestone was placed into the permeameter and consolidated by rodding. A one inch bedding layer of No. 9 crushed limestone was placed over the No. 57's. The paver units were trimmed and placed so as to fit the cross sectional area of the permeameter (figures 2 and 3). Additional No. 9 crushed limestone was placed in the joints and around the perimeter and struck flush (figures 4 and 5). A 1-in. thick metal plate approximately fitting the cross sectional area of the permeameter was placed on top of the assemblage with a 200-lb. surcharge weight and the entire assemblage was vibrated at the amplitude and frequency specified in ASTM D 4254 to simulate compaction used during construction. The permeameter was filled with water to the top of a sight tube and the initial level ( $h_0$ ) was recorded. A stop watch was started with the four rubber stoppers pulled simultaneously and the final level ( $h_f$ ) and elapsed time ( $t$ ) was recorded.

The hydraulic conductivity was calculated for each of the two types of units in accordance with EM 1110-2-1906 (Appendix VII, figure 2, setup b).

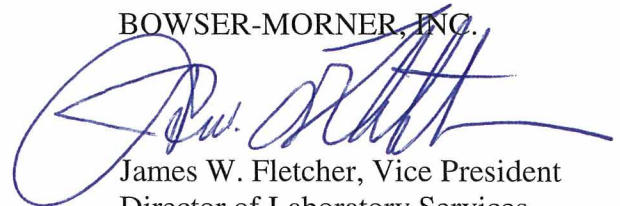
Results are as follows:

Measurements	4 x 8 Permeable 2-1/4" Beveled Paver	3" Boardwalk Permeable Paver
Height of Water Above Discharge Level at Time $t_0$ ( $h_0$ ), cm:	46.36	46.36
Height of Water Above Discharge Level at Time $t_f$ ( $h_f$ ), cm:	29.21	29.21
Length of Test Specimen, Stone Layers & Paver Units (L), cm.:	23.18	25.40
Elapsed Time ( $t = t_f - t_0$ ), sec.:	15.57	12.80
Hydraulic Conductivity [Permeability] (k):		
• Centimeters per Second (cm/sec):	0.69	0.92
• Inches per Hour (in/hr):	970	1300
• Feet per Day (ft/day):	1950	2600

Should you have any questions, or if we may be of further service, please contact me at (937) 236-8805, extension 235.

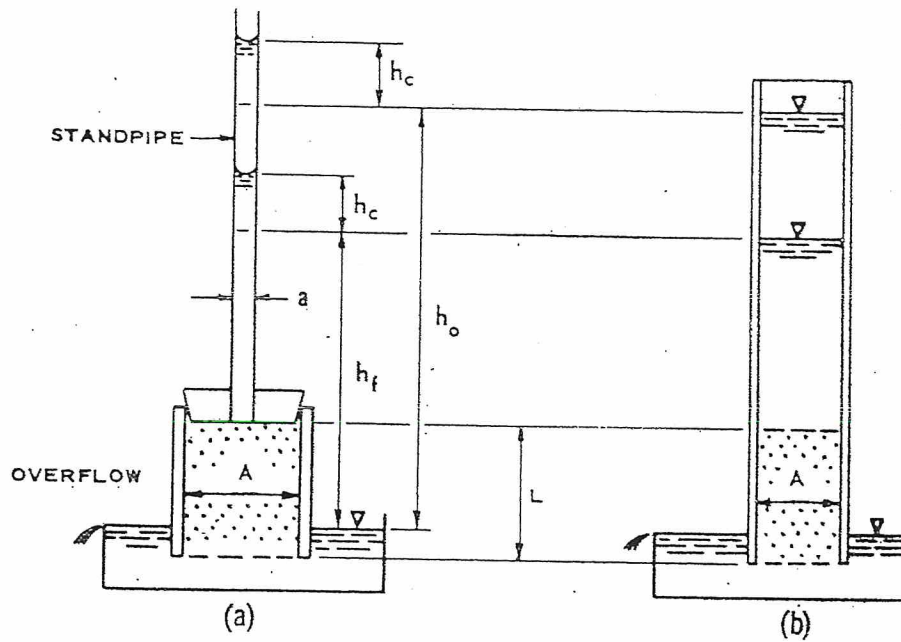
Respectfully submitted,

BOWSER-MORNER, INC.



James W. Fletcher, Vice President  
Director of Laboratory Services  
Construction Services Division

JWF/jwf  
104303  
4-Client  
1-File



USING SETUP SHOWN IN (a), THE COEFFICIENT OF PERMEABILITY IS DETERMINED AS FOLLOWS:

$$k = \frac{La}{At} \ln \frac{h_o}{h_f} = 2.303 \frac{La}{At} \log_{10} \frac{h_o}{h_f}$$

USING SETUP SHOWN IN (b), THE COEFFICIENT OF PERMEABILITY IS DETERMINED AS FOLLOWS:

$$k = \frac{L}{t} \ln \frac{h_o}{h_f} = 2.303 \frac{L}{t} \log_{10} \frac{h_o}{h_f}$$

- WHERE:  $h_c$  = HEIGHT OF CAPILLARY RISE  
 $a$  = INSIDE AREA OF STANDPIPE  
 $A$  = CROSS-SECTIONAL AREA OF SPECIMEN  
 $L$  = LENGTH OF SPECIMEN  
 $h_o$  = HEIGHT OF WATER IN STANDPIPE ABOVE DISCHARGE LEVEL MINUS  $h_c$  AT TIME,  $t_o$   
 $h_f$  = HEIGHT OF WATER IN STANDPIPE ABOVE DISCHARGE LEVEL MINUS  $h_c$  AT TIME,  $t_f$   
 $t$  = ELAPSED TIME,  $t_f - t_o$

Figure 2. Principle of falling-head test





Figure 2  
4x8 Permeable 2-1/4" Beveled Paver  
As Trimmed



Figure 3  
3" Boardwalk Permeable Paver  
As Trimmed





Figure 4  
4x8 Permeable 2-1/4" Beveled Paver  
After Compaction

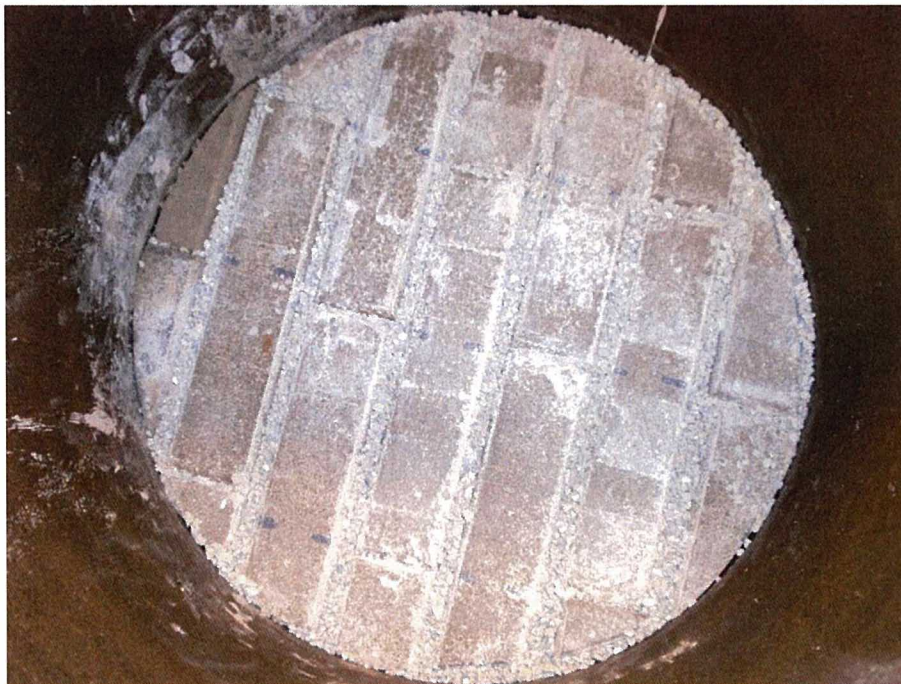


Figure 5  
3" Boardwalk Permeable Paver  
After Compaction