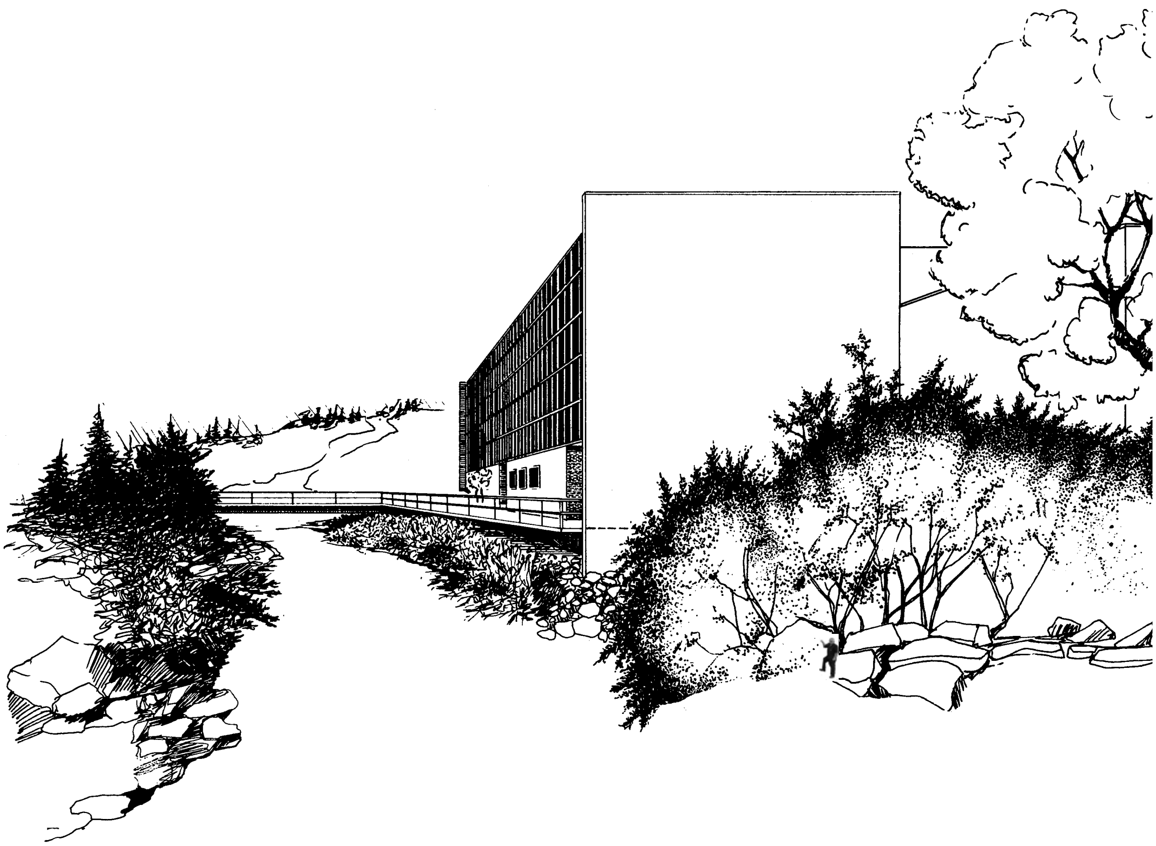
Sport Court Infiltration Findings

Prepared for

Sport Court, Inc.

June 1, 2010



UTAH WATER RESEARCH LABORATORY

Utah State University
Logan, Utah

Hydraulic Report No. 2210

Sport Court Infiltration Initial findings

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Introduction

A water infiltration test of SportBase tiles was performed to determine the rate at which water passes through the drain holes and tile joints. The infiltration test bench was constructed, which featured a sealed and painted 6-ft x 6-ft x 2-ft deep wooden box with 16 SportBase tiles as the floor. The floor had 9 whole tiles in the center, 6 tiles were cut in half for the edges, and the remaining tile was cut in fourths to place in the corners. Each tile was supported by two 2-inch by 4-inch wooden studs and the box was leveled to create a uniform pool depth over the entire floor. Water was introduced at different rates as a point source in the center of the floor. The water was introduced into a diffusing structure that would produce even water distribution in all directions. The test set up can be seen in Figure 1.

Figure 1. The model setup.

The objective of the test was to determine a representative infiltration rate for the tiles, which was done by calculating a representative hydraulic conductivity (k) value for each flow condition. Hydraulic conductivity is calculated per Equation (1). Permeability is related to hydraulic conductivity per Equation (2).

$$K = -\frac{QL}{Ah_L} \qquad (1)$$

$$k = \frac{K\mu}{\rho g} \qquad (2)$$

In Equations (1) and (2), Q is the volumetric flow rate (cfs) per tile, L is the length of the porous media (tile height), A is the flow area (total area of the test box floor divided by the number of tiles), h_L is the energy gradient (depth of water in the box), μ is the water dynamic viscosity (lb-s/ft^2), ρ is the water density (slugs/ft^3), and g is the gravitational constant (ft/s^2). The test results report Q in terms of gallons per minute (gpm); a conversion factor is applied for calculating k.

Test Results

Different flow rates were supplied to determine the infiltration rate of the tiles. As shown in Figure 1, the discharge into the box was concentrated at the center of the box; a baffle structure was used to uniformly distribute the flow radially.

Drain Holes Open
At 12.5 gpm/tile and the drain holes open, the tiles passed water efficiently enough that tiles in the corner of the box remained dry. At flow rates of 62.5 gpm/tile and less, the flow exiting the baffle in the center of the box was supercritical (shallow flow depth, high velocity), with a hydraulic jump transitioning the flow to subcritical (deeper flow depth, slower velocity) some distance from the center, resulting in a non-uniform reservoir conditions. At 75 gpm/tile, a uniform flow depth was present in the box (no supercritical flow was present) with a flow depth of 4 inches. Figures 2 through 6 show images of different flow rates being introduced into the box.

The test results for the open drain hole tests are shown in Table 1. As previously discussed, a uniform flow depth did not exist in the box for the majority of the test conditions due in part to the high drainage capacity of the tiles and the point-source method of supplying water to the test facility. The flow depth around the perimeter of the box (subcrtical flow) was used as the representative flow depth (h_L). Consequently, the reported k values should be considered conservative (actual k values would be higher if a uniform flow depth existed for all flow rates). k decreased as h_L increased; the average value of k was 0.076 ft/sec.

Drain Holes Closed
The same tests were repeated with the tile drain holes plugged (corks were used to plug the drain holes). The test results are also reported in Table 1. The drain holes appear to provide little contribution to drainage, relative to the test conducted (k values essentially unchanged from the drain hole open testing). If the supercritical flow condition did not exist and a uniform flow depth were present in the box for all flow conditions, the holes would likely have made a more significant contribution to the total drainage capacity of the tiles. The average k value for the closed drain hole condition was 0.070.

Table 1. Summary of infiltration test data

Tile height (ft)	0.167									
Tiles	16									
Total Area (sf)	36	Flow Rate			Drain Holes Open			Drain Holes Closed		
Area/Tile (sf)	2.25	Q	Q/tile	V/tile	Pond Depth	K	k	Pond Depth	K	k
		(gpm)	(gpm/tile)	(fps)	(inches)	(ft/s)	(m^2)	(inches)	(ft/s)	(m^2)
Water Temp (deg F)	45									
viscosity, μ (lb-s/ft^2)	0.00002982	200	12.5	0.012	0.2	0.124	5.921E-08	0.2	0.124	5.921E-08
g (ft/s^2)	32.2	400	25.0	0.025	0.5	0.099	4.736E-08	0.63	0.079	3.759E-08
density, ρ (slug/ft^3)	1.94	600	37.5	0.037	1.125	0.066	3.158E-08	1.125	0.066	3.158E-08
		800	50.0	0.050	-	-	-	1.5	0.066	3.158E-08
		1000	62.5	0.062	2.25	0.055	2.631E-08	2.5	0.050	2.368E-08
		1200	75.0	0.074	4	0.037	1.776E-08	4.5	0.033	1.579E-08
		1400	87.5	0.087	-	-	-	7.25	0.024	1.143E-08
					Average	0.076	3.644E-08		0.063	3.012E-08


Figure 2. Drain holes open, 2.5 gpm/tile


Figure 3. Drain holes open, 25 gpm/tile


Figure 4. Drain holes open, 37.5 gpm/tile


Figure 5. Drain holes open, 62.5 gpm/tile


Figure 6. Drain holes open, 75 gpm/tile

Conclusions

Typical K values for gravel, sand, silt, and clay are shown in Table 2. A comparison of the data presented in Tables 1 and 2 indicates that the SportBase tiles have a hydraulic conductivity that falls within the gravel category (>0.003 fps), exceeding the conductivity of sand, silt, and clay. The substrate materials above which the tiles would be installed will likely control the infiltration capacity of the SportBase tiles. One factor that may influence the composite conductivity of a tile/substrate assembly is that fact that the water draining though the tiles is confined to the area between the tiles (and the drain holes if included), meaning that the water will not be uniformly supplied at the tile/substrate interface and the composite conductivity will likely be reduced.

Table 2.

Material	Typical Hydraulic Conductivity (*K*) values	
	(fps)	(mm/sec)
Gravel†	>0.03	>10
Sand†	0.03 - 3E-7	10 – 1E-4
Silt†	3E-7 - 3E-9	1E-4 – 1E-6
Clay†	<3E-9	< 1E-6
Pervious Concrete‡	3E-5 – 3E-6	0.01 – 0.02
SportBase Tiles with holes	0.076	23
SportBase Tiles without holes	0.07	21

†based on Dunn et al. (1980).

‡ based on Sumanasooriya et al. (2009) (water temperature of 20°C assumed).

Sumanasooriya et al. (2009) conducted tests to determine the permeability of pervious concrete. They reported pervious concrete permeability values of ~ 1E-9 to 2E-9 m2, which produce K values of 0.01 to 0.02 mm/s for water at 20ÁC, as shown in Table 2. For the conditions under which it was tested (no substrate material), the permeability of the SportBase tiles, shown in Table 1, is an order of magnitude higher (~ 3E-8 m2) than the pervious concrete values. Figure 7 summarizes the hydraulic conductivity values of the SportBase tile (with and without drain holes), the substrate materials listed in Table 2, and the pervious concrete. Consistent with the conductivity discussion, the composite permeability of the SportBase tiles and an underlying substrate material will likely decrease, relative to the value reported in Table 1 due to the fact that the water draining through the SportBase tiles is limited to a small cross-sectional area (gaps between the tiles) at the point where it transitions to the substrate.

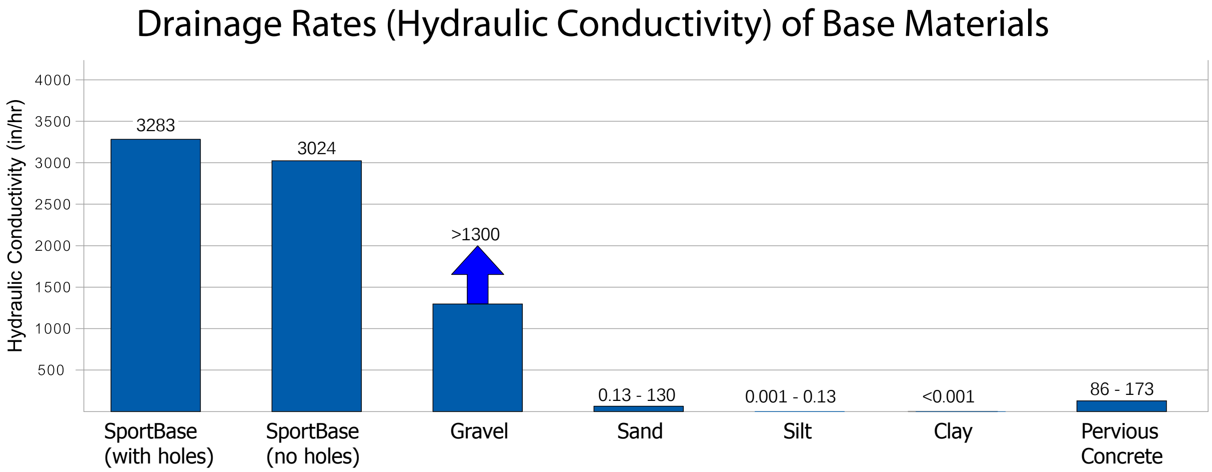

Figure 7. Hydraulic conductivity chart for SportTile, common substrate materials, and pervious concrete* (*based on Sumanasooriya et al., 2009)

References

Dunn, Anderson, and Kiefer (1980). Fundamentals of Geotechnical Analysis, John Wiley & Sons, New York, pp.60.

Sumanasooriya, M.S.; Bentz, D.P., and Neithalath, N. (2009). "Predicting the Permeability of Pervious Concrete from Planar Images." www.nist.gov/manuscript-publicaiton-search.cfm?pub_id=902014&division=861.