The Role of Joint Filling Materials in Permeable Interlocking Concrete Pavements

More than any other factor in PICP, the permeability of joint filling material is key to long-term surface infiltration performance

Like all permeable pavements, new permeable interlocking concrete pavement (PICP) can accommodate all rainfall intensities. PICP will acquire dirt and detritus in the stone-filled openings and this will decrease surface infiltration rates. These clogging materials are typically from airborne particulates, abraded particles from tire traffic, soil and organic substances that wash or erode from adjacent areas. The good news is that most of these materials are trapped in the first inch (20 – 25 mm) of the stones that fill openings between the paving units. The even better news is that PICP still infiltrates rainfall and runoff from the highest intensity storms even with these materials present in the stone-fillec openings.

Research shows that PICP is affected by the entrapment of fines in the aggregates used in joints (BWW, 1984; Binnewies, W. and M. Schuetz, 1985; Borgwardt, S., 1995). Surface infiltration is also explained by Dr. Soenke Borgwardt (2006). He shows the relationship between the amount of fines or particles passing the (approximate) No. 200 sieve (0.063 mm) and infiltration. Figure 1 illustrates this relationship and clearly demonstrates that even a small increase in fine material will dramatically decrease infiltration.

Dr. Borgwardt's research has also demonstrated the infiltration rate of various types of joint filling material in PICP. He demonstrated that larger joint materials will have higher infiltration rates than smaller stone sizes at the beginning of

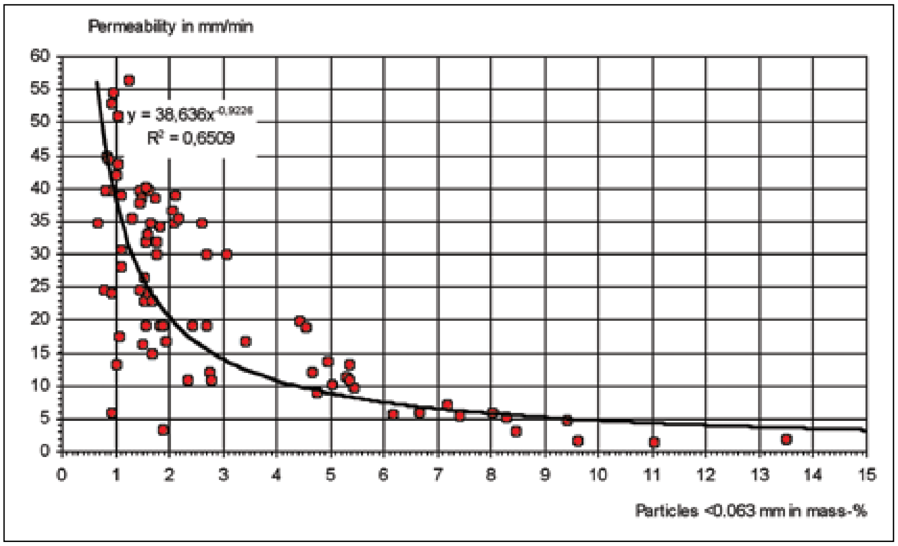

Figure 1. Relation between permeability and particle fraction < 0.063 mm (Borgwardt 2006)

Approximate particle size	Permeability (k) in./hr (m/s)
ASTM No 8 (10 to 2 mm)	4000 to 1400 (3 x 10^{-1} to $1x10^{-2}$)
ASTM No. 9 (2 to 5 mm)	1400 to 140 ($1x10^{-2}$ to $1x10^{-3}$)
ASTM No. 10 (1 to 3 mm)	140 to 14 ($1x10^{-3}$ to $1x10^{-4}$)
ASTM C 33 or CSA A23.1 Sand (0 to 5 mm)	14 to 1.4 ($1x10^{-4}$ to $1x10^{-5}$)
ASTM C 144 or CSA A179 Sand (0 to 2 mm)	1.4 to 0.14 ($1x10^{-4}$ to $1x10^{-5}$)

Table 1. Permeability ranges of aggregates for joint fillings (after Borgwardt 2006)

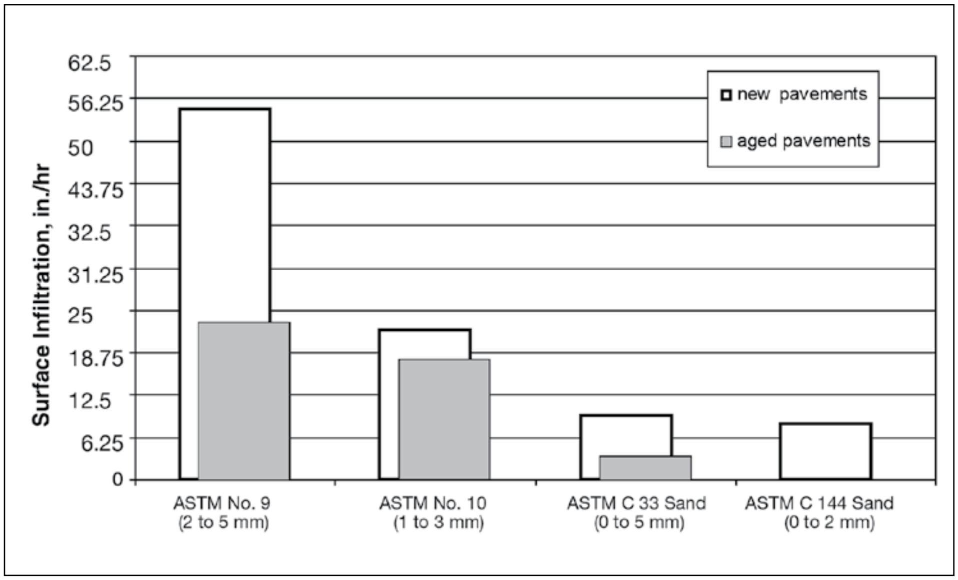

Figure 2. Infiltration performance of different aggregates for joint fillings (after Borgwardt 2006)

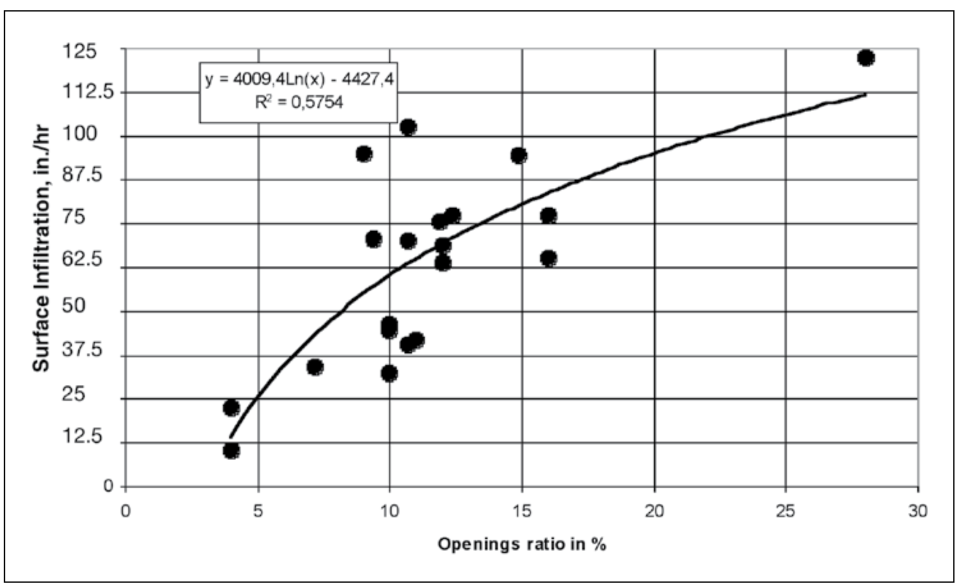

Figure 3. Infiltration performance in relation to openings ratio with new permeable CBP (Borgwardt 2006)

service and several years into service. However, the important point of his research is that PICP surface infiltration rates for larger and smaller joint filling stones *are still significantly above all rainstorm intensities.* Therefore, decision on stone size is driven more by constructability, i.e., having sufficiently small material to enter the joints rather than any need to maximize surface infiltration. Table 1 illustrates the infiltration rates of various PICP joint filling materials with references to similar ASTM stone and sand sizes. Figure 2 shows Dr. Borgwardt's correlation between infiltration performance and aggregate sizes used for joint filling using a sample size of 50 testing areas. Note that sands have the lowest infiltration rates. For this reason sand is not recommended by ICPI for use in any PICP openings, bedding or base.

PICP comes in various designs with various percentages of open area on the surface. How does this affect surface infiltration rates? Dr. Borgwardt found a positive correlation between the percent of open area and the surface infiltration rate in new PICP. In other words, the greater the open area, the higher the initial surface infiltration. All of these rates are well over the heaviest rain events (see in Figure 3). However, he notes that the central issue in infiltration performance depends on the amount of fines that collect in the openings over time. Therefore, PICP with a high percentage of surface openings can have a low infiltration rate if there is a significant amount of fines in the openings.

Dr. Borgwardt has reviewed many PICP sites of various ages and tested them for surface infiltration rates. As with all permeable pavements, he notes a reduction in surface infiltration over time and has developed an approximate correlation between time and surface infiltration. This correlation is shown in Figure 4 from studying PICP with 11.9 %

open surface area and a joint material similar to ASTM No. 9 stone. The infiltration rate in new condition is about 62 in./hr (5000 l/s ha) and decreases in the period under review of 10 years to about 16 in./hr (1300 l/s ha).

He further summarizes his research data into an overall trend line for PICP surface infiltration. This is shown in Figure 5. A key consideration of all of this data is that surfaces were likely not vacuumed to remove sediment since that would yield increased surface infiltration. His data indicates that PICP can still provide more than adequate surface infiltration even when not maintained with regular (one to two times annually) vacuum sweeping. Figure 5 suggests a reduction in surface infiltration rates over the life of PICP without maintenance. However, the initial or new surface infiltrate rate is so high, that a 80% to 90% reduction can still render a surface that will infiltrate most or all rainstorms. In his conclusions, Dr. Borgwardt stresses the need to carefully select joint materials with high infiltration rates as that affects the life-time performance of the entire PICP system. These are typically ASTM Nos. 67, 68, 7, 78, 8, 89 and 9 washed stone gradations. ❖

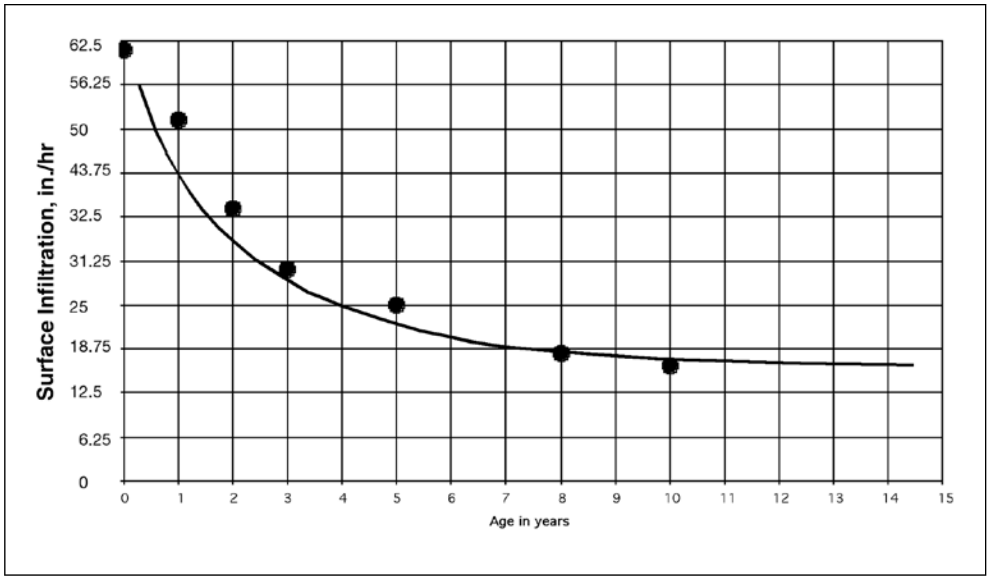

Figure 4. Monitored PICP surface infiltration rates using 2 to 5 mm stone (approximate to ASTM No.9) joint filling material with an 11.9% open surface area (Borgwardt 2006)

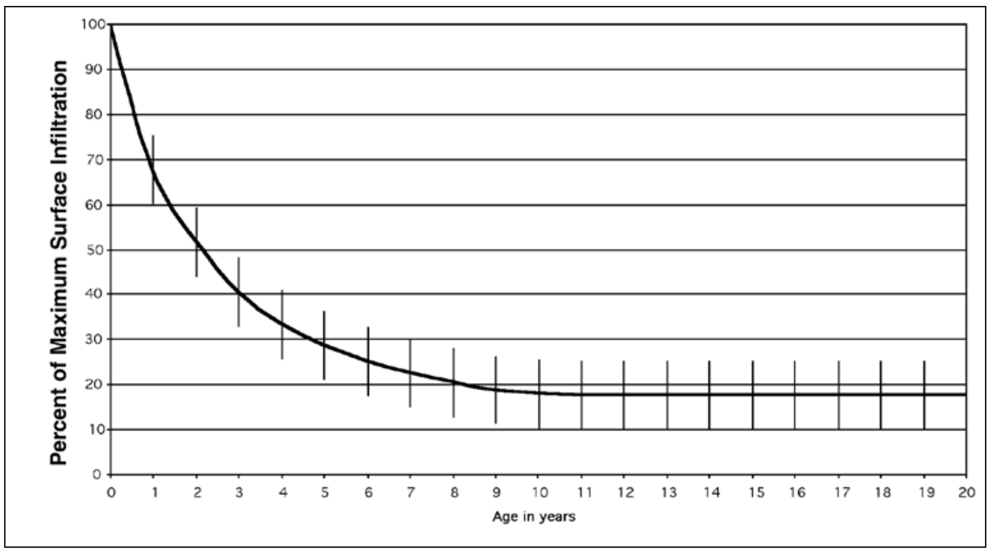

Figure 5. Overall trend of infiltration performance (Borgwardt 2006)

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