



INFILTRATION RATES FOR BELGARD® PERMEABLE PAVERS

Belgard permeable pavers are an excellent choice for stormwater management providing property owners with a low maintenance stormwater control measure and structural pavement surface in one system. And best of all, it is considered green infrastructure, infiltrating rainwater directly through the pavement openings, improving site drainage and dramatically reducing the need for deicing salts. This Technical Note provides information concerning joint aggregate permeability and surface infiltration performance for Belgard permeable pavement systems.

Joint Aggregate Properties

The ability for concrete pavers to infiltrate stormwater is due to enlarged spacer-bars designed to accommodate highly permeable aggregate in the joint openings at the surface. Most permeable pavers create between ¼ - ½" surface openings. These joints are filled with a poorly-graded, washed angular gravel, with known particle gradations as defined below:

| | ASTM NO. 8 | ASTM NO. 89 | ASTM NO. 9 |
|--------------------|------------|-------------|------------|
| SIEVE SIZE | % PASSING | % PASSING | % PASSING |
| 1/2 in. (12.5 mm) | 100 | 100 | 100 |
| 3/8 in. (9.5 mm) | 85 to 100 | 90 to 100 | 100 |
| No. 4 (4.8 mm) | 10 to 30 | 20 to 55 | 85 - 100 |
| No. 8 (2.4 mm) | 0 to 10 | 5 to 30 | 10 - 40 |
| No. 16 (1.2 mm) | 0 to 5 | 0 to 10 | 0 to 10 |
| No. 50 (0.3 mm) | NA | 0 to 5 | 0 to 5 |
| No. 200 (0.075 mm) | 0 to 2 | 0 to 2 | 0 to 2 |

Joint aggregate must be crushed rock with 90% fractured face and have an LA Abrasion value < 40 (per ASTM C131). These types of aggregate are considered open-graded aggregate, as compared to traditional road base material which is typically well graded with up to 15% passing the No. 200 sieve and is considered dense-graded aggregate. It is important to specify the joint aggregate size best suited for the installed field joint widths to prevent aggregate settlement or surface migration. Rounded river gravel or recycled concrete should not be used.

Joint Aggregate Performance Research

Borgwardt (2006) observed a correlation between infiltration performance and the kind of aggregates used for joint filling with permeable pavers. He found that "...aggregates with a coarse particle size exhibit a higher infiltration rate than others with fine grained aggregates, unconcerned that the testing area was new or aged."

Kim (2013) concluded, based on accelerated clogging test pads, that permeable paver joints filled with ASTM No. 8 aggregate provided the highest surface infiltration rates, while ASTM No. 9 aggregate provided more optimal Total Suspended Solids removal. He observed a relationship between higher TSS loading and decreased surface infiltration and found both ASTM No. 8 and 9 aggregate size offered long term performance advantages.

Kevern (2016) took a closer look at clogging rates of various joint stone gradations and joint widths. He measured infiltration flow rate through the surface over time. He noted that aggregate sizes smaller than ASTM No. 8 clogged faster and over a shorter time interval.

Contact a Belgard sales representative if you would like a copy of these reports.

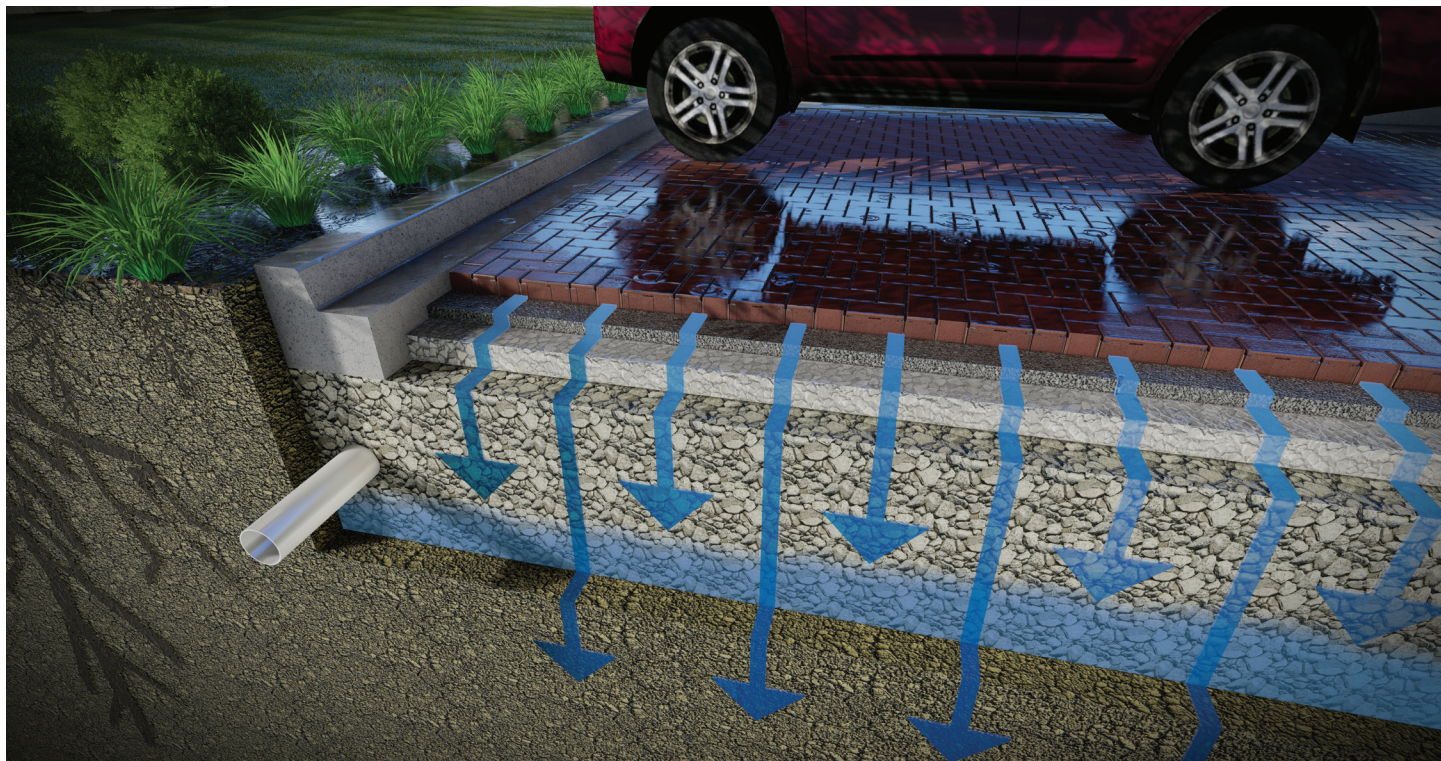
Surface Infiltration Rates of Belgard Permeable Pavers

Belgard Permeable Paver products provide a minimum surface infiltration rate of over 500 in/hr. when newly installed. The actual value will vary based on the specific paver and type of joint fill used. Hydraulic conductivity (i.e. coefficient of permeability) is equal to the infiltration rate for open-graded aggregates not subject to saturation, which is the case for the open-graded aggregates used as joint fill material in a permeable pavement section. An infiltration rate of 500 in/hr. is equivalent to a hydraulic conductivity (k) of 3.52×10^{-1} cm/s, which is orders of magnitude better than the hydraulic conductivity of a medium to coarse sand (10^{-3} to 10^{-2} cm/s). If the pavement systems infiltration rate is reduced by 90% due to clogging (Infiltration Rate = 50 in/hr.), the pavement will still have a hydraulic conductivity in the range of a medium to coarse sand ($k = 3.5 \times 10^{-2}$ cm/s).

Correctly designed, installed and maintained, permeable paver systems have surface infiltration rates higher than that of almost any natural soil and several times greater than the maximum possible rainfall intensity. This is why permeable paver surfaces should be given complete credit for 100% perviousness as would a meadow or forest.

The surface infiltration rate of an installed permeable paver system can be measured in accordance with ASTM C1781, Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems. Infiltration rates can vary widely for Belgard's large collection of permeable pavers combined with the use of various open-graded joint aggregates. In addition, site conditions including contributory run-on can reduce initial surface infiltration rates. The following selection of permeable pavers and infiltration rates tested in the field represent the most common permeable paver types installed nationwide.

INFILTRATION RATES FOR BELGARD PERMEABLE PAVERS



Select Belgard Permeable Paver Infiltration Rates¹

| PAVER/SIZE | MANUFACTURED JOINT WIDTH (MM) | RECOMMENDED MAXIMUM TRAFFIC LOADING | % SURFACE OPENING | SURFACE INFILTRATION RATE ASTM C 1781 (INCHES/HOUR) |
|--|-------------------------------|-------------------------------------|-------------------|---|
| Aqua-Bric® 5" x 10" | 9 | OHV | 9 | 749 |
| Aqua Roc® 4.5" x 9" | 8 | FHV | 9 | 834 |
| Eco Holland / Aqua Roc® II 4" x 8" | 8 | FHV | 9 | 706 |
| Eco Dublin® (3-piece) 3.5" x 7", 7" x 7", 7" x 10.5" | 12 | LV | 7 | 612 |
| Aqualine™ 9" L-Shape | 10 | FHV | 10 | 778 |
| Aqualine™ 4.5" x 9" | 10 | FHV | 10 | 749 |
| Aqualine™ 6" x 12" | 10 | LV | 10 | 967 |
| Aqualine™ Ashlar 4.5" x 4.5", 4.5" x 9", 9" x 9" | 10 | FHV | 12 | 819 |

All Permeable pavers listed above are 3 1/8" thick (80 mm) and can be used to construct ADA compliant pavements

¹: Newly installed. Values vary based on joint infill gradation.

LV: Light Vehicles - Commercial parking lots, access ways ≤ 30,000 ESALs

OHV: Occasional Heavy Vehicles - Large facility parking, residential roadways ≤ 110,000 ESALs

FHV: Frequent Heavy Vehicles - Local and commercial roadways, minor collectors ≤ 1 M ESALs

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