OPERATION & MAINTENANCE GUIDE FOR
BELGARD PERMEABLE INTERLOCKING CONCRETE PAVEMENT SYSTEMS
BELGARD PERMEABLE PAVER PRODUCTS are produced by Oldcastle plants throughout North America and are manufactured in accordance with ASTM C-936 Standard Specification for Solid Concrete Interlocking Paving Units. Permeable Interlocking Concrete Pavement (PICP), like all types of permeable pavement, is a stormwater control measure that requires periodic inspection and maintenance to ensure long-term performance throughout the design life of the system. The type of maintenance differs from traditional impermeable pavements, and methods vary based on site-specific conditions.

All permeable pavements will collect sediment and debris, which results in a decreasing infiltration rate over time. The rate of decrease depends on the sources of sediment. The surface infiltration rate reduction is gradual over time, and most rain events are still infiltrated through the sediment-filled joints. Gradual clogging captures suspended solids near the surface where seasonal maintenance can readily remove the sediment.

This document addresses the key inspection and maintenance requirements for Belgard PICP systems and does not address other types of permeable pavement systems or the cleaning and maintaining of standard concrete pavers. Belgard recommends that a site-specific Operations & Maintenance (O&M) Manual be developed, based on guidelines presented in this document, for all commercial and municipal projects.

Visit www.BelgardCommercial.com for a full collection of resources related to Belgard PICP including typical details, guide specifications, hatch patterns and other reference material.

Oldcastle, a part of CRH International, is committed to delivering sustainable products that provide environmental benefits including concrete products for stormwater management. Belgard permeable pavers are used throughout North America as part of a Low Impact Development strategy to infiltrate stormwater and reduce runoff and associated flooding. Oldcastle’s commitment to a cleaner environment extends beyond the products we manufacture and now includes a variety of post-construction maintenance programs for owners, municipalities and facility managers. For more information about Oldcastle’s commitment to the environment, go to http://www.crh.com/sustainability.
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SITE CONSTRUCTION PROTECTION FOR PICP SYSTEMS

Protecting PICP from excessive sediment buildup during construction is important to long-term performance and effective future maintenance efforts. Most sites build PICP systems first to protect the open-graded aggregates from debris, dirt, etc., and then the PICP is used for site access during construction. During the pre-construction meeting, various trades should review material flow that will impact the PICP system by contamination or staining. Concrete trucks, masonry equipment, and delivery vehicles may utilize the PICP, but consideration on how washout and debris from these trades will impact the paver surface must be addressed. Excessive mud tracked on the pavers may cause clogging in some areas, but can be removed with a vacuum street sweeper at the conclusion of construction activities and prior to turning the project over to the owner. In addition, the PICP system can serve as an integral part of the project’s Stormwater Pollution Prevention Plan if designated before construction with a plan to maintain and restore the PICP to full surface infiltration capacity. Oldcastle recommends that the PICP be used by construction traffic if the joint material is removed and replaced upon substantial completion of the project. Surface infiltration testing should be performed with infiltration results of at least 100-inches/hour or as agreed upon by the owner.

An alternative solution to protect the PICP system would be to make an initial cut to within 12-inches of final sub-grade and cover with a sacrificial layer of ASTM No. 2 aggregate subbase to use as a construction traffic and sediment trap. When final PICP construction can proceed, the sacrificial 12-inches of soil and aggregate layer can be excavated, and the PICP system is built in its entirety as designed. Once final road construction begins, prohibit construction traffic access over the open-graded aggregate subbase and base materials.
Another alternative solution would employ the use of a sacrificial layer of asphalt over the base (ASTM No. 57 aggregate). This approach would require the eventual removal of the asphalt layer and re-grading of the base layer before proceeding with setting the bed layer and paver installation.

Each of these options would allow immediate traffic flow after the permeable pavers have been installed, compacted and joint fill added. Protection of the pavers may or may not be required based on the stage at which they were installed, the projected use by the trades, and needs of the property owner. Plywood, fabric with chips, tarps and numerous other methods have been used in attempts to provide a protective layer over the paver surface, however, most have been costly and ineffective.

**POST-CONSTRUCTION INSPECTION/CLOSE-OUT DOCUMENTS**

When the PICP construction is complete, the owner or its representative should confirm that the newly built PICP was installed in general conformance with the construction documents including surface infiltration and hydraulic performance objectives defined by the designer. Confirmation that the proper materials and drainage elements were installed by site observations and photographs is recommended to ensure the long-term performance of the PICP system.

**Example Construction Detail for a PICP System**
Project close-out documentation should include all required information listed in the project specifications (inspection test reports, material certifications, etc.); including the items described below:

**BELGARD PERMEABLE PAVER POST-CONSTRUCTION INSPECTION CHECKLIST**

- The pavers utilized are the type, thickness and dimensions specified per the construction details.
- Surface infiltration testing in accordance with ASTM C1781, *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems*, has been conducted within 60 days post-installation, and results exceed 100-inches/hour.
- Paver joint opening filled with specified aggregate to at least 1/2-inch below the top of the paver. Confirm area around PICP perimeter is stabilized and covered with required vegetation or specified surface material.
- Paver surface contains no deformations (depressions/settlement) exceeding 1/2-inch.
- Paver height offsets are no more than 1/4-inch above or below adjacent units, and offsets are no more than 1/8-inch lippage from paver-to-paver.
- Cracked paver units (if existing) that could impair surface structural integrity have been removed and replaced.
- Drains and outfalls (if existing) related to the PICP system are constructed for the free flow of water and connected to an outlet structure in accordance with the construction plans.
- Observation wells (if existing) have been accessed and confirm that reservoir is draining (based on the size of the last rain event).
- The required edge restraint system is installed per the construction details.
- The installed surface slope is in compliance with the construction documents.
TYPES OF PICP MAINTENANCE ISSUES

The following examples of PICP maintenance issues can provide visual indicators of issues that require corrective actions.

*Condition Observed: Excessive ponding after rain events*

*Possible Cause:* Sediment build-up in joints from contributory run-on.

*Corrective Action:* Verify correct joint fill is being used. Identify possible sources of excessive run-on that can be mitigated. Validate observation based on several rain events. Conduct ASTM C1781 and perform remedial maintenance if needed.

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*Condition Observed: Loss of joint infill*

*Possible Cause:* Scouring on slopes, improper joint infill used, pumping under traffic, improper sweeping during seasonal maintenance, and failure to refill joints as needed.

*Corrective Action:* Verify correct joint fill is being used. Replace joint fill material to within 1/2-inch below the top of the paver.
Condition Observed: Surface settlement, depressions or ruts

Possible Cause: Weak subgrade conditions, improper compaction of subbase/base during construction, excessive loading.

Corrective Action: Verify surface deformation is in excess of 1/2-inch using a 10 foot straight edge. Contact a civil or geotechnical engineer to determine the cause of rutting and follow remedial action plan provided by the engineer.

Condition Observed: Damaged pavers – chips, cracks, spalls

Possible Cause: Differential settlement, excessive loading.

Corrective action: Remove and replace broken pavers as needed based on severity.

Condition Observed: Excessive in-field joint width (1/2-inch)

Possible Cause: Improper or lack of joint infill; poor edge restraint system; settlement of sub-grade, subbase, base, or bedding layer; utility trench failure.

Corrective action: Re-instate pavers based on severity and frequency. Evaluate surface for indications of settlement and address accordingly.
UTILITY REPAIRS

One advantage of PICP is that the pavers can be easily removed and reinstated for access to underground utilities. This important advantage allows the pavement surface to be utilized immediately after repairs are made.

Should utility repairs be required below the PICP surface, the pavers can be removed by hand without the use of saw cutting equipment or pneumatic jack hammers. Specialty equipment like a paver extractor can be used. Once the first paver is removed, it is relatively easy to remove the remaining pavers to beyond the extent of excavation. Set the pavers aside for future reinstalation. Undisturbed pavers can be secured with a wood or metal frame as shown in the Figure.

The bedding material (ASTM No. 8 Stone) encountered should be removed and disposed of, then replaced with new aggregate. The ASTM No. 57 base and ASTM No. 2 subbase can be carefully removed and stored separately for reinstalation. Care must be taken to prevent intermixing of the base and subbase materials, and store these materials in a place where the aggregates will remain clean. Any aggregates that become dirty or contaminated should be discarded and replaced.

Where repairs require excavation into the underlying subgrade soil, Oldcastle recommends using flowable concrete fill (200 to 500 psi) to support the repaired utility. The open graded base cannot adequately fill under pipes or boxes, nor can it be compacted in these places. When pouring the flowable fill, use a plastic sheet or geotextile to prevent the flowable fill from seeping into the ASTM No.2 Stone. A minimum 4-inch layer of flowable concrete fill should be used to cover a pipe or box structure.

When reinstalling the aggregates, place and level the ASTM No.2 stone in no more than 4-inch lifts and use a plate compactor to compact each lift; the thinner lift thickness is to accommodate the smaller sized compactor that will likely be used due to access limitations in the excavation. The ASTM No. 57 stone can be placed, leveled and compacted in one 4-inch thick lift. The setting bed of ASTM No. 8 stone shall then be placed and screeded in one 2-inch lift without compaction.

When reinstalling the pavers, place the pavers level with the adjacent pavers, or slightly higher to account for settlement of the underlying materials (based on the depth of excavation). In either scenario, the bedding layer should be 1/8-inch higher so that once the pavers are reinstalled and compacted, they should be the same elevation as the adjacent units. Once the desired grades are accomplished, sweep jointing material into the joints and vibrate into place; repeat until the joints are full. Belgard can provide an authorized paver contractor to reinstate pavers if required.

Replacement of a single broken or stained paver may be required. However, replacement is not recommended for isolated individual pavers with hairline cracks or other cracks than are not adversely affecting the structural performance of the pavement system. If the paver is otherwise intact and locked in place with little evidence
of movement such as spalling at the crack, the individual paver should be left in place. However, if the paver moves freely or is spalling, then the paver should be replaced. Place the new replacement paver to match the existing laying pattern. Compact the paver as described above. If the newly reinstalled paver is not flush to plus 1/8-inch with the surrounding pavers following compaction, it should be removed and the thickness of the #8 bedding should be either increased or decreased to result in a flush to plus 1/8-inch surface following paver replacement and compaction. Once the desired grades are accomplished, sweep joint aggregate (#8 stone) into the joints and compact into place; repeat until the joints are full.

WINTER CONSIDERATIONS

SNOW REMOVAL
Standard snow removal equipment used for impervious pavements may be used on Belgard PICP systems without damaging the surface. It is not necessary to utilize rubber tips or shoes on snow plow blades because the chamfered edges on the pavers prevent chipping. However, steel blades may scratch or abrade the paver surface leaving behind steel particles that may rust and stain the paver surface.

When using a snow plow or snow plow box, the utilization of rubber or plastic snow blades with properly adjusted skis/guides will prevent unwanted rust or scrape marks on the permeable paver surface. When using a snow blower, ensure the guides are properly adjusted to keep the rotating impeller from scraping and damaging the permeable paver surface and from displacing the joint fill material. Plowed snow should not be piled on the permeable paver surface because winter sediment deposition can accelerate clogging. If snow must be piled on the permeable paver surface, a spring-time vacuuming will likely be needed to remove winter sediment.

Note: These same practices will prevent unwanted rust, scrape marks and winter sediment on the surface of asphalt and concrete pavements.

DEICING CHEMICALS
The use of Belgard PICP systems can greatly reduce the need for deicing chemicals when compared to conventional impervious pavements or standard concrete pavers. If needed, use sodium chloride (rock salt) without sand. If air temperatures fall below 14 degrees Fahrenheit, calcium chloride may be used in moderation. Any deicing chemical should be used sparingly and in accordance with the manufacturer’s application instructions. Never use magnesium chloride or materials containing ammonium nitrate and ammonium sulfate.

The use of sand or cinder mixes for snow or ice removal is not recommended because it can accelerate clogging.
SNOW AND ICE MELT SYSTEMS
There are electric and liquid glycol melt systems that can be installed beneath Belgard PICP systems that can reduce or eliminate the need for snow and ice removal. When considering the use of these systems, it is imperative that the guidelines and details established in ICPI’s Tech Spec 12 Snow Melting Systems for Interlocking Concrete Pavements be followed. Because the snow melt system is below the permeable pavers, it is important to follow the maintenance requirements provided by the snow melt equipment supplier to ensure the long-term functionality of the system.

ANNUAL INSPECTION & SEASONAL MAINTENANCE PROGRAM
An annual inspection is recommended in the spring after snow events have subsided for the year. The purpose of the annual inspection is to assess the functional condition of the permeable pavers as a structural pavement and stormwater control measure. Once the annual inspection is completed, seasonal maintenance activities should be performed to correct deficiencies identified in the annual inspection.

The following items are minimum requirements for any annual PICP maintenance program:

- Replenish paver joints with additional aggregate if the level is more than 1/2-inch below the top of the chamfer at the paver surface.
- Inspect vegetation around PICP perimeter for cover & soil stability. Repair/replant as needed.
- Inspect and repair all paver surface deformations (depressions/settlement) exceeding 1/2-inch.
- Repair paver heights offset by more than 1/4-inch above or below adjacent units, or offset by more than 1/8-inch lippage from paver-to-paver.
- Replace cracked paver units impairing surface structural integrity.
- Check drains and outfalls (if existing) for the free flow of water. Remove any obstructions.
- Check observation wells (if existing) to confirm reservoir is draining (based on last measurable rain event).
- Conduct Seasonal Maintenance and increase frequency based on sediment loading.
- If evidence of surface clogging exists, test surface infiltration rate using ASTM C1781. If pavement infiltration rate is < 100-inches/hour increase Seasonal Maintenance from annually to quarterly. If surface infiltration rates fall to 10-inches/hour, employ a Remedial Maintenance program utilizing a vacuum sweeper/method to extract affected clogged openings and replace joint space with No. 8, 89 or 9 washed chip aggregates (based on original design requirements). Retest surface infiltration rate to confirm reinstated areas exceed 100-inches/hour. Repeat the remedial process as needed to exceed the 100-inches/hour criteria.
The initial Seasonal Maintenance cycle of a permeable pavement should commence 6 months from the substantial completion date of the project and be repeated every 12 months, or more frequently as needed. The objective is to remove debris and sediment from the surface with standard sweeping equipment such as power or manual brooms, blowers, mechanical sweepers or regenerative air vacuums. Examples of seasonal maintenance equipment are shown below:

It is not recommended to use power washing (i.e. pressure washers) to remove sediment within the joints or paver openings. The water will lubricate the sediment particles and force them further into the joint aggregates. In addition, excessive water will also create a slurry containing contaminants that may require special off-site disposal. Lawn maintenance personnel should be instructed to blow grass clippings away from permeable pavement and blow off any grass clippings, plant debris, or leaves that are deposited on the permeable pavement during lawn maintenance and landscaping operations.

A dry mechanical or regenerative air type sweeper may be used during dry periods to remove encrusted sediment, leaves, grass clippings, etc. Vacuum or sweeper settings may require adjustments to prevent uptake of aggregate from the paver voids or joints. Leaf blowers or other standard onsite manual methods that are used for standard pavement maintenance may be employed to remove this surface debris.
**REMEDIAL MAINTENANCE**

In rare cases, excessive sediment loading can occur in PICP surfaces. These conditions are typically in isolated areas within the pavement (often along edges) and are usually due to contributory run-on. Fortunately PICP, unlike other types of porous pavements, provides vertical filter columns (joints with specific aggregate infill) that allow for the capture and extraction of sediment build-up within the paver openings. Remedial maintenance should be done utilizing a vacuum sweeper, such as the Elgin Whirlwind as shown below, or an equivalent. A regenerative air vacuum is more appropriately suited for seasonal maintenance, as it only will remove the near-surface sediment. A true vacuum machine will remove the entire 3-inch column of joint aggregates.

Sediment collects within the joint or paver openings (voids). As particles attach to the interior infill aggregates, the fine particles bind together below the surface as shown. The majority of the particulate or sediment travel is limited to the near surface and typically does not advance more than 1-2-inches below the paver surface and typically does not reach the bedding layer. The ability for PICP to collect sediment near the surface is a key advantage to this type of infiltration system. Maintenance can be easily performed on the near-surface joint filters within a PICP system.
Municipal vacuum trucks and other equipment, even a shop vac, may be used for remedial maintenance in smaller areas. Remedial maintenance should be attempted in dry conditions and if removal is not achieved, flooding the area with water will help release the sediment under pressure from the vacuum source (water may be effective for remedial maintenance).

Replace openings with joint fill (ASTM No. 8, 89, or 9) specified in the construction documents by sweeping joints full to within 1/2-inch from the top of the paver surface. Remove excess chip materials from surface, and pavement is ready for use.

**WHEN IS REMEDIAL MAINTENANCE NEEDED?**

Remedial maintenance is sometimes required on older installations not seasonally maintained. An indication that remedial maintenance is needed is when rainwater ponds on permeable paver surfaces. In addition, on some land development or phased construction projects, permeable pavers are installed early in the project and often are subjected to significant sediment loading prior to overall project completion or owner acceptance. Project developers, HOAs, and municipal inspectors may require that the PICP system is restored to full surface infiltration capacity or to a minimum industry standard of 100 inches/hour to achieve final acceptance and approval. On these projects subject to sediment loading, Belgard Commercial recommends a remedial maintenance program be implemented to restore the PICP infiltration rate and jointing material.

**PICP RESOURCES**

The following resources address PICP design and maintenance and may provide additional guidance:

- *Permeable Interlocking Concrete Pavements*, a comprehensive design manual that provides specifications and information on construction and maintenance, published by the Interlocking Concrete Pavement Institute (ICPI).

- *Permeable Pavements*, a reference document that addresses maintenance for a variety of different permeable pavement systems, published by the American Society of Civil Engineers, Environmental & Water Resources Institute.

Go to BelgardCommercial.com/PICP/Resources to download the following resources for Belgard permeable paver systems:

- Guide specification
- Typical details
- Case Studies
- Product Description Sheets (cut sheets)
- Color options
- Installation guidelines
- Inspection & Maintenance checklists

**BELGARD COMMERCIAL OFFERS THE FOLLOWING POST-CONSTRUCTION SERVICES:**

**Project-specific O&M Manual** - Belgard Commercial has developed O&M manual templates for commercial and municipal PICP projects to restore clogged areas with new joint fill and establish surface infiltration rates exceeding 100 inches/hour. Assistance with developing a project-specific O&M manual can be provided.

**ASTM C1781 Surface Infiltration Testing** – Belgard Commercial can provide surface infiltration testing along with a report documenting the methodology and results for municipal and commercial PICP projects.

**Seasonal PICP Maintenance** – Belgard Commercial can recommend routine maintenance service contracts for commercial and municipal PICP projects. The frequency and cost of this program is quoted on a project-specific basis.

**Remedial PICP Maintenance** – Belgard Commercial can facilitate remedial maintenance services on an as-needed basis to restore clogged areas with new joint fill and establish surface infiltration rates exceeding 100-inches/hour. Belgard Commercial will ensure that appropriate equipment will be operated by qualified and trained contractors approved by Belgard Commercial. Projects that elect remedial maintenance will receive results of an ASTM C1781 surface infiltration test upon completion of the scope of work.
Belgard Commercial offers design support services for commercial paver technical support services. Design professionals that need assistance or technical input regarding PICPs can obtain the following technical support services at no cost:

- Project-specific details
- Project-specific specifications
- Input on stormwater conveyance, storage and water quality strategies
- Concept plans for alternative PICP designs
- Stormwater Management Plan reviews
- Cost analysis comparing PICP systems to conventional impervious pavement systems
- Life-cycle cost analysis comparisons

For more information and to find a location near you visit www.belgardcommercial.com