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ACRONYM GLOSSARY

AASHTO American Association of State Highway and Transportation Officials
ADA Americans with Disabilities Act
ASCE American Society of Civil Engineers
ASTM American Society for Testing and Materials
BMP Best Management Practice
CN Curve Number
CSA Canadian Standards Association
CSO Combined Sewer Overflow
DCOF Dynamic Coefficient of Friction
DGA Dense-graded Aggregate
ESAL Equivalent Single Axle Load
FSW Freestanding Wall
GRS-IBS Geosynthetic Reinforced Soil - Integrated Bridge System
GSI Green Stormwater Infrastructure
ICP Interlocking Concrete Pavement
ICPI Interlocking Concrete Pavement Institute
LCCA Life Cycle Cost Analysis
LEED Leadership in Energy and Environmental Design
LID Low Impact Development
NCMA National Concrete Masonry Association
OGA Open-graded Aggregate
PICP Permeable Interlocking Concrete Pavement
RCA Recycled Concrete Aggregate
SCM Stormwater Control Measure
SRI Solar Reflectance Index
SRW Segmental Retaining Wall
TMDL Total Maximum Daily Limit
TI Traffic Index
TP Total Phosphorous
TSS Total Suspended Solids
USEPA United States Environmental Protection Agency
Belgard® is a leader in the concrete paver industry. Through rigorous internal research and development, Belgard continually develops unique and innovative pavement solutions that meet or exceed ASTM standards and are available in an array of colors, finishes, shapes, and sizes to meet the design needs of any pedestrian or vehicular application. In addition, Belgard offers a variety of tools and services to ensure the success of every project, from downloadable CAD files, engineering service to life cycle costing.
DESIGNING THE PAVEMENT SYSTEM

The Science Behind the Structural Design

Interlocking concrete pavement (ICP) systems, including permeable interlocking concrete pavement (PICP), are versatile and durable pavement systems which can be used for a variety of pedestrian and vehicular applications. The success of any pavement is dependent on proper design, construction, and maintenance. Fortunately, ASCE has published design standards for both ICP and PICP. ASCE 58-16 is the latest edition of the ICP standard for structural design, and ASCE 68-18 is the recently published standard for PICP for both structural and hydrologic design.

ASCE developed both design standards based upon the 1993 AASHTO Guide for Design of Pavement Structures, which is used to calculate the thickness of a road cross section required to withstand the damage of repetitive dynamic loading from traffic over the lifespan of the pavement based upon the native soil’s bearing capacity. Equivalent single axle loads (ESALs) are used to determine the pavement damage done by each vehicle type compared to the damage caused by an 18,000-pound axle load. For example, passenger cars having a vehicle load factor of 0.0004 (it takes 2,500 cars to equal one ESAL) while a fully loaded fire truck can be as many as 10 ESALs. Once the traffic loading is calculated, paver thickness and aspect ratio must be selected to maximize performance and durability. The heavier the expected traffic, the thicker the paver needs to be to prevent rotation. Key factors for design of both ICPs and PICPs are subgrade strength, thickness of the base materials, paver thickness, paver aspect ratio, and laying pattern.

Is the Concrete Segmental Product a Paver, Slab or Plank?

Paver shape and thickness must be selected based on the application. Most long planks and large slabs are not suitable for vehicular applications. The success of any pavement is dependent on proper design, construction, and maintenance. Fortunately, ASCE has published design standards for both ICP and PICP. ASCE 58-16 is the latest edition of the ICP standard for structural design, and ASCE 68-18 is the recently published standard for PICP for both structural and hydrologic design.

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Sample Aspect & Plan Ratios

<table>
<thead>
<tr>
<th>WIDTH</th>
<th>LENGTH</th>
<th>THICKNESS</th>
<th>ASPECT RATIO</th>
<th>PLAN RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>6”</td>
<td>12”</td>
<td>60 mm (2½”)</td>
<td>5:1</td>
<td>2:1</td>
</tr>
<tr>
<td>6”</td>
<td>12”</td>
<td>90 mm (3½”)</td>
<td>3:1</td>
<td>2:1</td>
</tr>
<tr>
<td>6”</td>
<td>12”</td>
<td>101.6 mm (4”)</td>
<td>2:1</td>
<td>2:1</td>
</tr>
<tr>
<td>6”</td>
<td>9”</td>
<td>60 mm (2½”)</td>
<td>1:1</td>
<td>1:1</td>
</tr>
<tr>
<td>6”</td>
<td>9”</td>
<td>90 mm (3½”)</td>
<td>2:1</td>
<td>2:1</td>
</tr>
<tr>
<td>6”</td>
<td>9”</td>
<td>90 mm (3½”)</td>
<td>2:1</td>
<td>2:1</td>
</tr>
<tr>
<td>6”</td>
<td>24”</td>
<td>80 mm (3¼”)</td>
<td>7:1</td>
<td>6:1</td>
</tr>
</tbody>
</table>

Paver Application Recommendations

The following chart contains general recommendations for both interlocking and permeable concrete pavement systems including minimum thickness and maximum aspect ratio for several traffic types and uses. While this chart provides general recommendations, a pavement design professional should confirm that the product selected meets local standards and site-specific traffic and use conditions.

<table>
<thead>
<tr>
<th>TRAFFIC TYPES</th>
<th>TYPICAL USES</th>
<th>TYPICAL LIFETIME DESIGN ESALS</th>
<th>TRAFFIC INDEX (TRAFFIC RATING)</th>
<th>MAXIMUM ASPECT RATIO</th>
<th>MINIMUM THICKNESS</th>
<th>IC Pavers</th>
<th>PIC Pavers</th>
<th>HEAVY VEHICLES PER DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>Pedestrian</td>
<td>≤ 10,000</td>
<td>0.5</td>
<td>0.6</td>
<td>60 mm</td>
<td>✅</td>
<td>✅</td>
<td>0 ≤ 1</td>
</tr>
<tr>
<td>Light Vehicles</td>
<td>Commercial</td>
<td>≤ 30,000</td>
<td>5.9</td>
<td>5.1</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
<tr>
<td>Ocasional</td>
<td>Business</td>
<td>≤ 60,000</td>
<td>6.9</td>
<td>6.1</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
<tr>
<td>Heavy</td>
<td>Residential</td>
<td>≤ 120,000</td>
<td>7.8</td>
<td>7.1</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
<tr>
<td>Vehicles</td>
<td>Local Roads</td>
<td>≤ 350,000</td>
<td>8.7</td>
<td>8.1</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
<tr>
<td></td>
<td>Commercial</td>
<td>≤ 500,000</td>
<td>9.3</td>
<td>9.1</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
<tr>
<td></td>
<td>Roads</td>
<td>≤ 1,000,000</td>
<td>10.2</td>
<td>10.3</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
<tr>
<td></td>
<td>Major Collector</td>
<td>≤ 5,000,000</td>
<td>11.0</td>
<td>11.1</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
<tr>
<td></td>
<td>Major Collector</td>
<td>≤ 5,000,000</td>
<td>11.6</td>
<td>11.7</td>
<td>80 mm</td>
<td>✅</td>
<td>✅</td>
<td>≤ 10</td>
</tr>
</tbody>
</table>

Pedestrian

Designed for areas that are pedestrian only, or commercial plazas that may require occasional access for emergency or maintenance vehicles.

Light Vehicles

Designed for vehicular areas, access ways, and parking lots where only cars and light trucks are anticipated. Heavy vehicles should have limited access and use.

Occasional Heavy Vehicles

Designed for vehicular areas, parking lots, and roadways where limited heavy vehicles are anticipated daily such as large delivery trucks or garbage trucks.

Frequent Heavy Vehicles

Designed for vehicular areas, parking lots, and roadways where heavy vehicles are a regular component of the daily traffic volume.
**PATTERN VERSATILITY**

**Traditional Moduline Series® & Aqualine™ Series**

Belgard’s Moduline and Aqualine series were developed to create the ultimate in pattern versatility. All units are based on imperial 3-inch or 4-inch dimensional increments and have a raster / footprint that is exactly as specified, allowing all series pieces to fit together as intended. Add to this the various aesthetic elements (including colors and textures) that are available to create unique patterns, accents, highlights and borders and the possibilities are truly endless.

The following are examples of some popular paver patterns:

- **Basket Weave**
- **Checker Board**
- **Box Pattern 4**
- **Box Pattern 5**
- **Coursed Runner Bond**
- **Ashlar Runner Bond**
- **Spanish Bond**
- **K Pattern**
- **Box Pattern 1**

**CREATE YOUR OWN PATTERNS**

**Step 1**

Typically there is a look or feel that you want to express in an area, and there is nothing better to help with that than the laying pattern of the pavement surface. Stack or running bond patterns create a structural elegance, enlarged herringbone patterns can utilize a lot of different shapes, and block patterns mask the repeat layout creating a random appearance and provide increased interlock (necessary for vehicular applications). Start off by selecting the general shape that best fits your intent, or create your own unique repeatable pattern, such as the one shown adjacent. Make sure the general shape is repeatable before proceeding.

**Step 2**

Now select the scale of the pattern, keeping in mind the size of the area - larger patterns can be used in larger areas, and the application.

**Step 3**

Once you have decided on the scale of the laying pattern, it is time to fill the shape. The following are examples of the previous pattern with different sized pieces – note that even slight changes in the pieces used can alter the appearance dramatically.

**Step 4**

Adding colors, textures, and borders are where the true versatility of Belgard pavers are realized.
CONCRETE & ASPHALT OVERLAY

When installing pavers over the top of an existing asphalt or concrete pad, there are three installation options listed below in order of preference.

1. Sand Set
   In a sand set application, a 1” sand bedding layer is placed between the pavers and underlying asphalt or concrete (similar to a standard installation). Drain holes are required at low spots to allow water that seeps into the joints to escape. This method is most common in pedestrian applications, although it can be applied in vehicular applications as long as suitable curb & durable bedding sand is used.

2. Bituminous Set
   This is similar to sand set except a bituminous binder is added to the bedding sand which, in essence, adheres the pavers to the underlying concrete (pedestrian or vehicular applications) or asphalt (pedestrian applications only).
   This approach is also commonly used for high impact traffic areas such as cross walks, as the bituminous material helps prevent rotational failure of the pavers.

3. Mortar Set
   Mortar set uses a latex modified mortar under and around the pavers (similar to what is done for ceramic tiles).
   This approach is only recommended over concrete, as asphalt is too flexible and will crack the mortar. In northern climates, the mortared joints need to be regularly maintained to prevent moisture penetration, and the use of de-icing salts is discouraged.

HANDLES H-20/HS-20 LOADING

AASHTO’s H-20 and HS-20 are live load ratings applied to the design of bridges or other suspended items (e.g. lids for concrete vaults).

Because the pavers sit on a flat aggregate surface, they are not subject to the same bending moments and shear, and therefore will not collapse under the applied loads. Paver systems are actually designed for thousands, if not millions, of ESAL, which represent the estimated number of vehicles that pass over the surface during the design life.

See “Designing the Pavement System” on page 6 for more details.

In terms of being able to withstand the surface pressure exerted by the truck tires, the heaviest gross axle weight (GAW) for a firetruck that is allowed is 24,000 pounds. Assuming standard tires are used (even though Super Single tires are required) the maximum weight on each of the wheels is 12,000 pounds (24,000 pounds/2 wheels). Using a conservative contact area on the bottom of the wheel of 8 inches square, the pressure exerted by each front wheel is 187.5 psi (12,000 pounds/64 square inches). Any concrete paver offered under the Belgard line is made in accordance with ASTM C936, which calls for an average compressive strength of 8,000 psi with no individual unit being less than 7,200 psi. Simply put, the pavers are on average 40 times stronger than required to withstand the surface pressure that would be exerted under the most extreme conditions.
ENSURING COMPLIANCE & PUBLIC SAFETY

The 2010 ADA Accessibility Guidelines provide design requirements for accessibility to buildings and site by individuals with disabilities. The following sections address how Belgard® pavers and slabs can be used to meet ADA guidelines.

Section 302.1
Floor and ground surfaces shall be stable, firm and slip resistant.

Wet Dynamic Coefficient of Friction (DCOF) slip resistance testing per ANSI A1371.1 was conducted on Belgard pavers with a smooth finish. The minimum suggested requirements to achieve a high traction rating, meaning there is a low risk of slips and falls, are:

- DCOF ≥ 0.42 for level floors
- DCOF ≥ 0.46 for ramps up to 4.76°

Section 302.3
Openings in floor and ground surfaces shall not allow passage of a sphere more than ½ inch (13 mm) diameter.

To verify the openings in a ground surface are compliant, a simple test is done to see if a ½ inch diameter sphere can pass through the opening. In the case of pavers, this test would be conducted on the joints in a relaxed state without jointing material in place.

The following icon is used on the website and in the product information pages in company catalogs to identify ADA Accessibility.

Section 302.3
Changes in level of ¼ inch (6.4 mm) high maximum shall be permitted to be vertical.

Pavers, when installed correctly, are placed on a loose layer of bedding aggregate, then compacted down into it to set the pavers into place. One purpose of the bedding layer is to adjust for possible height variances in the paver thickness so that the final surface does not have any changes in elevation present.


**LRV FOR NATIONAL COLORS**

<table>
<thead>
<tr>
<th>COLOR</th>
<th>LRV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundry</td>
<td>20.5</td>
</tr>
<tr>
<td>Graphite</td>
<td>9.8</td>
</tr>
<tr>
<td>Linen</td>
<td>30.6</td>
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</tr>
<tr>
<td>Linen</td>
<td>30.6</td>
</tr>
</tbody>
</table>
LOWER CAPITAL & MAINTENANCE COST

Machine Installation

The standard pre-conception for pavers is that they are expensive. This, for a large part, is due to the need for labor to hand install individual units. Belgard has various pavers that are manufactured in machine installation patterns, whereby specialized equipment can install upwards of 5,000 square feet in a single work day.

This automation of the installation process significantly reduces the capital costs. Entire parking lots, streets, ports & airport tarmacs have been economically constructed using this approach.

The fact that pavers are factory manufactured in accordance with ASTM C-936 “Standard Specifications for Solid Interlocking Concrete Paving Units” also benefits the bottom line. Test reports can accompany the product when it is shipped onsite, eliminating the potential risk of having to replace the product due to poor quality. Once the jointing material is installed, the surface is immediately ready for traffic — no curing delays are required.

Access of Underground Utilities

The annual cost of utility cuts in the average city is in the millions of dollars. The existing surface material needs to be broken out and disposed of, the underground repairs made, and then new material used for the final patch. With each patch, the service life of the pavement is also reduced.

With interlocking concrete pavements, the short term costs and long term impacts are both reduced. Clusters of pavers can be removed by hand— saw-cutting equipment and pneumatic jack-hammers are not required. The same pavers can also be reinstated, reducing the waste disposal and replacement material costs. Short term patching products are eliminated, and there are no changes to the area’s overall appearance. Being a flexible pavement system with built in control joints, the pavement also has an increased ability to deal with any subsequent fill settlement.

IMPROVED LIFE CYCLE

Longer Service Life, Less Maintenance, Greater Value

An investment in roadway infrastructure does not stop after initial construction. Like any asset, it requires some investment to keep it in usable condition. For roadways, this includes ongoing surface maintenance, periodic restoration and eventual base rehabilitation.

Life cycle costing analysis is a technique that quantifies all of the costs associated with the construction and maintenance of a pavement over a set analysis period. According to the report “Life Cycle Cost Management of Interlocking Concrete Block Pavements – Methodology Report” from ARA/ICPI, a paver system is expected to last 30 or more years before it reaches the trigger pavement condition index where rehabilitation is required. During this time, the following level of maintenance is expected.

At years 8 and 28, it is expected that approximately 2% of the pavers over the entire surface will have become cracked or chipped and will need to be replaced. In years 20 and 35, a more significant maintenance is expected to take place—this includes removal of a larger area of pavers (most likely in the wheelpaths), leveling/replacement of the bedding sand underneath, then reinstatement of a majority of the original pavers.

When compared to the equivalent life cycle costing of other traditional paving practices, the results for paver systems are often better because of the:

1. Higher performance life of pavers as compared to asphalt.
2. Lower capital cost of pavers compared to cast-in-place concrete
3. Lower/easier maintenance requirements
4. Reduced vulnerability to utility cuts

Although we cannot guarantee the life cycle costing will be less in every circumstance, we are willing to assist with the analysis to determine if pavers are ultimately more economical. Contact your local Belgard Representative for details.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ACTIVITY QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Replace Cracked Pavers 2</td>
</tr>
<tr>
<td>20</td>
<td>Replace Worn/Rutted Pavers (wheelpath) 5</td>
</tr>
<tr>
<td>25</td>
<td>Replace Cracked Pavers 2</td>
</tr>
<tr>
<td>35</td>
<td>Replace Worn/Rutted Pavers (wheelpath) 5</td>
</tr>
</tbody>
</table>

Sample Range of Results of Life Cycle Analysis
Use of PICP on various pedestrian and vehicular applications can add to the aesthetic look of a project, eliminate the need for traditional stormwater conveyance works, improve groundwater quality, and increase usable land space by decreasing or eliminating the need for a retention pond. Belgard experts can work closely with your design team to design and gain approval for the PICP system that best matches the onsite soil conditions, design storms, and local regulatory requirements.
PRESERVING OUR DRINKING WATER SUPPLY

Stormwater Filtration
The US Geological Survey reports that half of the drinking water in America comes from groundwater reserves, while the other half comes from lakes and rivers. Both of these sources are adversely impacted when impervious surfaces like buildings, parking lots and roads prevent rain from infiltrating back into the ground. Groundwater reserves are not being recharged and shallow groundwater flow systems, which maintain the base flow conditions between rainfall events in lakes and rivers, are reduced.

With partial infiltration systems, which are used on Type C and some D soils, the amount of excess rain that accumulates in the base/subbase is regulated by the elevation of the outlet control for the underdrain, which is set to only store as much water as can drain in 1 to 2 days post rainfall event.

It is a common misconception that a high soil infiltration rate is required for an infiltration system to work. The majority of 95th percentile design storms in the US range from one to two inches total precipitation. Even at infiltration rates as low as 0.05”/hour, it would only take 40 hours for full 2” of rain to drain out of the aggregate base/subbase storage zone.

The Natural Resources Conservation Service (NRCS) method and amount of rainfall using a parameter known as a curve number (CN). Curve Numbers predict runoff from rainfall excess, and can range between 30 to 100, with lower numbers indicating lower runoff potential. Caution should be applied when using CNs for permeable pavement. Results can underestimate runoff in small watersheds (under 5 acres) for small storm events (below the 2-year storm), so for these cases, calculations should be verified by another method. Sample CNs per USDA Technical Release-95 are listed on this page. However, traditional hydrologic modelling requires CN modifications to properly model permeable pavement to account for reservoir storage. CNs for PICP systems can range anywhere between 45 for A soils to between 70-80 for D soils.

The Goal of PICP
The goal of PICP is to mimic, if not improve upon a site’s preddevelopment hydrology by detaining as much stormwater as possible in the base/subbase, so that it can infiltrate back into the ground. PICP is considered a Low Impact Development (LID) Best Management Practice (BMP) for stormwater management. As a distributive infiltration practice, PICP conserves space by providing a functional pavement and Stormwater Control Measure in one system. Various methods are used to model the site hydrology and calculate runoff flow rates and volumes. Depending on the hydrology model used, a curve number or a runoff coefficient is needed to represent the PICP site condition. Belgard permeable pavers have a variety of shapes and surface openings. Based on the type of aggregate used in the base/subbase, the majority of 95th percentile design storms in the US range from one to two inches total precipitation. Even at infiltration rates as low as 0.05”/hour, it would only take 40 hours for full 2” of rain to drain out of the aggregate base/subbase storage zone.

Credit for Pervious Surface
Correctly designed, installed, and maintained, PICP 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 a PICP surface should be given complete credit for “100% perviousness,” as would a meadow or forest.

Water Volume Control
PICPs can detain or retain water quality volume through storage in the aggregate base and subbase. Most design storm requirements are easily controlled in the underground reservoir created until the subgrade soils infiltrate the water or until underdrains release the volume at a controlled rate.
CONTROLLING PEAK DISCHARGE RATES

Stormwater Infiltration

Traditional site design has focused on estimating the peak runoff rate from large, but less frequent, extreme storm events (or how much stormwater runoff is leaving the site under worst case conditions) to ascertain if the receiving body, be it a river or stormwater collection system, can handle the anticipated flow. Detention facilities are built to slow down the rate of runoff to levels the receiving body can handle, with the outflow from the pond being controlled by the diameter and number of outlet pipes; the discharge rate can be calculated using a standard orifice equation.

As shown previously, for full and partial infiltration systems, any outflow is eliminated from the PICP area until the system design is exceeded. However, where either the native soils do not drain, or infiltration is not desired (underlying swelling clays or contaminated soils), there can be no reliance on infiltration so a no infiltration system is used. What is unique to a no infiltration system is the inclusion of an impervious liner underneath the storage aggregates; this turns the PICP system into a large detention device, with the available storage volume being the void ratio of the aggregate base/subbase. As the native subgrade soils are not exposed to moisture, there are no structural limitations on how long the water can be stored.

PREVENTING DOWNSTREAM IMPACTS

Erosion Control

Improperly managed stormwater can result in downstream hydrologic impacts, such as erosion along existing drainage courses, flooding of adjacent low lying areas, and sedimentation/contamination of receiving waters (including ecological areas such as wetlands and estuaries, recreational areas such as lakes and rivers, and/or surface water supplies of drinking water).

These impacts can be minimized, if not effectively avoided, through better site design using PICPs. Studies have shown that “the slower and more controlled outflow (from PICP) closely mimics natural interflow and reduces the risk of flooding and erosion in downstream receiving waters”.

Source: Drake, Jennifer and Tim Van Seters “Evaluation of Permeable Pavements in Cold Climates” Toronto and Region Conservation Authority (TRCA), December 2012.

Reduced Thermal Impacts on Receiving Waters

Under predevelopment conditions, stormwater that infiltrates into the ground stays at a relatively constant temperature; conversely, post development stormwater runoff from impervious areas can be very hot in the summer months and extremely cold in the winter months. These temperature extremes can have a devastating effect on aquatic organisms. Many fish species can be harmed by acute temperature changes of only a few degrees. That is why the Independence & Security Act (2007) requires that predevelopment temperatures be maintained from all Federal development or redevelopment.

With PICP systems, the water is stored below ground, so the thermal temperature impacts are minimal.

Studies conducted at North Carolina State University verified that both warm and cold thermal buffering were provided by shallow infiltration systems like PICP, therein reducing the frequency of harmful temperatures.

PICPs are recognized by several agencies, including the US EPA, as providing stormwater quality improvements. Reported removal efficiencies for Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN) from different states are listed on the adjacent table.

PICP reduces pollutant concentrations through several processes including adsorption, microbial action, volatilization and filtration. Contaminants within the subgrade infiltrate will undergo further bacterial and chemical reactions with the native soils prior to reaching the groundwater table or receiving waters.

Filtration is not only effective at removing large particulate and suspended solids, but potentially also metals, Total Phosphorous (TP), and hydrocarbons subject to the degree that each binds (adsorbs) to the filtered particulates. Within the open graded base/subbase, it is expected that volatilization and microbial action in addition to adsorption, is taking place with some pollutants.

### Recommended Maintenance

Studies have found a relationship between joint infill material and long term infiltration rates. ASTM No. 8, 89, or 9 stone in properly sized joint openings provide the best performance. The joints of the PICP system, like any other filter, can become clogged. The FGCU study estimated it would take 7-20 years for a typical system to deteriorate to the point were it is no longer functional if infiltration rate less than 10 inches per hour, with the range being subject to the contaminant loading rate and the size of the jointing material used. Where contaminant loading is concentrated, such as around tree canopies, winter snow storage piles or stormwater run-on areas (water is running onto the PICP surface from adjacent areas), clogging can be accelerated.

The recommended regular maintenance includes semi-annual cleaning (spring and fall) using a mechanical or regenerative air sweeper to remove any surface debris, especially compostables like leaves and winter sand. Annual infiltration testing following ASTM C1781 should also be done on the PICP surface, especially at the previously listed spots. Where the infiltration rate is found to be approaching 10 inches per hour, or where there is any surface ponding noted, remedial maintenance using a vacuum truck should be conducted. Vacuum trucks are capable of extracting the accumulated debris and jointing material from between the pavers. New jointing material is then swept back in, and the system is almost as good as new. Please note that power washing is not recommended as this will only push debris deeper into the joints.

To allow for replacement of pavers that may become damaged, and to ensure an even match with existing, a rule of thumb is to store 2 to 5% of the total project as attic stock. Damaged pavers can be pulled up and the new ones reinstated with a few simple tools.

### Stormwater Quality

<table>
<thead>
<tr>
<th></th>
<th>Total Suspended Solids</th>
<th>Total Phosphorus</th>
<th>Total Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georgia</td>
<td>80%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>New Jersey</td>
<td>80%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>New York</td>
<td>82 - 95%</td>
<td>65%</td>
<td>80 - 85%</td>
</tr>
<tr>
<td>North Carolina</td>
<td>75 - 84%</td>
<td>60 - 80%</td>
<td>70 - 85%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>85%</td>
<td>85%</td>
<td>30%</td>
</tr>
<tr>
<td>Texas (TCEQ)</td>
<td>89%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Virginia</td>
<td>-</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

### Handling Roof Water

In some locations, roof water can be managed by the PICP system if the system is designed to accommodate the additional water volume. When discharging roof water onto the PICP surface, the water is filtered the same as any direct rainfall, but the run-on area may be subject to accelerated clogging. Large roof drains may require flow dissipation to prevent washout of the jointing aggregates. When roof water is diverted into the subbase, FloGard® Downspout Filters can be used to pre-treat the roof water and a catch basin can be used to dissipate the energy of the falling water. Surface water can also be collected using FloGard® Catch Basin Insert Filters to pre-treat runoff that enters the catch basin. The illustration below depicts both scenarios.

**Diagram:**
- Regenerative Air Sweeper for Regular Maintenance.
- Vacuum Truck for Remedial Maintenance.
SITE STORMWATER MANAGEMENT

Complementary LID Solutions

Many jurisdictions now prefer Low-Impact Development (LID) solutions as the first choice to manage stormwater runoff. In addition to Permeable Interlocking Concrete Pavements (PICP), Oldcastle offers other LID Solutions to meet a variety of site constraints. These systems can be used as stand-alone treatment or in conjunction with PICP.

BioPod™ Biofilter

BioPod™ Biofilter is a tree box filter provided with high flow rate media to reduce the treatment footprint. The system removes sediment, metals, nutrients and petroleum hydrocarbons, as well as gross solids and trash normally found in stormwater runoff.

BioMod® Modular Bioretention System

BioMod® Modular Bioretention System is a modular precast concrete bioretention cell system that uses soil-based filtration to remove sediment, metals, nutrients, petroleum hydrocarbons, gross solids and trash from stormwater runoff. BioMod systems can incorporate non-proprietary, low flow rate media as specified by a local agency.

STORMWATER HARVESTING

Using PICP System as a Storage Reservoir

Water harvesting utilizes a free resource to reduce municipal water supply costs, while complying with regional stormwater management guidelines.

In southern climates, a no infiltration system (complete with liner) can be used as the long term storage reservoir, with the water being used for irrigation, washing, or other non-potable applications. An integrated control system, which include water harvesting information (www.stormcapture.com) is typically used to operate these harvesting systems. In addition, where the PICP is also serving a stormwater management function, it is recommended that an active control system be used to monitor weather forecast information and to automatically draw down the water volume to accommodate projected precipitation rates.

PermeCapture™

In certain applications, combining the benefits of PICP with the high volume detention/retention capabilities of StormCapture® vaults provides solutions for challenging site conditions. Examples of potential applications for PermeCapture include: coastal areas or sites with high water tables; poor or limited aggregate availability; poor soils, shallow rock, or excavation challenges; sites requiring access for inspection & maintenance of retention/detention water; or sites where aggregate water storage is not recognized or credited. The need to maintain an aesthetic surface is another reason to utilize this type of system. PermeCapture vaults are H-20 rated, and include HydraPorts to allow water from the PICP system to drain into the storage chambers. When used as a retention system, treatment and harvesting technology can be incorporated into the PermeCapture system.
URBAN ENVIRONMENT

Reducing Deicing Salt Use
PICP perform very well in cold weather conditions. Studies have found that freezing temperatures do not result in surface heaving and temperatures in the base and subbase remain above freezing even when surface air temperatures are well below freezing.

Studies conducted at the University of New Hampshire have shown that “pervious pavements exhibit greater frictional resistance, and can become clear of snow and ice faster, than conventional pavements. Substantial reductions of up to 77% in annual salt loads for anti-icing/de-icing practices were demonstrated.” The reduction in salt usage was primarily due to the ability of melt water to drain through the porous surface because of the insulating qualities of the PICP system; surficial re-freezing as black ice is therefore eliminated and the associated salt usage prevented.

Rather than use de-icing salts or sand, an alternative is to use the same ASTM #8 or #9 chip as used in the paver joints. Because permeable pavers are made with high quality concrete, snow can be plowed or shoveled without the need for special blades or equipment.

Mitigating Urban Heat Island
The “heat island” effect impacts urban areas that have systematically used up existing natural ground cover by replacing them with buildings, parking lots and paved streets. The resulting lack of parkland and trees results in higher overall temperatures in these microclimates. In turn, these temperatures place a higher demand on energy, produce more pollution and greenhouse gas emissions, and clearly create quality of life issues for all those living in such environments.

One strategy to mitigate the heat island effect is to use high reflectance paving materials. Solar Reflective Index (SRI), an indication of how well a surface emits absorbed heat, is used to assess the reflectivity of roofing materials. Solar Reflectance (SR) in now used by LEED projects to assess non-roofing materials such as pavers. A number of Belgard paver colors have been tested to verify SRI and SR values. Contact your local Belgard sales representative for latest results.

Urban Cooling
Although using lighter colored pavers does benefit Urban Heat Island, the increased pavement reflectance adversely affects human thermal comfort during hot periods due to an increase in the Mean Radiant Temperature contributed by the increased reflected radiation striking the human bodies. Using the PICP system as an evaporative system is a way of mitigating this impact. Water that is stored in the base is allowed to slowly evaporate through the pavers thereby cooling the paver surface. It is no different than how our bodies cool off by perspiring.

Studies at University of California-Davis found that keeping water near the surface of the pavement, through sprinkling water on the surface or injecting water into the pavement to keep the water level near the surface, will increase the evaporation rate and consequently produces a better evaporative cooling effect.

Paving Around Trees
The ability of air and water to be able to move through the PICP to new or existing vegetation is key to their survival and growth. By adding load bearing tree soils, which support the weight of pavement and vehicles but still provides space for tree roots to flourish, the pavement can extend right up to the border of the tree pit. This practice is not possible with conventional paving without the use of specialized structural supports (steel grates, concrete vaults).


MEETING IMPERVIOUS COVER REQUIREMENTS

Decreasing Impervious Cover

In certain jurisdictions, there are limits on the amount of impervious cover that can exist on a site in order to control either the amount of runoff that is generated and/or the water quality of the runoff.

Examples of impervious surfaces include buildings, pavement, and recreational facilities (patios, pool decks, tennis courts, etc.). In North Carolina for example, there are Built Upon Area (BUA) restrictions on new developments, which is a percentage of impervious cover that is allowed on a given site and is based on a number of factors including allocated density, location in the watershed, etc.

The use of PICP typically allow for credits against the impervious cover requirements because of their ability to control and treat the rain falling on them, as well as any run-on from other areas accounted for in the design. The following is an example of BUA credit calculations per the North Carolina Department of Environment and Natural Resources.

Simply put, using PICP allows for the site design to accommodate a wider range of possibilities that would otherwise not have been possible, including a larger building footprint or a separate garage, addition of outdoor recreational facilities, and/or more parking. This not only meets the intended environmental requirements, but also increases the property value due to the increased flexibility of the lot.

By designing a PICP system that can handle all of the direct rainfall and run-on from the building, the required water quality and quantity requirements are met.

As a low density development, there is a 24% BUA limit. Building and pavement consume all available impervious cover quantities.

Using Permeable Pavement as a BMP

In other commercial developments or subdivisions, additional building lots were added, with the revenue of the additional building or house exceeding any increased capital cost of the PICP system. In high density developments, more parking spots were available using PICP, and therefore more units were added to the high rise building.

One developer in a particularly tight ocean front development referred to the additional parking stalls achieved by PICP as “million dollar lots” as he was able to add a one million dollar condo for each additional parking spot.

With the water detention/retention facility located below ground, we also eliminate public safety concerns associated with the accidental drowning of children and do not provide breeding grounds for insects that transmit diseases like West Nile Virus.

Note: Images courtesy of North Carolina Department of Environment and Natural Resources.

OPTIMIZING LAND USE

Increased Value & Safety

In conventional stormwater drainage designs, detention or retention ponds can consume a large portion of the site. These ponds have limited alternative applications (assuming the pond dries out sufficiently for the intended alternative use) and reduce the income generating footprint of the site.

PICP combine the parking and drive lanes with the retention or detention footprint, therein allowing the lands that would otherwise be consumed by the pond to be transformed into continuous use green space, recreational areas, or even reclaimed for increased development.

Examples exist where the use of PICP allowed for the preservation of wooded/ecological areas that would have otherwise been cleared for, or impacted by, the stormwater detention or retention systems.

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Note: Images courtesy of North Carolina Department of Environment and Natural Resources.
**LOWERING INFRASTRUCTURE COSTS**

PICP = Road + Stormwater Management

Infrastructure refers to items that are essential to enable, sustain, or enhance societal living conditions in a new development. These include roads, water supply, stormwater management, sanitary sewers, electrical grids, telecommunications, and so forth.

Experience has shown that total infrastructure costs can be lower using PICP than with conventional roads and stormwater management systems. The cost savings are realized through the reduction or elimination of the stormwater works, including catchbasins, manholes, underground pipes, ponds, treatment systems, and associated appurtenances.

The following is an example of an infrastructure analysis conducted for a subdivision development in cooperation with the design firm. The capital cost savings were $566,612, or a net savings of 28.1% as compared to the original design approach. Although we cannot guarantee the infrastructure cost analysis will prove PICP to be less in every circumstance, we are willing to assist with the analysis to determine if a PICP system is ultimately more economical.

Consider the ever-increasing cost of oil, the increased design life of pavers, the ease of maintenance, and the capital savings realized through mechanical installation, and the end result is a superior, more aesthetically pleasing surface at a lower cost.


**GREY VERSUS GREEN INFRASTRUCTURE**

**Being Green Doesn’t Cost More**

In many older cities, stormwater and indoor sewage are combined into a single network of drain pipes referred to as Combined Sewer Overflow (CSO) systems. Although these systems are adequate during low rainfall events, the CSO systems are unable to adequately treat much of the wastewater during heavy rainstorms. As a result, large volumes of untreated wastewater enter local rivers and lakes. To reduce these issues, the cities are either required to update their entire grey infrastructure system or look at ways to reduce stormwater runoff across the city through the implementation of LID “green” practices like PICP.

In West Union, Iowa, they compared the life cycle cost of a permeable paver system in the downtown area with those of traditional pavement systems. Results showed that although permeable pavement will initially be more expensive, the lower maintenance and repair costs will result in cost savings in the long run. The city would begin to realize these cost savings by year 15 of the project. Estimated cumulative savings over a 57 year period were calculated to amount to $2.5 million. Additional benefits beyond reduced flooding included (1) enhancement of the groundwater supplies; (2) improved water quality in an impaired lake downstream from the development; (3) enhanced recreational amenities at the lake; (4) improved pavement surface temperatures; and (5) improved street appearance.


<table>
<thead>
<tr>
<th>Item No</th>
<th>Item</th>
<th>Description</th>
<th>Standard Design</th>
<th>Permeable Pavement</th>
<th>Difference</th>
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<tbody>
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<td>1</td>
<td>Site Prep</td>
<td>Clearing/Grubbing</td>
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<td>$4,500.00</td>
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<tr>
<td>2</td>
<td>Stormwater Collection</td>
<td>Area Drains (grassed areas)</td>
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<td>-300.00</td>
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<tr>
<td>3</td>
<td>Stormwater Retention and Treatment</td>
<td>Roadway Wearing Surface</td>
<td>$4,000.00</td>
<td>$3,800.00</td>
<td>-200.00</td>
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<tr>
<td>4</td>
<td>Roadway Base</td>
<td>Roadway Base</td>
<td>$5,000.00</td>
<td>$4,800.00</td>
<td>-200.00</td>
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<tr>
<td>5</td>
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<td>Roadway Base</td>
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<td>$5,800.00</td>
<td>-200.00</td>
</tr>
<tr>
<td>6</td>
<td>Underground Storage/Detention System</td>
<td>Site Prep</td>
<td>$7,000.00</td>
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<td>-2,500.00</td>
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<tr>
<td>7</td>
<td>Site Prep</td>
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<td>8</td>
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<td>9</td>
<td>Stormwater Retention and Treatment</td>
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<td>10</td>
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<tr>
<td>11</td>
<td>Underwater Storage/Detention System</td>
<td>Underwater Storage/Detention System</td>
<td>$7,000.00</td>
<td>$4,500.00</td>
<td>-2,500.00</td>
</tr>
</tbody>
</table>

**The Philadelphia Water Department performed a full Benefit Cost Analysis (BCA) comparison of green versus grey infrastructure to evaluate the best approach for investing the city’s funds to solve the CSO problem in a dense urban environment. The analysis demonstrated that for equal investment amounts and similar overflow volume reductions, the use of LID/GI would provide 28 times the benefits of traditional stormwater infrastructure such as large tunnels and pumping stations.**

The City of New York, for example, determined that the operation & maintenance of the Green Strategy was $200,000 less annually than their Grey Strategy. Over a 20-year period, the Green Strategy would reduce CSO volumes by nearly 2 billion gallons more than was possible by the Grey Strategy. In total, the Green Strategy would cost $5.3 billion, which is $1.5 billion less than the $6.8 billion for the Grey Strategy. Plus the Green Strategy provides additional valuable benefits not provided by the Grey Strategy, including (1) improved neighborhood aesthetics; (2) lower summer temperatures; (3) reduced energy use; (4) cleaner air and water; and (5) increased property values.

Segmental Retaining Walls (SRW)

Backed by years of experience and a national network of manufacturing facilities, Belgard® offers technical expertise and SRW products to meet the site challenges of projects that range from light commercial to the most challenging of site conditions. From functional to aesthetic wall systems, Belgard offers a variety of options.
**TYPES OF RETAINING WALL CONSTRUCTION**

**Gravity Wall Construction**
A gravity retaining wall relies on the weight and batter of the SRW units to resist the soil forces exerted on the wall. Geogrid soil reinforcement is not used with gravity walls. The allowable heights of gravity retaining walls are typically limited to 2 to 3 times the front-to-back depth of the SRW facing unit.

**Geosynthetic-Reinforced Retaining Wall**
Geosynthetic reinforced walls use soil reinforcement layers, typically geogrids, to stabilize the soil behind the SRW facing, creating a coherent mass large enough to resist the soil forces acting on the wall system. The SRW facing unit, the geosynthetic reinforcement and the reinforced together form the retaining wall system. To resist more load, the reinforcement layers are lengthened and/or strengthened to provide the required resistance. Thus, reinforced wall systems can be designed for much taller earth retention heights and loading conditions than conventional gravity walls. Reinforced retaining walls should be designed by a qualified engineer and constructed by experienced contractors.

**Structural Backfill**
In many retaining wall applications, sufficient space does not exist behind the face units to allow excavation or placement of geosynthetic reinforcement. For these instances, a wall system can be designed that is reliable, aesthetically pleasing and cost-effective. Using specialized structural backfill, the depth and mass of the wall can be effectively extended. Since the structural backfill also serves as the required drainage zone. With the proper product selection, a retaining wall system can be designed that completely eliminates the need for the construction of a mechanically stabilized earth zone behind the wall facing and requires substantially less excavation than is usually necessary in grid-reinforced wall construction. Retaining walls using structural backfill should be designed by a qualified engineer and constructed by experienced contractors. Structural backfill is also referred to as ho fines concrete”, “stabilized aggregate" and “Anchorplex® System”.

**Geosynthetic Reinforced Soil – Integrated Bridge System (GRS-IBS)**
The Federal Highway Administration has developed GRS-IBS technology as an innovative and cost-effective bridge system that is an alternate option to conventional bridge construction. The system uses closely spaced geosynthetic reinforcement layers and compacted aggregate to directly support bridge superstructure. Due to the simplicity of design, construction speed, use of readily available materials and the elimination of deep foundations, the GRS-IBS method can reduce costs by 25-60% compared to conventional methods. GRS-IBS should be designed by a qualified engineer and constructed by experienced contractors.
SEGMENTAL RETAINING WALL BEST PRACTICES GUIDE

The National Concrete Masonry Association (NCMA), the trade organization representing masonry and segmental retaining wall (SRW) producers and affiliates, has recently completed its SRW Best Practices Guide. The Guide provides educational materials in support of NCMA’s Zero Wall Failures Initiative. This initiative is “an industry-wide program to educate owners, designers, site civil engineers, geotechnical engineers, and installers of SRW systems on the industry’s recommended best practices and to promote a philosophy that strives for ensuring successful wall performance.” Using the Guide will help reduce poor retaining wall performance in addition to reducing liability of the involved design professionals by presenting information and guidelines regarding standards of practice. Some key suggestions from the Guide include:

- Follow provided guidelines for optimum project organization that define roles and responsibilities for the various parties involved in retaining wall design and construction.
- Retaining wall design should be done during the design phase of the project by a design professional working directly for the project owner or owner’s representative and not be procured by the retaining wall contractor during the construction phase.
- Global and Compound Stability must be evaluated.
- The SRW components, Face unit, soil reinforcement and soil, must meet basic industry standards.
- Taller walls require special considerations including tighter standards for the reinforced soil.

Planning Considerations

The SRW design should be performed during the design phase of the project with the SRW designer as part of the design team. At the onset of the project, the SRW design engineer and site civil engineer should meet with the property owner to understand how the site will be used, project timeline and aesthetic objectives. Everyone on the team should also have an understanding of any special considerations, including local codes or ordinances, unusual site conditions and project relation to existing structures or utilities. Other issues that will impact design include existing site drainage and topography, surface water, soil characteristics, property lines, and proposed locations of structures, roads and utilities. The owner or site civil engineer should contract with a geotechnical engineer to obtain a report on soil characteristics, groundwater conditions, applicable seismic coefficients and applicable foundation remediation needs. Site access constraints may also exist that will impact construction or staging and should be discussed in the planning phase.

Choosing SRW Units

Segmental retaining wall units are available in a myriad of sizes, shapes, textures and colors. The minimum requirements for SRW units are covered in ASTM C1372, Standard Specification for Dry-Cast Segmental Retaining Wall Units. As with any product standard, these minimum requirements are appropriate for many, but not all, SRW applications. In areas that require extreme freeze/thaw durability, higher performance products may be required.

Building Tall Walls

Walls in excess of 10 feet require better soils, more rigorous attention to quality control, closer scrutiny to potential settlement, greater attention to compaction efforts during construction and careful attention to detailing. Project designer professionals must pay careful attention to site conditions well beyond the location of the SRW system. In addition, layout considerations, such as the wall batter and geosynthetic reinforcement lengths, become more significant. Other considerations include site geometry, existing or new structures above or below the wall, property boundaries and the extent of required excavation.

Choosing Geosynthetic Reinforcement

The full evaluation of geosynthetic reinforcement materials is very important, yet very complex. Fortunately, a third-party review system is already in place to verify the strength properties and QC standards of reinforcement materials through the National Transportation Product Evaluation Program (NTPEP). Therefore, a best practice is to only use geosynthetic reinforcements with a current NTPEP report.

Reinforced Fill Gradation For Tall Walls

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>WALLS BETWEEN 10-20’</th>
<th>WALLS &gt; 20’</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 200</td>
<td>0-35, Pl &lt; 6</td>
<td>0-40</td>
</tr>
<tr>
<td>No. 40</td>
<td>0-60</td>
<td>0-40</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-35, Pl &lt; 6</td>
<td>0-15, Pl &lt; 6</td>
</tr>
</tbody>
</table>
HOW SEGMENTAL RETAINING WALLS HELP IN LAND DEVELOPMENT

Proper Site Planning

Proper site planning can save significant time and money. Segmental retaining walls can convert a slope that uses horizontal space to a vertical grade change creating more useable and valuable land space. Segmental retaining walls should be considered for:

- Cost effectiveness
- Performance
- Aesthetics
- Versatility
- Speed of Construction
- Durability
- Environmentally Friendly

EXAMPLES OF SITE UTILIZATION:

Slope Stabilization and Erosion Control

Soil stabilization is key to maintaining the integrity of the project site. By increasing the stability of the soil, you can increase your useable space on any project site and help prevent unnecessary erosion.

Water Management

The most significant slopes at most typical land development projects are around the project perimeter, along interior water courses, around stormwater management ponds and wetland boundaries and between buildings. Segmental retaining walls help minimize the loss of valuable real estate at these locations by minimizing developmental impacts of stormwater ponds footprint and encroachments into wetland.

Terraced Walls

Terracing walls creates horizontal spaces that may improve landscape maintenance by eliminating steeper slopes that are hard to vegetate and maintain. Terraces can also provide valuable space for utilization of parking, patios and landscape.

- Create more useable space by replacing an unusable slope with flat terrain
- Create a variety of levels on the site, such as terraced gardens and outdoor seating areas
PRODUCT OFFERING

LOWER SOUTHEAST

ALABAMA, GEORGIA & MISSISSIPPI
PAVER FINISHES & APPLICATIONS

Finishes

Standard (smooth)
Unit surfaces and micro-chamfers are carefully molded using a high-quality precision machined steel shoe assembly which creates units with an extremely smooth surface and precision detailed chamfer.

Sand Blast
Exposes the surface of the paving unit to reveal the natural beauty of the aggregates and pigmentation.

Antiqued
Units are molded to form specific surface and side textures that are processed through tumbling equipment, imparting a distressed or aged appearance.

Pedestrian
Designated for areas that are pedestrian only, or commercial plazas that may require occasional access for emergency or maintenance vehicles.

Light Vehicles
Designated for vehicular areas, access ways, and parking lots where only cars and light trucks are anticipated. Heavy vehicles should have limited access and use.

Occasional Heavy Vehicles
Designated for vehicular areas, parking lots, and roadways where limited heavy vehicles are anticipated daily such as large delivery trucks or garbage trucks.

Frequent Heavy Vehicles
Designated for vehicular areas, parking lots, and roadways where heavy vehicles are a regular component of the daily traffic volume.
### Vehicular & Architectural Pavers

#### Moduline Series® (Special Order)

<table>
<thead>
<tr>
<th>Units</th>
<th>Thickness</th>
<th>Size</th>
<th>Applications</th>
<th>ADA*</th>
<th>Mechanical Install</th>
<th>Finishess</th>
<th>Chamfer Width</th>
<th>Sq. Ft. Per Pallet</th>
<th>Pcs. Per Pallet</th>
<th>Pallet Weight (Lbs)</th>
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</thead>
<tbody>
<tr>
<td>Moduline 3&quot; x 12&quot;</td>
<td>60 mm</td>
<td>3&quot; x 12&quot;</td>
<td>Standard</td>
<td>✓</td>
<td>✓</td>
<td>Sand Blast</td>
<td>3 mm</td>
<td>110 (60 mm)</td>
<td>64 (101.6)</td>
<td>2,915 (60 mm)</td>
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<tr>
<td></td>
<td>80 mm</td>
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<td>✓</td>
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<td>3 mm</td>
<td>352 (80 mm)</td>
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<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>72</td>
<td>144</td>
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<tr>
<td>Moduline 4&quot; x 24&quot;</td>
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<td>4&quot; x 24&quot;</td>
<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>96</td>
<td>144</td>
<td>3,667</td>
</tr>
<tr>
<td>Moduline 6&quot; x 8&quot;</td>
<td>60 mm</td>
<td>6&quot; x 8&quot;</td>
<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>120 (60 mm)</td>
<td>96 (80 mm)</td>
<td>3,288 (60 mm)</td>
</tr>
<tr>
<td></td>
<td>80 mm</td>
<td>6&quot; x 8&quot;</td>
<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>384 (80 mm)</td>
<td>192 (80 mm)</td>
<td>3,546 (80 mm)</td>
</tr>
<tr>
<td>Moduline 6&quot; x 12&quot;</td>
<td>80 mm</td>
<td>6&quot; x 12&quot;</td>
<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>120 (60 mm)</td>
<td>96 (80 mm)</td>
<td>3,240 (60 mm)</td>
</tr>
<tr>
<td></td>
<td>80 mm</td>
<td>6&quot; x 12&quot;</td>
<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>240 (60 mm)</td>
<td>192 (80 mm)</td>
<td>3,546 (80 mm)</td>
</tr>
<tr>
<td>Moduline 12&quot; x 12&quot;</td>
<td>80 mm</td>
<td>12&quot; x 12&quot;</td>
<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>120 (60 mm)</td>
<td>96 (80 mm)</td>
<td>3,288 (60 mm)</td>
</tr>
<tr>
<td></td>
<td>80 mm</td>
<td>12&quot; x 12&quot;</td>
<td>ADA</td>
<td>✓</td>
<td>✓</td>
<td>Antiqued</td>
<td>3 mm</td>
<td>384 (80 mm)</td>
<td>192 (80 mm)</td>
<td>3,546 (80 mm)</td>
</tr>
</tbody>
</table>

Interlocking pavers can be used for a variety of different vehicular applications. Appropriate shape and thickness is based on project-specific conditions including type of loading, base design, and subgrade conditions. It is recommended that you consult a Belgard representative in your area before specifying products for vehicular applications.

Product installation and surface maintenance influence compliance with ADA Standards for Accessible Design Section 302 Floors or Ground Surfaces. Tumbling or antiquing pavers can also create surfaces or edges that may make the product unsuitable for ADA applications.

* May be suitable for ADA applications. Always evaluate the specific use to ensure surface suitability.
MODULINE SERIES®
AVAILABLE COLORS

Graphite  Foundry*  Linen*

Desert*  Sunset  Almond

* Light colored paver has an SRI value of ≥ 29 and/or an SR value of ≥ 0.33

PICTURED ON PAGE: MODULINE SERIES
### Vehicular & Architectural Pavers (Continued)

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Size</th>
<th>Applications</th>
<th>ADA*</th>
<th>Mechanical Install</th>
<th>Finishes</th>
<th>Chamfer Width</th>
<th>Sq. Ft. Per Pallet</th>
<th>Pcs. Per Pallet</th>
<th>Weight (Lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18” Hexagon</td>
<td>48 mm</td>
<td>18” x 18”</td>
<td>48 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>7 mm</td>
<td>140</td>
<td>72</td>
</tr>
<tr>
<td>Cambridge Cobble</td>
<td>30 mm</td>
<td>3 x 6”, 6” x 6”, 6” x 9”</td>
<td>60 mm</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Round Chamfer</td>
<td>718 (30 mm)</td>
</tr>
<tr>
<td>City Paver (special order)</td>
<td>60 mm</td>
<td>6” x 6”</td>
<td>60 mm</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>7 mm</td>
</tr>
<tr>
<td>Dublin Cobble</td>
<td>60 mm</td>
<td>3 x 6”, 6” x 6”, 6” x 9”</td>
<td>60 mm</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Round Chamfer</td>
</tr>
<tr>
<td>Holland Stone</td>
<td>60 mm</td>
<td>7½” x 3¾”</td>
<td>60 mm</td>
<td>60 mm</td>
<td>80 mm</td>
<td>✓</td>
<td>80 mm</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Holland Stone ADA Truncated Dome</td>
<td>60 mm</td>
<td>7½” x 3¾”</td>
<td>60 mm</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>7 mm</td>
</tr>
<tr>
<td>Lafitt® Paver</td>
<td>30 mm</td>
<td>7⅛” x 3⅛”, 7⅛” x 7⅛”, 7⅛” x 10⅛”</td>
<td>30 mm</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>170 (30 mm)</td>
</tr>
<tr>
<td>Lafitt® Rustic Slab</td>
<td>50 mm</td>
<td>14⅛ x 7⅛”, 14⅛ x 22⅝”, 14⅛ x 14⅛”</td>
<td>50 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>151</td>
<td>104</td>
</tr>
<tr>
<td>Mega-Cambridge™</td>
<td>60 mm</td>
<td>6” x 9”, 9” x 9”, 9” x 12”</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Round Chamfer</td>
<td>114</td>
<td>200</td>
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<tr>
<td>Mega-Lafitt™</td>
<td>80 mm</td>
<td>10½” x 5½”, 10½” x 10½”, 10½” x 15½”</td>
<td>80 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>92</td>
<td>117</td>
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<td>Mega-Stone™ (special order)</td>
<td>80 mm</td>
<td>9½” x 4½”</td>
<td>80 mm</td>
<td>80 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>96</td>
</tr>
<tr>
<td>Melville™ Plank</td>
<td>60 mm</td>
<td>5” x 11”, 5” x 15”, 5” x 19½”</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>4.5</td>
<td>114.5</td>
<td>210</td>
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<tr>
<td>Melville™ Slab</td>
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<td>14⅝ x 7⅛”, 14⅝ x 14⅛”, 14⅝ x 22⅝”</td>
<td>60 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>4.5</td>
<td>128</td>
<td>80</td>
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<tr>
<td>Old World Paver™ (special order)</td>
<td>80 mm</td>
<td>5½” x 7¼”, 5½” x 10⅛”, 5½” x 12½”</td>
<td>80 mm</td>
<td>80 mm</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>90</td>
</tr>
</tbody>
</table>

* May be Suitable for ADA applications. Always evaluate site-specific uses to ensure surface suitability. Product installation and surface maintenance influences compliance with ADA Standards for Accessible Design Section 302 Floors or Ground Surfaces. Tumbling or antiquing pavers can also create surface or edges that may make the product unsuitable for ADA applications.

∆ For vehicular applications, it is recommended that pavers be installed on a concrete slab as designed by a local P.E.

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For vehicular applications, it is recommended that pavers be installed on a concrete slab as designed by a local P.E.
PAVER AVAILABLE COLORS

**Hexagon 18”**
- Gray*

**Cambridge Cobble**
- Avondale
- Brasstown
- Chattahoochee
- Country Blend
- Graphite (6 x 9 only)

**City Paver**
- Red*
- Charcoal*

**Dublin Cobble**
- Ardennes Gray
- Avondale
- Carriage House
- Fossil Beige

**Holland Stone**
- Country Blend
- Georgia Blend
- Gray-Granite
- Spice Blend

**Holland Stone ADA Truncated Dome**
- Red*
- Charcoal*

**Lafitt Paver**
- Avondale
- Belgian Stone
- Brasstown
- River Street

**Lafitt Rustic Slab**
- Ashwood
- Avondale
- Belgian Stone
- River Street

*Swatch represents product color only, not surface texture, dimension or shape.

**Special Order.
PAVER AVAILABLE COLORS

Mega-Cambridge

- Ashwood*
- Avondale
- Chattahoochee
- Country Blend

Mega-Lafitt

- Ashwood*
- Avondale
- Belgian Stone
- River Street

Mega-Stone**

- Carriage House*
- Ardennes Grey

Melville Slab

- Ashwood*
- Avondale
- Foundry
- Linen

Old World Paver**

- Belgian Stone
- River Street

Melville Plank

- Ashwood*
- Avondale
- Graphite
- Linen

* Swatch represents product color only, not surface texture, dimension or shape.
** Special Order.
### Permeable Pavers

<table>
<thead>
<tr>
<th>Units</th>
<th>Thickness</th>
<th>Size</th>
<th>Applications</th>
<th>ADA</th>
<th>Mechanical Install</th>
<th>Finishes</th>
<th>Manuf. Joint Width</th>
<th>% Surface Opening</th>
<th>Charnel Width</th>
<th>Sq. Ft. Per Pallet</th>
<th>Pcs. Per Pallet</th>
<th>Pallet Weight (Lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AQUALINE™ Series</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4½” x 9”</td>
<td>80 mm</td>
<td>4½” x 9”</td>
<td>80 mm</td>
<td>80 mm</td>
<td>80 mm</td>
<td></td>
<td>Standard</td>
<td></td>
<td></td>
<td>10 mm</td>
<td>10%</td>
<td>3 mm</td>
</tr>
<tr>
<td>Aslar 3-Piece (special order)</td>
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<td>4½” x 9”, 4½” x 4½”, 9” x 9”</td>
<td>80 mm</td>
<td>80 mm</td>
<td>80 mm</td>
<td></td>
<td>Standard</td>
<td></td>
<td></td>
<td>10 mm</td>
<td>12%</td>
<td>3 mm</td>
</tr>
<tr>
<td>9” x 9” L-Stone (special order)</td>
<td>80 mm</td>
<td>9” x 9” L-Stone</td>
<td>80 mm</td>
<td>80 mm</td>
<td>80 mm</td>
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<td>Standard</td>
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<td>10 mm</td>
<td>10%</td>
<td>3 mm</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eco Urbana™</td>
<td>80 mm</td>
<td>3½” x 7½”, 3½” x 7½”, 7½” x 11½”</td>
<td>80 mm</td>
<td>80 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.7 mm</td>
<td>9.5%</td>
<td>7 mm</td>
</tr>
<tr>
<td>Eco Urbana™ Large Square</td>
<td>80 mm</td>
<td>11½” x 11½”</td>
<td>80 mm</td>
<td>80 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.7 mm</td>
<td>9.5%</td>
<td>7 mm</td>
</tr>
</tbody>
</table>

* May be suitable for ADA applications. Always evaluate site-specific uses to ensure surface suitability. Product installation and surface maintenance influence compliance with ADA Standards for Accessible Design in Sections 302 Floors or Ground Surfaces.

** Tumbling or antiquing pavers can also create surface edges that may make the product unsuitable for ADA applications.

---

### Concrete Grid Pavements

<table>
<thead>
<tr>
<th>Units</th>
<th>Thickness</th>
<th>Size</th>
<th>Applications</th>
<th>ADA</th>
<th>Mechanical Install</th>
<th>Finishes</th>
<th>% Surface Opening</th>
<th>Sq. Ft. Per Pallet</th>
<th>Pcs. Per Pallet</th>
<th>Pallet Weight (Lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turfstone™</td>
<td>80 mm</td>
<td>15½” x 23½”</td>
<td>80 mm</td>
<td>80 mm</td>
<td></td>
<td></td>
<td>40%</td>
<td>133</td>
<td>67</td>
<td>2.832</td>
</tr>
</tbody>
</table>

** Including antiqued finish
PERMEABLE AND GRID PAVER AVAILABLE COLORS

Aqualine 4.5 x 9
- Avondale
- Graphite
- Gray-Granite

Eco Urbana
- Avondale
- Belgian Stone
- River Street

Turfstone
- Gray
<table>
<thead>
<tr>
<th>UNITS</th>
<th>THICKNESS</th>
<th>SIZE</th>
<th>ADA APPLICATION</th>
<th>PEDESTAL APPLICATION</th>
<th>SQ. FT. PER PALLET</th>
<th>PCS. PER PALLET</th>
<th>PALLET WEIGHT (LBS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noon</td>
<td>3⁄4&quot;</td>
<td>12&quot; x 48&quot;</td>
<td>☑️</td>
<td>☑️</td>
<td>155</td>
<td>40</td>
<td>1,480</td>
</tr>
<tr>
<td>Turin</td>
<td>3⁄4&quot;</td>
<td>24&quot; x 24&quot;</td>
<td>☑️</td>
<td>☑️</td>
<td>232.5</td>
<td>60</td>
<td>2,160</td>
</tr>
<tr>
<td>Verona</td>
<td>3⁄4&quot;</td>
<td>24&quot; x 24&quot;</td>
<td>☑️</td>
<td>☑️</td>
<td>232.5</td>
<td>60</td>
<td>2,160</td>
</tr>
</tbody>
</table>

**Noon**
- Charcoal
- Daylight
- Ember
- Honey
  - V3
  - V4

**Turin**
- Frost
- Canyon
- Rapids
- Stream
  - V3

**Verona**
- Blue Stone
- Platinum
- Teos
- Yukon
  - V3
  - V4
## SEGMENTAL RETAINING WALLS (SRW)

<table>
<thead>
<tr>
<th>UNITS</th>
<th>UNIT SIZE</th>
<th>CONNECTION TYPE</th>
<th>ACCESSORIES* (SOLD SEPARATELY)</th>
<th>TEXTURE</th>
<th>FACE STYLES</th>
<th>BATTER/SETBACK</th>
<th>SQ. FT. PER PALLET</th>
<th>PCS. PER PALLET</th>
<th>PALLET WEIGHT (LBS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashlar Tandem™</td>
<td>7&quot;</td>
<td>13 1/4&quot;, 15 1/4&quot;, 18 1/4&quot;</td>
<td>Reinforced Polypropylene</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 / 4°</td>
</tr>
<tr>
<td>Diamond Pro®</td>
<td>8&quot;</td>
<td>18&quot;</td>
<td>12&quot;</td>
<td>Rear Lip</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>7.1°</td>
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<tr>
<td>Diamond Pro® Virtual Joint</td>
<td>8&quot;</td>
<td>18&quot;</td>
<td>12&quot;</td>
<td>Rear Lip</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>7.1°</td>
</tr>
<tr>
<td>Diamond Pro® PS</td>
<td>8&quot;</td>
<td>18&quot;</td>
<td>12&quot;</td>
<td>Fiber Glass Pins</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>near vertical / 7.1°</td>
</tr>
<tr>
<td>Diamond® 9D</td>
<td>6&quot;</td>
<td>17 1/4&quot;</td>
<td>9&quot;</td>
<td>Rear Lip</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>10.6°</td>
</tr>
<tr>
<td>Diamond® 9D Virtual Joint</td>
<td>6&quot;</td>
<td>17 1/4&quot;</td>
<td>9&quot;</td>
<td>Rear Lip</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>10.6°</td>
</tr>
<tr>
<td>Mega Tandem™ 3-in-1 Wall System</td>
<td>12&quot;</td>
<td>24&quot;</td>
<td>3&quot;</td>
<td>41&quot;, 22&quot; &amp; 7&quot; Reinforced Polypropylene Connectors</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>2.6°</td>
</tr>
<tr>
<td>Weston Stone™ (2 pc)</td>
<td>4&quot;</td>
<td>8/9&quot;</td>
<td>12/9&quot;</td>
<td>8&quot;</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>vertical</td>
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<tr>
<td>Weston Stone™ Universal</td>
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<td>12&quot;</td>
<td>8&quot;</td>
<td>✓</td>
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<td></td>
<td></td>
<td></td>
<td>vertical</td>
</tr>
</tbody>
</table>

* Sold separately: all walls have available cap options. Contact your representative for more information.

## SPECIALTY PRODUCTS

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>SIZE</th>
<th>PALLET INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglia Edger®</td>
<td>5 1/4 x 8 1/4 x 8, 5 1/4 x 10 1/4 x 8, 5 1/4 x 13 1/4 x 8, 5 1/4 x 18 x 8</td>
<td>60 units per pallet</td>
</tr>
<tr>
<td>Eastwood Coping 60mm</td>
<td>4&quot; x 9&quot; x 2 3/4&quot;</td>
<td>336 units per pallet</td>
</tr>
<tr>
<td>Landings™ Step Unit</td>
<td>6&quot; x 48&quot; x 18&quot;</td>
<td>2 units per pallet</td>
</tr>
<tr>
<td>Sevilla® Coping 20mm</td>
<td>4&quot; x 9&quot; x 4&quot; - 2 1/2&quot; drop</td>
<td>336 units per pallet</td>
</tr>
<tr>
<td>U Start Base Block®</td>
<td>Full Unit = 18 7/16&quot; x 12&quot; x 3 1/2&quot; As Laid Unit = 18 7/16&quot; x 12&quot; x 3 1/2&quot;</td>
<td>56 units per pallet</td>
</tr>
</tbody>
</table>

* Sold separately: all walls have available cap options. Contact your representative for more information.
SEGMENTAL RETAINING WALL
AVAILABLE COLORS

Ashlar Tandem

Diamond Pro

Diamond Pro Virtual Joint

Diamond Pro PS

Diamond 9D

Diamond 9D Virtual Joint

Mega Tandem

Weston Stone

* Special Order
SPECIALTY PRODUCT AVAILABLE COLORS

**Anglia Edger**
- Cotswold Mist
- Gascony Tan

**Eastwood Coping**
- Ashwood*
- Avondale*
- Linen*

**Landings Step Unit**
- Charcoal
- Linen
- Tan

**Seville Coping**
- Charcoal
- Chestnut
- Cream

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* Swatch represents product color only. Not surface texture, dimension or shape.
Belgard consultants can work with your team to develop the best PICP system design or retaining wall configuration to control runoff volume and discharge rates, improve the quality of local groundwater, reduce or prevent downstream impacts, and minimize the land consumed for stormwater management.

The experts at Belgard can help you optimize your site in a number of ways—whether you’re looking for creative ways to define public spaces, manage or harvest stormwater, or increase the usable space for development.

Our team of design consultants can help address both aesthetic and engineering design concerns, material quantity estimates and permit ready plans.

For your convenience, Belgard offers a constantly expanding library of easy-to-download CAD files of our products and patterns.

Belgard offers a variety of ongoing educational programs for our industry partners, including Lunch & Learns, online CEU courses, and our Belgard University training program.

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Jonesboro, GA 30236
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Toll Free: 800-621-5222