



Sustainable & Permeable Pavement Systems

Engineered Site Solutions



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Environmental Collection



Beauty, functionality and quality are hallmarks of the **Belgard® Commercial Hardscapes brand**, and our **Environmental** Collection of permeable pavers is no exception. Belgard permeable pavers combine the best of Belgard with innovative stormwater management for a superior product line that provides sustainable solutions and aesthetically appealing designs.

Increased development has led to a continually raising percentage of impermeable surfaces which limits the recharging of the natural aquifer reserves and contributes to environmental pollutants in our lakes, rivers and streams. Permeable pavers are a best management practice for controlling stormwater runoff even to the point of eliminating the need for detention and retention ponds or sewer pipes. Permeable pavers create a pervious surface allowing water to infiltrate the ground, naturally filtering pollutants and replenishing ground water reserves.

With Belgard, there is no need to sacrifice beauty or design for sustainable practices. The Belgard Environmental Collection of permeable pavers and the Belgard Wall Collection provide beautiful and functional products as part of engineered systems for all your projects.



Location: Fair Oaks Promenade,
Sacramento, California

Sustainable Development

is meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Belgard® Permeable Paving Stone Systems

- Listed in the U.S. Environmental Protection Agency's (EPA) menu of structural BMPS for onsite stormwater management
- Can contribute toward LEED NC-2009 points
- Ability to capture and treat high percentage of stormwater nutrient, metal and oil loadings
- Reduces stormwater runoff by up to 100% (subject to onsite conditions)
- Certified SRI Colors Reduce Heat Island Effect
- Can reduce, or even replace, traditional drainage and detention infrastructure
- With three design options (full, partial and no exfiltration), can accommodate all native soil types
- Selected styles of pavers are ADA compliant
- Offer a variety of paver options for design aesthetics and/or structural settings

Common Applications

Pedestrian: Office and shopping plazas, sidewalks, tree planting areas, parks and outdoor seating areas.

Vehicular: Parking lots, driveways, parking bays on roadways, subdivision roads, secondary/emergency access routes.

Industrial: Ports, trucking terminals, fire stations, storage facilities.

Sustainable Sites: Brownfield Developments.

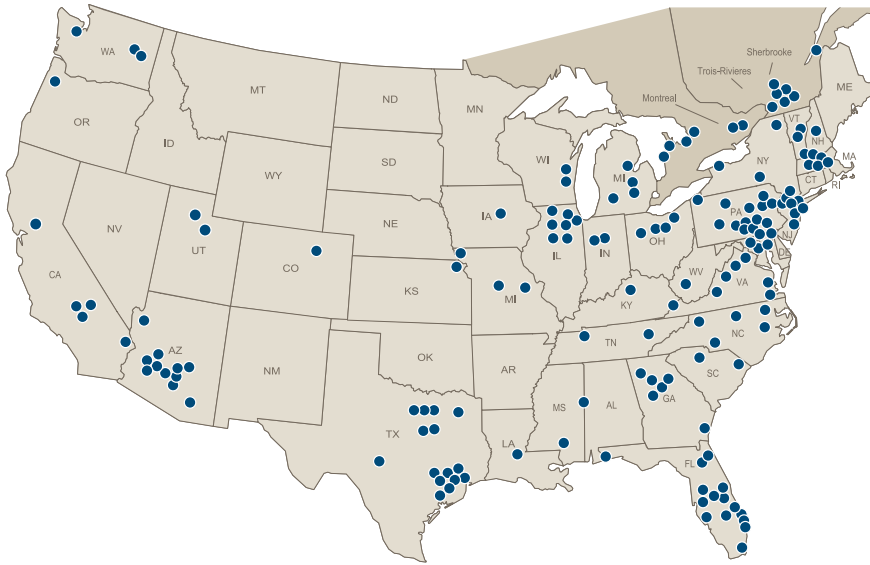


Oldcastle Research and Development Facility

Oldcastle Building Products

The Innovative Building Solutions Leader

Belgard® Hardscapes is a brand of Oldcastle Architectural, a division of Oldcastle Building Products, which is a subsidiary of CRH plc. CRH is ranked by a number of leading socially responsible investment rating agencies, including Dow Jones Sustainability Indexes and SAM (Sustainability Asset Management) Gold Class, FTSE4Good Index, ECPI Ethical Index, Governance Metrics International, Business in the Community and the Ethisphere Institute.



Oldcastle has been addressing environmental concerns and stewardship as a core component of our Corporate Social Responsibility commitment. Each Oldcastle product group is developing products and processes that will help us succeed as environmental stewards well into the future. As a responsible member of the U.S. Green Building Council (USGBC), Oldcastle is proud to provide products that support green building initiatives.

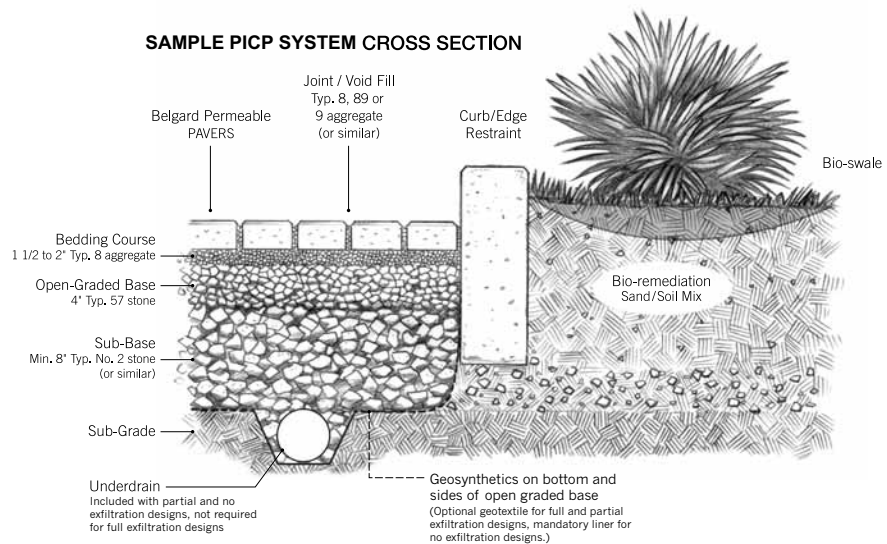




Low Impact Development

To improve sustainable development, U.S. federal law, through the National Pollution Discharge Elimination Systems (NPDES), mandates that states control non-point source water pollution. Best Management Practices (BMPs) are techniques identified by state authorities to achieve this goal.

Low impact development (LID) is a leading BMP design strategy used to reduce the negative impacts of traditional development on watershed areas and receiving waters. The goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate and detain runoff close to its source.



The availability of specific aggregate will often vary from region to region. In cases where it becomes necessary to substitute a similar size, your project engineer should always be consulted.

Permeable interlocking concrete pavement supports low impact development principles by potentially –

- Providing stormwater treatment, storage and infiltration uniformly throughout the applied area; can be combined with other detention practices such as bio-retention swales, rain gardens, open swales and roof gardens
- Recharging the groundwater system therein maintaining groundwater based drinking water supplies, and base flow conditions in downgradient surface water ways.
- Maintaining, or decreasing/delaying (subject to design intent), pre-development surface water discharge peak flows, total flows and time of concentration
- Minimizing, or eliminating, resulting 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)

PICP also provides for environmental stewardship by potentially –

- Better utilizing onsite spaces: Roads, parking, stormwater infiltration and retention all combined into the same space creating more green space or building opportunities
- Allowing for the preservation of any wooded/ecological areas that would have otherwise been cleared for/impacted by stormwater detention or retention works
- Promoting tree survival and growth in planting areas by maintaining air/water exchange to the root zones
- Contributing to urban heat island reduction through controlled evaporation and/or reflective, light-colored pavers
- Providing for shallow geothermal, or rainwater harvesting applications



Project: Gateway
 Location: Murfreesboro, Tennessee

Benefits of Infiltration

The U.S. Geological Survey reports that half of 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 rain is prevented from infiltrating back into the groundwater system (shallow groundwater flow systems maintain base flow conditions in lakes and rivers between rainfall events.) Base flow conditions are also vital for the survival of the waterway vegetative and animal species.

With new development, the building envelope and asphalt/concrete areas are impervious, while the associated retention ponds are highly subject to evaporation -in short, infiltration is dramatically reduced. Permeable pavers act as natural underground water collectors by serving as 24/7 stormwater infiltration percolators, therein replenishing these valuable resources.

Typical Infiltration Rates of Various Soil Groups

SOIL CONSERVATION SERVICE GROUP	Typical Soil Type	SATURATION INFILTRATION RATE	
		in/hr	mm/hr
A	Sand	8.27"	210 mm
A	Loamy Sand	2.41"	60 mm
B	Sandy Loam	1.02"	26 mm
B	Loam	0.52"	12.7 mm
C	Silt Loam	0.27"	6.8 mm
C	Sandy Clay Loam	0.17"	4.3 mm
D	Clay Loam and Silty Clay Loam	0.09"	2.3 mm
D	Clay	0.06"	1.5 mm

PICP may be used on clay soils with use of underdrains, bio-remediation and other soil amended practices.

Benefits of Improved Water Quality

Living things from the smallest to the largest simply cannot survive without clean water. Unfortunately, stormwater runoff from our streets and parking lots are typically laden with contaminants that accumulate on the surfaces between precipitation events. With PICP systems, sediment and debris is filtered within the joint/void aggregates, where they can be subsequently vacuumed out. Bacterial and chemical reactions within the open graded base material also provide for secondary treatment of nutrients, hydrocarbons, etc. The end result is much cleaner water exiting the site (see below). In fact, the Environmental Protection Agency acknowledges that permeable paver systems are a Best Management Practice (BMP) in the effort to meet federal stormwater quality requirements.

Median Pollutant Removal

POLLUTANT	INFILTRATION TRENCH DESIGN TYPE*			INFILTRATION TRENCHES & PERVIOUS PAVEMENT
	0.5 in (13 mm) Runoff per Impervious Acre	1.0 in (25 mm) Runoff per Impervious Acre	2-Year Design Storm Treatment	Median Pollutant Removal**
Total Suspended Solids	60 – 80%	80 – 100%	80 – 100%	95%
Total Phosphorous	40 – 60%	40 – 60%	60 – 80%	70%
Total Nitrogen	40 – 60%	40 – 60%	60 – 80%	51%
Biological Oxygen Demand	60 – 80%	60 – 80%	80 – 100%	—
Bacteria	60 – 80%	60 – 80%	80 – 100%	—
Metals	60 – 80%	60 – 80%	80 – 100%	99 (Zn)

*Note: These rates are not based on actual data since monitoring what enters and leaves any infiltration facility is difficult to measure. These data are based on land application of pollutants and their treatment through soils.

**Actual monitored removal rates.

A good deal of early permeable pavement research relating to water quality was conducted at North Carolina State University; by William F. Hunt, PhD, PE, Eban Z. Bean, EI and David A. Bidelspach, EI. For Details, log onto www.NCSU.edu and search "Water Quality Studies".



Project: Fair Oaks Promenade,
Location: Sacramento, California

Detention and Volume Control Opportunities

The ability of the permeable paved areas to collect, infiltrate and store water provide the additional benefit of eliminating the need for space stealing water retention ponds, which have limited alternate applications (assuming the pond dries out sufficiently for the intended alternate use). By using the proper measures of aggregate base materials, valuable land that would otherwise be under utilized can be transformed into continuous use green spaces or recreational areas, or even reclaimed for increased development.

Base Storage Capacity

CRITERIA				RAINWATER HARVEST VOLUME		BASE STORAGE CAPACITY		SURPLUS (DEFICIT) STORAGE		
Rainfall In/Hr (mm/hr)	Surface Area Ft ² (m ²)	Sub-base Depth In (cm)	Void Space	Cubic Ft (m ³)	Gallons (m ³)	Cubic Ft (m ³)	Gallons (m ³)	Cubic Ft (m ³)	Gallons (m ³)	% Used
1 (25 mm)	43,560 (4,047 m ²)	12 (30 cm)	40%*	3,630 (103 m ³)	27,154 (103 m ³)	17,424	130,341 (493 m ³)	137,794 (391 m ³)	130,187 (391 m ³)	20.8%
1 (25 mm)	43,560 (4,047 m ²)	18 (46 cm)	40%*	3,630 (103 m ³)	27,154 (103 m ³)	26,136	195,511 (740 m ³)	22,506 (637 m ³)	168,357 (637 m ³)	13.9%
3.5 (89 mm)	43,560 (4,047 m ²)	12 (30 cm)	40%*	12,705 (360 m ³)	95,039 (360 m ³)	17,424	130,341 (493 m ³)	4,719 (134 m ³)	35,302 (134 m ³)	72.9%
3.5 (89 mm)	43,560 (4,047 m ²)	18 (46 cm)	40%*	12,705 (360 m ³)	95,039 (360 m ³)	26,136	195,511 (740 m ³)	13,431 (380 m ³)	100,472 (380 m ³)	48.6%
5 (127 mm)	43,560 (4,047 m ²)	24 (61 cm)	40%*	18,150 (520 m ³)	135,770 (520 m ³)	34,848	260,681 (987 m ³)	16,698 (473 m ³)	124,911 (473 m ³)	52.1%
7.4 (188 mm)	43,560 (4,047 m ²)	18 (46 cm)	40%*	26,862 (761 m ³)	200,940 (761 m ³)	26,136	195,511 (740 m ³)	[726] (21 m ³)	[5,429] (21 m ³)	102.8%

Detention volumes or storage capacities for permeable paving are based on different rainfall events.

*Void space can vary with different aggregate.

ASTM C29 / C29M-09 Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

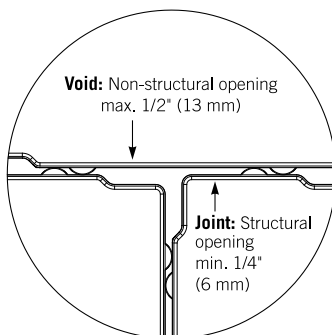
Volume Control and Reduction

Research has demonstrated that PICP systems can reduce runoff by as much as 100%. For example, a design storm of 3 inches (75mm) can easily be accommodated where the underlying soils are sandy and there is a 12 inch (300 mm) thick open-graded aggregate base. This would be an example of a full exfiltration system.

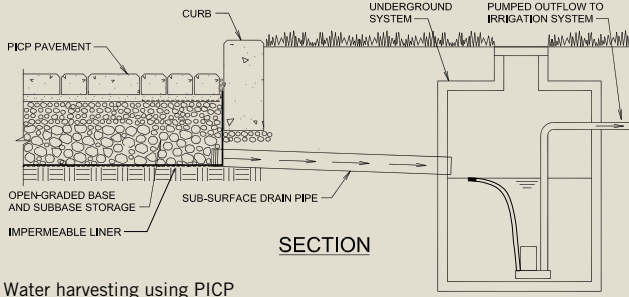
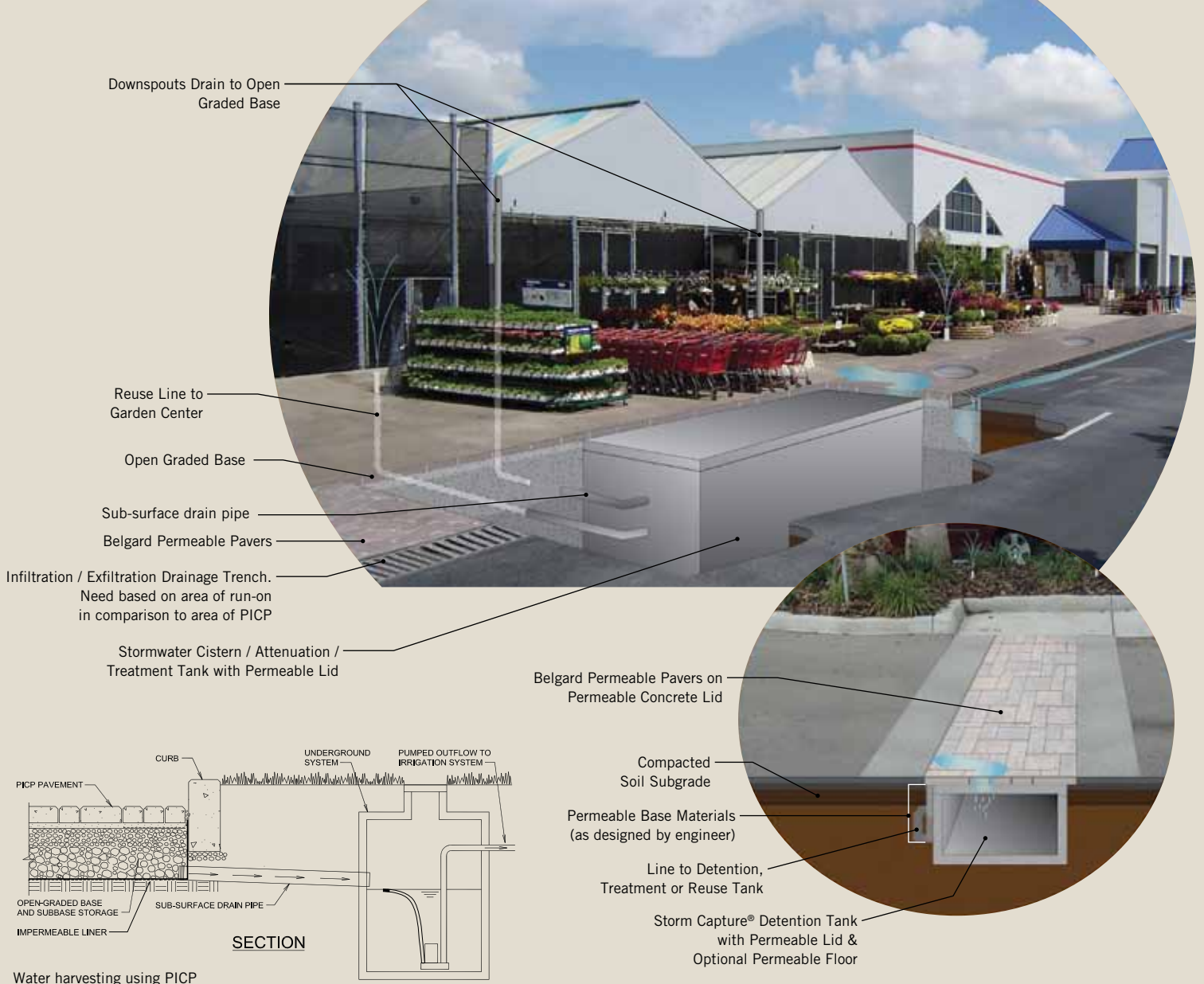
With partial exfiltration systems, PICP systems traditionally reduce annual runoff between 30-80%, depending on the severity of the precipitation events, storage capabilities of the base materials, and/or native soil infiltration rates. With no exfiltration systems, pre development runoff volumes, peak flows and time of concentration can all be maintained, if not improved, through discharge control works.

Structural and Non-Structural Openings

(Surface Void Ratio) When viewed from above (plan view), permeable paver systems consist of solid paver units with openings (joints and voids) around the outside that are filled with drainage aggregate – see adjacent. The percent open area, or void area, is the surface area of the joints and voids compared to the total surface area. The initial approach was to oversize the void area to between 8% to 12% because of the lack of long term performance data. Infiltration testing conducted by Borgwardt determined however that the infiltration rate of the joint/void fill aggregates is as important as the percent open area of the surface. For example, using a #8 aggregate with a flow rate of 1,000 – 1,500 in/hr in a paver with a void opening of 5% yields an initial infiltration rate for the entire surface of 50-75 in/hr; in comparison, a sand with a flow rate of 5-10 in/hr in a paver with a void ratio of 10% only yields an initial infiltration rate of 0.5 to 1 in/hr. This revelation has allowed for pavers with a smaller percent open area as long as the approved fill material is used.



Measurements are nominal.



Water harvesting using PICP

For additional information, see "Application of WE Credit 1", ICPI Tech Spec 16 at www.icpi.org

Water Harvesting

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

The expertise and products directly related to Stormwater Harvesting are provided by Oldcastle Precast.

In a typical detention/retention system, stormwater is collected in vaults, ponds or swales and dispersed slowly into the ground or elsewhere. With harvesting, a detention/retention system is adapted to not only store the stormwater, but filter and supply it to other areas where it can be used to replace or reduce the consumption of municipal potable water.

The idea of harvesting and reusing rainwater and other water resources is not new, but the practice fell out of favor in the U.S. during the last century when water was inexpensive. Attitudes have changed with the realization that our fresh water supply is not inexhaustible. With one third of the United States experiencing very dry or drought conditions annually, there is a renewed interest in water conservation and reuse.

For details on system design options and/or available technical support, contact your Belgard Commercial Technical Representative.

Permeable Paver Design Considerations

The design of a permeable pavement system begins with regional knowledge of the environment, including expected rainfall intensities for the area.

While general guidelines are provided, a local engineer should always be consulted in order to ensure system adherence to existing local and state regulations. Based on site-specific geological surveys, local hydrological collected data and predictions, as well as the owner's design purposes, the engineer will prepare and approve plans that are best suited for that particular project. The cross section on page 11 shows those design variables that should be considered when designing any permeable system.

In addition to an attractive appearance, the more important benefit of the permeable paver system in comparison to other impervious surfaces, including asphalt, concrete and grass turf, is runoff reduction. Civil engineers calculate the runoff discharge from an area using the Rational Method, with the Coefficient of Runoff "C" being a generalized value which characterizes the percentage of runoff generated from all storms. With a full exfiltration system, the C value is theoretically zero as no runoff occurs. For partial exfiltration systems, conservative values are 0.25 on high infiltration soils and 0.4 on low infiltration soils (ICPI PICP Design Manual, 2011).

Typical Runoff Coefficients for the Rational Method

LAND USE TYPE	RECOMMENDED VALUE	SURFACE TYPE	RECOMMENDED VALUE
Industrial	0.75	Bituminous Asphalt	0.85
Downtown Business District	0.85	Pour-in-place Concrete	0.85
Single Family Residential	0.40	Lawns - Sandy Soils	0.13
Multi-Family Residential	0.60	Lawns - Heavy Soils	0.20
Parks	0.20	Permeable Pavers	0.0 to 0.4*

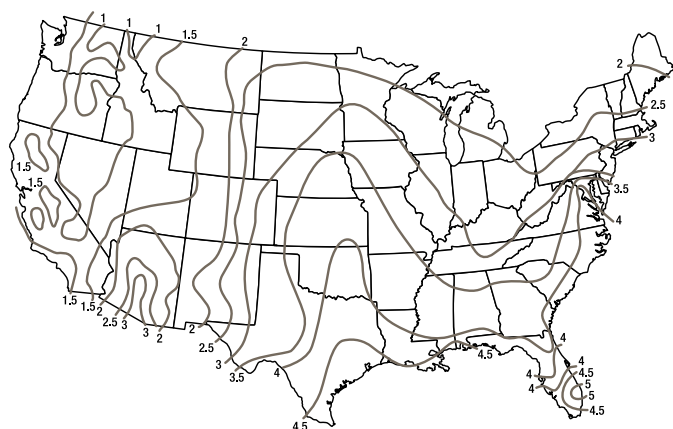
Source: Design and Construction of Sanitary and Storm Sewers. American Society of Civil Engineers, New York, p. 332, 1969. Coefficients are based on 5 – 10 year storm frequencies.

*Range subject to native soil type.

Using asphalt pavement as an example, the C value is 0.85; this means that 85% of the rainfall that falls on the surface runs off (the balance wets the surface, ponds in depressions and evaporates). PICP surfaces in comparison directs water through the joints/voids and into the underlying base where it is allowed to infiltrate into the subgrade. It is only when the infiltration rate and storage capacity are exceeded by the precipitation/run-on that runoff (i.e overflow) occurs.”

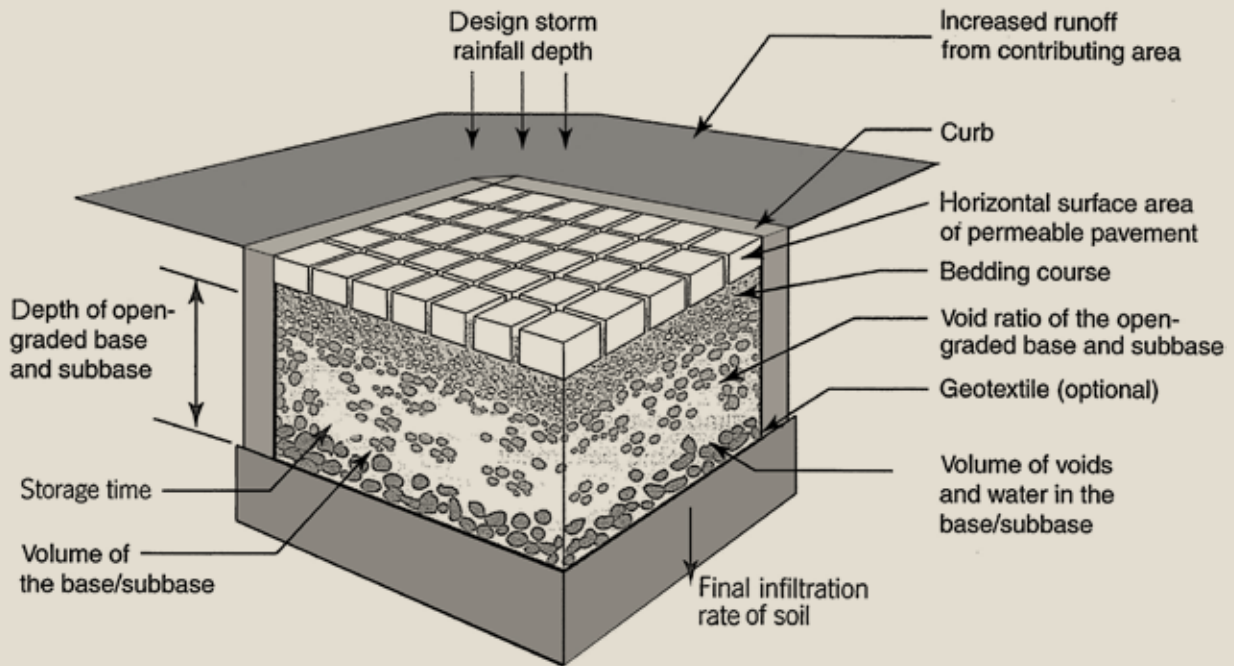
100 Year Rainfall Map

One Hour Rainfall in inches to be expected once in 100 years



Design Parameters For Calculating Base Depth

Direct Infiltration into Permeable Subgrade



This cross section drawing is intended for preliminary design purposes only. Site evaluation, as well as the actual structural design, should be performed by a qualified engineer.



Permeable Design Aids

ICPI has developed an excellent design software tool, ICPI Permeable design Pro Software. Free downloads of the software can be obtained from your local Belgard Commercial Technical Representative.

Performance and Design

The system's natural characteristics for design life durability is green/sustainability.

LT. VEHICULAR-60MM 

LT. VEHICULAR-80MM 

VEHICULAR-80MM 

Pavers are environmentally inert, and the open joints/voids allow for much more efficient regeneration during cleaning than porous asphalt or pervious concrete. The inherent compressive strength and flexible interlocking mechanism of pavers safely handles the heavy loads from vehicular traffic affording a longer life-cycle.* The infiltration rate of PICP systems can also handle tremendous volumes of water, including not only direct precipitation but also run-on from adjacent impervious areas and roof drain discharge. Studies throughout the continent have proven that PICPs are capable of providing excellent service in a wide range of climates.

*Life-cycle cost studies available from ICPI.

Belgard® Paving Stones are manufactured to exacting standards which ensure that they exceed ASTM C-936-09 "Standard Specification for Solid Concrete Interlocking Paving units".

Project: Fire Station #2
Location: Columbia, Tennessee





Mechanical installation of commercial parking lot.
Location: Marietta, Georgia

PICP Installation



The ICPI points out that because permeable pavers are factory manufactured, they have a consistency in quality, can be manufactured in patterns that allow for either mechanical or manual installation, can be installed in freezing temperatures without being adversely impacted, and are immediately traffic ready once the joints/voids are filled.

PICP systems are relatively simple to install both mechanically and manually. For mechanical installations, the product is manufactured such that each layer can be lifted entirely by a laying machine and put into place – this allows each machine to be capable of installing upwards of 5,000 square feet per day. For manual installations, the product is manufactured such that sections can be handled using a bundle buggy – this dramatically increases the efficiency of each worker.

Choosing the most appropriate style of paver and type of installation depends on the application. General questions to consider include: installation procedure; vehicle loading; what depth of base is needed for storage; and, the infiltration rate of the native soil. The native soil type also affects the base course depth (depending on its load bearing capacity). In cold climates, the surface’s ability to be plowed may also be a consideration.

Because permeable pavers are available in different colors, there is no need to paint striping in the case of parking lots or handicapped areas. It also eliminates the need for re-striping, greatly reducing maintenance costs. Complimentary shades can add an architectural style as well. Colors also can be chosen to reflect heat in urban “heat islands” and earn potential LEED (Leadership in Energy and Environmental Design) credits. A properly installed permeable pavement system will also benefit adjoining landscaping by allowing water and nutrients to reach the roots of trees and plants more naturally. Shades can add an architectural element as well.

Choosing Products and Installation Methods

Should the need arise,
Belgard Authorized
Commercial Contractors and
Trained Technicians
are always available.



Design & Technical Information

Suggested Rates, Sizes and Percentages

Aggregate Infiltration Rates

APPROXIMATE PARTICLE SIZE	PERMEABILITY (k) in./hr (m/s)
ASTM No. 8 (2 – 10 mm)*	1,400 – 4,000 (3×10^{-2} to 1×10^{-2})
ASTM No. 9 (2 – 5 mm)*	140 – 1,400 (1×10^{-2} to 1×10^{-3})
ASTM No. 10 (1 – 3 mm)*	14 – 140 (1×10^{-3} to 1×10^{-4})
ASTM No. 57 (12.5 – 25 mm)	500 – 2,000 (3.5×10^{-3} to 1.4×10^{-2})
ASTM No. 2 (50 – 63 mm)	> 1,000 ($> 7 \times 10^{-3}$)

Permeability ranges of joint fill aggregate alternatives for permeable pavers

Aggregate Material Gradation

Setting Bed

SLEVE SIZE	PERCENT PASSING
0.5" (12 mm)*	100
0.375" (9.5 mm)	85 – 100
(4.75 mm) (No. 4)	10 – 30
(2.36 mm) (No. 8)	0 – 10
(1.16 mm) (No. 16)	0 – 5

Grading requirements for ASTM No. 8 bedding. Setting bed aggregate can also be used as joint/void aggregate

Base

SLEVE SIZE	PERCENT PASSING
1.5" (37.5 mm)	100
1" (25 mm)	95 – 100
0.5" (12 mm)	25 – 60
(4.75 mm) (No. 4)	0 – 10
(2.36 mm) (No. 8)	0 – 5

Grading requirements for ASTM No. 57 base

Subbase

SLEVE SIZE	PERCENT PASSING
3" (75 mm)	100
2.5" (63 mm)	90 – 100
2" (50 mm)	35 – 70
1.5" (37.5 mm)	0 – 15
0.75" (19 mm)	0 – 5

Sieve sizes for ASTM No. 2 aggregates

Typical Base Thickness*

PAVEMENT USE	SUBBASE ASTM NO. 2	BASE ASTM NO. 57	MIN. TOTAL
Heavy-duty industrial	14" (355 mm)	4" (102 mm)	18" (457 mm)
Municipal street	12" (305 mm)	4" (102 mm)	16" (407 mm)
Light-duty parking lot	8" (203 mm)	4" (102 mm)	12" (305 mm)
Residential driveway	n/a	6 – 12" (305 mm)	6-12" (153-305 mm)
Non vehicular sidewalk	n/a	10" (254 mm)	10" (254 mm)

Notes:

- 1) All permeable pavers systems require an additional 1.5" (35 mm) setting bed of ASTM No. 8 for placement.
- 2) All thicknesses are after compaction.
- 3) Geotextiles between subgrade and ASTM No. 2 are optional and based on soil conditions.
- 4) Geotextiles are not required between the subbase, base or setting bed layers.

*Final aggregate material thickness should be designed by a qualified engineer.

Maximum Allowable Storage Depth, inches (m)

		SOIL SUBGRADE TEXTURE / INFILTRATION RATE inches/hour (mm/sec)										
		Sand	Loamy Sand	Sandy Loam	Loam	Silty Loam	Sandy Clay Loam	Clay Loam	Silty Clay Loam	Sandy Clay	Silty Clay	Clay
Criterion	T_s (hrs)	8.27 (6×10^{-5})	2.41 (2×10^{-5})	1.02 (7×10^{-5})	0.52 (4×10^{-5})	0.27 (2×10^{-5})	0.17 (1×10^{-5})	0.09 (6×10^{-7})	0.06 (4×10^{-7})	0.05 (3×10^{-7})	0.04 (2×10^{-7})	0.02 (10^{-7})
$f \times T_s / V_r$	24	496 (12.6)	145 (3.7)	61 (1.5)	31 (0.8)	16 (0.4)	10 (0.25)	5 (0.12)	4 (0.1)	3 (0.07)	2 (0.05)	1 (0.02)
	48	992 (25.2)	290 (7.4)	122 (3.1)	62 (1.6)	32 (0.8)	20 (0.5)	11 (0.3)	7 (0.17)	6 (0.15)	5 (0.15)	2 (0.05)
	72 ($V_r = 0.4$)	1489 (37.8)	434 (11)	184 (4.6)	94 (2.4)	49 (1.2)	31 (0.8)	16 (0.9)	11 (0.13)	9 (0.2)	7 (0.17)	4 (0.1)

T_s = Maximum allowable storage time V_r = Voids ratio Highest values unless base exfiltration is supplemented with drain pipes.

Maximum allowable storage depth, inches (m) of storage for selected maximum storage times (T_s in hours), minimum infiltration rates and inches/hour (mm/sec)(31).

The availability of specific aggregate will often vary from region to region. In cases where it becomes necessary to substitute a similar size, your project engineer should always be consulted.



Project: Walmart,
Location: Tampa, Florida

Permeable Paver Maintenance



Because pavers are designed to wick water from the surface into the substrate below, removing environmental dust and dirt becomes a natural occurrence with rain and melting snow. However, should the voids between the pavers become clogged with sediment impeding their ability to drain run-off, a commercial-grade sweeper, a power vacuum or a blower can be employed to remove the debris. A visual inspection after rain or snowfall will indicate this condition. After several years, it may also be necessary to enlist a commercial vacuum truck to remove existing aggregate and accumulated sediment; remember to refill the voids and replace the void with clean aggregate. It should also be noted that **power-washing is not recommended**.

Because permeable pavers are made with high-quality concrete, snow can be plowed or shoveled without the need for special blades or equipment. De-icing chemicals are best used sparingly and often are not necessary because of the insulated qualities of the system and the warmer temperatures in the substrate.

Properly installed paving systems can last for decades. Due to the modular make-up of the PICP, repairs are easily made by removing the damaged paver and replacing it with a new one. A rule of thumb is to store 2% of the project as replacement pavers to ensure an even match should repairs be necessary.

LEED® & Belgard® Permeable Pavers

The Leadership in Energy and Environmental Design (LEED) rating system was developed by the United States Green Building Council to recognize sustainable site and building design, and is administered by the Green Building Certification Institute. Many municipal projects mandate LEED point objectives, and more private sector projects pursue LEED credits as evidence of environmental stewardship.

The summary below represents some LEED credit and prerequisites where Belgard permeable concrete paving stone systems may contribute toward earning points in accordance with LEED NC-2009. For more specific LEED information, please reference “Achieving LEED Credits with Segmental Concrete Pavement”, **ICPI Tech Spec 16** at www.icpi.org.

VERSION 3.0 Contributing to LEED® Credits with Permeable Pavers (A Sampling)

SUSTAINABLE SITES (SS)		
CREDIT	DESCRIPTION	POINTS
SS-P1	(Prerequisite) Construction Activity and Pollution Prevention	—
SS-c5.2	Site Development - Maximize Open Space Open spaces may consist of up to 75% of pedestrian hardscapes for jobsites that earn SS-c2, Development & Density and Community Connectivity.	1 Point
SS-c6.1	Stormwater Design: Quantity Control Stormwater management of a building site where the existing impervious area is greater than 50% and the runoff rate and quantity is reduced by at least 25%. Belgard permeable concrete paving stone systems can reduce runoff to zero for the most frequent storms.	1 Point
SS-c6.2	Stormwater Design: Quality Control A treatment system designed to remove 80% of the average annual post-development Total Suspended Solids (TSS), and 10% of the average annual post-development Total Phosphates (TP).	1 Point
SS-c7.1	Heat Island Effect: Non-roof Non-roof landscape and exterior designs that reduce heat island effect would entail the use of light colored/high albedo materials with a solar reflective index of at least 29 for 30% of the site's non-roof impervious surfaces, i.e., pavements. Manufacturing permeable concrete paving stones in light or natural colors can test with at least 29 can meet this requirement	1 Point
SS-c7.2	Heat Island Effect: Roof	1 Point

WATER EFFICIENCY		
CREDIT	DESCRIPTION	POINTS
WE-P1	(Prerequisite) Water Use Reduction	—
WE-c1	Water Efficient Landscaping Limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation	2–4 Points
WE-c2	Innovative Wastewater Technologies	2 Points

MATERIALS AND RESOURCES (MR)		
CREDIT	DESCRIPTION	POINTS
MR-c4	Recycled Content Use of materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% – 20% of the cost. - Recycled Content: 10% post-consumer & 1/2 pre-consumer (will receive 1 point). - Recycled Content: 20% post-consumer & 1/2 pre-consumer (will receive 2 points).	1–2 Points
MR-c5	Regional Materials - 10% extracted, processed & manufactured regionally. - 20% extracted, processed & manufactured regionally. Use building materials or products that have been extracted, harvested or recovered, as well as manufactured within 500 miles of the project site for a minimum of 10% of the cost.	1 Point

INNOVATION IN DESIGN		
CREDIT	DESCRIPTION	POINTS
ID-c1	Innovation in Design This credit category enables designers to incorporate improvements in building materials and design into the LEED® rating system. Besides original innovative design, credits may be awarded if a project achieves exceptional performance under an existing LEED® credit for that project	1–5 Points
RP-1	Regional Priority** Use building materials or products that have been extracted, harvested, recovered, processed or manufactured within 800 km (500 miles) (2,400 km if shipped by rail or water) of the project site for a minimum of 10% based on cost of the total materials value	4 Points

**Check with local USBGC Chapter for requirements



Project: Post Graduate Naval Academy,
Location: Sacramento, California

Reducing Urban Heat Islands

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 higher demands on energy and produce more pollution and greenhouse gas emissions, and clearly create quality of life issues for all those living in such environments.

Solar Reflectance Index

The SRI (Solar Reflective Index) is a composite measure or indication of how well a surface emits absorbed heat. Since solar heat represents approximately 47% of the sun’s energy at the earth’s surface, it is an important consideration when selecting paver colors. Belgard has tested a number of their lighter color pavers to verify that they achieve the desired SRI of 29 in accordance with LEED SS-c.7.1.

In an effort to address the remaining 53% (ultraviolet 3% and infrared radiation 50%), Belgard researchers are exploring the environmental benefits of photocatalytic cement.

Sustainability Initiative

Belgard is currently working with Green Ideas, an environmental consulting group, to assist with the training and technical aspects of our Sustainability Initiative. As part of that initiative, we are developing a series of technical booklets based on regional testing results and locally-mined aggregates. The results of these tests will make it easier to determine LEED point contributions on a regional level.

LifeTime Fitness Stormwater Management

While many case studies follow the path of the construction process, the LifeTime Fitness study also provides a deeper look into the design and savings standpoint.

This study validated that for LifeTime Fitness, a permeable interlocking concrete pavement (PICP) addressed the need for effective stormwater management by safely reducing runoff for 2, 10 and 100-year storm events, created an attractive business setting, and did so at a considerable cost savings over other paving options.

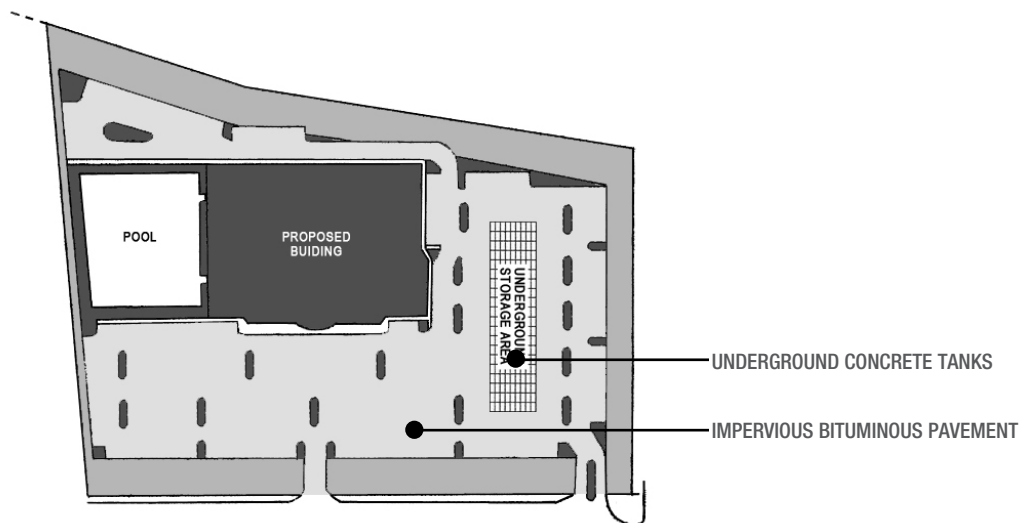
Preliminary construction specifications call for a 116,800 square-foot, three-story building and a 36,900 square-foot swimming pool/deck area. *Three options were proposed for the parking areas surrounding the structures: bituminous driving and parking lanes; PICP parking stalls with bituminous drive lanes; PICP over the complete parking and drive areas.*

Looking to establish the most favorable choice, both cost and the environment were paramount choices, and each of the options offered advantages and disadvantages to the construction and long-time use of the parking area.

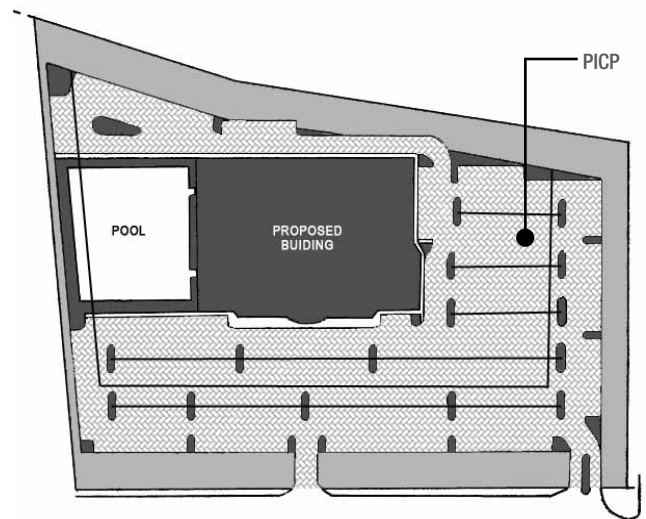
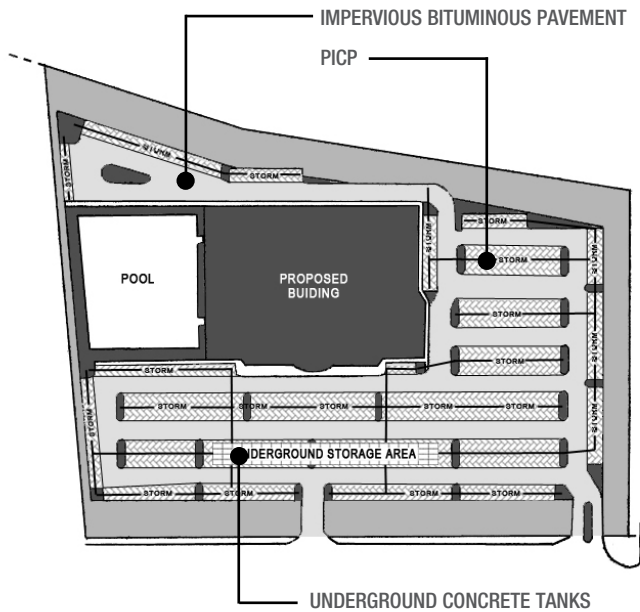
The 9.8 acre site is not large enough to provide adequate space for a water retention pond, along with building, pool footage, and required parking. Although LifeTime Fitness has not yet obtained a geotechnical report or topography survey, it is generally believed the site will drain to one specific point and that the soil is of low permeability.

Whatever method is chosen to build the vehicular drive areas, refining the substrate is required. However, the surface material selected will have a large effect on the amount of work needed to prepare the substrate and this will contribute extensively to the overall cost of the project.

PROPOSED OPTION 1: When a standard impervious bituminous material was considered for the driveways and the parking stalls, it was recognized that such a system would necessitate a significant amount of underground storage to accommodate the site storm water volume.



PROPOSED OPTION 1: Standard Bituminous with underground storage tanks



PROPOSED OPTION 3: PICP without underground storage tanks

PROPOSED OPTION 2: An alternative method examined was the use of bituminous material for the drive areas and a PICP system for the parking stalls. While this procedure would enhance the infiltration of stormwater into the subgrade, it nevertheless also would require underground storage tanks, although in smaller capacity than needed for the bituminous material surface alone.

PROPOSED OPTION 3: The third option under discussion is utilizing PICP for all drive lanes and parking stalls. With an increased aggregate section built into the substrate, no underground storage tanks would be required.

Although each of the three options would apparently satisfy all local ordinances, choosing a PICP system offers the best option on several accounts. Bituminous material being impervious, impedes infiltration and causes runoff to flow in haste, which not only increases the stormwater volumes that require substantial and expensive underground storage, but also attracts and collects unsightly trash, as well as impedes pedestrian traffic. In winter weather, this can lead to icing and the need for salt to melt walking areas. While ease of maintenance and construction of asphalt is a consideration, aesthetically, black pavement is anything but ecologically-friendly.

The combination of bituminous material and concrete pavers ameliorates some of the aesthetics missing with the solid blacktop; however, it would still necessitate the construction of underground storage tanks to contain runoff.

Because less tank storage would be required, however, this option is slightly less expensive than the total bituminous process.

A PICP system earns high marks for the LifeTime Fitness construction process. It scores higher when aesthetics are considered, particularly if different colored pavers are used to delineate parking and drive areas. This also helps reduce maintenance costs for routine painting or striping. Additionally, the PICP system is the most environmentally friendly of the three options under consideration.

When the various labor, construction and materials' expenditures are calculated on best case scenarios, the bituminous pavement including storm sewer design and construction, grading and miscellaneous is estimated at \$3,239,641. For the partial PICP with the required underground storage tanks, the cost drops to \$2,860,316, a 12% savings. The PICP system which eliminates the need for storm sewers and has no miscellaneous costs comes in at \$2,148,068. **This represents a remarkable savings of 33% or \$1,091,573 less than the cost of the bituminous system.**

While any of the above solutions would provide LifeTime Fitness with a suitable parking lot and driveways, the total PICP system is leagues above the other two options in aesthetics, practicality and overall costs, in addition to best protecting the environment below the surface.

When all things are considered, the PICP system scores as the clear winner in terms of cost, aesthetics and environmental benefit.

Case Study: St. John's Church

PROBLEM: The site required a permeable solution capable of controlling rainwater pooling and runoff, while delivering long-term durability under light vehicular traffic. The surface also had to be pedestrian-friendly.

SOLUTION: Landscape Architect, CLH Design, chose a Belgard® permeable system because of the company's established reputation in the area of stormwater management. The specific product was chosen (Aqua-Bric® Type 1) because it is ADA compliant and features smaller void openings than competing products.

Installation Size:
15,000 sq. ft.

Installation Time:
2-months

Installation Method:
Hand-installed

Value of Hardscaping:
\$100,000.

Landscape Architect:
CLH Design

Contractor:
Hickory Hardscapes

Belgard Rep.:
Darryl Sapp

Pavers Supplied By:
Adams Products



Runoff study conducted by the University of Tennessee

Under the direction of Dr. John Tyner, Associate Professor of Biosystems at the University of Tennessee, a study was conducted to measure runoff before and after system installation. In an attempt to collect samples from beneath the permeable system, monitoring equipment capable of collecting data on time, flow rates and storm conditions was installed at the lowest point of the site. The equipment remained in place through multiple storm events.

According to Dr. Tyner, the capacity of the paver system to manage runoff was such that his team was never able to collect a sample from the stone base beneath the pavers. Perplexed over the difficulty they were experiencing in obtaining a water sample, Dr. Tyner drove to the site during a heavy rainfall. He observed a minimal amount of water running across the sidewalk adjacent to the monitoring site. A check of the equipment validated the fact that almost all of the rainwater was being retained or percolating on-site.



Teledyne ISCO 3700 Sampler

Case Study: Pinellas Park Arts Center

PROBLEM: The larger of the two lots to be developed fell within a flood plain. Managing stormwater runoff was a paramount issue that required careful planning in order to comply with Southwest Florida's water management requirements for storage volume and infiltration. The lot also had to be durable, attractive and ADA compliant.

SOLUTION: The low impact solution was achieved through a combination of precise engineering and the use of a proven permeable pavement system. The system chosen was one developed by Belgard® Hardscapes, a leader in the development of permeable technology.

Installation Size:
70,000 sq. ft.

Installation Time:
3-months

Installation Method:
Hand-installed

Value Of Hardscaping:
\$515,000.

Developer:
City of Pinellas Park

Engineers:
Cardino TBE, Bryan Zarlenga PE

Paver Contractor:
Paver & Setting Bed Installation:
Paver Crafters.
Base & Sub-base Installation:
MTM Construction

Belgard Rep.:
Bill Megrath

Manufacturer:
Oldcastle Coastal



Utilization of Available Space Maximized

A major key to the success of the Eco-Holland Stone permeable pavers in this application is in the careful and thorough preparation of the substrate levels beneath the surface. It begins with the excavation of all unsuitable materials in the parking areas and replacing it with drainable soil to a depth of about one foot. A layer of non-woven geotextile material was installed covering the soil subgrade and extends to the sides of the curbing. Eight inches of #4 stone was placed on top of this material and compacted with a ten ton vibratory roller. This was followed by a 4 inch layer of #57 stone and also compacted. Two inches of #89 aggregate then serves as a bedding course for the Eco-Holland Stone pavers. The joints of the permeable pavers are then filled with a fractured DOT joint chip material. Rainfall easily passes through the joints and infiltrates its way into the underlying stone reservoir. This temporarily stores the surface runoff allowing it to slowly percolate directly into the soil below ultimately recharging the aquifer.

While the north lot is totally surfaced with Eco-Holland Stone permeable pavers, the smaller south lot employs these pavers for the drive aisle and parking spaces are on the grass. Water quality treatment for the north lot is provided in the pervious pavement system through dry retention, while in the south lot water quality is realized in the equalized ponds through effluent filtration. An added Belgard benefit of the north lot design is that with the stormwater held beneath the pavers, Pinellas Park was able to create a soccer field in the area that otherwise would have been needed for a stormwater retention basin.

Permeable Interlocking Concrete Paving Stones



Aqua-Bric®

DIMENSIONS: 4 15/16" × 9 7/8" × 3 1/8"
(125mm × 250mm × 80mm)

Basic in form, with a clean, modular shape, Aqua-Bric permeable pavers are an attractive, yet practical choice, easily adaptable to a wide range of design options. Strength and durability are combined with environmental compatibility, resulting in a permeable paver that's ideally suited for pedestrian or light vehicle applications.

Reg. TM of Advanced Pavement Technology, Inc.



Aqua-Bricloc®

DIMENSIONS: 4 7/16" × 8 7/8" × 3 1/8"
(112.5mm × 225mm × 80mm)

Aqua-Bricloc meets American Disabilities Act (ADA) standards and is designed to handle extremely heavy traffic, making it ideal for a wide range of applications. Aqua-Bricloc's unique shape also allows for combination with other paver shapes to achieve any number of attractive patterns. Aqua-Bricloc is an attractive, yet environmentally sound choice for an industrial grade parking lot or street.

Reg. TM of Advanced Pavement Technology, Inc.



Aqua-Bric® Type 4

DIMENSIONS: 4 15/16" × 9 7/8" × 3 1/8"
(125mm × 250mm × 80mm)

Belgard offers a pedestrian-friendly and heavy-duty stormwater management system with Aqua-Bric Type 4 permeable pavers. Aqua-Bric Type 4 is a superior choice for areas with high foot traffic – especially for those in high heels or wheel chairs. Aqua-Bric Type 4 permeable pavers are an attractive, natural way to handle stormwater runoff, ultimately improving water quality and reducing pollution.

Reg. TM of Advanced Pavement Technology, Inc.



Aqua Roc™

DIMENSIONS: 4 1/2" × 9" × 3 1/8"
(114.3mm × 228.6mm × 80mm)

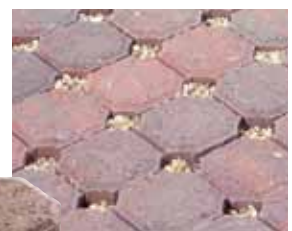
Aqua Roc is a versatile paver featuring not only the environmentally-friendly benefits of a permeable paver, but also high visual appeal, low maintenance, and proven durability. Aqua Roc's versatile pattern range allows for flexible design options, making it an excellent choice for vehicular use.



Drainstone®

DIMENSIONS: 4" × 8" × 3 1/8"
(101.6mm × 203.2mm × 80mm)

Drainstone permeable pavers effectively minimize paved areas' impact on the local groundwater system. Providing the same strength, durability and range of design options as conventional pavers, Drainstone permeable pavers are the natural way to handle stormwater runoff, ultimately improving water quality and reducing pollution in surface waters.





Eco-Brick®

DIMENSIONS: 3 15/16" × 7 7/8" × 3 1/8"
(100mm × 200mm × 80mm)

Economically sound. Eco-Brick delivers results in both cost-effectiveness and long-term durability in harsh climates, particularly those with extreme freeze/thaw cycles. It's not only environmentally sound, but responsible too-surpassing EPA stormwater requirements while creating curb appeal that's short of remarkable.

Reg. TM of Advanced Pavement Technology, Inc.



Eco Dublin®

DIMENSIONS: 3 7/16" × 6 7/8" × 3 1/8"
6 7/8" × 6 7/8" × 3 1/8"
6 7/8" × 10 1/4" × 3 1/8"
(87.78mm × 174.57mm × 80mm)
(174.57mm × 174.57mm × 80mm)
(174.57mm × 261.35mm × 80mm)

Smart-looking style meets smart science. The classic look of cut stone combines with contemporary materials technology in Eco Dublin, the latest addition to Belgard's Environmental Series of permeable pavers.



Eco-Holland™

DIMENSIONS: 3 15/16" × 7 7/8" × 3 1/8"
(100mm × 200mm × 80mm)

Belgard's Eco-Holland Stone pavers feature the look of classic brick and were designed to reduce stormwater runoff by allowing a high level of natural filtration. This permeable pavement system is ADA compliant and suitable for light vehicular traffic.

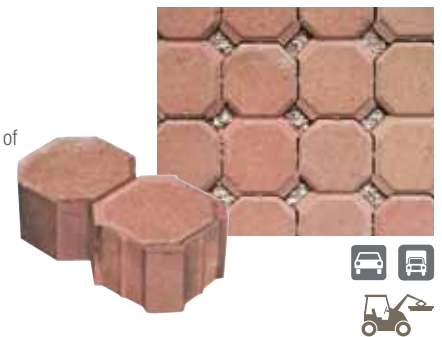


Eco-Stone®

DIMENSIONS: 4 1/2" × 9" × 3 1/8"
(115mm × 230mm × 80mm)

Concern for the earth's resources inspired the development of Eco-Stone interlocking permeable pavement. The product's unique design controls site runoff by allowing rainwater to filter or drain into the soil.

Reg. TM of F. Von Langsdorff Licensing Limited

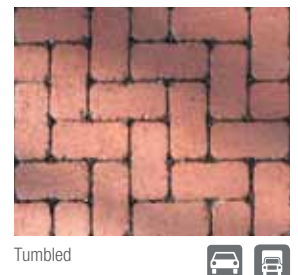


RainPave™

DIMENSIONS: 4" × 8" × 2 3/4"
(102mm × 204mm × 70mm)

RainPave clay brick pavers provide an environmentally-friendly option for preserving natural water drainage through a classic segmental pavement. With the look of a traditional, antiqued clay pavement, RainPave is the perfect choice for areas where pervious surface restrictions exist or where on-site retention/infiltration is mandated.

RainPave is a registered trademark of Pine Hall Brick, Inc.



Tumbled

Permeable Interlocking Concrete Paving Stones



Stormpave™

DIMENSIONS: 4" × 8" × 2 3/4" / 4" × 8" × 2 1/4"
 (102mm × 204mm × 70mm /
 102mm × 204mm × 60mm)

StormPave is ideally suited to preserve natural water drainage in a smooth segmented pavement. With large spacers for open joint drainage and a maximum opening of less than a half inch, this clay paver meets ADA requirements making it perfect for plazas, pathways, parking lots – particularly those at colleges or universities where on-site LID stormwater management techniques are employed.

StormPave is a registered trademark of Pine Hall Brick, Inc.



Subterra® Stone

DIMENSIONS: 7 5/8" × 11 3/8" × 3 1/8"
 (194mm × 289mm × 80mm)

Great-looking and green. Subterra Stone may very well be the most attractive, natural-looking permeable paver on the market. With its false joint structure, Subterra offers the elegant look of natural chiseled stone, yet it is easy to install. Combined with its unsurpassed environmental benefits, Subterra is ideal for those who desire environmental stewardship without compromising beauty and style.



Note: Turfstone is only considered as a permeable paver when it is filled with proper joint fill material. When used as a grass paver, the infiltration rate, and in turn the functionality as part of a PICP system, is significantly reduced.



Turfstone™

DIMENSIONS: 15 3/4" × 23 5/8" × 3 1/8"
 (400mm × 600mm × 80mm)

Environmentally responsible. Nowadays, concern for the Earth's resources is at an all-time high. In response, Belgard has created the environmentally responsible Turfstone paver. This high-tech design allows rainwater to be gradually filtered back into the soil naturally, resulting in the control and stabilization of soil erosion. Common applications include fire access lanes and remote parking.



All dimensions are nominal. Some slight regional differences may exist.

To confirm product dimensions, please contact your local Belgard Commercial Technical Representative.



Identifies those products that can be installed mechanically. Some regional differences exist. For full details contact your local Belgard Representative.

ADA COMPLIANT

VEHICULAR-80MM

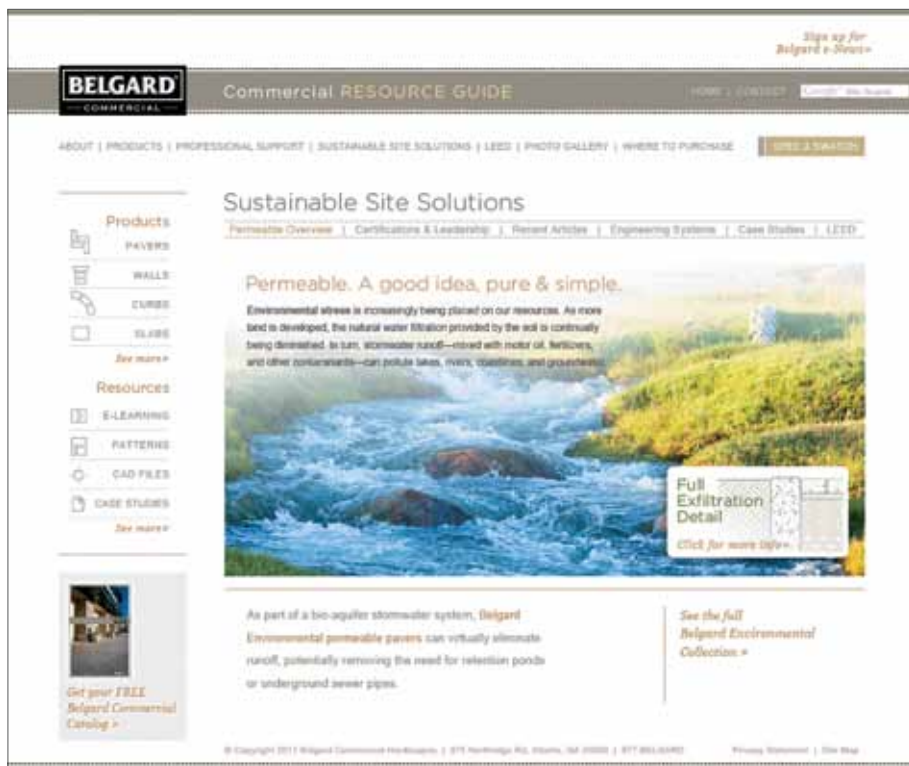
LT. VEHICULAR-80MM



New Belgard Color Selection Guide

Belgard Provides the Tools that Make Your Job Easier.

For details concerning the tools currently available to our Design Professionals and Authorized Contractors, please contact your local Belgard Representative or visit: www.belgardcommercial.htm.



A totally New Belgard Commercial Website will be online soon.

The Belgard® Difference

Belgard Commercial is part of the Oldcastle Architectural Group, the largest concrete products manufacturer in North America. With over 180 locations and a company culture characterized by a commitment to customer satisfaction, Oldcastle adheres to a level of service and consistency that no other supplier can match. Our combination of local market presence and national capabilities allow us to meet and exceed the demanding needs of an ever-changing industry.

Belgard® Paving Stones are manufactured to exacting standards which ensure that they exceed ASTM C-936-09 "Standard Specification for Solid Concrete Interlocking Paving units".

Professional Support

Continuing Education

From our popular "Lunch & Learn" seminars, to the industry-acclaimed Belgard University, we offer continuous training and educational opportunities across the country and throughout the year for design professionals and contractors.

Technical Resources & Patterns

View and download Belgard paver and wall unit laying patterns and technical specifications in DXF and DWG formats.

BIM & CAD Files

Access a constantly expanding library of easy-to-download Building Information Modeling (BIM) CAD drawings of Belgard pavers, wall units and patterns.

Case Studies

View featured projects that employ Belgard Hardscapes to achieve remarkable results and satisfied clients. Documents available in downloadable PDF format.

e-Literature Downloads

An extensive online library of Belgard product literature, available in downloadable PDF format.

e-Learning

Select from a range of topics highlighting specific applications and benefits offered by Belgard hardscape products.

Order A Sample

Order an actual example of a Belgard paver or wall product that you are interested in by selecting from our online sample inventory.

Details available on <http://www.belgard.biz/tools.htm>

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