

Invisible Structures, Inc. family of other products for site improvement.

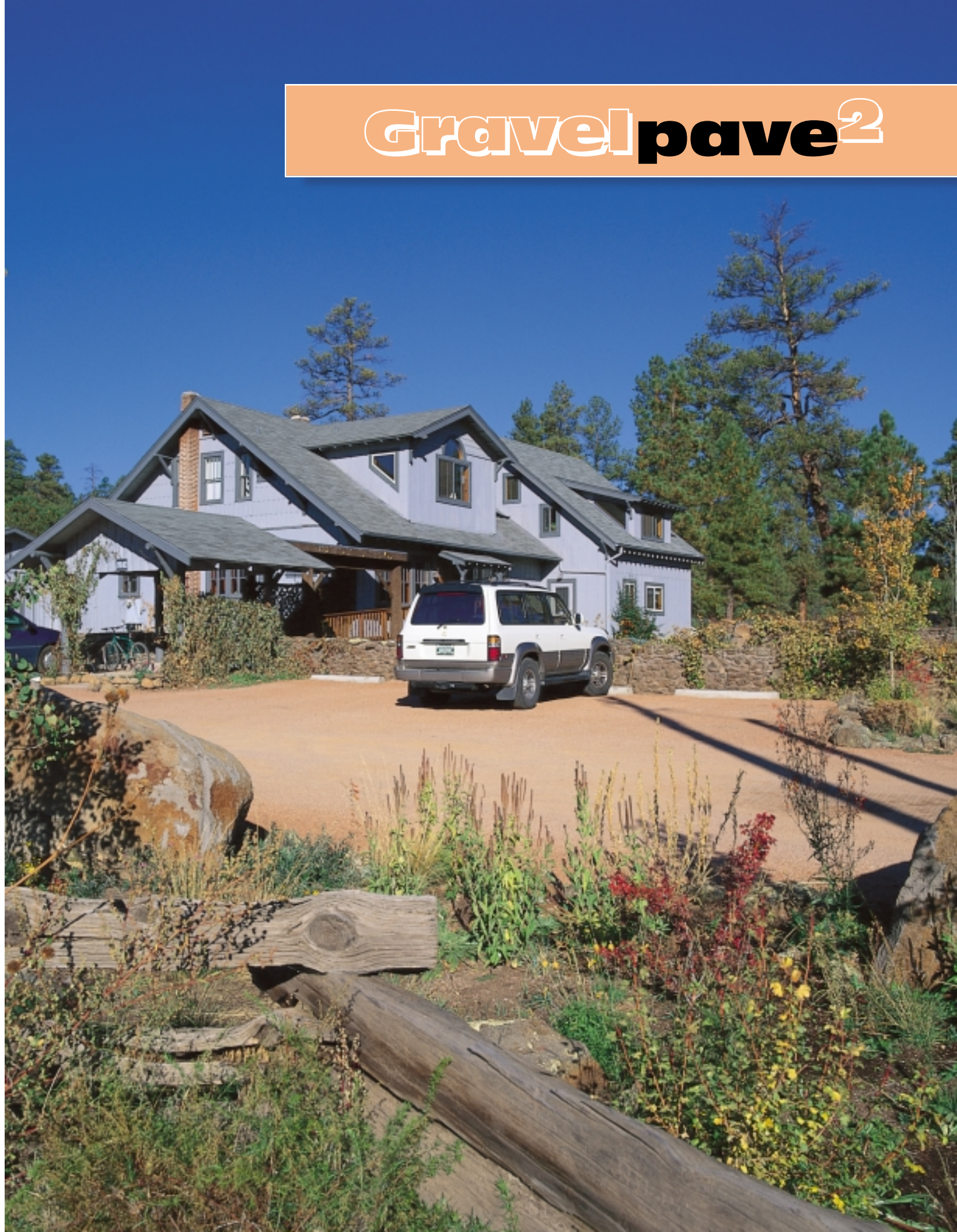


Invisible Structures — Standard Product Roll Sizes

Model	Width		Length		Diameter		Area		Weight	
	m	ft	m	ft	m	ft	m ²	ft ²	kg	lbs
1010'	1	3.3	10	32.8	0.5	1.7	10	108	19	41
1020	1	3.3	20	65.6	0.8	2.7	20	215	37	82
1050	1	3.3	50	164	1.2	4	50	538	93	205
1520	1.5	4.9	20	65.6	0.8	2.7	30	323	56	123
1550*	1.5	4.9	50	164	1.2	4	75	807	139	308
2020'	2	6.6	20	65.6	0.8	2.7	40	430	75	164
2050*	2	6.6	50	164	1.2	4	100	1,076	186	410
2520	2.5	8.2	20	65.6	0.8	2.7	50	538	93	205
2550*	2.5	8.2	50	164	1.2	4	125	1,346	233	513

*Most popular roll sizes, usually in stock.
*Roll sizes marked with asterisks should be installed by lifting machines only. All other rolls can be installed manually (2 people advised). Rolls apply to Grasspave², Gravelpave², Draincore², and Slopetame². Custom roll sizes available by request.

Gravelpave²



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www.invisiblestructures.com
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Introduction

Providing designers a second option of porous pavement that would tolerate high frequency and low speed traffic was our goal in 1993 when we developed Gravelpave². By molding our 2" diameter × 1" high ring and grid structure onto a non-woven polyester filter fabric we were able to create a new product to contain fine gravel and prevent particle migration and rutting.

Gravelpave² is sold in large rolled mats to provide fast installation for the top wearing course on roads, driveways, parking lots, or trails. A variety of colors of 3/16" minus sharp gravel is used to fill Gravelpave² mats, which come in earth tone colors to visually blend. This smooth, firm, and stable surface accommodates virtually any tire, ranging from garbage trucks and tractor trailer rigs to bicycles and wheelchairs. The very low maintenance of Gravelpave² is a big bonus compared to traditional hard surfaces.

The well-groomed finished appearance is porous, allowing for storm water to percolate into the cross section and replenish historical water tables. Trees can be maintained or introduced into parking lots to help maintain a cooler environment.

History of Porous Paving

Concrete turfblock for grass paving began mid-1940, and plastic versions began in the late '70s and early '80s. We introduced Grasspave² in 1982. While perfect for low traffic volumes, grass is a living plant which has limitations for withstanding high

traffic frequencies. In 1993, by reinforcing and stabilizing gravel instead of grass, we lowered the maintenance requirements and increased wearability. Polyester filter fabrics attained popular acceptance for allowing water to filter through while also serving as a weed barrier. The attachment of the filter fabric to our plastic ring-and-grid structure to form a container occurs in the injection molding process where molten plastic permanently bonds with the fabric.

CSI Adds 02795 — Porous Paving

After twelve years of lobbying, Construction Specifiers Institute (CSI) finally recognized the porous paving industry in 1997 with its own specification number, used for both grass and gravel reinforced paving products. Sweets Catalog had given Invisible Structures two alternate numbers in an effort to include us in their Site Work Section from 1983.

Improved Water Quality

Filtering storm water is our specialty! Rain collects airborne dust particles and pollutants such as vehicle exhaust and brake dust. On impervious surfaces such as asphalt and concrete, this stormwater (non-point source pollution) is collected, concentrated, and discharged into surface waters, affecting vegetation and wildlife. The President's Clean Water Action Plan and the EPA are regulating storm water quality by requiring silt fencing, erosion control, and decontamination systems. The natural way to clean

Cover: Grand Canyon Trust, Flagstaff, AZ — Thirty-car employee parking lot after several years of snow removal and excellent maintenance. Spaces are defined with concrete bumpers.



Mitchell Arena, University of South Alabama, Mobile AL — Nearly three-acre parking facility using Grasspave² for bays and Gravelpave² for aisles. This system reduced maintenance costs compared to asphalt and restricted storm water runoff, which contributed to prior downhill intersection flooding.



Rocky Mountain Village Easter Seals Camp, Empire, CO — Wheelchair-accessible trail built by Volunteers for Outdoor Colorado using existing site soils.

3.03 Installation of Gravelpave² Units

- A. Install the Gravelpave² units by placing units with rings facing up, and using snap fit fasteners provided along each edge to maintain proper spacing and interlock the units. Cutting can be performed with pruning shears and scissors, or portable power saw. Units shall be anchored to the base course, using anchors described above, as required to secure units in place from movement by traffic, at an average rate of 2 pins per square meter (high speed, heavy vehicles, fast turning movement will require additional anchors, up to 4 to 8 pins per square meter). Tops of rings shall be flush, or slightly below the surface of adjacent hard surfaced pavements.
- B. Install gravel into rings after the units are anchored by “backdumping” directly from a dump truck, or from buckets mounted on tractors, which then exit the site by driving forward over rings already filled. Sharp turning of vehicles on bare rings must be avoided. The gravel is then spread laterally from the pile using power brooms, blades, flat bottomed shovels and/or wide “asphalt rakes” to fill the rings. A stiff bristled broom should be used for final “finishing.” The gravel should be “compacted,” if necessary, by using a vibrating plate or small roller, with the finish grade no less than the top of rings and no more than 6mm (0.25”) above top of rings.

- C. If a binder for fill stone is desired, due to traffic speed, concentrated water flow, or other reason, use of cement, mixed dry at 7% by weight, placed into rings after thoroughly wetting the base, then lightly misting the surface after fill and compaction, then finally covering with a water resistant tarp material for a period of 3 days, or until the mixture has bonded.

3.06 Cleaning

- A. Remove and replace segments of Gravelpave² units where three or more adjacent rings are broken or damaged, reinstalling as specified, with no evidence of replacement.
- B. Perform cleaning during the installation of work and upon completion of the work. Remove from site all excess materials, debris, and equipment. Repair any damage to adjacent materials and surfaces resulting from installation of this work.

If you have any questions regarding this specification, please call Invisible Structures, Inc. 1-800-233-1510

Version 6/99



Private Residence, Arnold, MD — Exclusive water-front property, adjacent to environmentally sensitive Chesapeake Bay, improved by winding Gravelpave² drive.



Golf Course Applications Using ISI Products

1 Grasspave²

- Primary and overflow parking
- Cart paths (irrigated zones)
- Cart staging areas
- Pedestrian traffic areas
- Road shoulder stabilization

2 Gravelpave²

- Parking aisles
- Cart paths (non-irrigated)
- Cart storage areas
- Pedestrian traffic areas
- Maintenance yards and roads

3 Draincore²

- Green and tee underdrains
- Sand trap and bunker drains
- Retaining wall drains
- Problem area French drains
- Tunnel/underpass drainage

4 Slope tame²

- Vegetation stabilization
- Pond shoreline stabilization
- Bunker slope stabilization
- Stream edge stabilization
- Steep slope erosion control

storm water is by percolation through soils that are usually active with bacteria. Gravelpave² allows rain to fall on a developed site and quickly replenish historical water tables with clean filtered water. There is considerable cost savings with reduced or eliminated drainage systems and EPA pollution control requirements.

Applications

Storm Water Management

Gravelpave² can easily handle storm water from an intense storm dropping three inches of rain in less than thirty minutes! In one square meter (40" × 40") there are 144 rings, 2" diameter by 1" high. With 1" of gravel-filled rings and a standard road base of sandy gravel 6" thick, our Gravelpave² system will percolate approximately 35 inches of rain per hour! The 7-inch section can store 3.2 inches of water (about 35% void after compaction). Alternatively, hard surfaces, such as asphalt and concrete, shed 95% of storm water.

The City of Chicago has spent billions of dollars on its TARP storm sewer project since the 1970s to temporarily separate storm water from waste water flows, and it is still not finished. Concrete alleys contribute to additional runoff. Asphalt alleys must be replaced every 10-15 years and add pollutants to the runoff. The original cinder alleys were not an ideal surface but at least they drained in place!



Burger King, Henderson, NC — Porous parking areas around building. Asphalt areas are graded to drain into the Gravelpave² bays.

Chicago is not alone with its storm water runoff problem. North Carolina has enacted statewide legislation requiring developers of new sites to restrict hard surface coverage and contain storm water on site. Porous parking lots, mainly the parking bays, are being approved for a variety of commercial installations.

Increased Trees and Preservation

Many towns and cities are becoming aware of the Cool Communities Program funded by the Department of Energy. The goal is to reduce ambient air temperatures and smog generation and improve air quality in cities by using light colors for building and pavement surfaces and increasing trees and vegetation, i.e., porous paving. Gravelpave² can be filled with light-colored stone and support air and water access to tree roots.

Eighty percent of tree roots are concentrated in the top 12" of soil. Root system diameters are similar to canopy diameters. Gravelpave² prevents compaction while allowing for ample amounts of water and air. Cars can then drive and park below tree canopies. To save beautiful mature trees by building a porous paving cross section on top of existing tree ground, please see our tree preservation detail available on CD-ROM or web site.

Parking and Driveway

Stadiums, arenas, shopping centers, maintenance access, parks, residential drives, golf courses, campus parking, and church parking are locations appropriate for Gravelpave². The University of

PART 2 — PRODUCTS

2.01 Availability

A. Manufacturer: (Gravelpave²) Invisible Structures, Inc., 20100 East 35th Drive, Aurora, Colorado 80011. Call from USA and Canada 800-233-1510 toll free, (International 303-373-1234), Fax 800-233-1522 (International 303-373-1223).

2.02 Materials

A. Base Course: Sandy gravel material from local sources commonly used for road base construction, passing the following sieve analysis.

BASE	% Passing	Sieve Size
	100	¾"
	85	½"
	60	#4
	30	#40
	5	#200

- Sources of the material can include either "pit run" or "crusher run." Crusher run material will generally require sharp sand to be added to mixture (25–35% by volume) to ensure long term porosity.
 - Alternative materials such as crushed shell, limerock, and/or crushed lava may be considered for base course use, provided they are mixed with sharp sand (25–35%) to ensure long term porosity, and are brought to proper compaction. (Crushed shell and limerock alone can set up like concrete without sand added.)
- B. Gravelpave² Paving Units: Lightweight injection molded plastic units 1.0m × 1.0m × 0.025m (40" × 40" × 1" high, 10.76 ft² each) with hollow rings rising from a strong open



Garden of the Gods Park, Colorado Springs, CO

grid with a geotextile fabric heat fused to the bottom of the grid. Units will be shipped in pre-assembled rolls of various dimensions. Loading capability is equal to 5,700 psi when filled with sand, over appropriate depth of roadbase. Standard colors are milk chocolate, pewter grey, terra cotta and cashew brown. Unit weight = 1.97 kg (4.34 lb.); volume = 8% solid.

C. Gravel Fill: Obtain clean fine decorative gravel to fill the 25mm (1") high rings and spaces between the rings, with the following sieve analysis:

FILL	% Passing	Sieve Size
	100	#4 Screen
	80	#8 Screen
	50	#16 Screen
	30	#30 Screen
	15	#50 Screen
	5	#100 Screen

D. Anchors: Anchor pins shall be 12" or 8" long nails with "fender" type washers 5mm id × 37mm od (¾" id × 1½" od), all galvanized metal or similar coating.

PART 3 — EXECUTION

3.01 Inspection

A. Examine subgrade and base course installed conditions. Do not start Gravelpave² installation until unsatis-

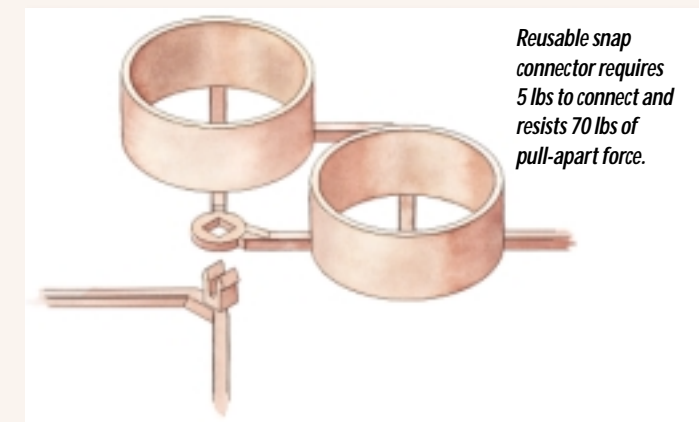
factory conditions are corrected. Check for poor drainage, improperly compacted trenches, debris, and improper gradients.

B. Installation constitutes acceptance of existing conditions and responsibility for satisfactory performance. If existing conditions are found unsatisfactory, contact Project Manager for resolution.

3.02 Preparation

(Ensure that subbase materials are structurally adequate to receive designed base course, wearing course, and designed loads. Ensure that grading and soil porosity of the subbase will provide adequate subsurface drainage.)

A. Place base course material over prepared subbase to grades shown on plans, in lifts not to exceed 150mm (6"), compacting each lift separately to 95% modified Proctor. Leave 25mm (1.0") for Gravelpave² unit and gravel fill to final grade.



Specifications

SECTION 02795 — Gravelpave² Porous Paving

PART 1 — GENERAL

1.01 General Provisions

- A. The Conditions of the Contract and all Sections of Division 1 are hereby made a part of this Section.

1.02 Description of Work

A. Work Included:

1. Provide and install sandy gravel roadbase as per Geotechnical Engineer's recommendations and/or as shown on drawings, to provide adequate support for project designs loads. See 2.02 Materials.
2. Provide Gravelpave² Paving products including Gravelpave² units, anchors and installation per the manufacturer's instructions furnished under this section.
3. Provide and install fine decorative gravel to fill the Gravelpave² units.

B. Related Work:

1. Subgrade preparation under Section 02200 — Earthwork.
2. Subsurface drainage materials — Section 02710 — Subsurface Drainage, when needed.

1.03 Quality Assurance

- A. Follow Section 01340 requirements.
- B. Installation: Performed only by skilled work people with satisfactory record of performance on landscaping or paving projects of comparable size and quality.



Jim is carrying Model 1010, which is one meter by ten meters, or 3.3' by 33' long, 108 sf, trail reinforcement for remote locations — weight 41 pounds. Tools necessary include shovel, hammer, pruning shears, and anchors. For steep trails, Gravelpave² with erosion-stopping crossbars can be ordered.

1.04 Submittals

- A. Submit manufacturer's product data and installation instructions.
- B. Submit a 10" × 10" section of Gravelpave² product for review.
Reviewed and accepted samples will be returned to the contractor.
- C. Submit material certificates for base course and sand fill materials.

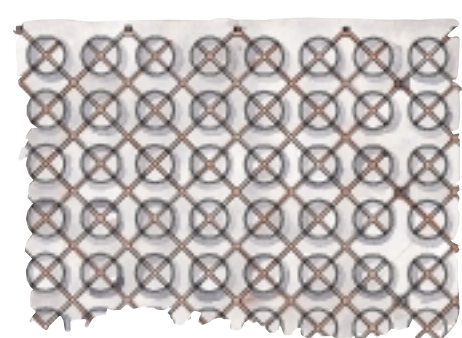
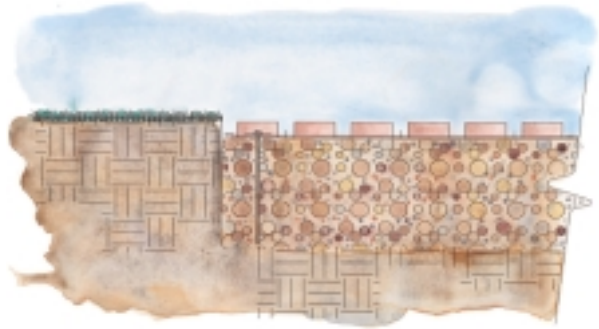
1.05 Delivery, Storage, and Handling

- A. Protect Gravelpave² material units from damage during delivery and store under tarp when time from delivery to installation exceeds one week.

1.06 Project Conditions

- A. Review installation procedures and coordinate Gravelpave² work with other work affected.
- B. All hard surface paving adjacent to Gravelpave² areas, including concrete-walks and asphalt paving, must be completed prior to installation of Gravelpave².
- C. Cold weather:
1. Do not use frozen materials or materials mixed or coated with ice or frost.
 2. Do not build on frozen work or wet, saturated or muddy subgrade.
- D. Protect partially completed paving against damage from other construction traffic when work is in progress.
- E. Protect adjacent work from damage during Gravelpave² installation.

Compacted sandy gravel road base placed above compacted subgrade, 95% modified Proctor density. Gravelpave² rolls are laid, pinned, and filled with clean, sharp gravel.



*Available in 9 roll sizes.
Squares weigh 1.97 kg (4.34 lb) each.
Colors: Cashew Brown, Milk Chocolate, Pewter Grey, Terra Cotta.
Resin: HDPE.
Strength: 402 kg/cm² (5,720 psi).*



Frostburg State University, Frostburg, MD — Student dormitory parking lot improved with excellent drainage advantages of Gravelpave².

South Alabama used Gravelpave² for aisles and Grasspave² for parking bays at their new Mitchell Center Arena. Frostburg State University in Maryland and Vail Lutheran Church both have Gravelpave² parking lots, which are shown in this brochure.

Storage Yards, Utility Access, RV Parking

Gravelpave² is a low maintenance, reliable surface with excellent drainage, easy accessibility, and no rutting. Materials can be placed on top for long periods of time without damage to the gravel or the stored items. Examples include car and truck dealerships and factories; steel, brick and lumber yards; nurseries and greenhouses; stock, boat and mobile home yards.

Pedestrian and Horse Trails and Paths

Garden paths, greenhouse aisles, sidewalks, park paths, and wilderness trails in Gravelpave² are also stable for strollers, bicycles, wheelchairs, and horses. There are no puddles or mud, and traction is very good. Tree roots break up hard surface sidewalks. Our mats flex to accommodate such shifts and gradient changes, and with the high proportion of air, roots are discouraged from moving upward.

Wilderness Trails

Pedestrian Access through the Wilderness (PAW) worked with Volunteers for Outdoor Colorado in constructing demonstration trails for American Disabilities Act (ADA) access at Rocky Mountain Village Easter Seals Camp. Please see our two photos included in this brochure. Trail design testing reports of materi-

als and methods used at five national sites will be made available when completed.

Gravelpave² is ideal for remote locations where it is necessary for installers to carry in materials. Advantages of Gravelpave² trails include lightweight construction materials (one Model 1010 roll is 3.3' × 33' long (108 sf) and weighs 41 pounds), effective surface containment, and reduced base course demands — often using site soils. Pins, cement, shovel, hammer, and pruning shears are simple materials used for installation. Volunteer labor can produce quick, well-constructed trails. Down-slope or cross-trail storm water won't wash out fill when 7% cement is added.

Golf Cart Paths

Gravelpave² golf cart paths give the look of a natural path through trees, along fairways, and around greens. With crushed brick, stone, gravel, or sand, the appearance will be softer than concrete, and traction excellent on sloped paths. The flush surface requires no trimming or edging, but may be included if desired.

Industry Challenges

Overcoming Stereotypes and Hard Surface Requirements

Gravelpave² system has had to overcome some long-standing negative stereotypes regarding gravel driveways, roads, and pathways. Asphalt was the “improved” driving surface over dirt and gravel roads and driveways, free of washboarding and rutting,



Taco Bell, Henderson, NC — Remote gravel parking bays receive storm water from asphalt areas.



Fort Shantok State Park, The Mohegan Tribe, Uncasville, CT — Low-maintenance parking lot stable for cars, strollers, and wheelchairs. This lot is plowed in the winter.

ponds and drainage ditches required by local laws when lots are paved with blacktop. So, when you take that into account, the overall cost is about the same as asphalt. Because pervious paving is tree friendly — i.e., allowing air and water through for trees to feed naturally — additional parking can be gained by paving under drip lines.”

The *Mobile Register* article further says: “But perhaps the biggest reason more sites don’t install porous systems in Mobile is that the idea has been virtually outlawed by the city. The city’s zoning laws, written in 1967 and revised in 1991, require hard-surface parking for most commercial operations. ‘The rationale behind the requirement was to prevent unsightly, muddy parking areas,’ said Chris Boone, deputy director of land use administration for the city.”

Dale Sandine, groundskeeper for the Orange Bowl, said about the Grasspave² system (our grass paving product installed in 1995), “It looks better, it’s environmentally better, and it’s economical because we didn’t have to put in as much drainage. It can rain like a hurricane and we still won’t have ruts and stuff.” A copy of this article is available upon request.

Brief Project Histories

Grand Canyon Trust

Grand Canyon Trust in Flagstaff, Arizona, was one of our first all Gravelpave² parking lots (shown on the cover). Since they are a not-for-profit organization, very concerned about the environment, they chose Gravelpave² for their staff parking lot of approximately 30 cars. Concrete bumpers define the spaces and no striping was used. Initially, the contractor did not pin the Gravelpave² mats down to the base course and we discovered during the first winter how important the pins were when freezing slush under tires tugged at the mats and gravel. Fortunately the folks at Grand Canyon Trust were willing to work with the contractor, and 12” pins with washers were used to secure the mats to the ground. No displacement occurred in the second or third winters, and no snow plow damage was seen, even with regular snow (in amounts of 30”-plus) removal.

Vail Lutheran Church

Vail, Colorado, has enacted regulations restricting storm water runoff. Our Gravelpave² was used for the parking bays at the Vail Lutheran Church and School (see photo in this brochure). Frequent winter snow plowing removes top layers of snow, leaving approximately 1” of snow, which melts as quickly as if on asphalt or grass.

Frostburg State University

Frostburg State University in Frostburg, Maryland, installed Gravelpave² for a dormitory parking lot (about 50 spaces) which has one entry/egress point. The lot has no striping on the ground, but marks spaces with a white line on high log bumpers. The lot drains well and has corrected a muddy mess.

Wallace Residence

In Savannah, Georgia, Gravelpave² was installed with a 7% cement additive because of their typical tropical downpours and the fact that the particular location was at the lowest point of a major watershed area fed by a four-lane boulevard arterial. The finished product was stabilized sufficiently to handle frequent three-inch flooding without floating off and had the added feature of being the perfect answer to total wheelchair accessibility. Petrus UTR owner Chere Peterson (one of our Partners) went to inspect the site prior to some VIPs arriving to see the installation. Bricklayers had dumped two tons of sand right in the middle of the seventy foot driveway. After the bricklayers relocated the bulk of the sand, they tried to wash off the remainder, much like one would hose off a sidewalk, but they couldn’t because the water just disappeared! An easy solution for the sand removal was a vacuum. Obviously, the Gravelpave² is very porous!

Sales and Technical Support Partners

In addition to the high quality, professional experienced staff at our main headquarters in Colorado, we have excellent Partners representing their geographical areas. They are prepared to assist you locally, at all levels, with your project needs. Please contact us or check our web site for your Partner name and information.

Cal Callahan of MCCA, with offices in Destin, Florida, and Atlanta, Georgia, specializes in environmental paving and erosion control, and offers a wide range of assistance to clients in southeastern United States. By securing the University of South Alabama project and following through with all aspects of client requirements and contractor support, Cal is a distinguished example of our growing list of sales and technical support Partners.

Web Site and CD-ROM

Our product details, drawings, specifications, photographs, slide shows, videos, project information, and staff résumés are available on our web site www.invisiblestructures.com and on our CD-ROM with CAD details. We’re ready to assist you with your design solutions.

Vicki, Bill, and the Folks at Invisible Structures

Patent No. 5,250,340 held by William W. Bohnhoff, ASLA

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Rocky Mountain Village Easter Seals Camp, Empire, CO — Switchback trail does not develop erosion or rutting that would impede wheelchair access and safety. Existing site soils were used as base and fill.

easy to walk on, dust free, with a finished “all-weather” appearance. Communities wrote regulations requiring asphalt or concrete to be used for driveways and parking lots to eliminate the mud holes, rutting, and yearly leveling and addition of new gravel. Those hard surface requirements are still in place today, and are hurdles to overcome toward getting approvals for porous paving, due primarily to misunderstandings of the design and construction differences between porous and impervious pavements.

Traditional pavements, including gravel roads, were always designed to shed water and keep water away from the entire cross-section. Porous pavements are designed to do the opposite — provide structural load bearing support and traffic capacity while welcoming water through the cross-section. This is not difficult to do, and can be done with only slight modifications to material specifications we have used for decades. We encourage state transportation departments to add specification criteria for porous pavements to their design standards and assist local communities with means to properly construct these pavements.

Porous Asphalt and Porous Concrete

The asphalt and concrete associations are well funded. When the public demand for porous paving increased, these industries

introduced porous asphalt and porous concrete as solutions to making their products more agreeable with the environment. At \$4.50 per square foot, porous concrete isn't within the economic reach of most developers.

Earlier studies indicated some short-term success with porosity. Auto fluids, exhaust, worn tire deposits, airborne dust, leaves, debris, and sediments began to fill the voids, rendering the systems useless as a porous paving surface. Vacuuming and periodic high pressure washing is necessary to keep it relatively clean, free of mildew, and open for water movement. With a more open structure, porous asphalt and concrete surfaces are physically weaker and require greater maintenance.

After years of approving and requiring only asphalt or concrete, communities are now suffering from acres of hard, non-porous surfaces. Storm water runoff has increased, causing flooding and property damage to development downstream. Water quality has suffered dramatically, with negative impacts on drinking water supplies and wildlife. Air quality has suffered by increasing ambient air temperatures and resultant smog generation, and through the loss of millions of trees and their natural filtration capabilities.



Fort Negley, Chattanooga Neighborhood Enterprise, Chattanooga, TN — Driveway is stable for auto, bicycle and pedestrian traffic on this two-year-old surface, while allowing storm water infiltration. Note the absence of weeds and car oil stains.

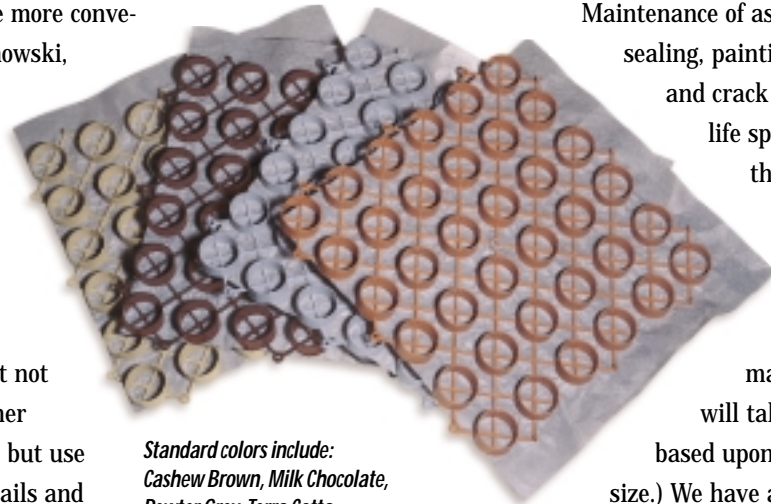


Garden of the Gods Park, Colorado Springs, CO — Horse and pedestrian trail stabilization to prevent ruts previously as deep as three feet. Horse traffic contributes to loose soil erosion without Gravelpave². Terra Cotta rings were used to match existing sandstone soils.

gravel colors so they will be less visible should some portion of the ring show. All plastic colors contain UV inhibitors to retard sun damage. A small amount of excess stone fill should be left above the top of rings to provide visual cover and additional UV protection. This excess will migrate, but usually not very far.

1999 New Snap Fit Fastener

This improvement over heat-welded peg and hole connectors will make assembly on site more convenient. Our engineer, Jim Czarnowski, has designed a two-pronged arrow that fits into a rectangular slot. Simply push the slot over the prongs to snap together easily. To take them apart, just squeeze the prongs together and lift off the slot. Should the fasteners of one mat not align over the distance of another mat, then do not connect them, but use anchor pins (or 8" ring shank nails and large washers) to secure the mats along the seam. Forcing the alignment can cause the mats to ripple and not lay down evenly. The two mats may have been molded from two different batches of plastic resin.



Standard colors include:
Cashew Brown, Milk Chocolate,
Pewter Grey, Terra Cotta.

Not Harmful to the Environment

The HDPE plastic, also used for food containers, is non-biodegradable and has UV inhibitors. The polyester filter fabric backing is a useful weed barrier. It is not necessary to apply any chemicals to retard weeds, but a few aggressive plants may need to be removed with Roundup™, which is not harmful to the environment. Roundup™ accelerates leaf growth and the roots can't keep up, so the weed dies.

Snow Removal Is Not a Problem

The cover photograph showing Grand Canyon Trust installation in Flagstaff, Arizona, has been plowed since 1996 with little to no damage. Either use experienced drivers who can plow leaving a thin layer of snow, or attach skids to the bottom of the blades. Types and specifications are available upon request.

Price Savings of Gravelpave² Over Asphalt

When asphalt is compared with Gravelpave², the initial product and installation cost is higher for Gravelpave². Some designers stop at this point and disregard using porous paving. However, when one considers savings in long-term maintenance costs, Gravelpave² is a bargain, as illustrated in the following paragraph. Additional costs of asphalt include: Critical grading,

drainage pipe, catch basins, manholes, outfalls, lost revenue from land dedicated to detention basins, storm water treatment systems, and dealing with the impacts downstream.

A. (Andy) E. Lindsey, Director of Grounds Maintenance, University of South Alabama, in his written analysis dated February 18, 1999, compared the cost of our porous system to asphalt pavement using historical data from university records.

Maintenance of asphalt included: Resurfacing and sealing, painting and striping, pothole repair and crack filling. "Over 20-year assumed life span, the 13,944 square yards of the Mitchell Center parking lot would require \$138,603. Since no historical data exist for the porous paving surface at USA, these figures are estimates: 1.6 acres of Grass Pavers will take 2 hours to mow. (This is based upon areas similar in shape and size.) We have assumed 40 mowings per year — once per week for 30 weeks during Bermuda

grass growing season, and 10 times during remaining 22 weeks of the annual ryegrass (overseeded) growing season." Irrigation maintenance, water cost, fertilizer and lime, painting and striping were added. "We have also assumed 4 hours/month of boxblading and leveling in the gravel pave areas. Over 20 years assumed life span, the 7,667 yds² of Grasspave² and 6,277 yds² of Gravelpave², the maintenance total would be \$82,709. The estimated costs of grass/gravel pave system are 40.4% lower than the historical costs of the asphalt."

Storm Water Containment

As written by William Rabb in the *Mobile Register*, March 7, 1999, Mobile, Alabama, there is a serious problem with high volume rains flooding the "intersection of Old Shell Road and University Boulevard, where three people have lost their lives in the past two years." The University of South Alabama is uphill from that intersection and has taken a bold move for their new basketball arena, Mitchell Center, by constructing a porous parking lot using Grasspave² for 450 grass parking bays, and Gravelpave² for gravel aisles. Natural infiltration rates into the parking lot will not add to a collection of water at the intersection downhill, but in fact will reduce the historical runoff from native clay soils.

Reporter Rabb writes about his conversation with Environmental Engineer Spence King: "Permeable paving actually allows more parking spaces, since less of the area has to be occupied by retention



Vail Lutheran Church and School, Edwards (Vail), CO — Flush concrete curbs separate asphalt aisle (not shown) from Gravelpave². It is used daily with frequent winter snow removal.

Installation Procedures

1. Base Course Preparation

Prepare sandy gravel base course to a depth as determined by a soils engineer or to a depth equal to that required under 2" (50 mm) asphalt. Compact with a vibrating plate type compactor or use a heavy motorized roller for large jobs. To test porosity, water with a hose and check to see that water drains readily through the base course before installing the Gravelpave² mats.

Use a sandy gravel (75% sized 3/4" to 1/2" + 25% sand, blended) base course compacted to 95% modified Proctor. For example, in Colorado Class 6 Road Base is used, and in California, Class 2. One key element in designing for porous pavement is to keep "fines" (materials that pass #200 screen) to less than 3% if possible. Greater amounts increase compaction and reduce air voids which restricts percolation.

Note: Base material should not exceed 3/4". Be sure that no rocks protrude, as they will cause the rings to rest unevenly. Large rocks in the mix will not settle evenly. If sources of this mixture are not readily available, it would be better to buy 3/4" gravel (66%) and crusher run or sand (34%) separately and mix them on site prior to placement.

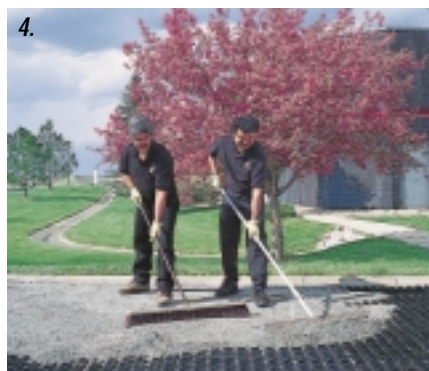
Another benefit to hiring a soils engineer would be to determine the subsoil composition. Clay layers will inhibit good drainage

and can be structurally poor when wet. When you have clay subsoils, we recommend use of non-woven geotextile fabrics (woven fabrics are nearly impervious) to isolate the base course — like a floating slab. Also, be careful to provide outfall drainage in low areas so you don't end up with a bath tub effect. Many sites may have underlying porous layers which can be tapped with French drains or dry wells.

Depending upon native soil conditions, trails and golf cart paths may not need a base course, while parking lots, access roads, and firelanes may require 4" to a maximum of 12" of road base material. Loading is transferred through Gravelpave² rings to the base below, so make sure the base can support the weight of your intended traffic. When multipurpose areas are designed, use the heaviest weight loading requirements to determine base course depth.

Limestone Base Caution

Crushed limestone is used for base material in many geological areas. Lime absorbs moisture, but it also becomes soluble in water and capable of re-cementing into solid rock. One hundred percent limestone will eventually become impervious. To avoid this, mix in clean sharp sand (mason's sand or concrete sand) at a rate of 25-30%. The sand particles will maintain void spaces and prevent limestone from re-cementing to rock.



1. Excavate for base course as determined by soils and loading requirements. Place and compact clean sharp sand and gravel varying in size, not more than 3/4". Check porosity with a hose to see that water flows into the base and drains away. Add subsurface drainage as necessary to low spots.
2. Roll out Gravelpave², aligning the snap fit fasteners. The sun will relax the plastic so it lays flat. Cut the grid between rings using pruning shears, then cut the fabric with scissors. Utilize small pieces in the same spacing.
3. Secure mats with 12" anchor pins and 1 1/2" fender washers, 2 pins per square meter. Use additional pins in high-traffic areas and along the outside edges.
4. Fill rings with clean gravel using rakes and brooms so the rings are covered slightly.
5. Compact gravel with vibrator roller or flat plate compactor (not shown). Water the site to aid the compacting process. Gravelpave² area can be used immediately.



Wallace Residence, Savannah, GA — Gravelpave² creates a wheelchair-accessible surface by stabilizing gravel and supporting tire pressure. 7% dry cement was mixed with gravel before filling rings.

5. Filling Mats

Gradually place gravel fill into rings by using a front end loader and shaking out the fill as the machine drives forward. Carefully lower the bucket when empty and back up while dragging it above the rings to smooth out the gravel, finishing with a stiff broom. Wheel barrow and shovel works well for small jobs. For large projects, consider renting a stone chipper machine that will evenly disburse the gravel fill to the 1" depth required. Some clients prefer to add additional gravel fill to hide the rings completely which may be appropriate for some applications. The excess can be removed if traction is an issue on sloped surfaces. Contractor tip — please store excess material for future maintenance dressing as may be necessary.

Cement Binder

Adding 7% cement to gravel fill for driveways has been very successful in Savannah, Georgia, where the installer has had experience in working with this medium. This can be an alternative to use rounded stone material to prevent migration. Please note that adding cement will make the color a uniform gray, unless cement pigments are added.

Edge Protection

Over time, adjacent turf can grow onto the Gravelpave² areas. Maintenance considerations may suggest installing a durable edging material between the surfaces, such as steel, aluminum, wood, brick, or concrete. Keep the edging flush with finished grade.

6. Tools for Distributing Fill

Use rakes and/or push brooms to distribute the gravel fill to a level slightly above rings so that compacting the fill will barely show the rings.

7. Compacting Fill

Use the vibrating plate compactor or large driving roller again to compact the gravel fill. Additional gravel may be necessary to finish filling the rings. Then use the compactor again till the material appears solid in the rings. By wetting the gravel, it may interlock better.

8. Immediate Use

Drive on the installation when finished. If



Stone chipper machine distributing gravel fill at University of South Alabama, Mobile, AL.

car tires make a pattern, there may be too much gravel or it may need additional compaction. Some or many rings may be visible at the top surface only. If sides of the rings show, then add more fill material and repeat the compaction process.

9. Maintenance

Potholes will only appear if the base course has not been compacted properly before laying the rings, or if base material is allowed to mix into clay soils below (use nonwoven fabric to keep separate). Should this occur, remove a section by vacuuming the gravel from the rings, unfasten the snap fit fastener, bring the base course to the proper grade and compaction, put the Gravelpave² square back in place, anchor, and fill to the top of the rings. Seasonally check the rings in high-traffic areas and entrance lanes for lower levels of fill, and replace by brooming from other areas to bring it level again. Leaves should be raked or vacuumed and not allowed to decay over the winter since organic matter

will stimulate weed growth and reduce porosity. To attack any occasional weeds that may locate within the Gravelpave² installation, simply spray them with a weed killer (such as Roundup™) and remove them when dead.

Competitive Advantages

Nine Mat Sizes in Large Rolls

Gravelpave² comes pre-assembled into large rolls from our factory in Aurora, Colorado, near Denver International Airport. Many contractors have complimented us on shortening their installation times and appreciate the money saved by working with large rolls that cover up to 1,345 sf (125 m²) in one piece.

In choosing which size is appropriate for your job, measure the area before calling one of our technical advisors who will assist you in converting your dimensions and areas into the most efficient rolls for your job.

Gravelpave² Ring Color

Four standard colors are available to blend with your gravel/soil choices — pewter grey, cashew brown, milk chocolate, and terracotta. It is intended that ring colors blend with



"I have absolutely no problem with this surface. I wish all the surfaces I need to use were this good."
— Peggy Flobeck, Savannah School of Art and Design

Warning — No Sand Setting Bed

Concrete pavers, bricks, and other rigid paver units require sand setting beds to level joints. None of Invisible Structures, Inc., products require sand under the pavers. Be sure to set our flexible paving mats directly on the prepared base course. Remove any large stone so Gravelpave² lays smooth and even.

Remove Large Stones or Clods of Dirt

Large stones and dirt can cause the rings to buckle up and lay unevenly. This will become the source of broken rings at the surface. The rings can undulate with the terrain without problems.

2. Install Gravelpave² Mats

Roll out mats with the grain (in the same direction) so that the snap fit fasteners can be used with neighboring mats. To fit around boxes and curbs, cut the grid between the rings with pruning shears and scissors, or a small portable electric hand saw.

3. Fastening

Fasten the mats together using the snap fit fasteners that are molded into the product inserting the prongs into the rectangular opening. Tuck the fabric underneath the fasteners to keep joints closed.

4. Anchoring

Anchor pins must be used to attach the mats to the base. Use extra pins along the edges. Eight-gauge 12" long anchor pins with 1 1/2" washers are shipped with every order to ensure availability for the job. Usually 2 pins per square meter are adequate, with additional pinning required where turning movements would cause additional stress. Quarter-meter pieces will need one each. There is no additional charge for these pins. Directions for pinning are included in the specifications section. Eight-inch ring shank nails with large fender washers can be substituted should your project require more anchors. Anchoring is a tedious process requiring additional hammers and personnel, but very valuable to the overall finished installation. After all, this surface will likely last upward of 20 years, depending upon traffic. Reciprocating hammers can speed up the anchoring process. Please check with us for availability.



Front-end loader distributes gravel fill at Burger King, Henderson, NC.



Anchor pins are used to secure rolls to base course.

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Crushed Granite $\frac{3}{16}$ " (actual size)

Decomposed Granite $\frac{3}{8}$ " (actual size)

Hard Limestone $\frac{3}{8}$ " (actual size), Chicago, IL. Add 25-30% clean sharp mason's sand to maintain porosity.

Carbon Canyon $\frac{5}{16}$ " minus, (actual size) San Diego, CA.

Sonoran Tan $\frac{3}{8}$ " (actual size) Tucson, AZ.

Sharp Angular Pea Gravel (actual size), Elgin, IL. Do not use rounded pea gravel.

Size/Shape Fill Requirements

You will need 1" of gravel fill, compacted. Be careful to order enough for the compaction process and choose a gravel size that will nest well into the rings. We have found that $\frac{3}{8}$ " minus crushed stone and sometime $\frac{3}{8}$ " with limited small sharp screenings (#40 to #100 screen) works well. Washed gravel will roll within the rings and will also "roll about." For this reason, we do not recommend pea gravel, even though it is often very pretty. A visit to your local quarry is suggested. We have found that some geological areas of the United States have limited types of sharp gravel available. It has been necessary to import gravel from a neighboring state, but remember the amounts are relatively small — just the upper one inch of the cross section. Gravel should be as free of fines as possible. To maintain porosity, avoid soft stone materials that break easily or form a powder.

Other Fill Materials

Please ask our staff for assistance with this category since it is use-specific and often experimental. Ground rubber, crushed glass, crushed brick, and many other materials can be useful as attractive fill materials for various applications. Thermoset (epoxy, polyurethane, etc.) binders may be cost prohibitive for most projects, but offer unique design possibilities, including clarity, color enhancement (wet look), flexibility, and durability.

Our technical support staff will assist with selection of gravel sources. The photographic samples shown here in actual size will help you narrow your gravel choices. Should you have questions concerning the selection, please submit a small sample for approval prior to specifying or securing the materials.



Terra Cotta Gravelpave² with Sonoran Tan $\frac{3}{8}$ " fill. Snap fit fasteners enable large rolls to be connected quickly using finger pressure. For roll sizes, see chart on back cover. Gravelpave² can be ordered with crossbars between rings for sloped trail applications.