Construction Specifications
Load Support: Grass Pavements

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PART 1 GENERAL

1.01 SECTION INCLUDES

A. The work covered by this section includes the furnishing of all labor, materials, equipment and incidentals for construction and installation of the Cellular Confinement System as shown on the Construction Drawings and described by the Contract Specifications.

B. Use of the Cellular Confinement System to enhance the long-term load-deformation performance of grassed or granular paved roads, tracks, runways, aprons and access structures.

C. Work includes furnishing and installing topsoil, fertilizer and other soil amendments for grass surface applications.

D. Products and materials which form the system include: cellular confinement sections, select infill and granular base course materials, woven & nonwoven geotextiles, drainage composites, surface treatments, integral tendons, straight stake rebar anchors, HDPE Plastic Restraint Clip Retaining Device and galvanized staples.

1.02 RELATED WORK

A. Section [ ] - Earthwork, Subgrade preparation.

B. Section [ ] - Subsurface Drainage. Install drainage materials, as required, in areas where in-situ soils have poor permeability.

1.03 REFERENCES

A. AASHTO Specification M-288-00, ASTM D-1557 and relevant CSI (Construction Specifications Institute) Spec Data Documentation.

B. American Society for Testing and Materials (ASTM).

C. International Organization for Standardization (ISO)

D. Manufacturer's Technical Notes and Design and Installation Guidelines.

1.04 QUALITY ASSURANCE AND CERTIFICATION

A. The manufacturer shall provide certification of compliance to all applicable testing procedures and related specifications upon written request. Request for certification shall be submitted no later than the date of order placement.

B. The manufacturer shall have earned a certificate of registration, which demonstrates that its Total Quality Management system (TQM) for its Cellular Confinement System is currently registered to the ISO 9002 quality standards (or latest ISO standard). The scope of the ISO 9002 registration shall be for the entire Cellular Confinement System product manufacturing process from incoming raw materials (resin) to finished product. Earned registration shall be verifiable by providing a copy of the current continuous registration certificate upon the customers written request.

C. Material Substitutions: No material will be considered as an equivalent to the geocell materials specified herein unless it meets all areas of this specification without exception. Manufacturers seeking to supply what they represent as equivalent material must submit records, data, independent testing results, samples, certifications, and documentation deemed necessary by the Engineer to prove equivalency. The Engineer shall approve or disapprove other manufacturers materials within 60 days after all submitted information is studied and tested.

1.05 SYSTEM DESCRIPTION

A. Cellular Confinement System consists of geocell material into which specific infill material may be placed. The Cellular Confinement System section is an assembly of high-density polyethylene sheet strips, connected by a series of ultrasonic welded seams. When expanded, the interconnected strips form the walls of a flexible, three-dimensional, honeycomb like, cellular structure.

B. The Cellular Confinement System is produced in a range of cell depths. Standard cell depths are: 75 mm (3 in.), 100 mm (4 in.), 150 mm (6 in.) & 200 mm (8 in.)

1.06 SUBMITTALS

A. Submit shop drawings.

B. Submit product data, drawings and samples.

C. The manufacturer shall provide a Manufacturer Qualified Representative (MQR) on site at the start of construction to provide the installing contractor and Project Engineer with technical support and information regarding installation of the geocell system. The MQR shall document a minimum of 5 years experience assisting with the installation of geocell systems.

D. Submit qualifications of MQR. Request for qualifications of the MQR shall be submitted by the purchasing agency to the manufacturer or the manufacturer's representative no later than the date of order placement. MQR's submittal shall include a written certification verifying that the MQR has completed a minimum of one manufacturer-sponsored technical training course of minimum duration of 20 hours in the design principles and installation practices of cellular confinement systems. The certificate submitted must show the name of the qualifying MQR, give the date and location where the training occurred and be signed by an authorized representative of the manufacturer. Availability of MQR personnel shall be subject to scheduling, fees for travel and per diem expenses.

E. The manufacturer shall have earned a certificate of registration, which demonstrates that its quality-management system for its Cellular Confinement System is currently registered to the ISO 9002 quality standards. The scope of the ISO 9002 registration shall be for the entire Cellular Confinement System product manufacturing process from incoming raw materials (resin) to finished product. Earned registration shall be verifiable by providing a copy of the current continuous registration certificate upon the customer's written request. Under the scope of the ISO quality standard, the manufacturer shall compile, keep record of, and provide for each customer order or production lot, actual and certified values for the following:

1. Resin Lot Number
2. Resin Density
3. Carbon Black content (where applicable)
4. High Pressure Oxidation Induction Time (HPOIT) (where applicable)
5. Sheet Thickness
6. Short-term Seam Peel Strength
7. Long-term Seam Peel Strength
    a. 7-day hot box method
8. 10,000 hour hang strength test

PART 2 PRODUCTS

2.01 MANUFACTURER and AVAILABILITY

A. One of the products meeting these requirements is manufactured by Presto Products Company, Geosystems Products, PO Box 2399, Appleton, WI 54913-2399.

B. The Presto Products Cellular Confinement System is supplied by Soil Stabilization Products Co., Inc., PO Box 2779, Merced, CA 95344. Phone: (800) 523-9992.

2.02 CELLULAR CONFINEMENT SYSTEM

A. Polyethylene Composition and System Properties

PROPERTY	Value & Test Method
1) Resin Density	0.935 - 0.960 g/cm² (58.4-60.2 lb/ft²) per ASTM D 1505. Performed by Resin manufacturer. Results are verified on Certificate of Analysis that accompanies each lot number of resin received.
2) Carbon Black Content	1.5 - 2.0% by weight through the addition of a carrier with a certified carbon black content. Tested during manufacturing every 15,800 ft² of 203 mm (8.0 in) cell depth, every 20,000 ft² of 150 mm (6.0 in) cell depth, every 31,600 ft² of 102 mm (4.0 in) cell depth and every 40,000 ft² of 75 mm (3.0 in) cell depth.
3) Sheet Thickness	1.27 mm (50 mil) -5% + 10% per ASTM D 5199. Tested during manufacturing every 2,900 ft² of 203 mm (8.0 in) cell depth, every 3,800 ft² of 150 mm (6.0 in) cell depth, every 5,800 ft² of 102 mm (4.0 in) cell depth and every 7,600 ft² of 75 mm (3.0 in) cell depth.
4) Resin ESCR	Minimum 3000 hours per ASTM D374. Performed by Resin manufacturer. ESCR = Environmental Stress Crack Resistance

5) Short-Term Seam Peel Strength

See Appendix A.

6) Long-Term Seam Peel Strength

See Appendix B.

7) 10,000 hour hang strength

The manufacturer shall provide data showing that the high-density polyethylene resin used to produce the geocell sections has been tested using an appropriate number of seam samples and varying loads to generate data indicating that the seam peel strength shall support a loading of at least 52 kg (115 lbf) for a minimum of 10,000 hours without failure.

B. Surface Treatment
Performance: The peak friction angle between the surface of the perforated, textured plastic and a #40 silica sand at 100% relative density shall be no less than 85% of the peak friction angle of the silica sand in isolation when tested by the direct shear method per ASTM D 5321. The quantity of perforations shall remove 22.1% ± 0.5% of the cell wall area.

Material: The surface texturing shall be a multitude of rhomboidal (diamond shape) indentations. The rhomboidal indentations shall have a surface density of 22 - 31 per cm² (140 - 200 per in²). The thickness of the textured sheet shall be 1.52 mm ±0.15 mm (60 mil ± 6 mil) determined per ASTM D5199. The perforations shall be horizontal rows of 10 mm (0.391 in) diameter holes. Perforations within each row shall be 19 mm (0.75 in) on-center. Horizontal rows shall be staggered and separated 12 mm (0.50 in) relative to the hole centers. The edge of strip to the nearest edge of perforation shall be 8 mm (0.312 in) minimum and the centerline of the weld to the nearest edge of perforation shall be 18 mm (0.7 in) minimum.

C. Assembly
Standard Cellular Confinement System sections are fabricated using strips of sheet polyethylene each having a length of 3.61 m (142 in) and a width equal to the cell depth. The polyethylene strips shall be connected using uniformly-spaced, full-depth ultrasonic spot-welds. Welds shall be off-set and aligned perpendicular to the longitudinal axis of the strips. Weld spacing shall be 356 mm ± 2.5 mm (14 in. ± 0.10 in). The ultrasonic weld melt-pool width shall not exceed 25 mm (1.0 in).

Cellular confinement sections shall be made from high density polyethylene plastic. The polyethylene shall have properties per paragraph A above.

D. Individual cells of the standard Cellular Confinement System section shall be variable in shape within the following limits: 245 mm (9.65 in.) long x 234 mm (9.20 in) wide @ max section length and 204 mm (8.02 in.) long x 281 mm (11.07 in) wide @ minimum section length. Standard expanded section size is 16.8 m2 (181 ft2) when utilized in the listed min/max expansion range +/- 1% tolerance. Sections shall have a cell density per m² (yd²) of 34.6 (28.9) and a nominal cell area (±1%) of 289 cm² (44.8 in²). See Standard Section Properties Table 3.08.

2.03 ANCHORING COM PONENTS

A. Integral High-Tenacity Polymer Tendons
Where required in project plans and specifications, Cellular Confinement System sections shall be supplied with a series of aligned holes, pre-formed in the cell walls, to accommodate insertion of polymer tendons throughout their length.

B. Standard tendons shall be manufactured from bright, high-tenacity, industrial-continuous-filament polyester yard woven into a braided strip. Elongation shall be 9-15% at break. Alternate tendons using woven polypropelene yarn or Kevlar yarn shall be utilized where concrete infill will be used within the geocell system. The maximum and minimum dimension of the tendon shall be given in addition to its minimum break strength.

1.	Cell depths:	200 mm (8 in.)	150 mm (6 in.)	100 mm (4 in.)	75 mm (3 in.)
2.	Nominal Cell Area:	289 cm2 (44.8 in2)	289 cm2 (44.8 in2)	289 cm2 (44.8 in2)	289 cm2 (44.8 in2)
3.	Section Area:	14.5 m2 (156 ft2)	14.5 m2 (156 ft2)	14.5 m2 (156 ft2)	14.5 m2 (156 ft2)
4.	Section weight:	37.5 kg (82.8 lbs.)	28.4 kg (62.7 lbs.)	18.8 kg (41.4 lbs.)	14.2 kg (31.3 lbs)

E. Straight Stake Anchors
Standard #4 steel construction rebar, diameter of 12.7 mm (½"). Optional corrosion resistant HDPE Plastic Restraint Clip Retaining Device. Project plans and specifications may call for alternate anchor types depending upon design requirements (e.g., GFRP anchors which may be specified for critical applications and severe service environments).

F. HDPE Plastic Restraint Clip
The HDPE Plastic Restraint Clip GFRP stake shall be composed of glass fiber-reinforced polymer with the outer surface of the stake sand coated and deformed by a helical wrap of glass. Glass reinforcement content shall be 75% minimum by weight and shall be continuous longitudinal filament. Polymer shall be vinyl ester, isopthalic polyester, or other matrix material. The outer surface of the stake shall be sand coated and deformed by a helical wrap of glass. The HDPE Plastic Restraint Clip GFRP stake shall have a minimum tensile strength of 655 MPa (95 ksi) per ASTM D638. The stake shall be non-magnetic, non-conducting and corrosion resistant. The stake diameter shall be 12-13 mm (1/2 in). The length shall be per construction drawings.

2.04 RELATED GEOSYNTHETIC COMPONENTS

A. Geotextiles
Select the geotextile components of cellular confinement structures in accordance with either, AASHTO Specification M 288-00, or equivalent local standards. Functions include: drainage, filtration, separation and reinforcement. Design review and careful consideration of local conditions are recommended.

B. Geo-composite Drainage Systems
Geo-composite drainage systems, including geotextile wrapped perforated pipes and sheet drainage cores, may be incorporated as sub-drains and interceptor drains. Product selection and application shall be determined by the design engineer.

C. Geogrid and Geotextile Sheet Reinforcement
Sheet reinforcement materials shall meet appropriate durability, long-term strength, and soil interaction requirements. In the absence of local design and selection standards, the recommendations given in AASHTO M 288-00 shall be followed.

2.05 CELL INFILL MATERIALS

Aggregate/Topsoil Engineered Base (ATEB) - Defined

ATEB is a homogenous mixture consisting of 1. a clear-stone/ crushed rock having an AASHTO #5 or similar designation blended with 2. a topsoil. This homogenous mixture will promote vegetative growth and provide the required structural support.

The aggregate portion shall have particles ranging in size from 9.5 to 25 mm (0.375 to 1.0 in) with a D50 of 13 mm (0.5 in). When compacted, the percentage void-space of the aggregate portion shall be at least 30%. Topsoil, equal to but not exceeding the aggregate void percentage, shall be added and blended to produce a homogenous mixture prior to placement. Once placed, the mixture shall be compacted to a density that will produce a minimum California Bearing Ratio (CBR) of 7%. (see notes 1, 2 & 3 following)

(Note 1.) The load bearing capacity of the Cellular Confinement System is derived from confinement of incompressible infill materials (such as clean washed sand or crushed rock). The health of the vegetation, however, depends upon topsoil infill, which is typically compressible (plastic) as well as sufficient void space within the topsoil. The uncompressed topsoil facilitates passage of water, air and nutrients while also protecting root systems. These requirements seem to be in direct conflict - but they are not. Using Aggregate/Topsoil Engineered Base (ATEB) infill within the cellular confinement system and if desired, in an ATEB base layer immediately below the cellular confinement syste, one can construct vegetated cellular confinement systems that meet both horticultural and civil requirements.

(Note 2.) CBR is the abbreviation for California Bearing Ratio. Methods for determining CBR vary from more sophisticated laboratory methods to simple field identification methods that use hand manipulation of the soil. Presto Products Company does not recommend one method over the other. However, the user must have a high degree of confidence in the results produced by the chosen method.

(Note 3.) If other than CBR soil strength values exist, use available correlation charts to relate the value to CBR.

ATEB PREPARATION

Start with an aggregate relatively free from fines and with a void space of 30% or greater. A convenient field method to determine the void space and volume of topsoil to be blended with the aggregate is:

1. Overfill a 5-gallon plastic bucket (or other calibrated container) with the selected aggregate. The exact capacity of the container must be known to obtain correct results.

2. Completely compact the aggregate in the bucket and level so the surface of the aggregate is at the top of the bucket.

3. Fill the bucket with water and let stand for several minutes, then add additional water so the water is at the same level as the top of the bucket.

4. Drain the water off into another container making sure that all the water is captured.

5. Measure the volume of the captured water and compare it to the volume of the bucket to determine the percentage voids in the aggregate. This is the amount of loose topsoil that is to be blended with the aggregate. Caution do not exceed this amount of topsoil.

2.06 GRANULAR BASE COURSE MATERIALS

A. The granular base material shall be free draining crushed road base or sand with a maximum particle size of 38 mm (1-1/2 in) and no greater than 8% passing the #200 sieve.

B. An alternate base material may be Aggregate Topsoil Engineered Base (ATEB).

2.07 GRASS SEED and FERTILIZER

A. Grass - Use species resistant to wear by traffic. Check with local seed suppliers for preferred mixtures.

B. Fertilizer - Product selection and application shall be determined by the design engineers. Use a commercial grade starter fertilizer that is granular and uniform in composition as recommended by local seed supplier, for rapid germination and root development.

PART 3 INSTALLATION

3.01 EXAMINATION

A. Verify that site conditions are as indicated on Construction Drawings. Examine subgrade (native soil) conditions to ensure soil is structurally adequate to support base course materials and design loads. Do not start base course soil placement until unsatisfactory conditions are corrected. Check for insufficient compaction, slumping areas, improper gradients, debris, and improper drainage.

B. Verify that all materials required for the work and delivered to site comply with contract specifications. Contact the project engineer for resolution of unsatisfactory conditions. Installation of materials constitutes acceptance of existing conditions and responsibility for satisfactory performance.

3.02 SITE and SUBGRADE PREPARATION

A. Start site preparation by removing debris and vegetative cover from the installation area.

B. Excavate, shape and/or fill the subgrade soils to the grades, elevations and dimensions shown on the Construction Drawings. Ensure that the grade and permeability of the subgrade soils will provide adequate subsurface drainage. Install landscape irrigation system as required.

C. Proof roll and examine the subgrade soil to ensure that it meets minimum strength requirements assumed for the design. Remove unacceptable materials and replace with approved compacted fill.

3.03 SEPARATION and DRAINAGE

A. Where specified, install a suitable geotextile separation layer prior to placement of the base material. Secure in position according to project plans and specifications.

B. Where specified, install appropriate drainage materials. Ensure that the system is functional and connected to an appropriate drainage system.

3.04 BASE COURSE INSTALLATION

A. Place, shape and compact specified granular subbase materials to the line and grade shown on construction drawings. Compact to a minimum of 95% Modified Proctor Dry Density (MPDD, ASTM D-1557). Lifts not to exceed 150 mm (6 in) before compacting.

3.05 CELLULAR CONFINEMENT SYSTEM SECTION INSTALLATION

A. Expand Cellular Confinement System sections to proper dimension and position, as indicated on construction drawings. Hold sections into position using either a stretcher frame or rebar stakes, or by infilling several peripheral cells.

B. Check the dimensions of each section to ensure it is properly expanded.

C. Align interleaf edges and/or butt joints of adjoining sections as detailed in the construction drawings. Ensure that upper surfaces of adjoining sections are flush. Fasten sections together by stapling the interleaf and butt joints with pneumatic stapler.

3.06 PLACEMENT OF INFILL

A. Place specified infill into expanded cells with suitable equipment such as front-end loader, dozer or backhoe. Limit drop height to a maximum of 1 m (3 ft).

B. Overfill the cells and level the surface approximately 50mm (2 in) above cell walls so that after compaction the infill will be flush with top of the cells. Maintain sufficient granular cover to ensure that material handling equipment trafficking over the geocell does not damage the cell walls.

C. Using a straight edge, bucket or dozer blade, shape the compacted surface to the required elevation. Compact the ATEB infill into the cell of the geocell system to a density that will produce a minimum CBR of 7% using suitable compaction equipment (see note following).

Note: Typical compaction densities and testing do not apply to the ATEB infill since only the aggregate portion of the engineered base is compacted. The topsoil portion will remain relatively uncompacted when the mixture is correct. Therefore, conventional density testing and resulting densities will produce values that are not meaningful.

3.07 FINISHING PROCEDURES

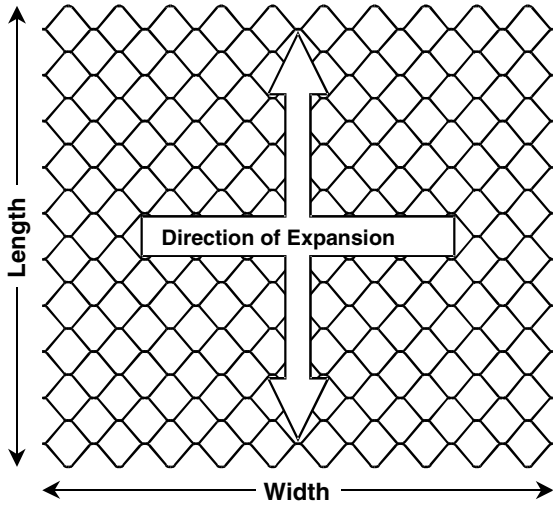
A. Topsoil

B. Seeding

C. Dust Control

3.08 STANDARD SECTION PROPERTIES

Standard Section (Figure 1)



Cellular Confinement System section length and width shall be as indicated in Figure 1. Sections shall have expanded dimensions per Table 1.

Note: All measurements are subject to manufacturing tolerances unless otherwise noted.

Table 1 Section Dimensions

Minimum Expansion		Maximum Expansion		Nominal Area
Length	Width	Length	Width	
16.7 ft	9.2 ft	20.1 ft	7.7 ft	156 ft^2

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Appendix A

Short-Term Seam Strength Test Procedure

Figure A1

Frequency of Test

The short-term seam peel strength test (referred to as the 'test' in this section) shall be performed on a geocell section randomly taken directly from the production line each two hours.

Test Sample Preparation

Randomly choose 10 welds within the selected section and cut those welds from the section such that 10 cm (4 in) of material exist on each side of the weld. The test sample shall have a general appearance as illustrated in Figure A1. Prior to testing, the test samples shall have air cool for a minimum of 30 minutes from the time the selected geocell section was manufactured.

Short-term Seam Peel Strength Test

The apparatus used for testing the short-term seam peel strength shall be of such configuration that the jaws of the clamp shall not over stress the sample during the test period. Load shall be applied at a rate of 300 mm (12 in) per minute and be applied for adequate time to determine the maximum load. The date, time and load shall be recorded.

Short-term seam peel strength shall be defined as the maximum load applied to the test sample. Minimum required short-term seam peel strength shall be:

• 2840 N (640 lbf) for the 200 mm (8 in) depth cell

• 2130 N (480 lbf) for the 150 mm (6 in) depth cell

• 1420 N (320 lbf) for the 100 mm (4 in) depth cell

• 1060 N (240 lbf) for the 75 mm (3 in) depth cell

Definition of Pass / Failure

Two methods shall be used to determine acceptability of the manufactured geocell sections. The successful passing of the short-term seam peel test shall not be used to determine acceptable of the polyethylene for use in manufacturing of the geocell sections. Acceptability of the polyethylene shall be determined through tests conducted in Appendix B.

The Tested Value

If more than one of the tested seam samples fails to meet the minimum peel strength, all sections manufactured after the previously successful test shall be rejected.

If all tested seam samples meet the minimum peel strength, all geocell sections manufactured since the last successful test shall be considered to have passed the test.

When one of the tested seam samples fails to meet the minimum peel strength, another 10 samples shall be randomly selected and cut from the previously selected section. If more than one of these samples fails, all sections manufactured after the previously successful test shall be rejected. Otherwise, all geocell sections manufactured since the last successful test shall be considered to have passed the test.

Visual Failure Mode

After each sample is tested, the seam shall be examined to determine the failure mode. Two failure modes are possible.

• Material failure within and adjacent to the weld indicated by material strain and

• Weld failure resulting in complete separation of the seam and shows little or no material strain.

Upon examination, when the failure mode results in complete separation of the seam and indicates little or no material strain, product manufactured shall be rejected.

Appendix B

Long-Term Seam-Strength Test Procedure

Figure B1

Frequency of Test

The long-term seam peel strength test (referred to as the 'test' in this section) shall be performed:

1. on each new resin lot number if the geocell manufacturer extrudes the sheet or strip used to produce the geocell material.

2. on each new order of sheet and/or strip if the geocell manufacturer does not extrude the sheet and/or strip used to produce the geocell material.

Test Sample Preparation

A test sample shall be made using four of the strips meeting all aspects of the material portion of this specification. The four strips are to be welded together using a warm welder producing a 2-cell long section of geocell product. The 2-cell section of geocell shall have 3 rows of welds connecting the four strips. The rows of welds are to be labeled A, B and C. The individual welds within each row shall be numbered consecutively from left to right starting with the number 1 (one). The sample shall air cool for a minimum of 30 minutes. Randomly choose 10 welds and cut those welds from the geocell sample such that 10 cm (4 in) of material exist on each side of the weld. These samples shall be cut to a width of 10 cm (4 in). Properly identify each weld using the row letter and weld number. These samples are now ready to be tested.

Long-term Seam Peel Strength Test

The long-term seam peel strength test shall take place within an environmentally controlled chamber that undergoes temperature change on a 1-hour cycle from room temperature to 54°C (130°F). Room temperature shall be defined per ASTM E41. Within the environmentally controlled chamber, one of the ends of the samples (10 samples in total) shall be secured to a stationary upper clamp. The jaws of the clamp shall be of such configuration that the grip does not over stress the sample during the test period. The sample shall be secured so that its axis is vertical and the welds being tested are horizontal as the sample hangs within the environmentally controlled chamber. A weight of 72.5 kg (160 lb) shall be lifted via a hoist or lift platform and attached to the free lower end, of the sample. The weight shall be lowered in a way so that no impact load occurs on the sample being tested. The weight shall be sufficient distance from the floor of the chamber so that the weight will not touch the floor of the chamber as the sample undergoes creep during the test period. The date and hour the weight is applied shall be recorded. The temperature cycle shall commence immediately within the environmentally controlled chamber. The test period for the applied load shall be 168 hours.

Definition of Pass / Failure

If any of the 10 seams fail prior to the end of the 168-hour (7-day) period, the date and hour of the failure shall be recorded and the polyethylene resin and strip material shall be considered unsuitable for geocell manufacturing.