

3.2 GreenLoxx[®] MSE Vegetated Retaining Wall

PURPOSE & DESCRIPTION

Vegetated retaining walls are a green alternative for retaining walls that offer higher aesthetic appeal than conventional block or concrete systems. **GreenLoxx[®] MSE vegetated retaining walls** are a mechanically stabilized earth (MSE) system that is reinforced with geotextile support to form a green wall that ‘locks’. The locking system is created by the integration of Filtrex geogrids (FLW) and a fascia made from Filtrex GroSoxx[®] filled with Filtrex[®] GrowingMedia[™]. The addition of vegetation growing through the facing with healthy roots penetrating the entire structure adds environmental service, natural aesthetics and structure.

APPLICATION

GreenLoxx[®] MSE vegetated retaining walls are to be used where other retaining walls are specified. These include but are not limited to:

- Steep embankments and grade changes
- Roadside slopes
- Road underpasses (culverts)
- Stormwater outfalls
- Stream banks
- Shoreline slopes
- Residential retaining walls

GreenLoxx[®] MSE vegetated retaining walls are comprised of five primary components: Filtrex GroSoxx used as the vegetated fascia, filling the GroSoxx with Filtrex GrowingMedia, FLW geogrid wrapped around the filled fascia GroSoxx, compacted, select backfill behind the fascia, and vegetation throughout. These components work together to establish a system of Mechanically Stabilized Earth (MSE) with a vegetated fascia.

ADVANTAGES

- Construction components are lighter than soil
- No poured concrete footing required
- Seed incorporation throughout the fascia profile within the GroSoxx (optional)
- A GreenLoxx MSE vegetated retaining wall system includes GrowingMedia which establishes, sustains, and provides reinforcement for vegetation, unlike rip rap and other hard armoring devices.
- GrowingMedia in a vegetated retaining wall has the ability to bind and adsorb soluble nutrients, metals, and hydrocarbons that may be in stormwater runoff, thereby reducing loading to adjacent receiving waters.
- Microorganisms in GrowingMedia have the ability to degrade organic pollutants and cycle captured nutrients into beneficial and/or less toxic forms.
- Contained GrowingMedia within a vegetated retaining wall creates an ideal system for biotechnical engineering projects.
- Humus colloids and organic matter in GrowingMedia provide physical structure for seed, seedlings, and live stakes.
- Humus colloids and organic matter in GrowingMedia provide increased water holding capacity and reduced water evaporation to aid in seed germination, plant sustainability, and the potential for reduced irrigation.
- Vegetated retaining walls are a good option for arid and semiarid regions where germination, moisture management, and irrigation can be difficult.

- GrowingMedia provides organic nutrients that slow release for optimum efficiency to establishing vegetation.
- GrowingMedia provides organic nutrients that are less prone to runoff transport and pollution of surface waters, relative to mineral nutrients supplied by fertilizers.
- Low volume, low pressure drip tape irrigation system can be installed within the GroSoxx fascia to promote vegetation establishment.
- Easily reinforced for challenging applications
- Improved drainage and reduction of hydrostatic pressure over conventional structural walls
- Customizable vegetation using plugs, live stakes, seed, sprigs or bulbs
- Faster installation than conventional walls
- Fascia is fully wrapped in FLW geogrid to support both top and bottom of each layer
- GroSoxx fascia is installed in short modular sections or installed in continuous lengths, reducing the presence of breaks and potential weak points in the structure
- Installation method can create individual terraces on each level of the fascia, facilitating vegetation growth.
- GreenLoxx MSE vegetated retaining walls may assist in qualification for LEED[®] Green Building Rating and Certification credits under LEED Building Design & Construction (BD+C), New Construction v4. Awarded credits may be possible from the categories of Sustainable Sites, Water Efficiency, Materials & Resources, and Innovation. *Note: LEED is an independent program offered through the U.S. Green Building Council. LEED credits are determined on a per project basis by an independent auditing committee. Filtrex neither guarantees nor assures LEED credits from the use of its products. LEED is a trademark of the U.S. Green Building Council.*

MATERIAL SPECIFICATIONS

The five components of the GreenLoxx MSE vegetated retaining wall work together to establish a system of Mechanically Stabilized Earth (MSE) with a vegetated fascia. Note: backfill and geogrid requirements are specific to each project and should be reviewed by a Professional Engineer.

1. Filtrex GroSoxx[®]

The fascia of the GreenLoxx MSE vegetated retaining wall is comprised of knitted tubular geotextile units called Filtrex

ADVANTAGES			
	LOW	MED	HIGH
Installation Difficulty		✓	
Soil Retention Ability			✓
Vegetation Establishment			✓
Aesthetic Quality			✓
Drainage			✓

GroSoxx. GroSoxx are specifically designed to retain Filtrexx GrowingMedia, seed and live stakes to promote healthy vegetation growth. This system is also designed to reduce hydrostatic pressure by increasing drainage of surface and run-on/runoff and subsurface flow to the vegetated fascia. The openings in the GroSoxx allow for root growth while retaining GrowingMedia for healthy and sustainable vegetation. GroSoxx wall fascia units are manufactured in diameter 12 in (300mm)

2. Filtrexx Certified GrowingMedia™

GreenLoxx MSE vegetated retaining walls use only Filtrexx® GrowingMedia™ which is specifically designed for stability within the system and establishment and sustainability of vegetation growth. GrowingMedia can be third party tested and certified to meet minimum performance criteria defined by Filtrexx International. Performance parameters include: vegetation growth, water holding capacity, pH, organic matter, soluble salts, moisture content, biological stability, maturity bioassay, and percent inert material, bulk density and particle size distribution. For information on the physical, chemical, and biological properties of GrowingMedia refer to Specification 5.2 Filtrexx GrowingMedia. Alternative specifications may be used by the design engineer, which would include blends of GrowingMedia with additional inorganic materials to meet local site requirements (i.e., sand, soils, aggregates, etc.).

3. Geogrid Reinforcement

Geogrid is a required component of a GreenLoxx MSE vegetated retaining wall and specifications must be followed or performance may be diminished. Refer to Table 2.2 for technical data detailing the properties and strength of Filtrexx FLW35 geogrid.

When utilizing geogrids with a vegetated retaining wall, a wrap is recommended for every two courses. Typically the 12" GroSoxx will deform to 9" of effective height per row (see Figure 2.3) such that every two courses wrapped in FLW35 geogrids yields 18" reinforcement lifts. Geogrid spacing may vary as determined by the wall design engineer and included in the project plans and specs.

Geogrid Length

Geogrid tie-back length is typically equivalent to the height of the wall per lift. Lengths will increase with increased slope, loading, soil conditions and acting pressures. Site specific engineering is required from a locally registered Professional Engineer.

4. Construction of Footer for Structural Stability

Although a concrete footer is not required for a GreenLoxx MSE vegetated retaining wall, a stable foundation must be ensured or created. When possible the bottom GroSoxx should be buried or keyed in to increase stability so that the depth is equal to 10% of wall height. Depth will be determined by site specific engineering.

5. Vegetation

Examples of vegetation that may be selected include:

- Grasses, including natives
- Vines and groundcover, including Ivy, Myrtle, Sedum, etc.
- Wildflowers
- Perennials and annuals
- Woody vegetation from live stakes or pots 2" or less so that grids are not cut in planting

Vegetation Selection

Successful planning for any vegetation establishment project should consider aesthetics, wildlife habitat, climate, prevailing weather, temperature, sun exposure, prolonged moisture exposure, available moisture/irrigation requirements, topography, soil type, soil pH, soil amendments, nutrient requirements, drought tolerance, time/coordination with construction phases, site preparation/coordination with construction phases, protection from erosion and sedimentation, concentrated flow and runoff velocity potential, maintenance, and seed mix/plant selection (Fifield, 2001).

Quick establishing annual grasses, legumes and non-reproductive wheat grass/oat grass hybrids are normally specified for temporary and nurse crop applications. Perennial grasses are typically specified for permanent applications, and if possible native grasses should be utilized (Fifield, 2001; USDA-NRCS, 2004) as these will be better adapted to local climate, native soil, and hydrology. If a vegetated retaining wall system will be exposed to prolonged moisture, wetland species may be required.

Generally, tall and sturdy grasses are better at reducing runoff and flow velocity and increasing sediment removal than low growing, flexible grasses and legumes (Grismer et al., 2006; USDA-NRCS, 2004) - as taller vegetation generally increase surface roughness values (Manning's n). Additionally, deep rooted grasses will be more stable under high storm runoff and, high concentrated flow velocity.

GreenLoxx MSE vegetated retaining walls may be designed for biotechnical engineering applications. GrowingMedia fill within the GroSoxx system creates an optimum fertile and structural environment for establishing and sustaining live stakes, seed, tubers, rhizomes, and plugs. A live stake is a 1 to 3 ft. (300-900mm) long cutting from a live hardwood tree or shrub and planted vertically into a GrowingMedia (KYTC, 2006). Typical live stake species include, willow, poplar, maple, cottonwood, dogwood, sycamore, and oak (KYTC, 2006). Drip tape irrigation installed within the vegetated retaining wall system maintains moisture for plants used in biotechnical engineering projects, particularly in drought prone regions and seasons.

Local landscape architects, NRCS personnel, or cooperative extension specialists should be consulted and used as resources for local/regional seed and plant selection. Many state erosion and sediment control and storm water management manuals have specifications for seed and plant selection, seeding rates, and planting requirements. VegSpec, a design program created by the USDA-NRCS, may be a helpful tool for seed and plant selection. It can be accessed at <http://plants.usda.gov>.

Establishing & Sustaining Vegetation

GreenLoxx vegetated retaining walls may be seeded at the time of application by injection into GrowingMedia during vegetated retaining wall construction. Nurse crops, such as annual rye, oats, millet, or wheat may be considered to establish a quick vegetative cover until perennial grasses and/or live stakes are established. Grasses within the GreenLoxx vegetated retaining wall should be mowed and maintained between 4 in (100mm) and 10 in (250mm) high, unless otherwise specified. Taller grasses may have higher sediment removal efficiency, sediment storage capacity, and a greater ability to dissipate runoff energy and reduce storm flow velocity relative to low growing or low maintained grasses. Live stakes should be 1 to 3 ft. (300-900mm) long and planted vertically with at least 2" of one end planted into a GrowingMedia, and spaced 3

to 5 ft. (1-1.5 m) apart (KYTC, 2006).

Although GrowingMedia typically has a higher water holding capacity than topsoil, irrigation may be required to ensure successful establishment. In arid and semi-arid regions or hot and dry weather regular irrigation may be required. Drip tape irrigation may be installed within the GroSoxx to maintain moisture within GrowingMedia for establishing vegetation or in drought prone regions and seasons.

The GrowingMedia inside the GreenLoxx vegetated retaining wall supplies humus, organic matter, beneficial microbes, and slow release organic nutrients that contribute to increased fertility, plant health and sustainability.

Organic vs. Fertilizer Nutrients

Although most specification and design manuals include fertilizer recommendations or requirements for vegetation, mineral nutrients from fertilizers may not be preferable where vegetation sustainability and water quality are a concern. Vegetated retaining walls provide organic nutrients which are slow release, provide plant micronutrients, and are less likely to be transported in storm runoff to receiving waters – which can lead to pollution and eutrophication of waterways (Faucette et al, 2005).

Weed Establishment

Invasive weed growth has been more closely associated with mineral fertilizer than organic fertilizer fertility practices (Faucette et al, 2004). Vegetation practices should always be inspected for invasive and noxious weeds. The use of approved Filtrexx products will reduce the chances of noxious weeds being introduced.

Methods for Establishing Vegetation:

- Plant Plugs 2 in x 2 in (50mm x 50mm) or smaller
- Live stakes
- Bulbs or dormant rootstocks buried in GreenLoxx vegetated retaining walls during construction
- Sprigs
- Annual or perennial plants
- Injection of seed into the GroSoxx or pre-mixing seed and GrowingMedia prior to filling
- Broadcast seeding, especially natives and wildflowers

PERFORMANCE

The local registered Professional Engineer shall determine appropriate tests using recognized engineering performance testing and standard specifications for materials. These may include the following:

American Society for Testing and Materials (ASTM):

- C1372 – Standard Specification for Segmental Retaining Wall Units
 - C33-93 – Specifications for Concrete Aggregates
 - D698 – Test method for Laboratory Compaction Characteristics of Soil Using Standard Effort
 - D424 – Atterburg Limit of Soils
 - D422 – Gradation of Soils
 - D5262 – Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics
 - D4355 – Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet light
- Geosynthetic Research Institute (GRI)

- GG1 – Standard Test Method for Geogrid Rib Tensile Strength
- GG4 – Standard Practice for Determination of Long Term Design Strength of Geosynthetic Reinforcements
- GG5 – Standard Test Method for Determination of Geogrid Pullout

Using Geogrid for Reinforcement

Geogrid has been used for decades in building structural wall systems with block and other hard aggregate structures. In most cases, the geogrid is attached to the fascia block via pins or other hook devices. With a GreenLoxx MSE vegetated retaining wall, the Filtrexx FLW geogrid is wrapped around the entire fascia, providing support to both top and bottom of the fascia and preventing movement of the GroSoxx from within the wrapped layer. There may be situations where the geogrid wrap can cover more than one layer of GroSoxx. Because the GroSoxx fascia is permeable, it retains less water than a block wall and should prevent soil saturation, mass wasting of soil, and hydrostatic pressure behind the fascia. The specifications and guidelines here are recommended procedures and considerations. Site specific engineering should be performed for all structural applications via a Professional Engineer.

INSTALLATION

Required Tools / Materials

- PPE/Safety Equipment
- Normal soil working tools including shovels, rakes, hand compactor, broom, pick, etc.
- Mechanical compactor
- Filtrexx GroSoxx
- Filtrexx FLW35 geogrid
- Sod staples (8 in or 200mm)
- Traffic control and safety measures, where required

Excavation and Base Preparation

Prior to construction of a GreenLoxx MSE vegetated retaining wall the area of excavation shall follow plan specifications. The excavated area shall tightly fit the first layer of GroSoxx to create a firm foundation. Excavation is a land disturbing activity that requires use of temporary sediment control devices; see Section 1.1 for information on Filtrexx Sediment control.

Compaction of the area using a plate compactor or equivalent is required prior to adding any fill or the first course of GroSoxx. No footings are required for GreenLoxx MSE vegetated retaining walls; however, a level base that is buried 10% of the wall may be necessary.

Drainage

Unlike hard-walls, a drainage zone behind the face of the GreenLoxx retaining wall may not be required as the GroSoxx fascia is highly permeable. This permeability greatly reduces hydrostatic pressure and facilitates hydration of the GrowingMedia and fascia vegetation. Where increased drainage is desired or is required for high-flow areas, stone may be added to the GrowingMedia in the first and/or second GroSoxx course to enhance the movement of subsurface and/or runoff flow. As with other retaining walls, additional drainage systems may be installed behind the wall. Drainage requirements shall be addressed by a geotechnical engineer and/or hydrologist.

Installation of Base Course

After the initial excavation, fine-tuning of the base surface should commence. Use a laser-level to prepare the surface for the first course of GroSoxx. The surface should be free of roots and rocks that may interfere with the GroSoxx or result in an uneven surface. The base surface should be level.

After preparation of the base surface, place an 8 in (200mm) layer of granular material over the native material, including within any the trenched section. A layer of semi-porous geogrid may be necessary to separate the granular fill from the native soil. Application may be made manually, by excavator or by pneumatic blower.

At courses where the construction drawings indicate that geogrid is required, the geogrid is laid down prior to placement of GroSoxx and wrapped around the GroSoxx fascia.

After placing and compacting the base material the first course of geogrid should be installed. Place FLW geogrid over granular material and fasten with sod staples or ½ ft. (150mm) rebar stakes to temporarily anchor the geogrid while commencing work. Once the geogrid is anchored, install the modular or continuous GroSoxx the required length horizontally and parallel to the wall face. Fill GroSoxx in place - the first course will be installed at the base of the wall, or if present, in the trench.

When installing geogrid, ensure that it is laid flat over the backfill. Pull back on the geogrid to ensure good connection with the GroSoxx fascia and to remove any folds in the material.

Place non-woven geotextile to separate native and structural backfill then apply structural backfill with excavator/pneumatic blower. Fill should be placed and compacted using 6-12 in (150-300mm) lifts. Apply native backfill with excavator/ pneumatic blower. Note: typical compaction of fascia when using 12 in (300mm) diameter GroSoxx will result in approximately 30% reduction in height (8 in [200mm]) lift. To reduce this compaction, pressure can be exerted on the geogrid to pull tight against the fascia, reducing compaction and increasing height.

Installation of Succeeding Courses

Successive courses will be set upon previous courses in a batter prescribed by the site engineer. Continue placing GroSoxx, aggregate and native soil or backfill as needed.

For slopes from 70° - 90°, see GreenLoxx MSE Vegetated Retaining Wall design details in Figure 2.1.

For slopes from 50° - 70°, see GreenLoxx MSE Vegetated Retaining Wall - Reinforced Soil Slope (RSS) design details in Figure 2.2.

Backfill Compaction

A Professional Engineer shall specify the backfill type and proctor tests should be conducted using standard ASTM testing procedures or equivalent field procedures as directed by the Engineer. Compaction of materials will vary with soil type but typically, smaller lifts of material (less than 12 in [300mm]) will be easier to compact.

Final Seeding - Cap

The top of the wall or 'cap' requires temporary seeding. For specifications and design for Compost Vegetated Cover (Temporary

Seeding) and Compost Storm Water Blankets see sections 1.7 and 2.1, respectively. Each of these applications will effectively join the GreenLoxx MSE vegetated retaining wall system with any existing vegetation or terrain.

Prior to seeding the top of a GreenLoxx wall, be sure that the upper layer of FLW geogrid is buried to a minimum of 6 in (150mm). GroSoxx can be used to complete the cap in combination with final seeding.

INSPECTION

Regular inspections should be conducted. After six months, if 70% uniform cover of nurse crop has not occurred, it is recommended that reseeding or remedial planting be performed. A minimum of 70% uniform cover for vegetation within 2 seasons should be targeted. Areas that lack vegetation should be spot seeded using a compost/seed mixture.

MAINTENANCE

1. The Contractor shall maintain the GreenLoxx MSE vegetated retaining wall in a functional condition at all times and it shall be routinely inspected.
2. Seeded GreenLoxx walls shall be maintained until a minimum uniform 70% cover of the applied area has been vegetated, permanent vegetation has established, or as required by the jurisdictional agency.
3. Seeded GreenLoxx walls may need to be irrigated in hot and dry weather and seasons, or arid and semi-arid climates to ensure vegetation establishment.
4. Where a GreenLoxx wall lift falls or becomes dislodged, the Contractor will ensure the product is in good contact with the soil and backfill media, repair, and use additional staking if necessary.
5. Where bank or shoreline erosion occurs, the Contractor will regrade the soil if necessary and repair or replace the GreenLoxx MSE vegetated retaining wall.
6. Where vegetation does not establish the Contractor will reseed, replant, replace live stakes, or provide an approved and functioning alternative.
7. If a GreenLoxx MSE vegetated retaining wall is only seeded at time of installation, live stakes may be added to increase stability, aesthetics, wildlife habitat, and ecological succession.
8. No additional fertilizer or lime is required for vegetation establishment and maintenance.
9. No disposal is required for this product/practice.
10. GreenLoxx MSE vegetated retaining walls shall become part of the permanent landscape.
11. Regular cutting of grass vegetation on a seeded GreenLoxx MSE vegetated retaining wall to a minimum height of 4 in (100mm) and a maximum height of 10 in (250mm) will deter invasive weeds, allow sunlight to kill captured pathogens from storm water, and provide maximum sediment removal efficiency and sediment storage capacity in the vegetation.
12. Storm debris and trash deposited on a vegetated retaining wall should be removed immediately.
13. Sediment shall be removed if it reaches 25% of the height of the vegetation (mowed) to prevent diversion of storm runoff and reduction of vegetation health and cover.
14. If drip tape irrigation system is installed, once vegetation is fully established, connections to drip tape irrigation system may be removed, leaving the drip tape inside the GroSoxx.

METHOD OF MEASUREMENT

GreenLoxx MSE vegetated retaining walls shall be itemized as "Supply and Installation of Filtrexx GreenLoxx MSE Vegetated Retaining Wall". Bid prices shall be based on a per ft² or m² of fascia and shall include the supply and installation of the following:

- Filtrexx Durable mesh filled with Filtrexx GrowingMedia and vegetated with site specific seed or plantings (Filtrexx GroSoxx)
- Filtrexx FLW35 Geogrid
- GrowingMedia/aggregate/soil backfill as needed

Submittals

- 1. Shop Drawings:** Retaining wall design calculations, including global stability analysis and drawings are to be stamped by a registered Professional Engineer licensed in the state of the project.
- 2. Product Data:** Material description for all components listed in "Performance" section of this document to include, composition, MSDS sheets, manufacturer certifications and installation information for each product specified as part of the system.
- 3. Planting and Irrigation Plan:** Plant list with elevation views, approved suppliers, seasonal requirements for planting, fertilization, plant coverage targets, methods of measurement, erosion control plans addressing site runoff during and after construction, maintenance agreements.

Delivery, Storage & Handling

Contractor shall check the materials upon delivery to assure the proper materials have been received.

GroSoxx are to match specified length and diameter per engineered drawings, while also being free of any rips or tears in mesh material.

Contractor shall protect the materials from damage, as damaged materials shall not be used in the project.

FIELD APPLICATION PHOTO REFERENCES

Eroded roadway project site, before

ADDITIONAL INFORMATION

For other references on this topic, including additional research reports and trade magazine and press coverage, visit the Filtrexx website at filtrexx.com

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GreenLoxx MSE Vegetated Retaining Wall, after

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Table 2.1. Filtrexx GroSoxx® Mesh Material Specifications.

Material Type	DURABLE (Multi-Filament Polypropylene MFPP)
Material Characteristic	Photodegradable
Design Diameters	12 in (300mm)
Mesh Opening	1/8 in (3mm)
Tensile Strength (ASTM 5035-95) ¹	MD: 545 lbs TD: 226 lbs
% Original Strength from Ultraviolet Exposure (ASTM G-155)	100% at 1000 hr
Functional Longevity/ Project Duration ²	up to 5 yr

¹ Tensile Strength is based on 12" diameter using ATSM D4595. See Filtrexx TechLink #3342 for full tensile strength testing.

² Functional longevity ranges are estimates only. Site specific environmental conditions may result in significantly shorter or longer time periods.

Table 2.2. Filtrexx FLW Geogrid Details.

FLW Geogrids are composed of high molecular weight, high tenacity multifilament polyester yarns that are bidirectional and woven into a stable network placed under tension. The high strength polyester yarns are coated with a PVC material. FLW Geogrids are inert to biological degradation and are resistant to naturally encountered chemicals, alkalis and acids. FLW Geogrids are typically used for soil reinforcement applications such as retaining walls, steepened slopes, embankments, sub-grade stabilization, embankments over soft soils and waste containment applications.

FLW 35 Tensile Properties	Test Method	MARV Values (lbs/ft) MD/CMD
Ultimate Strength	ASTM D 6637	3,600
Creep Limited Strength	ASTM D 5262	2,278
T _d = Long Term Design Strength	NCMA 97	1,918
Aperture Size - 2.00 x 2.00 (inches)	Measured	N/A

RF Creep - 1.58 RF Durability - 1.10 RF Installation Damage (Soil Type 3) - 1.08

Figure 2.1. Engineering Design Drawing for Filtrexx GreenLoxx® MSE Vegetated Retaining Wall

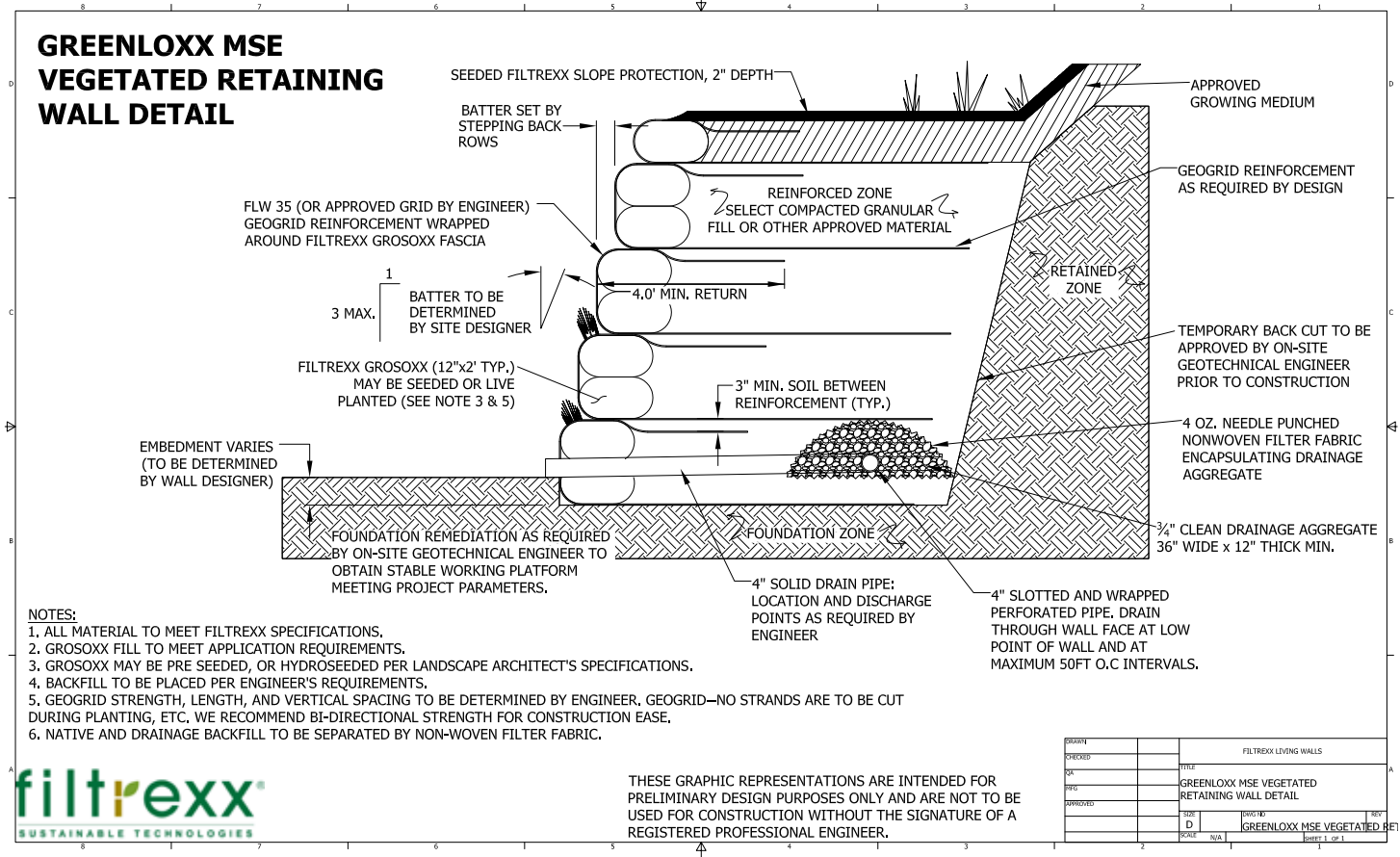


Figure 2.2. Engineering Design Drawing for Filtrexx GreenLoxx® MSE Vegetated Retaining Wall - Reinforced Soil Slope (RSS)

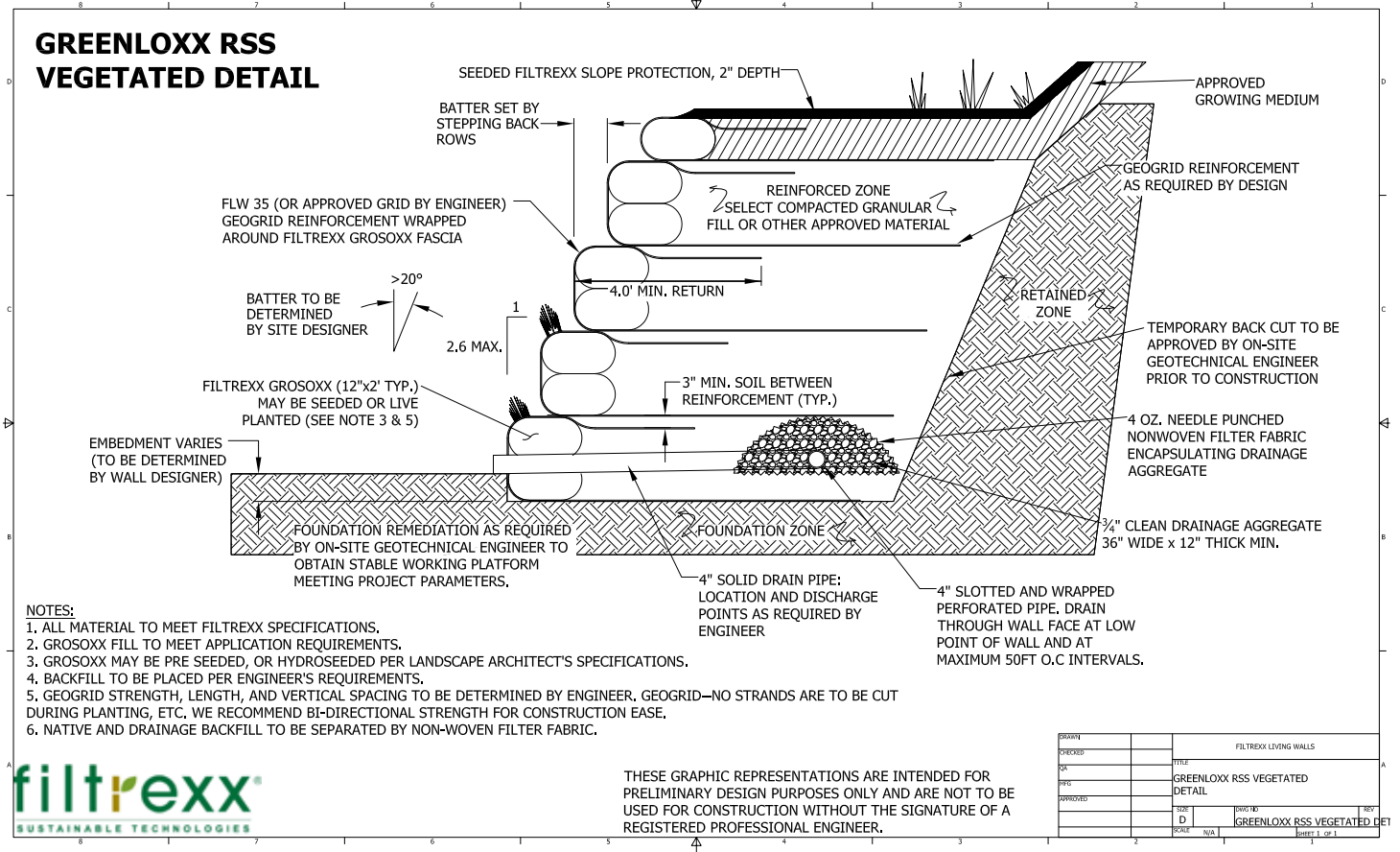


Figure 2.3. Filtrexx® GreenLoxx® 12" GroSoxx® Module Dimensions Detail

