FlexMSE™

Vegetated Wall System

Installation Guidelines

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Changing the way we Build

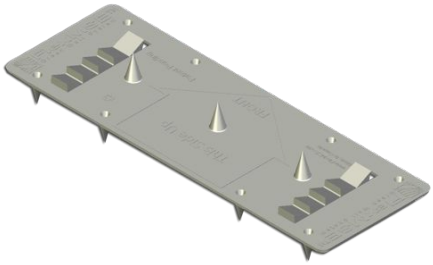
1. Introduction: Changing the way we Build

FLEX MSE DESCRIPTION

Flex MSE is a second generation technology that leverages existing revolutionary soft armour systems to create a superior solution. This soft armour segmental systems allows for construction of permanent slope, wall and shoreline protection installations while creating full vegetation of the wall face. No concrete, no rebar, no forming, and often no levelling pad are needed.

Flex MSE is a patent pending engineered system that creates near vertical vegetated walls, protects stream, lake and coastal banks from erosion, stabilizes hillsides, creates beautiful landscapes, and re-establishes nature's strength.

Flex MSE consists of only two components – a proprietary non woven polypropylene (PP) geotextile Bag, and an engineered recycled PP Plate. The Flex MSE Creep Resistance Plate mechanically connects to the vegetated Bags, creating a structure with great strength, flexibility, and sustainability.



Flex MSE Plate

Raw material: 100% recycled polypropylene
100% recyclable

Height	42.2mm
Length	285 mm
Width	99 mm
# Spikes	11
Creep Resistance Strips	2
Geogrid Hooks	2
Weight	63 grams

The Flex MSE Plate provides a positive interconnection between every Bag. It allows for mechanical connection between geosynthetic reinforcement and the Flex MSE Bag using either the 8 spike array underneath or the Geogrid Hooks on top. Two Creep Resistance Strips provide an additional friction zones, improving Bag to Plate contact.

Flex MSE Bag

The Flex MSE spun PP Bag is the ideal planter block for permanent vegetation. Its 5 micron mesh enables excellent drainage, containment, filtration, and root growth.

Unfilled Bag Size	Approx. Facing Area/Filled Bag*
15" X 35" 38cm X 89cm	1.0 Ft2 0.09 m2

*Facing area per Bag may vary based on quantity/compaction of Bag fill material.

FLEX MSE SPECIFICATIONS

Flex MSE follows established Segmental Retaining Wall (SRW) and Mechanically Stabilized Earth (MSE) principles. Standard engineering design and construction considerations will apply in all installations. The use of additional reinforcement in the form of geosynthetics and/or Flex MSE units (Tie back Method) should be considered in all applications prior to the start of construction. For complete specifications, refer to the *Flex MSE Specifications and Best Practices* document. Structural design considerations may include, but are not limited to:

- *Installation height, including terraces, exceeding 4' in height (depending upon jurisdictions)*
- *Presence of unstable soils, such as clays or organic materials*
- *Hydrostatic loading or erosion from wave action, scour, flow velocities, drainage or site runoff*
- *Load resulting from slopes or structures behind, or above, the wall*
- *Installation slope/batter*
- *Geosynthetic soil reinforcement or other mechanical soil stabilization methods*

FLEX MSE ADVANTAGES

- Lightweight, compact components – 100 unfilled units weighs under 30 lbs (3600 ft2 ships on 3 pallets)
- 120 year ASTM lifetime rating
- Simple crew training
- No forms, rebar, footings or leveling pad required
- Two components satisfy slopes from 0° - 82°
- No extra drainage systems required
- Superior Differential Settlement capabilities over concrete and gabions
- 3% the GHG profile of concrete
- Reuses excavated material
- Reestablishes native vegetation and landforms
- Wide range of vegetation options
- Installs in 60% of the time vs concrete segmental systems
- 60% the cost of concrete installed

FLEX MSE APPLICATIONS

Environmental

- **Erosion Control**
- **Steep Slope Stabilization**
- **Slip Repairs**
- **Culvert Headwalls**
- **Riverbank Protection**
- **Slope Repairs**
- **Open Pit Mining Restoration**

Infrastructure

- **Retaining Walls**
- **Highway Walls**
- **Bridge Abutments**
- **Levees/Dikes**
- **Noise Barriers**

Commercial, Industrial and Residential

- **Site Leveling/Optimization**
- **Terraced Garden Walls**
- **Landscaping and Landforms**
- **Sensitive Sites**

Please refer to Trexiana Wholesale and Distribution's complete package of *Flex MSE CADs* for further information on specific applications.

2. Installation: Engineered by Design

EQUIPMENT LIST

The following is a list of Equipment that may or may not be required depending on the scale or type of installation. Every installation and contractor demands its own set of tools.

a. Site specific safety protection
b. Skidsteer and/or excavator with appropriate attachments (bucket, scoop and forks for Bag pallets)
c. Rounded digging and flat edge transfer shovels
d. Uitility knives
e. Bag closures
f. Filling Jigs
g. Pick and cutting spade for root removal
h. 6' Pry bars for larger rock removal
i. Hand tamper
j. Wheel barrows
k. Heavy duty 5 gallon Buckets
l. 4 ft or laser level
m. Batter board
n. Tape measure
o. Walk behind compactor – soil specific
p. String line and stakes
q. Tarps for Bag pallets

FLEX MSE BAG PREP

All areas serviced by Trexiana Wholesale and Distribution offer prefilled Flex MSE units. Contact local retailers for pricing and supply. These units consistently match the spec found in the Flex MSE Specification and Best Practices and the dimensions illustrated in the Flex MSE Components CAD. Slight variations that have no effect on the overall quality of the build and number of estimated units will occur.

Contractors or others filling Bags shall follow the instructions laid out in the *Flex MSE Bag Filling Jig and Process* document. The Jig is built to 30" table height, allowing for optimally filled Bags that rest level on the ground in groups after the table top and frame are moved. Underfilling of Bags results in more units being used and can also effect geogrid and running bond spacing from row to row. Optimally filled units should measure 30"x12"x5.5" (762mmx305mmx140mm). Weights vary depending on Bag fill mediums and moisture content.

When palletizing Bags, ensure that pallet nail heads are buried and that the bottom layer of Bags does not overhang the edges or slip between the slats. **A consistent Flex MSE Bag filling process is very important to the efficiency and success of the system as a whole.*

Building two or more Jigs dramatically increases Bag output. With two filling jigs, three labourers, and a skidsteer output is typically 500-600 filled units/day. Bag closures are zip or rebar ties and hog rings, although sewing with an appropriate industrial quality sewing head can also be done. Even if not using excavated materials in the Bag Fill Medium, it is recommended to fill Bags on site to minimize transportation costs.

For further details, please see the *Flex MSE Bag Filling Jig and Process* document.

EXCAVATION

The project site may need to be excavated and should be done so to design-specified parameters. During excavation, care should be taken not to disturb additional foundation material.

The foundation must be adequately compacted and proof-rolled to minimize wall settlement. The excavated area must be large enough to accommodate the Flex MSE Bag embedment, the required geogrid lengths and sloped backfill cut depths.

If required, construct an embedment trench as specified in the engineering documentation. Standard practice is to create a 12" wide x 12" deep trench to accommodate the first layer of bags and drainage layer. On smaller, low surcharge walls or where excavation isn't permitted or possible (bedrock or a sensitive stream bank for example), it is acceptable to build directly on top of compacted native materials.

Place the excavated materials in a convenient location if site materials will be used to fill the Bags. No moorings or footings are required, only a reasonably leveled base layer of 6" of clear crush. Note that a drainage zone behind the wall face is typically not required because the wall face is water permeable. The permeability of the wall face reduces hydrostatic pressure and helps maintain vibrant vegetation by providing hydration to the root zone. Engineer drawings may specify otherwise, depending on quality backfill availability.

BASE COURSE

A) Begin at the lowest point of the installation. Once the trench and leveling layer has been prepped, begin with a course of Flex MSE Plates to provide mechanical connection for your first course of Flex MSE Bags. Place filled Bags end to end with maximum 1" gaps - compaction will cause the Bags to fill the space and become more dense. Fold the 'hose' end of the Bag between the Bags to ensure plates engage fully to the bag material. If possible, install the entire length of the base course before starting subsequent courses. Step into the in situ soils at appropriate points to meet the finished design parameters and elevations.

**Note that the trench is occasionally not specified due to a smaller total height and surcharge, or limitations on excavation (stream beds, bedrock).*

In the case of streambeds, adequate armouring with riprap or river rock is typically installed over the initial layers of Bags to protect against scour and in stream projectiles. In al cases, begin with a course of Flex MSE Plates situated at Bag joints on the ground and level the Bags front to back and side to side. It is advised that Flex MSE walls built on bedrock be designed by a qualified Engineer to integrate the structure into the site appropriately.

B) On the next course, place a Flex MSE Plate on top of each Bag joint so that a Plate spans every Bag. Situate the Plate on the Bag lengthwise according your batter/set back, so that the next row of Bags fully envelops the Plate below.

Engage the Plate's spikes by walking along or hand tamping each course of Flex MSE Bags. For larger engineered or steeper walls, hand or plate compacting every row is recommended, as it creates more uniform units. **Maintaining the specified batter is essential to the integrity of all MSE walls. It is highly recommended to construct batter boards at the wall toe to accurately maintain the specified batter.* Backfill and compact every two rows of bags, or the specified soil lift. When coming to a backfill compaction level, it is safe to run a vibratory Plate compactor over the Bags on that row, speeding up the tamping process.

C) As you add successive layers of Bags, pay strict attention to the 'running bond' pattern between the Bags on different layers. This running bond pattern is essential to all SRW systems' performance. The multiple points of contact of the Plate to the three surrounding Bags give the system its strength and considerable flexibility.

**Due to the occasional inconsistencies in filled Bags or changes in the wall's profile, the bond spacing will sometimes change slightly as you lay Bags down the line.* To correct this, you can turn a Bag 90 degrees to the face to correct the

spacing of the offset pattern as needed. This also adds to the strength of the wall by increasing the tie-back/reinforcement. The same occurs when there is any designed curvature to the wall. When the top Bag get 6-8" off the centre of the Bags underneath a Tie-Back unit should be inserted into the pattern. Note that only occasional Tie Back units are required, there is no need to do entire rows in the pattern. Refer to the *Flex MSE Gravity Wall -Tie Back CAD* for design reference. A smaller filled Bag can also be used to reset the pattern, laid in the standard way. Corners or wall ends are typically finished by alternately laying the Bag or Bags 90 degrees to face to reset the bond. The Running Bond and Tie Back Reset method are illustrated below for reference.

D) Continue systematically placing Bags, backfill, and reinforcement until the desired height is reached. Place the backfill from front to back of the excavated area to keep tension on the reinforcement. (Geogrid installation is covered in more detail below.) When the height reaches the level specified by the Designing Engineer, lay down the appropriate lengths of reinforcement according to the manufacturer's guidelines. Contact the Engineer at every point required in the Design.

E) If the design calls for the Tie back method of reinforcement, follow the instructions as laid out in the *Flex MSE Gravity Wall – Tie Back CAD.* Tie back walls are ideal for smaller, low surcharge installations, particularly where minimal excavation is required (culvert headwalls on stream banks). Geosynthetic reinforced MSE walls often integrate Tie Back sections into tougher areas on the ends to speed up installation. A few more Bags/m2 are used (17 vs 13), but the time saved is often worth it.

Fig.1 'Running Bond' Pattern

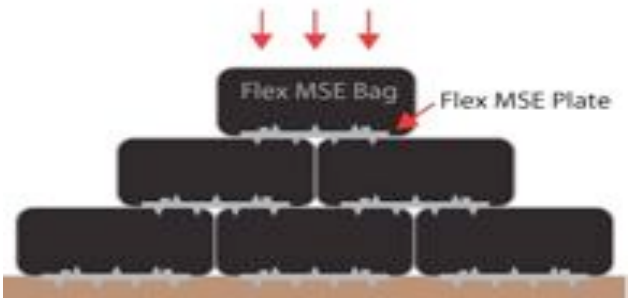


Fig.2 Tie-Back Reset

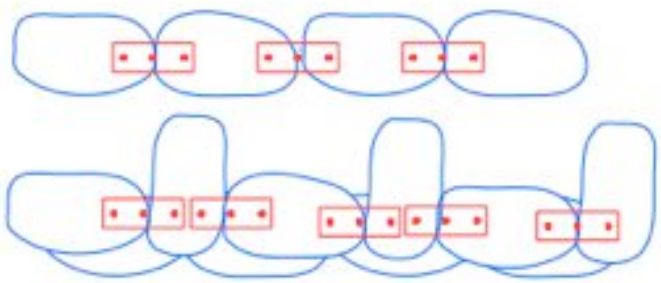
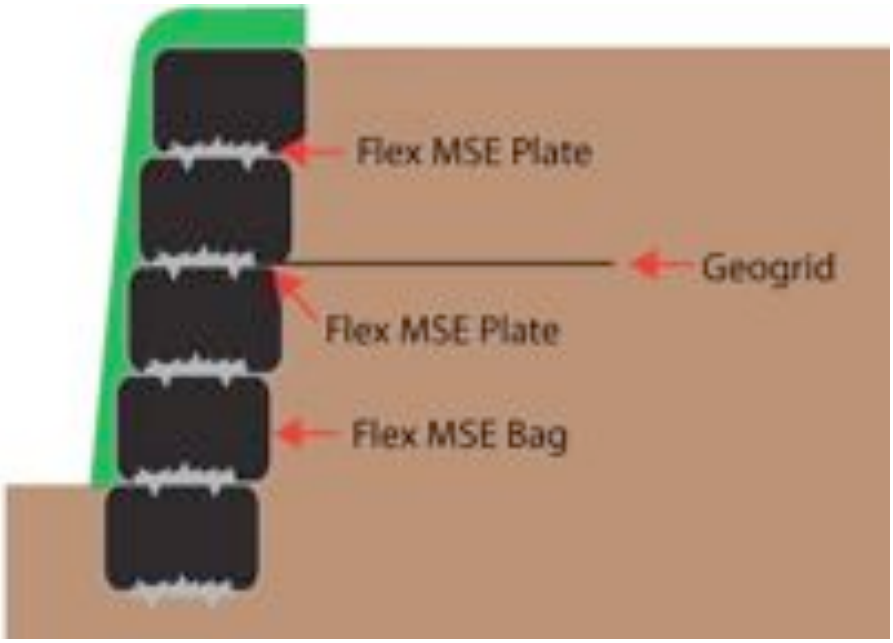


Fig. 3 Flex MSE Cross Section with Reinforcement



BACKFILL

Proper backfill and its compaction is critical to the stability of Segmental Retaining and Mechanically Stabilized Earth Walls. Poorly compacted, clayey or silty backfill puts extra pressure on the wall, especially when it gets wet. Backfill will also not compact properly if outside the specified optimal moisture content during compaction.

Geogrid reinforcement does not function if the soil around it is not properly compacted at the specified soil lifts. *Backfill soils for Flex MSE installs are compacted to a minimum 95% Standard Proctor.* Engineers will often specify 98% as well. Both the type of material and the compaction equipment needed

must be considered to achieve this minimum standard. When available, use well compacted engineered fill to guarantee a solid installation.

Consult an engineer for specific recommendations and use these basic guidelines for Backfill:

a) Backfill material must have the proper moisture content for optimum performance when compacting.

b) Organic or heavy clay material should not be used. These materials hold excessive moisture and do not compact properly.

c) Walk-behind mechanical compaction equipment may be used to compact soils.

d) Ride-on mechanical compaction equipment should be operated no closer than 1 meter (3') of the wall face.

e) Avoid over-compaction of soils next to the wall face.

f) Qualified Technical Personnel should perform all soil testing. Soil tests should be taken no closer than three feet from the back surface of the Flex MSE Bags.

The proper thickness of material placed in a single lift is dependent on the type of soils and compaction equipment being used. Most site soils are easily influenced by moisture levels and must be placed in smaller lifts, requiring greater compaction effort.

GEOGRID

Geogrid is used to reinforce retained soil fill. Site characteristics, soil types, wall loading, and seismic conditions all influence the specification of geogrid reinforcement placement.

Geogrid is specified at certain wall elevations on Engineer drawings. At courses where the construction drawings indicate that geogrid is required, lay the geogrid 1-2" over the front edge of the Bag (for inspection purposes) and place the Flex MSE Plate on top, providing a mechanical connection between the Bags and the geogrid. The Geogrid hooks on top of the interlocking Plate may also be used, and are often much more convenient when using ovoid aperture uniaxial grids.

Once the geogrid is anchored by the Plate, lay the required length tightly and without wrinkles, ensuring that the highest strength direction is perpendicular to

the wall face. Certain grids (biaxial and triaxial) may be laid lengthwise off the roll depending on the application, but it is critical to follow manufacturer guidelines on orientation.

When installing geogrid, ensure that it is flat when it is placed onto the backfill. This can be achieved by rolling out the geogrid, and then pinning it into position at the back of the backfill zone. By placing fill from the wall face to the back of the backfill zone, the weight of the backfill will help keep the geogrid straight and tense.

Lay the next Bag course to further drive the Flex MSE Plate into the Bags and to help anchor the geogrid to the wall. Then, place and compact backfill on top of the geogrid to the level of the bag. For less steep walls with more course set back, or to satisfy design specifications, it may be necessary to lay and compact backfill every course to ensure even compaction.

Unixial geogrid is stronger in one direction than the other, so it is crucial to place it in the correct direction. The strongest direction of the grid must be perpendicular to the wall face. Follow the geogrid manufacturer's directions to ensure the geogrid is properly oriented.

**Note: Reference the manufacturers installation guideline for each geogrid product and the Notes in the Engineer's drawing for important information on spacing and lengths, as they may differ throughout the wall.*

VEGETATION BEST PRACTICES

Flex MSE structures are essentially built like retaining walls and finished like a landscaping project. The two aspects are integral to the system's unique strengths and lifetime rating. Typical practical considerations can include: application type, growing zone, local invasive plant control programs, exposure to sunlight, wind and fauna, medium nutrients, wave action and inundation. Vegetation planning for Flex MSE is a balance between the practical concerns and the aesthetic desires.

Certain applications have commonalities. For infrastructural and industrial installs, the lowest maintenance and most financially prudent solution will be the most suitable. Hydroseeding is often used by itself in Flex MSE roadway projects for its cost effectiveness, easy customization, and low long term maintenance. Attention must still be paid to planting windows, invasive species introduction, salinity issues, periods of drought, nitrogen fixing for long term soil viability, and plant competition, amongst others.

Residential and architectural applications typically incorporate more elaborate planting and irrigation plans. Long term maintenance and water access should

always be considered when planning a Flex MSE install. For obvious reasons, planting a cedar tree directly on top of a Flex MSE wall is not advised. That being said, root structures of established willow stands 12-15' tall in Vegetated GeoModular walls actually contribute to the long term viability of the installation. Consulting with a horticulturalist or nursery with experience in living walls, native species, or good doers for the area is strongly advised for all Flex MSE installs.

Depending on the method, vegetation is installed into the structure upon completion or during construction of the project. It is recommended that full vegetation be achieved within 6 months of completion, but this may vary according to application, site characteristics and local climate.

Depending on the local climate, installation timing, plant choice, and application consider installing an irrigation system or adhering to a set watering schedule to guarantee the initial establishment of vegetation. A spray head, drip, or soaker style irrigation system located on select rows is often specified. Application of liquid fertilizer at regular intervals may also be necessary, depending on Bag fill medium characteristics, plant choice, and environmental concerns.

Native drought tolerant plants will increase the long term viability of vegetation, as well as contribute to the sustainability of local plant life. Nitrogen binding varieties such as legumes (clover and trefoil for example) should also be considered when developing the Vegetation Specification.

Listed below are the five practical methods for sustainable vegetation along with common applications where such methods are utilized.

Hydroseeding

Hydroseeding is the most common vegetation method – very cost effective and fast, consistent growth. Standard native, drought resistant blends are typically less than $1.00/ft2 installed and achieve full vegetation within 60 days under optimal conditions. Custom blends may occasionally be warranted depending on local climate and environmental concerns. Respect local seeding time windows to increase success rates.

For the best results, saturate Flex MSE Bags with water before applying the hydro seed mulch. This will help to ensure water from the mix is not drawn into the Flex MSE Bag, causing the mulch and seed to dehydrate. This also holds true for all approved vegetation methods. Typical mulches used in the systems higher slopes include tackified wood fibre, Bonded Fibre Matrix (BFM), and Flexible Growth Medium (FGM). Please confirm with local suppliers and installers which mulch and tackifier is most suitable to the project prior to the application. A mulch appropriate for extreme slope applications will dramatically improve vegetation results and provide a maintenance free finish.

Watering hydroseeded Flex MSE structures should be done under 'Frequent Light Watering' guidelines standard to hydroseeding Best Practices.

Common Applications:

- All applications except those affected by significantly changing water levels during germination and initial root development stage, and grazing/picking by wildlife.
- Examples: Walls, Slopes, Land & Water Erosion control

Preseeding

Mixing grass seeds with the growing medium in the Bag is another method. Vegetation outcome varies due to UV exposure and variable seed distribution in the medium. Only seeds close to the surface of the Bags will emerge through the Flex MSE Bag material. For this reason, an increased estimate of seed volume for the coverage area is recommended. Increase the g/m3 seed application in the Bag Fill Medium to 5x that of the g/m2 rate. For example, if the prescribed seed coverage for a flat surface were 10g/m2, consider mixing 50g of seed into 1m3 of Flex MSE Bag fill medium. Avoid overseeding as this can lead to overgrowth and competition. As with all methods, saturate Pre-seeded Bags thoroughly after installation is complete.

Common Applications:

- Shorelines where varying water height or birds can strip hydraulically applied seeds on the outside of the Bag.
- Remote areas or areas where access or ability to re-visit the site is restricted.
- Sites where exposed seed could be eaten by local birds or animals.
- Often combined with live staking or brush layering vegetation methods, and as supplementation to hydroseeding.

Live Staking

Live Staking is often used in shoreline and stream bank applications, erosion control sites, or when desired outcome is for a more 'rugged/wilder' slope or wall. Live Staking can be done during or after the Flex MSE System placement is complete and is often used in combination with hydroseeding.

When placing stakes during the construction process, simply lay or insert cut minimum 1" diameter stakes between Flex MSE Bags leaving 20% of the length of the stake exposed. Up to 3 sharpened stakes can also be pierced directly into the exposed material of each Bag. As with live planting, the entry point should be above the halfway mark of the Bag. Do not puncture Bags beneath the high water mark, as any holes will lead to significant medium loss through hydraulic

effects.

When Live Staking in between Flex MSE units after their placement, it helps to use a rounded tool slightly larger in diameter than the live stakes to make a pilot hole for the stakes to be inserted into. (ie: re-bar with a rounded nose)

For vegetating structures subject to variable water levels, only place stakes between Bags below the high water mark. Do not puncture Bags below the high water mark.

For best results, saturate the structure thoroughly before or after live staking. Attention must be paid to backfill characteristics when Live Staking or Brush Layering. A structural soil, with organic content and finer sands added, or appropriate native materials will provide nutrition for plants embedded in these ways.

Common Applications:

- Shorelines & Stream banks.
- Erosion Control Applications calling for significant subsurface root development.

Live Planting

Plants/plugs with smaller root balls (under 4") can be inserted directly into the Flex MSE Bag. When Live Planting the face of the installed Flex MSE unit, up to three inverted 'T' cuts 2-3" in width and height are permitted per Bag. Always minimize the size of the hole cut for the root ball. Situate the horizontal cuts in the top 1/3 of the Bag face to prevent medium loss. Seedling plugs can be up to 4", but smaller (2-2/1/2") are easier to install and decrease the planting's hole size. After cutting the material, make a 45° sloping cavity in the Bag fill medium large enough for the plug and fully embed it into the hole. If the 'T' cut is too big, the Bag material can be closed by sewing or stapling around the plant stem.

A spiked planting tool such as a dibble may also be used to create the hole, and is often more efficient and precise than the 'T' cut. Position the dibble on the upper 1/3 of the Bag and insert at a 45° angle. Ensure the full root ball is embedded in the opening.

Use a 'spacer' guide such as a string to appropriately space live vegetation. Depending on the vegetation it may be necessary to place a fertilizer pellet in with the root ball to help promote initial root growth.

As with all methods, saturate the Flex MSE structure and root ball before placement to encourage initial growth.

**Note: When designing for Live Planting, it is necessary to limit plant holes per Bag to three, and to not cut Bags below the water line*.

Common Application:

- Landscape walls & slopes
- Restoration / reintroduction of cultivated Native Plant species

Brush Layering

A similar practice to Live Staking between Bags – this method ties the root ball into the backfill behind face of the Flex MSE system. Brush Layering needs to be completed during Bag placement. When inserting plants, angle brush layers downward into the fill or native material. When using larger root balls on Walls and Slopes, insert the plant after completing every second layer of Bags (ie before infilling and compacting the specified soil lift). More established plants may be used when Brush Layering (up to 1 gallon standard pot). It is recommended to use an approved Structural Soil when Brush Layering to increase the root development of the plant and provide nutrition.

Common Applications:

- Shorelines & Stream banks (Semi – aquatic plants)
- Landscaping walls
- Any Flex MSE structure requiring larger plants at the outset

INSPECTION AND MAINTENANCE

Properly designed and constructed Flex MSE structures provide a very low maintenance solution. However, as with all building systems, a regular inspection and maintenance routine is suggested.

It is recommended to inspect the structure annually and after any major climatic or seismic event. It is also recommended to keep a photo record, showing the application from similar view points for year-to-year comparisons. Annual inspection reports should ideally include Structural and Aesthetic components, along with any additional criteria recommended by the Engineer or Designer.

Structural Inspection:

- Bulging: are there any localized areas where Flex MSE Bags seem to be bulging out of the structure? It may be necessary to trim vegetation cover for a closer inspection.

- Rotation: Flex MSE can be safely constructed to many slope angles in the same install; note if there are noticeable changes in the face slope angles at the time of inspection from the slope angles at completion of construction.

- Excessive water flow through the Flex MSE structure: the system allows for superior drainage, however excessive water flowing through the structure, especially at localized areas should be reviewed for cause. Often the solution is as simple as auguring through the face and inserting a perforated pipe to relieve the hydrostatic pressure in the wall.

- Differential settlement of the structure: the Flex MSE system allows for significant differential settlement, but always confer with the Engineer of record regarding the stability of any wall experiencing differential settlement.

- Ripped or damaged Bags: Due to Flex MSE's capacity for differential settlement, Bag Fill medium loss from single Bags is not a grave concern. Repair by sewing, stapling or replacing or re-apply vegetation through Live Planting or spot seed mulch application.

The Engineer of Record should be notified of any significant irregularities, so they may evaluate the cause and recommend any need for remedial action.

Vegetation Inspection and Maintenance:

At six months, if complete coverage of the Flex MSE Modular Bags has not occurred it is recommended to consider the following remedial measures:

- Irrigate: Vegetation may need water; spray, soaker, or drip irrigation is advised.
- Fertilize: Vegetation may need nutrients; liquid fertilizer is recommended.
- Re-apply Vegetation: Pay attention to particular varieties that did well, and the method of failure. Occcasionally quick germinating plants can stifle slower perennial varieties.

Consult with a qualified horticulturist or contact the local Flex MSE Distributor for further assistance.