SPECTRA®

ROADWAY IMPROVEMENT SYSTEM

INSTALLATION GUIDE

Tensar®
INTERNATIONAL

The Spectra® System incorporates a mechanically stabilized base or subbase layer that offers a predictable, cost-effective solution.

Tensar® Geogrids

The **Spectra System** owes its strength and durability to **TriAx,®** Tensar's patented reinforcement geogrids. With its unique triangular structure, **Tensar® TriAx® Geogrid** represents an advancement in geogrid technology. Its multi-directional properties leverage the triangular geometry to provide in-plane stiffness through 360º.

Introduction

When weak subgrade, heavy loads, thick fill layers, high structural fill costs, contaminated subgrades or shallow utilities disrupt your construction schedule or budget, the Spectra® Roadway Improvement System can provide an optimal solution. The Spectra System includes mechanically stabilized layers (MSL) utilizing one or more layers of Tensar TriAx Geogrid. The purpose of this Installation Guide is to provide guidance for the installation of the MSL incorporating Tensar TriAx Geogrid.

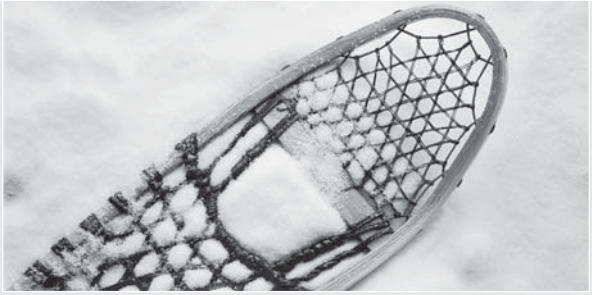
Not only does this system allow access and construction for less than ideal situations, it also offers a predictable engineered solution. This solution relies on Tensar® TriAx® (TX) Geogrids and granular fill acting together to create a stronger composite structure. The mechanically stabilized layer increases the performance of both paved and unpaved road structures.

Tensar TriAx Geogrids have proven their performance and cost-efficiency in thousands of applications. Over soft ground, Tensar TriAx Geogrids improve the soil's effective bearing capacity by distributing applied loads more efficiently, similar to the way a snowshoe supports a man's weight over soft snow. Tensar TriAx Geogrids interlock and stiffen triangular fill materials by confining granular particles within the triangular apertures, thus yielding a stronger component for increased serviceability and durability.

The long-term performance of both paved and unpaved applications are predetermined by ground or foundation support. Proper geogrid installation is also based on subgrade strength. We use California Bearing Ratio (CBR) to quantify this important variable and correlate most measures of soil subgrade support values (such as R-value, SPT data, k-value, M_r, and C_u) to CBR.

Tensar TriAx Geogrids are used to minimize aggregate fill requirements, reduce or eliminate undercut, improve compaction, serve as a construction platform and extend service life. These features depend upon the proper installation procedures presented in this guide.*

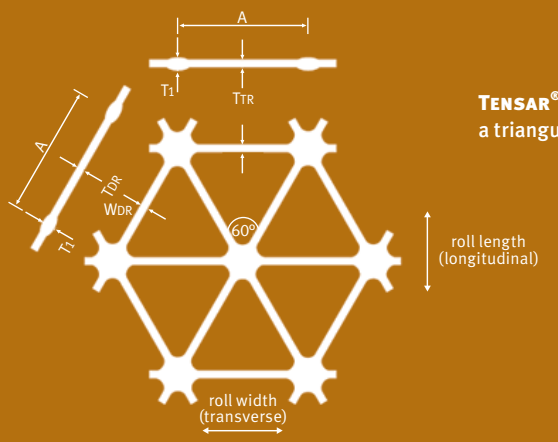
*This guide cannot account for every possible construction scenario, but it does cover most applications of the Spectra System. If you have questions regarding a specific project, call 800-TENSAR-1 or visit www.tensar-international.com.



The Snowshoe Effect – Tensar TriAx Geogrids distribute heavy loads over soft soils just like a snowshoe supports the weight of a man over soft snow.

Spectra® System Components

COMPONENT	FUNCTION
Tensar TriAx Geogrids	Stiff geosynthetic reinforcement
Design	Roadway sections developed using the latest design technology
Site Assistance	Expert Tensar personnel available to visit the project site to ensure an expedited installation



TENSAR® TRIAX® GEOGRIDS have a triangular aperture structure.

1. Getting Started

- When placing an order, communicate all pertinent project and/or application criteria, including certification requirements, if any, to your Tensar International Corporation (TIC) representative. It is normally advisable to schedule a pre-construction meeting with this representative and any other appropriate parties at this time.
- Upon delivery, check the Tensar® TriAx® Geogrid roll labels to verify that the intended product has been received. For instance, TX5 and TX7 Geogrids have a similar appearance, but different structural characteristics so their distinction is important. Inspect the geogrid to ensure it is free of any flaws or damage that may have occurred during shipping or handling. If variable roll widths are supplied, please confirm that the correct quantities have been delivered. Tensar TriAx Geogrid rolls are assigned distinct nomenclature to distinguish the roll width and length.*
- Store Tensar TriAx Geogrids in a manner that prevents excessive mud, wet concrete, epoxy or other deleterious materials from coming in contact with and affixing to the geogrid. Store geogrids above –20˚F (–29˚C) and avoid handling below 14˚F (–10˚C). Please contact TIC if project conditions require storing and handling beyond these recommended limits. Tensar TriAx Geogrids may be stored uncovered for up to six (6) months in direct exposure to sunlight without any loss of certifiable structural properties (contact TIC if longer exposure is anticipated). The geogrids may be stored vertically (rolls stood on end) or horizontally in stacks not exceeding four rolls high (Image 1).
- Anticipate potential issues and resolve them with TIC prior to construction. To contact the local TIC representative for your area, call 800-TENSAR-1.

Tensar® TriAx® Geogrid		
Product	**Roll Width**	**Roll Length**
Tensar TriAx TX5-475	13.1 ft (4 m)	246 ft (75 m)
Tensar TriAx TX7-450	13.1 ft (4 m)	164 ft (50 m)

***Additional roll characteristics can be found on page 9 of this guide under "Tensar TriAx Roll Characteristics."**

Image 1 Storing the Tensar TriAx Geogrid rolls (horizontally).

Image 2 Rolling out Tensar® TriAx® Geogrid.

2. Site Preparation

- Clear, grub and excavate (if necessary) to the design subgrade elevation, stripping topsoil, deleterious debris and unsuitable material from the site. For very soft soils (CBR < 0.5), it may be beneficial to minimize subgrade disturbance and leave root mats in place. Cut stumps and other projecting vegetation as close and even to the ground surface as practical. For moderately competent soils (CBR > 2), it may be prudent to lightly proof roll the subgrade to locate unsuitable materials. When possible, backdrag to smooth out any ruts.
- Smooth grade and compact the soils using appropriate compaction equipment. Swampland, peat, muskeg or marshes may be difficult to smooth grade and/or compact. In these situations, create a surface that is as uniformly smooth as possible. Grade or crown the surface for positive drainage away from the construction zone.

Note: Routine construction procedures are normally recommended for site preparation. Special measures are rarely required to accommodate Tensar TriAx Geogrids.

- Place the rolls of Tensar® TriAx® Geogrid* in position, cut the roll tape and manually unroll the material over the prepared surface (Image 2). In unpaved applications, this surface will always be the subgrade. In paved applications, it may be the subgrade, the granular subbase or an elevation (ex., mid-depth) within the aggregate base course.
- Fine grained, non-cohesive soils such as silts present unique challenges, especially with the presence of excessive moisture. TIC recommends that a Tensar representative be contacted so that site conditions can be analyzed to ensure the geogrid performance is optimized.

***Tensar International Corporation manufactures several different types of geogrid. Selection and optimization depends on structural performance requirements, subgrade and fill parameters, economic considerations and local availability.**

Summary of Tensar® TriAx® Geogrid Installation Parameters

Subgrade Strength	Clear All Vegetation?	Geogrid Orientation[3]	Geogrid Overlap[4]	Nylon Zip Ties?[1, 2]	Direct Traffic?[5]	Geotextile?[6]
CBR ≤ 0.5	N	T or L	3 ft	Y	N	Analysis Req'd
0.5 ≤ CBR ≤ 2	Usually	L	2–3 ft	N	N	Analysis Req'd
2 ≤ CBR ≤ 4	Y	L	1–2 ft	N	Limited	Analysis Req'd
4 ≤ CBR	Y	L	1 ft	N	N	N

Notes:
1. Summary is a generalized presentation; see text for specifics.
2. Y = Yes, normally required; N = No, not normally required.
3. Geogrid Orientation (roll axis in relation to traffic): T = Transverse, L = Longitudinal.
4. General Geogrid Overlap Rule: Overlap = 3 ft for CBR ≤ 1; Overlap = 1 ft for CBR ≥ 4; interpolate between.
5. Direct Traffic pertains only to conventional rubber-tired equipment.
6. Analysis Required = Geotextile required only if filtration criteria is not met by aggregate fill.

Table 1

Overlapping Tensar® TriAx® Geogrid in the field is quick and easy.

3. Placing and Overlapping Geogrid

- Unroll the geogrid in the direction of travel so that the long axis of the roll is parallel with channelized traffic patterns. For very soft subgrades (CBR < 0.5), unrolling geogrid transversely or perpendicular to the roadway embankment alignment, may be preferred, particularly if lateral spreading and separation of overlaps is a concern (Table 1).
- Overlap adjacent rolls along their sides and ends in accordance with Table 1.
- Overlap ("shingle") geogrids in the direction that the fill will be spread (Image 3) to avoid "peeling" of geogrid at overlaps by the advancing fill. To expedite the shingling process, consider placing rolls at the far end of the coverage area first, and work toward the near end from where the fill will be advanced. Weaker subgrades that are easily rutted with conventional construction traffic will require an end-dumping operation. Please refer to page 7 "Dumping and Spreading Aggregate Fill" for more information.
- Adjacent geogrid rolls are normally not connected to one another, particularly if fill is placed and spread as described herein (Table 1). A notable exception is over very soft subgrades (CBR < 0.5) where nylon cable ties (or "zip ties") can be effective in helping maintain overlap dimensions. These ties are not considered structural connections, but rather construction aids. In most applications their use is not required.
- Cut and overlap the geogrid to accommodate curves (Image 4). Cutting may be done with sharp shears (Image 5), a knife-like implement or handheld power (i.e., "cutoff") saws. Cut the geogrid to conform to manhole covers and other immovable protrusions such as vertical utilities.
- In some cases, especially on cooler days, Tensar® TriAx® Geogrid will exhibit "roll memory" where a few feet may roll back upon cutting or reaching the end of the roll. It is recommended that the installer take appropriate measures to ensure that the product lies flat during fill placement. This can be easily achieved by using sod staples, zip ties or simply adding a shovelful of fill to weigh down the product.
- **Safety Note**: The use of safety glasses and gloves is highly recommended when installing Tensar TriAx Geogrids.

Image 3 Tensar TriAx Geogrid should overlap in the direction of advancing fill.

Image 4 Placing Tensar TriAx Geogrid to accommodate curves.

Image 5 Cutting Tensar TriAx Geogrid is easily achieved.

4. Tensioning and Anchoring

Tensar® TriAx® Geogrids may be anchored in place to aid in maintaining product overlaps and alignment over the coverage area.

- Before fully unrolling the geogrid, anchor the beginning of the roll, in the center and at the corners, to the underlying surface.
- Anchor the geogrid with small piles of aggregate fill (Image 6), if necessary. Alternatively, sod staples or washers and pins may also be used by driving them into the subsoil through the apertures of the geogrid. This measure is rarely required unless a significant crown or sloping of the subgrade requires some mechanical anchoring to prevent lateral sliding of the product during fill placement.
- Unroll the geogrid. Align and pull it taut to remove wrinkles and laydown slack with hand tension, then secure in place as necessary. Because of the unique manufacturing process and roll sizes of Tensar TriAx Geogrid, maneuvering an unrolled sheet of geogrid is easily achieved. **Gloves should be worn while handling Tensar TriAx Geogrids.**
- Additional shoveled piles of aggregate fill may be required to hold the geogrid in place prior to placement of the aggregate fill along overlaps and the ends of rolls.
- When constructing over very soft soils (CBR < 1.0), it is critically important to maintain overlaps during placement of the fill material. The use of nylon zip ties placed every 5–10 ft is optional to maintain the overlap width recommended in Table 1.

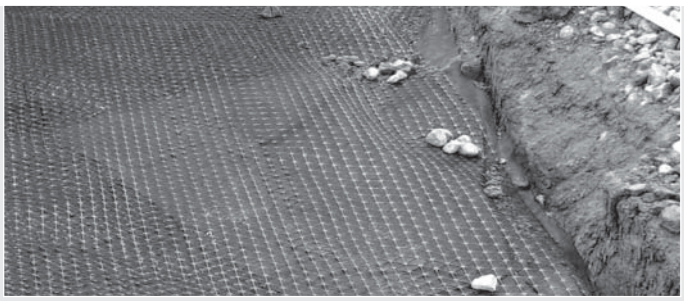


Image 6 Tensar TriAx Geogrid anchored with small piles of aggregate.

5. Dumping and Spreading Aggregate Fill

- Generally, at least 6 in. of compacted aggregate fill is required for the initial lift thickness over a Tensar® TriAx® Geogrid. However, for very soft conditions, a significantly thicker fill layer will be required to prevent excessive rutting and/or bearing capacity failure of the underlying subgrade soils.
- Over relatively competent subgrades (CBR › 4, see Table 1), aggregate fill may be dumped directly onto the geogrid. **Standard, highway-legal, rubber-tired trucks (end dumps and belly dumps) may drive over the geogrid at very slow speeds (less than 5 mph) and dump aggregate fill as they advance, provided this construction traffic will not cause significant rutting upon bare subgrade. Turns and sudden starts and stops should be avoided.**
- Over softer subgrades, back the trucks up and dump fill from the edge of the previously placed material (Image 7). For very soft subgrades (CBR ‹ 0.5), extreme caution should be taken to avoid overstressing the subgrade soil both during and after fill placement. Please contact a Tensar representative at 800-TENSAR-1 for guidance with constructing over very soft subgrade soils (CBR ‹ 0.5).
- Do not drive tracked equipment directly on a Tensar TriAx Geogrid. Ensure at least 6 in. of compacted aggregate fill (or the required minimum design fill thickness) is spread between the geogrid and any tracked equipment (Image 8).
- Over softer subgrades (CBR ‹ 1.5), a lightweight, low ground pressure (LGP) dozer is recommended to evenly push out the initial lift of fill over the exposed geogrid.
- Care should be taken not to catch the dozer blade or other equipment on the geogrid. The dozer blade should be raised gradually as each lift is pushed out over the geogrid. The desired effect is fill that cascades onto the geogrid, rather than being pushed into it.
- When building over a soft subgrade, it is desirable to work from stronger to weaker areas.
- Be aware of geogrid overlaps and advance the aggregate fill with the shingle pattern.

Note: When aggregate fill is spread by pushing it over the geogrid with heavy equipment, such as bulldozers, the shoving action may create a "wave" in the sheet of geogrid ahead of the advancing fill. Shoveled fill can trap this wave and force the geogrid up into the aggregate layer where it can be damaged by the spreading equipment. Pulling the geogrid taut will mitigate laydown slack, thereby removing "waving." If significant waving occurs, the shoveled material should be removed to allow the waves to dissipate at the ends and edges of the roll.

Image 7 End dumping aggregate fill on top of Tensar TriAx Geogrid over soft subgrade.

Image 8 Spreading aggregate fill over Tensar TriAx Geogrid.

Image 10 Compacting the aggregate fill.

6. Compacting

- Standard compaction methods may be used unless the soils are very soft. In these cases, static instead of vibratory compaction is prudent, particularly over fine-grained, non-cohesive soils such as silt. Compaction is then achieved using a light roller. Keeping the moisture content of the fill material near optimum will make compaction more efficient. Water spray is most effective with sand fill (see Image 9). For construction over very soft soils, compaction requirements are normally reduced for the initial lift as the primary intent of the initial lift is to achieve a suitable working surface.
- If rutting or severe pumping occurs under truck or dozer traffic, fill should be added immediately to strengthen the section. Saturated silty subgrades are particularly prone to pumping. In some cases, it may be prudent to cease operations for a period of time, allowing pore pressures to dissipate and the subgrade to stabilize. Otherwise, de-watering measures such as “bleeder ditches” should be considered to reduce the moisture content of the uppermost silty subgrade layer. Please contact a Tensar representative for more information.
- Compact aggregate fill to project specifications, after it has been graded smooth and before it is subject to accumulated traffic (Image 10). Inadequate compaction will result in surface rutting under wheel loads. Rutting reduces the total effective thickness of the fill and increases stress on the subgrade.*
- If the aggregate fill thickness is insufficient to support imposed load(s) when constructing over soft soil, excessive subgrade and surface rutting will result. Measures should be taken to ensure the proper thickness of granular fill is placed atop the geogrid to maximize support and minimize movement at the surface.

*__Note:__ Compaction equipment and methods should be appropriate for the type of fill being used, its thickness and the underlying subgrade conditions.

Image 9 Moistening the fill before compaction.

Tensar® TriAx® Geogrid Roll Characteristics								
	Roll Width		Roll Length		Roll Area		Roll Weight	
Product	(m)	(ft)	(m)	(ft)	(m^2)	(SY)	(kg)	(lbs)
Tensar TriAx TX5-475	4	13.1	75	246	300	358.5	66.4	143
Tensar TriAx TX7-450	4	13.1	50	164	200	239	58.2	128

7. Special Considerations

Make Repairs

- If Tensar® TriAx® Geogrids become damaged during or after installation, repair them by patching the area with the following measures:
  1. Remove fill from the surface of the damaged geogrid and clear a 3-ft area around the damage.
  2. The geogrid patch should cover the damaged area and extend 3 ft beyond it in all directions.

Surface Rutting

- If deep rutting occurs beneath truck wheels, do not grade out the ruts. Rutting is normally indicative of fill that is too thin, too wet or inadequately compacted. Grading out the rut will reduce aggregate fill thickness between the wheel paths and may lead to geogrid exposure.
- Fill in the ruts with additional specified aggregate fill and compact. This places extra fill where it's needed and may prevent further rutting under channelized traffic.
- Crown the fill during the grading process to ensure rainfall runoff and to prevent fill saturation.

Cold Weather

- At sub-freezing temperatures, the polymer in a Tensar TriAx Geogrid becomes less resistant to impact and can be fractured by applying a dynamic force (i.e., striking with a hammer). Other aspects of dynamic loading associated with very cold temperatures should be avoided. Tensar Geogrids may be installed in extremely cold climates as long as proper storage and placement procedures are employed. For more information regarding the installation of geogrids in cold climates, please consult a Tensar representative at 800-TENSAR-1.

Aggregate Fill Considerations

- The preferred (not required) fill gradation for roadway applications is well-graded crushed aggregate fill with a maximum particle size of 1½ in. and less than 10% fines (passing #200 sieve). The gradation ranges listed below are recommended for the enhanced load distribution and positive drainage of flexible pavement applications where granular base courses are typically utilized. For unpaved applications, most clean granular fills, including sands, are acceptable.

Preferred Fill Gradation	
Size	% Passing
1½ in.	100
¾ in.	50–100
#4	25–50
#40	10–20
#100	5–15
#200	less than 10

Image 12 A backhoe excavation through a Tensar TriAx Geogrid.

Excavating Through Tensar® TriAx® Geogrid

When confined beneath and within compacted fill, the geogrid should pose no significant challenges to post-construction activities like utility trenching or driving/auguring supports for rails, signs or standards. Conventional excavation equipment will shear directly through the geogrid leaving a clean cut as shown in Image 12

- Tensar® TriAx® Geogrids will structurally enhance coarser or finer fill gradations, as long as the aggregate fill is compacted and placed at, or just below, optimum moisture content. For coarser fill, a graded filter analysis is recommended to guard against potential contamination from the underlying subgrade (see Table 1 on pg. 4). If the aggregate fill does not meet the requirement(s) of a graded filter over soft and saturated clays and silts it is recommended that a sand filter layer be placed at a minimum depth of 6 in. on top of the geogrid layer. The sand fill thickness may need to be increased in the event the design fill thickness requires a thicker initial lift.
- The use of uniformly sized coarse granular fill is not recommended as it does not compact well and may rut under repeated wheel loading, despite the improved stability brought about by Tensar TriAx Geogrids.
- The moisture content of the fill should not exceed optimum. Wet granular fill is not easy to compact and may perform poorly under construction equipment wheel loading. The use of poor quality and/or overly wet fill material that is difficult to prepare and compact over a firm condition, even with Tensar TriAx Geogrid, is not recommended.

Preferred Equipment

- Soft Ground – the preferred equipment imposes low contact pressure on the ground surface. This may be done with smaller machinery and/or low ground pressure (LGP) vehicle. Equipment that concentrates heavy loads over a relatively small contact area such as front-end loaders, are not recommended. In all soft ground cases, the fill must be sufficiently thick to avoid overstressing the underlying soils and Tensar TriAx Geogrid.
- Firm Ground – the preferred equipment maximizes productivity for specific construction requirements. Over competent ground, geogrids can be trafficked directly by rubber-tired equipment, making hauling equipment (i.e., dump trucks) and spreading equipment (i.e., motor graders) ideal as shown in Image 11. Spreader boxes are not recommended – wrinkling in the geogrid between the screed and wheels of the box and dump trucks can cause slack to become trapped, raising the geogrid up into the aggregate layer.

Image 11 Tensar TriAx Geogrid can be trafficked directly by rubber-tired equipment.

8. SpectraPave4-Pro™ Software for Paved & Unpaved Applications

Tensar International Corporation breaks new ground with the 2010 release of our industry-leading SpectraPave4-Pro™ Software. This design aid allows the user to accurately predict the performance of geogrid reinforced and unreinforced roads with both paved and unpaved surfaces. The software offers application-specific modules for:

- Unpaved roads
- Paved roads
- Cost Analyses – Initial and Life Cycle

Unpaved Applications Module

Based on the Giroud-Han design methodology, the unpaved applications module incorporates an existing design method, which supports the use of certain geosynthetics, to reduce aggregate thickness requirements and improve the subgrade performance. It indicates the required thickness for unreinforced aggregate fill layers and aggregate fill layers reinforced with Tensar® TriAx® Geogrids.

Paved Applications Module

The SpectraPave4-Pro software includes a module for the design of Spectra System Solutions in paved road applications. This module incorporates the design methodology prescribed by AASHTO in their Pavement Design Guide (1993) and also their Interim Standard PP46-01 (2003). Tensar TriAx Geogrids can be used in an AASHTO design to extend the design life of a flexible pavement and/or reduce the thickness of the pavement layers.

Cost Analysis Tools

The cost analysis tools provide total in-place costs (and savings) for each design option. The results can be represented in dollars per unit area or as a lump sum giving you the flexibility to predict performance and economic benefits for a range of design scenarios. Additionally, the SpectraPave4-Pro software offers the flexibility to evaluate the long-term benefits of Tensar TriAx Geogrids for paved applications using the life cycle cost analysis tool.

SpectraPave-Pro software enables engineers to design a Spectra® System Solution for paved and unpaved roads. In early 2010, the software will be available free of charge following the completion of a short training module. To apply for training and your free software, visit us online at www.tensarcorp.com or call 800-TENSAR-1.

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