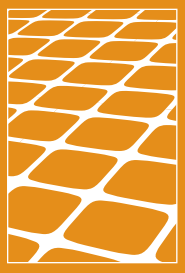
SPECTRA®
ROADWAY IMPROVEMENT SYSTEM

INSTALLATION GUIDE

Tensar®

The Spectra® System provides soil reinforcement and offers a predictable, cost-effective solution.



Tensar® Geogrids

The Spectra System owes its strength and durability to **Biaxial (BX)** Geogrids, Tensar's patented geosynthetic reinforcement grids. These geogrids stand the test of time, performing better than other commercially available geosynthetics due to their stiff interlocking capability. For more information, visit www.tensarcorp.com.

Introduction

When weak subgrade, heavy loads, thick fill layers, high aggregrate costs, contaminated subgrades or shallow utilities disrupt your construction schedule or budget, the Spectra System can provide the best solution.

Not only does this system allow access and construction in less than ideal situations, it also offers a predictable engineered solution. This solution relies on Tensar Biaxial (BX) Geogrids and crushed aggregate base acting together to create a stronger composite structure, which increases the performance of the underlying subgrade or aggregate base course.

Tensar BX Geogrids have proven their performance and cost-efficiency in thousands of applications. Over soft ground, BX Geogrids improve the soil's effective bearing capacity by distributing applied loads more widely, similar to the way a snowshoe supports a man's weight over soft snow (Figure 1). Over firmer ground, geogrids stiffen and interlock with fill materials by confining aggregate particles within its apertures.

The subgrade improvement and base reinforcement applications, and their primary mechanisms, are predetermined by ground or subgrade strength. Proper geogrid installation is also based on subgrade strength. We use CBR (California Bearing Ratio) to quantify this important variable.

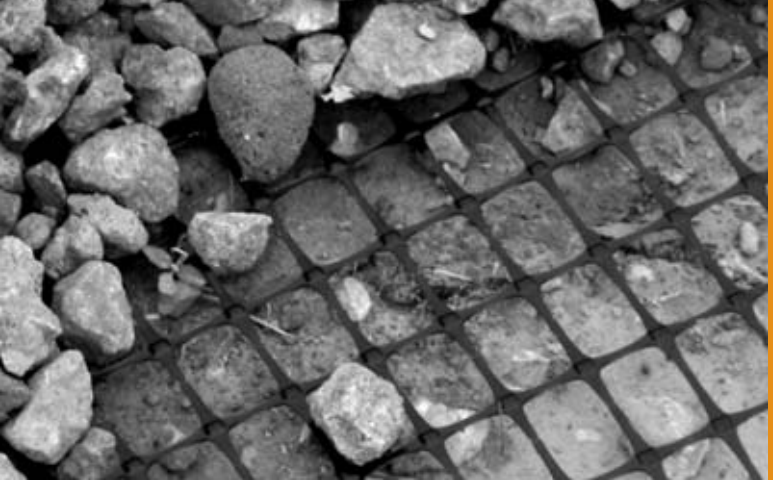
Tensar BX Geogrids are used to minimize aggregate fill requirements, reduce or eliminate undercut, improve compaction, serve as a construction platform and extend service life. These benefits depend upon proper installation as put forth in this guide.*

*This guide cannot account for every possible 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.tensarcorp.com.

Figure 1: The Snowshoe Effect – Tensar BX 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 Biaxial Geogrids	Stiff geosynthetic reinforcement
Design	Roadway sections developed using SpectraPave2™ Software
Site Assistance	Reduce project costs and expedite the installation process



1. Getting Started

- When placing an order, communicate all pertinent project and/or application criteria, including certification requirements, if any, with your Tensar Earth Technologies (TET) representative. It is normally advisable to schedule a pre-construction conference with this representative and any other appropriate parties at this time.
- Upon delivery, check the BX Geogrid roll labels to verify that the intended product has been received. For instance, BX1100 and BX1200 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.
- Store Tensar BX 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) – the glass-transition temperature for polypropylene used in BX Geogrids. Tensar BX Geogrids may be stored uncovered for up to six months in direct exposure to sunlight without any loss in certifiable structural properties (contact TET if longer exposure is anticipated). BX Geogrids may be stored vertically (rolls stood on end) or, typically, horizontally in stacks up to five rolls high (Figure 2).
- Anticipate potential issues and resolve them with TET prior to construction. To contact the local TET representative for your area, call 800-TENSAR-1.

Figure 2: Storing the BX Geogrid rolls (horizontally).

Figure 3: Rolling out the BX Geogrid.

2. Site Preparation

- Clear, grub and excavate (if necessary) to the design grade, 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, cutting stumps and other projecting vegetation as close and even to the ground surface as practical (Table 1). 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 BX Geogrids.

- Place the rolls of BX Geogrid* in position, cut the roll bands and manually unroll the material over the prepared surface (Figure 3). In subgrade improvement applications, this surface will always be the subgrade. In base reinforcement applications, it may be the subgrade, the subbase or at an elevation (say, mid-depth) within the base course.

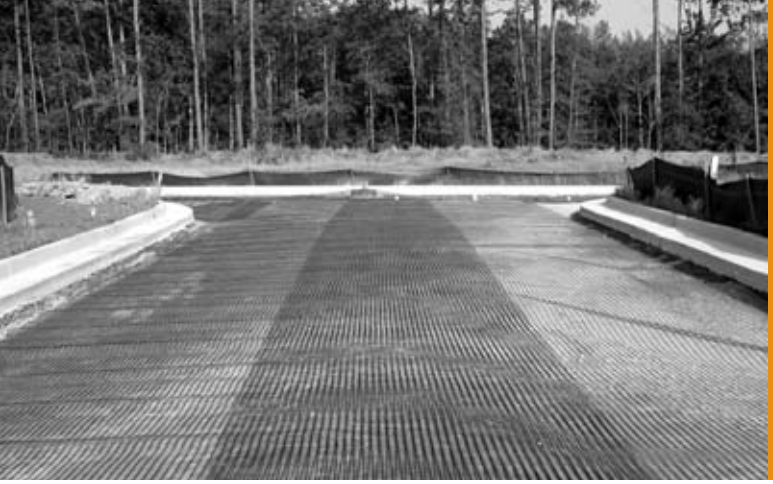
*Tensar Earth Technologies manufactures several different types of BX Geogrids. Selection and optimization depends on structural performance requirements, subgrade and fill parameters, economic considerations and local availability.

Table 1: Summary of BX Geogrid Installation Parameters

Subgrade Strength	Clear All Vegetation?	BX Orientation[3]	BX Overlap[4]	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	Y	N

Notes:

1. Summary is a generalized presentation; see text for specifics.
2. Y = Yes, normally required; N = No, normally not 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 ≥ 3; interpolate between.
5. Direct Traffic pertains only to conventional rubber-tired equipment.
6. Analysis Req'd = Geotextile required only if filtration criteria not met by aggregate fill.



3. Placing Overlapping Geogrid

- On roads, 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 the fill will be spread (Figure 4) to avoid "peeling" of geogrid at overlaps by the advancing fill. To expedite "shingling", 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.
- 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 can be effective in helping maintain overlap dimensions. These ties are not considered structural connections, but rather construction aids.
- Cut and overlap the geogrid to accommodate curves (Figure 5). Cutting may be done with sharp shears, a knife-like implement or handheld power (i.e., "cutoff") saws (Figure 6). (Wear appropriate safety equipment.) Cut grid to conform to manhole covers and other immovable protrusions.
- Place geogrids in daily work sections so that proper alignment is maintained.

Figure 4: Geogrid should overlap in the direction of advancing fill.

Figure 5: Placing BX Geogrid to accommodate curves.

Figure 6: Using a handheld power saw to cut geogrid.

4. Tensioning and Pinning

Tensar BX Geogrids may be anchored in place to maintain 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 BX Geogrid with small piles of aggregate fill or a washer and pin (Figure 7a). Large, heavy-gauge staples (Figure 7b) may also be used by driving them into the subsoil through the apertures of the grid.
- Unroll the geogrid. Align it and pull it taut to remove wrinkles and laydown slack with hand tension, then secure in place.
- Additional shoveled piles of aggregate fill, pins or staples may be required to hold the geogrid in place prior to placement of the aggregate fill.

Note: When aggregate fill is spread by pushing it over the BX 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 or pins 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 pins or shoveled material should be removed to allow the waves to dissipate at the ends and edges of the roll.

Figure 7a: Anchoring geogrid with a washer and pin.

Figure 7b: Staples for anchoring BX Geogrid.

Figure 8: Dumping aggregate fill on top of BX Geogrid over competent subgrade.

5. Dumping and Spreading Aggregate Fill

- Generally, at least 6 inches is required for the initial lift thickness of aggregate fill over BX Geogrids. However, for very soft conditions, a significantly thicker fill layer may be required to prevent excessive rutting and/or bearing capacity failure.
- Over relatively competent subgrades (CBR › 4, see Table 1), aggregate fill may be dumped directly onto the geogrid (Figure 8). 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 are not advised.
- Over softer subgrades (CBR ‹ 2), back trucks up and dump fill upon previously placed fill (Figure 9a). For very soft subgrades (CBR ‹ 0.5), limit the fill pile height to avoid overstressing caused by excessive dead loads.
- Do not drive tracked equipment directly on the BX Geogrid. Ensure at least 6 inches of aggregate fill is spread between the geogrid and tracked equipment (Figure 9b).
- Also, only operate rubber-tired equipment directly on the geogrid if the underlying subsoil is not prone to rutting under limited construction traffic.
- Over softer subgrades (CBR ‹ 2), a light-weight, low ground pressure (LGP) dozer is recommended to evenly push out the fill over the exposed geogrid.
- Care should be taken not to catch the dozer blade or other equipment on the BX Geogrid. The dozer blade should be raised gradually as each lift is pushed out over the BX 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 BX Geogrid overlaps and advance the aggregate fill with the shingle pattern.

Figure 9a: Dumping aggregate fill on top of BX Geogrid over soft subgrade.

Figure 9b: Spreading aggregate fill over BX Geogrid.

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 silty subgrades. Compaction is then achieved using a light roller. Keeping fill moisture content near optimum will make compaction more efficient. Water spray is most effective with sand fill (see Figure 10). For construction over very soft soils, compaction requirements are normally reduced for the initial lift.
- If rutting or severe pumping occurs under truck or dozer traffic, fill should be added immediately to strengthen the section. 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.

  Note: If the aggregate fill thickness is insufficient to support imposed load(s), deep rutting will result.
- Compact aggregate fill to project specifications, after it has been graded smooth and before it is subject to accumulated traffic (Figure 11). Inadequate compaction will result in surface rutting under wheel loads. This rutting reduces the total effective thickness of the fill and increases stress on the subgrade.

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

Figure 10: Moistening the fill before compaction.

Figure 11: Compacting the aggregate fill.

Tensar BX Geogrid Roll Characteristics								
Product	Roll Width		Roll Length		Roll Weight		Roll Area	
	(m)	(ft)	(m)	(ft)	(kg)	(lbs)	(m^2)	(sy)
BX110047	3	9.8	75	246	45.6	100.5	225	268
BX110075	4	13.1	75	246	61.2	135	300	358.6
BX120040	3	9.8	50	164	46.3	102	150	179.3
BX120060	4	13.1	50	164	62.6	138	200	239.1
BX130060	4	13.1	50	164	50.5	111.5	200	239.1

7. Special Considerations

Make Repairs

- If Tensar BX Geogrids become damaged during or after installation, repair them by patching the area.
- Remove fill from the surface of the damaged geogrid and clear a 3 foot area around the damage.
- The geogrid patch should cover the damaged area and extend 3 feet beyond it in all directions.

Don't Grade Out Ruts

- 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

- Cold temperatures increase BX Geogrid stiffness; warm temperatures decrease it. From a handling perspective, rolls will have "memory" on cool mornings that relaxes with the warmth of solar radiation. Securing roll ends before kick out will prevent the geogrid from rolling back up.
- At sub-freezing temperatures, BX Geogrid is less impact resistant and can be fractured with dynamic force (i.e., striking with a hammer). Other aspects of dynamic loading associated with very cold temperatures should be avoided. For example, direct trafficking by rubber-tired equipment atop geogrid is permissible when the subgrade is competent. However, it's not advisable at very cold temperatures.

Aggregate Fill Considerations

- The preferred gradation for base reinforcement applications is well-graded crushed aggregate fill with a maximum particle size of 1½ inches and less than 10% fines (passing #200 sieve). The gradations listed in Table 2 (below) provide good stability and low moisture susceptibility. For subgrade improvement applications, any clean granular fill may be acceptable.

Table 2: Preferred Fill Gradation	
Size	% Fines
1½ in.	100
¾ in.	50 – 100
#4	25 – 50
#40	10 – 20
#100	5 – 15
#200	less than 10

- Over relatively competent subgrades (CBR › 2), gradation and moisture content of aggregate fills are key elements for stability. (Recycled Portland Cement Concrete meeting this gradation is often ideal.) Soft subgrades (CBR ‹ 2) are normally characterized by elevated moisture contents. Care must be taken to ensure that the moisture in them is not trapped, which induces porewater pressure and could result in pumping. For this reason, it is important that aggregate fill be non-plastic and the fines limited to less than 10%.
- BX 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). If the aggregate fill does not meet the requirement(s) of a graded filter over soft and saturated clays and silts, a non-woven geotextile should be placed beneath the geogrid.
- Do not use uniformly sized coarse fill as it does not compact well and will rut under wheel loading, despite the improved stability brought about by BX Geogrids.
- The moisture content of the fill should not exceed optimum. Wet fill is not easy to compact and will rut under wheel loading.

Preferred Equipment

- **Soft Ground** – the preferred equipment imposes low contact pressure on the ground surface. This may be done with smaller machinery, wide tires and/or LGP tracks. Equipment that concentrates heavy loads over relatively small contacts, such as front-end loaders, are not recommended. In all soft ground cases, fill must be sufficiently thick to avoid overstressing the underlying soils and BX Geogrid.
- **Competent 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 (Figure 12). 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.

Excavating through BX Geogrid

- When confined beneath and within compacted fill, the geogrid should pose no significant threat to post-construction activities like utility trenching or driving/auguring supports for rails, signs or standards (Figure 13).

Figure 12: Geogrid can be trafficked directly by rubber-tired equipment.

Figure 13: A backhoe excavation through BX Geogrid.

8. SpectraPave2™ Software and Subgrade Improvement Slide Rule

Drs. J.P. Giroud and Jie Han have developed new technology for subgrade improvement design. Their methodology is the most comprehensive advancement in the design of unpaved roads in the last 20 years. TET has taken this a step further by creating the SpectraPave2 Software which features three main modules:

- Subgrade Improvement
- Cost Analysis
- Base Reinforcement

Subgrade Improvement Module

Based on the Giroud-Han study, the subgrade improvement module incorporates a new 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 BX Geogrids.

Cost Analysis Module

What's more economical: a road reinforced with BX Geogrids or a conventional section? The cost analysis module provides cost comparisons between an unreinforced subbase and a subbase reinforced with Tensar BX Geogrids.

Base Reinforcement Module

The base reinforcement module incoporates the design methodology prescribed by AASHTO in their Pavement Design Guide (1993) and also their Interim Standard PP46-01 (2003). BX 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.

Subgrade Improvement Slide Rule

You can't always have a computer at your fingertips, so TET created a pocket-sized slide rule version of the subgrade improvement module from the SpectraPave2 software for your convenience. It is versatile, accurate and handy – just right for making timely and informed decisions about building over soft soils with BX Geogrids. For more information and to obtain your own free slide rule, call 800-TENSAR-1 or contact your local Tensar BX representative.

Available in CD-ROM format supporting Windows® 95, 98, 2000, XP or NT, SpectraPave2 Software may also be downloaded at no charge from www.tensarcorp.com. For more information or to request your free copy, call 800-TENSAR-1 or e-mail info@tensarcorp.com.

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