

SIERRA[®] SLOPE RETENTION SYSTEM

INSTALLATION GUIDE



► The Sierra® Slope Retention System provides an economical and aesthetic alternative to conventional retaining walls.



Tensar® Geogrids

The **Sierra® System** owes its long-term performance and durability to high-strength **Tensar® Uniaxial (UX) Geogrids**. Due to their stiff interlocking capabilities, these geogrids stand the test of time, outperforming other commercially available geosynthetics. For more information, visit www.tensarcorp.com.

Introduction

In worldwide use since 1982, the Sierra® Slope Retention System continues to be the premier reinforced soil slope (RSS) solution among Owners and Developers, Engineers, Architects and Contractors alike. Developed by Tensar International Corporation (Tensar), the world leader in geogrid technology and engineering ingenuity, Sierra Slopes ensure a combination of performance, economy and beauty that is unmatched by other types of earth retention systems.

The Sierra System is a complete and fully integrated RSS solution. Each of the system's components have been specifically designed and detailed to work together for optimum efficiency and performance. Furthermore, these components create a structural system whose integrity and dependability have been proven in a variety of challenging site and loading conditions.

Tensar understands the need for sound engineering and proper construction techniques to assure the success of any project. To support this belief, we have a full, in-house professional engineering staff to assist your design needs, and an operations group able to provide on-site installation assistance when requested. This additional hands-on expertise ensures your project is handled professionally and that you will get the results you intend.

This document is intended to provide the Owner, Engineer, Contractor and Inspector with the general guidelines and criteria required to facilitate construction and quality control of the Sierra Slope Retention System. For more detailed information please refer to the Approved Shop Drawings within the Contract Documents, or consult your Tensar representative.

Sierra® System Components

COMPONENT	FUNCTION
Tensar Uniaxial (UX) Geogrids	Primary reinforcement that internally reinforces the backfill materials.
Tensar Biaxial (BX) Geogrids	Secondary reinforcement that ensures surficial stability of the slope structure.
Site-Specific Facing System	Provides aesthetic value by offering multiple facing options, including bioengineering.
Full Engineering and Construction Services	Detailing, design, site assistance and stamped drawings for each Sierra project upon request.



Tensar provides a full line of services, including site assistance and final stamped drawings

Responsibilities for Construction Compliance

The Contractor is responsible for:

- ▶ Providing construction in accordance with the Contract Documents and to coordinate the slope construction with related work.
- ▶ Using the most recent set of Approved Shop Drawings (hereafter referred to as Drawings) to perform the work and for verifying line, grade and offset needed to establish slope location according to the Contract Documents.
- ▶ Monitoring material supply and assuring that adequate lead time is provided with each request for delivery and that sufficient quantities are available to prevent construction delays.
- ▶ Unloading and inspecting materials upon delivery to the job site, and for providing proper storage and protection of materials.
- ▶ All site preparation and survey layout
- ▶ Slope construction in its entirety
- ▶ Installation of the top-of-slope treatment where required

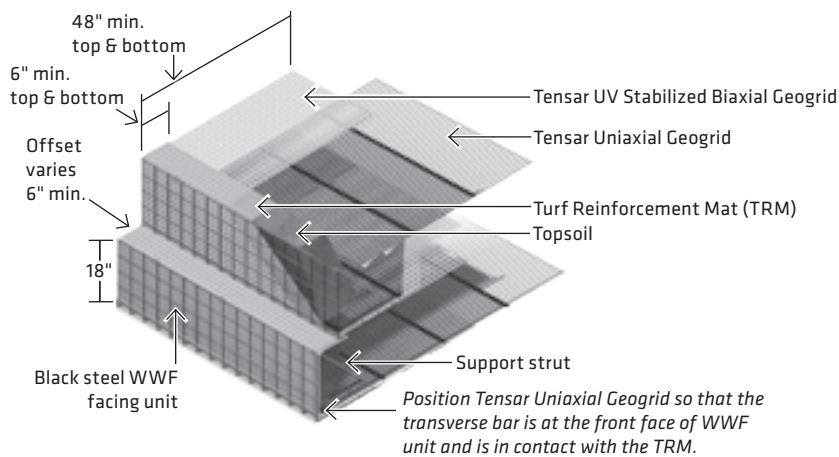
- ▶ The Owner's Engineer (or Contractor's QA/QC Engineer) is responsible to inspect the work and to enforce the requirements of the Contract Documents and the Drawings.

If requested, services provided by Tensar include:

- ▶ MSE structure shop drawings
- ▶ On-site technical assistance at the start of construction – if required by the Contract Documents, the Tensar Technical Advisor will be available at the start of the project to assist the Contractor in the coordination of the initial material delivery schedule and to advise the Contractor's project team of the recommended construction procedures within the scope of this manual. The Tensar Technical Advisor is not a member of the inspection or quality control staff on the project.



Sierra® Slope System installed, before and after vegetation.



Sierra® System welded wire form with plantable fill

Materials and Handling

MATERIALS SUPPLIED BY TENSAR

- ▶ Tensar® Uniaxial (UX) and Biaxial (BX) Geogrid soil reinforcements which are to be field cut by the Contractor to the various lengths required per the Drawings.
- ▶ Welded Wire Forms (WWF) (if required) – Standard 4 in. x 4 in. wire forms or Strut Indicator Forms (SIF). Figures 1 and 2.
- ▶ Support Struts (for use with WWFs)
- ▶ Bodkin Bars (if required)
- ▶ Turf Reinforcement Mats (TRM)

MATERIALS, TOOLS, AND EQUIPMENT PROVIDED BY THE CONTRACTOR:

- ▶ Select or plantable fill
- ▶ Cable ties or tie wire as needed
- ▶ Utility saw for field cutting of material
- ▶ Steel “U” pins for positioning geogrid
- ▶ Staples/stakes for securing TRMs
- ▶ Smooth-drum roller for mass-compaction
- ▶ Small, hand-operated vibratory plate tamper or roller for compaction within 3 ft (0.9 m) of the back face of the slope.
- ▶ All labor, equipment, and supervision necessary to perform the total slope construction.

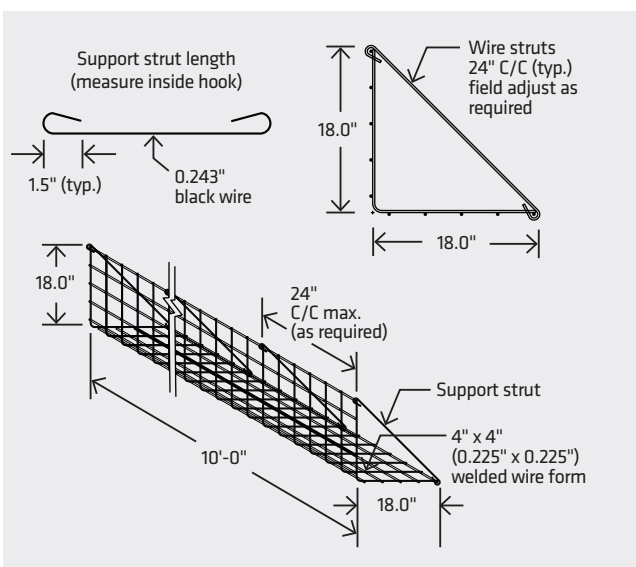


FIGURE 1: Standard 4 in. x 4 in. welded wire form.

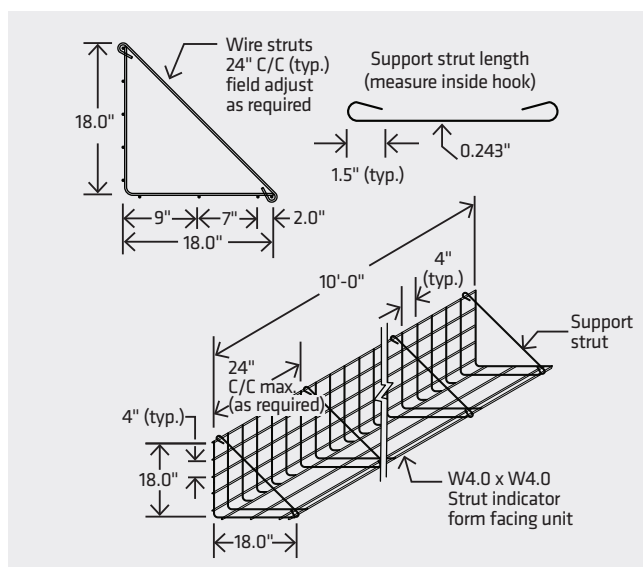


FIGURE 2: Strut Indicator Form (SIF).



Color-coded geogrid rolls

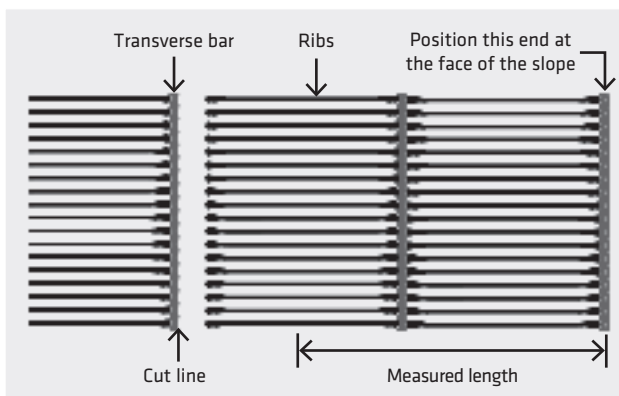
STEP 1. MATERIAL PREPARATION

- ▶ Color code the ends of the Tensar® Geogrid rolls if more than one type of Uniaxial (UX) Geogrid is specified.
- ▶ Cut Tensar Geogrids to the lengths shown on the Drawings (from the first rib to the last rib). Make the cut next to the heavy transverse bar that spans the width of the geogrid roll. Cut geogrids flush at the nearest transverse bar beyond the measured length.
- ▶ As geogrid lengths are cut, mark and tag them according to the length and type, and then stockpile them for later use.

NOTE: The correct geogrid type and length must be used at each lift level according to the project's Drawings.

STEP 2. INITIAL GRADING, FOUNDATION PREPARATION, AND DRAINAGE

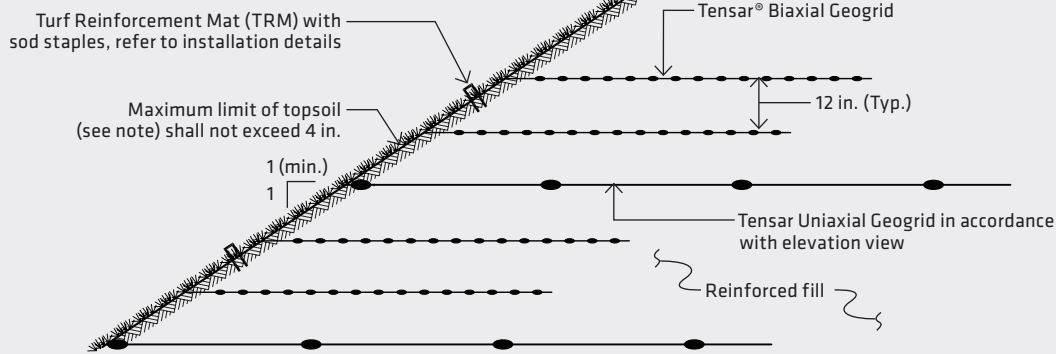
- ▶ Excavate to the lines and grades shown on the Drawings or as directed by the Engineer.
- ▶ The subgrade should be approved by the Owner's Engineer before proceeding with the slope construction. Any soils found unsuitable by the Engineer should be dealt with in a manner approved by the Engineer.
- ▶ In cut situations, it is recommended that the backcut embankments be benched into competent soil or rock. Benching sequence and/or design shall be dictated by the Owner's Engineer.
- ▶ Install drainage composite and/or drainage system as specified in the Drawings, and install the drainage system according to the Contract Documents.



Measured length and cut line for UX Geogrids.



Field cutting the UX Geogrid.



NOTE: Topsoil shall be loamy sand or finer gradation with 10% – 15% organic content or material approved by a qualified landscape architect. Vegetation and specific topsoil shall be specified by a qualified landscape architect.

Typical detail for 1H:1V graded Sierra® Slope

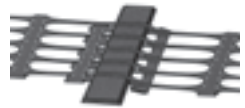
Construction of the Sierra® Slope Retention System

STEP 3. INSTALL THE FIRST LAYER OF PRIMARY REINFORCEMENT

- ▶ Tensar® UX Geogrids are most often used as “primary” reinforcement, and Tensar® BX Geogrids are typically used as “secondary” or “surficial” reinforcement. UX Geogrids are supplied in roll widths of 4.3 ft (1.3 m).
- ▶ Place UX Geogrids perpendicular to the slope with the transverse bar end of the geogrid at the slope face.
- ▶ UX Geogrids should extend back from the slope face to the embedment distance specified on the Drawings and must be placed at the elevations shown on the Drawings.
- ▶ Adjacent UX Geogrids should be butted together side-by-side without overlap unless a gap between the roll widths is specified (known as partial coverage).

NOTE: A small geogrid overlap may be specified for “wrap around” construction, check Drawings to verify.

- ▶ Shorter lengths of UX Geogrids can be spliced together using flat polymer “Bodkin” bars available from Tensar. Typically there is only one bodkin connection permissible per geogrid embedment length, or as specified in the Drawings. The spliced geogrid piece on either side of the bodkin connection shall be at least 6 ft (1.8 m) long unless the geogrid terminates in a fixed connection.



STEP 4. FILL PLACEMENT

- ▶ Fill can be placed and spread directly upon the geogrids with rubber tired equipment. Keep speeds slow and avoid turns and stops on the geogrids. If needed, the geogrids can be secured into place to prevent movement during fill placement. Use pins, staples, sandbags, small piles of soil, etc. as anchors.
- ▶ Spread and level the soil. **Do not operate tracked equipment on exposed geogrids.**



Installing the first layer of UX Geogrid perpendicular to the slope face.



Fill should be placed and spread away from or parallel to the slope face.



STEP 5. COMPACTION

- Compact the soil to the specified density and backfill lift thickness using required compaction equipment and procedures. A minimum 6 in. (15 cm) lift thickness is required to ensure that tracked equipment will not come in direct contact with the geogrid.
- For curved slope faces, the primary geogrids butt edge-to-edge at the slope face (unless shown otherwise on the Drawings) and either fan out or overlap into the fill.

STEP 6. SECONDARY REINFORCEMENT

- BX Geogrids provide stability of the slope surface. Generally, the BX Geogrids will be unrolled parallel to the slope face unless shown otherwise on the Drawings. Tensar® BX Geogrids are supplied in roll widths of 9.8 ft (3 m) or 13.1 ft (4 m), but may be cut to required widths prior to unrolling.

- Fill can be spread directly upon the geogrids.
- Spread and level the fill. **Do not operate tracked equipment directly on the exposed geogrids.**
- BX Geogrids may be cut periodically to conform to horizontal curves. The cut should be made perpendicular to the slope face often enough to allow the geogrid to lay flat on the ground.

STEP 7. REPEAT STEPS 3-6 PER THE DRAWINGS

END OF WORKDAY PROCEDURE

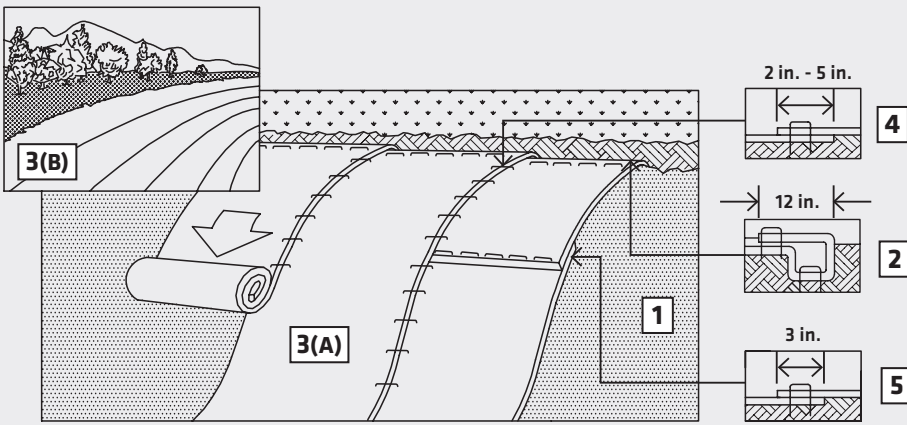
At the end of each workday and upon completion of the slope, grade the top of the completed slope to ensure that water runoff is directed away from the face of the new slope. Positive drainage must be provided so that water does not collect above or behind the reinforced soil.



Heavy compaction equipment should be kept at least 3 ft from the face of the slope.



Tensar BX Geogrids used for secondary reinforcement are typically rolled out parallel to the slope face.



Installation sequence for erosion control products on the face of a graded slope

Site Specific Facing Options

One of the unique advantages of the Sierra® Slope System is the variety of facing options available depending on the project's slope angle and aesthetic requirements. The following sections will give the installation sequence of specific facing treatments for graded slopes, wrapped face slopes, and WWF wrapped face slopes.

EROSION CONTROL INSTALLATION ON GRADED SLOPES

1. In preparation for the installation of the Tensar® North American Green® rolled erosion control products (RECPs), grade soil smooth.
2. Begin at the top of the slope by anchoring the RECPs in a 6 in. (15 cm) deep x 6 in. (15 cm) wide trench with approximately 12 in. (30 cm) of RECPs extended beyond the up-slope portion of the trench. Anchor the RECPs with a row of staples/stakes approximately 12 in. (30 cm) apart in the bottom of the trench. Backfill and compact the trench after stapling. Apply seed to compacted soil and fold remaining 12 in. (30 cm) portion of RECPs back over seed and compacted soil. Secure RECPs over

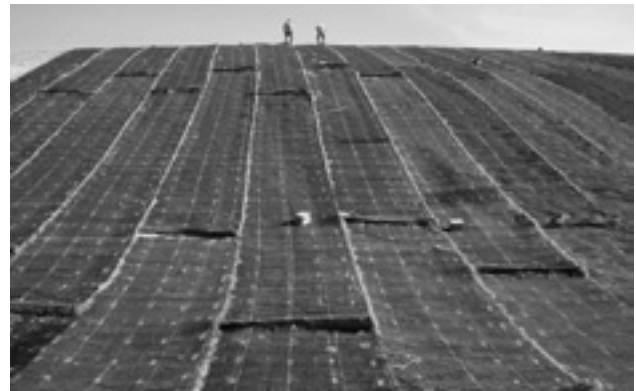
compacted soil with a row of staples/stakes spaced approximately 12 in. (30 cm) apart across the width of the RECPs.

3. Roll the RECPs (A) down or (B) horizontally across the slope. RECPs will unroll with appropriate side against the soil surface. All RECPs must be securely fastened to soil surface by placing staples/stakes in appropriate locations as shown in staple pattern guide.
4. The edges of parallel RECPs must be stapled with approximately 2 in. - 5 in. (5 cm - 12.5 cm) overlap depending on the type.
5. Consecutive RECPs spliced down the slope must be placed end over end (shingle style) with an approximate 3 in. (7.5 cm) overlap. Staple through overlapped area, approximately 12 in. (30 cm) apart across entire RECP width.

NOTE: In loose soil conditions, the use of staple or stake lengths greater than 6 in. (15 cm) may be necessary to properly secure the RECPs.



Slope face is graded smooth in preparation for RECP installation.



RECP installation down the face of the slope.

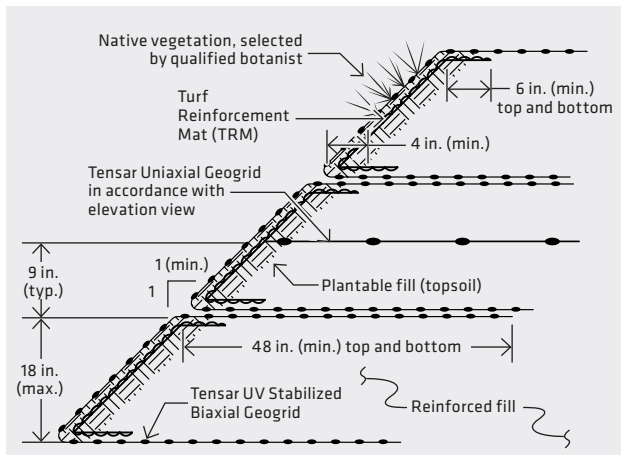


BX and TRM Installation in Wrapped Face Slopes

For steeper slopes, and face angles greater than 1H:1V with significant design heights and/or scour potential, a geogrid wrap around and/or wire form system may be used. Wire forms can be utilized in conjunction with an ultraviolet (UV) stabilized BX Geogrid wrap to aid in maintaining facing alignment and stability.

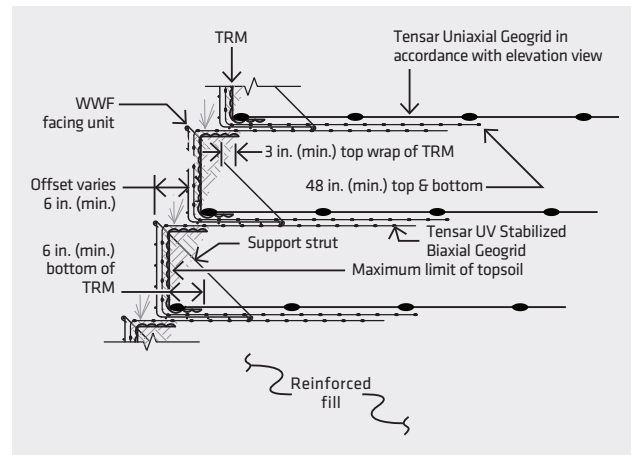
BX AND TRM WRAPPED FACE

- ▶ Place UV stabilized BX Geogrid as specified in the Drawings. The top wrap will be temporarily folded over the face below until the fill is placed and compacted.
- ▶ Place TRM with a minimum embedment of 6 in. (15 cm) on the top and bottom of the wrap, or as noted in the Drawings.
- ▶ Install UX Geogrid as specified in the Drawings. The outermost transverse bar of the UX Geogrid should be located close to and inside the final profile of the slope face.
- ▶ Place and compact fill as specified in the Drawings. When the fill has reached the top of the wrap thickness specified, pull the top wrap of BX and TRM back over the fill and pull tight. The top wrap may be secured in place with pins or small piles of soil until you are ready to place the next lift.



WWF WITH BX AND TRM WRAPPED FACE

- ▶ Install the WWF facing units on level grade. Butt the units and overlap adjacent units by 4 in. (20 cm).
- ▶ Attach the end of the vertical wires of the adjacent units with cable ties, hog rings, or wires to aid in maintaining alignment.
- ▶ Place UV stabilized BX Geogrid as specified on the Drawings. The top wrap will be temporarily folded over the WWF until the fill is placed and compacted.
- ▶ Place TRM as specified in the Drawings, with minimum embedment of 6 in. (15 cm) on bottom of the wrap and extended at least 3 in. (7.5 cm) under the WWF unit above.
- ▶ Install UX Geogrid as specified in the Drawings. The outermost transverse bar of the UX Geogrid must be positioned immediately adjacent to the WWF, with the TRM located in between the UX Geogrid and the WWF.
- ▶ Place and compact fill as specified in the Drawings. When the fill has reached the top of the WWF, pull the top wrap of BX and TRM back over the fill and pull tight. The top wrap may be secured in place with pins or small piles of soil until you are ready to place the next lift.



NOTE: Topsoil shall be loamy sand and finer gradation with 10-15% organic content or material approved by a qualified landscape architect. Vegetation type shall be specified by a qualified landscape architect.



Definitions

APPROVED SHOP DRAWINGS

The final slope Drawings signed and sealed by a Licensed Professional Engineer, provided to the Contractor for submittal to the Engineer and subsequently approved by the Engineer for construction.

CONTRACT DOCUMENTS

The agreement between the Owner and the Contractor including the plans and specifications, the conditions and provisions of the agreement, including any addenda and other modifications issued prior to or after the bid and the execution of the original contract.

CONTRACTOR

The individual, firm or corporation acting directly through its agents or employees to undertake the execution of the work under terms of the contract.

ENGINEER

The Owner's representative with authoritative charge over the inspection and acceptance of the slope construction in accordance with the Contract Documents.

INSPECTOR

An authorized representative of the Owner assigned to see that the workmanship and materials are in accordance with the terms of the contract.

OWNER

The Owner of the project with whom a contract has been made for payment for the work performed under the terms of the contract.

PLANS

The part of the Contract Documents consisting of the plans, profiles, typical cross-sections, working Drawings and supplemental Drawings, or exact reproductions thereof, which show the location, character, dimensions and details of the work to be performed.



UX Geogrid and fill placement.



Completed Sierra® Slope at a plant expansion facility.



*Graded Sierra Slope with
vegetation fully established*

TENSAR TECHNICAL ADVISOR

An authorized representative of Tensar available at the start of the project to advise the Contractor and Inspector on recommended construction procedures within the scope of this document. The Tensar representative is not an inspector or member of the quality control staff on the project, and is not responsible to supervise the work.

SPECIFICATIONS

The part of the Contract Documents consisting of a description of the quality and quantity of the materials and workmanship that will be required of the Contractor in the execution of the work under the contract between the Owner and the Contractor.

WORK

All work items to be performed by the Contractor under the terms and conditions of the contract that are necessary to fulfill the obligations of said contract.

For more information on the Sierra® System, please call **800-TENSAR-1**, visit **www.tensarcorp.com** or e-mail **info@tensarcorp.com**. We are happy to supply you with additional Sierra Slope product information, complete design guidelines, system specifications, design details, preliminary cost estimates, summaries of completed projects and much more.





Tensar International Corporation
2500 Northwinds Parkway, Suite 500
Alpharetta, Georgia 30009

800-TENSAR-1
tensarcorp.com

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