Tensar Mesa™
Retaining Wall System
Initial Report 2006-5
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Reporting on Work Plan 2001-S-9
Category II Experimental Project

State of Vermont
Agency of Transportation
Materials and Research

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Introduction

In 2003 the Vermont Agency of Transportation constructed its first Tensar Mesa™ retaining wall system as part of the Brattleboro NH010-2(2) project. The wall was constructed as the northwest wing wall of the railroad bridge over RT 9.

Tensar Earth Technologies, Inc provided the shop drawings for the project, based upon design criteria provided by CLD Consulting Engineers. Since this was the State of Vermont's first time using this particular type of MSE wall, it was designated a Category II Experimental Feature.

The Tensar Mesa™ retaining wall system is an economical and aesthetically customizable product that worked reasonably well for this project. The wall is approximately 9 meters high and 17 meters long, for a total wall area of approximately 98 square meters (1052 square feet).

The Tensar Mesa™ retaining wall system was thought to be beneficial for several reasons:

- Complete details of the wall system would be solicited in advance and incorporated into the contract documents. This would allow contractors in this area not familiar with this type of construction to become better acquainted with the construction requirements.

- The design could be reviewed in advance by the Agency of Transportation. This would allow the Agency to resolve any problems it had with computations, allowable stresses, design loads, construction details and specifications, before bid letting.

- An MSE wall can be constructed to greater heights compared to a conventionally reinforced concrete abutment.

- In accordance with the Agency's "Policy on Earth Retaining Structures" dated November 1995, successful completion and satisfactory performance of this wall in the field would allow the addition of another MSE system to the Agency's Approved Product List and more competitive bidding of future projects.

- An MSE wall would be more tolerant of differential settlement than a conventional reinforced concrete wall.

This report documents our observations during and post construction, laboratory testing performed on the facing elements and provides a summary of our recommendations.

Product Description

The retaining wall system supplied by Tensar achieves its structural integrity through the use of geogrid, placed within layers of compacted fill material, which are attached to concrete blocks to form a reinforced earthen embankment, wall or abutment (Figure 1). The blocks are formed with grooves which are then fitted with plastic clips to provide a means of securing the geogrid to the blocks during construction (Figure 2). The geogrid is laid out horizontally behind the panels, secured to the blocks and covered with compacted select backfill. The layered system of geogrid forms a mass which is sufficiently stable to provide structural support without the use of piles.

Figure 1: Geogrid being placed in layers of compacted fill.

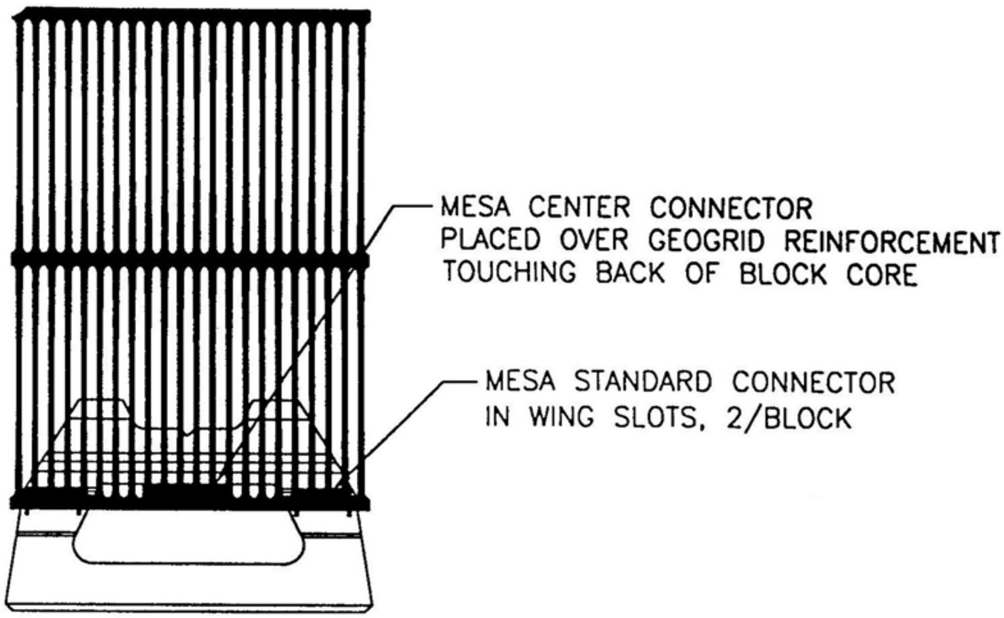

Figure 2: Geogrid Connection to Concrete Blocks

Reinforcement Geogrid

The geogrid is made from high density polyethylene (HDPE). The length and strength of the geogrid would be project specific, based upon the design requirements.

Wall Units

Figure 3: Split Face Block

Each unit has a face dimension of 203 mm (8 inches) high and 457 mm (18 inches) wide with a minimum thickness of 279 mm (8 inches). Each unit weighs approximately 35 kilograms (77 pounds). The split face block can be seen in Figure 3.

Leveling Pad

The leveling pad is the base for the Tensar Mesa™ retaining wall system. It is constructed of non-reinforced concrete with a minimum 28 day strength of 20.7 MPa (3000 psi). The leveling pad had nominal dimensions of 150-mm (6 inches) thickness and 610-mm width (24 inches).

Design Considerations

The height of the wall needed was approximately 7.5 meters (24 feet). A standard cast in place concrete wall would have required a wide footing to resist the overturning forces of the retained material. The size of the footing would have made a concrete wall very expensive.

The Tensar Mesa™ retaining wall system does not need a large footing. A small leveling pad is poured and approximately 1 meter (4 feet) of the wall is constructed below grade. For this reason this option is much more cost effective.

Construction

The Tensar Mesa™ retaining wall system was assembled by the J.A. McDonald Construction company from Lyndon Center, Vermont. See Figure 4 for Typical Cross-Section.

The first stage of construction involved placing the 610mm by 150mm non-reinforced concrete leveling pad on which the blocks rest. The geogrid is laid out and attached to every third course of blocks

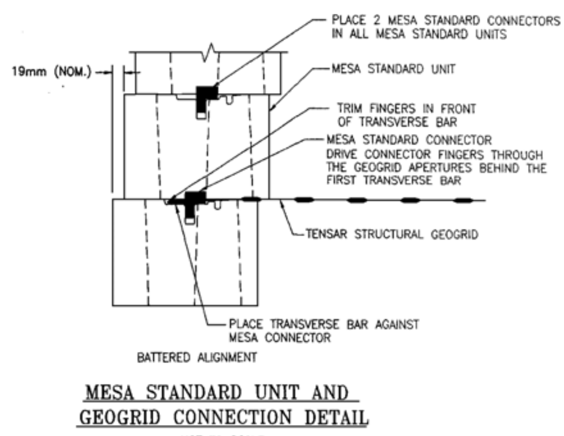

Figure 4: Typical Cross section of block and geogrids connection

using the plastic clips provided (Figure 5) by the wall supplier. After securing the geogrid to the blocks, the backfill material was placed on the geogrid and spread out with CAT 325c excavator. The backfill material was placed in maximum lifts of 250mm (10 inches) compacted with an Ingersoll-Rand SD-450 roller and a plate compactor. The plate compactor was used in any area within 3 feet of the wall face to limit vibration transmitted to the wall.

For this wall, 4 different strength geogrids were used. The strongest geogrid was used at the bottom of the wall. At the suggestion of Tensar's representative the different types of geogrid were color coded using spray paint and flagging. The color coding system allowed for the different strength geogrids to be easily distinguishable and prevented the wrong geogrid from being used.

Figure 5: Clips installed through geogrid into modular block.

Observations

- In the courses where the geogrid was placed, the blocks had to be shimmed. The geogrid was placed under the back edge of the block and tipped the block slightly forward. If the blocks were not shimmed the batter of the wall would be lost in these courses.

- The batter of the wall is designed to be 19mm ($^5/_8$ inch) per course of blocks. This is achieved by placing the block back firmly against the plastic clip set in the block below it. The batter in the field was closer to 13mm (½ inch) per course.

- The dimensions varied from block to block. In order to keep the seams of the block lined up gaps were left between some of the blocks. (Figure 3) The variation in dimensions also made it hard to keep the wall face straight. (Figure 6)

Figure 6 – Wall Face

- A number of the plastic clips were broken. The cause was not seen, but it could have been due to tight fit between the blocks and the clips or due to careless installation of the blocks and/or clips. Supposedly no broken clips were used in rows where geogrid was placed.

Freeze-Thaw Testing

During the construction of the Tensar Mesa™ retaining wall system in the fall of 2003 a random concrete block used for the wall facing was taken from the construction site and brought to the Vermont Agency of Transportation's Materials and Research Testing Laboratory. Two rectangular cubes were cut from the concrete block. The initial dimensions of the samples can be found in Table 1. The two samples were tested according to AASHTO T 161-00 (ASTM C 666-97), Resistance of Concrete to Rapid Freezing and Thawing. The test was conducted with a freeze temperature of 0^{o}F and a thaw temperature of 40^{o}F. A complete freeze-thaw cycle time of approximately 4 hours was used. Prior to the beginning of the test the fundamental transverse frequencies and initial weights were measured on the samples and then performed weekly, after approximately 50 cycles. The State of Vermont requires one modification of the standard method. Due to the severity of the winters in the region and the high use of salt on the roadways the samples were tested in a 3% salt water solution.

Test Results:

Sample 1 - Dimensions 2 11/16" x 2 15/16" x15 5/8"

Date	Cycle	Weight (g)	% Weight Loss	Frequency	Relative Dynamic Modulus of Elasticity	Recorder Comments
02/18/2004	0	4744.1	-	1613		
02/27/2004	63	4677.4	1.41	1430	78.60	A little mortar loss on ends
03/04/2004	103	4524.0	4.64	1466	82.60	Lots of loss, top cracked
03/12/2004	153	3847.5	18.90	-		4 pieces
03/19/2004	194	-				

Table 1a: Test Results - Sample 1

Sample 2 - Dimensions 2 7/8" x 2 3/4" x15 11/16"

Date	Cycle	Weight (g)	% Weight Loss	Frequency	Relative Dynamic Modulus of Elasticity	Recorder Comments
02/18/2004	0	4572.7	-	1554		
02/27/2004	63	4472.1	2.20	1470	89.48	A little mortar loss on ends
03/04/2004	103	4050.8	11.41	-	-	Lots of loss on ends
03/12/2004	153	-	-	-	-	Broken into 4 small pieces, much mortar loss

Table 1b: Test Results – Sample 2

Both samples performed very poorly. The test method requires up to 300 cycles or failure, whichever occurs first. Neither sample could continue the test past 200 cycles, as they had fallen apart. Figure 7 shows Sample 1 when testing was terminated after 194 cycles.

Figure 7a: Sample prior to removal from freeze-thaw apparatus.

Figure 7b: Drained sample.

Figure 7c: Sample removed from tray.

Observations January 2006

In January 2006 a site visit was performed as the final follow up to the construction of the Tensar Mesa MSE wall. The wall appeared to be functioning well with the following few exceptions:

Two blocks (Figure 8) appeared to have vertical stress fractures. The blocks were not located in the same vicinity.

Figure 8a – Vertical fracture

Figure 8b – Vertical fracture

There was one area of 5 blocks (Figure 9) where they all seemed to have a corner chipped away. This condition could possibly have existed from construction or occurred after construction.

Figure 9 – Blocks with chipped corners

Recommendations

- The tolerances for block height and width should be tightened in order to provide a more uniform block.
- The specification should be written in such a manner as to allow the inspector more authority to reject blocks. The inspectors commented that some blocks were chipped or cracked and should not have been used.
- The blocks performed extremely poorly under the AASHTO T 161-00 (ASTM C 666-97), Resistance of Concrete to Rapid Freezing and Thawing test. A sealant should be specified to be applied to the wall face after construction and as part of a periodic maintenance schedule.

In conclusion, it is recommended that the Tensar Mesa™ retaining wall system for use on Agency projects be withheld until the manufacturer can clearly demonstrate that the facing units will not deteriorate in a freeze-thaw environment in the presence of de-icing chemicals. The authors feel that this important issue has not been adequately addressed through prior research and field studies.

It is also recommended that this project be monitored into the future for any adverse changes and the changes are reported in future updates.