REPORT

RESULTS OF REDI-ROCK BLOCK UNIT WITH ONE 7/16 INCH DIAMETER FIBERGLASS ROD USING THE ANCHORED TAIL CONFIGURATION AND MIRAGRID 3XT GEOGRID CONNECTION CAPACITY TESTING

submitted to

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Introduction

This report gives the results of a connection testing program carried out to evaluate the mechanical/frictional performance of the connection between Redi-Rock® modular concrete block units manufactured by Redi-Rock International, LLC and Miragrid 3XT® geogrid using the anchored tail configuration and one 7/16 inch diameter fiberglass connection rod.

The test program was initiated in response to a verbal authorization to proceed from Mr. Jack Bergmann of Redi-Rock International, LLC, received 10 December 2009.

The tests were carried out at the laboratories of Bathurst, Clarabut Geotechnical Testing, Inc. in Kingston, Ontario, under the supervision of Mr. Peter Clarabut.

Objectives of test program

The facing-geogrid connection between Redi-Rock concrete block units and Miragrid 3XT geogrid was investigated using a large-scale connection test apparatus.

The principal objective of the testing was to evaluate the frictional/mechanical performance of these connections. A second objective was to make preliminary recommendations for the selection of long-term tensile connection capacities to be used in the design and analysis of geogrid-reinforced soil wall systems that employ Redi-Rock blocks in combination with Miragrid 3XT geogrid.

Materials

The Redi-Rock units used in this investigation are solid concrete blocks. The nominal dimensions of the blocks are 28 inches (toe to heel) by 18 inches high by 46 inches long and weigh approximately 1625 lb per unit. Construction alignment and wall batter is achieved by means of two dome-shaped concrete shear keys cast into the top surface of the units. The Redi-Rock block system employs one 7/16 inch diameter fiberglass rod to mechanically attach the geogrid reinforcement. The fiberglass rod was placed into a cast-in-place channel located at the back of the block. The blocks used in this series of tests were supplied by Redi-Rock International and were received at our laboratory on 21 December 2005 and designated as BIC-05-060 and BIC-05-061.

Miragrid 3XT is a coated bi-directional grid composed of 100% polyester multifilament yarn with a tensile strength of 3500 lb/ft in the machine direction (based on ASTM D 6637 method of test and reported on the manufacturers' website - www.tencate.com on 27 October 2009). The geogrid specimens used in this series of testing were cut from roll/lot #032092006/06244-2-4 received at our laboratory on 8 December 2006. The index strength of roll/lot # #032092006/06244-2-4 was 3484 lb/ft (test data supplied by TC Mirafi).

Apparatus and general test procedure

The method of test used in this investigation follows that reported by Bathurst and Simac (1993) and recommended by the NCMA (Simac et al. 1993) and ASTM D 6638. A brief description of the apparatus and test methodology is presented here. The test apparatus used to perform the tests is illustrated in **Figure 1**. The test apparatus allows tensile loads of up to 35,000 pounds to be applied to the geogrid while it is confined between two block layers. The facing blocks were laterally restrained and surcharged vertically. A strip of geogrid reinforcement 39 inches (one meter) wide was extended over the lower blocks. One 7/16 inch diameter fiberglass rod was then placed over the grid and inserted into the concrete channel. The grid was then wrapped back over the fiberglass rod, and fed out of the interface. A single block was then placed over the grid and both ends of the reinforcement were attached to roller clamps; the bottom portion of grid was attached to a moving roller clamp and the upper portion was attached to a fixed roller clamp. The connection detail and roller clamp arrangement is illustrated in **Figure 2**. Two wire-line LVDT(s) were connected to the lower grid to measure grid displacement at the back of the block. Wall heights were simulated by placing one block over the interface and applying an additional surcharge load using the vertically-oriented hydraulic jack shown in **Figure 1**. Gum rubber mats were placed over the top block to ensure a uniform distribution of vertical surcharge pressure. The connection force was applied at a constant rate of displacement (i.e. 0.75 inch/minute) using a computer-controlled hydraulic actuator. The load and displacements measured by the actuator and the LVDT(s) were recorded continuously during the test by a microcomputer/data acquisition system. All blocks used in the tests were visually inspected to confirm that they were free of defects. Each test was continued until there was a sustained loss in connection load due to grid rupture. Following each test, the blocks were removed and the grid examined to confirm failure modes. A virgin specimen of grid was used for each test.

The only variable in this series of connection tests was the magnitude of surcharge load.

Test program

The surcharge loads used in the test program are given in **Table 1**. Also tabulated are the failure loads observed for each test.

Test results

A summary of tensile loads at peak capacity is given in **Figure 3**.

The peak connection capacity between Redi-Rock units and Miragrid 3XT for walls between 456 and 5958 lb/ft normal load, ranged between 21 and 51% of the index tensile strength of Miragrid 3XT. Miragrid 3XT has a reported tensile strength of 3500 lb/ft in the machine direction (based on ASTM D 6637 method of test and reported on the manufacturers' website - www.tencate.com on 27 October 2009).

Two repeat tests were performed and results in **Figure 3** illustrate that there is variability in connection capacity between nominal identical tests. The variability is 7.9% and hence within the ± 10% of the mean peak load criterion required by the NCMA. This variability is likely the result of small differences in the setting up of the blocks and laying out of the geogrid reinforcement. The trend in data for peak connection loads has been plotted using a bi-linear curve. The reduced connection capacity at lower surcharge loads may be due to the combined effect of lower surcharge pressure and more geogrid slippage.

All tests ended in rupture of the longitudinal geogrid members. There was evidence of slippage of the grid within the concrete block-grid interface in all tests. Grid straining and slippage caused abrasion of longitudinal members and junction failure as the geogrid was pulled across the concrete surfaces. The amount of slippage was seen to diminish with an increase in wall height.

Implications to Redi-Rock design and construction with Miragrid 3XT geogrid using the anchored tail configuration

The long-term design connection capacity in the field must be less than the peak capacity envelope determined in this test series for the same method and quality of construction. The NCMA Segmental Retaining Wall Design Manual (First Edition, 1993) recommends that the design connection capacity at a given surcharge load for a critical wall structure be the lesser of the peak capacity divided by a minimum factor of safety (not less than 1.5) or the capacity based on a 3/4 inch displacement criterion. The *design* curve in **Figure 4** has been selected based on peak capacity load data only.

The design capacity envelope illustrated in **Figure 4** should be used with caution. The actual design capacity envelope should be lower if the quality of construction in the field is less than that adopted in this controlled laboratory investigation and/or lower quality concrete is used in the manufacture of the blocks. For example, the interface concrete surfaces should be free of debris before placement of grid and blocks in order to minimize abrasion to the grid and to maximize the frictional resistance that is developed at the concrete block-grid interface.

It is very important that production blocks have uniform dimensions so that there is no stepping at the block joints that can lead to non-uniform frictional resistance at the block-grid interface, pinching of the grid at the block edges and possibly fracture of the concrete units.

Summary of conclusions

A laboratory testing program was carried out to evaluate the mechanical/frictional connection performance of Redi-Rock modular block facing units in combination with Miragrid 3XT polyester grid using the anchored tail configuration and one 7/16 inch diameter fiberglass connection rod. The following conclusions can be drawn:

1. The peak connection capacity between Redi-Rock units and Miragrid 3XT geogrid for walls between 456 and 5958 lb/ft normal load, ranged between 21 and 51% of the index tensile strength of 3500 lb/ft in the machine direction (based on ASTM D 6637 method of test and reported on the manufacturers' website - www.tencate.com on 27 October 2009).
2. The trend in data for peak connection loads has been plotted using a bi-linear curve. In addition, minor variability in strength values was observed between nominal identical tests

due to small differences in setting up of the blocks and laying out of the geogrid reinforcement.

3. Care must be taken during the installation of Redi-Rock units in order to prevent accumulation of soil and rock debris at the concrete block-grid interface surfaces. This debris may significantly reduce the capacity of the Redi-Rock facing unit-grid system.

4. The design envelope in **Figure 4** is based on an interpretation of test data as recommended in the NCMA Segmental Retaining Wall Design Manual (First Edition, 1993). The choice of design connection strengths may vary from site to site and quality of construction in the field may require lower design values than those taken from **Figure 4**.

R. J. Bathurst, Ph.D., P. Eng.

P. Clarabut

Table 1:

Test Program:

Redi-Rock modular block unit with 1 fiberglass rod - Miragrid 3XT polyester geogrid connection using the anchored tail configuration

Test number	normal load (lb/ft)	peak tensile capacity (lb/ft)	observed failure mode
1	2862	1555	Rupture
2	846	1101	Rupture
3	5958	1610	Rupture
4	2848	1782	Rupture
5	1830	1555	Rupture
6	4933	1782	Rupture
7	2848	1727	Rupture
8	3887	1782	Rupture
9	456	732	Rupture

REFERENCES

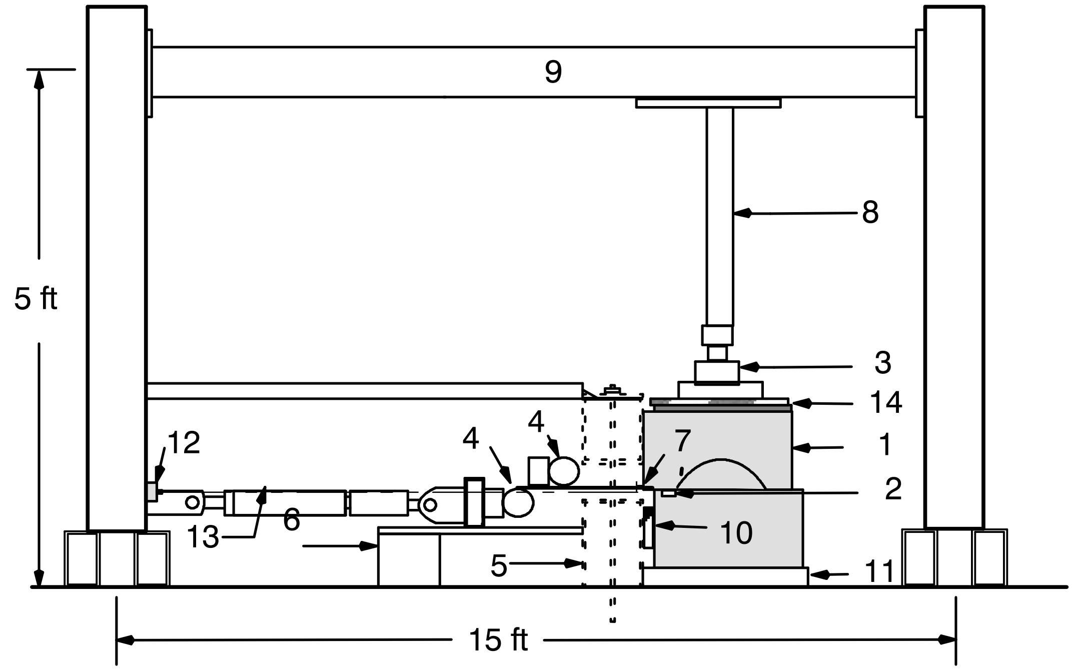
ASTM D 6638-01. Standard Test Method for Determining Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks), American Society for Testing and Materials, West Conshohocken, PA 19428-2958 USA.

Bathurst, R.J. and Simac, M.R., 1993. Laboratory Testing of Modular Unit/Geogrid Facing Connections, *ASTM Symposium on Geosynthetic Soil Reinforcement Testing Procedures*, San Antonio, 19 January 1993.

Simac, M.R., Bathurst, R.J., Berg, R.R. and Lothspeich, S.E., 1993. *NCMA Segmental Retaining Wall Design Manual (First Edition),* National Concrete Masonry Association, 2302 Horse Pen Road, Herndon, VA 22071-3406.

LEGEND

1	Redi-Rock	6	guide rail	11	platform
2	Miragrid 3XT	7	LVDT clamp	12	wire-line LVDT
3	loading platen	8	surcharge actuator	13	computer controlled hydraulic actuator
4	roller clamps	9	loading frame		
5	lateral restraining system	10	spacers	14	stiff gum rubber mat



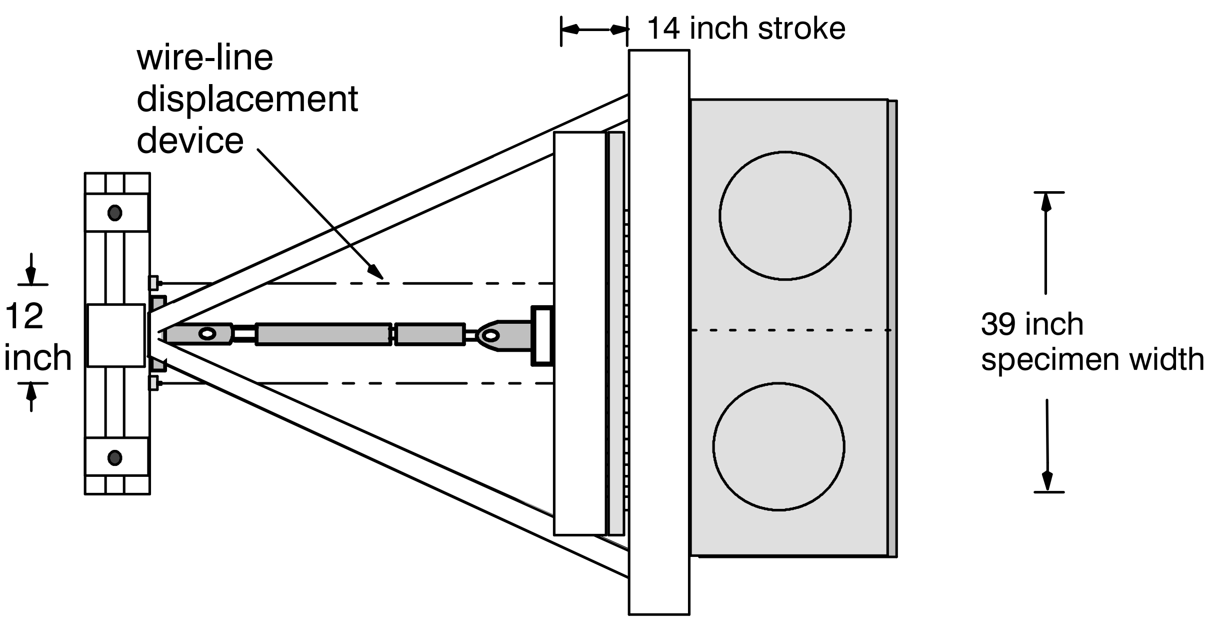


Figure 1: Schematic of connection test apparatus showing Redi-Rock units and Miragrid 3XT geogrid using the anchored tail configuration

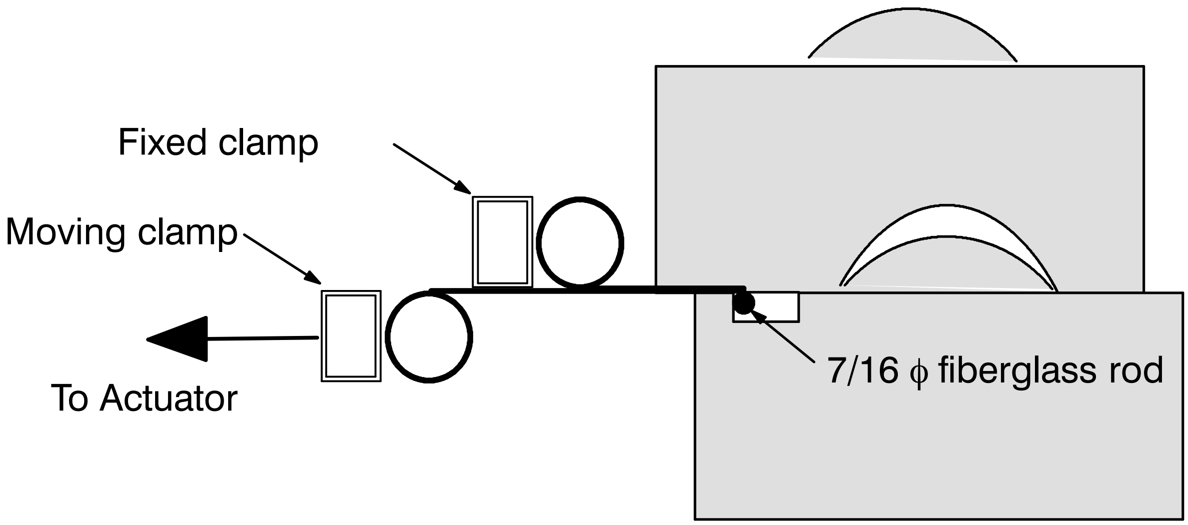


Figure 2: Schematic of connection detail and clamp arrangement

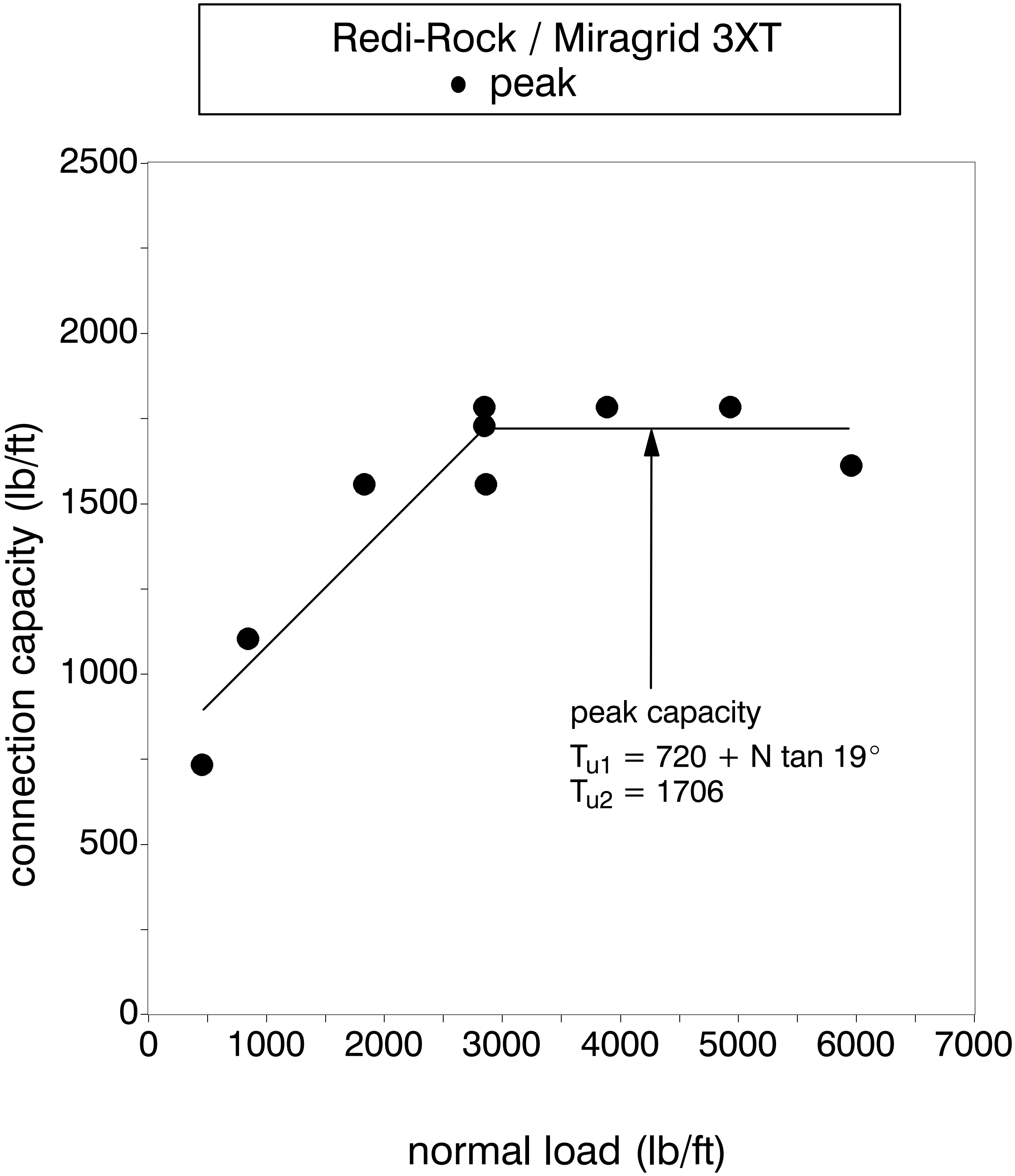


Figure 3: Connection capacity versus normal load for Redi-Rock block with one 7/16 inch diameter fiberglass connector rod and Miragrid 3XT using the anchored tail configuration

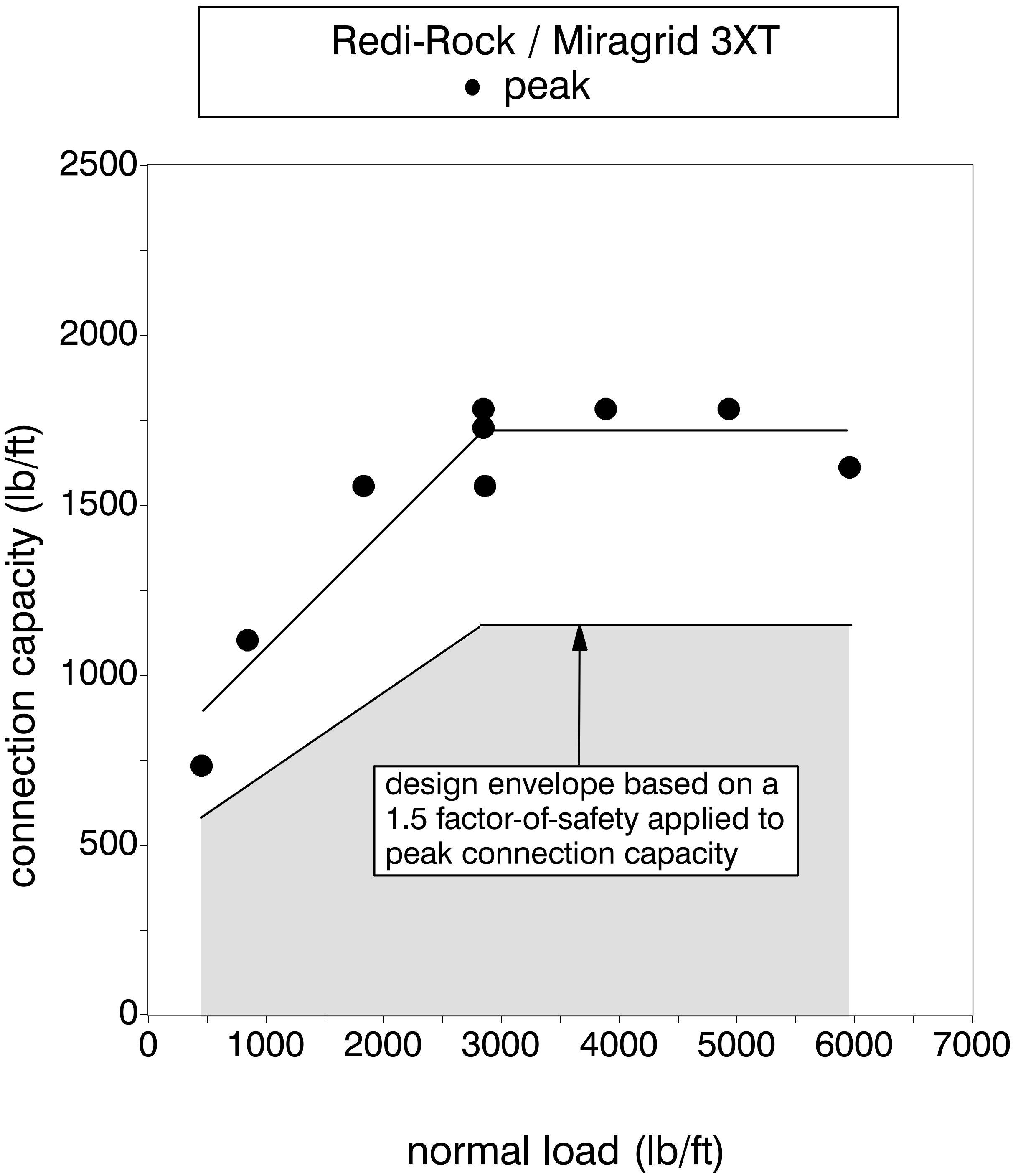


Figure 4: Preliminary design capacity envelope for Redi-Rock modular block units with one 7/16 inch diameter connector rod and Miragrid 3XT geogrid combination using the anchored tail configuration