TEST REPORT:

NOVUM WALL® RETAINING BLOCK

BLOCK TO BLOCK INTERFACE SHEAR CAPACITY

WITH MIRAGRID GEOGRID REINFORCEMENT INCLUSION

Tested By:
Aster Brands Testing Laboratory
6328 Ferry Ave.
Charlevoix, Michigan 49720
Phone: 866-222-8400

Project Number: 33-A

Report Issued: June 17, 2024

1.0 Introduction

This report presents the results of a laboratory testing project that was performed to evaluate the block-to-block interface shear capacity between Novum Wall® retaining blocks with geogrid inclusion. The testing was performed by Aster Brands personnel, under the supervision of Aster Brands engineers at its testing facility located in Charlevoix, Michigan from February to April 2024. Novum Wall® is an Aster Brands product.

2.0 Purpose

The objective of the test series for this project was to define an interface shear capacity design envelope by investigating the block-to-block interface shear capacity of the Novum Wall® blocks with the inclusion of geogrid reinforcement under varying normal loads using a large testing frame.

3.0 Materials

Novum Wall® blocks are wet-cast concrete, precast modular block (PMB) units with a consistent height of 9 in (229 mm), and a width of 24 in (610 mm) plus the face texture of variation of 1-1/2 in (38 mm). The length of the block is 46-1/8 in (1172 mm). Standard block dimensions are as shown in **Figure 1** below. The blocks are manufactured from wet-cast, first purpose, air-entrained, non-reconstituted, structural grade concrete mixes in accordance with ASTM C94 or ASTM C685. They have a minimum specified 28-day compressive strength of 4,000 psi (27.6 MPa) and weigh approximately 610 lb (277 kg) +/- 30 lb (13.6 kg).

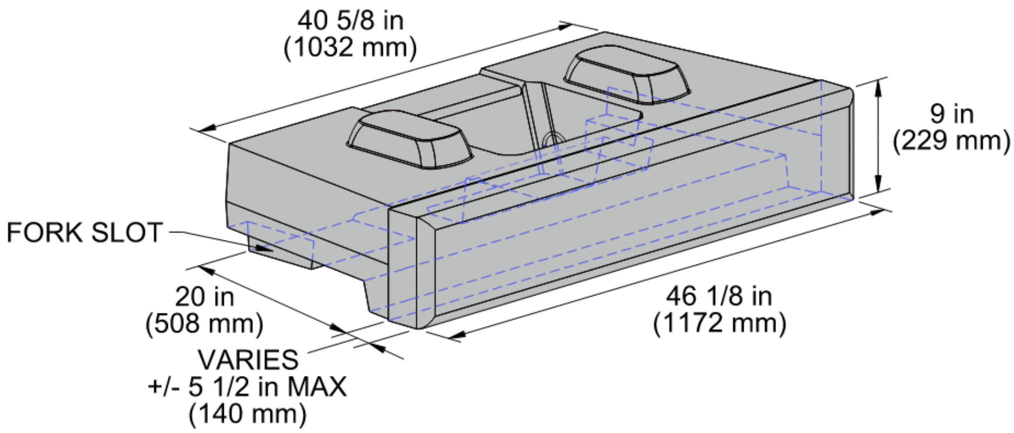


Figure 1 – Novum Wall® Block Dimensions

Shear engagement between subsequent rows of blocks is achieved by two trapezoidal shaped shear knobs protruding from the top of the block that interlock with a groove cast into the bottom of the block above, as well as friction. The shear knobs also set the wall face batter at a nominal value of approximately 5.2 degrees, so the setback between two rows of blocks is approximately (13/16 in (20 mm). Blocks are designed to be dry stacked in a running bond configuration with the vertical joints offset, or staggered, by half of a block length.

Blocks used for this series of testing were produced by Truemont Materials at its Green Cove Springs, Florida facility. The blocks were produced from August to October 2023 and cured for 112 to 245 days prior to testing. Average 28-day compressive strength of the concrete that was used to produce the test blocks was 3,971 psi (27.4 MPa), and average compressive strength at the testing date was 5,017 psi (34.6 MPa), as determined by ASTM C39 on 4 in by 8 in (102 mm by 203 mm) field-cured concrete cylinder specimens.

The geogrid reinforcement used for these tests consisted of Solmax Miragrid® geogrid, manufactured from high molecular weight, high tenacity polyester multifilament yarns woven in tension and finished with a PVC coating. Individual samples were cut from Lot Numbers 20240120-2-1 (3XT), 20240102-2-1 (5XT), 20240105-1-1 (8XT), and 20240120-1-1 (10XT) for testing and were cut to fit the interface area between the blocks. Published values for the physical and design properties of this product are available on the manufacturer's website.

4.0 Test Apparatus

All tests were completed in a high-capacity structural testing frame located at the Aster Brand testing facilities in Charlevoix, Michigan, USA. This testing frame consists of a reconfigurable, steel reaction frame mounted to a 40-inch (1.0 m) thick solid concrete "strong floor".

Testing forces were induced by a precision hydraulic actuator system. The system is capable of providing up to 12 in (300 mm) of travel movement and a maximum of 150,000 lb force (670 kN) simultaneously in two directions using two separate hydraulic pump systems. This allows for precise control of both horizontal and vertical loading. The hydraulic systems are controlled by high-precision directional flow control, needle, and pressure relief valves.

Forces, pressures, and displacements were recorded with electronic sensing devices. Forces were measured with load cells mounted to the ends of the hydraulic cylinders and pushing directly on the block. Displacements were measured with an integral LDT sensor mounted inside the horizontal hydraulic cylinder.

All measurements were recorded with a National Instruments cDAQ data acquisition module and Labview data acquisition software. Data was recorded at a minimum of one datum per sensor per second.

5.0 Methodology

Interface shear capacity testing was completed in general accordance with ASTM D6916 "Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)". In this test method, one block was set on top of two blocks in a staggered, running bond pattern, with a piece of geogrid reinforcement inserted between the two layers of blocks. Base blocks were firmly fixed, and a horizontal load was applied to the back of the top block. A normal load was applied vertically on top of the top block to simulate varied wall heights.

The upper block was pushed horizontally to failure to determine the peak interface shear capacity between the block units with geogrid inclusion. Steel beams and plates with rubber pads are used to spread the loads evenly across the surfaces of the blocks. Tests are run until there is a significant reduction in the applied load and/or excessive deflection. An overview of the test set-up and the configuration of some of the components is shown in **Figure 2** and an isometric image view of the test setup is shown in **Figure 3**.

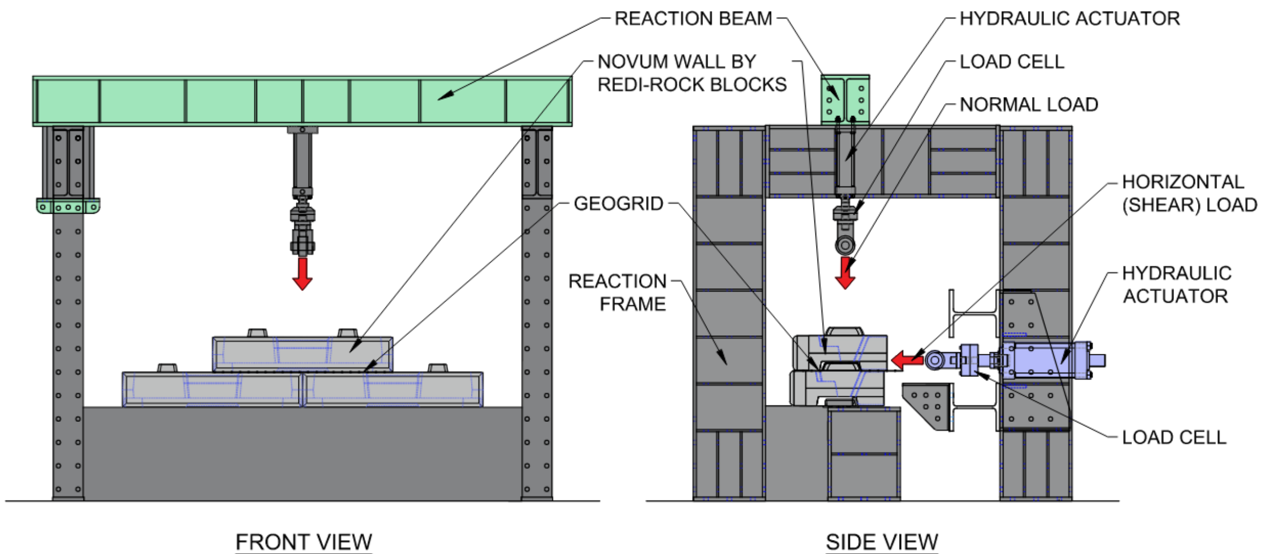


Figure 2 – Schematic test frame set-up

Figure 3 – Interface shear with geogrid inclusion test setup

All interface shear tests were taken to the point of maximum shear load to induce failure of the shear knobs or back of the groove, or visible cracking in the test blocks. The block was moved forward so both of the shear knobs were fully aligned and engaged, and an average initial preload (alignment load) of 511 lb (232 kg) was placed on the block before deflection measurements were recorded. Displacement was measured at the point of load by the integral LDT sensor mounted inside the horizontal hydraulic cylinder. The displacement rate (velocity) at which the load was applied to the blocks as they were tested was manually controlled with an average displacement rate of 0.20 in/min (5.1 mm/min).

For this testing project, normal load levels varied from 118 to 6,757 lb/ft (1.7 to 98.6 kN/m) to simulate the performance of block-to-block interface shear with geogrid inclusion at different vertical locations in a wall cross-section. These values correspond to wall heights ranging from approximately 1 to 25 ft (0.3 to 7.6 m). Additional tests were run at similar nominal normal loads in order to check the repeatability of the testing protocol.

6.0 Laboratory Test Results

Three different failure modes were observed during the testing program. The first mode of failure was crushing at the back of the shear groove of the upper block, and slight knob crushing of the blocks beneath, but portions of the knobs did not break off, as shown in **Figure 4**. The second failure mode occurred when the shear knobs, or pieces of the knobs broke, sometimes one or both knobs, in addition to the failure modes of the first failure, as shown in **Figure 5**. The third mode of failure resulted in cracked and/or broken bottom blocks, as shown in **Figure 6**.

Figure 4 – Groove and slight knob crushing

Figure 5 – Broken shear knobs

Figure 6 – Broken bottom blocks

Block displacement plotted against horizontal load for interface shear tests for each geogrid type is shown in **Figures 7 - 10**. A summary of the peak shear test results organized by geogrid type is shown in **Table 1**.

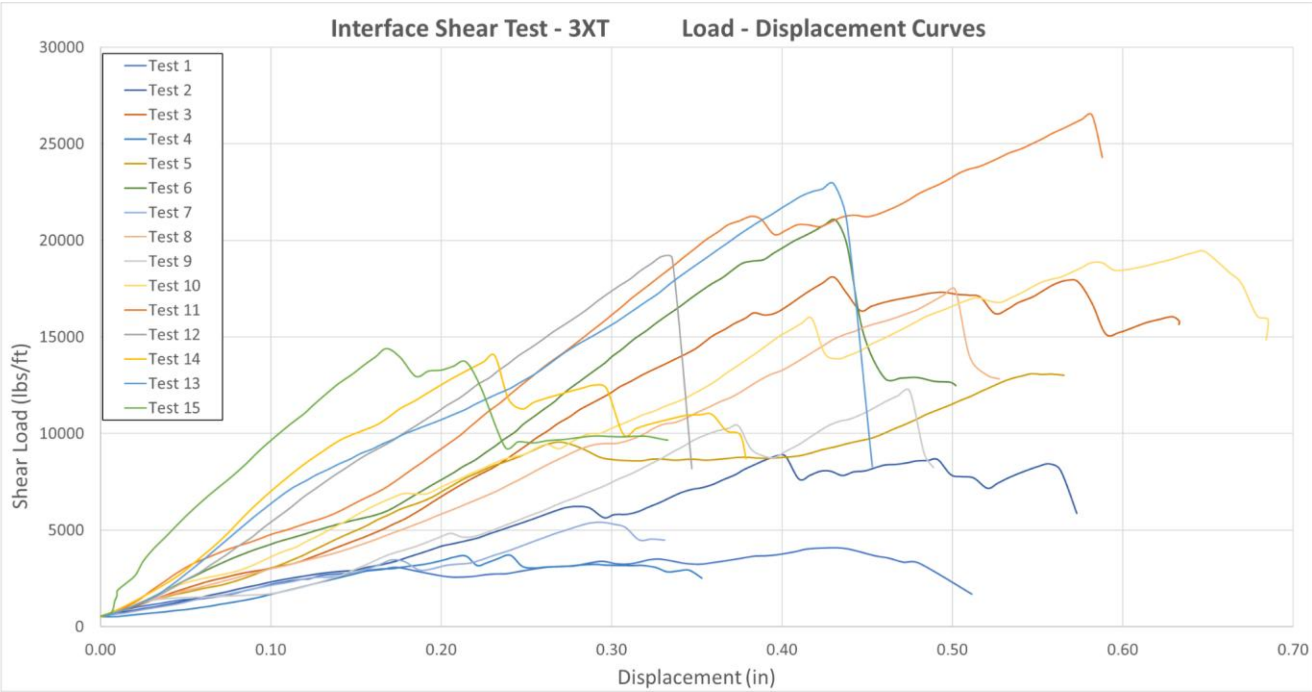


Figure 7 - Horizontal Interface Shear Force versus Horizontal Displacement - 3XT Geogrid

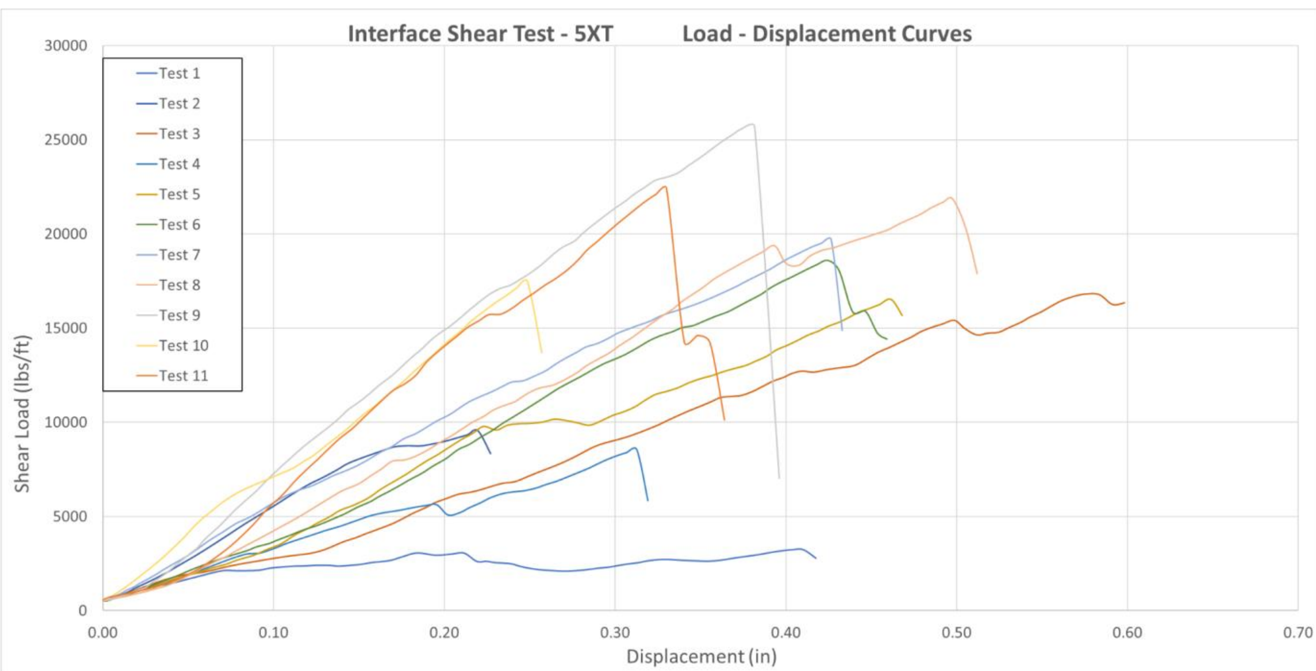


Figure 8 - Horizontal Interface Shear Force versus Horizontal Displacement - 5XT Geogrid

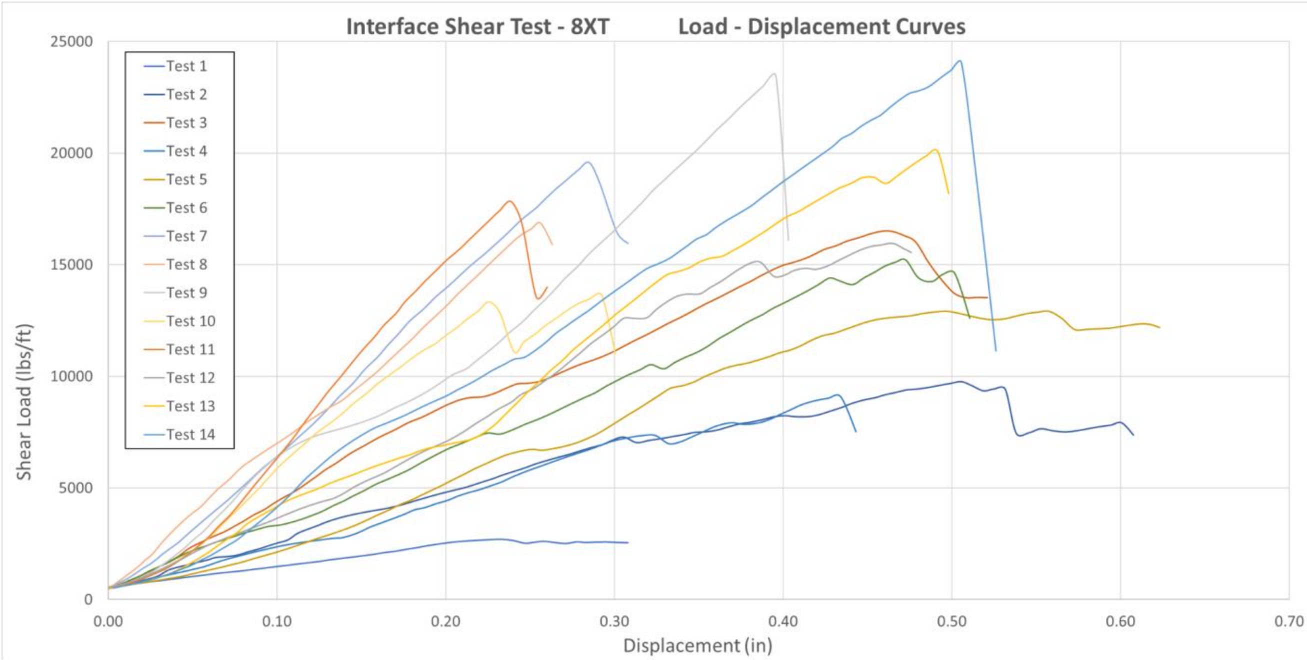


Figure 9 - Horizontal Interface Shear Force versus Horizontal Displacement - 8XT Geogrid

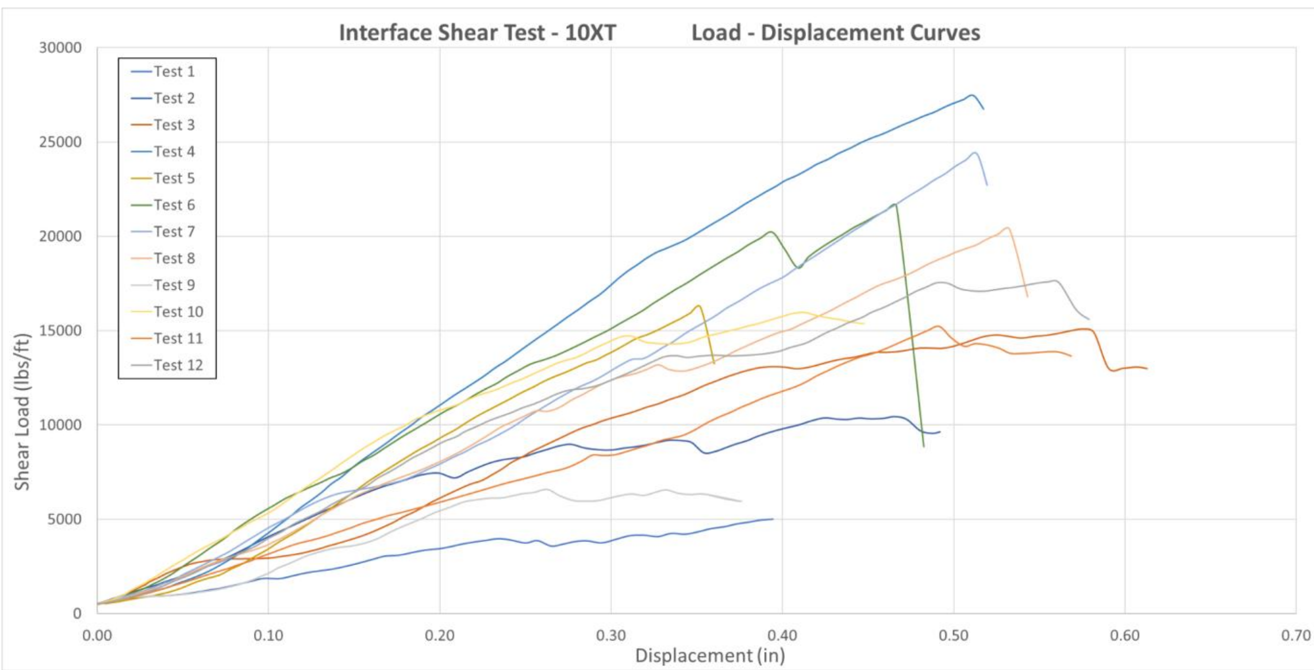


Figure 10 - Horizontal Interface Shear Force versus Horizontal Displacement - 10XT Geogrid

Table 1 – Summary of Peak Interface Shear Test Results

Test Number	Normal Load lb/ft	Normal Load kN/m	Peak Shear lb/ft	Peak Shear kN/m	Observed Failure
Mirafi 3XT Geogrid					
1	122	1.8	1,063	15.5	Crushed Groove
2	357	5.2	2,341	34.2	Crushed Groove
3	1,259	18.4	4,724	68.9	Broken Knob
4	118	1.7	973	14.2	Crushed Groove
5	681	9.9	3,410	49.8	Broken Knobs
6	1,241	18.1	5,485	80.0	Broken Knobs
7	126	1.8	1,413	20.6	Crushed Groove
8	973	14.2	4,554	66.5	Broken Knobs
9	684	10.0	3,191	45.6	Broken Knobs
10	1,261	18.4	5,060	73.9	Broken Knob
11	2,509	36.6	6,920	101.0	Broken Blocks
12	3,748	54.7	5,059	73.8	Broken Blocks
13	5,014	73.2	6,023	87.9	Broken Blocks
14	6,208	90.6	3,663	53.5	Broken Blocks
15	6,274	91.6	3,817	55.7	Broken Blocks
Mirafi 5XT Geogrid					
1	120	1.8	849	12.4	Crushed Groove
2	665	9.7	2,499	36.5	Crushed Groove
3	1,267	18.5	4,381	63.9	Crushed Groove
4	365	5.3	2,233	32.6	Crushed Groove
5	954	13.9	4,343	63.4	Broken Knobs
6	1,253	18.3	4,847	70.7	Broken Knobs
7	1,245	18.2	5,136	75.0	Broken Knobs
8	2,492	36.4	5,694	83.1	Sheared Off Knob
9	3,773	55.1	6,729	98.2	Broken Blocks
10	5,060	73.9	4,569	66.7	Broken Blocks
11	6,757	98.6	5,851	85.4	Broken Blocks
Mirafi 8XT Geogrid					
1	118	1.7	705	10.3	Crushed Groove
2	676	9.9	2,541	37.1	Broken Knob
3	1,270	18.5	4,304	62.8	Crushed Groove
4	356	5.2	2,364	34.5	Crushed Groove
5	961	14.0	3,363	49.1	Broken Knobs
6	1,269	18.5	3,961	57.8	Broken Knob
7	1,241	18.1	5,104	74.5	Sheared Off Knob
8	2,502	36.5	4,393	64.1	Broken Blocks
9	3,770	55.0	6,132	89.5	Broken Blocks
10	5,022	73.3	3,559	51.9	Broken Blocks
11	6,262	91.4	4,721	68.9	Broken Blocks
12	1,247	18.2	4,152	75.2	Broken Knobs
13	2,501	36.5	5,264	46.8	Broken Bocks
14	5,051	73.7	6,300	91.9	Broken Blocks

Test Number	Normal Load lb/ft	Normal Load kN/m	Peak Shear lb/ft	Peak Shear kN/m	Observed Failure
Mirafi 10XT Geogrid					
1	120	1.8	1,305	19.0	Crushed Groove
2	671	9.8	2,722	39.4	Crushed Groove
3	1,248	18.2	3,939	57.5	Broken Knobs
4	6,247	91.2	7,195	105.0	Broken Blocks
5	5,015	73.2	4,276	62.4	Broken Blocks
6	3,745	54.7	5,638	82.3	Broken Blocks
7	2,521	36.8	6,408	93.5	Broken Blocks
8	1,270	18.5	5,338	77.9	Broken Blocks
9	357	5.2	1,718	25.1	Crushed Groove
10	1,266	18.5	4,155	60.6	Broken Knobs
11	958	14.0	3,970	57.9	Broken Knobs
12	1,277	18.6	4,577	66.8	Broken Knob

Peak interface shear loads were taken as the maximum measured load during each interface shear test. Peak loads plotted against normal loads are shown in **Figure 11**.

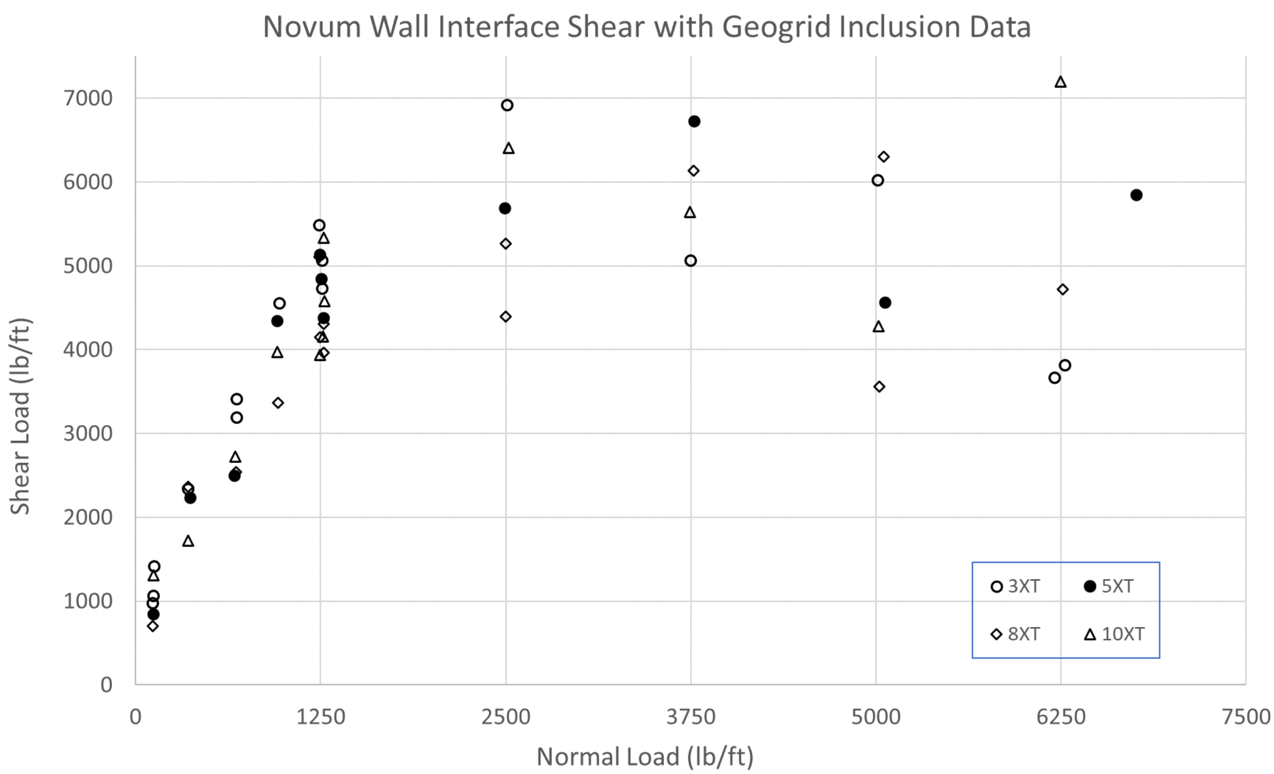


Figure 11 - Peak Shear Load versus Normal Load - All Geogrid Types

The Novum Wall® block to block interface shear capacity with geogrid inclusion tests were conducted in general accordance to ASTM D6916. Small deviations from the standard can be further elaborated upon request.

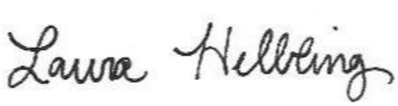
The recommended interface shear capacity envelope for Novum Wall® blocks with geogrid reinforcement for use in design and analysis can be found in the design resources section of the website for Novum Wall®.

7.0 Closure

The data and conclusions contained herein should be used with care. The user should verify that project conditions are equivalent to laboratory conditions and should account for any variations.

This test data is accurate to the best of our knowledge and understanding. It is the responsibility of the end user to determine suitability for the intended use.

ASTER BRANDS



Laura B. Helbling, PE
Civil Engineering Consultant

Matthew A. Walz, PE
Testing Manager

Daniel J. Cerminaro, PE
Civil Engineering Manager

James R. Johnson, PE
Director of Innovation