TEST REPORT:

REDI-ROCK 41-INCH SOLID RETAINING BLOCK ON 52-INCH HOLLOW CORE XL RETAINING BLOCK
BLOCK TO BLOCK INTERFACE SHEAR CAPACITY

Tested By:
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1.0 Introduction

This report documents testing to evaluate the block-to-block interface shear capacity between Redi-Rock 41-inch (1030 mm) solid (R-41M) retaining units and 52-inch (1320 mm) hollow core XL (R-5236HC) units. The testing was performed by Aster Brands at its testing facility in Charlevoix, Michigan in May and June 2018. Redi-Rock is an Aster Brands company.

2.0 Purpose

The objective of the test series was to investigate the block-to-block interface shear capacity of full-size Redi-Rock solid retaining units on hollow-core XL units under varying normal loads using a large testing frame. Crushed stone core fill material was not included in this testing. No attempt has been made to quantify the additional interface shear capacity provided by properly installed core fill.

3.0 Materials

Redi-Rock R-41M blocks are wet-cast concrete, precast modular block (PMB) units with a nominal width of 40½ inches (1,029 mm), length of 46⅛ inches (1172 mm), and height of 18 inches (457 mm). They weigh approximately 1,625 lbs (7.23 kN) each.

Redi-Rock R-5236HC XL blocks are also wet-cast concrete, precast modular block (PMB) units with a nominal length of 40½ inches (1,029 mm). These XL units have a width of 52 inches (1320 mm) and a height of 36 inches (914 mm). They weigh approximately 3,330 lbs (14.8 kN) each.

Block dimensions are shown in **Figure 1**. The blocks are manufactured from wet-cast, first purpose, non-reconstituted, structural-grade concrete mixes in accordance with ASTM C94 or ASTM C685 and have a minimum specified 28-day compressive strength of 4,000 psi (27.6 MPa).

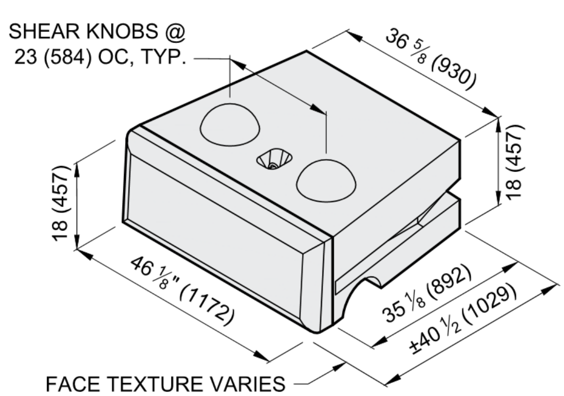

Figure 1 - R-41M block

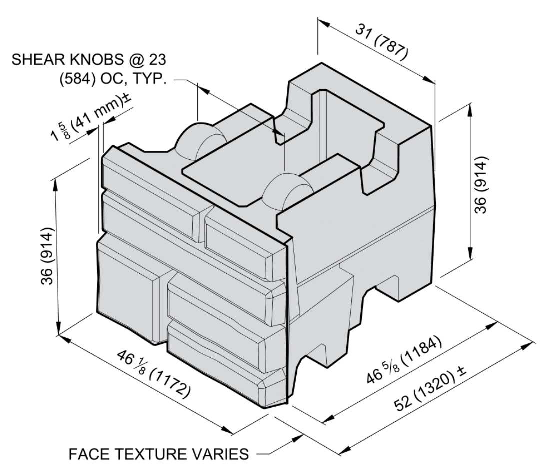

Figure 2 - R-5236HC

Shear engagement between subsequent rows of blocks is achieved by two dome-shaped shear knobs protruding from the top of each block that interlock with a groove cast in the bottom of each overlying block. The shear knobs and groove also set the wall batter at a nominal value of 5 degrees (1 5/8 inches (41 mm) per 18-inch (457 mm) course). Blocks are typically stacked in a staggered, or running bond, configuration.

Blocks used in this series of testing were produced by MDC Contracting, LLC at its Charlevoix, Michigan facility. Blocks were produced in November 2017 through May 2018 and cured for 37 to 225 days prior to testing. Average compressive strength of the concrete on the day of testing was 4,639 psi (32.0 MPa) for the 41-inch blocks and 5,147 psi (35.5 MPa) for the XL test blocks, as determined by ASTM C39 on 4-inch by 8-inch (102 mm by 203 mm) field-cured concrete cylinder specimens tested on the day the blocks were tested.

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 inches (300 mm) of movement and a maximum of 150,000 pounds of force (670 kN) simultaneously in two directions through the use of 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. Forces were verified with electronic pressure gauges installed in the hydraulic systems. Displacements were measured with a pair of LVDTs and 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 is set on top of two blocks in a staggered, running bond pattern. Base blocks are firmly fixed and a normal load is applied vertically to simulate varied height walls. The upper block is then pushed horizontally to failure to determine the peak interface shear capacity between the block units. Tests are run until there is excessive deflection, visible cracking seen in the test blocks, or significant reduction in applied load. Details of the test set-up are shown in **Figure 2**.

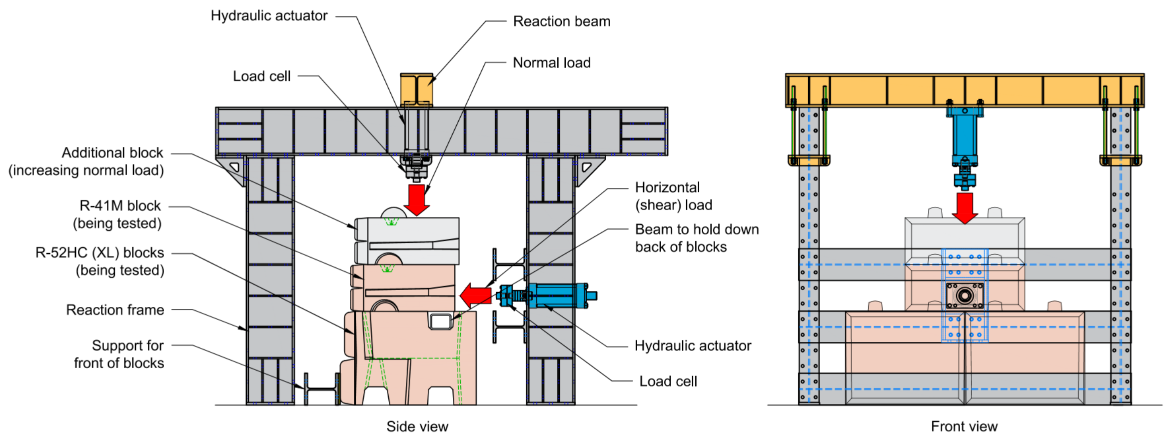

Figure 2: Schematic test frame set-up

For this testing program, normal load levels were varied from 561 to 16,621 lb/ft (8.2 to 243 kN/m) to simulate the performance of block to block interface shear at different vertical locations in a wall cross-section. These values correspond to approximate wall heights from 1.5 to 40 feet (0.5 to 12 m). Three tests were run at the same normal load near the middle of the range of loads tested to check repeatability of the testing protocol.

Blocks were initially set such that the shear grooves were not firmly engaged with the shear knobs on the underlying blocks. Normal load was applied and horizontal load was applied in two stages: an initial sliding friction stage to measure the coefficient of friction between precast blocks (without the shear knobs engaged) and the final shear resistance stage with the shear knbs engaged to obtain the full interface shear capacity.

Blocks were preloaded with an average of approximately 1,000 lb (4.5 kN) to set the blocks. Displacement was measured using a pair of LVDTs. The displacement rate (velocity) at which the blocks were tested was manually controlled with a displacement rate generally around 1.1 mm/min (0.04 in per minute) instead of the 5 mm/min +/- 1mm/min (0.197 in per minute +/- 0.04" per min) rate specified in ASTM D6916.

6.0 Results

All tests were taken to block failure. Failure generally involved cracking that started behind the knob and exited through the block face, as shown in **Figure 3**.

Figure 3 - Failure through block face

Block displacement plotted against horizontal load is shown in **Figure 4**. Peak loads were taken as the maximum measured load during each test and are summarized in **Table 1**. Peak loads plotted against normal loads are shown in **Figure 5**.

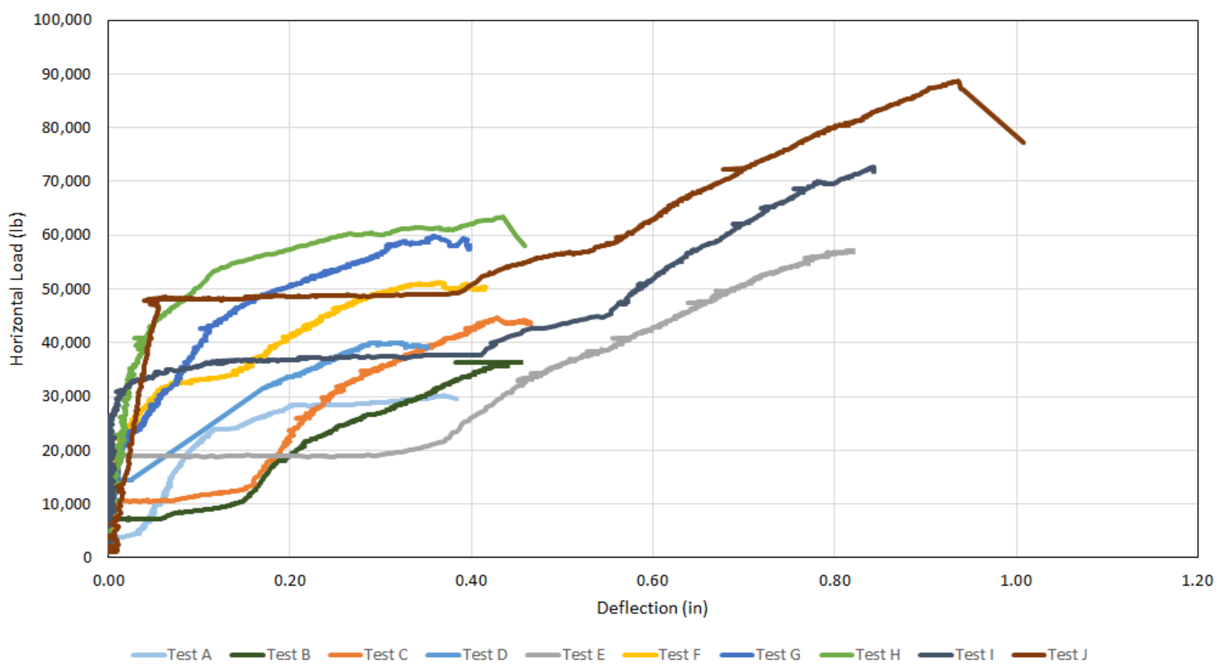

Figure 4 - Horizontal Shear Force versus Horizontal Displacement

Table 1 - Sliding friction and interface shear results

Test Number	Normal Load		Sliding Friction(1)		Peak Shear(2)		Observed Failure(2)
	lb/ft	(kN/m)	lb/ft	(kN/m)	lb/ft	(kN/m)	
A	561	8.18	416	6.07	7,753	113.14	Failure through block face
B	2,333	34.05	1,886	27.53	10,485	153.01	Failure through block face
C	3,664	53.47	2,706	39.49	11,601	169.30	Failure through block face
D	5,066	73.93	3,538	51.64	10,276	149.97	Failure through block face
E	6,626	96.70	4,982	72.71	13,450	196.29	Failure through block face
F	7,777	113.49	5,698	83.15	13,268	193.63	Failure through block face
G	7,784	113.60	6,140	89.60	15,089	220.21	Failure through block face
H	7,785	113.61	--	--	15,610	227.80	Failure through block face
I	12,697	185.30	9,522	138.96	18,211	265.77	Failure through block face
J	16,621	242.56	12,514	182.62	22,634	330.31	Failure through block face

(1) Shear knobs not engaged.
(2) Shear knobs engaged.

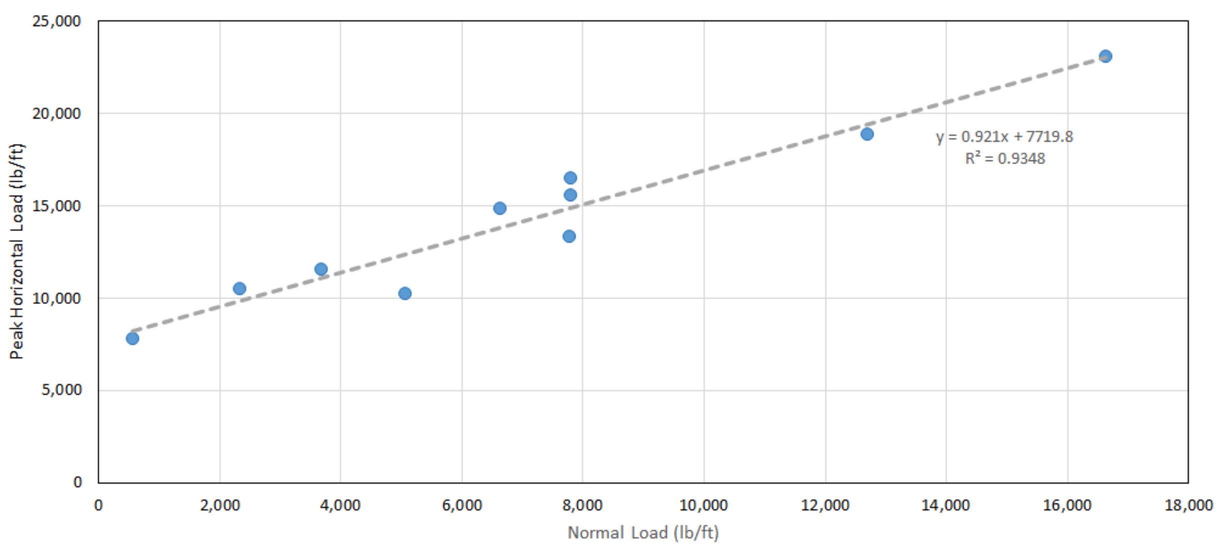

Figure 5 - Interface shear strength versus normal load (shear knobs engaged)

Three tests were run at approximately 7,780 lb/ft (113.5 kN/m) normal load to check repeatability of the testing protocol. ASTM D6916 uses a value of ±10% variation for each test from the mean of the tests as a measure of repeatability. Maximum variability of the three repeatability tests was 9 percent.

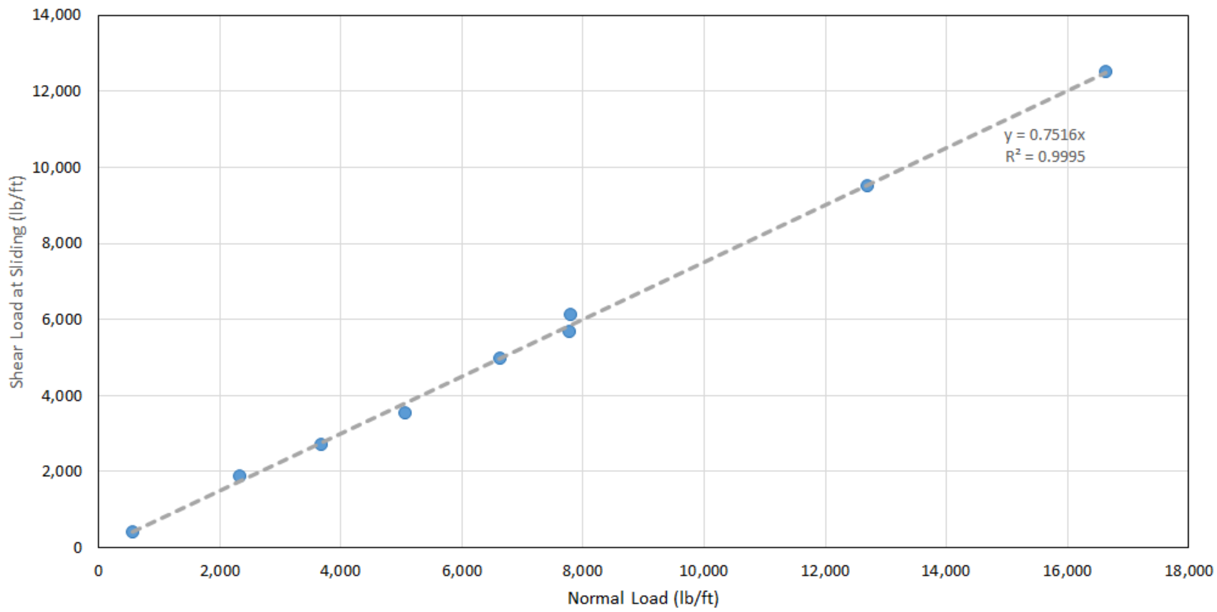

Figure 6 -Sliding friction load versus normal load (shear knobs not engaged)

Normal load versus sliding friction load appeared to follow a very linear relationship. Linear regression trendline resulted in a best-fit line with a slope of 0.7516, which is equivalent to a friction angle of 36.9°.

7.0 Closure

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

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

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