REDI+ROCK

41" HOLLOW-CORE RETAINING BLOCK INTERFACE SHEAR DESIGN PARAMETERS

Block Type:

R-41HC 41" Hollow-Core Retaining Block

Test Methods: ASTM D6916 & NCMA SRWU-2 Tested By: *r*: Aster Brands | Nov. 19-25, 2019

		CE SHEAR DATA ^(a)			
Test	Normal		Peak		Observed
No.	Load		Shear		Failure
	lb/ft	(kN/m)	lb/ft	(kN/m)	
1	5,993	(87.5)	12,620	(184.2)	Failure through face
2	6,039	(88.1)	14,209	(207.4)	Failure through face
3	472	(6.9)	7,552	(110.2)	Failure through face
4	2,064	(30.1)	8,644	(126.1)	Failure through face
5	3,991	(58.2)	10,715	(156.4)	Failure through face
6	8,019	(117.0)	12,146	(177.3)	Knobs sheared
7	6,000	(87.6)	10,414	(152.0)	Knobs sheared
8	10,016	(146.2)	15,243	(222.5)	Knobs sheared
9	5,998	(87.5)	12,221	(178.3)	Knobs sheared





(a) The average compressive strength of concrete blocks as-tested ranged from 2,865 psi (19.8 MPa) to 3,872 psi (26.7 MPa), with an average of 3,323 psi (22.9 MPa). The data reported represents the actual laboratory test results. No statistically-significant correlation between block strength and interface shear resistance was found.

(b) The equations for peak shear envelope represent the slope of the trend line of the raw data, offset to pass thorugh the lower 95% confidence limit for the repeatability values, with no increase in shear capacity for normal load values above those tested. No further adjustments have been made. Appropriate factors of safety for design should be added.

The information contained in this report has been compiled by Redi-Rock International, LLC as a recommendation of peak interface shear capacity. It is accurate to the best of our knowledge as of the date of its issue. However, final determination of the suitability of any design information and the appropriateness of this data for a given design purpose is the sole responsibility of the user. No warranty of performance is expressed or implied by the publishing of the foregoing laboratory test results.

TEST REPORT:

REDI-ROCK 41-INCH HOLLOW-CORE RETAINING BLOCK BLOCK TO BLOCK INTERFACE SHEAR CAPACITY

Tested By: Aster Brands 2940 Parkview Drive Petoskey, Michigan 49770 866-222-8400

June 16, 2020

ASTERBRANDS

•••



ROSETTA



1.0 Introduction

This report documents testing to evaluate the block to block interface shear capacity between Redi-Rock 41-inch (1030 mm) Hollow-Core (R-41HC) retaining units. The testing was performed by Aster Brands at its testing facility in Charlevoix, Michigan in November 2019. 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 41-inch (1030 mm) Hollow-Core (R-41HC) retaining 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-41HC blocks are wet-cast concrete, precast modular block (PMB) units with a nominal width of 40¹/₂ inches (1,029 mm), length of 46¹/₈ inches (1172 mm), and height of 18 inches (457 mm). 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. They have a minimum specified 28-day compressive strength of 4,000 psi (27.6 MPa) and weigh approximately 1,625 lbs (7.23 kN).



Figure 1 - R-41HC block

Shear engagement between subsequent rows of blocks is achieved by two dome-shaped shear knobs protruding from the top of the block that interlock with a groove cast in the bottom of the block. The shear knobs and groove also set the wall batter at a nominal value of 5 degrees ($1\frac{5}{8}$ inches (41 mm) per 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 late September and early October 2019 and cured for 50 to 54 days prior to testing. Average compressive strength of the concrete used to produce the test blocks was 3,320 psi (22.9 MPa), as determined by ASTM C39 on 4-inch by 8-inch (102

mm by 203 mm) field-cured concrete cylinder specimens. Because all test blocks had compressive strength values at the time of testing below the minimum specified 28-day value for Redi-Rock R-41HC blocks, tested interface shear values were assumed to be lower bound values and no attempt was made to adjust test results for concrete strength.

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" (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" (300 mm) of movement and a maximum of 150,000 pound 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 string potentiometer 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 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 472 to 10,016 lb/ft (6.9 to 146.2 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 to 25 feet (0.3 to 7.5 m). Four 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 preloaded with an average of approximately 950 lb (4.2 kN) to set the blocks. 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 blocks were tested was manually controlled with an average displacement rate of 4.3 mm/min (0.17" per minute) which is within the tolerance of 5 mm/min +/- 1mm/min (0.197" per minute +/- 0.04" per min) rate specified in ASTM D6916.

6.0 Results

All tests were taken to block failure. Two modes of failure were observed during the tests. In the first mode, shown in **Figure 3**, the block cracked starting behind the knob and running through the block face. In the second mode, shown in **Figure 4**, failure occurred either in the knob or at the interface between the knob and the block.





Figure 3 - Failure through block face

Figure 4 - Failure by knob shear

Block displacement plotted against horizontal load is shown in **Figure 5**. 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 6**. The two failure modes are shown with different markers for ease in distinguishing them.



Figure 5 - Horizontal Shear Force versus Horizontal Displacement

Table 1	- Re	sults
---------	------	-------

Test Number	Normal Load		Peak Shear		Observed Failure
	lb/ft	(kN/m)	lb/ft	(kN/m)	
1	5,993	(87.5)	12,620	(184.2)	Failure through block face
2	6,039	(88.1)	14,209	(207.4)	Failure through block face
3	472	(6.9)	7,552	(110.2)	Failure through block face
4	2,064	(30.1)	8,644	(126.1)	Failure through block face
5	3,991	(58.3)	10,735	(156.7)	Failure through block face
6	8,019	(117.0)	12,146	(177.3)	Knob shear
7	5,951	(86.9)	10,418	(152.0)	Knob shear
8	10,016	(146.2)	15,243	(222.5)	Failure through block face
9	5,998	(87.5)	12,221	(178.4)	Knob shear



Figure 6 - Shear strength versus Normal loads

Four tests were run at approximately 6,000 lb/ft (87.6 kN/m) normal load to check repeatability of the testing protocol. ASTM D6916 uses a value of $\pm 10\%$ variation for each test from the mean of the tests as a measure of repeatability. In testing, two different failure mechanisms were observed in the repeat tests. When looking at the total combined data, the high and low values do not fall within 10% of the mean of the tests. If the high and low values are averaged, the average high and low value and the two middle values vary less than 1.3% from the mean of the tests. If the two failure modes are analyzed separately, both tests vary less than 10% from the mean of the tests.

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.

ASTER BRANDS

Allew A Wal

Matthew A. Walz, P.E. Testing Manager

this wifel

Nils W. Lindwall, P.E. Chief Engineer