STONE LABORATORY TEST REPORT

Report No.: 24-0036.01-R1
Test Date(s): 04/01/24 – 05/28/24
Initial Report Date: 05/01/24
Revision Date: 05/30/24
Retention Date: 05/01/28

Prepared for: Jacobs Stone Products, Inc.
1210 W. Pierce Street
San Saba, TX 76877

Product: Natural Stone Product – Black Pearl

Scope: The Natural Institute (NSI) was contracted by Jacobs Stone products, Inc. to perform physical properties evaluations for one natural limestone product (Black Pearl). The scope of testing included absorption, density, compressive strength, modulus of rupture, flexural strength, abrasion resistance, slip resistance, and freeze-thaw durability for both cladding and paving installation conditions. All testing was performed at the NSI laboratory located in Oberlin, Ohio.

Methods: The products were evaluated in accordance with the following test method(s):

ASTM C568/C568M-22, *Standard Specification for Limestone Dimension Stone*

ASTM C97/C97M-18, *Standard Test Method for Absorption and Bulk Specific Gravity of Dimension Stone*

ASTM C170/C170M-23, *Standard Test Method for Compressive Strength of Dimension Stone*

ASTM C99/C99M-18*, Standard Test Method for Modulus of Rupture of Dimension Stone*

ASTM C1353/C1353M-20, *Standard Test Method for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic Using a Rotary Platform Abraser*

ASTM C880/C880M-23, *Standard Test Method for Flexural Strength of Dimension Stone*

ASTM C666/C666M-15, *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing*

ASTM C1645-21, *Standard Test Method for Freeze-Thaw and De-Icing Salt Durability of Solid Concrete Interlocking Paving Units*

ASTM C936/C936M-23a, *Standard Specification for Solid Concrete Interlocking Paving Units*

ANSI A326.3-2021 – *American National Standard Test Method for Measuring Dynamic Coefficient of Friction of Hard Surface Flooring Materials*

Test Materials: Test materials were provided by Jacobs Stone products, Inc. on 03/28/24, designated as Black Pearl, and were received in good condition for testing. Specimens were tested as received other than preconditioning as required by the applicable test method(s) prior to testing. Representative test materials shall be retained by the NSI for a period of four years.

Test Witness Record

Name	Company
Clint Eads	NSI
Roger Lawson	NSI
Scott D. Scallorn	NSI

Test Procedure(s): Unless otherwise stated, all specimen conditioning and testing was conducted in standard laboratory conditions. Test photos are located on pages 22-28 of this report. Equipment calibration certificates are available upon request.

ASTM C97 - Absorption and Density Evaluation

The absorption and density evaluations were conducted in accordance with the procedures detailed in ASTM C97. The specimens were dried in a ventilated oven maintained at 60°C (ICN: NSI00012) to a stable mass condition (minimum 48 hours), reacclimated to ambient lab temperature and weighed on an Ohaus digital balance (ICN: NSI00022) for determination of dry condition mass. They were then immersed in filtered water bath maintained at 22°C temperature (verified by an Omega HH509R Thermometer (ICN: NSI00010) for 48 hours prior to individual specimen removal, surface drying and determination of wet condition mass. The specimens were then suspended in the water within a wire cage and weighed for determination of immersed condition mass. Absorption (%) and bulk specific gravity were calculated for each specimen as per the equations in ASTM C97, Section 9. Test results were averaged for the test series and evaluated against the performance criteria presented in ASTM C568, Table 1.

ASTM C170 – Compressive Strength Evaluation

The compressive strength evaluation was conducted on a Test Mark compression tester (ICN: NSI00001) in accordance with the procedures detailed in ASTM C170. Pretest specimen dimensions were measured with a 6" x 0.0005" Digital Caliper (ICN: NSI00008). Specimens were tested in both oven-dry and wet conditions. Dry condition specimens were oven-dried at 60°C for a minimum of 48 hours and cooled to ambient prior to testing. Wet condition specimens were immersed in water for 48 hours prior to individual removal and testing. Compressive strength was calculated for each specimen as per the equation in ASTM C170, Section 10.1. Test results were averaged for each test series and evaluated against the performance criteria presented in ASTM C568, Table 1.

ASTM C99 – Modulus of Rupture Evaluation

The Modulus of Rupture (MoR) evaluation was conducted on an ATS Universal Test Machine (ICN: NSI00003) employing a 12.5-kip load cell (ICN: NSI00004) in accordance with the procedures detailed in ASTM C99. Pretest specimen dimensions were measured with a 6" x 0.0005" Digital Caliper (ICN: NSI00008). Specimens were tested in both oven-dry and wet conditions. Dry condition specimens were oven-dried at 60°C for a minimum of 48 hours and cooled to ambient prior to testing. Wet condition specimens were immersed in water for 48 hours prior to individual removal and testing. Specimens were supported at a test span of 7.0 in. and loaded at midspan until failure. Flexural strength was calculated for each specimen as per the equation in ASTM C99, Section 11.1. Test results were averaged for each test series and evaluated against the performance criteria presented in ASTM C568, Table 1.

ASTM C1353 – Abrasion Resistance Evaluation

The abrasion resistance evaluation was conducted in accordance with the procedures detailed in ASTM C1353. The specimens were oven-dried at 60°C for a minimum of 48 hours and cooled prior to determination of pre-abrasion mass on an Ohaus digital balance (SN: B614316489) The specimens were then evaluated on a Taber Industries rotary platform abraser (SN: 20161679) employing H-22 Calibrade abrasive wheels with 1,000 grams of downward force applied to each for a total of 1000 wear cycles. Upon completion of cycling, post-exposure mass was determined for each specimen. Employing the bulk specific gravity results obtained from ASTM C97 evaluation, Index of Abrasion was calculated for each specimen as per the equation in ASTM C1353, Section 9.1. Test results were averaged for the series and evaluated against the performance criteria presented in ASTM C568, Table 1.

ANSI A326.3 – Dynamic Coefficient of Friction (DCOF) Evaluation

The DCOF evaluation was conducted in accordance with the procedures detailed in ANSI A326.3, sections 7 & 8. Specimens were evaluated with a BOT 3000E tribometer (ICN NSI00002) in wet condition (employing a 0.05% SLS solution). Four perpendicular passes were conducted, and test values averaged for each specimen. Individual specimen results were averaged for the test series and evaluated against the ANSI A326.3, Section 3.1 recommended wet condition performance criteria of 0.42.

ASTM C666 – Freeze-Thaw Durability (Cladding Application)

The freeze-thaw exposure cycling was conducted in modified ESPEC EPX-4H environmental conditioning chamber (ICN: NSI00015) in accordance with ASTM C666, Procedure B (Freeze-in-Air, Thaw-in-Water). The specimens were subjected to a total of 100 exposure cycles each consisting of lowering the temperature of wetted specimens from 40°F to 0°F in an air-surround condition and returning to 40°F in an immersed condition. Upon completion of each 25-cycle exposure increment, five specimens were removed from cycling and visually evaluated for breakage of other readily visible deleterious effects. The removed specimens were immersed in water for 48 hours prior to individual removal and testing in flexure as per ASTM C880 (detailed below).

ASTM C880 – Flexural Strength

The Flexural strength evaluation was conducted on an ATS Universal Test Machine Test Machine (ICN: NSI00003) employing a 12.5-kip load cell (ICN: NSI00004) in accordance with the procedures detailed in ASTM C880. Control series (no exposure cycling) specimens were tested in both oven-dry and wet conditions. Post-exposure series specimens were tested after 25, 50, 75, and 100 cycle completion and in wet condition only. Dry condition specimens were oven-dried at 60°C for a minimum of 48 hours and cooled to ambient prior to testing. Wet condition specimens were immersed in water for 48 hours prior to individual removal and testing. Specimens were supported at a test span of 12.5 in. and loaded at quarter point (6.25 in. loading span) until failure. Flexural strength was calculated for each specimen as per the equation in ASTM C880, Section 10.1. Test results for both wet and dry condition control series were averaged for each test series and the post-exposure mean flexural strength of each exposure series was evaluated against both the comparative zero-cycle wet condition control series and the preceding freeze-thaw exposure series for evaluation of potential strength loss.

ASTM C1645 – Freeze-Thaw Durability Evaluation (Paving Application)

The freeze-thaw durability evaluation was conducted in modified ESPEC EPX-4H environmental conditioning chamber (ICN: NSI00014) in accordance with the procedures detailed in ASTM C1645 without inclusion of de-icing salt considerations. The specimens were immersed in potable water for a period of 24 hours prior to initiation of exposure cycling. A total of 28 exposure cycles were conducted, each consisting of a 16 ± 1 hr. freezing period (to -5 ± 3°C [23 ± 5°F]) followed by an 8 ± 1 hr. thawing period (to 5°C [40°F]). Upon completion of both 7 and 28 cycles, specimen visual condition was documented and any loose debris in the exposure bin was collected. Debris filtered from solution and oven dried to determine total mass loss relative to initial test specimen surface area. Mass loss results were averaged for the series and evaluated against the performance criteria presented in ASTM C936, Section 5.5. The post-exposure specimens were oven conditioned to equilibrium dry mass for additional visual evaluation of condition relative to the unexposed control specimen for each test series.

Specimen Details

Test Method	Quantity	Nominal Dimensions	Description
ASTM C97	5	2.25 in. cubes	Light Grey Natural Limestone Product with Darker Grey Veining
ASTM C170	20 Total Perpendicular, Wet: 5 Perpendicular, Dry: 5 Parallel, Dry: 5 Parallel, Wet: 5	2.25 in. cubes	
ASTM C99	20 Total Perpendicular, Wet: 5 Perpendicular, Dry: 5 Parallel, Dry: 5 Parallel, Wet: 5	4 in. x 8 in. x 2.25 in. thickness	
ASTM C1353	3	4 in. square x 0.375 in. thickness	
ANSI A326.3	3	12 in. square x 1.375 in. thickness	
ASTM C880	20 Total Perpendicular, Wet: 5 Perpendicular, Dry: 5 Parallel, Dry: 5 Parallel, Wet: 5	4 in. x 15 in. x 1.25 in. thickness	
ASTM C666 (ASTM C880)	20 Total <u>Perpendicular:</u> 25 Cycle: 5 50 Cycle: 5 75 Cycle: 5 100 Cycle: 5	4 in. x 15 in. x 1.25 in. thickness	
ASTM C1645	3	9 in. x 9 in. x 2.25 in. thickness	

Test Results

ASTM C97 – Absorption & Density Evaluation

Specimen No.	Measured Mass (g)			Absorption (%)	Bulk Specific Gravity	Density (lbs/ft^3)
	Oven-Dry	48-Hour Wetted	Immersed Suspended			
1	485.92	490.56	304.12	0.95	2.606	162.7
2	513.77	517.85	323.21	0.79	2.640	164.8
3	502.24	506.34	314.72	0.82	2.621	163.6
4	501.67	505.28	314.45	0.72	2.629	164.1
5	491.03	495.62	307.63	0.93	2.612	163.1
Series Average				**0.84**	**2.622**	**164.0**
Standard Deviation				0.10	0.014	0.83
Coefficient of Variation (%)				11.74	0.515	0.50

ASTM C1353 – Abrasion Resistance Evaluation

Specimen No.	Bulk Specific Gravity	Mass (g)			Wear Cycles Completed	Index of Abrasion
		Initial	End	Loss		
1	2.62	226.25	219.89	6.36	1,000	15.2
2		229.02	221.82	7.20		13.4
3		241.10	233.49	7.61		12.7
Series Average						**13.7**
Standard Deviation						1.3
Coefficient of Variation (%)						9.3

ANSI A326.3 - Dynamic Coefficient of Friction

Sawn Finish (Wet Condition)

Specimen No.	Test Orientation				Wet Condition DCOF
	0°	90°	180°	270°	
Wet - 1	0.67	0.68	0.68	0.70	0.68
Wet - 2	0.71	0.70	0.69	0.71	0.70
Wet - 3	0.66	0.68	0.68	0.68	0.68
Series Average					**0.69**
Standard Deviation					0.02
Coefficient of Variation (%)					2.3

ASTM C170 – Compressive Strength Evaluation – Wet Condition, Perpendicular Loading

Specimen No.	Test Condition	Specimen Dimensions (in)		Loading Area (in^2)	Failure Load (lb_f)	Compressive Strength (psi)
		Length	Width			
PP-W-1	Loaded Perpendicular to stone rift plane Wet Condition	2.26	2.25	5.10	40,450	7,930
PP-W-2		2.26	2.24	5.06	54,550	10,780
PP-W-3		2.25	2.26	5.10	42,020	8,240
PP-W-4		2.25	2.24	5.05	46,590	9,230
PP-W-5		2.24	2.24	5.02	46,690	9,300
Series Average						**9,100**
Standard Deviation						1,117
Coefficient of Variation (%)						12.3

ASTM C170 – Compressive Strength Evaluation – Dry Condition, Perpendicular Loading

Specimen No.	Test Condition	Specimen Dimensions (in)		Loading Area (in^2)	Failure Load (lb_f)	Compressive Strength (psi)
		Length	Width			
PP-D-1	Loaded Perpendicular to stone rift plane Dry Condition	2.26	2.24	5.06	52,840	10,440
PP-D-2		2.26	2.25	5.10	41,380	8,110
PP-D-3		2.26	2.26	5.12	41,430	8,090
PP-D-4		2.25	2.27	5.09	50,780	9,980
PP-D-5		2.25	2.26	5.10	52,100	10,220
Series Average						**9,370**
Standard Deviation						1,169
Coefficient of Variation (%)						12.5

ASTM C170 – Compressive Strength Evaluation – Wet Condition, Parallel Loading

Specimen No.	Test Condition	Specimen Dimensions (in)		Loading Area (in^2)	Failure Load (lb_f)	Compressive Strength (psi)
		Length	Width			
LL-W-1	Loaded Parallel to stone rift plane Wet Condition	2.27	2.29	5.20	54,290	10,440
LL-W-2		2.26	2.35	5.31	56,010	10,550
LL-W-3		2.40	2.26	5.41	48,420	8,950
LL-W-4		2.26	2.32	5.26	51,580	9,810
LL-W-5		2.41	2.26	5.44	56,110	10,310
Series Average						**10,010**
Standard Deviation						658
Coefficient of Variation (%)						6.6

ASTM C170 – Compressive Strength Evaluation – Dry Condition, Parallel Loading

Specimen No.	Test Condition	Specimen Dimensions (in)		Loading Area (in^2)	Failure Load (lb_f)	Compressive Strength (psi)
		Length	Width			
LL-D-1	Loaded Parallel to stone rift plane Dry Condition	2.30	2.24	5.14	46,750	9,100
LL-D-2		2.26	2.31	5.22	45,240	8,670
LL-D-3		2.26	2.28	5.16	46,380	8,990
LL-D-4		2.26	2.31	5.21	48,530	9,310
LL-D-5		2.25	2.31	5.20	47,820	9,200
Series Average						**9,050**
Standard Deviation						245
Coefficient of Variation (%)						2.7

ASTM C99 – Modulus of Rupture Evaluation – Wet Condition, Perpendicular Loading

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Modulus of Rupture (psi)
No.	**Test Condition**		**Width**	**Depth**		
PP-W-1	Loaded Perpendicular to stone rift plane Wet Condition	7.0	3.99	2.32	2,682	1,310
PP-W-2			3.98	2.25	3,510	1,830
PP-W-3			4.01	2.28	3,650	1,830
PP-W-4			3.99	2.30	3,177	1,580
PP-W-5			4.00	2.30	3,635	1,800
Series Average						**1,670**
Standard Deviation						227
Coefficient of Variation (%)						13.6

ASTM C99 – Modulus of Rupture Evaluation – Dry Condition, Perpendicular Loading

Specimen No.	Test Conditions	Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Modulus of Rupture (psi)
			Width	**Depth**		
PP-D-1	Loaded Perpendicular to stone rift plane Dry Condition	7.0	4.01	2.27	3,568	1,820
PP-D-2			4.02	2.28	3,485	1,760
PP-D-3			3.98	2.29	2,402	1,210
PP-D-4			4.00	2.28	3,508	1,780
PP-D-5			4.00	2.30	3,524	1,750
Series Average						**1,660**
Standard Deviation						255
Coefficient of Variation (%)						15.4

ASTM C99 – Modulus of Rupture Evaluation – Wet Condition, Parallel Loading

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Modulus of Rupture (psi)
No.	**Test Condition**		**Width**	**Depth**		
LL-W-1	Loaded Parallel to stone rift plane Wet Condition	7.0	4.00	2.21	3,133	1,690
LL-W-2			4.00	2.21	3,235	1,740
LL-W-3			4.00	2.26	3,237	1,670
LL-W-4			4.00	2.25	3,202	1,660
LL-W-5			4.01	2.23	2,984	1,570
Series Average						**1,670**
Standard Deviation						62
Coefficient of Variation (%)						3.7

ASTM C99 – Modulus of Rupture Evaluation – Dry Condition, Parallel Loading

Specimen No.	Test Conditions	Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Modulus of Rupture (psi)
			Width	**Depth**		
LL-D-1	Loaded Parallel to stone rift plane Dry Condition	7.0	4.00	2.14	3,269	1,880
LL-D-2			4.01	2.22	3,228	1,710
LL-D-3			4.00	2.25	2,967	1,530
LL-D-4			4.00	2.14	3,186	1,830
LL-D-5			4.00	2.14	3,011	1,730
Series Average						**1,740**
Standard Deviation						135
Coefficient of Variation (%)						7.8

ASTM C880 – Flexural Strength Evaluation – Wet Condition, Perpendicular Loading

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Flexural Strength (psi)
No.	**Test Condition**		**Width**	**Depth**		
PP-W-1	Loaded Perpendicular to stone rift plane Wet Condition	12.5	4.02	1.28	1,083	1,540
PP-W-2			4.01	1.32	1,090	1,470
PP-W-3			4.00	1.34	970	1,270
PP-W-4			4.00	1.39	1,216	1,470
PP-W-5			4.00	1.36	1,150	1,460
Series Average						**1,440**
Standard Deviation						101
Coefficient of Variation (%)						7.0

ASTM C880 – Flexural Strength Evaluation – Dry Condition, Perpendicular Loading

Specimen No.	Test Conditions	Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Flexural Strength (psi)
			Width	**Depth**		
PP-D-1	Loaded Perpendicular to stone rift plane Dry Condition	12.5	3.99	1.32	1,216	1,640
PP-D-2			4.02	1.30	1,341	1,850
PP-D-3			4.02	1.35	1,256	1,600
PP-D-4			4.00	1.32	1,024	1,370
PP-D-5			4.03	1.33	1,136	1,500
Series Average						**1,590**
Standard Deviation						178
Coefficient of Variation (%)						11.2

ASTM C880 – Flexural Strength Evaluation – Wet Condition, Parallel Loading

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Flexural Strength (psi)
No.	**Test Condition**		**Width**	**Depth**		
LL-W-1	Loaded Parallel to stone rift plane Wet Condition	12.5	4.00	1.35	812	1,040
LL-W-2			4.03	1.35	656	840
LL-W-3			4.00	1.34	650	850
LL-W-4			3.94	1.34	643	850
LL-W-5			4.00	1.33	842	1,110
Series Average						**940**
Standard Deviation						128
Coefficient of Variation (%)						13.6

ASTM C880 – Flexural Strength Evaluation – Dry Condition, Parallel Loading

Specimen No.	Test Conditions	Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Flexural Strength (psi)
			Width	**Depth**		
LL-D-1	Loaded Parallel to stone rift plane Dry Condition	12.5	4.00	1.23	965	1,510
LL-D-2			3.99	1.34	799	1,050
LL-D-3			4.02	1.31	988	1,350
LL-D-4			4.00	1.31	733	1,000
LL-D-5			4.01	1.27	751	1,100
Series Average						**1,200**
Standard Deviation						219
Coefficient of Variation (%)						18.3

ASTM C666 – Post Freeze-Thaw Flexural Strength
Test Condition: Perpendicular Rift, 25-Cycle (Wet)

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lbf)	Flexural Strength (psi)
No.	**Test Condition**		**Width**	**Depth**		
PP-FT25-1	Loaded Perpendicular to stone rift plane Post 25-Cycles Freeze-Thaw Exposure Wet Condition	12.5	4.01	1.38	981	1,200
PP-FT25-2			4.02	1.42	954	1,100
PP-FT25-3			4.01	1.36	782	990
PP-FT25-4			4.00	1.28	1,043	1,490
PP-FT25-5			4.02	1.26	1,038	1,520
Series Average						**1,260**
Standard Deviation						236
Coefficient of Variation (%)						18.7

- ***No 25-cycle specimen showed readily visible signs of degradation post-exposure.***

Post Freeze-Thaw Comparative Flexural Strength Evaluation (25 Cycles C666, Proc. B)

Evaluation Condition		Result (% Change)
Perpendicular stone rift plane	Against Wet Condition Control	-12.5
	Against Preceding Freeze-Thaw Exposure Set	N/A

ASTM C666 – Post Freeze-Thaw Flexural Strength
Test Condition: Perpendicular Rift, 50-Cycle (Wet)

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lbf)	Flexural Strength (psi)
No.	**Test Condition**		**Width**	**Depth**		
PP-FT50-1	Loaded Perpendicular to stone rift plane Post 50-Cycles Freeze-Thaw Exposure Wet Condition	12.5	4.01	1.27	1,080	1,570
PP-FT50-2			4.02	1.28	1,153	1,640
PP-FT50-3			4.00	1.35	930	1,200
PP-FT50-4			4.00	1.34	1,019	1,330
PP-FT50-5			4.01	1.33	987	1,300
Series Average						**1,410**
Standard Deviation						188
Coefficient of Variation (%)						13.3

- ***No 50-cycle specimen showed readily visible signs of degradation post-exposure.***

Post Freeze-Thaw Comparative Flexural Strength Evaluation (50 Cycles C666, Proc. B)

Evaluation Condition		Result (% Change)
Perpendicular stone rift plane	Against Wet Condition Control	-2.1
	Against Preceding Freeze-Thaw Exposure Set	+11.9

ASTM C666 – Post Freeze-Thaw Flexural Strength
Test Condition: Perpendicular Rift, 75-Cycle (Wet)

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lbf)	Flexural Strength (psi)
No.	**Test Condition**		**Width**	**Depth**		
PP-FT75-1	Loaded Perpendicular to stone rift plane Post 75-Cycles Freeze-Thaw Exposure Wet Condition	12.5	4.02	1.33	875	1,160
PP-FT75-2			4.02	1.33	945	1,240
PP-FT75-3			4.04	1.42	942	1,090
PP-FT75-4			4.01	1.36	1,105	1,390
PP-FT75-5			4.02	1.35	884	1,120
Series Average						1,200
Standard Deviation						120
Coefficient of Variation (%)						10.0

- ***No 75-cycle specimen showed readily visible signs of degradation post-exposure.***

Post Freeze-Thaw Comparative Flexural Strength Evaluation (75 Cycles C666, Proc. B)

Evaluation Condition		Result (% Change)
Perpendicular stone rift plane	Against Wet Condition Control	-16.7
	Against Preceding Freeze-Thaw Exposure Set	-14.9

ASTM C666 – Post Freeze-Thaw Flexural Strength
Test Condition: Perpendicular Rift, 100-Cycle (Wet)

Specimen Details		Support Span (in)	Specimen Dimensions (in)		Failure Load (lb_f)	Flexural Strength (psi)
No.	**Test Condition**		**Width**	**Depth**		
PP-FT100-1	Loaded Perpendicular to stone rift plane Post 100-Cycles Freeze-Thaw Exposure Wet Condition	12.5	4.03	1.27	1,184	1,700
PP-FT100-2			4.00	1.33	989	1,310
PP-FT100-3			4.00	1.36	887	1,130
PP-FT100-4			4.00	1.31	1,141	1,560
PP-FT100-5			3.99	1.31	1,154	1,590
Series Average						**1,460**
Standard Deviation						232
Coefficient of Variation (%)						15.9

- ***No 100-cycle specimen showed readily visible signs of degradation post-exposure.***

Post Freeze-Thaw Comparative Flexural Strength Evaluation (100 Cycles C666, Proc. B)

Evaluation Condition		Result (% Change)
Perpendicular stone rift plane	Against Wet Condition Control	+1.4
	Against Preceding Freeze-Thaw Exposure Set	+21.7

ASTM C1645 – Paving Freeze-Thaw Durability

Specimen No.	Specimen Facing Area		Collected Residue Mass (g)			Mass Loss g/m²
	in²	m²	7-Day	28-Day	Total	
1	81	0.0523	0.18	0.64	0.82	15.7
2			0.27	0.31	0.58	11.1
3			0.10	5.56	5.66	108.3
Series Average						**45.0**
Standard Deviation						54.8
Coefficient of Variation (%)						121.8

Specimen No.	Visual Evaluation
1	Light Spalling, No other deleterious effects
2	Light Spalling, No other deleterious effects
3	Light Spalling, No other deleterious effects

Conclusion: The average test results were evaluated against the performance criteria presented in ASTM C568 Table 1, ANSI A326.3, and ASTM C936, Section 5.5. The results of these evaluations are presented in the table(s) below:

ASTM C568 Performance Evaluation Summary				
Physical Requirement	**Test Series Detail**		**Result**	
			Mean Test Value	**Performance Evaluation**
C97 Absorption (%): Class I (Low Density): ≤12.0 Class II (Medium Density): ≤7.5.0 Class III (High Density): ≤3.0			0.84	Meets as Stated: Class III
C97 Density (lbs/ft^3): Class I (Low Density): ≥110 Class II (Medium Density): ≥135 Class III (High Density): ≥160			164.0	Meets as Stated: Class III
C170 Compressive Strength (psi): Class I (Low Density): ≥1,800 Class II (Medium Density): ≥4,000 Class III (High Density): ≥8,000	Perpendicular	Wet	9,100	Meets as Stated: Class III
		Dry	9,370	
	Parallel	Wet	10,010	
		Dry	9,050	
C99 Modulus of Rupture (psi): Class I (Low Density): ≥400 Class II (Medium Density): ≥500 Class III (High Density): ≥1,000	Perpendicular	Wet	1,670	Meets as Stated: Class III
		Dry	1,660	
	Parallel	Wet	1,670	
		Dry	1,740	
C1353 Abrasion Resistance: Class I (Low Density): H_a ≥10 Class II (Medium Density): H_a ≥10 Class III (High Density): H_a ≥10			13.7	Meets as Stated: Class III
C880 Flexural Strength (psi): No Performance Criteria Stated	Perpendicular	Wet	1,440	Design Property Only
		Dry	1,590	
	Parallel	Wet	940	
		Dry	1,200	
C666/C880 Post-Freeze-Thaw Exposure Flexural Strength (psi): No Performance Criteria Stated	Perpendicular (Wet)	25 Cycles	1,260	Design Property Only
		50 Cycles	1,410	
		75 Cycles	1,200	
		100 Cycles	1,460	

ANSI A326.3 Performance Evaluation Summary			
Physical Requirement	**Test Series Detail**	**Result**	
		Mean Test Value	**Performance Evaluation**
ANSI A326.3 - Dynamic Coefficient of Friction (Wet): DCOF ≥0.42	Sawn Finish	0.69	Meets as Stated

ASTM C666 (ASTM C880) Freeze-Thaw Comparative Flexural Strength Evaluation Summary				
Test Series	**Test Condition**	**Series Mean Wet Flexural Strength (psi)**	**Comparative Performance Evaluation (%)**	
			vs. Wet Control	**vs. Preceding Freeze-Thaw Exposure Set**
0 Cycle (Wet)	Perpendicular Wet	1,440	N/A	N/A
25 Cycles (Wet)		1,260	-12.5	N/A
50 Cycles (Wet)		1,410	-2.1	+11.9
75 Cycles (Wet)		1,200	-16.7	-14.9
100 Cycles (Wet)		1,460	+1.4	+21.7

ASTM C936 (ASTM C1645) Performance Evaluation Summary			
Physical Requirement	**Mass Loss Result**		**Post-Exposure Specimen Condition**
	Mean Test Value (g/m^2)	**ASTM C936 Performance Evaluation**	
<u>ASTM C1645 – Freeze-Thaw Durability:</u> After 28 cycles, total mass loss shall be equal to or less than 225g/m^2	45.0	Meets as Stated	Light Surface Spalling

ASTM C568 – Limestone Properties Evaluation

The Black Pearl limestone product satisfied the ASTM C568 performance requirements for a Class III (High-Density) Limestone product for Absorption, Density, Compressive Strength, Modulus of Rupture, and Abrasion Resistance.

There are no ASTM C568 performance criteria for ASTM C880 Flexural Strength, so these values are reported as a design property only.

ANSI A325.3 Evaluation

The Black Pearl limestone product (sawn finish) satisfied the ANSI A326.3 recommended minimum performance criteria of 0.42 DCOF for wet condition (Mean Wet Condition DCOF: 0.69).

ASTM C666 – Freeze-Thaw Durability Evaluation (Cladding Application)

No post-exposure freeze-thaw specimen showed readily visible signs of degradation post-exposure. While incremental post-exposure flexural strength values varied, the mean documented strength change between control series and post-100 exposure cycles was +1.4%. As such, the range of values observed are more likely due to variations within the specimens themselves rather than any freeze-thaw induced strength degradation.

ASTM C1645 (ASTM C936) – Freeze-Thaw Durability Evaluation (Paving Application)

The Black Pearl Limestone product satisfied the minimum mass loss requirement presented in ASTM C936 for freeze-thaw durability but expressed light spalling post exposure completion. The specimens showed no other signs of degradation (cracking, color shift, or other deleterious effects) post exposure.

It has been our pleasure to provide this product testing service for your project. Please do not hesitate to contact us if you have any questions or require additional information. Contact information is listed below.

Respectfully submitted,

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Revision Log

No.	Date	Page(s)	Description
0	05/01/24	N/A	Initial report release
1	05/30/24	3-4, 13-20, 25, 28	Inclusion of ASTM C666 and ASTM C1645 Freeze-Thaw Durability Testing Results

Document Control Number: *NSICD 00001-R0*

Photographs

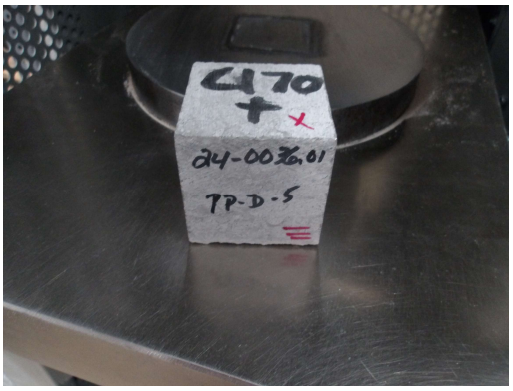

Photo No. 1
ASTM C170 – Representative Pretest Condition Specimen

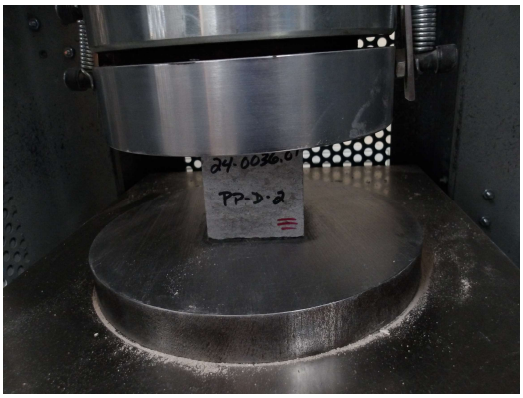

Photo No. 2
ASTM C170 – Test Setup

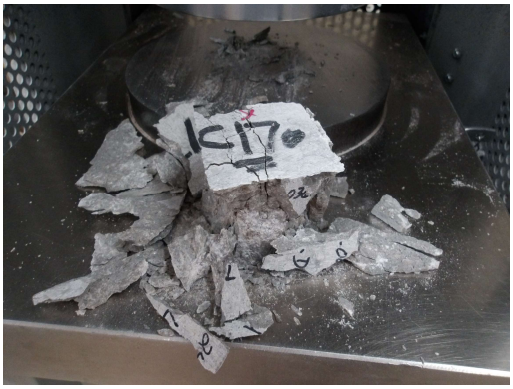

Photo No. 3
ASTM C170 – Specimen Failure Mode: Loading Parallel to Rift
(Dry Condition)

Photo No. 4
ASTM C170 – Specimen Failure Mode: Loading Perpendicular to Rift
(Wet Condition)

Photo No. 5
ASTM C97 – Absorption & Density Test Setup

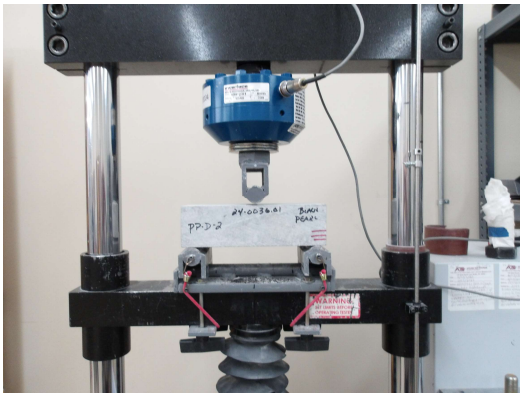

Photo No. 6
ASTM C99 – Modulus of Rupture Test Setup

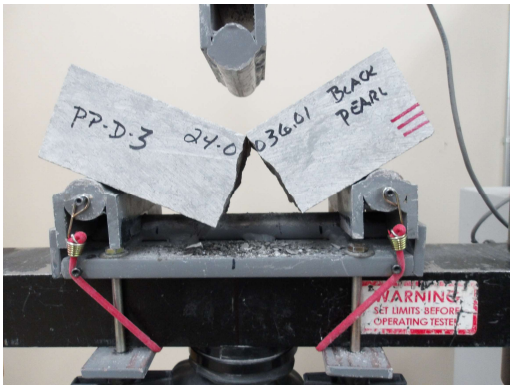

Photo No. 7
ASTM C99 – Specimen Failure Mode: Loading Perpendicular to Rift (Dry Condition)

Photo No. 8
ASTM C99 – Specimen Failure Mode: Loading Parallel to Rift (Wet Condition)

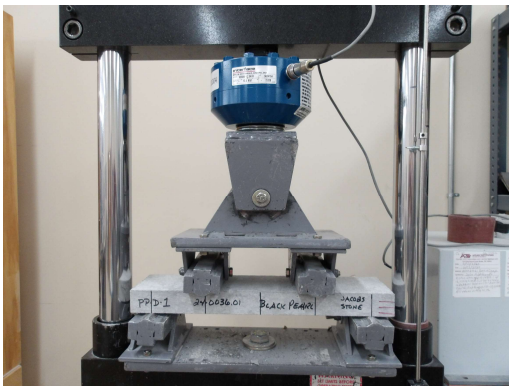

Photo No. 9
ASTM C880 – Flexural Strength Test Setup

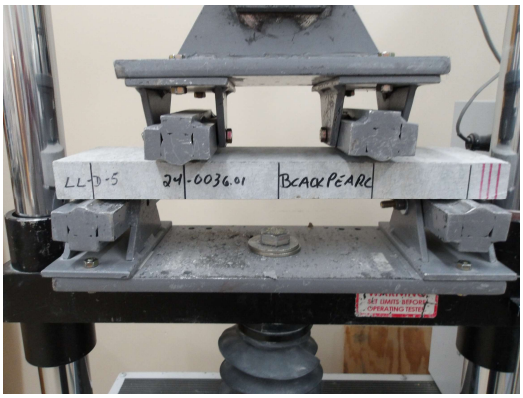

Photo No. 10
ASTM C880 – Specimen Loading Detail

Photo No. 11
ASTM C880 – Specimen Failure Mode:
Loading Perpendicular to Rift
(Wet Condition)

Photo No. 12
ASTM C880 – Specimen Failure Mode:
Loading Parallel to Rift
(Dry Condition)

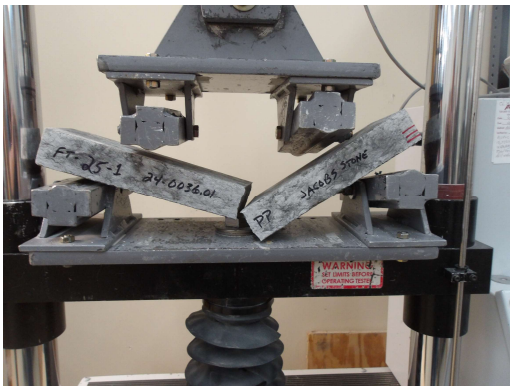

Photo No. 13
ASTM C666 (C880) - Failure Mode:
Representative 25-Cycle Specimen
(Perpendicular, Wet Condition)

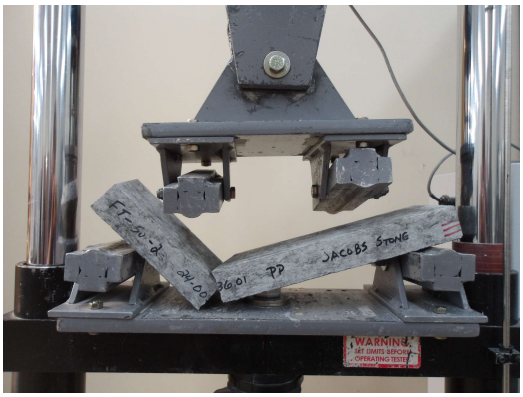

Photo No. 14
ASTM C666 (C880) - Failure Mode:
Representative 50-Cycle Specimen
(Perpendicular, Wet Condition)

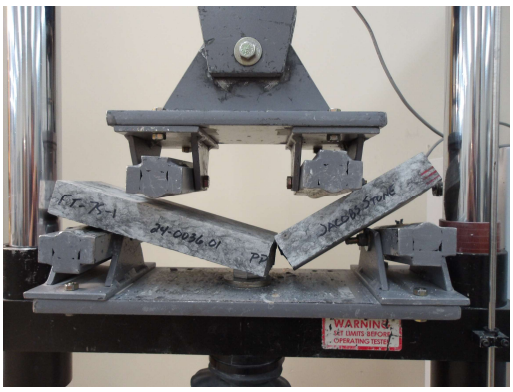

Photo No. 15
ASTM C666 (C880) - Failure Mode:
Representative 75-Cycle Specimen
(Perpendicular, Wet Condition)

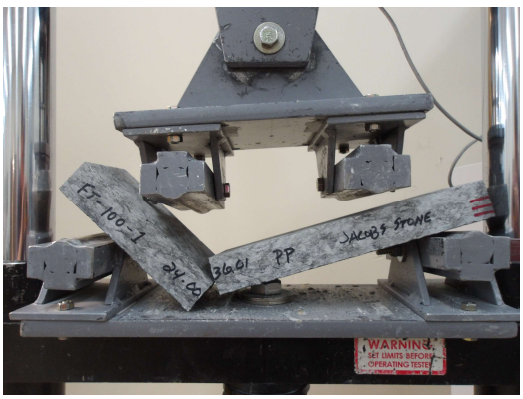

Photo No. 16
ASTM C666 (C880) - Failure Mode:
Representative 100-Cycle Specimen
(Perpendicular, Wet Condition)

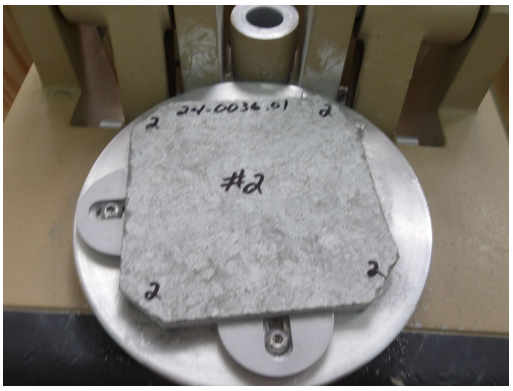

Photo No. 17
ASTM C1353 – Representative Pretest Specimen Condition

Photo No. 18
ASTM C1353 – Abrasion Test Setup

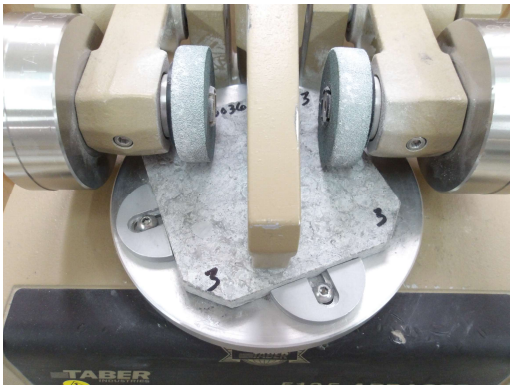

Photo No. 19
ASTM C1353 – Test in Progress

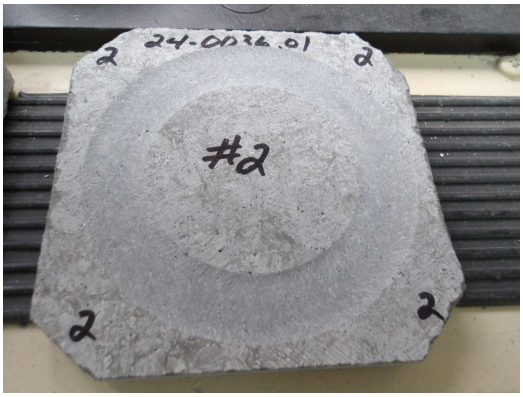

Photo No. 20
ASTM C1353 – Representative Post-Abrasion Specimen Condition

Photo No. 21
BOT 3000E Test Apparatus

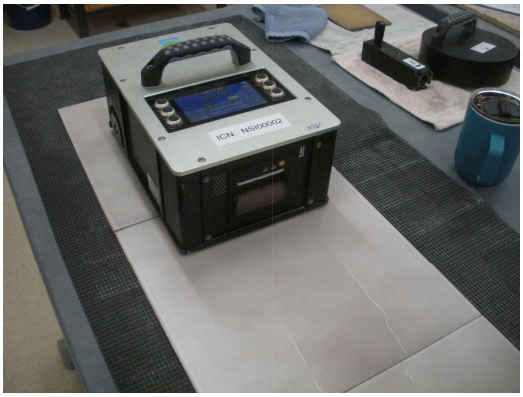

Photo No. 22
ANSI A326.3 – DCOF Evaluation
BOT 3000E Pretest Unit Calibration

Photo No. 23
Black Pearl Limestone Surface Detail
(Sawn Finish)

Photo No. 24
ANSI A326.3 - Test Set Up

Photo No. 25
ASTM C1645 – Post-Exposure Condition Freeze-Thaw Durability Specimens

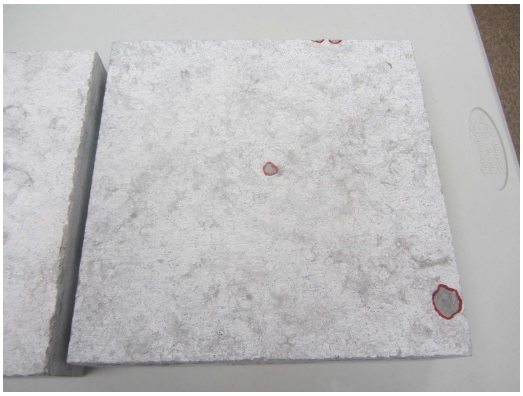

Photo No. 26
ASTM C1645 – Specimen No. 3 Exterior Facing (Maximum Top Face Spalling Specimen Condition Observed)

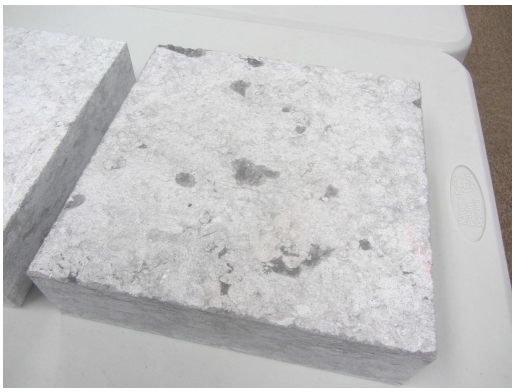

Photo No. 27
ASTM C1645 – Specimen No. 3 Underside Facing (Maximum Rear Face Spalling Specimen Condition Observed)

Photo No. 28
ASTM C1645 – Comparative Post-Exposure Specimen Condition (Unexposed Control Depicted Top, Post-Exposure Depicted Bottom Left and Right)