

27 July 2006

Allstone Pty Ltd
207-211 Devonport Terrace
PROSPECT SA 5082

Attention: Mr. Peter Wood

EVALUATION OF ALLSTONE BASALT (DAWN GREY)

CLIENT REFERENCE

Fax Dated 7 July 2006

OUR REFERENCE

ALL0706-1

INVESTIGATING OFFICER

James P. Mann & Graham Baggs



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1. INTRODUCTION

A request was received from the client to carry out a series of tests on supplied samples of *Allstone Basalt (Dawn Grey)* that were considered representative of general supply material.

2. TEST PROGRAM

The appropriate specimens were prepared by Stone Initiatives from the supplied samples and the following test work was undertaken:

- Water Absorption
- Bulk Specific Gravity
- Flexural Strength
- Modulus of Rupture
- Compressive Strength
- Resistance to Salt Attack (Durability)
- Abrasion Resistance
- Slip Resistance

Bulk specific gravity and water absorption were determined in accordance with ASTM C97-02 "Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone". The specimens had been dried at $60 \pm 2^\circ\text{C}$ for 48 hours followed by soaking at $22 \pm 2^\circ\text{C}$ for a further 48 hours.

The flexural strength of each specimen was determined in accordance with ASTM C880-98 "Standard Test Method for Flexural Strength of Dimension Stone. The dry specimens had been dried at $60 \pm 2^\circ\text{C}$ for 48 hours prior to testing. The soaked specimens had been immersed in water for 48 hours at $22 \pm 2^\circ\text{C}$.

The modulus of rupture of each specimen was determined in accordance with ASTM C99-87 (2006) "Standard Test Method for Modulus of Rupture of Dimension Stone. The dry specimens had been dried at $60 \pm 2^\circ\text{C}$ for 48 hours prior to testing. The soaked specimens had been immersed in water for 48 hours at $22 \pm 2^\circ\text{C}$.

Compressive strength was determined in accordance with ASTM C170-90 (1999) "Standard Test Method for Compressive Strength of Dimension Stone". The dry specimens had been dried at $60 \pm 2^\circ\text{C}$ for 48 hours prior to testing. The soaked specimens had been immersed in water for 48 hours at $22 \pm 2^\circ\text{C}$.

Resistance to salt attack was determined according to Method A of AS/NZS 4456.10:2003 "Masonry Units and Segmental Pavers- Methods of Test - Method 10: Determining Resistance to Salt Attack". This involved subjecting the specimens to 15 cycles of soaking in a 6.2% sodium sulphate solution for a period of 2 hours followed by overnight drying at 65°C . On completion of the cycling the weight loss was determined by filtering the residue collected.

Index of Abrasion Resistance was determined in accordance with ASTM C1353-98 "Test Method for Abrasion Resistance of Dimension Stone by the Taber Abraser". Three representative specimens were subjected to 1000 cycles using H-22 wheels with a 1kg load.

Slip resistance was determined in a wet condition on specimens with a 'Spring Rain' finish in accordance with Appendix A of AS/NZS 4586:2004 "Slip resistance classification of new pedestrian surface materials". Testing was carried out at five sites using a British Pendulum fitted with a 4S rubber slider.

3. RESULTS

Results are summarised in the table below and compared with typical results for Victorian Bluestone (basalt); full test data are detailed in Appendix A of this report.

Property	Allstone Basalt (Dawn Grey)	Typical Victorian Bluestone ¹
Bulk Specific Gravity (kg.m ⁻³)	2710	2580 - 2650
Water Absorption (mean)		
% by weight	0.44	1.2 – 2.0
% by volume	1.19	-
Flexural Strength (MPa)		
- Dried Strength	23.7	18 - 20
- Soaked Strength	23.5	17 - 19
Modulus of Rupture (MPa)		
- Dried Strength	25.8	Not known
- Soaked Strength	27.7	Not known
Compressive Strength (MPa)		
- Dried Strength	218.7	100 - 130
- Soaked Strength	223.9	80 - 110
Abrasion Resistance		
- Abrasion Index (Ha)	59	24 – 28
- Use category	All uses	-
Resistance to Salt Attack		
- Weight Loss (%)	0.04	Not known
- Classification	AA	-
Slip Resistance (Spring Rain)		
- BPN (mean)	48	Not known
- Classification	W	-
- Risk of Slipping When Wet	Low	-

¹ Typical range of material currently produced from Victorian bluestone (basalt) and available on the market.

4. DISCUSSION

4.1 Water Absorption / Bulk Specific Gravity

The mean water absorption of the Allstone Basalt was determined to be 0.44% by weight; this result is much lower than that for Victorian Bluestone (basalt) typically available in Australia. The water absorption is very low and would be considered suitable for use as residential and commercial paving and external façade cladding. A low water absorption greatly assists in reducing the establishment of biological growths such as moss as well as reducing the risk of staining.

The mean bulk specific gravity of 2710 kg/metre³ is an indication of high strength and durability.

4.2 Flexural Strength

The mean flexural strength was determined to be 23.7 MPa in a dried condition and 23.5 MPa after soaking. The results show the stone is stronger than traditional Victorian Bluestone and is considered suitable for use as paving and external cladding².

4.3 Modulus of Rupture

The mean modulus of rupture was determined to be 25.8 MPa in a dried condition and 27.7 MPa after soaking. The slight increase in strength when soaked is usually an indication that the stone is fresh and does not contain a significant level of alteration minerals.

The modulus of rupture data can be used to determine the minimum breaking load of the stone when used as segmental pavers. If it is assumed that the minimum flexural strength of the stone is 25 MPa, then the minimum breaking load for the following paver sizes can be approximated.

Length (mm)	Width (mm)	Thickness (mm)	Breaking Load (kg)
600	600	30	1670
600	150	30	417
600	300	60	3340
600	150	60	1670

Standard AS/NZS 4455 recommends a minimum breaking load of 2 kN (204 kg) for segmental pavers to be used in residential pedestrian locations and 5 kN (510 kg) for pavers to be used in residential vehicular locations. All paver sizes quoted above comply with the recommendation for residential pedestrian pavers. The 60mm thick units comply with the recommendation for pavers subjected to residential vehicular loads. It is recommended that the actual breaking load of the segmental pavers³ be confirmed by physical testing.

The standard does not give recommendations for segmental pavers in commercial locations, but the 60mm thick pavers are likely to be suitable for vehicular traffic in most commercial and public locations.

4.4 Compressive Strength

The mean compressive strength was determined to be 218.7 MPa in a dried condition and 223.9 MPa after soaking. As for the other strength tests, the Allstone Basalt has a strength that is significantly higher than typical Victorian bluestone.

² Given that standard engineering practices for determining unit size and installation method are adopted.

³ Test method AS/NZS 4456.5 "Determining the breaking load of segmental pavers and flags"

4.5 Abrasion Resistance

Allstone Basalt was found to have a mean Abrasion Index of 59; the stone is considered to have a 'high' abrasion resistance and is considered suitable for all uses including high traffic commercial flooring situations.

4.6 Resistance to Salt Attack (Durability)

The mean weight loss was determined to be 0.04% by weight. This weight loss gives the stone an AA⁴ Grade durability classification that would normally be considered suitable for locations that may be exposed to frequent wetting and drying or significant exposure to salt attack such as pool surrounds. The stone would be worthy of consideration for commercial projects as they usually specify a maximum weight loss of 1.0 %.

The mode of decay was classified as *very slight surface pitting*, which indicates that the stone did not undergo any significant structural change, with no detectable crumbling of corners or arrises.

4.7 Slip Resistance

The samples of *Allstone Basalt* tested with a *Spring Rain* finish have a mean BPN of 48 using the 4S slider and therefore achieves a "W" classification (BPN range 45-54). Table 2 of the standard states the contribution of the stone surface to the risk of slipping when wet is considered LOW.

According to Table 3 of the Australian Standards HB 197:99 this surface finish is suitable for selection for locations that include:

- External colonnade, walkways and pedestrian crossings
- Undercover concourse areas
- Swimming pool surrounds and communal shower rooms
- Accessible internal stair nosings (wet) – handrails present
- External stair nosings

⁴ An internal Stone Initiatives classification designating sandstone with a high resistance to salt attack.

Appendix A

Test Data

(7 pages)



ABSORPTION & BULK SPECIFIC GRAVITY OF DIMENSION STONE

TEST CERTIFICATE

TEST METHOD: ASTM C97-02
 TEST DATE: 7 - 13 July 2006
 CLIENT: Allstone Pty Ltd
 OUR REF : ALL0706-1

SAMPLE: Allstone Bluestone (Dawn Grey) (O1)
 QUARRY LOCATION: Not known
 SAMPLING LOCATION: Not known SAMPLING DATE: Jul-06

SPECIMEN SIZE: 50x 50 x50 mm
 SPECIMEN PREPARATION METHOD: Diamond sawn

Test Number	Specimen Identification	Dried Mass (g)	Soaked Mass (g)	Suspended Mass (g)	Bulk Specific Gravity (kg.m-3)	% Absorption by Volume	% Absorption by Weight
W0744	O1/33	384.37	386.99	250.06	2807	1.91	0.68
W0045	O1/34	380.76	383.76	244.28	2730	2.15	0.79
W0746	O1/35	366.30	369.00	237.53	2786	2.05	0.74
W0747	O1/36	371.46	375.34	236.85	2682	2.80	1.04
W0748	O1/37	372.22	374.81	238.83	2737	1.90	0.70
AVERAGE:					2749	2.16	0.79

COMMENTS (Including variations to procedure): Nil

Testing Officer: J. Mann

Approved Signatory:

Date: 13-Jul-06

Name: James P. Mann

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FLEXURAL STRENGTH OF DIMENSION STONE TEST CERTIFICATE

TEST METHOD: ASTM C880-98
 TEST DATE: 14-Feb-06
 CLIENT: Allstone Pty Ltd
 OUR REF : ALL0706-1

SAMPLE: Allstone Bluestone (Dawn Grey) (O1)
 QUARRY LOCATION: Not known
 SAMPLING LOCATION: Not known SAMPLING DATE: Jul-06

SPECIMEN SIZE: 102 x 400 x 30 mm (nominal)
 SPECIMEN PREPARATION METHOD: Sawn
 LOADING ORIENTATION: Not known

CONDITION: Dried for 48hrs @ 60deg C. FINISH IN TENSION: Honed

Test Number	Specimen Identification	Span (mm)	Width (mm)	Thick (mm)	Load (N)	Dried Strength (MPa)
F0860	O1/1	300	103.5	28.8	9058	23.8
F0861	O1/2	300	103.4	30.3	10689	25.4
F0862	O1/3	300	103.7	30.6	8878	20.6
F0863	O1/4	300	104.9	31.1	11785	26.2
F0864	O1/5	300	103.7	30.6	9725	22.6
Mean						23.7
Standard Deviation						2.3

CONDITION: Soaked for 48hrs @ 19deg C. FINISH IN TENSION: Honed

Test Number	Specimen Identification	Span (mm)	Width (mm)	Thick (mm)	Load (N)	Soaked Strength (MPa)
F0865	O1/6	300	102.4	31.3	10726	24.1
F0866	O1/7	300	104.1	31.3	9925	22.0
F0867	O1/8	300	103.9	30.4	10754	25.2
F0868	O1/9	300	105.2	31.1	11139	24.7
F0869	O1/10	300	103.5	31.0	9451	21.4
Mean						23.5
Standard Deviation						1.7

Soaked to Dried Strength Ratio: 0.99

Remarks: Nil

Tested by: G. Baggs

Approved Signatory:

Date: 15-Feb-06

Name: James P. Mann



MODULUS OF RUPTURE OF DIMENSION STONE

TEST CERTIFICATE

TEST METHOD: ASTM C99-87 (2000)
TEST DATE: 14-Jul-04
CLIENT: Allstone Pty Ltd
OUR REF : ALL0706-1

SAMPLE: Allstone Bluestone (Dawn Grey) (O1)
QUARRY LOCATION: Not known
SAMPLING LOCATION: Not known SAMPLING DATE: Jul-06

SPECIMEN SIZE: 102 x 203 x 57 mm nominal
SPECIMEN PREPARATION METHOD: Diamond sawn
LOADING ORIENTATION: Not known

CONDITION: Dried for 48hrs @ 60deg C. FINISH IN TENSION: Honed

Test Number	Specimen Identification	Span (mm)	Width (mm)	Thick (mm)	Load (N)	Strength (MPa)
M0347	O1/21	178	102.8	60.6	35206	24.9
M0348	O1/22	178	102.9	61.8	35772	24.3
M0349	O1/23	178	102.5	60.6	43678	31.0
M0350	O1/24	178	104.0	61.8	36506	24.6
M0351	O1/25	178	101.9	61.2	34705	24.3

AVERAGE: 25.8

CONDITION: Soaked FINISH IN TENSION: Honed

Test Number	Specimen Identification	Span (mm)	Width (mm)	Thick (mm)	Load (N)	Strength (MPa)
M0352	O1/26	178	103.9	60.8	40160	28.0
M0353	O1/27	178	103.1	60.7	38998	27.4
M0354	O1/28	178	101.7	61.6	40272	27.9
M0355	O1/29	178	104.1	61.9	37751	25.3
M0356	O1/30	178	103.8	60.7	43043	30.0

AVERAGE: 27.7

COMMENTS / VARIATIONS: Modified specimen thickness.

TESTED BY: J. Mann

Approved Signatory:

Name: James P Mann

Date: 14-Jul-04



COMPRESSIVE STRENGTH OF DIMENSION STONE

TEST CERTIFICATE

TEST METHOD: ASTM C170-90 (1999)

TEST DATE: 25-Jul-06

CLIENT: Allstone Pty Ltd

OUR REF : ALL0706-1

SAMPLE: Allstone Bluestone (Dawn Grey) (O1)

QUARRY LOCATION: Not known

SAMPLING LOCATION: Not known

SAMPLING DATE: Jul-06

SPECIMEN PREPARATION METHOD: Diamond sawn

LOADING ORIENTATION: Unknown

Test Number	Specimen Identification	Test Condition	Width 1 (mm)	Width 2 (mm)	Max. Load (Newtons)	Height Adjusted Compressive Strength (MPa)
C1200	O1/11	Dried	40.4	42.7	323682	202.6
C1201	O1/12	Dried	43.1	42.5	376048	220.0
C1202	O1/13	Dried	42.8	42.6	381694	224.3
C1203	O1/14	Dried	42.5	42.7	369319	218.3
C1204	O1/15	Dried	42.2	42.7	383094	228.3
Mean Compressive Strength (dried):						218.7

Test Number	Specimen Identification	Test Condition	Width 1 (mm)	Width 2 (mm)	Max. Load (Newtons)	Height Adjusted Compressive Strength (MPa)
C1205	O1/16	Soaked	43.0	43.3	314234	180.4
C1206	O1/17	Soaked	43.6	45.6	464412	247.6
C1207	O1/18	Soaked	45.8	42.3	481444	264.2
C1208	O1/19	Soaked	41.7	42.4	343823	209.3
C1209	O1/20	Soaked	42.6	42.8	369697	217.9
Mean Compressive Strength (soaked):						223.9

COMMENTS / VARIATIONS: Modified Size

TESTED BY: G.Baggs

Approved Signatory:

Name: James P Mann

Date: 27-Jul-06



ABRASION RESISTANCE OF DIMENSION STONE

TEST CERTIFICATE

TEST METHOD: ASTM C1353-98
 TEST DATE: 14-Jul-06
 CLIENT: Allstone Pty Ltd
 OUR REF: ALL0706-1

SAMPLE: Allstone Bluestone (Dawn Grey) (O1)
 SAMPLING DATE: Jul-06
 QUARRY LOCATION: Not known
 SAMPLING LOCATION: Not known

SPECIMEN PREPARATION METHOD: Sawn finish
 RELATIVE HUMIDITY: 50 % RH

BULK SPECIFIC GRAVITY: 2.75

Test Number	Specimen Identification	Total Cycles	Initial mass (g)	Final mass (g)	Weight loss (g)	Index of Abrasion Resistance
A0243	O1/44	1000	306.56	304.80	1.76	57.4
A0244	O1/45	1000	308.14	306.47	1.67	60.5
A0245	O1/46	1000	321.11	319.41	1.70	59.4

AVERAGE: Index of Abrasion Resistance: 59

COMMENTS (Including variations to procedure): nil

Testing Officer: J. Mann

Approved Signatory:

Date: 14-Jul-06

Name: James P. Mann



RESISTANCE TO SALT ATTACK OF DIMENSION STONE TEST CERTIFICATE

TEST: Determining Resistance to Salt Attack
TEST METHOD: AS/NZS4456.10-2003 Method A
TEST DATE: 8 - 26 July 2006
CLIENT: Allstone Pty Ltd
OUR REF : ALL0706-1

SAMPLE: Allstone Bluestone (Dawn Grey) (O1)
QUARRY LOCATION: Not Known
SAMPLING LOCATION: Not known
SAMPLING DATE: Jul-06

SPECIMEN PREPARATION METHOD: Diamond sawn

SOLUTION USED: 6.2% sodium sulphate

Test No.	Specimen	Initial Mass (grams)	Filtered Residue (grams)	Loss after 15 cycles (%)	Mode of Decay
X0246	O1/19	378.46	0.1	0.03	VSL SP
X0247	O1/20	373.38	0.2	0.05	VSL SP
X0248	O1/21	375.09	0.14	0.04	VSL SP
Mean				0.04	

Key to Mode of Decay

Degree	Type
VSL= Very Slight	SP= Surface pitting
SL= Slight	CE= Crumbling of edges
MD= Moderate	CR= Cracking
SV= Severe	DL= Delamination
	EX= Exfoliation

Comments/Compliance/Variations: Nil

Approved Signatory:

Date: 27-Jul-06

Name: James P. Mann



SLIP RESISTANCE DETERMINATION

TEST SPECIFICATION: AS/NZS 4586:2004 Appendix A

CLIENT: Allstone Pty Ltd

REPORT NO.: ALL0706-1

TEST DATE: 9 July 2006

TEST SITE: Stone Initiatives laboratory

TEST TYPE: UNFIXED

SURFACE AND TYPE: Allstone Basalt (Dawn Grey) – *Spring Rain* finish

SURFACE PREPARATION PRIOR TO TEST: Washed with potable water and cloth

AIR TEMPERATURE: 16.4°C

WEATHER (if appropriate): -

COEFFICIENT OF FRICTION (WET)

RUBBER SLIDER TYPE: 4S (Expiry July 2006)			
TEST NO.	ORIENTATION	BPN READINGS	MEAN ¹
SL716	Parallel to ribs	55, 52, 49, 47, 47, 47	47
SL717	Perpendicular to ribs	55, 55, 53, 52, 52	52
SL718	Diagonal to ribs	55, 53, 50, 48, 47, 47	47
SL719	Parallel to ribs	55, 53, 50, 49, 48, 48, 48	48
SL720	Perpendicular to ribs	50, 49, 48, 47, 46, 46, 46	46
MEAN BRITISH PENDULUM NUMBER (wet)			48
SLIP RESISTANCE CLASSIFICATION			W

COMMENT: The specimens of honed Allstone Basalt (Grey Dawn) tested with a *Spring Rain* finish using the 4S slider type have a mean BPN of 48 and therefore achieve a "W" classification (BPN >45). Table 2 of the standard states the contribution of the stone surface to the risk of slipping when wet is **Low**.

TESTED BY: J. Mann

CERTIFIED BY:

James P. Mann

¹ Readings in *italics* not included in mean