MEMORANDUM

TO W. Fletcher
Manager, Heritage Services

CC P. Wilkins, Programs Group
Dr. B.J. Franklin

DATE 22 October, 1998

FROM J.F. Young
Geotechnical Engineering

SUBJECT BUNDANOON SANDSTONE
LABORATORY TEST RESULTS

OUR REF Report No 98-GD52A

McKell Building
2-24 Rawson Place
Sydney NSW 2000

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

Telephone 02 9372 7873
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1. INTRODUCTION

At your request, the Geotechnical Engineering Group has undertaken a laboratory testing program on a sandstone sample supplied by Bundanoon Quarry. It is understood that the sample is representative of the current quarry production. The aim of the testing program was to determine the engineering properties of the sandstone. In addition to the normal suite of laboratory testing a number of cubes, designated A, B and C were submitted which had been treated with a sealing agent. The cubes were to be specifically tested for durability.

The samples are described as:

- Bundanoon, Sample No S27 (BF98/41). The sample is 'untreated' and represents typical quarry production.
- Bundanoon, Sample Nos S27A, S27B and S27C. Treated cubes supplied by Bundanoon Quarry.

The results of the laboratory testing program are presented in this report, together with petrographic analysis of the sandstone (S27) by Dr. BJ Franklin (presented in **Appendix C**).

2. TESTING UNDERTAKEN

The following tests were completed on the quarry block designated S27:

- Water absorption, apparent porosity and bulk density
- Unconfined compressive strength
- Modulus of rupture
- Sodium sulphate soundness

In addition, the treated cubes (S27A, S27B and S27C) were subjected to sodium sulphate soundness testing. Water absorption, apparent porosity and bulk density were also determined for Sample S27C.

3. TESTING STANDARDS

Testing was carried out in accordance with the following standards:

- Draft Australian Standard; Methods for Sampling and Testing Aggregates, Water Absorption, Apparent Porosity and Bulk Density of Building Stone (CE/12/6/4/83-20, dated November 1983).
- Draft Standard AS3542; Methods for Sampling and Testing Building Stone as follows:
  - AS3542.3-Sodium Sulphate Soundness Test (CE/12/88-17, dated July 1988)
  - AS3542.5-Compressive Strength (CE/12/88-6, dated February 1988)
  - AS3542.6-Modulus of Rupture (CE/12/88-5, dated February 1988)

All testing was carried out at the Department's Geotechnical Centre, Ultimo.

4. LABORATORY TEST RESULTS

Reference is made to the petrographic analysis prepared by Dr. B.J. Franklin. The descriptions and comments are available in **Appendix C**, and should be read in conjunction with this laboratory test result section.

Test results are available in **Appendix A and B**, and a summary is presented in **Tables 1 and 2.** Comparative results from other dimension sandstone testing programs undertaken by the Geotechnical Centre are presented in **Appendix D.** In particular, the previously tested Bundanoon sandstone sample S21 should be noted (previous test results are reproduced in **Table 1**).

Water absorption (4.79%) and apparent porosity (10.65%) are regarded as marginally high for a fresh Sydney (Basin) sandstone.

A dry compressive strength of 45.4MPa was achieved, and a wet strength of 22MPa. The results are considered marginal. Minimum compressive strengths of 50MPa (dry) and 25MPa (wet) provide a reasonable bench mark for the use of Sydney Basin sandstones as dimension stone.

The dry modulus of rupture strength of 7.2MPa is considered acceptible; however, the wet strength of 2.2MPa is low (3MPa is often taken as a minimum acceptible wet modulus of rupture strength).

A comparison with the previously tested Bundanoon sandstone sample S21 is presented in **Table 1.** For the current sample (S27) porosity and water absorption are marginally higher, and wet strengths lower, particularly the modulus of rupture.

The sample (S27) failed the sodium sulphate soundness test. Two test cubes (S27/1 and S27/2) disintegrated after 11cycles (refer to **Plate 7**), and the third (S27/3) disintegrated after 14 cycles (refer to **Plate 8**). Significant loss of the cube edges and corners was observed after 4 cycles of emersion and drying (refer to **Plate 3**).

Three (3) sets of cubes treated with an unknown agent, designated S27A, S27B and S27C, were supplied by Bundanoon Quarry for additional sodium sulphate soundness testing. All three (3) samples were essentially unaffected and recorded a 0% loss after 15 cycles of emersion and drying (refer to **Plates 9 to 11**). A summary of the test results is presented in **Table 2**. Comparison of the test cubes to the untreated sample S27 after 4 cycles is shown in **Plates 4 to 6.** The sodium sulphate test solutions used for the treated cubes remained clear throughout the test (refer to **Plates 1 and 2**).

The treated sample S27C recorded an apparent porosity of 1.01% and a water absorption of 0.46%. The treating agent effectively sealed the test cubes. It should be noted that some discolouration (bleaching) was observed on the corners of the cubes towards the end of the program of cycles, suggesting that the sealing agent was beginning to breakdown.

5. COMMENTS

The Bundanoon sandstone sample S27 failed the sodium sulphate soundness test and had marginal results for the compressive strength and modulus of rupture. The sandstone is not regarded as suitable for use as a dimension stone; however, it would be suitable for landscape applications.

The treated cubes (S27A, S27B and S27C) were found to be effectively sealed by the application of an unknown agent* and consequently did not incur any mass loss during the sodium sulphate soundness test. The test was run for the standard 15 cycles at which time some bleaching of the test cube corners had occurred. It may be of interest to continue the cycles until the cube corners/edges show signs of failure.

* Dry-Treat 40SK (see enclosed letter 21.5.01)
SA

John Young.

J.F. Young
Senior Geologist

TABLE 1

Summary of Test Results

Test Type	Test Results	
	Sample S27 Bundanoon	Sample S21* Bundanoon
• Water absorption	4.79%	3.6%
• Apparent porosity	10.65%	8.5%
• Bulk density		
Dry	2.22 t/m³	2.34 t/m³
Wet	2.33 t/m³	2.42 t/m³
• Compressive Strength		
Dry	45.4 MPa	52 MPa
Wet	20.9 MPa	22 MPa
Ratio	0.460	0.414
• Modulus of rupture		
Dry	7.2 MPa	8 MPa
Wet	2.3 MPa	4 MPa
Ratio	0.322	0.523
• Sodium sulphate soundness	Disintegrated 11^{th} to 14^{th} cycle	15.2%

* **DPWS sample, tested December 1997.**

TABLE 2

Summary of Sodium Sulphate Soundness Test Results

TEST TYPE	TEST RESULTS			
	Sample S27 (untreated)	**Sample S27A (treated)**	**Sample S27B (treated)**	**Sample S27C (treated)**
Water absorption	4.79%	N/A	N/A	0.46%
Apparent porosity	10.65%	N/A	N/A	1.01%
Bulk density				
-Dry	2.22 t/m³	N/A	N/A	2.23 t/m³
-Wet	2.33 t/m³	N/A	N/A	2.24 t/m³
Sodium sulphate soundness	Disint. 11th to 14th cycle	0%	0%	0%

APPENDIX B

Laboratory Test Results

Treated Bundanoon Sandstone Cubes

Samples S27A, S27B and S27C

Geotechnical Centre, Ultimo

Bundanoon Sandstone P/L

MANUFACTURERS & SUPPLIERS OF
QUALITY SAWN & DRESSED SANDSTONE
ACN 004 007 989

Quarry Road, Bundanoon
P.O. Box 52 NSW 2578
Ph (02) 4883 6179 Fax (02) 4883 6075

Sydney Sales Centre:
Cnr. Parramatta Road &
George Street, Granville NSW 2142
Ph (02) 9637 2300 Fax (02) 9637 2330

FACSIMILE TRANSMISSION

TO: DRY TREAT AUST P/L FAX No.: 9953 2160

ATTENTION: AMANDA JOHNSON DATE: 21. 5. 01

FROM: JOHN PARKES TIME: 2.00 pm

REFERENCE: PUBLIC WORKS TEST RESULTS PAGES TO FOLLOW: 1

MESSAGE:

THESE TEST RESULTS HAVE BEEN FAXED TO YOU. THE DRY TREAT PRODUCT USED TO SEAL THE STONE ON WHICH THE TESTS WERE CARRIED OUT WAS "KOSK" & THE RESULTS SPEAK FOR THEMSELF.

KIND REGARDS

JOHN.

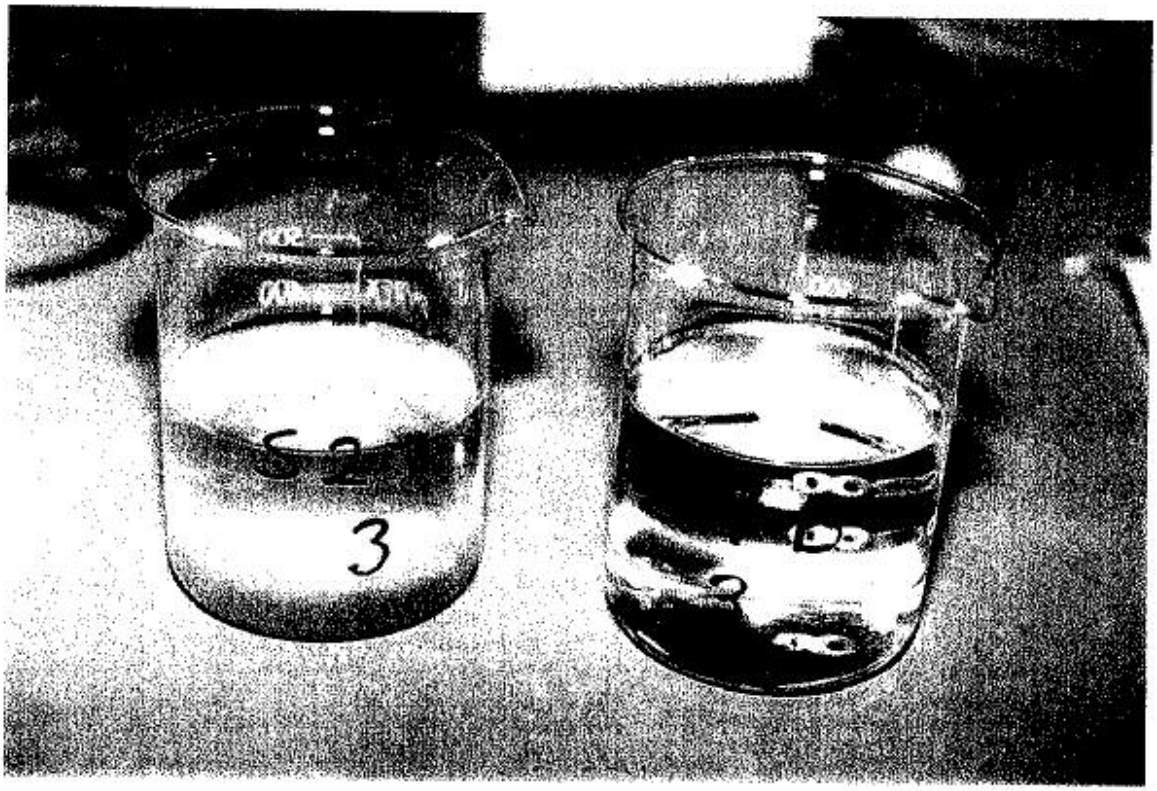

PLATE 1. Bundanoon, Sample S27. Sodium sulphate test solutions after 4 cycles; S27/3 (untreated) compared to S27B/3 (treated).

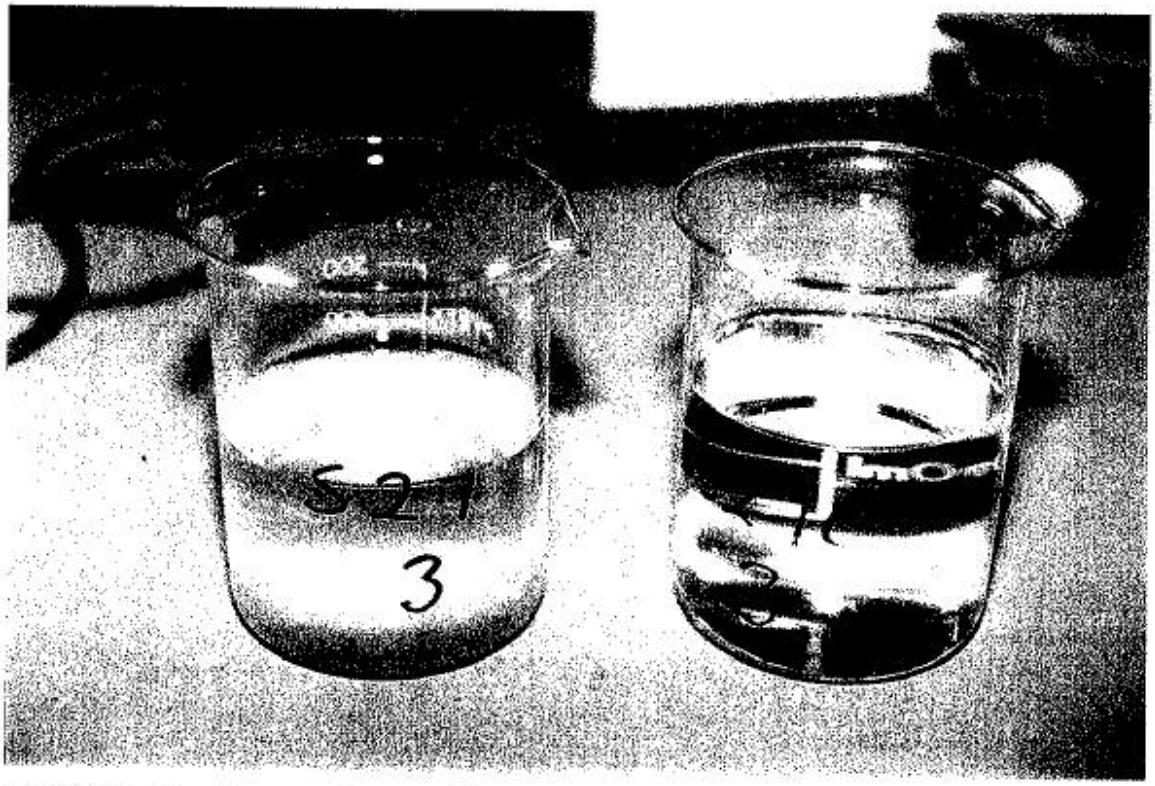

PLATE 2. Bundanoon, Sample S27. Sodium sulphate test solutions after 4 cycles; S27/3 (untreated) compared to S27C/3 (treated).

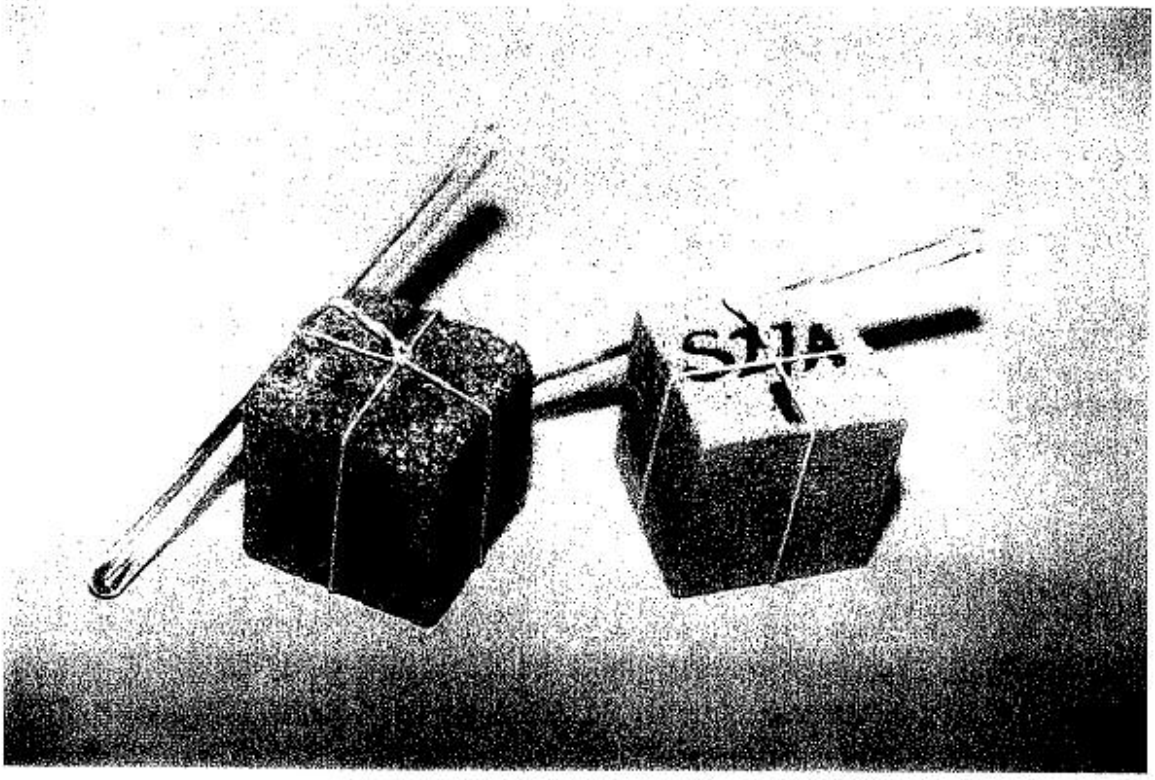

PLATE 5. Bundanoon. Sample S27/1 (untreated) after 4 cycles compared to Sample S27A/1 (treated) after 4 cycles.

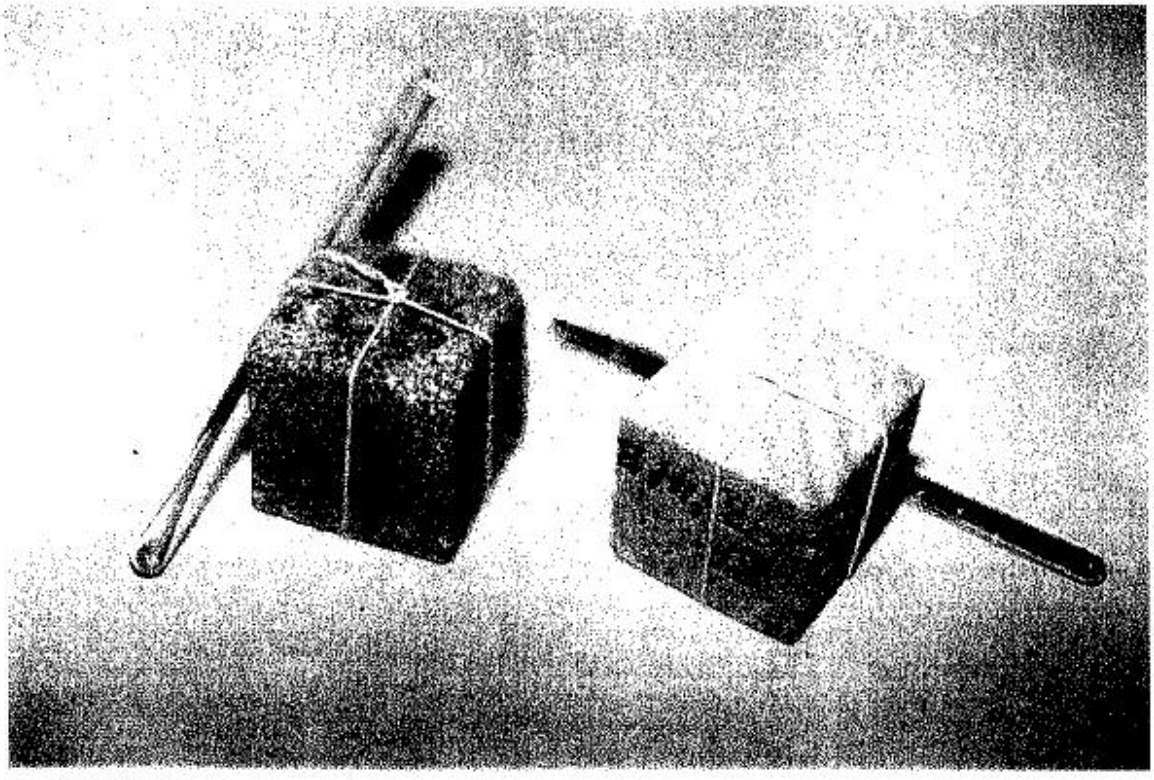

PLATE 6. Bundanoon. Sample S27/1 (untreated) after 4 cycles compared to Sample S27B/3 (treated) after 4 cycles.

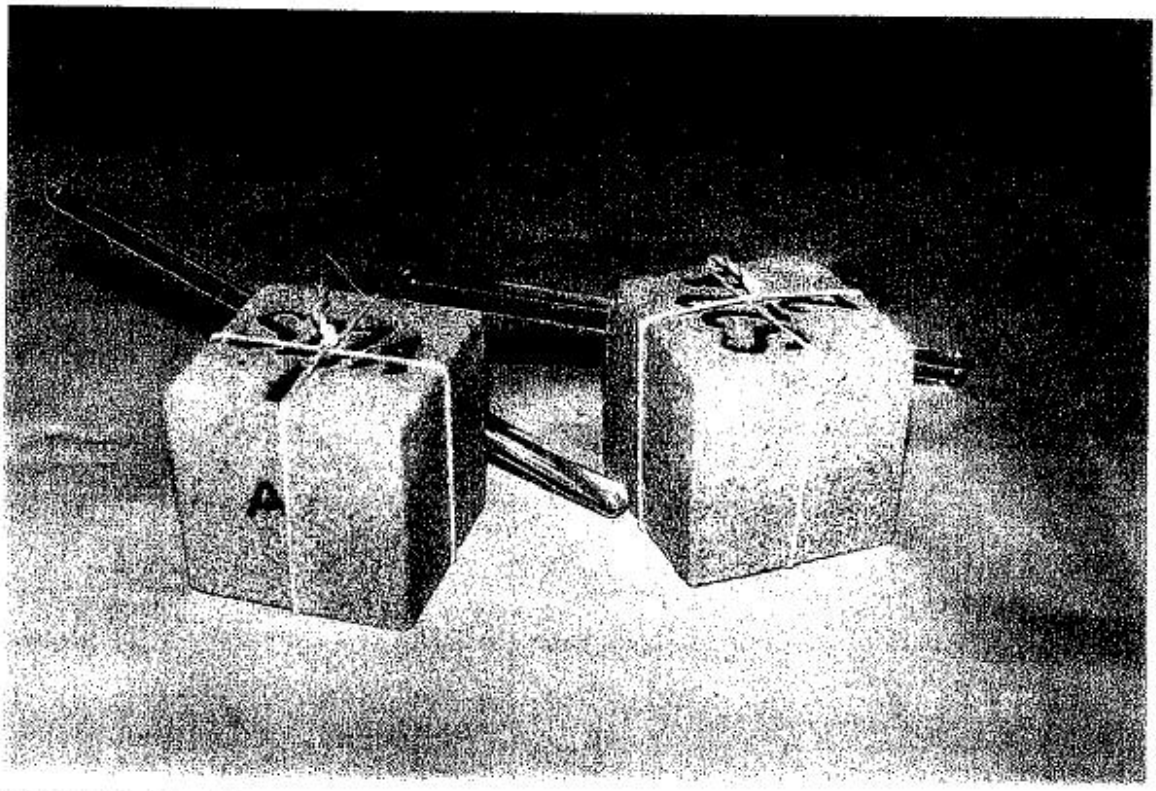

PLATE 9. Bundanoon. Samples S27A/1 and S27A/2 (treated). Essentially no loss after 15 cycles, minor discolouration on corners.

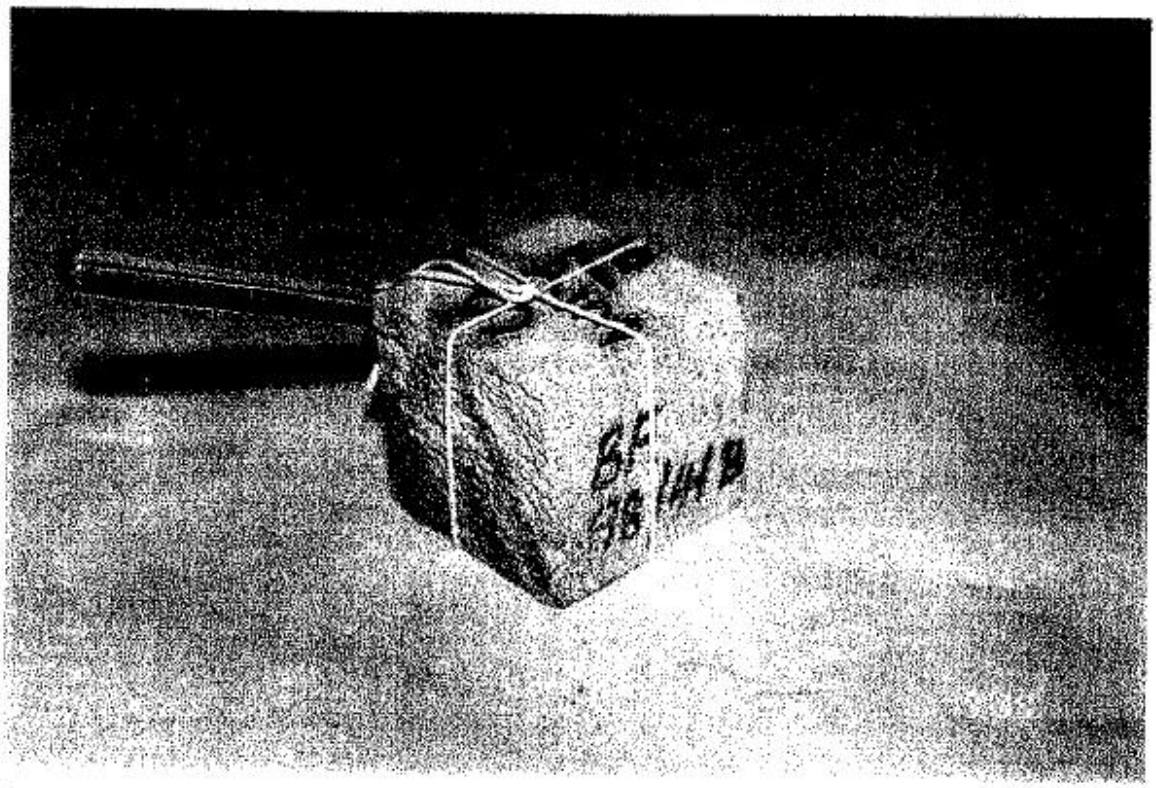

PLATE 10. Bundanoon. Sample S27B/3 (treated). Essentially no loss after 15 cycles, minor discolouration on corners.

Geotechnical Centre

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NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

CLIENT	HERITAGE SERVICES	BATCH No.	98040

SODIUM SULPHATE SOUNDNESS - FULL IMMERSION

PROJECT	BUNDANOON SANDSTONE	SAMPLE No	S27A
BLOCK IDENTIFICATION	BF 98/41A		

STONE TYPE:	SANDSTONE	SUPPLIER:	BUNDANOON QUARRY
TESTED BY:	ZG	DATE TESTED:	16.10.98

SPECIMEN No		1	2	3
DIMENSIONS OF BLOCK (mm)	x	50.40	50.14	
	y	51.56	51.14	
	z	50.28	50.41	
DESCRIPTION OF DAMAGE		DISCOLOURATION OF CORNERS		
MASS LOSS AFTER 15 CYCLES	%	0.0	0.0	
DISINTEGRATION AT CYCLE		---	---	

Test Method AS 3542.3

APPROVED SIGNATORY M Ashworth

DATE 21/10/98

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Unit W4K 42 Wattle St ULTIMO 2007
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NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

CLIENT	HERITAGE SERVICES	BATCH No.	98040

SODIUM SULPHATE SOUNDNESS - FULL IMMERSION

PROJECT	BUNDANOON SANDSTONE	SAMPLE No	S27B
BLOCK IDENTIFICATION	BF 98/41B		

STONE TYPE:	SANDSTONE	SUPPLIER:	BUNDANOON QUARRY
TESTED BY:	ZG	DATE TESTED:	16.10.98

SPECIMEN No		1	2	3
DIMENSIONS OF BLOCK (mm)	x	50.51		
	y	49.48		
	z	51.32		
DESCRIPTION OF DAMAGE		DICOLOURATION OF CORNERS		
MASS LOSS AFTER 15 CYCLES	%	0.0		
DISINTEGRATION AT CYCLE		----		

Test Method AS 3542.3

APPROVED SIGNATORY M [signature]

DATE 21/10/98

Form BS1009 (Issue 1) 1995

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NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

CLIENT	HERITAGE SERVICES	BATCH No.	98040

WATER ABSORPTION, APPARENT POROSITY AND BULK DENSITY

PROJECT	BUNDANOON SANDSTONE	SAMPLE No	S27C
BLOCK IDENTIFICATION	BF 98/41C		

STONE TYPE:	SANDSTONE	SUPPLIER:	BUNDANOON QUARRY
TESTED BY:	ZG	DATE TESTED:	30.09.98

SPECIMEN No		1	2
DIMENSIONS (mm)	X	51.13	48.81
	Y	49.33	51.55
	Z	50.35	50.50
WEIGHT OF MATERIAL OVEN DRY (g)	w1	273.78	273.42
WEIGHT OF MATERIAL UNDER WATER (g)	w2	152.17	151.63
WEIGHT OF MATERIAL SAT-SURFACE DRY (g)	w3	274.97	274.72

	Spec. 1	Spec. 2	Average
WATER ABSORPTION (% water by weight)	0.435	0.475	0.46
APPARENT POROSITY (% water by volume)	0.969	1.056	1.01
BULK DENSITY (dry) tonnes/cub.m	2.229	2.221	2.23
BULK DENSITY (soaked) tonnes/cub.m	2.239	2.232	2.24

Draft Australian Standard Methods for Sampling & Testing Aggregates	APPROVED SIGNATORY	M. Ashland
	DATE	21/10/98

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NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

CLIENT	HERITAGE SERVICES	BATCH No.	98040

SODIUM SULPHATE SOUNDNESS - FULL IMMERSION

PROJECT	BUNDANOON SANDSTONE	SAMPLE No	S27C
BLOCK IDENTIFICATION BF 98/41C			

STONE TYPE: SANDSTONE	SUPPLIER: HERITAGE STONEMASONRY
TESTED BY: ZG	DATE TESTED: 16.10.98

SPECIMEN No		1	2	3
DIMENSIONS OF BLOCK (mm)	x	50.48	50.55	50.37
	y	49.33	49.10	48.93
	z	51.26	51.97	51.40
DESCRIPTION OF DAMAGE		DISCOLOURATION OF CORNERS		
MASS LOSS AFTER 15 CYCLES	%	0.0	0.0	0.0
DISINTEGRATION AT CYCLE		----	----	----

Test Method AS 3542.1

APPROVED SIGNATORY M Aslett

DATE 21/10/98

PLATES 1 TO 11

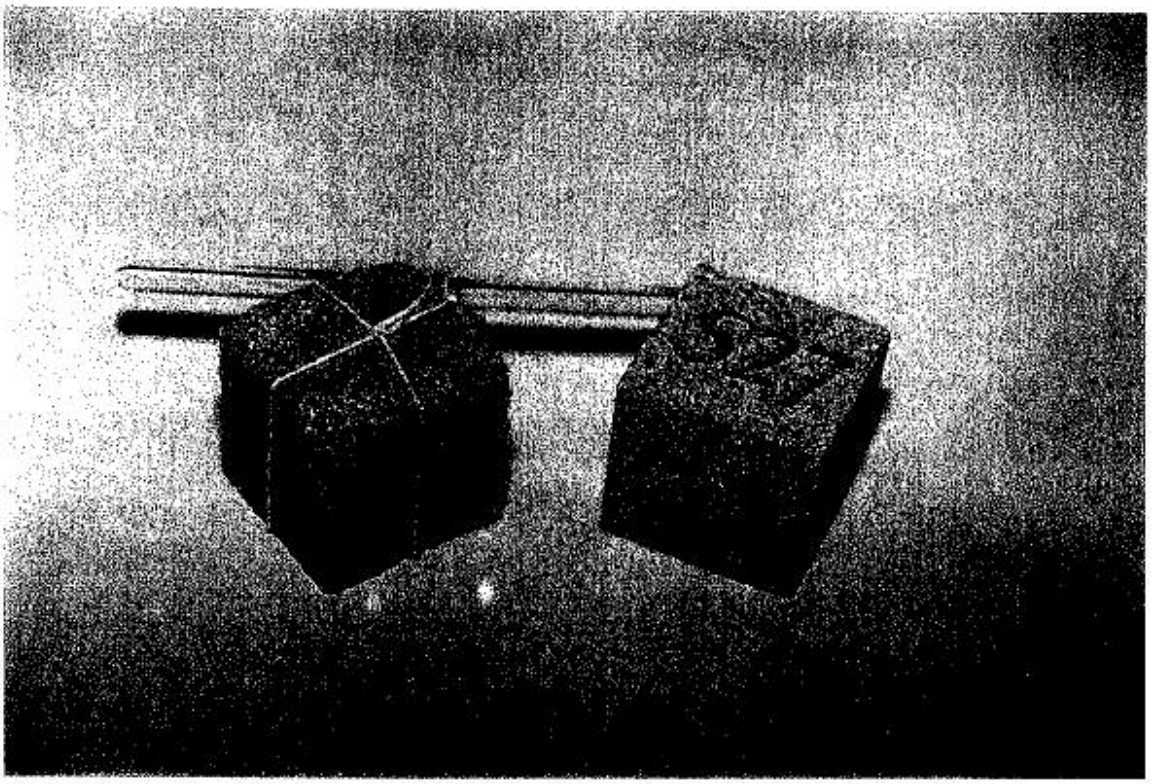

PLATE 3. Bundanoon. Sample S27/1(untreated) after 4 cycles compared to an untested cube (S27).

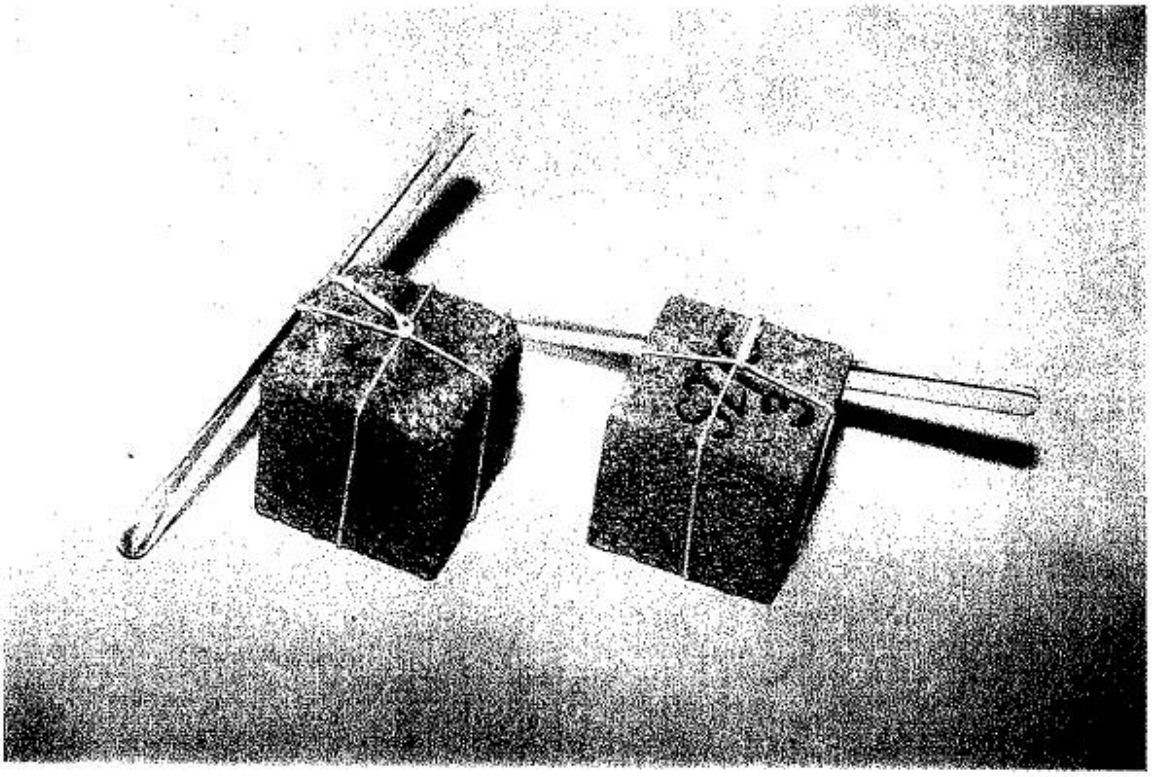

PLATE 4 Bundanoon. Sample S27/1 (untreated) after 4 cycles compared to Sample S27C/3 (treated) after 4 cycles.

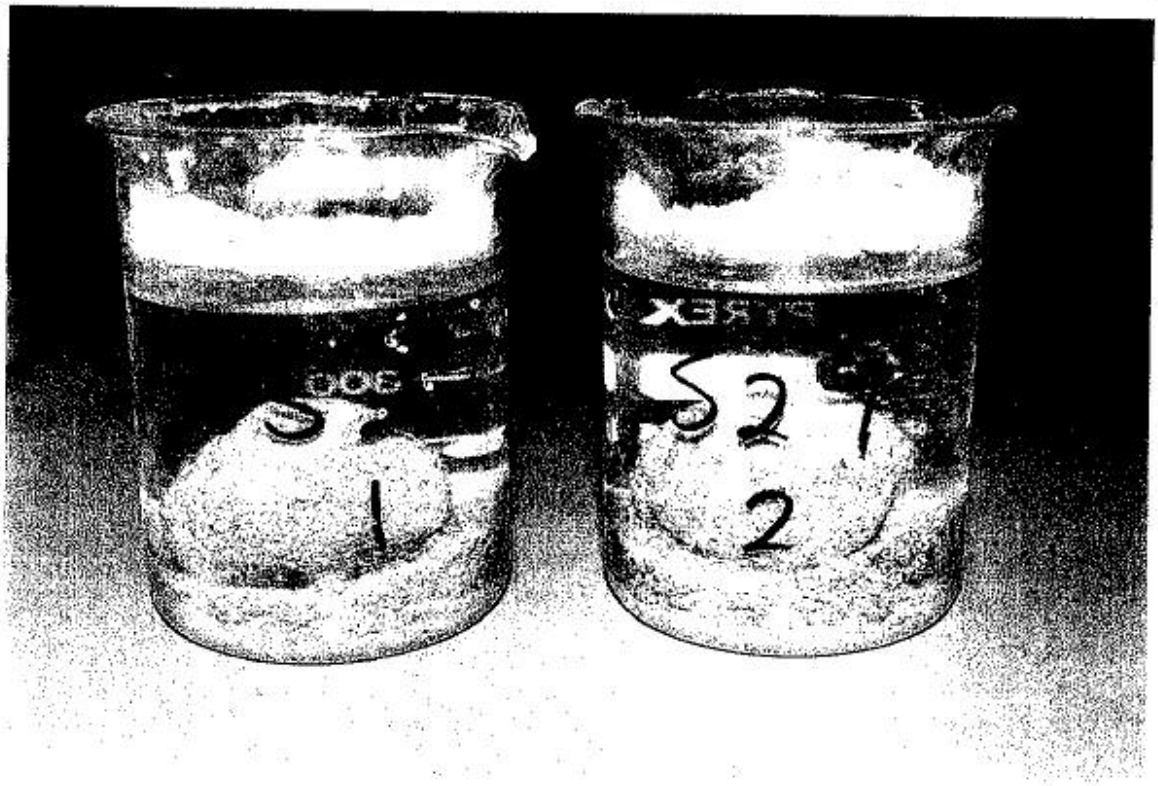

PLATE 7. Bundanoon. Samples S27/1 and S27/2 (untreated). Regarded as disintegrated after 11 cycles.

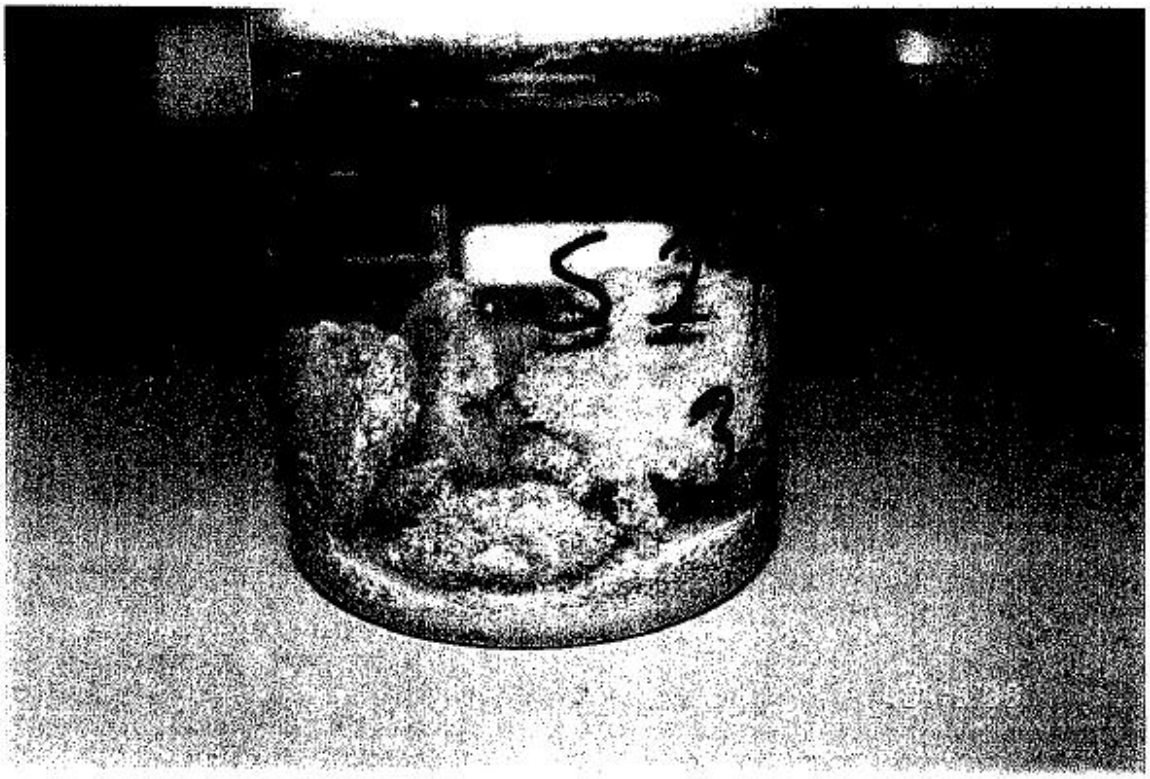

PLATE 8. Bundanoon. Sample S27/3 (untreated). Regarded as disintegrated after 14 cycles.

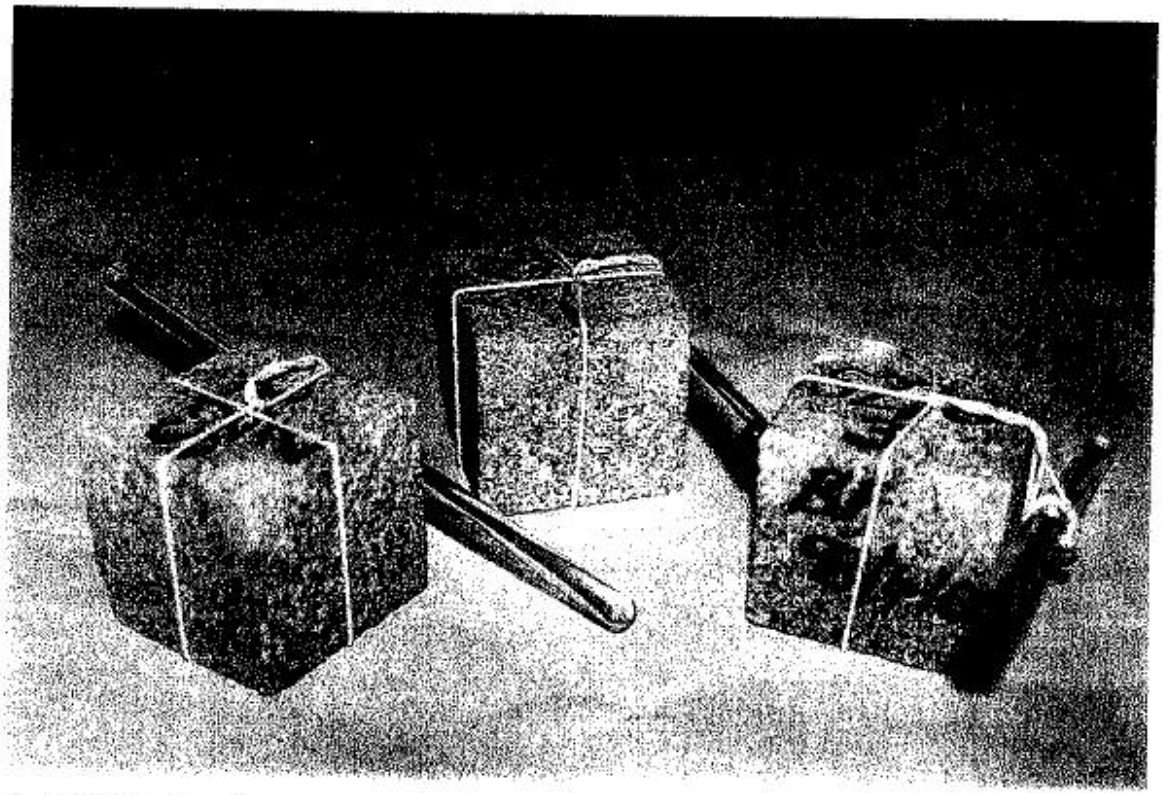

PLATE 11. Bundanoon. Samples S27C/1 to S27C/3 (treated). Essentially no loss after 15 cycles, minor discolouration on corners.