DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENGINEERING DIVISION

LITTLE PARA DAM

REPORT ON MATERIALS TESTING

Hd. of Yatala and Munno Para

Client: ENGINEERING AND WATER SUPPLY DEPARTMENT

by

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Rept.Bk.No.76/28
G.S. No. 5705
DM. No. 624/72
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SUMMARY AND CONCLUSIONS

This report summarizes the results of all material testing covering the period from the initial investigations to date.

Areas of material investigation mainly include petrographic description of rock, analyses of clays, concrete aggregate testing and rock strength testing of quartzite and dolomite.

Results of material testing can be stated as:

..... Only two rock types occur over the dam site and quarry area, namely quartzite and shaly dolomite. The quartzite is felspathic and the shaly dolomite shows a variable carbonate content. Beneath quartzite outcrops the dolomite may become siliceous.

..... Only the quartzite is suitable for concrete aggregate.

..... Quartzite will be suitable for rock fill in Zones 1 and 4. Siliceous dolomite when available should also be suitable for these zones.

..... A slightly fresh to weathered shaly dolomite is suitable for Zone 3.

..... Breakdown of the shaly dolomite due to weathering produces a montmorillonite rich clay.

..... Quartzite shows an unconfined compressive strength within the range 85.5 - 296 M Pa.

..... Axial and diametral point load tests on the shaly dolomite give values 1.7 - 13.8 M Pa.

INTRODUCTION

Testing of the rock, clay seams and soil in the vicinity of the dam site was carried out during the detailed geological investigation of the dam site and the early construction period.

Of major importance was the assessment of rock types for inclusion in the several rockfill zones of the dam embankment and the suitability of some rock as a possible convenient aggregate for on site concrete. Seventeen cored drill holes were put down and the core used for testing.

TABLE I

SUMMARY OF TESTING PROGRAMME

TESTING REQUIRED	PURPOSE	AGENT	REFERENCE THIS REPORT
Petrological Examination of Rocks. Mineralogy of Clays.	Define rock types and nature of clays pertinent to the dam site.	A.M.D.E.L.	Table II, III & IV.
	Define status of tectonism.		Appendix I
	Assess suitability of rock types for the dam rockfill zones and use as concrete aggregate.		Appendix III
Compaction and grading quality of soil.	Assess suitability for use as road fill.	E. & W.S. Ottoway Lab.	Appendix VIII
Durability testing of rock types.	Assess suitability for dam rockfill zones and use as concrete aggregate.		Table VI
Physical soil test (specific gravity, water adsorption, mechanical analysis, permeability).	Assess nature of rock types and permeability of silt.	E. & W.S. Netley Laboratory	Table VII
Logging of soil profiles.	Assess potential for soil movement.		
Physical Tests (Unconfined Compression Tests, Young's Modulus)	Assess nature of rock types: Suitability as fill, foundation and aggregate.	Flinders University	Table VII
Physical Tests (Point Load Tests)	Field assessment of rock strength. Reference to Field Definition of rock terms.	Dept. of Mines	Table VIII Appendix VI
Field Testing (Surveying of hillside monitor pegs)	Assessment of hillside slope stability.	E. & W.S. Survey Branch.	(text)

1. PETROLOGY OF ROCK SAMPLES

Samples from the dam site forwarded to A.M.D.E.L. were analysed for rock petrology or clay mineralogy or identification of tectonic features. Table II lists samples forwarded to A.M.D.E.L. over the period January, 1973 to February, 1975.

TABLE II

Examination of samples forwarded to AMDEL

Date	Report No.	Work Required	Refer to Table No.
4.1.73	MP2842/73	Petrological description.	III
18.6.73	MP5072/73	Petrological description.	III
2.8.74	MP4857/74	Assessment of gradational dynamic metamorphism.	(See Text)
7.11.74	MP1458/75	Determination of clay mineralogy.	VI
20.12.74	MP1835/75	Suitability for concrete aggregate.	V
3.2.75	MP2571/75	Petrological description and examination of tectonic fabric.	(See appendix I)
17.10.75	MP617/76	Petrographic and mineralgraphic description.	(See appendix II)

Table III summarizes the analyses of the two major rock types found over the dam site.

Six samples of dolomite forwarded to AMDEL show the presence of minerals associated with regional metamorphism. A description of their tectonic fabric and gradational metamorphism is found in Appendix I.

TABLE III

Petrological Description of Rock Types

REPT. NO.	SAMPLE NO.	ROCK TYPE	MINERAL CONTENT %						
			Quartz	Dolomite	Carbonate	Phyllo-silicates	FELDSPAR Plag.	FELDSPAR Ortho.	Opaques
MP2442/73	P853/72	QUARTZITE (1)	55-65			Tr (sericite/chlorite)	5-10	20-30	Tr
	P854/72	DOLOMITE (2)	3-6	90-95					2-4
	P855/72	DOLOMITE (3) (impure)	2-4	90-95					2-4
MP5072/73	P307-310/73 T.S.30620-3	QUARTZITE (4) (feldspathic)	80-90		0-2		1-5	7-10	1

(1) This rock is thought to be a well sorted sediment, an arkose sandstone that has been metamorphosed.

(2) This is a fine grained impure dolomite which has been strongly foliated and now has a schistose texture.

(3) As above (2) but lacking the schistose texture.

(4) Recrystallised arkose sandstone firmly welded by fracturing and crystal growth; feldspar grains have fractured but have been sealed by quartz. A high confined compressive strength for the rock is expected.

2. MINERALOGY OF CLAY SAMPLES

Quantitative and qualitative examinations have been carried out on clay weathering products from the dolcmite underneath the quartzite which forms the main foundation for the rockfill embankment on the right bank.

Such analyses show that the clay fraction is commonly dominant in montmorillonite with sub-dominant to accessory range quantities of kaolin type clays and vermiculite.

All clay samples taken from thin seams adjacent to cavities close to the quartzite-dolomite contact show montmorillonite to be dominant with accessory quantities of kaolin type clay, mica-vermiculite interstratified clay. Dolomite occurred in only one out of ten samples as a dominant mineral. In all other nine samples dolomite was completely absent, calcite occurring in eight of them and in three of these in dominant quantities, elsewhere appearing as an accessory or trace mineral with montmorillonite and mica. Sample taken from infilled joints in the quartzite show quartz as the dominant mineral.

The low quantity of dolomite found within the clays suggests either differential weathering of the original strata where the dolomite has been removed in preference to the calcite or that the original rock has a wide range in the dolomite to calcite ratio. A third possibility is that calcite rich clays have been introduced from elsewhere. This may be the case in the vicinity of the cavities where vuggy quartz veins occur adjacent to thin clay seams from which some of the samples were taken.

These cavities are believed to have originated at the site of thin quartzite strata overlying dolomite, where vuggy quartz veins are present. Carbonate solution adjacent to the vuggy quartz veins has encouraged formation of a cavity which later may have allowed the collapse of jointed quartzite into the cavity and by doing so increased the cavity to its present site.

It is possible that such cavities are inter-connected and for this reason great attention has to be paid to occurrences of soft seams, vuggy quartz veins and cavities during investigation of the grout cap.

TABLE IV

MINERALOGY OF CLAY SAMPLES

(a) Mineralogy by XRD of Total Sample

A379/74		A380/74		A382/74		A382/74		A383/74	
Cal	D	Q	D	Dol	D	Cal	D	Q	D
Mo	A-SD	UC	SD	Cal	A	Q	SD	F	A
G	A	K	A	V	A	M	A	M	A
M	A	F	A	Q	A	V	A	Mo	A
Q	Tr			M	A	Mo	A	Cal	A
F	Tr			F	Tr	K	A		
						F	Tr		
A384/74		A385/74		A386/74		A387/74		A388/74	
Cal	D	Q	D	Mo	CD	Mo	D	US	D
Q	A-SD	Mo	SD	Q	CD	K	SD	Mo	SD
M	A	M	A	M	CD	Cal	A	Q	A
V	A	F	A	K	A	M	A	F	A
F	Tr-A			M-V	A	G	A	M	Tr
				Cal	Tr-A	F	Tr	Ca	Tr
				F	Tr	Q	Tr		

(b) Mineralogy of Minus Two Micron Fraction

SAMPLE*	A383/74		A385/74		A386/74	
% - 2 pm	14		16		23	
Clay	Mo	D	Mo	D	Mo	D
Mineralogy	M	SD	M	A	K	A
			K	Tr	M-V	A

MINERAL KEY				SEMI QUANTITATIVE TERMS	
Cal	Calcite	K	Kaolin type, probably halloysite	D	Dominant
Dol	Dolomite	M	Mica	CD	Co-dominant
F	Feldspar	Mo	Montmorillonite	SD	Sub-dominant
G	Goethite	M-V	Mica-vermiculite interstratified	A	Accessory
K′	Kaolin	Q	Quartz	Tr	Trace
		UC	"undefined clays". Layer silicates of irregular or degraded type giving no basal reflections. Not subject to proper definition in work carried out here.		
		V	Vermiculite		

* Samples taken from infilled joints in quartzite and from clay seams and weathered dolomite adjacent to cavities in an exposure trench excavated on the right hand hillside close to the downstream toe of the dam.

Progressive Weathering of the Dolomite

Three samples of weathered dolomite were forwarded to AMDEL to analyse for any evidence of progressive weathering from the moderately weathered to the completely weathered dolomite. Appendix II Samples P273/75-P275/75, where a seam of completely weathered dolomite dips beneath the quartzite, i.e. beneath the right abutment.

Diamond drilling shows that either the seam thins or dies out completely. Sample P273/75 is taken from core of one of these drill holes at about the depth the weathered seam would have intersected the drill hole had it continued down dip beneath the quartzite.

Although the samples submitted exhibit varying degrees of weathering it is thought that the amount of and type of clay product is related to the original content of the siltstone rather than to its degree of breakdown by weathering. The clay (vermiculite and montmorillonite) has formed in situ from the breakdown of sericite and the introduction of Mg ions into the sericite lattice following removal of sodium ions from the lattice.

This means that the clay has not been introduced into the weathered dolomite from elsewhere and its occurrence can be expected to be confined only to dolomite which has suffered weathering.

Where the dolomitic siltstone has a low carbonate content (that is a paucity of Mg ions) kaolinite will be the favoured breakdown product in preference to vermiculite and montmorillonite.

3. MECHANICAL ANALYSIS OF A SOIL SAMPLE

Hillside colluvium from the foot of the quarry and water treatment works site was forwarded to Ottoway laboratories for a mechanical analyses with respect to using such material for road fill.

The analysis shows a soil comprised of approx. fifty percent gravel, forty percent silt and clay and ten percent sand. This is a very poorly graded gravel with the fines giving a plasticity index of 32.7. (See Fig. 1). The sample is most unsuitable for use as road fill as satisfactory compaction will be extremely difficult to achieve without the addition of sand sized material.

Results of testing are given in Fig. 1.

4. ROCKFILL AND CONCRETE AGGREGATE - MATERIAL TESTS

Table V lists results from testing quartzite and siliceous dolomite (see Plates 1-4). Design criteria for rockfill zones is shown in Table VI. Samples were taken from the proposed quarry and water treatment works site. Results show that the quartzite and siliceous dolomite can be satisfactorily used as Zone 1 and Zone 4 material. (See Fig. 2 and Fig. 3). The high values for the flakiness index probably result from using a small crusher jaw.

The accelerated weathering test results show that the phyllitic dolomite can be used satisfactorily in Zone 3, the bulk of the dam. Atterburg tests on the fines from the weathering test show that a low plastic clay is produced. The rock types are basically suitable for use as concrete aggregate although values for the Elongation Index are higher than would have been preferred.

Samples from several localities were forwarded to AMDEL (P384/74-P387/74) for petrological description with particular reference to the presence of deleterious minerals if the rocks were used in concrete aggregate. Descriptions of these samples are given in Appendix III.

TABLE V

ROCKFILL AND CONCRETE AGGREGATE - MATERIAL TESTS

TEST	QUARTZITE		SILICIOUS DOLOMITE		COMMENTS
	40 mm	20 mm	40 mm	20 mm	
LOS ANGELES ABRASION TEST (% weight loss)	21%	19%	21%	18%	Considered very resistant to abrasion.
AGGREGATE CRUSHING VALUE (% weight loss)	Insufficient material	18%	19%	19%	Considered hard material.
FLAKINESS INDEX	22%	24%	36%	36%	Australian Standard A.S. 1141 - recommended value less than 35.
ELONGATION INDEX	43	64	34	47	A.S. 1141 - recommended value less than 35.
SODIUM SULPHATE SOLUTION (% weight loss)	0.2%		6.5%		12% loss considered unacceptable
PHYLLITIC DOLOMITE ACCELERATED WEATHERING TEST	PRIOR TO CYCLES		FOLLOWING 10 CYCLES		≠ Zone 3 material Department of Main Roads. (N.S.W.). Test using Sodium Chloride. Sieve analyses were carried out using sieve sizes 3/4, 3/8, 3/16, 7, 14, 25, 52, 100, 200. Some break-down of the coarser material is shown, otherwise very little change following the weathering and compaction tests (modified Proctor).
	L.L.	26-27	L.L.	21-23	
	P.L.	14-15	P.L.	8- 9	
	P.I.	12-13	P.I.	13-14	
	LINEAR SHRINKAGE	2- 5	LINEAR SHRINKAGE	No Result	

SUMMARY - The carbonate of the dolomite is not affected to any great extent by the weak acid of the sulphate and chloride tests. Presence of silicates renders dolomite more resistant to abrasion but may however increase the flakiness and elongation indices.

5. QUARTZITE AND DOLOMITE ROCK TESTS

Rock Strength

Uniaxial compressive strength tests were carried out on wet and dry samples of quartzite taken from N.M.L.C. diameter drill core. Values vary from 86.5 (at 8.0 metres) to 296 MPa (at 16.0 metres) and the wide range obtained appears to be related to depth, degree of weathering and feldspar content.

Table VII lists values for Young's Modulus, Specific Gravity, Water Adsorption and values from Point Load Tests.

Values from the point load tests suggest a correlation for the quartzite between the point load values and the unconfined compressive strength values of a factor in the order of 4 to 6. Point load strength values for the quartzite appear to be 3 to 7 times higher than the dolomite values. (Definition of rock strength terms is shown in Appendix VI).

Tests for Frictional Angle (Shear Tests)

Using the Hoeck portable shear testing machine angles of friction were derived in the laboratory for quartzite and dolomite samples taken from the proposed quarry site. Work was carried out by the Consulting Engineers, Coffey and Hollingsworth Proprietary Ltd.

The high values (45^0-60^0) for the quartzite are accounted for by the high frequency of interlocking asperities. Folding in the quartzite has caused the bedding plane to dip into the quarry at approximately 22^0 and the samples were taken across this plane. Frictional values therefore suggest that movement of quartzite blocks along the bedding planes into quarry will be limited.

In contrast the phyllitic dolomite failed along the bedding plane at approximately 25^0-30^0. Fortunately the dolomite does not dip into the quarry but the measurement of the frictional angle is useful when considering batter angles for cuts excavated into the hillside for the access roads. See Appendix IV for individual sample results.

TABLE VII

MATERIAL TESTS

SUBSTANCE	TEST	RESULTS	COMMENTS
QUARTZITE	YOUNGS MODULUS	5.3×10^4 - 8.7 MPa	Tested wet and dry.
"	SPECIFIC GRAVITY	2.593 - 2.650	Gross Apparent: (SSD Basis)
DOLOMITE QUARTZITE	WATER ADSORPTION " "	1.2% * 0.14% - 0.60%	*range of values from different samples tested in different laboratories.
"	UNIAXIAL COMPRESSIVE STRENGTH	85.5 - 296 MPa	Tested wet and dry. Samples from 8.00-16.00 m depth. Axial failures.
"	POINT LOAD TESTS	DIAMETRAL: 36.2-44.8 MPa AXIAL : 15.5-39.6 MPa	Using N.M.L.C. diam. Core.
DOLOMITE	" " "	DIAMETRAL: 1.7- 4.8 MPa AXIAL : 8.3-13.8 MPa	" " " "
QUARTZITE	PETROLOGICAL DESC.	QUARTZ 55 - 95% FELDSPARS 5 - 45% OPAQUES) SERICITE) Traces only CHLORITE)	Quartzite to Metamorphosed arkosic sandstone
DOLOMITE	" "	DOLOMITE 90 - 95% QUARTZ 3 - 6% OPAQUES 2 - 4%	Foliated with Schistose texture (Referred to in test as phyllitic dolomite)
QUARTZITE	Ø Shear test	45^o - 69^o ≠	≠ Measured on plane dipping 22^o into proposed Quarry.
DOLOMITE	" "	25^o - 30^o §	§Measured along bedding plane in moderately weathered and highly weathered samples. Lower values should be expected.

6. PERMEABILITY TESTS ON COMPLETELY WEATHERED DOLOMITE

Two samples of completely weathered dolomite (SM-CL) taken from the base of a stress relief fracture on the left bank grout cap alignment were forwarded to the Engineering and Water Supply Department Soils Laboratory at Netley. Grading curves, specific gravity and permeability tests were requested.

The two samples are of the same material, one shows rock structure and the other, a less cohesive sample is deprived of all rock structure. Both samples immediately decomposed after being placed in distilled and mains water. Examination by binocular microscope revealed the presence of many voids up to 1.5 times the diameter of the silt grains. A mechanical analysis for the less cohesive sample is given in Figure 4.

The permeability test was carried out on the softer of the two samples (specific gravity 2.87) and gave an approximate result of 1.15×10^{-5} cm/sec.

At a later date three tube samples taken from a completely weathered seam at the top of the right bank grout cap were forwarded to the laboratory for further testing. (See Appendix VIII). A suggested permeability value from these tests is 5×10^{-7} m/sec.

The two values of permeability give a range of values approximately 3 metres to 15 metres per year. These values indicate that piping within the completely weathered dolomite leading to drainage through to grout curtain is not considered likely.

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APPENDIX I

EXAMINATION OF TECTONIC FABRIC

APPENDIX I

EXAMINATION OF TECTONIC FABRIC

Three samples, labelled P1/75 to P3/75 (See Table V) were submitted to A.M.D.E.L. for petrographic description. The samples were from the Little Para Dam site; they are from batters on the Grout Cap on the left bank. For the first two samples, P1/75 and P2/75 two orientation directions were marked on each which were labelled a-a and b-b, and it was requested that thin sections be cut parallel to these orientations and that comments be made on the tectonic origin of the fabric visible in the rock. For the third sample, P3/75 which contained carbonate, it was requested that emphasis be given to the chronology of mineralization.

P1/75 is a silty dolomite and on this sample two directions were marked: a-a parallel to the strike of the dolomite and b-b parallel to the dip of the dolomite. The constituent dolomite crystals in the sample have been elongated in the b-b direction and the phyllosilicate flakes are better aligned parallel to b-b than they are to a-a. There are flakes a number of veins/tension fillings composed of quartz, carbonate and iron oxide/hydroxides in the sample and these cross-cut the bedding foliation at a moderate angle and strike in a direction which roughly bisects the angle between a-a and b-b. There are a number of irregularly orientated fractures in the sample as well as a system of joints which are orientated parallel to a-a and are normal to the bedding foliation.

Sample P2/75 is described as a "Boudin" structure. This rod-like sample has an outer zone approximately 1 mm thick which is composed of quartz, phyllosilicates, carbonate and iron oxides/hydroxides, and an inner core which is composed essentially of equal amounts of quartz and iron oxides/hydroxides, with only trace amounts of phyllosilicates and no carbonate. In the outer zone the quartz crystals are elongated parallel to b-b and the phyllosilicate flakes are strongly aligned in that direction. In the core of the "Boudin" quartz crystals are elongated parallel to b-b whereas the iron oxides/hydroxides are essentially equant in shape. The latter which consist of goethite and limonite are thought to be pseudomorphs after pyrite. The phyllosilicates in the core of the "Boudin" are aligned parallel to b-b and to shears/foliae. The latter although striking parallel to b-b would result in the "Boudin" changing shape from a round to an oval cross-section if they were subjected to renewed movement.

Sample P3/75 was taken from the margins of a quartz vein in the dolomite. There is evidence that the quartz has been replacing dolomite and that the rock has suffered mild tectonic deformation. There are a few patches of iron oxides/hydroxides in the sample which are thought to be pseudomorphs after sulphides, probably pyrite. These are totally surrounded by quartz and are thought to have formed at about the same time as that mineral.

ASSESSMENT OF GRADATIONAL METAMORPHISM

Three hand specimen samples of meta-sedimentary rocks were submitted to A.M.D.E.L. by the Mines Department with a request for an assessment whether the dynamic metamorphism increased from the first sample (P147/74) to the third sample (P149/74 and P150/74). The samples were collected from the hundred of Munno Para, section 5461 adjacent to a low angled Shear Zone within shaly dolomite and approximately 60 metres east of drill hole 16. Stratigraphically the samples belong to dolomite unit 11 but in fact the rocks are relatively rich in quartz and feldspar and generally contain only accessory amounts of carbonate.

The hand specimens are similar to each other and consist of mottled rather platy schistose rocks which contain some fine grained lithologies and some containing porphyroblasts up to about 6-10 mm in size. These porphyroblasts actually consist of quartz and microcline and appear to be relicts of original detrital grains so that the original rock appears to have been a banded moderately calcareous sediment consisting of silty lithologies with some rather coarse grained and submature sandstone horizons. In the descriptions given below emphasis has been placed on the metamorphic effects shown by the samples and it is apparent that there is a slight to moderate increase in dynamic metamorphism effects passing from sample P147/74 to sample P149/74.

APPENDIX II

PETROGRAPHIC AND MINERAGRAPHIC DESCRIPTION OF PROGRESSIVELY WEATHERED DOLOMITIC SILTSTONE

APPENDIX II

THE LITTLE PARA DAMSITE

PETROGRAPHIC DESCRIPTIONS OF THREE VARIOUSLY WEATHERED METASILTSTONES

1. INTRODUCTION

Three samples, labelled P273/75 to P275/75, were submitted to AMDEL for petrographic and mineragraphic description. These samples, were from the vicinity of the Little Para Dam and consisted of metasiltstone in several states of weathering. It was hoped that the nature of the progressive breakdown of the minerals of this metasiltstone could be established.

2. SUMMARY

Sample P273/75 is a moderately foliated dolomitic siltstone and is the freshest of the three siltstone samples. Sample P274/75 is a quartz-sericite metasiltstone which contains trace amounts of dolomite and 5-10% of vermiculite. Sample P275/75 is a weathered quartz-sericite metasiltstone which contains no dolomite and 15-25% of montmorillonite. It is not certain that samples P274/75 and P275/75 ever contained as much dolomite as sample P273/75. However, dolomite is definitely one of the more susceptible minerals of these rocks and it has been dissolved away except for minor to trace amounts of limonite (the dolomite was possibly slightly ferroan).

In discussing the transformations occurring among the sheet silicates in these rocks the following minerals are relevant:

Chlorite	$(Mg, Al, Fe)_{12}((Si,Al)_8O_{20})(OH)_{16}$ A trioctahedral, non-expanding sheet silicate with generally a low cation exchange capacity.
Kaolinite	$Al_4(Si_4O_{10})(OH)_8$ A trioctahedral, non-expanding sheet silicate with a low cation exchange capacity.
Montmorillonite	$(^1/_2Ca, Na)_{0.7}(Al,Mg,Fe)_4((Si,Al)_8O_{20})(OH)_4.nH_2O$ A dioctahedral, expanding sheet silicate with a high cation exchange capacity.
Sericite	$KAl_2(AlSi_3)O_{10}(OH)_2$ A dioctahedral, non-expanding sheet silicate with a low cation exchange capacity.
Vermiculite	$(Mg, Ca)_{0.7}(Mg, Fe^{3+},Al)_{6.0}((Al, Si)_8O_{20}(OH)_4.8H_2O$ A trioctahedral, non-expanding sheet silicate with an extremely high cation exchange capacity.

The vermiculite in sample P274/75 and the montmorillonite in sample P275/75 appear most probably to have formed from sericite and possibly, to a lesser extent, from chlorite. These transformations involve the removal of potassium from sericite and the relocation of magnesium and to a lesser extent calcium and iron, being released through the breakdown of dolomite. Loughnan (1969) describes examples where the vermiculite and montmorillonite have formed from sericite. From reading Loughnan (1969) and Deer, Howie and Zussman, Vol. 3 (1963) it appears unlikely that vermiculite is an intermediate product in the formation of montmorillonite from sericite, the decisive factors in whether vermiculite or montmorillonite forms being related rather to the concentration of magnesium ions and the degree of drainage (intensity of leaching). In dolomite-free horizons, where a relative paucity of magnesium ions could be anticipated during weathering, kaolinite might be expected to form rather than montmorillonite and/or vermiculite.

3. PETROGRAPHIC & MINERAGRAPHIC DESCRIPTIONS

<u>Sample: P273/75; TS34563</u>

Location:

Hundred of Munno Para, section 4370, drill hole 2.

Rock Name:

<u>Moderately foliated dolomitic siltstone</u>

Hand Specimen:

This rock is grey, fine-grained, and not noticeably bedded or laminated but quite strongly foliated. Along joints and some cleavage planes the rock is brown and of altered appearance.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Dolomite	60-70
Quartz	10-20
Muscovite	10-20
Feldspar	3-6
Chlorite	1-3
Opaques (hematite-goethite and rutile)	trace-2

This sample has a texture transitional between that of a clastic sedimentary rock and a schist. The rock is composed principally of dolomite, with lesser amounts of quartz and muscovite, and minor amounts of a number of other minerals including feldspar, chlorite, and opaques. The rock is reasonably fresh except along some joints and cleavage planes where there is impersistent iron staining.

The dolomite occurs as equant xenoblastic grains which range in size from 0.01 mm or less up to 0.03 mm. The identity of the dolomite was confirmed by x-ray diffraction. The dolomite has probably been completely recrystallised but, whereas the quartz, feldspar, and phyllosilicate grains have been affected by the tectonic deformation the rock has undergone, the dolomite does not appear to have been so affected, probably because of recrystallisation. Under extremely high magnification many of the dolomite crystals are seen to contain minute opaque and colourless particles.

The quartz occurs as elongate xenoblastic grains which range in size up to 0.1 mm long. The elongation of the quartz grains appears to have been caused by the tectonic deformation the rock has undergone and to a lesser extent through replacement/reaction with the dolomite in the rock. The elongation of the quartz grains is parallel to the foliation in the rock, and this foliation appears to coincide with the original bedding. The quartz grains all show pronounced undulose (strain) extinction and some appear to have been granulated.

According to the X-ray diffraction results this rock contains accessory amounts of feldspar. However, in the thin section the feldspar is virtually impossible to detect and presumably it is untwinned and optically very similar to the quartz. The exact amount of feldspar present is therefore somewhat uncertain.

The phyllosilicates muscovite and chlorite occur as subidioblastic flakes which range in size up to 0.2 mm long. The bulk of the phyllosilicate flakes are aligned with the foliation in the rock.

Some of the chlorite is almost colourless and is optically very similar to the muscovite-sericite but can generally be distinguished because of its low, almost anomalous interference colours.

Opaques occur as subidiomorphic and xenomorphic (rounded) grains which range in size from 0.1 mm up to 0.04 mm. The bulk of the opaques appear to consist of goethite-limonite but a few grains of rutile were also seen. The limonite staining occurring along some cleavage planes has already been mentioned.

There are a few lithic fragments in the rock and one included in the thin section is well rounded and composed of dolomitic metasandstone.

This rock is a moderately foliated dolomitic siltstone which is fresh except for some impersistent iron staining along a few foliation planes.

<u>Sample: P274/75: TS34564</u>

Location:

Hundred of Munno Para, section 4370, drill hole 2.

Rock Name:

<u>Quartz-sericite metasiltstone</u>

Hand Specimen:

This rock is pale yellow-brown, fine-grained, and moderately foliated. The yellow-brown colour appears to be due to disseminated iron staining. There are also a few cleavage planes which are quite dark coloured and in these the iron staining is more concentrated. The portion of drill core has broken along joint surfaces and cleavage planes.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	45-50
Sericite	35-45
Vermiculite	5-10
Feldspar?	5
Opaques (mainly limonite)	5
Dolomite	trace

This rock is fine-grained, has a strongly foliated/schistose texture, and is composed principally of quartz and muscovite/sericite. The bulk of the muscovite/sericite is yellow-brown due to iron staining and it is thought that the vermiculite detected by the X-ray diffraction work has formed through partial alteration of the sericite.

The sericite flakes are strongly aligned, extremely wispy and range in length up to at least 0.1 mm. The sericite is present throughout the rock and is not concentrated in particular layers or bands. Although the X-ray diffraction results indicate that vermiculite is also present this mineral cannot be distinguished optically from the sericite.

The quartz grains are elongate/xenoblastic in shape and up to 0.3 mm long although most are 0.04 mm long. The elongation of the quartz grains has presumably been caused principally by the tectonic deformation the rock has suffered but reaction with the sericite flakes may also be significant. The larger quartz grains all show pronounced undulose (strain) extinction and some appear to have been granulated.

There are a few grains of feldspar in the rock and these are of similar size and habit to those of quartz.

Equant xenoblastic grains of carbonate up to 0.05 mm across are present in some portions of this sample. This carbonate is dolomitic and yellow-brown in colour. The grains and granular aggregates of carbonate do not appear to have been affected by the tectonic deformation/foliation the rock has undergone.

Besides extensive limonite staining there are also discrete opaque grains in this rock. These are typically equant and xenomorphic in shape and up to 0.02 mm in diameter. The bulk of these opaque grains appear to consist of iron oxides.

This sample contains more sericite and less carbonate than the previous sample. It is of more weathered appearance and from the X-ray diffraction work vermiculite is known to be present. It is possible that this vermiculite has formed through the alteration of sericite although derivation from pre-existing chlorite is also possible.

Sample: P275/75; TS34565

Location:

Hundred of Munno Para, section 4370, taken from trench at top of right bank grout cap, Little Para Dam.

Rock Name:

Weathered quartz-sericite metasiltstone

Hand Specimen:

This sample is yellow-brown friable, fine-grained and quite markedly laminated/foliated. The sample has broken mainly along joints and to a lesser extent parallel to foliation planes.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	40-50
Sericite	15-25
Montmorillonite	15-25
Feldspar	trace
Limonite	5

In the thin section this rock is seen to have a strongly foliated/schistose texture and to consist of quartz and iron stained phyllosilicates and clay.

The quartz grains are equant to elongate in shape and xenomorphic in outline. In most of the rock they appear to have been attenuated by the tectonic deformation that has taken place and possibly, to a lesser extent, through reaction with the phyllosilicates and clay in the rock. The quartz grains range in size up to 0.06 mm but most are 0.03 mm across. In a few places the quartz appears to have recrystallized into patches/"pods" where it is associated with goethite/limonite. These patches are up to 0.3 mm thick, extend along the foliation planes for several millimetres, and the constituent quartz crystals are typically equant in shape and up to 0.03 mm across.

The phyllosilicate flakes are a yellow-brown colour, mostly 0.03 mm across, with a few muscovite/sericite flakes being up to 0.4 mm long. The presence of montmorillonite was confirmed by X-ray diffraction work. The larger muscovite/sericite flakes are probably detrital in origin but the finely crystalline sericite and the montmorillonite is probably entirely authigenic.

Trace amounts of feldspar were detected in the rock by the X-ray diffraction work.

Iron oxides are present throughout this rock mainly as a staining on the phyllosilicates and clay. In association with "pods" of quartz there are patches of goethite/limonite which are up to 0.3 mm across.

This is the most heavily weathered of the three samples from the Little Para Dam and it contains significant amounts of montmorillonite.

APPENDIX III

SAMPLES P384/74 - P387/74.

EXAMINATION FOR MINERALS DELETERIOUS TO A CONCRETE AGGREGATE.

APPENDIX III

Sample: P384/74, TS33034

Rock Name:
Carbonate bearing mica schist.

Hand Specimen:
Beige coloured schistose meta siltstone.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	30-35
Feldspars	5
Muscovite and other Phyllosilicates	20
Carbonate	40
Opaques	1
Biotite	Trace

This sample represents a carbonate-bearing siltstone which has undergone greenschist facies regional metamorphism.

The rock is most probably unsuitable for use in concrete aggregate because it contains (?) dolomite and phyllosilicates.

Independent whole rock X.R.D. analysis indicated the following minerals and proportions.

Dolomite	D (Dominant)
Quartz	SD (Sub-dominant)
Muscovite	SD
Biotite or similar	SD
Feldspar (Albitic)	A (Accessory)
Chlorite	A
K-Feldspar	Tr (Trace)

Sample: P385/74, TS33035

Rock Name:
Feldspathic quartzite

Hand Specimen:
Fine grained, well sorted quartzitic feldspar bearing rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	75
K-Feldspar	20-25
Lithic fragments	2
Plagioclase	1
Opaques	trace
Muscovite	trace
Zircon	trace

The rock would most probably be suitable for use in concrete aggregate as it does not contain abundant phyllosilicates, dolomite or reactive forms of silica.

Sample: P386/74, TS33036

Rock Name:
Feldspathic quartzite

Hand Specimen:
Fine grained, well sorted, weakly bedded feldspar-bearing quartzitic rock containing minor muscovite.

Thin Section:
An optical estimate of the constituents gives the following:

	%	
Quartz	70-75	
K-Feldspar	15-20	
Lithic fragments	1-2	(Quartz-feldspar)
Plagioclase	1-2	
Muscovite	3-5	
Opaques	1-2	
Carbonate(?)	1-3	
Zircon, Sphene, rutile	trace	

The rock is clearly suitable for use in concrete aggregate as it does not contain reactive silica, phyllosilicates, dolomite or pyrite (the last mineral causes cosmetic problems due to secondary iron staining).

Sample: P387/74, TS33037

Rock Name:
Weakly metamorphosed siltstone.

Hand Specimen:
Grey green schistose metasiltstone.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	55-60
Feldspars	5
Muscovite and other Phyllosilicates	
Carbonate	1-2
Opaques	1-2

Texturally and mineralogically this rock closely resembles sample P384/74; however, carbonate is much less abundant and there is less evidence of re-crystallization. Petrographic evidence suggests that the rock would not be suitable for use in concrete aggregate for the earlier mentioned reasons. Independent whole rock X.R.D. analysis indicated the following minerals and proportions.

Quartz	D
Muscovite	SD
Plagioclase (albitic)	A
Chlorite	A
(?) Biotite or similar	A
K-Feldspar	Tr

SUMMARY

Sample		Suitability for use in concrete Aggregate
P384/74	Carbonate-bearing mica schist	Unsuitable
P385/74	Feldspathic quartzite	Suitable
P386/74	Feldspathic quartzite	Suitable
P386/74	Feldspathic quartzite	Suitable
P387/74	Meta-siltstone	Unsuitable

APPENDIX IV

HOEK SHEAR BOX: TEST RESULTS

Job no: A160/1

Sheet 1 of 2

HOEK SHEAR BOX (Summary Sheet)

office: ADELAIDE

client: S.A. DEPARTMENT OF MINES	date: 6/11/74
project: LITTLE PARA DAM	by: RAR & GS
location:	checked:

sample identification: UNIT 10, QUARTZITE. NORTH OF CENTRE. SAMPLE 1

SUBSTANCE DESCRIPTION: QUARTZITE, fine to medium grained, slightly weathered, strong

DEFECTS: One planar defect with interlocking asperities. 1-2 mm high

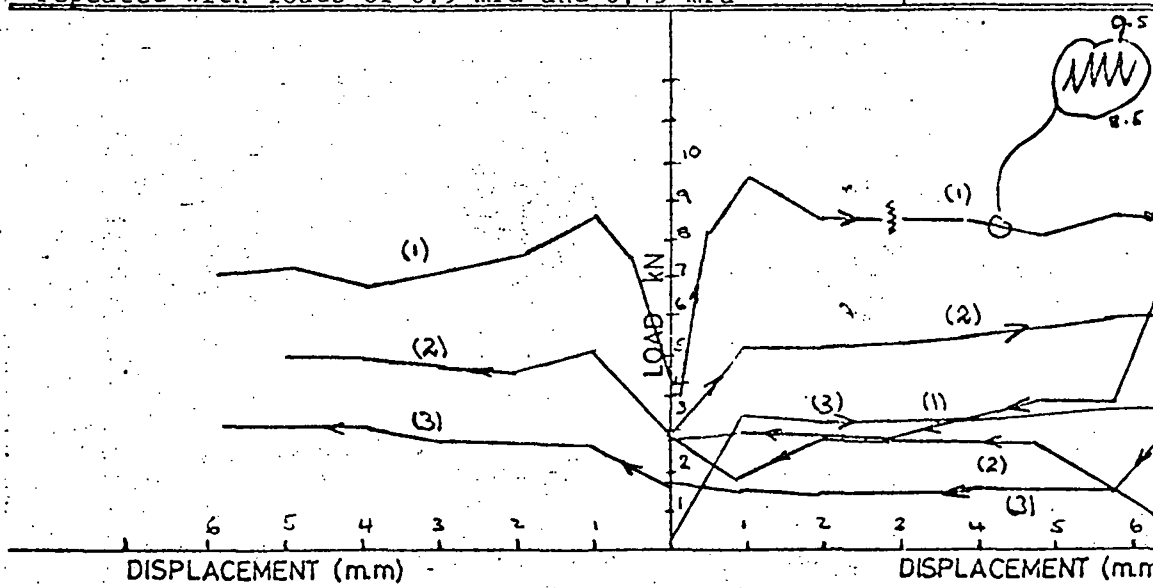
PHYSICAL PROPERTIES

Weight=	670.2	grns
Volume=	262	ccs
Bulk Density=	2.56	t/m^3
Moisture Cont=	-	%
Shear Area=	6.8×10^{-3}	m^2

TEST PROCEDURE: Normal load of 1.5 mPa applied. Shear applied to displace 7.0 mm, load reversed to bring back to starting position and shear continued until approx. 7.0 mm displacement in direction opposite to initial displacement. Procedure repeated with loads of 0.9 mPa and 0.45 mPa

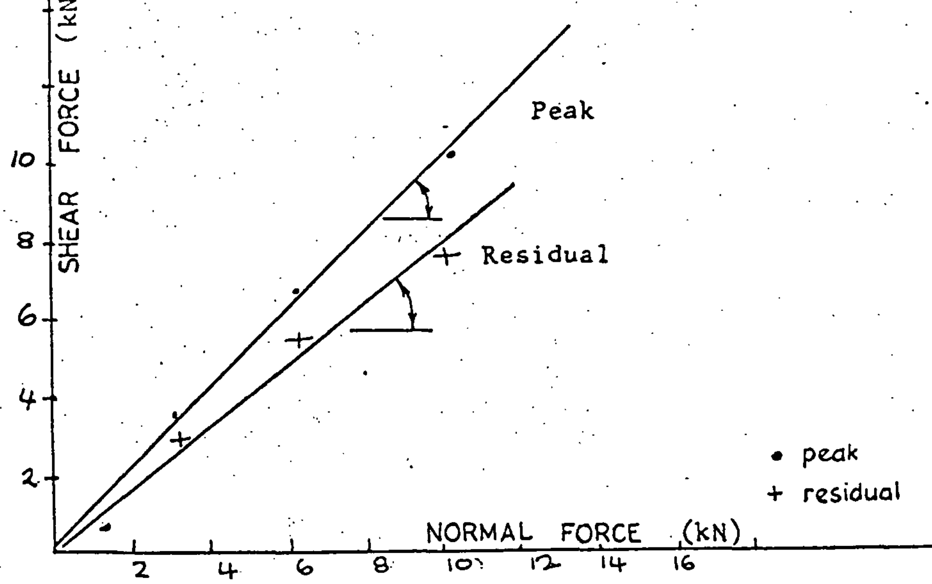
STRAIN RATE mm/min

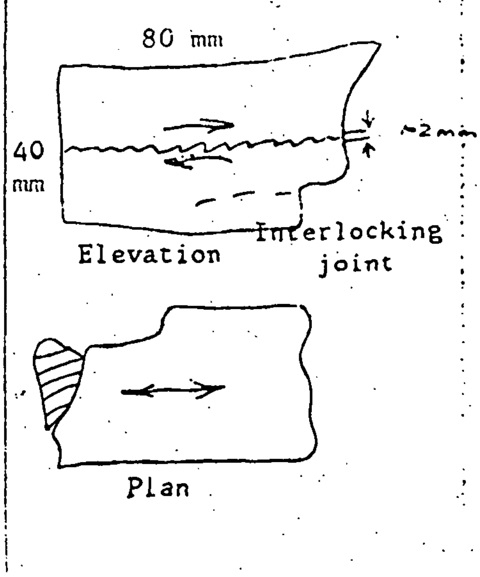
Stage	Normal Load	Normal Stress
(1)	10 kN	1.5 mPa
(2)	6	0.9
(3)	3	0.45



Note: Very erratic movement in all phases of test

Note: (1) Readings approximate owing to erratic movement
(2) Gauge readings corrected for ram friction





SAMPLE SKETCH

job no: A160/1

sheet 1 of 2

HOEK SHEAR BOX (Summary Sheet)

office: ADELAIDE

client: S.A. DEPARTMENT OF MINES
project: LITTLE PARA DAM
location:
sample identification: No. 2

date: 12/11/74
by: GS & RAR
checked:

SUBSTANCE DESCRIPTION: Dolomite siltstone, grey thinly laminated (1 mm bedding) finely micaceous

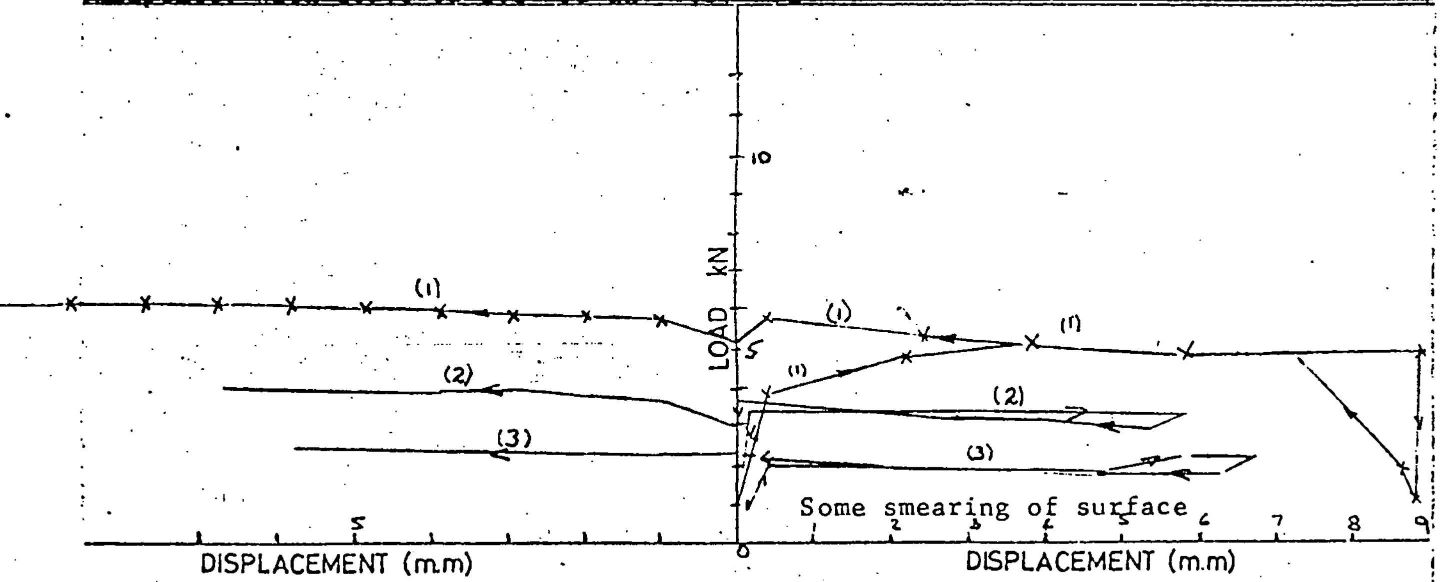
DEFECTS: Planar joint along bedding
Surface undulations ± 1-2 mm. Sample interlocks but not tightly

PHYSICAL PROPERTIES		
Weight =	1065.1	gms
Volume =	426	ccs
Bulk Density =	2.50	t/m^3
Moisture Cont. =	-	%
Shear Area =	5.3×10^{-3}	m^2

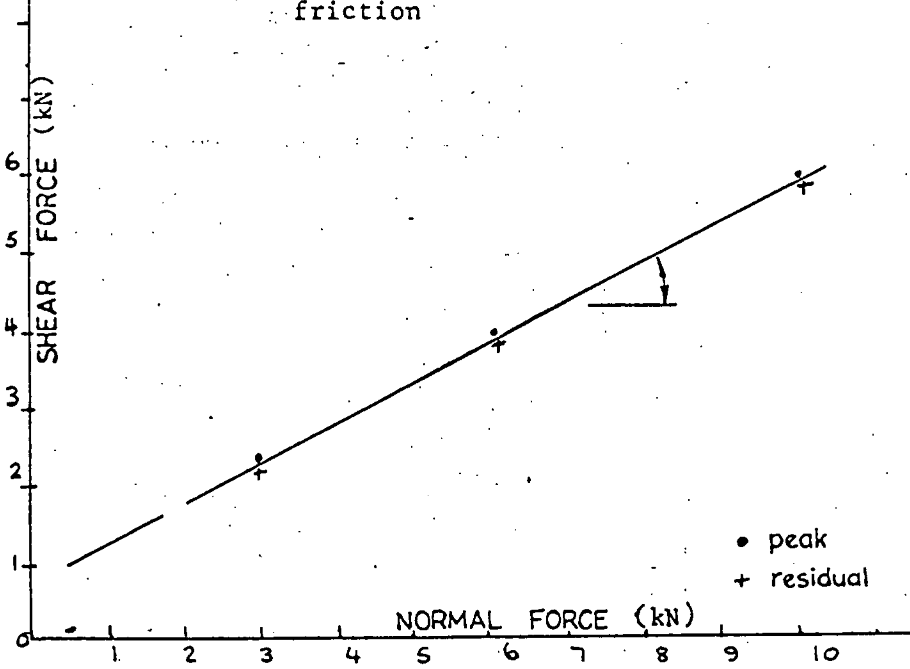
TEST PROCEDURE: Normal load of 1.9 mPa applied. Shear applied to displace approx. 7.0 mm, load reversed to bring back to starting position and shear continued until approx. 7.0 mm displacement in direction opposite to initial displacement. Procedure repeated with loads of 1.1 mPa and 0.57 mPa

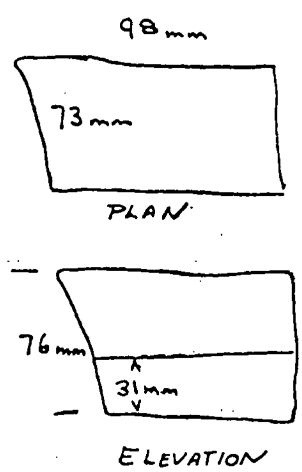
STRAIN RATE mm/min

Stage	Normal Load (kN)	Normal Stress (mPa)
(1)	10	1.9
(2)	6	1.1
(3)	3	0.57



(1) Gauge readings corrected for ram friction





SAMPLE SKETCH

job no: A160/1

sheet 1 of 2

HOEK SHEAR BOX (Summary Sheet)

office: ADELAIDE

client: S.A. DEPARTMENT OF MINES

project: LITTLE PARA DAM

location:

sample identification: No. 3

date: 11/11/74

by: RAR:& GS

checked:

SUBSTANCE DESCRIPTION: QUARTZITE - UNIT 10
grey brown, strong-very strong, fresh to slightly weathered

DEFECTS: UNDULATING SURFACE (UNDULATIONS ± 8 mm) though microsurface relatively smooth with fine lime coating

PHYSICAL PROPERTIES

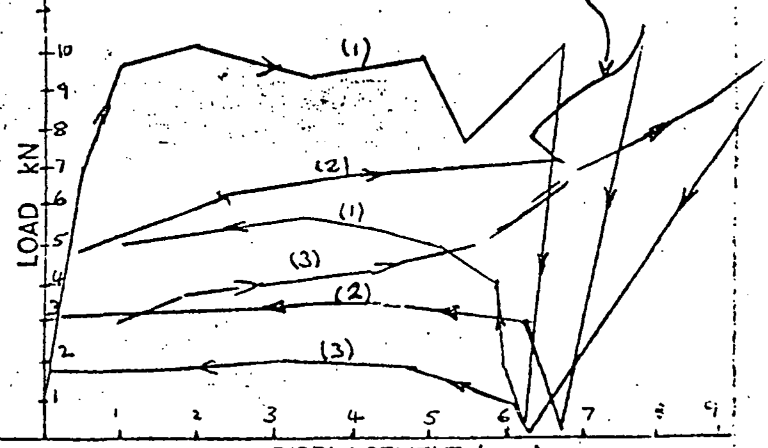
Weight =	1037	gms
Volume =	408	ccs
Bulk Density =	2.54	t/m³
Moisture Cont. =	-	%
Shear Area =	6.1×10^{-3}	m²

TEST PROCEDURE: Normal load of 1.6 mPa applied Shear applied to displace 7.0 mm and then load reversed to bring back to zero displacement. Procedure repeated with normal loads of 1.0 and 0.5 mPa

STRAIN RATE mm/min

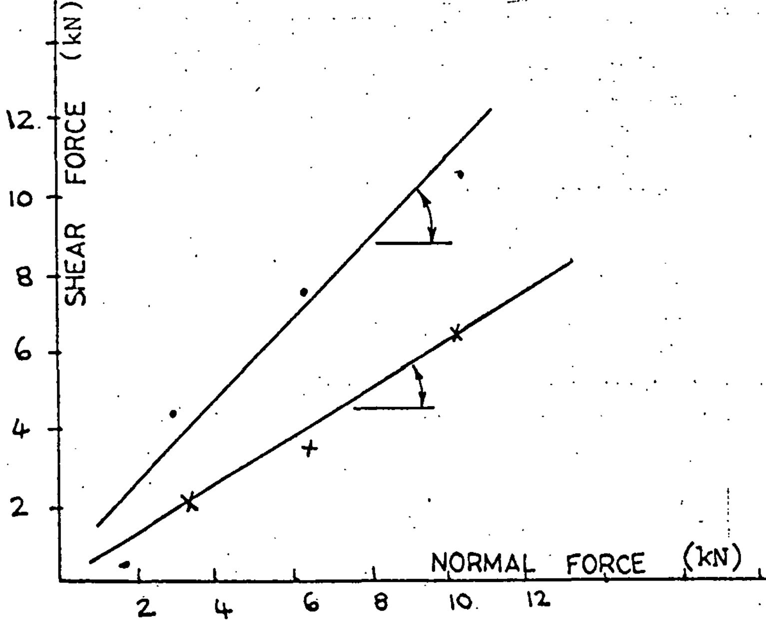
Stage	Normal Load	Normal Stress
(1)	10 kN	1.6 mPa
(2)	6	1.0
(3)	3	0.5

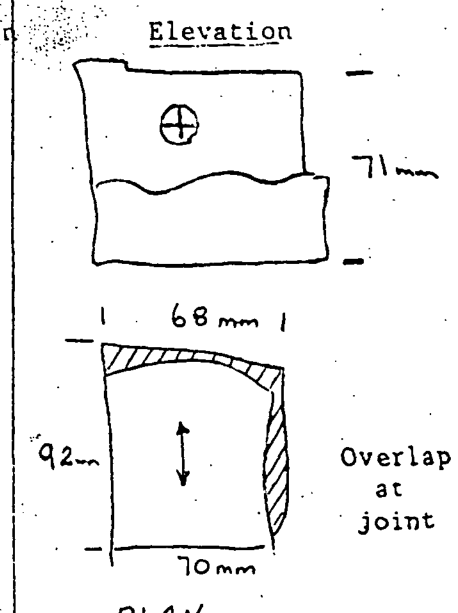
NOTE: Minor grinding of asperities and flaking of corners



DISPLACEMENT (m.m)

(1) Gauge readings corrected for ram friction





SAMPLE SKETCH

job no: A160/1

sheet 1 of 2

HOEK SHEAR BOX (Summary Sheet)

office: ADELAIDE

client: S.A. DEPARTMENT OF MINES
project: LITTLE PARA DAM
location:
sample identification: No. 4

date: 12/11/74
by:
checked:

SUBSTANCE DESCRIPTION: Dolomite siltstone

thinly laminated highly weathered, weak

DEFECTS:

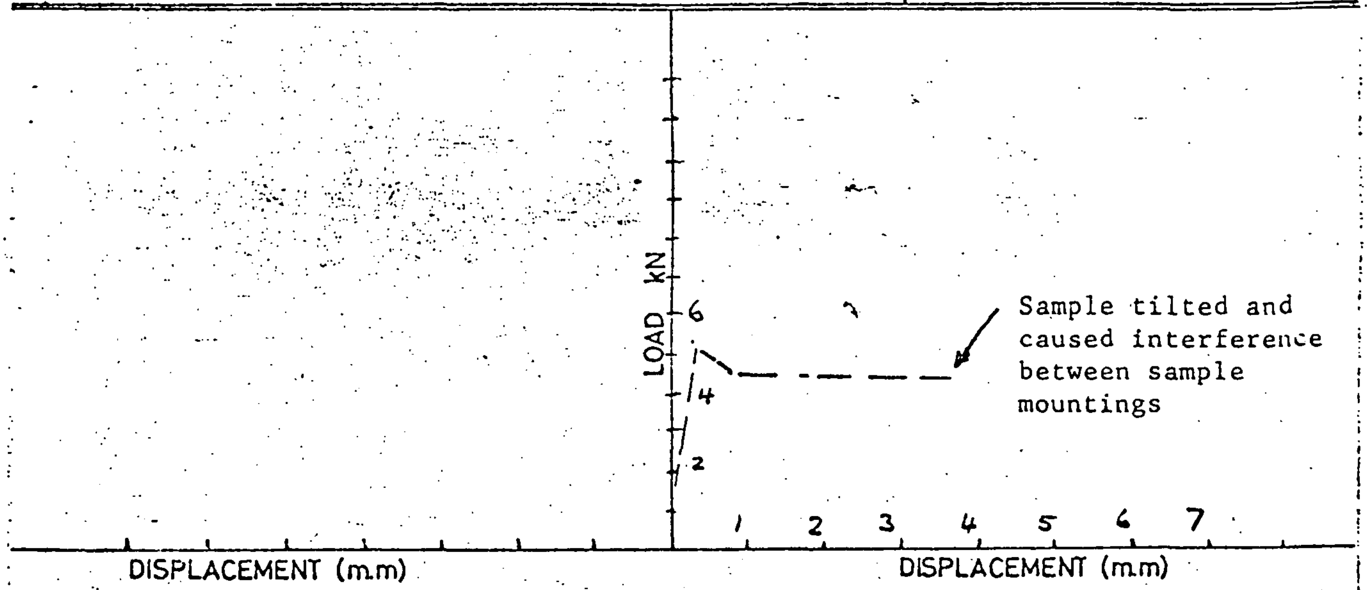
PHYSICAL PROPERTIES

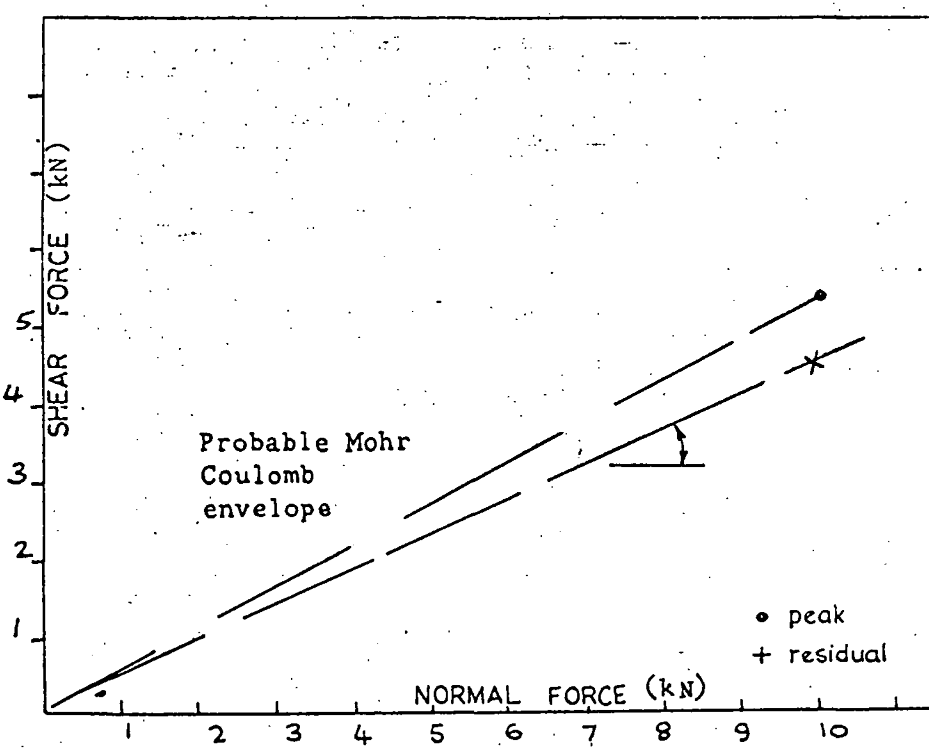
Weight=	1232	gms
Volume=	710	ccs
Bulk Density=	1.74	t/m^3
Moisture Cont=	27.4	%
Shear Area=	7.8×10^{-3}	m^2

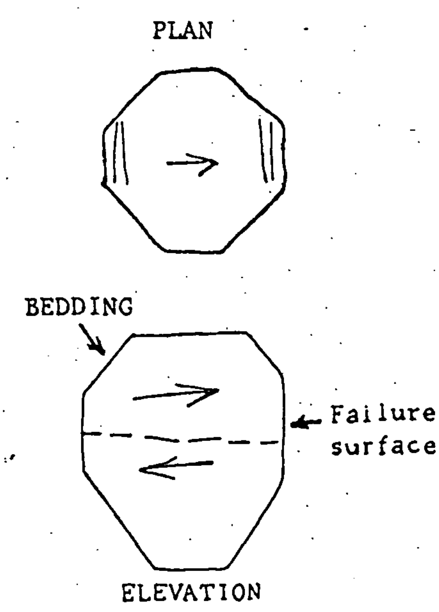
TEST PROCEDURE: Normal load 1.3 mPa applied. Shear applied to displace 4.0 mm. Sample tilted and caused interference between plaster sample mountings. Test discontinued.

STRAIN RATE mm/min

Stage	Normal Load	Normal Stress
(1)	10 kN	1.3 mPa
(2)	6	
(3)	3	







SAMPLE SKETCH

APPENDIX V

SOIL PROFILE LOGS

THE ENGINEERING AND WATER SUPPLY DEPARTMENT

TRIAL HOLE LOG

JOB: LITTLE PARA RESERVOIR

DATA LOGGED: 13/8/73

	DEPTH	PRIMARY TYPE	SECONDARY TYPE	COLOUR	M.C.	CONSISTENCY	REMARKS
Hole 1	0 - 140 mm	Top soil	Some organic matter	Dark brown	4	3	Holes 1-4 Upstream of Grout Cap
	140 - 920 mm	Clay		Deep red	3	2	Right Bank
	920 mm	Inpenetrable layer of Shale					Could chip with auger
Hole 2	0 - 380 mm	Top soil (silty sand)	Pockets of Organic matter	Dark brown	4	3	
	380 - 920 mm	Limestone	Weathered with some clay	Off white Mottled orange	3	Disturbed	
	920 mm	Inpenetrable layer of Hard carbonate rock					
Hole 3	0 - 178 mm	Top soil (sandy silt)	Patches of Organic matter	Dark brown	4	3	
	178 - 457 mm	Clay	with some sand	Reddish brown	3-4	3	
	457 - 920 mm	Limestone	Weathered	White stained brown	3	Disturbed	
	920 mm	Inpenetrable layer Hard carbonate rock					

T.H. TYPE

A. Auger
T. Test pit
G. Hollow Auger 50.8 mm

M.C.

1. Dry
2. Humid
3. Damp
4. Moist
5. Wet
6. Very wet

CONSISTENCY

1. Hard or cemented
2. Stiff or Dense
3. Firm or Medium Dense
4. Soft or Loose
5. Very Soft

THE ENGINEERING AND WATER SUPPLY DEPARTMENT

TRIAL HOLE LOG

JOB: LITTLE PARA RESERVOIR

DATE LOGGED: 13/8/73

	DEPTH	PRIMARY TYPE	SECONDARY TYPE	COLOUR	M.C.	CONSISTENCY	REMARKS
Hole 4	0 - 320 mm	Top soil	Organic	Dark brown	4	3	Upstream of grout cap; right bank
	320 - 1830 mm	Clay		Deep red	3	2	
	1830 mm	Inpenetrable layer of Shale					
Holes 5, 6, 7	12 - 30 mm	Topsoil overlying inpenetrable rock (carbonate)					Holes 5,6,7 located 45 metres downstream of the main investi-gation trench adjacent to downstream outline of dam.

T.H. TYPE

A. Auger
T. Test Pit
G. Hollow Auger 50.8 mm dia.

M.C.

1. Dry
2. Humid
3. Damp
4. Moist
5. Wet
6. Very wet

CONSISTENCY

1. Hard or Cemented
2. Stiff or Dense
3. Firm or Medium Dense
4. Soft and Loose
5. Very soft

APPENDIX VI

TESTING OF COMPLETELY WEATHERED DOLOMITE

TESTING OF COMPLETELY WEATHERED DOLOMITE TAKEN FROM THE RIGHT BANK GROUT CAP EXCAVATION

Engineers on the site requested that the decomposed rock found in the excavation for the grout cap at the top of the right abutment be tested and the following properties ascertained.

1. Grading and dispersion properties
2. Atterberg limits
3. Permeability

This information is to be used to determine the likely behaviour of this material when subjected to the head at full storage level of the reservoir.

Three tube samples were taken by the Soils and Foundations Laboratory, Engineering and Water Supply Dept. The samples were of soft decomposed dolomitic siltstone underlying a quartzite stratum and all samples were taken from the downstream face of the trench. In addition bag samples of this material was taken.

In situ the material appeared to vary over the depth of the deposit. Most apparent variations were in the moisture content, suggesting possible local water paths, and also the brittleness. In places the material was very fractured and could easily be broken into small, strong rectangular prisms. The three sub types i.e. normal, higher M.C.%, fractured, were all sampled and it was attempted to quantify the relative permeabilities in the laboratory.

RESULTS

The following results have been obtained from standard laboratory testing procedure on the material sampled:-

SAMPLE	M.C. %	SAND %	SILT %	CLAY %	L.L. %	P.L. %	k(perm) m/sec.	HT OF SAMPLE (mm)	HEAD WATER (mm)
1.	12	20(f) 5(m)	64	11	34	25	5.5×10^{-7}	100	1530
2.	19	29(f) 11(m) 4(c)	47	9	42	31	*	100	-
3.	11	29(f) 8(m) 5(c)	49	9	41	28	8.28×10^{-6}	65	1630

f = fine m = medium c = coarse

A clay dispersion test was done. This gave a negative result, i.e. no dispersion of fine material was noticed.

Comment on Permeability Values

The permeability test was carried out on the actual tube samples as taken in the field,i.e. no sub-sampling was necessary. This avoided any further disturbance to the material. Even so, some disturbance when jacking the samples in the field is unavoidable and in this case because of the presence of layers of very friable material is likely to cause significant increases in the permeability value as obtained from the laboratory test.

In all the tests the operator noticed an early rush of water through the sample which then slowed as a steady state flow was achieved. After the test was completed the sample was broken up and it was noticed that there had been a transportation of the fine particles through the sample. In sample I these particles were deposited on a fissure at right angles to the direction of flow. In sample 3 the fine particles migrated through the entire sample. Sample I probably gave the only realistic answer.

In samples 2 and 3 the operator noticed water passing through three or four small holes as well as around the edges of the sample. The hole in sample 3 was approx. 3-6 mm Ø and no sensible result could be obtained.

It would be dangerous to disregard these samples altogether as the layers of very friable material break off prismodially and constitute easy access paths for the water. However, the disturbance associated with sampling will have contributed to the high leakage between the sample and the tube. To get the effect of these causes into perspective is mostly intuitive.

Therefore, it is suggested that a permeability of 5×10^{-7} m/sec be used.

This result is similar to one obtained previously when other tests on similar material obtained from the upstream part of the abutment were done.

The confidence level which can be assigned to the above given value of permeability must be low (2 test results). If a decision, based on this result, involves expensive remedial work, it may be advisable to arrange for more tests to be done.

ASSISTANT DESIGNING ENGINEER

SOILS AND FOUNDATIONS

LITTLE PARA DAM

TESTING OF COMPLETELY WEATHERED DOLOMITE-RIGHT ABUTMENT

		SAMPLE 1	SAMPLE 2	SAMPLE 3
Moisture Content %		12	19	11
Liquid Limit		34	42	41
Plasticity Index (LL.-P.)	P.I. 20% is suspect	9	11	13
% passing .425 mm		99	93	93.5
Mech Analysis % passing .075 mm		81	63	65.5
% finer than 0.0005 mm	25% 0.0005 is suspect	17	14	13.5
% clay		11	9	9
Activity = PI / * % finer than .002 mm	Corrected activity should be 0.6	0.82	1.29	1.44

* Some typical Activity values are:-

Bentonite	7.2
Calcium Montmorillonite	1.5
Illite	0.9
Kaolinite	0.3 - 0.5
Clay Size (Mica	0.23
Clay Size (Calcite	0.18
Clay Size (Quartz	0

Values for the Activity Index fall within three main groups:

INACTIVE CLAY	0.75
NORMAL CLAY	0.75 - 1.25
ACTIVE CLAY	1.25

APPENDIX VII

DEFINITION OF ROCK TERMS

ENGINEERING CLASSIFICATION OF ROCK MATERIAL

1. ROCK CONDITION

TERM	ABBRN	DEFINITION
Fresh	(F)	No weathering effects visible to naked eye.
Weathered rock shows visible effects of chemical decomposition caused by air and groundwater. Can be subdivided.		
Slightly weathered	(SW)	- rock slightly discoloured particularly along fissures but no loss in strength.
Moderately weathered	(MW)	- discolouration starting to penetrate inwards from fisures and noticeable loss in strength
Highly weathered	(HW)	- discoloured with weathering penetrating deeply inwards but corestones are still present.
Completely weathered	(CW)	- changed to soil but original rock fabric may be preserved.
Altered	(A)	Shows chemical and physical alteration to rock fabric caused by temperature, pressure or injection of other material.

2. ROCK STRENGTH

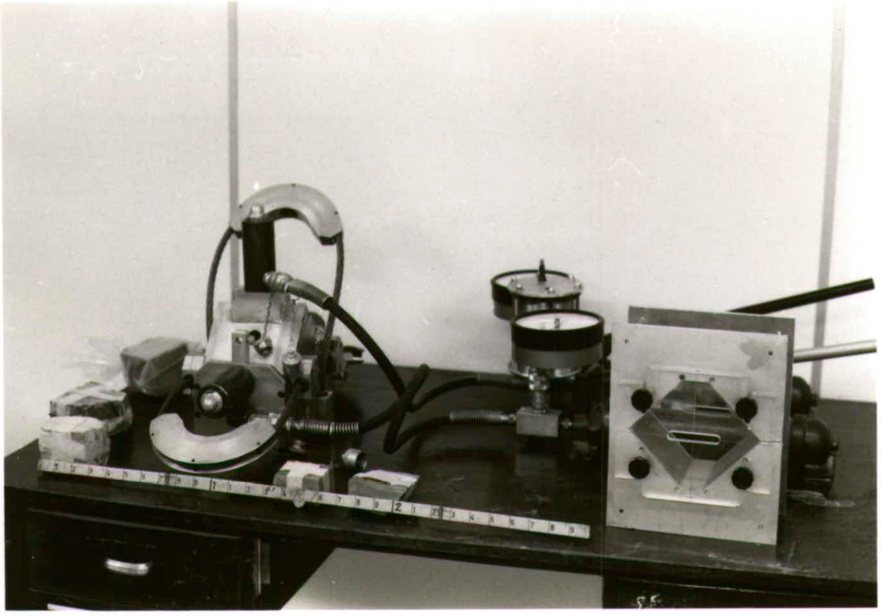
Can be correlated with uniaxial compressive strength tested on small intact samples in the laboratory.

TERM	ABBRN	MPa (p.s.i.)	FIELD TEST
Very weak	VW	<5 (730)	Breaks and crumbles easily in the hands.
Weak	W	5-12 (730-1750)	Breaks easily with hammer tap.
Medium strong	MS	12-50 (1750-7300)	Rings and breaks to firm hammer blow (Range of concrete).
Strong	S	50-100 (7300-14600)	(Very difficult to break with (hammer
Very strong	VS	>100 (>14600)	(and requires sledge (

Note that Condition and Strength terms do not necessarily correspond, e.g.

Rock Material	Conditions	Strength
Granite	Fresh	Strong
Schist	Fresh	Weak

PLATES

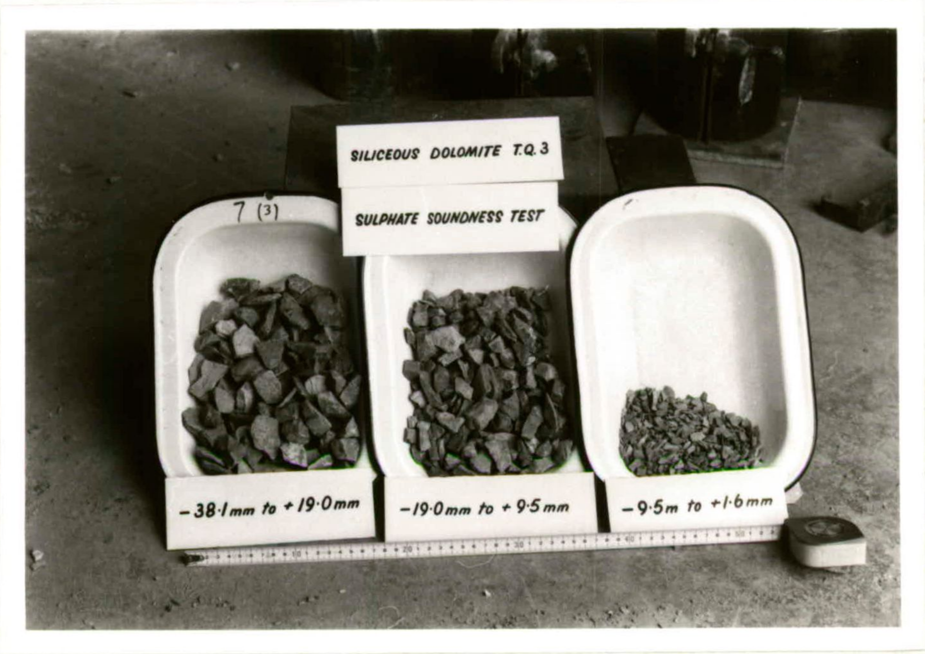


1. HOEK SHEAR BOX

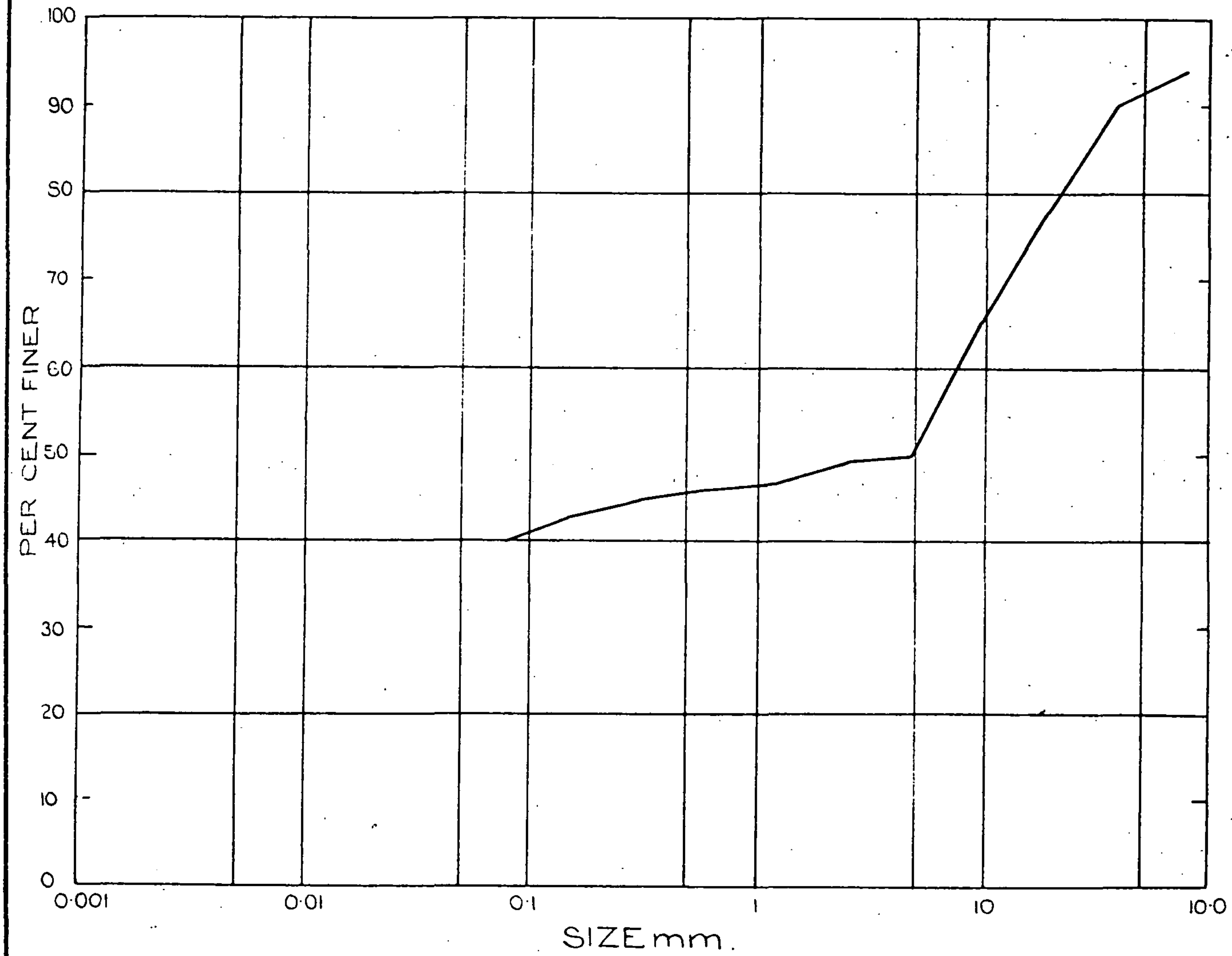
26522

2. POINT LOAD TESTER

26523



3. SULPHATE SOUNDNESS TEST ON SILICEOUS DOLOMITE 26521.



CLAY	SILT			SAND			GRAVEL
	Fine	Medium	Coarse	Fine	Medium	Coarse	

Mechanical Analysis	% Passing	Mechanical Analysis	% Passing	Soil Test Constants
75 mm.		9·5mm. (3/16")	56	LL. 46·4
63 mm.	96	6·7mm. (No. 7)	49	PL. 13·7
53 mm.	90	4·75mm. (No. 14)	47	PI. 32·17
37·5mm.	84	2·36mm. (No. 25)	46	LINEAL SHRINKAGE 8·7%
26·5mm.	78	1·18 mm. (No. 52)	45	COMPACTION TEST
19 mm.	71	600 mm. (No. 100)	43	Mod. A.A.S.H.O.
16 mm.	65	·425 mm. (No. 200)	40	O.M.C. 11·5% D.D. 120
13·2mm.	56			

FIG 1.

ENGINEERING GEOLOGY SECTION	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale :
Compiled J.C.B.	LITTLE PARA DAM	Date : 15-1-76
Drn. J.W. Ckd	MECHANICAL ANALYSIS-SOIL ROAD FILL	Drg. No. S12069

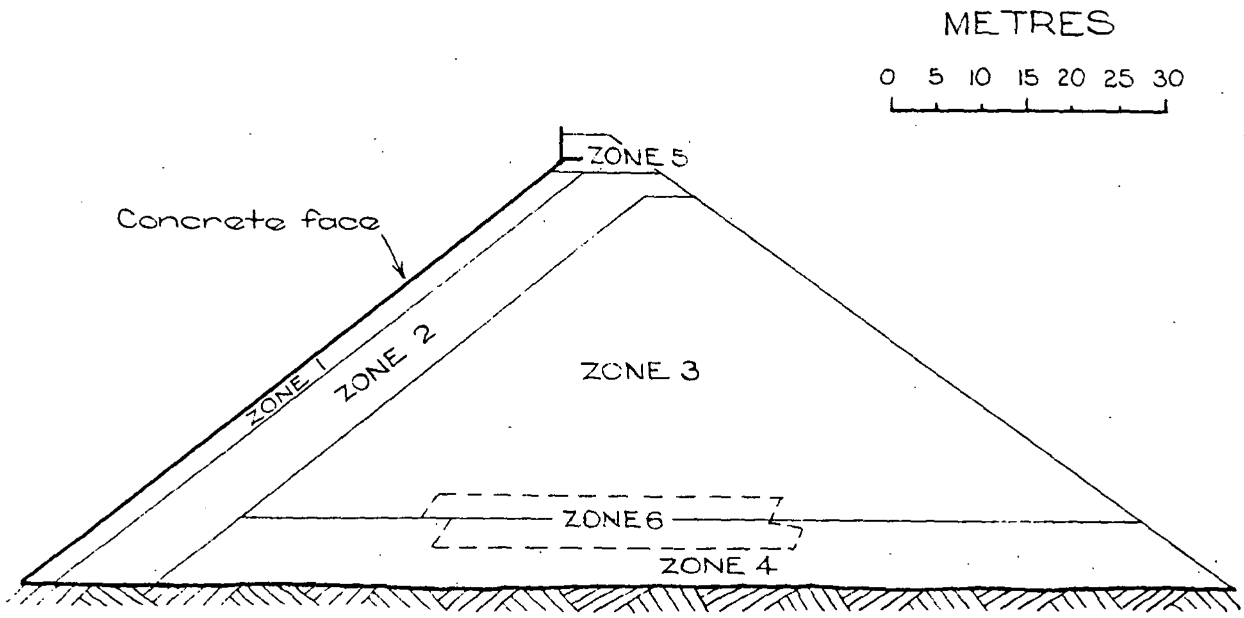


TABLE VI
DESIGN CRITERIA FOR ROCKFILL ZONES

ZONE 1 of well graded durable rock compacted in horizontal layers not exceeding 0·5 m. in thickness when compacted and graded as specified.

ZONE 2 of up to 1000 mm rock with not greater than 20% passing a 26·5 mm sieve compacted in horizontal layers not exceeding 1·0m in thickness when compacted.

ZONE 3 of up to 1000 mm rock with not greater than 30% passing a 26·5 mm sieve. Compacted in horizontal layers not exceeding 1·0 m thickness when compacted.

ZONE 4 of up to 1 300 mm rock with not greater than 20% passing a 26·5 mm sieve. Compacted in horizontal layers not exceeding 1·3 m in thickness when compacted

ZONE 5 of up to 500 mm rock with not greater than 40% passing a 26·5 mm sieve. Compacted in horizontal layers not exceeding 0·5 m in thickness when compacted.

ZONE 6 of up to 300 mm rock with not more than 40% passing a 26·5 mm sieve. Compacted parallel to the duct centre line in horizontal layers approx. 2·0m. thick when compacted.

FIG. 2

	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale :
Compiled J.C.B.	LITTLE PARA DAM CROSS SECTION SHOWING ROCKFILL ZONES	Date : 15 - 1 - 76
Drn J.W. Ckd		Drg. No. S12070

750—8.74 F332 O

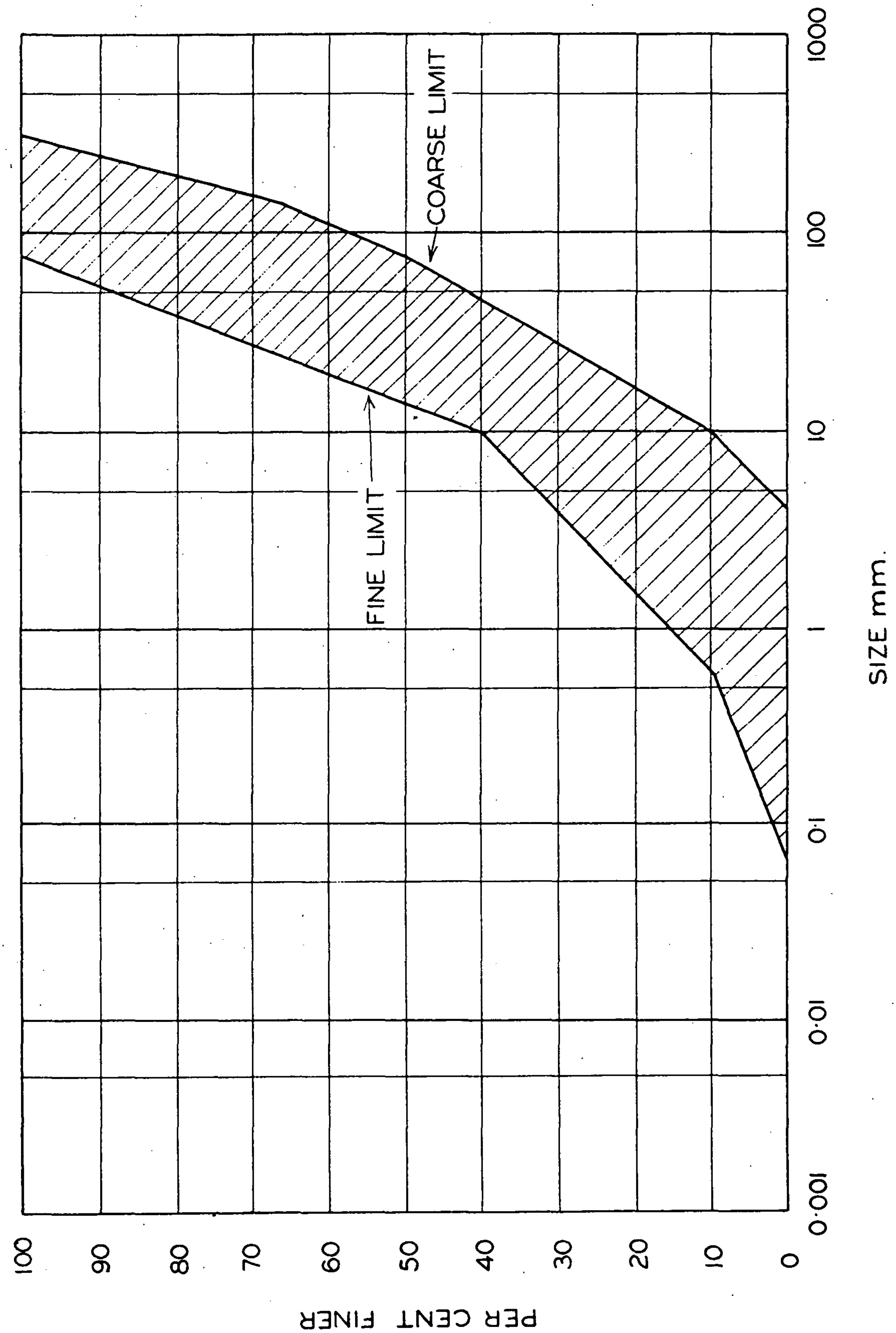


FIG. 3

DEPARTMENT OF MINES — SOUTH AUSTRALIA

LITTLE PARA DAM
EMBANKMENT
GRADING ENVELOPE FOR ROCKFILL IN ZONE I

Scale :

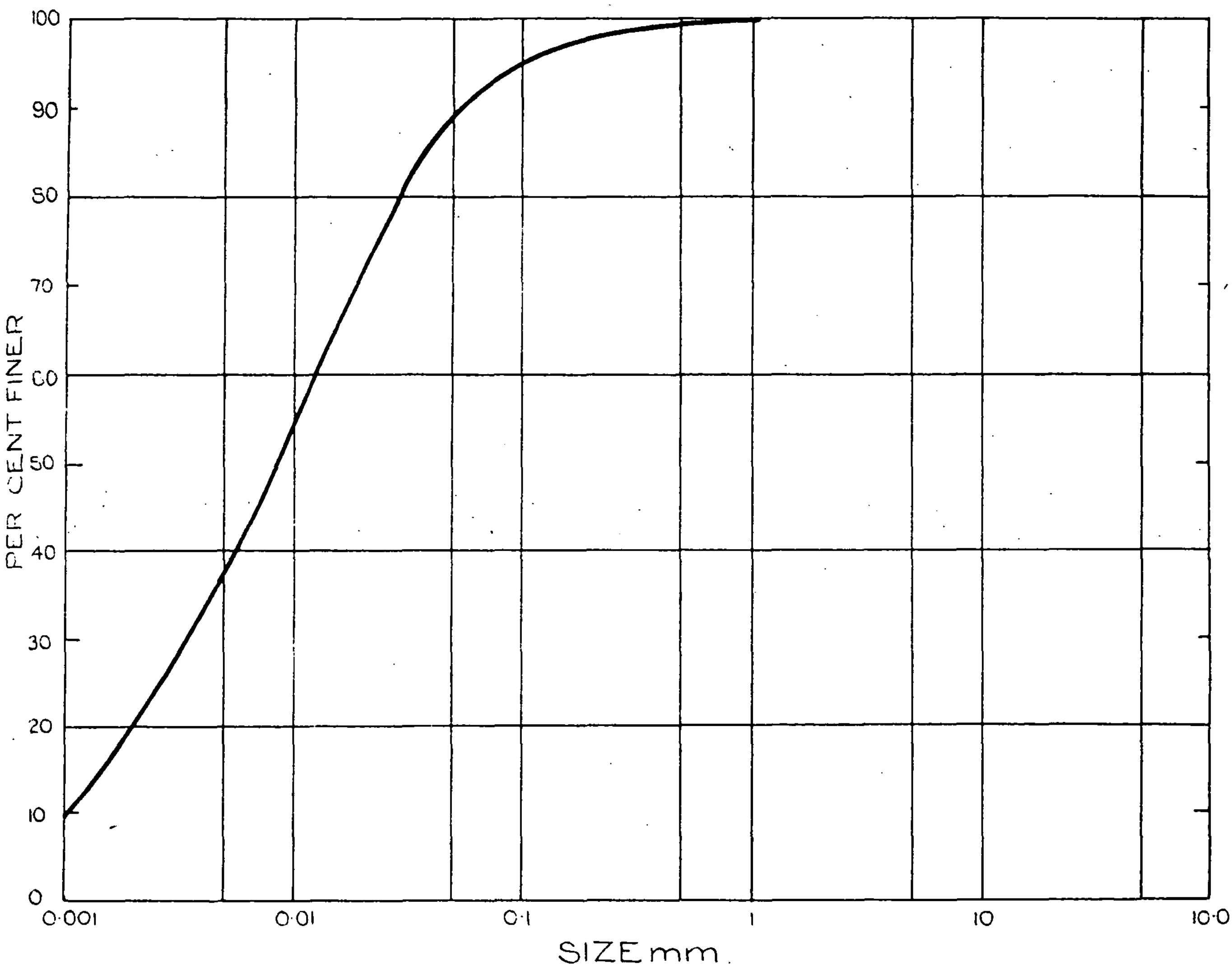
Date : 10th July '75

Drg. No. S11591

Compiled : J.C.B.

Drn. J.W. | Ckd

750—8.74 F332 O



Fine	Medium	Coarse	Fine	Medium	Coarse	
CLAY	SILT		SAND			GRAVEL

FIG 4

Date tested : 11-3-75

ENGINEERING GEOLOGY SECTION	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale :
Compiled J.C.B.	LITTLE PARA DAM LEFT BANK GROUT CAP MECHANICAL ANALYSIS - WEATHERED DOLOMITE	Date : 15-1-76
Drn. J.W. Ckd		Drg. No. S12067

750—8.74 F332 O

FIG. 5

Compiled from E&WS Dept plans   Contour values are in metres

DEPARTMENT OF MINES — SOUTH AUSTRALIA

LITTLE PARA DAM

GEOLOGICAL SUMMARY OF FIELD WORK & SAMPLE LOCATIONS FOR MATERIAL TESTING

ENGINEERING GEOLOGY SECTION	J. BEAL GEOLOGIST	Compiled J.W.	Scale 1:1000
			Date
		Drn A.S.F	Drg No. 76-141
Director of Mines		Ckd	