SECTION 3 : AGGREGATE PROPERTIES OF COARSE-GRAINED GRANITE FROM LAI KING

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FOREWORD

In order to help provide the Materials Division and the Hong Kong Geological Survey with much needed data on the characterization and possible usage of each of the Territory's major rock types the Office initiated the Fresh Rock Testing Programme in 1985.

This report forms part of the Fresh Rock Testing Programme and is one of a series of reports which presents the results of selected aggregate and index laboratory testing carried out on fresh block samples of discrete rock types.

The rock type described in this report is a coarse-grained granite from Lai King.

The author wishes to acknowledge the role played in the field sampling and sample preparation by GE J. M. Nash and TO's W. C. Lee and M. K. Chan and in the laboratory testing by GE K. H. Lee and other laboratory staff. The cooperation and assistance of the Materials Division is also acknowledged.

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CONTENTS

1. INTRODUCTION

This Technical Note on the aggregate properties of fresh, coarse-grained granite from the Lai King area forms the third report in the series of aggregate properties of selected Hong Kong rocks. The report presents the results of selected laboratory physical index and aggregate testing on fresh granite samples collected from a road cutting at Ha Kwai Chung, Lai King, and discusses the results and suitability of coarse-grained granite from this locality as aggregate in comparison with the typical aggregate acceptance values. The suitability of the rock is only assessed on the basis of a narrow range of selected rock properties in this report.

2. SITE DESCRIPTION AND SAMPLING

The sampling site is a 30 m high road cutting (cut slope no. 11NW-A/C29) along Wah Yiu Road opposite Kwai Chung Methodist College, Ha Kwai Chung, Lai King, Kowloon (Figure 1 and Plate 1).

The location from which the sample was taken is situated in the central portion of the cutting about 2 m above the toe (Plate 2). Three block samples were collected from the fresh granite for testing (Plate 3). While this outcrop of coarse-grained granite is not of sufficient size to form an economic source for aggregate, it does provide a typical representative of this rock type in the Territory for testing and assessment.

3. GEOLOGY

3.1 Site Geology

The rock type exposed and sampled in the road cutting is coarse-grained granite (gc). It is intruded by thin aplite dykes and a 3 m wide feldsparphyric rhyolite (rf) dyke trending in an east-northeast direction. The contact between the coarse-grained granite and a fine-grained granite can be observed round the corner along Lai Chi Ling Road (Figure 1). At the sampling station, the granite is slightly weathered and moderately to widely jointed (0.3-1.0 m). This is overlain by moderately to highly weathered granite in the upper portion of the slope. The rock is dissected by four sets of joints forming a blocky to tabular fabric with mean joint orientations of 60/350°, 75/066°, 67/156° and 10/085°.

3.2 Description of Test Sample

Engineering geological description (BS 5930:1981). The rock is very strong, light grey with pinkish patches, crystalline, fresh with slight staining along joint planes, coarse-grained GRANITE with inequigranular and porphyritic texture.

Detailed description. The rock consists of subhedral grains of quartz, alkali feldspar, plagioclase feldspar and biotite. Alkali feldspars are generally light pink in colour and form the larger grains, up to 20 mm in size, in a groundmass of mainly quartz and plagioclase feldspars with an average grain size of 6 to 8 mm. Biotite generally occurs as pods, up to 6 mm in size. Modal analysis carried out on three thin sections (Table 1) gave a mineralogical composition of 36.3% quartz, 60.2% feldspars, and 3.0% biotite.

Detailed description of coarse-grained granite occurring in Sheet 11 area is given in Strange & Shaw (1986).

4. AGGREGATE TESTING AND CHARACTERIZATION

4.1 Sample Preparation and Testing Methods

75 mm diameter cores were drilled from the block samples using a concrete coring machine and diamond bit in the Public Works Central Laboratory. Selected physical and rock index tests were performed on the cores. The remainder of the samples were broken into smaller pieces using a sledge hammer and a laboratory rock breaker. Point load testing was carried out on irregular lumps of rock using ISRM recommended methods (ISRM, 1985). Standard (10-14 mm) and nominal 20 mm size aggregates (Plate 4) were prepared from the smaller pieces of rock using a laboratory jaw crusher.

The rock index tests undertaken included the determination of bulk density, porosity, water absorption and sonic velocity using the PUNDIT (ISRM, 1978). The aggregate tests included aggregate crushing value, aggregate impact value, water absorption, flakiness and elongation indices (BSI, 1975) and Los Angeles abrasion value (ASTM, 1981).

4.2 Classification and Characterization of Aggregate

The CADAM scheme recommended by the Geological Society Working Party on Aggregates (Collis & Fox, 1985) is used to describe and classify the aggregate (Table 2). A more detailed petrographic evaluation of the aggregate is given in Table 3.

4.3 Test Results

The results of rock index tests on cores are given in Table 4. The test results on laboratory crushed coarse-grained granite aggregate are tabulated in Table 5.

5. DISCUSSION ON TEST RESULTS

5.1 Rock Index and Aggregate Properties

The rock index tests given in Table 4 show that the fresh coarse-grained granite from Lai King is a very strong rock with a point load strength value of about 9 MPa (or uniaxial compressive strength of about 225 MPa using the normal conversion factor of 25) and has very low water absorption and porosity properties.

In terms of rock index properties, the coarse-grained granite from this locality has very similar properties to the medium-grained granite from Turret Hill quarry (Table 3, in Irfan & Nash, 1987) having slightly higher dry bulk density (2.62 g/cm^3), lower water absorption (0.21 %) and effective porosity (0.55 %) values and lower point load strength (8.9 MPa). The test values for the medium-grained granite are 2.60 g/cm^3, 0.52 %, 1.34 % and 10.1 MPa respectively.

A comparison of the aggregate test results on the coarse-grained granite

(Table 5) with those of medium-grained granite (Table 6) shows slightly higher and hence less desirable properties for the former rock type in terms of aggregate impact and Los Angeles abrasion values and flakiness index.

The rock index and aggregate values presented in Tables 4, 5 and 6 are those of limited tests carried out on a few block samples chosen from particular single localities for each rock type. Their test values may not therefore be typically representative of the whole rock types occurring in the Territory.

5.2 Suitability of Rock as Aggregate

The existing aggregate quarries in Hong Kong are all in fine- to medium-grained and medium-grained granites (Strange & Shaw, 1986; Choy & Irfan, 1986 a, b). Commercial test results on coarse-grained granite are therefore not available to make a general assessment of the suitability of this rock type as an aggregate source rock. Coarse-grained granites, particularly porphyritic types, are generally less sought after for sources of aggregate because of their relatively low crushing strength which arises from fracturing along cleavages or boundaries of coarse crystalline constituents.

A comparison of the limited laboratory test results in Table 5 with typical, mainly UK, acceptance values (Table 7) indicates that the aggregates produced from the coarse-grained granite at Lai King are just within the acceptable limits for general use in concrete and as roadstone as far as the aggregate properties determined in this study are concerned. In terms of Los Angeles abrasion value, the test value of 31, although acceptable for general concrete purposes, is just outside the maximum value specified by the Australian Standard AS 2748.1-1985 for concrete exposed to severe conditions. Aggregate crushing value (or aggregate impact value) of the rock is also relatively high, making the aggregate from this type of granite less desirable as compared to the fine-grained granite for some special uses such as wearing course or heavy duty concrete floor.

Soundness tests, which are generally executed to determine the durability of aggregate to salt attack, have not been carried out because of the fresh state of the rock tested. It is, however, recommended that soundness tests are carried out if anything but fresh rock is to be used as aggregate. Polished stone values were not determined in this investigation.

6. CONCLUSIONS

The laboratory test results carried out on aggregate produced from the fresh coarse-grained granite collected from a road cutting at Lai King are just within the commonly accepted limiting values for general use in concrete and as roadstone. The aggregate impact value (or crushing value) and Los Angeles abrasion value test results are rather high and near or just above the specified limiting values. This makes the aggregate from this rock type less desirable for special uses such as wearing courses and heavy duty concrete floors compared to aggregates from fine-grained granites or basaltic rocks. No currently operating quarries in Hong Kong are extracting this type of granite and comparative test results are hence not available on plant-crushed aggregates. In-service performance of this granite type is therefore not known. Coarse-grained granites are, however, generally less sought after elsewhere in the world as an aggregate source because of their less desirable

properties.

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LIST OF TABLES

Table 1 - Modal Analysis of Coarse-Grained Granite from Lai King

Mineral	Feldspars (%)	Quartz (%)	Biotite (%)	Others (%)
Thin Section 1	57.5	39.6	2.2	0.6
Thin Section 2	53.6	41.8	3.6	0.7
Thin Section 3	69.5	27.3	3.0	0.0
Average	60.2	36.3	3.0	0.4

Table 2 - Description and Classification of Coarse-Grained Granite by the CADAM System (Collis & Fox, 1985)

AGGREGATE FORM	Crushed Rock		~~Gravel~~	~~Natural~~		~~Sand~~	~~Natural~~		~~Land won~~	
				~~Crushed~~			~~Crushed~~		~~Marine Dredged~~	
				~~Mixed~~			~~Mixed~~			
CLASS (or MISCELLANEOUS)	~~Carbonate Class~~		~~Quartz Class~~	Silicate Class					~~Miscellaneous Material (correct name to be given below)~~	
				Igneous		~~Sedimentary~~		~~Metamorphic~~		
Petrological name (if known)	GRANITE									
GEOLOGICAL AGE/ COLOUR/ GRAIN SIZE FISSILITY	Mesozoic/Light pinkish grey/Fresh/Very coarse-grained, porphyritic/No fissibility									
Comment (if any)										

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Date : 16.4.1987

CADAM - CLASSIFICATION and DESCRIPTION of AGGREGATE MATERIAL

LOCATION AND SAMPLE DETAILS	Quarry/Pit address : Wah Yiu Road Cutting, Lai King, Kowloon Operator : - Sample : Type Blocks Size 50 kg Preparation Lab. Crushed Supplied by E.G. Section	Grid Ref. 831500E 823650N	Date Rec'd
		Date of sampling 12.11.86	Sampling Cert. No. 3675 EG015

Table 3 - Petrographic Evaluation of Coarse-Grained Granite Aggregate

PETROGRAPHIC EVALUATION OF AGGREGATES		
SAMPLE REF LOCATION/GRID REF SAMPLING DATE	3675 EG 015 Wah Yiu Road Cutting, Lai King, Kowloon 831500 E 823650 N 12.11.1986	SAMPLE SIZE/WEIGHT Bulk sample : 50 kg Sub-sample : 1 kg (10-14 mm)
AGGREGATE PROPERTIES Particle Shape (BS 812:1975)	Mainly angular to irregular	
Surface Texture (BS 812:1975)	Crystalline	
Coating	None	
Cleanliness (Dust etc)	Some dust resulting from aggregate crushing	
GEOLOGICAL PROPERTIES Rock Type (GSS Classification)	Coarse-grained GRANITE (gc)	
Mineralogy		
Major Constituents	Quartz (36.3%), Feldspars (60.2%), Biotite (3.0%)	
Minor Constituents	Magnetite, chlorite, zircon	
Cementing Materials	Crystalline, no cementing minerals	
Expansive Minerals	None	
Weathering of Particles	Fresh, very few particles show slight staining	
Organic Material Content	None	
GENERAL COMMENTS	Granite is inequigranular and porphyritic with grain size 1 to 10 mm, occasionally 30 mm	Compiled by Date 16.4.1987
ADDITIONAL INFORMATION		

Table 4 - Rock Index Properties of Coarse-Grained Granite from Lai King

Rock Index Property		Average Value	Range
Mineral Grain Specific Gravity	(g/cm^3)	n.d.	n.d.
Bulk Density Dry	(g/cm^3)	2.62	2.61-2.62
Saturated	(g/cm^3)	2.62	2.62
Water Absorption	(%)	0.21	0.21
Porosity Total	(%)	n.d.	n.d.
Effective	(%)	0.55	0.54-0.56
Sonic Velocity	(m/s)	5008*	4890-5160
Point Load Strength	(MPa)	8.9+	7.0-11.3

Legend :

n.d. Not determined

\+ Mean of 16 tests on irregular lumps (ISRM, 1985)

* Determined on 75 mm diameter cores (ISRM, 1978)

Table 5 - Test Results on Laboratory Crushed Coarse-Grained Granite Aggregate (10-14 mm) from Lai King

Aggregate Property			Test Value+
Aggregate Crushing Value,	ACV	(%)	23
Aggregate Impact Value,	AIV	(%)	25
Los Angeles Abrasion Value,	LAAV	(%)	31
Water Absorption		(%)	0.3
Flakiness Index,	I_F	(%)	11
Elongation Index,	I_E	(%)	34

Legend :

\+ Mean of two test results

Table 6 - Test Results on Laboratory Crushed Medium-Grained Granite Aggregates (10-14 mm) from Turret Hill

Aggregate Property			Test Value
Aggregate Crushing Value,	ACV	(%)	23
Aggregate Impact Value,	AIV	(%)	24
Los Angeles Abrasion Value,	LAAV	(%)	29
Water Absorption		(%)	0.5
Flakiness Index,	I_F	(%)	7 (20)*
Elongation Index,	I_E	(%)	41 (30)*

Legend :

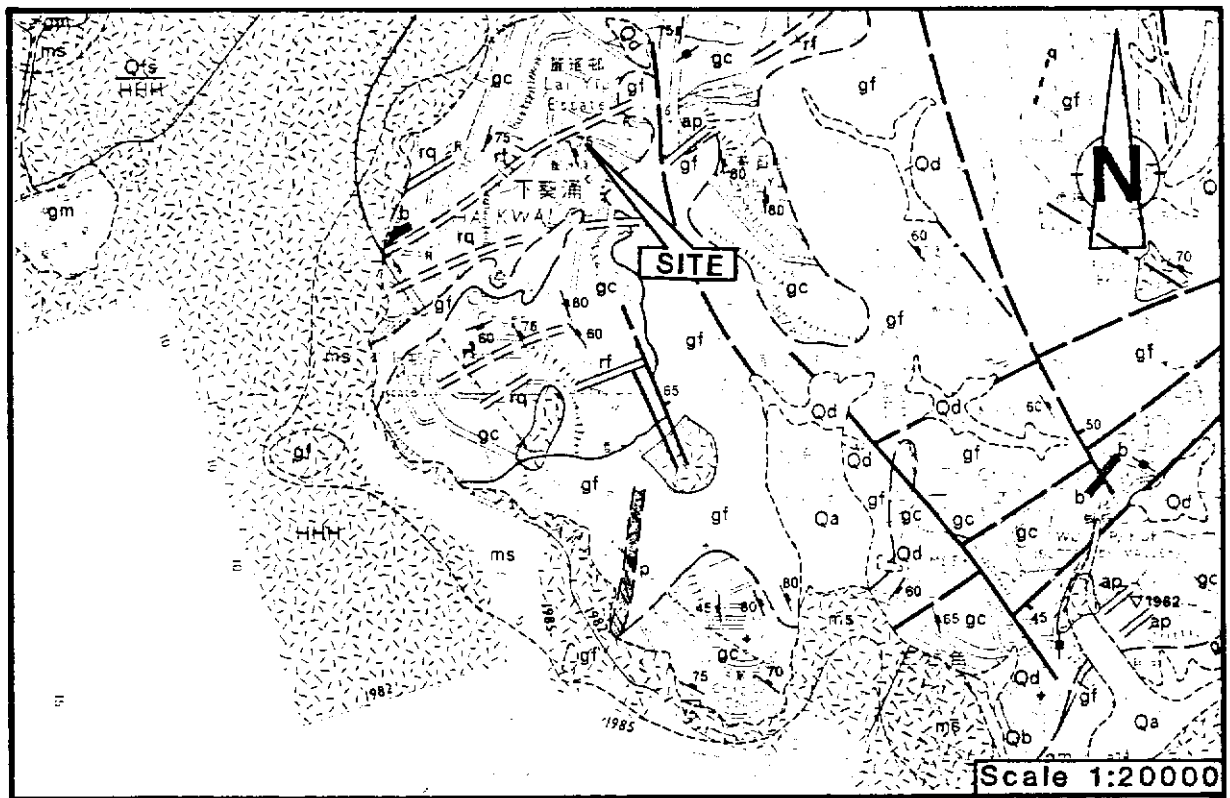
* 14-20 mm aggregate

Table 7 - British Standard and Other Acceptance Values for Test Results on Roadstone and Concrete Aggregates

Test	Test Value	Use	Authority
Aggregate Crushing Value, ACV (%)	Maximum 30	C.R.	Higginbottom (1976)
Aggregate Impact Value, AIV (%)	Maximum 45+ Maximum 30*	C.R.	BS 882:1983
10% Fines Value (kN)	Minimum 50+ More than 100* More than 150*	R.C. R. C.	Hosking & Tubey (1969) BS 882:1983 BS 882:1983
Aggregate Abrasion Value, AAV (%)	Maximum 10 (diff. cond.) Maximum 12 (av. cond.)	R.	DoT (1976)
Los Angeles Abrasion Value, LAAV (ASTM C-131)	Maximum 30 (diff. cond.) Maximum 40 (av. cond.) Maximum 35*	C. C. R.	Australian Standard 2758.1 (1985) Shergold (1948)
Water Absorption (Porosity) (%)	Less than 3+	C.R.	Higginbottom (1976) BS 5337:1976
Bulk Density (g/cm^3)	More than 2.60	C.R.	Higginbottom (1976)
Flakiness Index, I_F	Less than 35***	C.R.	BS 882:1983
Magnesium Sulphate Soundness (%)	Maximum 18 (5 cycles)	C.R.	ASTM C33-81
Sodium Sulphate Soundness (%)	Maximum 12 (5 cycles) Maximum 12 (5 cycles)	C.R. C.	ASTM C33-81 Australian Standard 2785.1 (1985)

Legend : R Road aggregates C Concrete aggregates + General use
* For wearing surfaces ** For heavy duty concrete floor *** For C20 and over concrete grade

LIST OF FIGURE



LEGEND :

SOLID GEOLOGY

Qa, Qb, Qd	Quaternary Superficial Deposits (Onshore)
ms, HHH	Quaternary Superficial Deposits (Offshore)
b	Basalt
rf	Feldsparphyric Rhyolite
rq	Quartzphyric Rhyolite
ap	Aplite
p	Pegmatite
gc	Coarse-grained Granite, >6mm
gf	Fine-grained Granite, <2mm
gm	Medium-grained Granite, 2-6mm
	Megacrystic

GEOLOGICAL LINES

- Geological Boundary, Superficial Deposits
- Geological Boundary, Solid Rock
- Fault
- Photogeological Lineament

STRUCTURAL SYMBOLS

	Horizontal	Inclined	Vertical
Jointing	+	20	—

NOTE :

The geological map is extracted from the published sheet 11 of the 1 : 20000 geological map series of Hong Kong. Not all the geological symbols are given in the legend.

Figure 1 - Location Map Showing Geology of the Site and the Adjacent Areas

LIST OF PLATES

Plate 1 - General View of Wah Yiu Road Cutting

Plate 2 - Sampling Locality

Plate 3 - Block Sample

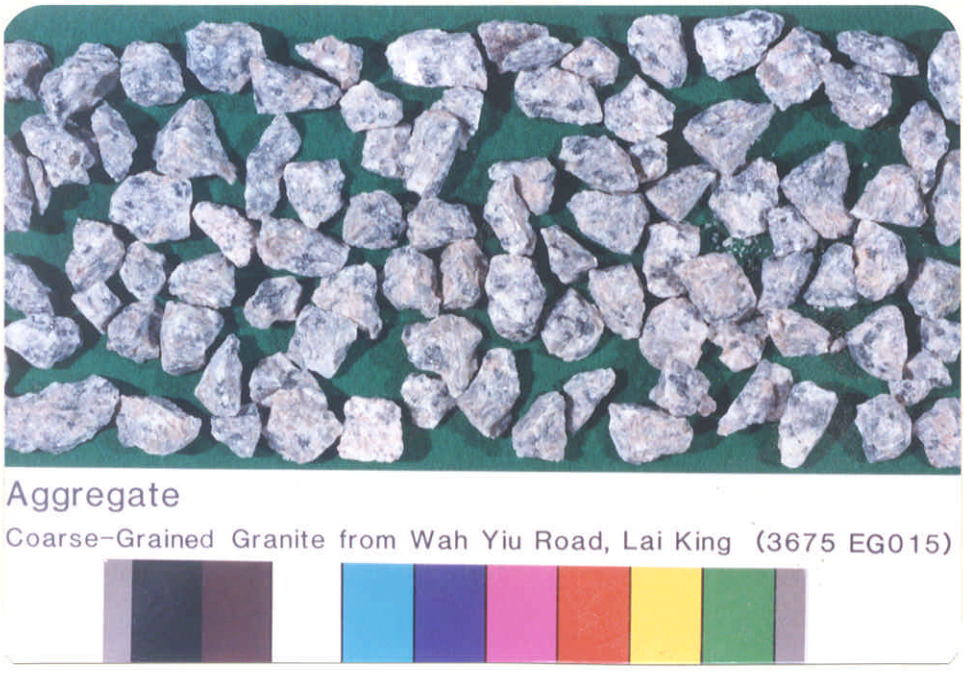


Plate 4 - Crushed Rock Aggregate from Coarse-Grained Granite