SECTION 4 : AGGREGATE PROPERTIES OF FINE-TO MEDIUM-GRAINED GRANITE FROM MA YAU TONG

T.Y. Irfan

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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 characterisation 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 fine-to-medium-grained granite from Ma Yau Tong.

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.

(Dr A.D. Burnett)
Chief Geotechnical Engineer/Planning

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1. INTRODUCTION

This Technical Note on the aggregate properties of fine- to medium-grained granite from Ma Yau Tong area forms the fourth 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 and discusses the results and suitability of fine- to medium-grained granite as aggregate in comparison with 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 study.

2. SITE DESCRIPTION AND SAMPLING

The sampling site is a new road cutting, northeast of Lam Tin Estate, Phase II and below Ma Yau Tong Controlled Tip, Kowloon (Figure 1 and Plates 1 and 2).

The rectangular shaped granite samples were collected from the rock excavated during the construction of the new road. Four fresh granite block samples were selected for testing (Plate 3). While this outcrop of fine- to medium-grained granite is not a suitable site to form an economic source for aggregate because of its location, it is, however, of the same rock type as that being quarried in the lower faces of the Anderson Road quarries (Choy & Irfan, 1986). The granite outcropping in this area is considered typical and representative of fine- to medium-grained granite in the Territory except for its counterpart cropping out in Central and Northern Lamma Island which has a distinctly modified texture (Strange & Shaw, 1986).

3. GEOLOGY

3.1 Site Geology

The road cutting is dominantly composed of fine- to medium-grained granite (gfm) with fine-grained granite (gf) occupying a small portion of the western end of the slope. The contact between the two types of granite is shown to be passing just below the controlled tip, east of the road cutting on the recently published geological map of Hong Kong and Kowloon (GCO, 1986). A number of basalt dykes, each approximately 1.0 to 1.5 m wide, cross the road cutting in a ENE-WSW direction. The granite exposed in the cutting is typical of the fine- to medium-grained granite type cropping out in East Kowloon having a generally equigranular texture and uniform character.

The road cutting is in mainly fresh to slightly weathered granite with more weathered granite zones near the crest and southern end of the cut face. The basalt dykes are parallel to the most dominant subvertical joint set in the granite, and trending ENE-WSW. Sub-horizontal sheeting joints are also present in the cut slope. The joint spacing as displayed on the cut face varies from widely spaced (0.6 - 2 m) to medium spaced (0.2 - 0.6 m).

3.2 Description of Test Sample

(1) Engineering geological description. The rock is an extremely strong, light pinkish grey, crystalline, fresh, fine- to medium-grained GRANITE with equigranular texture.

(2) Detailed description. The major granite constituents are quartz, plagioclase and alkali feldspars and biotite. Quartz forms about 30% of the rock and biotite less than 5%. The results of modal analysis on three sections is given in Table 1. Small amounts of muscovite are also present. Alkali feldspars are generally light pink in hand specimen while some plagioclases show slight greenish discoloration at their centres indicating slight alteration. The rock is equigranular and non-megacrystic with an average grain size of 1 to 2 mm. Occasional quartz and feldspar grains up to 4 mm in diameter are also present.

In thin section (Plate 5), some of the plagioclases show slight alteration in the form of either partial replacement by or growth of individual muscovite flakes (hydrothermal alteration ?). In addition, some plagioclases show slight alteration to minute kaolinite-like minerals at their centres. The amount of feldspar alteration is about 3.3% of the rock (Table 1). A few tight microcracks are present traversing quartz and feldspars grains.

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 sample 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 equipment (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 the rock index tests on cores are given in Table 4. The test results on laboratory crushed fine- to medium-grained granite aggregate are tabulated in Table 5.

5. DISCUSSION ON TEST RESULTS

5.1 Rock Index and Aggregate Properties

The fresh fine- to medium-grained granite from Ma Yau Tong is a very strong rock with a point load strength value of about 8.2 MPa (or uniaxial compressive strength of about 210 MPa using the normal conversion factor of 25) and has very low water absorption and porosity properties (Table 4). Although the density, water absorption, porosity values of this rock type is very similar to the coarse-grained granite from Lai King (Irfan, 1987a), and the medium-grained granite and monzonite from Turret Hill (Irfan, 1987b; Irfan & Nash, 1987), it has a lower strength than all the rocks tested so far in this project. The sound velocity is also very much lower than the value obtained on the coarse-grained granite; 3585 m/s against 5008 m/s for the latter.

A comparison of the aggregate test results of the fine- to medium-grained granite (Table 5) with those of medium- and coarse-grained granites and monzonite (Table 6) show significantly higher and hence less desirable properties for the former rock type in terms of aggregate impact value (AIV = 31), aggregate crushing value (ACV = 27) and Los Angeles abrasion value (LAAV = 41). This result is rather unexpected since finer grained granites generally have more favourable aggregate properties when compared with coarser grained equivalents.

The lower than expected strength and velocity values determined on intact rock and the slightly poorer aggregate strength properties of this rock type from Ma Yau Tong road cutting may be the result of slight hydrothermal alteration it has undergone, which can only be detected in thin section on petrographic examination (see Section 3.2).

The lower production platforms of both Pioneer and particularly K. Wah quarries are in fine- to medium-grained granite passing into more finer grained granite near the contact with the volcanics. A comparison of the test results on samples from Ma Yau Tong (Table 5) is therefore made with the test results available (1973-1985) on the quarry run material from both these quarries (Table 7). The results are similar in terms of aggregate crushing value, aggregate impact value, water absorption, density, flakiness and elongation indices. No Los Angeles abrasion values were determined for the Anderson Road quarry materials.

5.2 Suitability of Rock as an Aggregate

A comparison of the limited laboratory test results with typical, mainly UK, aggregate acceptance values (Table 5) indicates that the aggregates produced from the fine- to medium-grained granite at Ma Yau Tong are just within the acceptable limits for general use in concrete and as roadstone, in terms of aggregate crushing and impact values, water absorption value and flakiness index. However, in terms of Los Angeles abrasion value, the test value of 43 is outside the maximum value specified by the Australian Standard AS 2758.1-1985 for concrete exposed to even average conditions. The aggregate impact value of 31 is just outside the maximum value specified by BS 882 which makes the aggregate tested in this study less desirable for special purposes such as wearing surfaces or heavy duty concrete floors. No polished stone values or 10% Fines values were determined for Ma Yau Tong granite samples.

It is to be noted that the rock index and aggregate values presented in Tables 4 to 6 are those of limited tests carried out on few block samples chosen from one particular locality for this rock type, which appears to have undergone slight hydrothermal alteration. The test values may not therefore be fully representative of the fine- to medium-grained granite occurring in Territory.

6. CONCLUSIONS

The results of laboratory tests carried out on aggregate produced from fresh fine- to medium-grained granite from a road cutting at Ma Yau Tong are just within the commonly accepted limiting values for general use in concrete and as roadstone, except in terms of Los Angeles abrasion value where a higher than acceptable value of 43 was obtained. This value together with rather high (near or above the specified limiting) aggregate impact and crushing test values make the aggregate from this particular locality less desirable for specific uses such as wearing courses and heavy duty concrete floors compared to finer grained granites and basaltic rocks. The rock appears to have undergone slight hydrothermal alteration. The lower than expected strength and other properties of the intact rock as well as the aggregate properties are therefore attributed to this slight alteration.

The aggregate properties of the rock determined on laboratory crushed specimens is very similar to the test values available on quarry run granitic material of similar grain size from the Anderson Road quarries, and the aggregates from these quarries have been satisfactorily used in concrete for general building purposes in the Territory.

Further tests on samples from other localities are however necessary to assess more accurately the typical aggregate properties of the fine- to medium-grained granite occurring in the Territory.

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Table 1 - Modal Analysis of Fine- to Medium-Grained Granite from Ma Yau Tong

Mineral	Feldspars %	Quartz %	Biotite, Muscovite Chlorite %	Others %
Thin Section 1	68.4 (3.1)	27.8	3.6	0.2
2	68.5 (3.4)	27.3	4.0	0.2
3	65.1 (3.4)	33.6	1.3	0.0
Average	67.3 (3.3)	29.6	3.0	0.1

Note : The number in brackets is the percentage of altered feldspars per thin section

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

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

Compiled by : T.Y. Irfan, SGE/EG, GCO

Date : 21.8.1987

CADAM - CLASSIFICATION and DESCRIPTION of AGGREGATE MATERIAL

LOCATION AND SAMPLE DETAILS	Quarry/Pit address : Road Cutting below Ma Yau Tong Controlled Tip, Kowloon Operator : Sample : Type Blocks Size 50 kg Preparation Lab. crushed Supplied by EG Section	Grid Ref. 842810E 819440N	Date Rec'd 28.5.86
		Date of sampling 17.9.85	Sampling Cert. No.

Table 3 - Petrographic Evaluation of the Ma Yau Tong Aggregate

PETROGRAPHIC EVALUATION OF AGGREGATES

SAMPLE REF LOCATION/GRID REF SAMPLING DATE	3677EG017 Road Cutting below Ma Yau Tong Controlled Tip 842810E 819440N 17.9.1985	SAMPLE SIZE/WEIGHT Bulk Sample : 50 kg Sub-sample : 1 kg (10-14 mm)
AGGREGATE PROPERTIES		
Particle Shape (BS812:1975)	Mainly angular to irregular, very few flaky and elongated	
Surface Texture (BS812:1975)	Crystalline	
Coating	None	
Cleanliness (Dust etc)	Clean	
GEOLOGICAL PROPERTIES		
Rock Type (GSS Classification)	Fine- to Medium-grained GRANITE (gfm)	
Mineralogy		
Major Constituents	Quartz (29.6%), Feldspars (67.3%), Biotite (3.0%)	
Minor Constituents	Chlorite, muscovite	
Cementing Materials	Crystalline, no cementing minerals	
Expansive Minerals	None	
Weathering of Particles	Fresh	
Organic Material Content	None	
GENERAL COMMENTS	Granite is equigranular, with grain size 0.5 to 3.0 mm	Compiled by T.Y. Irfan Date 21.8.1987
ADDITIONAL INFORMATION		

Table 4 - Rock Index Properties of Fine- to Medium-Grained Granite from Ma Yau Tong

Rock Index Property			Average Value	Range
Mineral Grain Specific Gravity,		g/cm^3	n.d.	n.d.
Bulk Density	Dry	g/cm^3	2.60	2.59 - 2.60
	Saturated	g/cm^3	2.60	2.60
Water Absorption		%	0.32	0.32
Porosity	Total	%	n.d.	n.d.
	Effective		0.83	0.82 - 0.84
Sonic Velocity		m/s	3585*	3540 - 3620
Point Load Strength		MPa	8.2	5.1 - 10.2

Legend :

n.d. Not determined.

\+ Mean of 15 tests on irregular lumps (ISRM, 1985).

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

Table 5 - A Comparison of Aggregate Test Results from Ma Yau Tong with British Standard and Other Acceptance Values

Aggregate Property			Test Value+	Acceptance Value	Use	Authority
Aggregate Crushing Value,	ACV	%	27	Max. 30	C.R.	Higginbottom (1976)
Aggregate Impact Value,	AIV	%	31	Max. 45[1] Max. 30[2]	C.R. C.R.	BS 882:1983 BS 882:1983
Los Angeles Abrasion Value,	LAAV	%	43	Max. 30[3] Max. 40[4] Max. 35[1]	C. C. R.	Australian Standard 2758.1 (1985) Shergold (1948)
Water Absorption		%	0.4	Max. 3[1]	C.R.	Higginbottom (1976)
Flakiness Index	I_F		13	Max. 35[3]	C.R.	BS 882:1983
Elongation Index	I_E		28			

Notes :

1 - General use

2 - For wearing surfaces

3 - Difficult conditions

C - Concrete aggregate

4 - Average conditions

5 - For C20 and over concrete grade

\+ - Average of two test results (10-14 mm)

R - Road aggregate

Table 6 - Test Results on Laboratory Crushed Granitic Aggregates (10-14 mm)

Aggregate Property	Medium-Grained Granite Turret Hill[1]	Coarse-Grained Granite Lai King[2]	Monzonite Turret Hill[3]
Aggregate Crushing Value %	23	23	18
Aggregate Impact Value %	24	25	12
Los Angeles Abrasion Value %	29	31	22
Water Absorption %	0.5	0.3	0.5
Flakiness Index	7	11	20
Elongation Index	41	34	39

Notes :

1. Test results from Irfan & Nash (1987).
2. Test results from Irfan (1987a).
3. Test results from Irfan (1987b).

Table 7 - Aggregate Test Results from Anderson Road Quarries 1975-1985 (from Choy & Irfan, 1986)

Aggregate Property			K. Wah Quarry Granite	Pioneer Quarry Granite
Aggregate Crushing Value,	ACV	%	30** (24-34)	28** (23-30)
Aggregate Impact Value,	AIV	%	28 (19-33)	29 (25-34)
10% Fines		kN	145 (120-200)	126 (100-150)
Water Absorption		%	0.6 (0.3-0.8)	0.7 (0.5-0.8)
Relative Density		g/cm^3	2.60 (2.58-2.62)	2.60 (2.57-2.61)
Flakiness Index,	I_F	%	17 (10-27)	17 (13-22)
Elongation Index,	I_E	%	35 (26-41)	34 (22-42)
Na_2SO_4 Soundness		%	n.d.	n.d.

Legend :

n.d. Not determined, number in parentheses indicate ranges of values.

** Test results from 1975 to 1977, all other test results 1980-1985.

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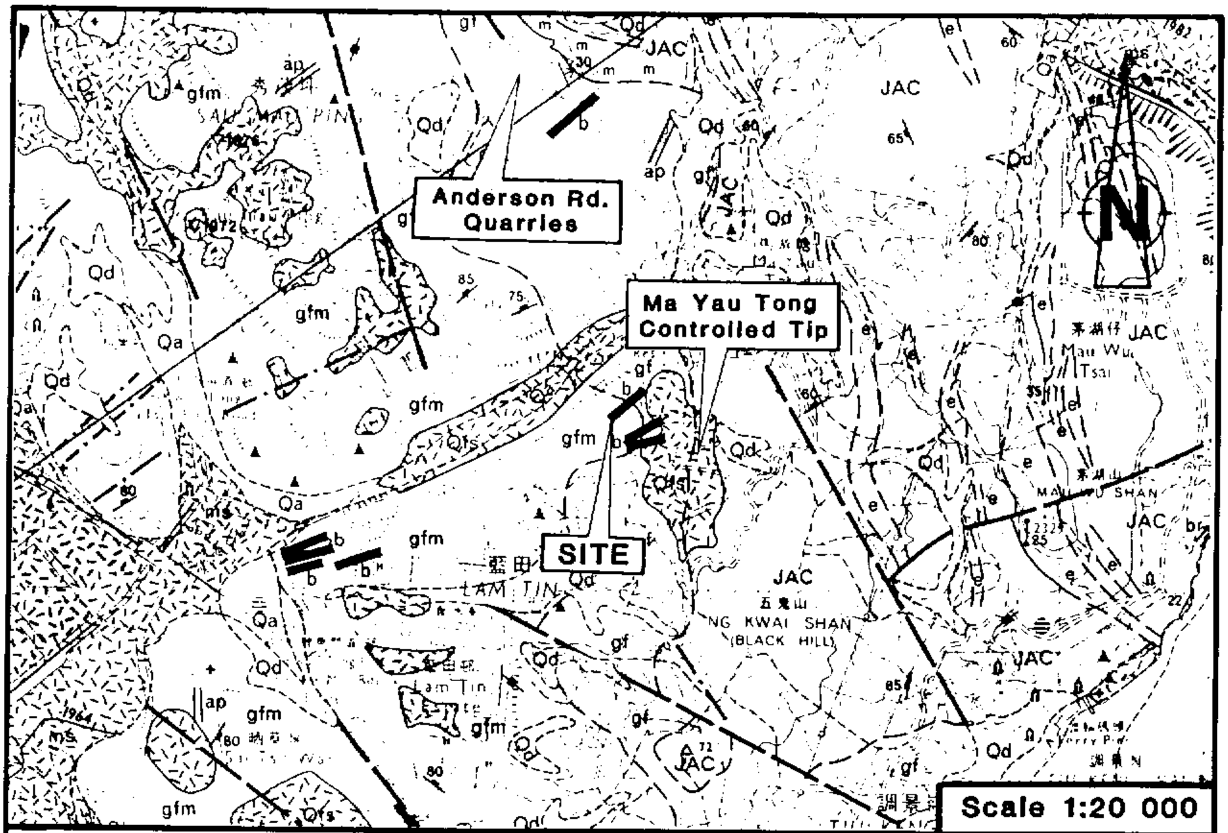

LEGEND :

SOLID GEOLOGY

Qa, Qb, Qd	Quarternary Superficial Deposits (Onshore)
ms, HHH	Quarternary Superficial Deposits (Offshore)
b	Basalt
ap	Aplite
JAC	Fine ash vitric tuff
e	Eutaxite
br	Epiclastic breccia
gf	Fine-grained granite, <2mm
gfm	Fine- to medium-grained granite
• • •	Megacrystic

GEOLOGICAL LINES

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

STRUCTURAL SYMBOLS

	Horizontal	Inclined	Vertical
Jointing		20	
Flow fabric		20	

NOTE :

The geology 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

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Plate 1 - General View of Sampling Locality (Road Cutting below Ma Yau Tong Controlled Tip)

Plate 2 - Jointing Pattern in Fine- to Medium-Grained Granite

Plate 3 - Block Sample

Plate 4 - Crushed Rock Aggregate from Fine- to Medium-Grained Granite

Plate 5a - Photomicrograph of fine-to medium-grained granite showing equigranular texture, alteration in plagioclose and grain boundary relationship (enlarged 100 times)

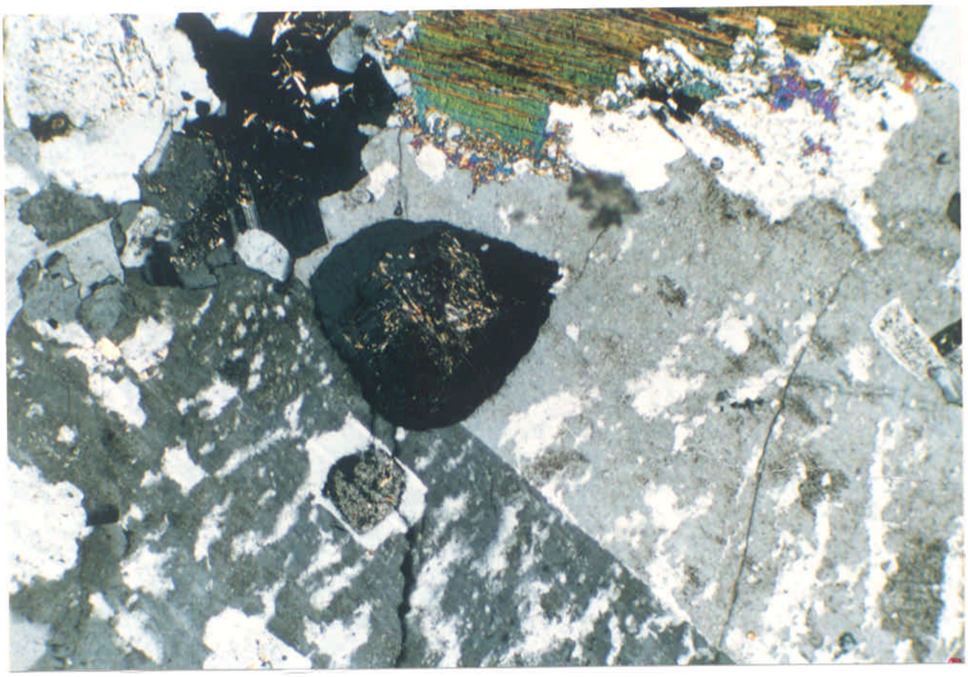

Plate 5b - Photomicrograph showing intragranular microcrack through alkali feldspar and transgranular microcrack through feldspars. Green and blue coloured mineral is biotite. Partial replacement of feldspar is evident near biotite grain.