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Evaluation of Suitability of The Rocks as Aggregates for Concrete of Rani-Pamohi Area, in Kamrup Metro, Assam

Abstract

The area of study is situated to the south of Guwahati, Kamrup, Assam and is confined between latitude $26^0 1'$ - $26^0 10'$ and longitude $91^0 35'$ - $91^0 48'$.While making a study of the different rock units of the area, it was observed that a large number of quarries are in operation.The geological characteristics of rocks influences the suitability of rocks as aggregates for concrete.The study reveals that the mineralogical composition and granularity of the rocks do determine the suitability of rocks.The impact and abrasion values decreases as the percentage of minerals of higher hardness increases in the rock unit and again the impact and abrasion are lesser in fine grained equigranular rock unit compared to the coarse grained inequigranular rock unit

Keywords: Amphibolites, Quartzo-Feldspathic Gneiss, Grey Porphyritic Granite, Fine Grained Granite, Water Bound Macadam And Bituminous Macadam.

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Introduction

The rock units of the area are mainly used as aggregates in concrete for construction of bridges, roads, buildings and various other constructions. One of the major contributing factors to the quality of concrete is the quality of aggregates used therein. In order to ensure safety and life of buildings, roads, bridges, etc. it is of utmost importance to assess the quality of aggregates. In a given situation, for a particular aggregate, it may not be necessary to assess all qualities and therefore it is necessary to determine beforehand the purpose for which a concrete is being used and the qualities of the aggregate which require to be assessed. For convenience of the users, the test methods are grouped into eight parts of Indian Standard Methods of Test for Aggregates for concrete (IS: 2386-1963)

Objective of the Study

To ensure the quality of aggregates for concrete which is required while using the rocks for different construction purposes, some properties of different rock units is to be determined.These properties are abrasion, attrition, impact, compressive strength, rigidity modulus, youngs modulus, density, specific gravity, water absorption, porosity, permeabilty, etc. For this material testing of the different rock units was done.

The main objective of these studies is to bring about a comprehensive account of the quality of the rocks in the area as aggregates. An attempt was made to establish a relation between the physical properties of the rock units and their geological characters.This account contains information regarding locality, quality and types of materials as well as the results of the various tests performed.

Review of literature

The area is a part of the northern extension of the “Shillong Plateau” that covers parts of the states of Assam and Meghalaya. Shillong plateau (covering approximately 47614 sq. km) is the singular representative of precambrian cratonic block of northeast India tectonically detached from the mainland of Indian Peninsula. This cratonic block is girdled by dextrally moving Dawki fault to the south, Brahmaputra lineament to the north, Garo-Rajmahal graben, Dhubri/Madhupur lineament to the west and belt of schuppen to the east.It consists of high to medium grade Paleoproterozoic basement gneisses and schist designated as Basement Gneissic Group (BGG) overlain by Mesoproterozoic metasediments and metavolcanics of the Shillong Group, both being intruded by Neoproterozoic acidic intrusives such as Mylliem pluton, South

Khasi pluton, Umroi granite, Nongpoh pluton and a few others enlisted by Mazumdar (1976); Ghosh *et al.* (2005); Devi and Sarma (2006, 2010).

Deka (1995) stated that the rock types in the area include the most abundant foliated quartzo-feldspathic gneiss (grey granite gneiss and pink granite gneiss) with other foliated rocks. Besides these a pluton of porphyritic granite occur to the north of the area. Fine grained granite is also observed in the area. Pegmatitic and quartzo-feldspathic veins are seen intruding into all the other rock types of the area. A good number of migmatitic outcrops are also present. Amphibolites occur as patches, lenses, sills, etc in quartzo-feldspathic gneiss and grey porphyritic granite.

Maswood and Deka (1989) stated that the material testing of the granite gneiss, the grey porphyritic granite and the hornblende biotite schist from the different stone quarries around Saukuchi in Kamrup metro district of Assam reveal that the rock units with some exceptions, are suitable to be used as aggregates for concrete.

Previous literature reveal that geological studies have been carried out in and around the area to some extent.While making a study of the different rock units of the area, it was observed that a large number of quarries are in operation. One of the major contributing factors to the quality of concrete is the quality of aggregates used therein. Hence it is thought important to assess the suitability of the rock units as aggregates for concrete.

Concept and Hypothesis

The rock aggregates are required in water bound macadam for sub base and base course and bituminous macadam for bases and wearing courses.

The water bound macadam for sub base and base course consist of clean, crushed aggregates mechanically interlocked by rolling and bonded together with screening binding material where necessary and water laid on a properly prepared sub base/ base or existing pavement, as the case may be and finished in accordance with the requirements of these specifications and in close conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the engineer. The course aggregates shall conform to the physical requirements set forth in table 1 and to one of the gradings given in table 2 as specified, provided however, the use of grading No.1 shall be restricted to sub-base course only.

Table 1: Physical requirements of coarse aggregates for water bound macadam for sub base/ base coarse

Test	Test method	Requirements
1. Los Angeles Abraision Value	IS : 2386 Part IV	50% maximum
2. Aggregate Impact value,	IS : 2386 (Part IV) Or IS : 5640 IS : 2386 Part I	40% maximum
3. Flakiness Index	IS : 2386 Part I	15% maximum

Table 2
Grading Requirements of Coarse Aggregate
(The compact thickness for a layer with grade 1 shall be 100 mm while for layer with other grades i.e. 2 and 3, it shall be 75 mm)

Grading No	Size Range	Sieve Designation	Percent by weight passing
1	90 mm to 45 mm	125 mm 90 mm 63 mm 45 mm 22.4 mm	100 90 – 100 25 – 60 0 - 15 0 - 5
2	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90 – 100 25 – 75 0 - 15 0 – 5
3	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95 – 100 65 – 90 0 – 10 0 - 5

The bituminous macadam for bases and wearing courses consists of construction, in a single course, of 50 mm/ 75mm thickness of compact crushed aggregates premixed with a bituminous binder, to serve as base/ binder course, laid immediately after mixing, on a base prepared previously in accordance with the line, grades and cross-section shown on the drawing or as directed by the engineer.The aggregates shall be clear, strong, durable of fairly cubical shape and free from disintegrated piece, organic or other deleterious matters and adherent coating. The aggregates shall satisfy the physical requirements set forth in table 3. The aggregate for bituminous macadam for thicknesses shall conform to the grading given in tables 4 and 5.

Table 3
Physical Requirements of Aggregates for Bituminous Macadam

Test	Test Method	Requirements
1. Los Angeles abrasion value	IS: 2386 (Part IV)	40% (Max)
2. Aggregate Impact value	do	30% (Max)
3. Flakiness Index	IS: 2386 (Part I)	35% (Max)
4. Stripping value	IS: 6241	25% (Max)
5. Sounding :		
(1) Loss with sodium sulphate 5 cycles		12%
(2) Loss with Magnesium sulphate 5 cycles	IS: 2386 (Part III)	18%
6. Water absorption		2 % (Max)

Table 4
Aggregate Grading for 50 Mm Compacted Thickness of Bituminous Macadam

Sieve Designation (IS)	Percent by weight passing the sieve
26.5 mm	100
22.5 mm	75 – 100
11.2 mm	50 – 85
5.6 mm	20 – 40
2.8 mm	5 – 20
90 µm	0 – 5

Table 5: Aggregate Grading for 75 Mm Compacted Thickness of Bituminous Macadam

Sieve Designation (IS)	Percent by weight passing the sieve
45 mm	100
26.5 mm	75 – 100
22.4 mm	60 – 95
11.2 mm	30 – 55
5.6 mm	15 – 35
2.8 mm	5 – 20
90 µm	0 - 5

Research Design/Materials and Result
Phase1

The study area is about 300 square kilometers between latitude 26^{0}1'- 26^{0}10' and longitude 91^{0}35'- 91^0 48'. (Fig 1: location map).Field work was carried out in successive field seasons for a couple of years. A good number of rock samples were collected systematically. The megascopic characters of the rocks were studied in handspecimens. The petrographic (thin section) study included the study of mineralogy, texture and modal variation of the different minerals present in the rocks.

Field and petrographic studies reveal that the area is covered dominantly by quartzo-feldspatic gneiss (Photo 1).The grey porphyritic granite occur in the form of plutons which bear intrusive relationship with the other rock types (Photo 2). Occurrence of fine grained granite (Photo 3) is much less compared to the quartzo-feldspathic gneiss and grey porphyritic granite.The amphibolites occur as patches, lenses, dykes and sills in quartzo-feldspathic gneiss (Photo 4).

The quartzo-feldspathic gneiss(grey granite gneiss and pink granite gneiss) is mainly composed of microcline, plagioclase, quartz and biotite. Hornblende, magnetite, sericite, kaolin, chlorite, epidote, zircon,sphene occur in minor quantity. (Table 6).It is fine to medium grained, equigranular and exhibits a gneissic texture. Usually the rock shows alteration of schistose and granulose bands.

Grey porphyritic granite is essentially composed of potassic feldspar, plagioclase, quartz and biotite. Sphene, magnetite, apatite, zircon, hornblende, sercite, kaolin, chlorite, epidote are the accessory minerals (Table 7). The rock is coarse grained, inequigranular and porphyritic in texture.

Fine-grained granite is essentially composed of feldspar, quartz and biotite. Feldspar is represented dominantly by microcline, plagioclase and perthite. Sericite, chlorite, magnetite, zircon, sphene, apatite, hornblende, epidote, allanite are the accessory minerals (Table 8).The rock possesses equigranular fine grained aplitic to medium grained hypidiomorphic texture.

The amphibolites are essentially composed of hornblende and plagioclase, with or without diopside, or with or without biotite. Sphene, magnetite, zircon, apatite, epidote and sericite also occur (Table 9). The rock is equigranular, medium grained and granoblastic in texture.

Photo: 1
Granite gneiss at Pamohi

Photo: 2
Contact of Grey Porphyritic Granite and Amphibolite at Gorchuk

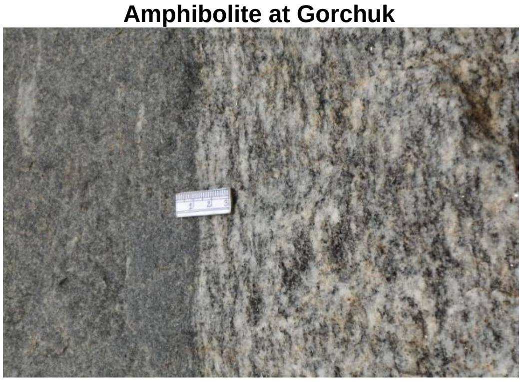

Photo: 3
Fine Grained Granite at Maghopara

Photo: 4
Amphibolite Rock in Quartzo-Feldspathic Gneiss at Pamohi

Table 6
Modal Analysis of Quartzo-Feldspathic Gneiss

Sample No	Microcline	Plagioclase	Quartz	Biotite	Perthite	Accessories	Total
Sau Q $_{2-81}$	32.6	36.8	20.4	4.6	4.8	.8	100
Mag Q $_{2-4A}$	37.0	13.3	12.0	12.3	25.3	.1	100
Sau Q $_{2-3}$	48.0	12.3	20.6	6.6	11.3	1.2	100
Mag Q $_{2-4B}$	33.6	31.3	18.6	12.6	3.6	.3	100
Sau Q $_{1-1A}$	44.5	24.2	20.5	4.5	6.0	.5	100
Sau Q $_{2-82}$	32.8	30	20.6	5.4	10.0	1.2	100
Sau Q $_{2-7}$	31.8	30	18.2	3.0	16.0	1.0	100
Deopara $_{1-B}$	42.2	22	16.4	9.6	9.8	0	100
MP_{20}	29	32.6	17.8	13.4	5.8	1.4	100
Gar Q $_{1-1}$	52.8	18.2	14.6	11.6	2.8	0	100
Mag Q $_{2-1}$	30.2	20.6	24.6	20.8	3.6	.2	100
R $_{1-7}$	17.8	26.2	31	5.2	19.8	0	100
R $_{1-4}$	10.7	39.6	26.7	20.9	1.3	.8	100

Table 7

Modal Analysis of Grey Porphyritic Granite

Minerals	Average mode of groundmass minerals excluding K-feldspar crystals >20 sq mm. From thin section				Phenocryst mode analysis only K-feldspar phenocryst >20 sq mm. In Field				Average intra phenocryst mode determined from thin section				Intra-phenocryst mode recalculated to 25,19,33,31				Final mode				Aver-age mode
Sample no	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
K-feldspar	37.2	22.1	32.2	18.2	25	19	33	31	78.6	78	53.8	69.4	19.65	14.82	17.8	21.51	45.48	31.03	37.59	30.31	36.10
Quartz	21.9	21.1	22.4	23.2					5.2	12.6	7.6	9.6	1.3	2.39	2.50	2.97	18.56	19.74	18.72	20.05	19.26
Plagioclase	24.3	32.5	24	30.0					5.8	1.2	27.4	14.4	1.45	.23	9.04	4.46	20.6	27.5	24.84	26.31	24.81
Biotite	13.9	18.5	15.4	26.2					.9	6.6	9.6	5.4	.22	1.25	3.16	1.67	11.29	16.60	13.95	21.27	15.78
Accessories	2.7	5.8	6.0	2.4					9.5	1.6	1.6	1.2	2.37	.30	.53	.37	4.05	5.13	4.91	2.11	3.87
Total	100	100	100	100					100	100	100	100	25	19	33	31	99.98	100	100	100	99.82

Table 8

Modal analysis of Fine Grained Granite

Sample no	K-feldspar	Quartz	Plagioclase	Biotite	Hornblende	Accessories	Total
R_{2-3}	57	34	5	-	3	1	100
D_1	61	20	10	6	1	2	100
R_{2-1}	58	33	2	1	4	2	100
R_{2-2}	39	37	12	2	9	1	100

Table 9

Modal Analysis of Amphibolite

Sample no	Horn-blende	Plagio-clase	Biotite	Diopside	Quartz	accessories	Total
R_{3-9}	30.2	36.0	-	25.4	1.3	7.1	100
A	25.1	29.6	-	44	.9	-4	100
R_{3-1}	67.2	26.7	-	-	2.5	3.6	100
R_{2-16}	59.0	32.5	-	-	3.3	5.2	100
R_{1-1}	45.4	24.6	21.8	-	8.0	-2	100
$MagQ_{1-1}$	37.9	33.3	19.6	-	5.3	3.9	100
$SauQ_{2-6}$	30.8	31.8	25.2	-	2.2	10.4	100
$SauQ_{2-5}$	32.0	32.2	24.6	-	2.2	9.4	100
$KatkiQ_{1-1}$	53.8	30.6	12.4	-	2.2	1	100

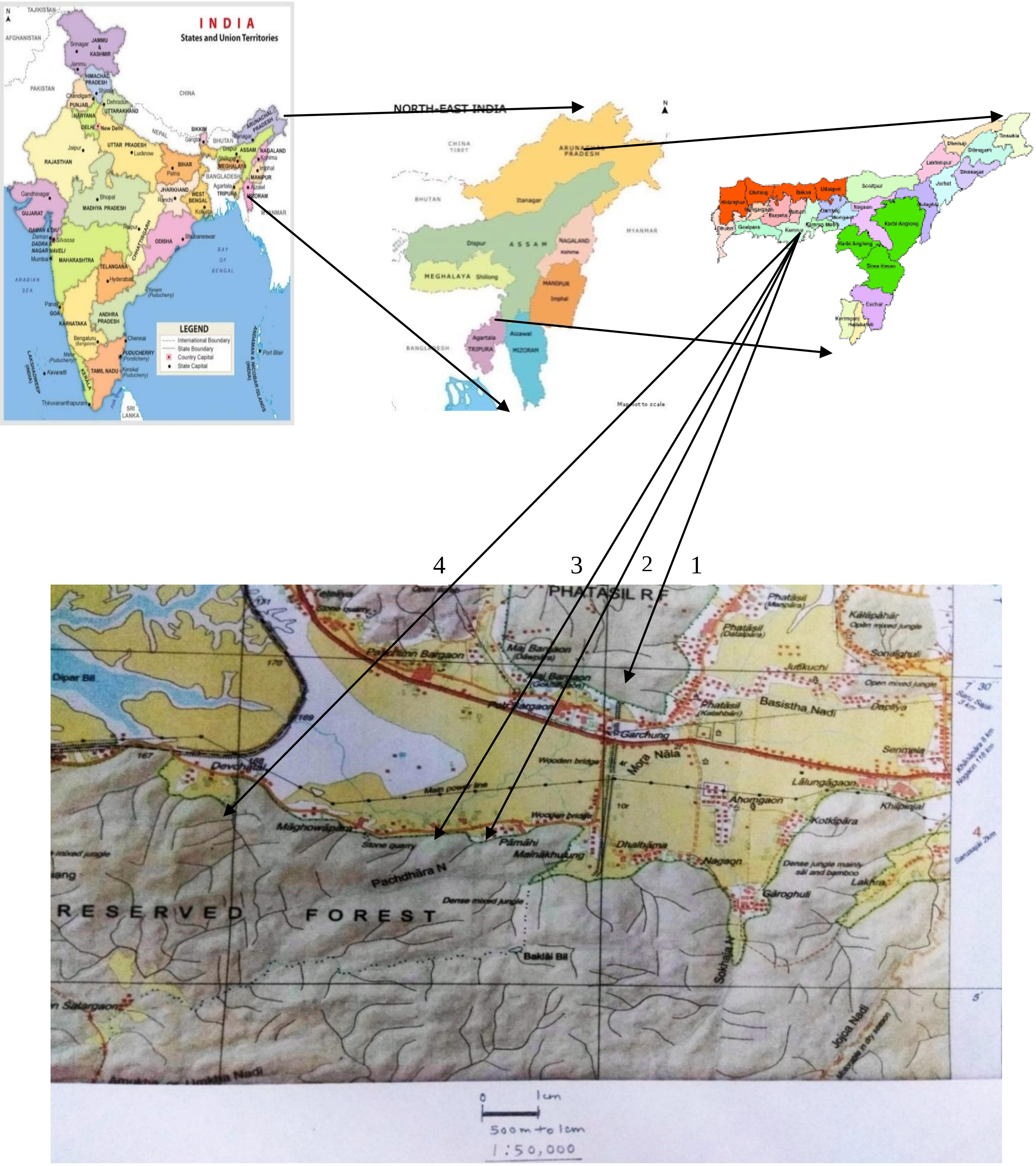

Fig 1: Location map of the study area. The exact locations from where samples were collected are shown by the arrows: 1: Saukuchi 2: Pamohi 3: Moghopara 4; Rani

Phase 2

A great emphasize was given in collection and preparation of samples because of its vital role in determining the accurate results of different tests. Samples were collected systematically so as to represent the main rock units of the area. All these samples were numbered properly in the field and entered in the field dairy with a brief description about the type, availability and access to the area.

The different types of rock units that were used as samples in the various tests were the quartzo-feldspathic gneiss (grey granite gneiss and pink granite gneiss), grey porphyritic granite, fine-grained granite and amphibolites.

As per availability of laboratory facilities the following tests were carried out:

1. Determination of flakiness index. [IS: 2386 (part I), 1963]

2. Determination of specific gravity and water absorption [IS : 2386 (Part III), 1963]
3. Determination of Aggregate Impact Value [IS : 2386 (Part IV), 1963]
4. Determination of Aggregate Abrasion Value [IS : 2386 (Part IV), 1963]

Determination of Flakiness Index

Flaky minerals and their presence in rocks are an important consideration in civil engineering projects, particularly in road construction. This test is done to determine the thinner platy particles in the aggregate, as thinner particles are detrimental in road construction and as such they are avoided.

Apparatus

The apparatus consists of the following:

1. Balance – The balance must be of sufficient capacity and sensitivity and must have an accuracy of 0.1 per cent of the weight of the test sample.
2. Metal gauge
3. Sieves: IS sieves sizes shown in table 10.

Test Sample

A quantity of aggregate was taken, sufficient to provide the minimum number of 200 pieces of any fraction to be tested.

Test Procedure

Sieving

The sample was sieved in accordance with the sieves specified in Table 10. Aggregate retained on each sieve was then weighed. The aggregate retained on the 63 mm IS sieve was avoided and not weighed.

Separation of Flaky Materials

Each fraction was gauged in turn for thickness on a metal gauge or in bulk on sieves having elongated slots. The width of the slot used in gauge or sieve was of the dimensions specified in column 3 of Table 10 for the appropriate size of the material.

Weighing of Flaky Materials

The total amount passing through each slot of gauge was weighed to an accuracy of at least 0.1 per cent of weight of the test sample.

Table 10
Dimensions of Thickness Gauge

Size of aggregates		Thickness gauge* (mm)
Passing through IS sieve	**Retained on IS sieve**	
63 mm	50 mm	33.90
50 mm	40 mm	27.00
40 mm	25 mm	19.50
31.5 mm	25 mm	16.95
25 mm	20 mm	13.50
20 mm	16 mm	10.80
16 mm	12.5 mm	8.55
12.5 mm	10 mm	6.75
10 mm	6.3 mm	4.89

* This dimension is equal to 0.6 times the mean sieve size.

Calculation

Flakiness of the material passing through each sieve of the thickness gauge = AXB/100 where

A = percentage retained in each sieve

B = percentage passing through each thickness gauge.

Flakiness index is the sum of the per cent of flaky materials passing through the various thickness gauge

Table 11A
Results of Flakiness Index Test for Rock Aggregates (Grey Granite Gneiss)

sam-ple no.	Description of the materials and colours, shapes, etc	Sieve designation (in mm)	Total quantity of sample (in gms)	Quantity retained in each sieve (gms)	Percent retained in each sieve (A)	Quantity passing through thickness gauge	Percent passing through thick-ness gauge (B)	Weight average (corrected percent loss) A X B / 100
GGG_1	The rock is fine to medium grained with well developed gneisssosity.It is characterized by light and dark bands of felsic and mafic minerals. Name of the rock is grey granite gneiss.	63	18,380	Nil	0.00	0.00	0.00	
		50		4055	22.06	240	5.9	1.30
		40		6205	33.75	750	12.08	4.07
		31.5		500	2.72	65	13	.35
		25		5545	30.17	1140	20.55	6.20
		20		1205	6.55	290	24.55	1.57
		16		465	2.52	210	45.16	1.13
		12.5		165	.89	55	33.33	.29
		10		240	1.30	92	38.33	.49
								15.4

Table 11B
Results of Flakiness Index Test for Rock Aggregates (Amphibolite)

Sample No.	Description of the materials and colours, shapes, etc	Sieve designation (in mm)	Total quantity of sample (in gms)	Quantity retained in each sieves (in gms)	Percent retained in each sieve (A)	Quantity passing through thickness gauge	Percent Passing through thickness gauge (B)	Weight average. corrected percent loss. A X B / 100
AMP_1	The rock is fine-grained and mesocratic. Name of the rock is amphibolite.	63	13020	Nil	22.27	450	15.51	3.45
		50		2900	20.73	670	24.81	5.14
		40		2700	37.63	270	5.51	2.07
		31.5		4900	3.22	170	40.47	1.30
		25		420	6.14	130	16.25	.99
		20		800	3.84	80	16	.61
		16		500	4.60	40	6.66	.30
		12.5		600	1.53	20	10	.15
		10		200				14.01

Table 11C
Results of Flakiness Index Test for Rock Aggregate (Grey Porphyritic Granite)

Sl. no.	Sample no.	Description of the materials and colours, shapes, etc	Sieve designation (in mm)	Total quantity of sample (in gms)	Quantity retained in each sieve (gms)	Percent retained in each sieve (A)	Quantity passing through thickness gauge	Percent passing through thick-ness gauge (B)	Weight average (corrected percent loss) A X B / 100
3	GPG_1	The rock is coarse grained and inequigra-granular and exhibits a porphyritic texture. Name of the rock is grey porphyritic granite.	3		Nil				
			50	1,850	4160	35.10	230	5.52	1.93
			40		1800	15.18	115	6.39	.97
			31.5		1500	12.66	65	4.33	.55
			25		1420	11.98	50	3.52	.42
			20		1145	9.66	105	9.17	.88
			16		985	8.31	75	7.61	.63
			12.50		500	4.21	45	9.0	.37
			10		340	2.86	37	10.88	.31
									---------- 6.06

Determination of Water Absorption and Specific gravity

The water absorption test gives the absorbent per cent of the rock sample, which gives bulk and apparent specific gravity.The value of the bulk specific gravity is generally required for the calculations with the Portland cement.

Apparatus

1. Balance - capacity not less than 3 kg with accuracy to 0.5g.
2. Oven
3. Wire basket
4. A water tight container
5. A shallow tray

Test Sample

The sample selected was crushed or broken and the material passing 20mm IS sieve and retained on 10mm IS sieve was used for the test.

Test procedure

The sample weighing about 2kg was thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at room temperature. Immediately after immersion the entrapped air was removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and aggregate were completely immersed during the operation and for a period of 24 + ½ hours.The basket and sample was then jolted and weighed in water at a temperature of 22^0 to 32^0C. The basket and the aggregate was then removed from the water and allowed to drain for a few minutes, after which the aggregate was gently emptied from the basket on to one of the dry cloths, and empty basket was again immersed in the water, jolted 25 times and weighed in water.

The aggregate placed on the dry cloth was gently surface dried with the cloth, and transferred it to the second dry cloth. The samples were then spread out, lest exposed to the atmosphere away from direct sunlight, until it appeared to be completely surface dry. The aggregate was turned over once during this period.The aggregate was weighed (weight B).

The aggregate was then placed in the oven in the shallow tray, at a temperature of 100^0 to 110^0C and maintained at this temperature for 24 + ½ hours. It was then removed from the oven, cooled in the airtight container and weighed (weight C).

Calculations

Specific gravity, apparent specific gravity and water absorption was calculated as follows:

Specific gravity = C/B=A

Apparent specific gravity = C/C-A

Water absorption (per cent by dry weight) = $\frac{100\,(B-C)}{C}$ where

A = the weight in gm of the saturated aggregate in water ($A_1 - A_2$)

B = the weight in gm in surface dry condition

C = the weight in gm of oven dried aggregate in air.

Table 12: Result of water absorption test of aggregate

Sl. no.	Sample no.	Name of the rock	Weight of the saturated aggregate in water 'A' (in gms)	Weight of aggregate in surface dry condition 'B' (in gms)	Weight of oven fried aggregate 'C' (in gms)	Apparent Sp.gr. = C/C-A Sp.gr. = C/B-A	Water Absorption Percentage
1	GPG_1	Grey porphyritic granite	1254	2005	1995	2.69 2.65	.50
2	AMP_1	Amphibolite	1305	2014	2007	2.85 2.83	.34
3	GPG_2	Grey porphyritic granite	1446	2304	2297	2.69 2.67	.30
4	PGG_1	Pink granite gneiss	1358	2207	2202	2.60 2.59	.22
5	GGG_1	Grey granite gneiss	1424	2298	2296	2.63 2.62	.08
6	GPG_3	Grey porphyritic granite	1433	2296	2288	2.67 2.65	.34
7	FGG_1	Fine grained granite	1429	2312	2308	2.62 2.61	.17

Determination of Aggregate Impact Value

With this test the compaction of rock was determined to know the strength of the road surface.

Apparatus

The apparatus consists of the following:

A. The impact test machine. It is complying with the following:
   1. Total weight not more than 60 kg not less than 45 kg.
   2. A metal base weighing between 32 and 30 kg with a plane lower surface of not less than 30 cm diameter and is supported on a level and plane concrete. The machine is prevented from rocking by fixing it to the floor.
   3. A cylindrical steel cup having internal dimensions not less than 6.3 mm thick with its inner surface case-hardened that can be rigidly fastened at the centre of the base and easily removed for emptying.
      Diameter - 102 mm
      Depth - 50 mm
   4. A metal top or hammer weighing 13.5 to 14.0 kg the lower end of which is cylindrical in shape, 100mm in diameter and 50 mm long with a 2 mm chamber at the lower edge. The hammer shall slide freely between vertical guides so arranged that the lower (cylindrical) part of the hammer is above, and concentric with the cup.
   5. Means for raising the hammer and allowing it to fall freely between the vertical guides from a height of 380 ± 5.0 mm on the test sample in the cup for adjusting the height of fall within 5mm.
   6. Means for supporting the hammer whilst fastening or removing the cup.

B. Sieves – IS sieves of sizes 12.5 mm, 10mm and 2.36mm.

C. Measure – a cylindrical metal measure, tared to the nearest gram, of sufficient rigidity to retain its form under rough usage and of the following internal dimensions.
   Diameter- 75 mm
   Depth- 50 mm

D. Tamping Rod – A straight metal tamping rod of circular cross-section 10 mm in diameter and 230 mm long, rounded at one end.

E. Balance – A balance of capacity not less than 500gm readable and accurate to 0.1gm.

Test Sample

The samples consists of aggregates the whole of which passes a 12.5mm IS sieve and is retained on a 11.0mm IS sieve. The sample is dried in an oven at temperature 100^0 to 110^0C for a period of four hours, in order to dry any moisture, if present and a constant weight obtained.

The measure is filled about one third full with the prepared aggregate and tamped with 25 strokes given. The measure is finally filled to overflowing, tamped 25 times and the surplus aggregate struck off, using the tamping rod as a straight edge. The net weight of the aggregate in the measure is determined to the nearest gram (Wt. A) and this weight of aggregate was used for duplicate test on the same material.

Test Procedure

The impact machine rests without wedging or packing upon the level plate, or floor, so that it is rigid and the hammer guide columns are vertical. The cup was fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by a single tamping of 25 strokes of the tamping rod.

The hammer was raised until the lower face was 380 mm above the upper surface of the aggregate in the cup, and allowed to fall freely on to the aggregate. The test sample was subjected to a total of 15 such blows each being delivered at an interval of not less than one second.

The crushed aggregate was then removed from the cup and the whole of it was sieved on the 2.36 mm IS sieve till no further significant amount passed in one minute. The fraction retain on the sieve was weighed to an accuracy of 0.1 gm (Wt. B). The fraction retained on the sieve (B) was then subtracted from the weight of the original oven dried sample (A). The resultant weight then represents the fraction passing 2.36 mm IS sieve (C). Two tests were conducted on the same sample and the average value was taken.

Calculation

The ratio of weights of the fines formed to the total sample in each test was expressed as percentage of the oven dried weight, the results being recorded to the first decimal place: Aggregate impact value = C/A X 100
where, C = weight of fines formed,
and A = weight of the oven dried sample

Table 13
Result of Impact Test Aggregate

Sl.No	Sample No.	Name of the rock	Weight of the sample taken for test 'A' (in gms)	Weight of the sample retained on 2.36mm sieve 'B' (in gms)	Weight of the sample passing through 2.36mm sieve 'C' (in gms)	Impact value percentage	Average impact value percentage
1	GPG_1	Grey porphyritic	321	212	109	33.95	
		granite	321	214	107	33.33	33.64 = 34
2	AMP_1	Amphibolite	337	169	168	49.85	
			337	172	165	48.96	49.41 = 49
3	GPG_2	Grey porphyritic	328	214	114	34.75	
		granite	328	212	116	35.36	35.05 = 35
4	PGG_1	Pink granite	303	211	92	30.36	
		gneiss	303	211	92	30.36	30.36 = 30
		Grey granite	321	214	107	33.33	
5	GGG_1	gneiss	321	209	112	34.89	34.11 = 34
		Grey porphyritic	317	209	108	34.06	
6	GPG_3	granite	317	205	112	35.33	34. 69 = 35
		Fine grained	312	214	98	31.41	
7	FGG	granite	312	207	105	33.65	32.53 = 33

Determination of Aggregate Abraision Value

The abrasion test was done to obtain the wear of rock aggregate, and their suitability for construction.

Apparatus

Los Angeles Machine

For the abrasion test of coarse aggregates, the Los Angeles Machine was used. The Los Angeles Machine consists of a hollow steel cylinder closed at both the ends having an inside diameter of 700 mm and inside length of 500 mm. the cylinder is mounted on a steel shaft attached to the cylinder but not entering it, and is mounted in such a manner that it may be rotated about its axis in a horizontal position. An opening in the cylinder is provided for the introduction of the test samples. The opening is closed dust tight with removal cover bolted in place. The cover is so designed as to maintain the cylindrical counter of the interior surface unless the shelf is so located that the charge will not fall on the cover or come in contact with it during the test. A removable steel shelf projecting readily 88 mm into the cylinder and extending its full length is mounted along one element of the interior surface of the cylinder. The shelf is of such thickness and so mounted by bolts or other approved means as to be firm and rigid. The position of the shelf is such that the distance from the shelf of the opening measured along the circumstances of the cylinder in the direction of rotation is not less than 1250mm.

Sieves

The 1.70 mm IS sieve with square holes.

Abrasive charge

The abrasive charge consists of cast iron spheres or steel spheres approximately 48 mm in diameter and each weighing between 390 and 445 gms.

The abrasive charge used depend upon the grading of the test samples (Table 14)

Test Sample

The samples consist of clean aggregate which were dried in an oven at 105^0 – 110^0 C to substantially constant weight conforming to one of the gradings. (Table 15)

Test Procedure

The test samples and the abrasive charge were placed in the Los Angeles abrasion testing machine. The machine was rotated for 500 revolution for grading A,B,C,D and 1000 revolution in the grading E,F,G as shown in table 10. The machine is so driven and so counterbalanced that as to maintain substantially uniform peripheral speed. If an angle is used as the shelf, the machine shall be rotated in such a direction that the charge is caught on the outside surface of the angle. After the completion of the rotation, the material is discharged from the machine and a preliminary separation of the samples made on a sieve coarser than 1.70 mm IS sieve. The finer portion is then sieved on a 1.70 mm IS sieve.The material coarser than the 1.70 mm IS sieve was washed, dried in an oven at 105^0 to 110^0 C to a substantially constant weight, and accurately weighed to the nearest gm.

Table 14: Grading and weight of the charge

Grading	Number of spheres	Weight of charge	No. of revolutions
A	12	5000 ± 25	500
B	11	4584 ± 25	500
C	8	3330 ± 20	500
D	6	2500 ± 15	500
E	12	5000 ± 25	1000
F	12	5000 ± 25	1000
G	12	5000 ± 25	1000

Calculation

The difference between the original weight and the final weight after sieving in 1.70 mm IS sieve of the test samples is expressed in percentage with respect to original weight of test samples.This value is reported as the percentage of wear. Wear = A-B/A X100, where A = original weight; B = final weight.

Table 15: Result of Los Angeles Abrasion test of aggregates

Sl. no.	Sample no.	Name of rock	Grading of Test Samples and weight (in gms)	Total weight of sample taken (in gms)	Final weight of the test sample retained after washing and sieving through 1.7 mm sieve (in gms)	Weight loss after washing and sieving by 1.70 mm sieve by 1.7 mm (in gms)	Aggregate abrasion value (per cent)
1	GPG_1	Grey Porphyritic granite	A	5000	3050	1950	39
	AMP_1	Amphibolite	B	5000	3100	1900	38
2	GPG_1	Grey Porphyritic granite	F	10000	6570	3430	34.3
3	PGG_1	Pink granite gneiss	G	10000	7600	2400	24
4	GGG_1						
5	GPG_1	Grey granite gneiss	B	5000	3300	1700	34
6	FGG_1	Grey Porphyritic granite	C	5000	2850	2150	43
7		Fine grained granite	A	5000	3440	1560	31.2

Discussion and Conclusion

The rock aggregates are used in water bound macadam for sub-base and base course, and bituminous macadam for bases and wearing courses.The physical requirements for water bound macadam are such that the maximum value of Los Angeles Abrasion is 50 per cent, aggregate impact value is 40 per cent and flakiness index is 15 per cent. It is seen that in grey granite gneiss the flakiness index value slightly exceeds the maximum required value, whereas the impact and abrasion value are within the required limits.Thus observations say that grey granite gneiss is unsuitable for water bound macadam for sub-base and base course. But the flakiness index can be reduced by decreasing the amount of flaky materials, and hence made suitable. In amphibolite the flakiness index and abrasion values are within the required limit but the impact value is much more, so it is very unsuitable. In Grey porphyritic granite the physical properties very well conform to the physical requirements for water bound macadam for sub-base and base course. The flakiness index of pink granite gneiss and fine-grained granite could not be done but the impact and abrasion values are within the required limit. Thus all the rock units mentioned except the amphibolite can be used as coarse aggregate in water bound macadam for sub-base and base course provided the grading of the materials is in conformity as shown in Table 2.

The physical requirements for bituminous macadam are such that the maximum limit for Los Angeles value is 40 percent, aggregate impact value 30 percent, flakiness index 35 percent and water absorption 2 percent. The results of the different experiments show that the impact value of pink granite gneiss is 30 percent and the maximum limit exceeds in all the other rock units. The other physical properties are very much within the required limits. Because of the Impact value all rock units except pink granite gneiss are unsuitable for bituminous macadam. Moreover the grading is to be done accordingly (Table 4 and 5).

Thus it can be stated that grey porphyritic granite, granite gneiss, and fine grained granite can be used as coarse aggregate in water bound macadam for sub-base and base course, and pink granite gneiss can be used in both water bound macadam and bituminous macadam.The amphibolite is unsuitable for its high impact value as coarse aggregate in water bound macadam for sub-base and base course and bituminous macadam for bases and wearing courses.

It is observed that the impact value and abrasion value in amphibolite are 49 percent and 38 percent, in grey granite gneiss 34 percent and 34 percent, and in pink granite gneiss 30 percent and 24 percent, respectively. From this it is inferred that the grade of metamorphism has no effect on the suitability of the rock. In grey granite gneiss and pink granite gneiss the percentage of quartzo-feldspathic minerals is more, whereas the percentage of ferromagnesium minerals is less, compared to that of amphibolite. From this it can be inferred that the impact and abrasion value decreases as the percentage of minerals of high hardness increases.

The impact value and abrasion value in grey porphyritic granite are 34.6 percent and 38 percent and fine grained granite are 33 percent and 31.2 percent respectively. Thus the abrasion and impact value are more in the grey porphyritic granite compared to fine- grained granite. Here though the mineral composition is same, there is much difference in their textures, one is inequigranular and coarse-grained, and the other equigranular and fine-grained. The impact value and the abrasion values are low in fine-grained equigranular rocks compared to the coarse-grained inequigranular rocks and hence it may be stated that fine-grained equigranular rock unit is more suitable.

Thus it can be concluded that both the mineralogical and textural features of a rock has great influence on the suitability of the rock for various construction purposes. Rocks having minerals of high hardness and rocks which have an equigranular textures are more suitable.

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