

Interim Report on

Laboratory Geotechnical Investigations on Rock Core Samples from Quarry Site of Gargaon and Khanivade pertaining to Vadhvan Port Project.



Centre for Testing Services (CTS)

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Contents

1.0 Introduction.....	2
2.0 Scope of Work.....	Error! Bookmark not defined.
3.0 Sample Preparation.....	Error! Bookmark not defined.
4.0 Methodology	3
4.1 Density (Dry/Saturated).....	3
4.2 Uniaxial Compression Test	3
4.3 Acid Reaction Test	4
4.4 Ultrasonic Pulse Velocity	5
5.0 Test results	6
5.1 Density (Dry/Saturated).....	6
5.2 Uniaxial Compression Test	7
5.3 Acid Reaction Test.....	8
6.0 Summary	9

1.0 Introduction

Laboratory geotechnical investigations were carried out by National Institute of rock Mechanics (NIRM) on the rock core samples belonging to the quarry site of Gargaon and Khanivade pertaining to Vadhvan Port Project, for the purpose of suitability of rock for the use as Armor stone in construction breakwater. The core samples were received from 5 Boreholes for determining physico mechanical properties. Accordingly the laboratory tests were conducted to determine various physico mechanical properties. This report includes sample preparation, methodology of testing and the results obtained.

2.0 Scope of Work

The scope of work includes determination of the following properties on both dry and saturated samples of surge pool and Pump house borehole core samples.

- Bulk Density (Dry/Saturated)
- Uniaxial compressive strength
- Acid Reaction Test
- Ultrasonic Pulse velocity test

3.0 Sample Preparation

The rock core samples received from 5 Boreholes from the quarry site of Gargaon and Khanivade pertaining to Vadhvan Port Project for laboratory investigations comprised of grey granite having a diameter of 54 mm. The selected core samples were cut to required length and grinded with surface grinder to obtain core samples having an L/D ratio of 2 for conducting uniaxial compression tests. Test specimens were prepared from the received core samples to determine Density, Uniaxial compressive strength, Acid Reaction test and Ultrasonic pulse velocity tests. All the tests were conducted as per International Society for Rock Mechanics (ISRM) standards including the sample preparation (Figure 1).

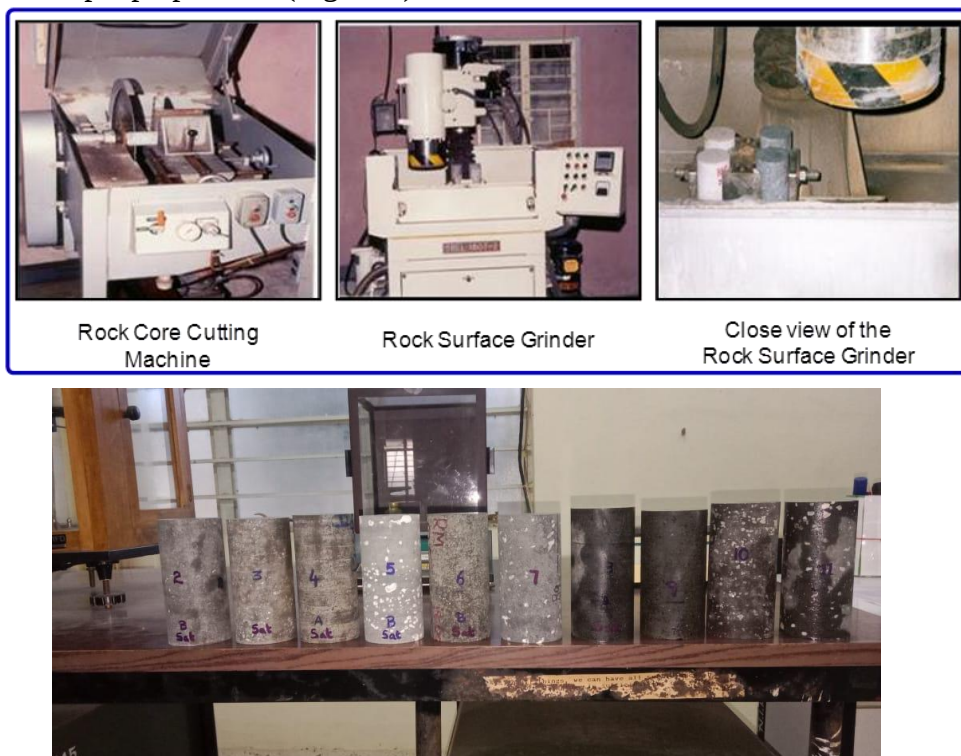


Figure 1: Sample preparation machines and prepared samples.

4.0 Methodology

4.1 Density

Density is determined by measurement method. The volume of the sample was calculated by measuring its dimensions using Vernier caliper and the mass was determined using weighing machine. Density was calculated by dividing the mass by volume and its unit is kg/m^3 .

4.2 Uniaxial Compression Test



Hardness is the basic quantitative physiomechanical property of a rock sample. Assessing the strength and deformability of rock mass is of great importance for the implementation of numerical analyses in rock mechanics.

Uniaxial compressive strength (UCS) is a geomechanical rock parameter that describes the maximum axial load that the sample can withstand without lateral loading. This is why it is also called unlimited compressive strength.

The rock is sampled by core drilling, and the sample that best represents the rock mass is selected. The minimum diameter of the sample is 54 mm. The ratio of length to diameter of the sample (L/D) must be between 2 according to the ASTM (American Society for Testing and Materials) standard, and between 2.5 and 3 according to the ISRM (International Society for Rock Mechanics) standard.

This test is intended to determine the Uniaxial compressive strength (UCS) of rock specimens under dry conditions. To test under dry condition, the test specimens were dried in atmosphere and then tested (Figure 2). The specimen is placed in the Compression testing machine and axial load is applied continuously at a constant stress rate of 0.5 to 1.0

MPa/s up to failure of the sample. The load and axial deformation were recorded continuously. Compressive strength is calculated from the maximum load recorded for each test specimen.



Figure 2: Compression testing set up and Data Acquisition System

4.3 Acid Reaction Test

Carbonate minerals and rocks (i.e. those that have calcite and/or dolomite in them, such as limestones, dolostone, and marble) are very common, and the quickest way to identify them is with an acid reaction.

The acid used is dilute hydrochloric acid. Just a few percent solution is good enough, and never more than 10 percent. We keep it in a squeeze or dropper bottle so that just a drop at a time can be placed on the specimen. And we wash the specimen well each time. Acid this weak will not hurt you, but it will eat holes in your clothes.

Any rock with calcite reacts quickly with large bubbles. Dolomite, however, reacts very slowly, and pure dolomite must be powdered to get even a weak reaction, very fine, slow bubbles.

Calcite and dolomite are a solid solution series; that is, there is a complete intergradation from 100% of one to 100% of the other, so in between there are intermediate reactions.

The biggest caution, aside from safety, is that many non-carbonate rocks are contaminated with more or less small amounts of calcite. These contaminated rocks react just as well as pure carbonate rocks, sometimes better. It takes careful observation to be sure, but look for a residue that did not react with the acid. This is a good indication that something else is in the rock, or may even be the majority of the rock.

4.4 Ultrasonic Pulse Velocity test

Ultrasonic pulse velocity: CUTE 103 is portable instrument designed with advanced features for non-destructive testing of rock/concrete quality by Ultrasonic Pulse Velocity (UPV) measurement method (Figure 3). Applications include estimation of properties of concrete such as strength, uniformity, crack depths, etc.



Figure 3: Ultrasonic pulse velocity.

Operating principal: The instrument uses transmission method for measurement of the transit time of ultrasonic pulses in the specimen under test. Two piezoelectric transducers are used, one as transmitter (Tx) and the other as receiver (Rx). Due to the non-homogeneous nature of the concrete, the use of low frequency transducers (in the range 20-600kHz) is necessary in order to achieve adequate penetration into the coarse grains of the concrete. The transmitting transducer is excited by a very short duration high voltage pulse, which causes vibrations at resonance frequency. These vibrations of ultrasonic frequency are coupled into the concrete specimen under test. The receiving transducer is used to detect these vibrations and to convert them back into electrical pulses. Suitable coupling media are used to minimise losses due to acoustic mismatch at the transducer- specimen interfaces. The path length (L) can be measured with a measuring tape. Time taken by the sound waves to travel the measured length is Transit time (T). Ultrasonic Pulse Velocity (PV) in the specimen under test can be computed, as

$$\text{UPV} = \text{Path length (L)} / \text{Transit Time (T)}$$

5.0 Test results

The samples were tested under uniaxial stress conditions for the determination of Uniaxial compressive strength.

5.1 Density

A total of 11 samples were tested from 5 different boreholes of the quarry site of Gargaon and Khanivade pertaining to Vadhvan Port Project for the determination of density. The results are presented in Table 1.

Table 1: Test Results – Density

Sl. No.	Borehole no	Depth (m)	Dry Density (kg/m ³)	Saturated Density (kg/m ³)
1	BH-1	19.50 - 21.00	2261	-
2	BH-1	25.50 - 27.00	2754	2756
3	BH-1	19.50 - 21.00	2680	2682
4	BH-2	15.00 - 16.50	2893	2894
5	BH-2	25.50 - 27.00	2647	2667
6	BH-5	18.00 - 19.50	2760	2763
7	BH-5	22.50 - 24.00	2723	2763
8	BH-3	10.50 - 12.00	2992	2992
9	BH-13	13.50 - 15.00	2830	2831
10	BH-13	18.00 - 19.50	2566	2587
11	BH-13	28.50 – 30.00	2722	2731

5.2 Uniaxial compressive strength, Young's Modulus and Poisson's ratio

Uniaxial compressive strength were determined for 11 samples were tested from 5 different boreholes of the quarry site of Gargaon and Khanivade pertaining to Vadhvan Port Project. The uniaxial compressive strength at dry condition varied from 90 MPa to 254 MPa and The uniaxial compressive strength at saturated condition varied from 42 MPa to 276 MPa The test results are presented in Table 2 ;

Table 2: Test Results - Uniaxial compressive strength

Sample no.	Bore hole no	Depth(m)	Condition	Uniaxial compressive strength (MPa)
1	BH-1	19.50 - 21.00	Dry	132
2A	BH-1	25.50 - 27.00	Dry	115
2B	BH-1	25.50 - 27.00	Saturated	149
3	BH-1	19.50 - 21.00	Saturated	114
4A	BH-2	15.00 - 16.50	Saturated	194
4B	BH-2	15.00 - 16.50	Dry	210
5A	BH-2	25.50 - 27.00	Dry	120
5B	BH-2	25.50 - 27.00	Saturated	92
6A	BH-5	18.00 - 19.50	Dry	90
6B	BH-5	18.00 - 19.50	Saturated	42
7	BH-5	22.50 - 24.00	Saturated	98
8A	BH-3	10.50 - 12.00	Dry	254
8B	BH-3	10.50 - 12.00	Saturated	276
9	BH-13	13.50 - 15.00	Saturated	118
10	BH-13	18.00 - 19.50	Saturated	117
11	BH-13	28.50 – 30.00	Saturated	119

Note: Sample No 6B of BH-5 of depth 18.00 to 19.50 was found to have multiple joints which resulted in earlier failure with low MPa.

5.3 Acid Reaction Test

Table 3: Test Results – Acid Reaction test

Sample no.	Bore hole no	Acid Reaction	Point Load (KN) after Acid reaction
1	BH-1	 HCL	4.2
2	BH-2	 Acetic Acid	3.6
3	BH-5	 Sulphuric Acid	2.4

6.0 Summary

Laboratory geotechnical investigations were carried out on core samples received from 5 Boreholes from the quarry site of Gargaon and Khanivade pertaining to Vadhvan Port Project. Tests were carried out as per ISRM suggested methods on the prepared test specimens both under dry & saturated conditions to determine various physico mechanical properties. The average test results obtained from these tests are listed below.

Property	Dry	Saturated
Density (kg/m ³)	2261-2992	2587-2992
Compressive Strength (MPa)	90 -254	42 -276
Acid Reaction test	BH-03 and BH-13 Test under process	
Ultrasonic Pulse velocity test	Test under process	


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