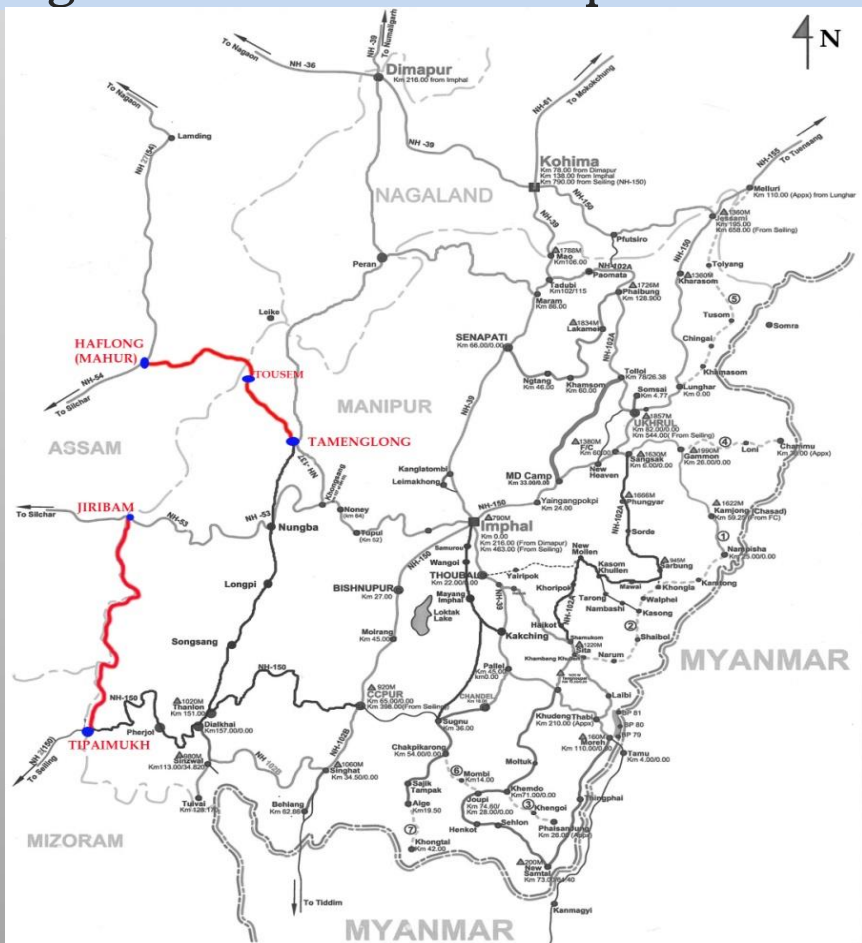


# NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

Consultancy Services for preparation of Feasibility Study and Detailed Project Report for Two Lane with Paved Shoulders of Tamenglong-Tousem-Haflong Road in the State of Manipur and Assam.



## DRAFT DETAILED PROJECT REPORT VOL-III MATERIAL REPORT PKG-10 P.LEIKUL- MAHUR(BOROWAPU) SECTION (FROM KM 156+489 TO KM 176+581) LENGTH-20.092 KM

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# CHAPTER 1

## INTRODUCTION

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# CHAPTER 1 INTRODUCTION

## 1.1 INTRODUCTION

### ○ GENERAL

The selected National Highway serve as lifeline for population living in rural areas scattered in vast geographical span of districts. In Assam the geographical rough & Hilly terrain demands for an effective road network in order to provide population proper connectivity. The condition of highways has quite improved in past years, however still lot of scope still remains for improvement in road infrastructure network across Manipur.

### ○ PROJECT BACKGROUND

National Highways and Infrastructure Development Corporation Limited.,(NHIDCL) have been constituted by the Government of India in the year 2014 with the purpose of up-gradation and development of National Highways and Strategic Roads including interconnecting roads in parts of the country which share international boundaries with neighboring countries. Private consultants will provide consultancy service to establish the technical, economical and financial viability of the projects with due consideration to environmental and social safeguards and to prepare Detailed Project Reports for widening, relaying and / or reconstruction of roads. LN Malviya Infra Projects Pvt. Ltd., BHOPAL as consultants to provide the Consultancy Services for Preparation of Detailed Project Report for Tamenglong-Mahur Road in the State of Manipur.

## 1.2 PURPOSE OF MATERIAL INVESTIGATION

The investigation for the soil and other construction material has been carried out to :-

- Determine the natural and physical characteristics of soil and soil profile for design of

embankment and pavement.

- Identify and locate borrow areas for their availability and suitability for use.
- Locate sources for aggregate require for pavement and structures and to ascertain their vitality and suitability for use.
- Locate sources of water suitable for construction.
- Gather general information regarding sub -soil, water level and flooding.
- Identify sources for other construction material such as cement, Sand, Aggregate, bitumen and steel.

### 1.3 DETAIL OF INVESTIGATION

The detailed investigation included both field and laboratory work. Samples of borrow soils, sand and crushed rock for use in embankment, pavement and in other structure were collected from the existing as well as proposed borrow sources / quarries within reasonable short haulage distance from the project corridor. Auger holes and test pits were excavated where necessary to obtain samples for testing.

The following **Table 1.1** Summarizes the investigation and testing accomplished by the consultant to archive the objective

**Table 1.1 Quantum of investigation and Testing**

S. No.	Description	Interval	Number
1.	Test pit excavation penetrating pavement structure down to sub-grade to record (a) pavement (b) field density and compaction and ( c) collection of sub-grade sample	Min 1 per 5 kms. (Hill Sides)	4
2.	Investigation of (I) Quarry sources (ii) Sand sources	----- -----	1 1

## 1.4 TEST PROCEDURE

The standard test procedure followed for soil sampling and laboratory testing is given in Table 1.2. All laboratory tests have been performed at our in-house laboratory located at Bhopal (M.P.) and the results are compiled in Annexure.

**Table 1.2 Standard Test Procedures**

S. No.	Type of Test	Method
1.	Sieve analysis - Natural Soils - Selected Soil	IS: 2720 Part 4 IS: 2386 Part 1
2.	Field Density Test	
3.	Modified Proctor Compaction Tests - OMC - MDD	IS :2720 Part 2 (Section I) IS :2720
4.	Atterberg Limits	IS :2720 Part 5
5.	CBR Soaked & Unsoaked & Swell Test	IS :2720 Part 16

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## CHAPTER 2

# SOIL PROFILE ALONG THE PROJECT ROAD

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## CHAPTER 2

# SOIL PROFILE ALONG THE PROJECT ROAD

### 2.1 FIELD AND LABORATORY TESTING

Test pits were excavated on an average at an interval of about 5 kms and at the location where the soil strata changes to perform field density and to collect samples for laboratory tests. They were carefully dug from the pavement surface up to sub grade level, after this they were manually leveled and prepared for field density tests. Field density tests on the sub-grade soil were conducted using the sand replenishment method at each test location and small quantity was collected in airtight containers for deterring the field moisture from each test pit.

Upon completion of field density test, respective sample of sub – grade soil was collected in bulk in gunny bag from each test pit for laboratory tasting. Finally holes were drilled using hand auger from the bottom of the test pit to collect soil samples for identification and laboratory classification test. Respective samples of soil and materials collected from the test pit and auger holes were subjected to various laboratory and field tests as listed below.

The tests performed were

- Grain size distribution
- Atterberg limit
- OMC & Maximum Dry Density for modified proctor Compaction
- CBR tests Soaked and Unsoaked

### 2.2 TEST RESULTS

The tests results of soil and soil field density are exhibited in Appendix 1 Summary of laboratory soil test result and field test result are given in Tables 2.1 and 2.2 respectively.



**Table 2.1 Laboratory Soil test Results**

S. No.	Chainage Km	Modified Proctor Compaction Test		Grain Size Analysis			Atterberg Limit			CBR
		OMC %	MDD gm/cc	Gravel %	Sand %	Silt & Clay %	L.L. %	P.L. %	P.I. %	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	164+000	8.50	2.097	20.25	39.60	40.15	37.75	26.45	11.30	12.14
2	168+850	8.25	2.212	22.80	48.25	28.95	25.70	19.78	5.92	36.50
3	174+250	10.9	1.918	14.85	36.60	48.55	30.55	22.36	8.19	9.80
4	182+165	8.25	2.149	20.15	56.25	23.60	25.55	NP	-	26.67

## 2.3 CONCLUSIONS

Along the entire corridor Four type of soil were encountered, Greyish Silty Sandy Clay, Light Yellow Clayey Silty Sandy clay, Light Brown Clayey Silty Sand & Reddish Clayey Silty Sand with high compressibility (CH) and granular properly and well graded soil. Field density measurements on the existing sub – grade reveals that they are within the acceptable range.

To evaluate the sub-grade strength in it existing condition, the CBR strength of the sub - grade were determine by compacting the samples in soaked (for four days) and unsoaked condition.

The soaked CBR of soil varies from 9.8% to 36.50% out of which 100 % of the results are above 8% CBR. Therefore CBR strength is quite good reflection of their potential strength.

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## **CHAPTER 3**

# **CONSTRUCTION MATERIALS**

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## **CHAPTER 3**

# **CONSTRUCTION MATERIALS**

### **3.1 OBJECTIVE**

The objective of the construction material survey was to:

- (I) Locate potential sources of soil borrow areas, gravel, rock quarries, water sources and other construction materials within the project vicinity.
- (II) Examine the engineering properties of materials relevant to the project as per MORTH specifications.

As a first step, material surveys were identified with the help of existing data, local enquiry and field assessment. Thereafter soil and aggregate samples were collected from the identified sources for testing.

### **3.2 BORROW AREAS**

#### **3.2.1 Identification**

Investigation has been done to locate the potential borrow areas for sub – grade / embankment fill and granular sub- base along the project corridor with economic hauling distance. To achieve the objective the offices of NHIDCL and local people were connected. Based on the information collected, field surveys carried out and personal experience, potential borrow areas have been identified which either existing old borrow areas or new ones are lying in the Existing Road land belonging to government or people.

Borrow areas have been identified in existing road side hill portion. These are spread between overall length of the project corridor. The soil from these borrow areas (or existing) is generally of hard moorum type with high CBR Value. The details of these areas i.e., location, distance from the project road, is given Table 3.1 below.

**Table 3.1: Borrow Areas Location**

Sr. No.	Location	Villages	Distance from project corridor
1.	From Km 160.875 To Km 182.169	-	On Corridor Both Side

All the borrow areas have sufficient quantity of material and can be used in the road. Some of borrow areas are pre-approved by the NHIDCL. Borrowing soil from these areas would require prior notice to the local authorities' private people and permission obtained from them with or without royalties.

Soil samples from these borrow areas were collected by excavating pits down to 1.0 m. depth from the existing surface. The top organic layer of 100 mm was removed before sampling.

### 3.2.2 Sampling and Laboratory Testing

3 borrow areas identified. The following tests were carried out on borrow soil samples

- Grain Size Analysis
- Atterberg Limits
- Proctor Compaction Test
- CBR Test

## 3.3 AGGREGATES

### 3.3.1 Quarries for Aggregates

Aggregates for sub- base, base and surface courses are proposed to be utilized from the crusher or quarries under operation within economical haulage distance of the project corridor. Some of these quarries have been leased by Assam Government and the lessees have installed crusher and sell aggregates. The allotted area is a small fraction of the total area of each quarry. It is learnt that further area can be leased out by the Assam Government for this purpose.

**Table 3.2 : Location of Aggregate Quarries**

Sr. No.	Location	Chainage (km.)
1.	At Jiri River	At 60km Lead
2.	At Laisong River	At 15km Lead

**Table 3.3: Location of Sand Quarries**

Sr. No.	Location	Chainage (km.)
1.	At Jiri River	At 60km Lead
2.	At Maibong	At 30km Lead

### 3.3.2 Sampling and Testing

The following tests were conducted

#### 3.3.2.1 For Aggregate

- Impact Value
- Specific Gravity
- Water Absorption

#### 3.3.2.2 For Sand

- Grading
- Fineness Modules

Four samples each of aggregates and sand collected from the identified quarries have been tested. The test report is exhibited in Appendix -1. Summary of test results of Aggregates and sand is given in Table 3.4.

**Table 3.4 Test Result of Aggregates at Location-1**

S. No.	Name of Test	Sample Details / Result
1.	% Impact Value	25.89%
2.	% Specific Gravity	2.58
3.	% Water Absorption	1.40%
4.	CBR	31.46%

**Table 3.5 Test Result of Aggregates at Location-2**

S. No.	Name of Test	Sample Details / Result
1.	% Impact Value	34.95%
2.	% Specific Gravity	2.47
3.	% Water Absorption	1.83%
4.	CBR	26.16%

### 3.3.2.3 Aggregates

For the Aggregates tested, the impact value is 25.89 % which is within the permissible limit. The specific gravity varies from 2.58% to which is acceptable. The water absorption varies from 1.4% and less than the permissible limit of 2%. On the basis of this property; all the samples are suitable as aggregate for any of the pavement layers. However it may be pointed out that a change in type of crusher can result in lower flakiness and elongation index. It is therefore expected that with the use of integrated crushing plants (cone crusher as secondary unit), this property will get satisfied.

It therefore reveals that aggregate from the tested quarries, which are with reasonable reach of the projected corridor, after meeting all the engineering requirement and specifications can be used for construction.

### **3.3.2.4 SAND**

The grading and fineness modules of sand samples tested are generally within the permissible limits and as such material from such quarries is fit for use.

### **3.4 WATER**

The potable water from tube well, opens wells, water supply schemes is considered suitable for construction and available in plenty.

### **3.5 OTHER CONSTRUCTION MATERIALS**

Bitumen is to be brought reputed oil refinery or from Distributor of Guwahati or near by places. Manufacturer's test / quality certificate is required for each consignment received. Steel of various grade including HYSD steel as per IS specification is available in Guwahati & other cities of Assam and can be bought from there or can be arranged from the Manufacturers. Manufacturer's test / quality certificate is needed for each consignment received.

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## **CHAPTER 4**

# **PROCUREMENT OF CONSTRUCTION MATERIALS**

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## **CHAPTER 4**

# **PROCUREMENT OF CONSTRUCTION MATERIALS**

### **4.1 BORROW AREA SOILS**

To get the soil, the contractor

- Shall have to meet the owner (Private Person or Government Department) of the borrow area.
- Negotiate the price of the land (for Government area as per notified rules).
- Specifically mentioning the area required, depth of cut, exact time and duration of operation.
- Should make a proper agreement on the stamp paper with all terms and condition mentioned in it.
- Replace the top soil of the borrow area at the time of handing over the borrow pit to the owner, which was removed in the beginning of the operation, of excavation.

### **4.2 AGGREGATES**

To get aggregates, the contractor

- Can purchase the aggregates. from the market as long as the aggregate meet the specification requirements.
- Can set up his own crusher in the quarry area, after taking the quarry area on lease from the revenue / mining department of the state.
- Take NOC from various Government Departments such as Police, Mining, Revenue etc. for new quarries.

### **4.3 SAND**

Sand can be obtained from the natural stream or quarries by paying royalty to the Government.

#### 4.4 WATER

To get Water, the contractor

- Can have it by installing pumps on the existing open well / bore holes along the road and payments may be paid to the owner of the wells / bore holes or
- Can dig his own tube well after taking approval from the state Ground Water Board.

#### 4.5 GRANULAR SUB-BASE

To obtain GSB, the contractor

- Can have it from his own crusher as 'Direct Crusher Run'

#### 4.6 OTHER CONSTRUCTION MATERIALS

To arrange other construction materials like cement, steel etc., the Contractor

- Can buy it directly from the sources / manufacturing unit or
- Can purchase from the local suppliers of nearby cities.

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# APPENDICES TO CHAPTER 1

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## Analysis Report

### I. SAND

#### a.Source: Maibong

S. No.	Tests	Test Values
1.	<u>Sieve Analysis</u>	
2.	Sieve size mm	% Passing
3.	10	97.86
4.	4.75	95.58
5.	2.36	95.42
6.	1.18	94.51
7.	600	92.88
8.	300	35.00
9.	150	7.59
10.	75	0.00
11.	Deleterious Material	-
12.	Deleterious Material-Coal & Lignite	-
13.	Deleterious Material-Clay & Lumps	-
14.	Silt & Clay	0.48%
15.	Finess Modulus	0.55%

**IS Codes Followed: 2720(Various parts),2386(Various parts),383**

**FREE SWELL INDEX OF SOIL (IS : 2720 PART 40) 1977**

Sample Location : 164+000

Date Sampling : 04/10/22

Source of Materials : Soil

Date of Testing : 05/10/22

Description of Sample :

**Observation Sheet**

Determination No			1	2
1	Mass of Dry Soil Passing 425 $\mu$ Sieve (gm)		10.00	10.00
2	Volume in Water 24 hrs swell (Vd) (cc)		13.50	14.00
3	Volume in Kerosene after 24 hrs (Vk) (cc)		10.50	11.00
4	Free Swell Index [(Vd-Vk)/Vk]x100 (%)		28.57	27.27
5	Average (%)		27.92 %	

**GRAIN SIZE ANALYSIS OF SOIL (AS PER IS :2720, PART-4)**

Sample Location : 164+000

Date of Sampled : 04/10/22

Source of Materials : Soil

Date of Soaking : 05/10/22

Description of Sample :

Date of Testing : 06/10/22

Method of Sieving : Wet/Dry

Weight of Sample(gm) : 1000

Sieve size	Weight Retained (gms)	Weight Retained (%).	Cumulative weight Retained (%).	Passing (%)	Remarks
100 mm	0	0	0	100	Gravel
75 mm	0	0	0	100	
19 mm	0	0	0	100	
4.75 mm	202.5	20.25	20.25	79.75	
2 mm	190.5	19.05	39.30	60.70	Sand
425 mic.	146.0	14.60	53.90	46.10	
75 mic.	59.50	5.95	59.85	40.15	
Pan					Silt & Clay
<b>Gravel</b>		<b>20.25 (%)</b>	<b>Sand Content</b>	<b>39.60(%)</b>	
<b>Silt/Clay Content</b>		<b>40.15(%)</b>			

**ATTERBERG'S LIMIT (As per IS 2720, Part - 5) BY CASA GRAND METHOD**

Source : Soil

Date of Sampled : 06/10/22

Location : 164+000

Date of Tested : 07/10/22

Description of Material :

Description	LIQUID LIMIT				PLASTIC LIMITS	
Trial No.	1	2	3	4		
Container No.	A-7	A-8	A-10	A-11	A-12	A-13
No.Of Blows	34	27	23	17	-	-
Empty weight container (a) (gm)	13.18	14.67	13.70	14.30	12.93	14.50
Wt. of container + wet soil (b) (gm)	33.09	34.45	38.22	36.98	28.98	30.47
Wt. of container + Oven dry soil © (gm)	27.95	29.10	31.36	30.45	25.59	27.16
Wt. of Water (b-c)=d (gm)	5.14	5.35	6.86	6.53	3.39	3.31
Wt. of dry soil (c-a)=e (gm)	14.77	14.43	17.66	16.15	12.66	12.66
Moisture Percent = d/e x 100 %	34.80	37.08	38.84	40.43	26.78	26.15

LL : 37.75 %

PL: 26.45%

PI:11.30%

**MOISTURE DENSITY RELATIONSHIP ( IS 2720 PART- 7 & 8 )**

Source : Soil

Date of Sampled : 04/10/22

Location : 164+000

Date of Tested : 08/10/22

Description of Material :

Type of Compaction : Dynamic

No. of Blows : 25

Type of Method : Standard / Modified

No. of Layers : 5

Wt. of Rammer : 4.89 Kg

Wt. of Original Sample : 3000 gms

S.no	Description	Unit	1	2	3	4	5	6
1	Volume of mould (V)	(cc)	1000	1000	1000	1000	1000	
2	Weight of mould (a)	(gm)	4193	4193	4193	4193	4193	
3	Weight of mould + Wet soil (b)	(gm)	6305	6391	6468	6460	6453	
4	Weight of Wet soil (b-a)=c	(gm)	2112	2198	2275	2267	2260	
5	Wet Density = c/v	(gm/cc)	2.112	2.198	2.275	2.267	2.260	
<b><u>Moisture Content Determination</u></b>								
S.no	Container No.	-	B-40	B-41	B-42	B-43	B-45	
1	Weight of container (1)	(gm)	43.74	44.90	46.47	42.78	46.85	
2	Weight of container + wet soil (2)	(gm)	194.13	177.23	173.48	166.68	176.85	
3	Weight of container + Dry soil (3)	(gm)	187.93	169.13	163.53	155.13	163.15	
4	Weight of water (2-3)=4	(gm)	6.20	8.10	9.95	11.55	13.70	
5	Weight of Dry soil (3-1)=5	(gm)	144.19	124.23	117.06	112.35	116.30	
6	Water Content (4/5x100)	%	4.30	6.52	8.50	10.28	11.78	
7	Dry density	(gm/cc)	2.025	2.063	2.097	2.056	2.022	
						<b><u>RESULTS</u></b>		
						MDD (gm/cc) : 2.097		
						OMC (%) : 8.50		

**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Sample Location : 164+000 Date of Sampled : 04/10/22  
Source of Materials : Soil Date of Soaking : 14/10/22  
Description of Sample : Date of Testing : 18/10/22

**Observation Sheet**

Type of Compaction : Dynamic Soaking : 96 Hours  
Surcharge Weight (gm) MDD : 2.097 gm/cc  
Weight of Original Sample : 6000 gm OMC : 8.50%

**California Bearing Ratio IS : 2720 (Part -16)**

Description	Before Soaking			After Soaking		
	10 Blows	30 Blows	65 Blows	10 Blows	30 Blows	65 Blows
Mould No.	13	14	15	13	14	15
Volume of the mould (V) (cc)	2250	2250	2250	2250	2250	2250
Wt. of mould (m <sub>1</sub> ) (gm)	6945	7027	6936	6945	7027	6936
Wt. of mould + Compacted soil (w <sub>2</sub> ) (gm)	11582	11928	11999	11686	12000	12077
Wt. of compacted soil (W <sub>3</sub> = W <sub>2</sub> -W <sub>1</sub> ) (gm)	4637	4901	5063	4741	4973	5141
Wet Density of Soil (D <sub>w</sub> ) = W <sub>3</sub> /V (gm/cc)	2.061	2.178	2.250	2.107	2.210	2.285
<b>Water Container Data</b>						
Container No.	B-28	B-29	B-30	B-28	B-29	B-30
Wt. of container (gm)	45.18	38.08	48.13	45.18	38.08	48.13
Wt. of container + wet soil (gm)	227.07	227.60	247.83	248.01	255.97	268.93
Wt. of container + Oven dry soil (gm)	212.42	212.48	232.05	227.09	234.82	248.13
Wt. of water (gm)	14.65	15.12	15.78	20.92	21.15	20.80
Wt. of Oven dry soil (gm)	167.24	174.40	183.92	181.91	196.74	200.00
Water Content (%)	8.76	8.67	8.58	11.50	10.75	10.40
Dry density of Soil (D <sub>d</sub> ) = 100xD <sub>w</sub> /(100+w) (gms/cc)	1.895	2.004	2.672	1.890	1.995	2.070
% of MDD :	90.37	95.57	98.81	90.13	95.14	98.71



**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Source Description : Soil 164+000

Providing Ring Constant (Kg/Div): 4.31

Proving Ring No : 01842

Penetration Rate : 1.25/min

Sl. No	Penetration (mm)	Mould No.		Mould No.		Mould No.	
		Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)
1	0.5	3	12.93	6	25.86	7	30.17
2	1.0	7	30.17	12	51.72	12	51.72
3	1.5	11	47.41	18	77.58	19	81.89
4	2.0	16	68.96	24	103.44	26	112.06
5	2.5	20	86.20	31	133.61	36	155.16
6	3.0	24	103.44	38	163.78	44	189.64
7	4.0	29	124.99	47	202.57	52	224.12
8	5.0	35	150.85	57	245.67	64	275.84
9	7.5	44	189.64	76	327.56	81	349.11
10	10.0	54	232.74	98	422.38	103	443.93
11	12.5	63	271.53	118	508.58	124	534.44
CBR of specimen at 2.5 mm (standard 1370 kg) by graph		6.29		9.75		11.33	
CBR of specimen at 5.5 mm (standard 2055 kg) by graph		7.34		11.95		13.42	
CBR Value of Sample @ 5.00 mm CBR Value = 12.14%							

**FREE SWELL INDEX OF SOIL (IS : 2720 PART 40) 1977**

Sample Location : 168+850

Date Sampling : 04/10/22

Source of Materials : Soil

Date of Testing : 05/10/22

Description of Sample :

**Observation Sheet**

Determination No		1	2
1	Mass of Dry Soil Passing 425 $\mu$ Sieve (gm)	10.00	10.00
2	Volume in Water 24 hrs swell (Vd) (cc)	14.50	14.00
3	Volume in Kerosene after 24 hrs (Vk) (cc)	11.00	10.50
4	Free Swell Index [(Vd-Vk)/Vk]x100 (%)	31.82	33.33
5	Average (%)	32.58 %	

**GRAIN SIZE ANALYSIS OF SOIL(AS PER IS :2720, PART-4)**

Sample Location : 168+850			Date of Sampled : 04/10/22		
Source of Materials : Soil			Date of Soaking : 05/10/22		
Description of Sample :			Date of Testing : 06/10/22		
Method of Sieving : Wet/Dry			Weight of Sample(gm) : 1000		
Sieve size	Weight Retained (gms)	Weight Retained (%)	Cumulative weight Retained (%)	Passing (%)	Remarks
100 mm	0	0	0	100	
75 mm	0	0	0	100	Gravel
19 mm	0	0	0	100	
4.75 mm	228.0	22.80	22.80	77.20	
2 mm	195.5	19.55	42.35	57.65	Sand
425 mic.	206.5	20.65	63.00	37.00	
75 mic.	80.5	8.05	71.05	28.95	
Pan					Silt & Clay
Gravel		22.80 (%)	Sand Content		48.25(%)
Silt/Clay Content		28.95(%)			

**ATTERBERG'S LIMIT (As per IS 2720, Part - 5) BY CASA GRAND METHOD**

Source : Soil

Date of Sampled : 06/10/22

Sample Location : 168+850

Date of Tested : 07/10/22

Description of Material :

Description	LIQUID LIMIT				PLASTIC LIMITS	
Trial No.	1	2	3	4		
Container No.	A-14	A15	A-16	A-17	A-18	A-20
No.Of Blows	33	28	24	19	-	-
Empty weight container (a) (gm)	13.72	12.95	13.75	14.72	11.90	14.00
Wt. of container + wet soil (b) (gm)	35.48	37.94	36.60	37.02	30.72	30.82
Wt. of container + Oven dry soil © (gm)	31.31	32.97	31.90	32.25	27.55	28.10
Wt. of Water (b-c)=d (gm)	4.17	4.97	4.70	4.77	3.17	2.72
Wt. of dry soil (c-a)=e (gm)	17.59	20.02	18.15	17.93	15.65	14.10
Moisture Percent = d/e x 100	%	23.71	24.83	25.90	27.21	20.26
<b>LL : 25.70%                      PL: 19.78%                      PI:5.92%</b>						

**MOISTURE DENSITY RELATIONSHIP ( IS 2720 PART- 7 & 8)**

Source : Soil

Date of Sampled : 06/10/22

Sample Location : 168+850

Date of Tested : 08/10/22

Description of Material :

Type of Compaction : Dynamic

No. of Blows : 25

Type of Method : Standard / Modified

No. of Layers : 5

Wt. of Rammer : 4.89 Kg

Wt. of Original Sample : 3000 gms

S.no	Description	Unit	1	2	3	4	5	6
1	Volume of mould (V)	(cc)	1000	1000	1000	1000	1000	
2	Weight of mould (a)	(gm)	4193	4193	4193	4193	4193	
3	Weight of mould + Wet soil (b)	(gm)	6431	6509	6586	6584	6581	
4	Weight of Wet soil (b-a)=c	(gm)	2238	2316	2393	2391	2388	
5	Wet Density = c/v	(gm/cc)	2.238	2.316	2.393	2.391	2.388	
<b>Moisture Content Determination</b>								
S.no	Container No.	-	B-25	B-26	B-27	B-28	B-14	
1	Weight of container (1)	(gm)	41.40	45.97	47.40	45.20	48.39	
2	Weight of container + wet soil (2)	(gm)	215.80	200.67	195.85	181.46	182.69	
3	Weight of container + Dry soil (3)	(gm)	208.45	191.57	184.60	168.96	168.73	
4	Weight of water (2-3)=4	(gm)	7.35	9.10	11.25	12.50	13.96	
5	Weight of Dry soil (3-1)=5	(gm)	167.05	145.60	137.20	123.76	120.34	
6	Water Content (4/5x100)	%	4.40	6.25	8.20	10.10	11.60	
7	Dry density	(gm/cc)	2.144	2.180	2.212	2.172	2.140	
						<b>RESULTS</b>		
						MDD (gm/cc) : 2.212		
						OMC (%) : 8.25		

**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Sample Location : 168+850

Date of Sampled : 04/10/22

Source of Materials : Soil

Date of Soaking : 16/10/23

Description of Sample :-

Date of Testing : 20/10/22

**Observation Sheet**

Type of Compaction : Dynamic

Soaking : 96 Hours

Surcharge Weight (gm)

MDD : 2.212 gm/cc

Weight of Original Sample : 6000 gm

OMC : 8.25 %

**California Bearing Ratio IS : 2720 (Part -16)**

Description	Before Soaking			After Soaking		
	10 Blows	30 Blows	65 Blows	10 Blows	30 Blows	65 Blows
Mould No.	40	41	42	40	41	42
Volume of the mould (V) (cc)	2250	2250	2250	2250	2250	2250
Wt. of mould (m <sub>1</sub> ) (gm)	7107	7064	7095	7107	7064	7095
Wt. of mould + Compacted soil (w <sub>2</sub> ) (gm)	12035	12300	12491	12138	12390	12603
Wt. of compacted soil (W <sub>3</sub> = W <sub>2</sub> -W <sub>1</sub> ) (gm)	4928	5236	5396	5031	5326	5508
Wet Density of Soil (D <sub>w</sub> ) = W <sub>3</sub> /V (gm/cc)	2.190	2.327	2.398	2.236	2.367	2.448
<b><u>Water Container Data</u></b>						
Container No.	B-23	B-22	B-21	B-21	B-22	B-23
Wt. of container (gm)	37.95	42.92	47.36	47.36	42.92	37.95
Wt. of container + wet soil (gm)	177.92	242.72	249.61	272.71	274.55	249.21
Wt. of container + Oven dry soil (gm)	166.96	226.97	234.11	250.16	252.35	228.66
Wt. of water (gm)	10.96	15.75	15.50	22.55	22.20	20.55
Wt. of Oven dry soil (gm)	129.01	184.05	186.75	202.80	209.43	190.71
Water Content (%)	8.50	8.56	8.30	11.12	10.60	10.78
Dry density of Soil (D <sub>d</sub> ) = 100xD <sub>w</sub> /(100+w) (gms/cc)	2.018	2.144	2.214	2.012	2.140	2.210
% of MDD :	91.23	96.93	100.09	90.96	96.75	99.81

**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Source Description : Soil (168+850)

Providing Ring Constant (Kg/Div): 4.31

Proving Ring No : 01842

Penetration Rate : 1.25/min

Sl. No	Penetration (mm)	Mould No.		Mould No.		Mould No.	
		Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)
1	0.5	8	34.48	10	43.10	16	68.96
2	1.0	16	68.96	32	137.92	36	155.16
3	1.5	28	120.68	55	237.05	59	254.29
4	2.0	40	172.40	79	340.49	85	370.66
5	2.5	56	241.36	104	448.24	115	495.65
6	3.0	70	301.70	132	568.92	145	624.95
7	4.0	80	344.80	166	715.46	182	784.42
8	5.0	89	383.59	202	870.62	225	974.06
9	7.5	116	499.96	245	1055.95	280	1206.80
10	10.0	140	603.40	287	1236.97	334	1439.54
11	12.5	163	702.53	333	1435.23	382	1646.42
CBR of specimen at 2.5 mm (standard 1370 kg) by graph		17.62		32.72		36.18	
CBR of specimen at 5.5 mm (standard 2055 kg) by graph		18.67		42.37		47.40	
CBR Value of Sample @ 5.00 mm CBR Value = 36.50 %							

### FREE SWELL INDEX OF SOIL (IS : 2720 PART 40) 1977

Sample Location : 174+250

Date Sampling : 04/10/22

Source of Materials : Soil

Date of Testing : 05/10/22

Description of Sample :

#### Observation Sheet

Determination No			1	2
1	Mass of Dry Soil Passing 425 $\mu$ Sieve (gm)		10.00	10.00
2	Volume in Water 24 hrs swell (Vd) (cc)		14.50	14.00
3	Volume in Kerosene after 24 hrs (Vk) (cc)		11.00	10.50
4	Free Swell Index [(Vd-Vk)/Vk]x100 (%)		31.32	33.33
5	Average (%)		32.58 %	

### GRAIN SIZE ANALYSIS OF SOIL (AS PER IS : 2720, PART-4)

Sample Location : 174+250

Date of Sampled : 04/10/22

Source of Materials : Soil

Date of Soaking : 05/10/22

Description of Sample :

Date of Testing : 06/10/22

Method of Sieving : Wet/Dry

Weight of Sample(gm) : 1000

Sieve size	Weight Retained (gms)	Weight Retained (%)	Cumulative weight Retained (%)	Passing (%)	Remarks
100 mm	0	0	0	100	Gravel
75 mm	0	0	0	100	
19 mm	0	0	0	100	
4.75 mm	148.5	14.85	14.85	85.15	
2 mm	130.0	13.05	27.90	72.10	Sand
425 mic.	103.0	10.30	38.20	61.80	
75 mic.	132.5	13.25	51.45	48.55	
Pan					Silt & Clay
<b>Gravel</b>		<b>14.85 (%)</b>	<b>Sand Content</b>		<b>36.60 (%)</b>
<b>Silt/Clay Content</b>		<b>48.55(%)</b>			





**MOISTURE DENSITY RELATIONSHIP ( IS 2720 PART- 7 & 8)**

Source : Soil

Date of Sampled : 06/10/22

Location : 174+250

Date of Tested : 08/10/22

Description of Material :

Type of Compaction : Dynamic

No. of Blows : 25

Type of Method : Standard / Modified

No. of Layers : 5

Wt. of Rammer : 4.89 Kg

Wt. of Original Sample : 3000 gms

S.no	Description	Unit	1	2	3	4	5	6
1	Volume of mould (V)	(cc)	1000	1000	1000	1000	1000	
2	Weight of mould (a)	(gm)	4193	4193	4193	4193	4193	
3	Weight of mould + Wet soil (b)	(gm)	6167	6226	6318	6303	6299	
4	Weight of Wet soil (b-a)=c	(gm)	1974	2033	2125	2110	2106	
5	Wet Density = c/v	(gm/cc)	1.974	2.033	2.125	2.110	2.106	

**Moisture Content Determination**

S.no	Container No.	-	B-16	B-17	B-18	B-19	B-29	
1	Weight of container (1)	(gm)	38.41	46.38	44.48	45.47	38.06	
2	Weight of container + wet soil (2)	(gm)	188.30	177.08	172.10	178.47	169.32	
3	Weight of container + Dry soil (3)	(gm)	179.35	166.73	159.65	163.87	153.12	
4	Weight of water (2-3)=4	(gm)	8.95	10.35	12.45	14.60	16.20	
5	Weight of Dry soil (3-1)=5	(gm)	140.94	120.35	115.17	118.40	115.06	
6	Water Content (4/5x100)	%	6.35	8.60	10.81	12.33	14.08	
7	Dry density	(gm/cc)	1.856	1.872	1.918	1.878	1.846	

**RESULTS**

MDD (gm/cc) : 1.918

OMC (%) : 10.90

**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Sample Location : 174+250 Date of Sampled : 04/10/22  
Source of Materials : Soil Date of Soaking : 15/10/22  
Description of Sample : Date of Testing : 19/10/22

**Observation Sheet**

Type of Compaction : Dynamic Soaking : 96 Hours  
Surcharge Weight (gm) MDD : 1.918 gm/cc  
Weight of Original Sample : 6000 gm OMC : 10.90 %

**California Bearing Ratio IS : 2720 (Part -16)**

Description	Before Soaking			After Soaking		
	10 Blows	30 Blows	65 Blows	10 Blows	30 Blows	65 Blows
Mould No.	33	32	31	33	32	31
Volume of the mould (V) (cc)	2250	2250	2250	2250	2250	2250
Wt. of mould (m <sub>1</sub> ) (gm)	6943	7017	6740	6943	7017	6740
Wt. of mould + Compacted soil (w <sub>2</sub> ) (gm)	11286	11560	11478	11346	11612	11544
Wt. of compacted soil (W <sub>3</sub> = W <sub>2</sub> - W <sub>1</sub> ) (gm)	4343	4543	4738	4403	4595	4804
Wet Density of Soil (D <sub>w</sub> ) = W <sub>3</sub> /V (gm/cc)	1.930	2.019	2.106	1.957	2.042	2.135
<b>Water Container Data</b>						
Container No.	B-17	B-16	B-15	B-34	B-37	B-39
Wt. of container (gm)	46.35	38.37	39.00	45.25	46.16	45.57
Wt. of container + wet soil (gm)	230.59	220.15	231.45	219.58	217.75	216.91
Wt. of container + Oven dry soil (gm)	211.84	201.90	212.30	199.32	198.40	197.44
Wt. of water (gm)	18.75	18.25	19.15	20.26	19.35	19.47
Wt. of Oven dry soil (gm)	165.49	163.53	173.30	154.07	152.24	151.87
Water Content (%)	11.33	11.16	11.05	13.15	12.71	12.82
Dry density of Soil (D <sub>d</sub> ) = 100xD <sub>w</sub> /(100+w) (gms/cc)	1.734	1.816	1.896	1.730	1.812	1.892
% of MDD :	90.41	94.68	98.85	90.20	94.47	98.64

**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Source Description : Soil (174+250)

Providing Ring Constant (Kg/Div): 4.31

Proving Ring No : 01842

Penetration Rate : 1.25/min

Sl. No	Penetration (mm)	Mould No.		Mould No.		Mould No.	
		Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)
1	0.5	3	12.93	3	12.93	5	21.55
2	1.0	6	25.86	7	30.17	9	38.79
3	1.5	8	34.48	11	47.41	14	60.34
4	2.0	10	43.10	14	60.34	18	77.58
5	2.5	12	51.72	17	73.27	26	122.06
6	3.0	14	60.34	20	86.20	32	137.92
7	4.0	18	77.58	26	112.06	40	172.40
8	5.0	22	94.82	31	133.61	53	228.43
9	7.5	28	120.68	37	159.47	71	306.01
10	10.0	35	150.85	43	185.33	89	383.59
11	12.5	41	176.71	52	224.12	105	452.55
CBR of specimen at 2.5 mm (standard 1370 kg) by graph		3.78		5.35		8.91	
CBR of specimen at 5.5 mm (standard 2055 kg) by graph		4.61		6.50		11.12	
CBR Value of Sample @ 5.00 mm CBR Value = 9.80							

**FREE SWELL INDEX OF SOIL (IS : 2720 PART 40) 1977**

Sample Location : 182+165

Date Sampling : 04/10/22

Source of Materials : Soil

Date of Testing : 05/10/22

Description of Sample :

**Observation Sheet**

Determination No		1	2
1	Mass of Dry Soil Passing 425 $\mu$ Sieve (gm)	10.00	10.00
2	Volume in Water 24 hrs swell (Vd) (cc)	12.50	12.00
3	Volume in Kerosene after 24 hrs (Vk) (cc)	10.50	10.50
4	Free Swell Index $[(Vd-Vk)/Vk] \times 100$ (%)	19.05	14.29
5	Average (%)	16.67 %	

**GRAIN SIZE ANALYSIS OF SOIL (AS PER IS : 2720, PART-4)**

Sample Location : 182+165			Date of Sampled : 04/10/22		
Source of Materials : Soil			Date of Soaking : 05/10/22		
Description of Sample :			Date of Testing : 06/10/22		
Method of Sieving : Wet/Dry			Weight of Sample(gm) : 1000		
Sieve size	Weight Retained (gms)	Weight Retained (%).	Cumulative weight Retained (%).	Passing (%)	Remarks
100 mm	0	0	0	100	
75 mm	0	0	0	100	Gravel
19 mm	0	0	0	100	
4.75 mm	201.5	20.15	20.15	79.85	
2 mm	178.5	17.85	38.00	62.00	Sand
425 mic.	180.5	18.05	56.05	43.95	
75 mic.	203.5	20.35	76.40	23.60	
Pan					Silt & Clay
Gravel 20.15 (%)		Sand Content 56.25 (%)			
Silt/Clay Content 23.60(%)					

**ATTERBERG'S LIMIT (As per IS 2720, Part - 5) BY CASA GRAND METHOD**

Source : Soil

Date of Sampled : 06/10/22

Location : 182+165

Date of Tested : 07/10/22

Description of Material :

Description	LIQUID LIMIT				PLASTIC LIMITS	
Trial No.	1	2	3	4	1	2
Container No.	A-30	A-31	A-32	A-33	-	-
No.Of Blows	17	19	22	25	-	-
Empty weight container (a) (gm)	14.09	14.23	12.37	11.44	-	-
Wt. of container + wet soil (b) (gm)	33.96	35.22	33.68	32.79	-	-
Wt. of container + Oven dry soil © (gm)	30.42	31.24	29.43	28.29	-	-
Wt. of Water (b-c)=d (gm)	3.54	3.98	4.25	4.50	-	-
Wt. of dry soil (c-a)=e (gm)	16.33	17.01	17.06	16.85	-	-
Moisture Percent = d/e x 100 %	21.68	23.40	24.91	26.71	-	-
				Average PL =		
LL : 23.55 % PL: PI:						

**MOISTURE DENSITY RELATIONSHIP ( IS 2720 PART- 7 & 8)**

Source : Soil

Date of Sampled : 06/10/22

Location : 182+165

Date of Tested : 08/10/22

Description of Material :

Type of Compaction : Dynamic

No. of Blows : 25

Type of Method : Standard / Modified

No. of Layers : 5

Wt. of Rammer : 4.89 Kg

Wt. of Original Sample : 3000 gms

S.no	Description	Unit	1	2	3	4	5	6
1	Volume of mould (V)	(cc)	1000	1000	1000	1000	-	-
2	Weight of mould (a)	(gm)	4193	4193	4193	4193	-	-
3	Weight of mould + Wet soil (b)	(gm)	6377	6455	6518	6477	-	-
4	Weight of Wet soil (b-a)=c	(gm)	2184	2262	2325	2284	-	-
5	Wet Density = c/v	(gm/cc)	2.184	2.262	2.325	2.284	-	-
<b><u>Moisture Content Determination</u></b>								
S.no	Container No.	-	B-21	B-22	B-23	B-24	-	-
1	Weight of container (1)	(gm)	47.36	42.95	37.98	38.45	-	-
2	Weight of container + wet soil (2)	(gm)	190.39	175.80	168.06	167.70	-	-
3	Weight of container + Dry soil (3)	(gm)	184.48	168.15	158.18	156.25	-	-
4	Weight of water (2-3)=4	(gm)	5.91	7.65	9.88	11.45	-	-
5	Weight of Dry soil (3-1)=5	(gm)	137.12	125.20	120.20	117.80	-	-
6	Water Content (4/5x100)	%	4.31	6.11	8.22	9.72	-	-
7	Dry density	(gm/cc)	2.094	2.132	2.148	2.082	-	-
						<b><u>RESULTS</u></b>		
						MDD (gm/cc) : 2.149		
						OMC (%) : 8.25		

**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Sample Location : 182+165 Date of Sampled : 04/10/22  
Source of Materials : Soil Date of Soaking : 14/10/23  
Description of Sample : Date of Testing : 18/10/22

**Observation Sheet**

Type of Compaction : Dynamic Soaking : 96 Hours  
Surcharge Weight (gm) MDD : 2.149 gm/cc  
Weight of Original Sample : 6000 gm OMC : 8.25 %

**California Bearing Ratio IS : 2720 (Part -16)**

Description	Before Soaking			After Soaking		
	10 Blows	30 Blows	65 Blows	10 Blows	30 Blows	65 Blows
Mould No.	01	02	03	01	02	03
Volume of the mould (V) (cc)	2250	2250	2250	2250	2250	2250
Wt. of mould (m <sub>1</sub> ) (gm)	6960	7050	6995	6960	7050	6995
Wt. of mould + Compacted soil (w <sub>2</sub> ) (gm)	11762	12153	12235	11867	12204	12330
Wt. of compacted soil (W <sub>3</sub> = W <sub>2</sub> - W <sub>1</sub> ) (gm)	4802	5103	5240	4910	5153	5337
Wet Density of Soil (D <sub>w</sub> ) = W <sub>3</sub> /V (gm/cc)	2.134	2.268	2.329	2.182	2.290	2.372
<b>Water Container Data</b>						
Container No.	B-25	B-26	B-27	B-15	B-16	B-17
Wt. of container (gm)	41.33	45.94	47.38	39.03	38.38	46.35
Wt. of container + wet soil (gm)	202.93	214.99	222.49	268.84	260.69	273.98
Wt. of container + Oven dry soil (gm)	190.23	201.89	209.04	245.59	238.84	251.33
Wt. of water (gm)	12.70	13.10	13.45	23.25	21.85	22.65
Wt. of Oven dry soil (gm)	148.90	155.95	161.66	206.56	200.46	204.98
Water Content (%)	8.53	8.40	8.32	11.26	10.90	11.05
Dry density of Soil (D <sub>d</sub> ) = 100xD <sub>w</sub> /(100+w) (gms/cc)	1.966	2.092	2.150	1.961	2.065	2.136
% of MDD :	91.48	97.35	100.05	91.25	96.09	99.40

**CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART-16/ASTM-1883-99)**

Source Description : Soil (182+165)

Providing Ring Constant (Kg/Div): 4.31

Proving Ring No : 01842

Penetration Rate : 1.25/min

Sl. No	Penetration (mm)	Mould No.		Mould No.		Mould No.	
		Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)	Proving ring Reading (Div)	Load (Kgs)
1	0.5	6	25.86	8	34.48	14	60.34
2	1.0	12	51.72	17	73.27	30	129.30
3	1.5	22	94.82	30	129.30	52	224.12
4	2.0	30	129.30	46	198.26	68	293.08
5	2.5	36	155.16	64	275.84	86	370.66
6	3.0	41	176.71	80	344.80	104	448.24
7	4.0	53	228.43	114	491.34	130	560.30
8	5.0	63	271.53	146	629.26	163	702.53
9	7.5	77	331.87	186	801.66	198	853.38
10	10.0	90	387.9	133	1004.23	236	1017.16
11	12.5	108	465.48	168	1155.08	274	1180.94
CBR of specimen at 2.5 mm (standard 1370 kg) by graph		11.33		20.13		27.06	
CBR of specimen at 5.5 mm (standard 2055 kg) by graph		13.21		30.62		34.19	
CBR Value of Sample @ 5.00 mm CBR Value = 26.67							