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3. ENGINEERING SURVEY & INVESTIGATIONS

3.1 GENERAL

Detailed topographic survey, road inventory, pavement condition survey and investigations including roughness survey, BBD survey and sub-grade investigations, structure inventory and condition survey and material surveys were conducted. Brief of all these are presented below and details are presented in a separate volume as **"Appendix to Main Report".**

3.2 TOPOGRAPHIC SURVEY

Topographical survey is important to generate the drawing and to give the overall existing features of the ground. The Topographical survey has been carried out along the project alignment to provide the information in 3D. The topo survey was carried out by using DGPS / Total station method.

3.2.1 Overview

A. The width of survey corridor will generally be as given under:

i. The width of the survey corridor considered the layout of the proposed alignment including the extent of embankment and cut slopes and the general ground profile. While carrying out the field surveys, the widening scheme (i.e. right, left or symmetrical to the centreline of the existing carriageway) were taken into consideration so that the topographic surveys covers sufficient width beyond the centreline of the proposed divided carriageway. The surveys covered a minimum of 55 m beyond either side of the centreline of the proposed divided carriageway or land boundary whichever was more.
ii. Where existing roads crosses the alignments, the survey was extended to 25m either side of the road centreline and will be of sufficient width to allow improvements, including at grade intersection to be designed.

B. Longitudinal and Cross-Sections

The topographic surveys for longitudinal and cross-sections covered the following:

i. Longitudinal section levels along final centreline at every 1 m interval, at the locations of curve points, small streams, and intersections and at the locations of change in elevation.
ii. Cross sections at every 1 m interval in full extent of survey covering sufficient number of spot levels on existing carriageway and adjacent ground for profile correction course and earth work calculations. Cross sections were taken at closer interval at curves.
iii. Longitudinal section for cross roads for length adequate for design and quantity estimation purposes.
iv. Longitudinal and cross sections for major and minor streams which cover Cross section of the channel at the site of proposed crossing and few cross

sections at suitable distance both upstream and downstream, bed level upto top of banks and ground levels to a sufficient distance beyond the edges of channel, nature of existing surface soil in bed, banks & approaches, longitudinal section of channel showing site of bridge etc.

3.2.2 Topo Survey by Total Station/DGPS

3.2.2.1 Permanent Control Points and Benchmarks

Before starting Topographic Survey, all Control Points and Benchmarks were established. Two basic Reference Stations were permanently established on the site so that the results of survey could be verified at any time in the future. These permanent Reference Points were placed in convenient position and well protected so that it was not disturbed in future. Pair of Main Differential Global Positioning System (DGPS) Control Points were established at every 5km intervals by using DGPS survey (WGS-84); a pair of pillars has been placed at 5-km intervals. A pair of Secondary Control Points was established at every 500m intervals which were transferred from Main DGPS Control Points by Total Station of 1-second accuracy or by GPS itself.

The Main DGPS Control Points had been concrete pillars with 50 cm x 50 cm (as shown in below figure) and the Secondary Control Points had been concrete pillars with 15 cm x 15 cm (as shown in below figure). Both Main DGPS Control points and Secondary Control Points had been of a minimum of 60-cm height and have been embedded up to depth of minimum of 45 cm into ground (15 cm protruding above the ground).

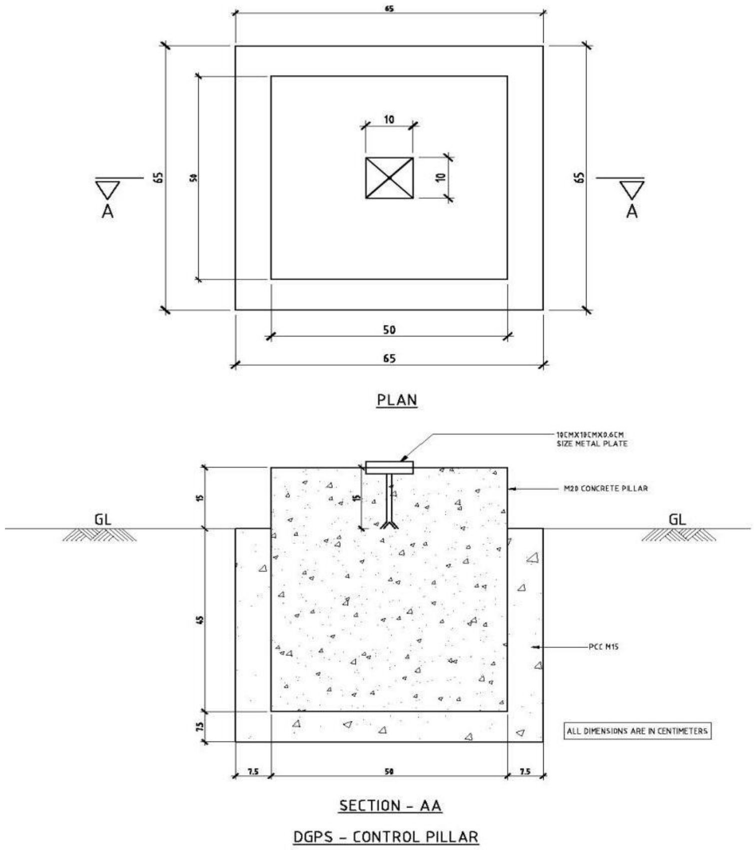


Figure 3-1 : Details of DGPS Control Pillar

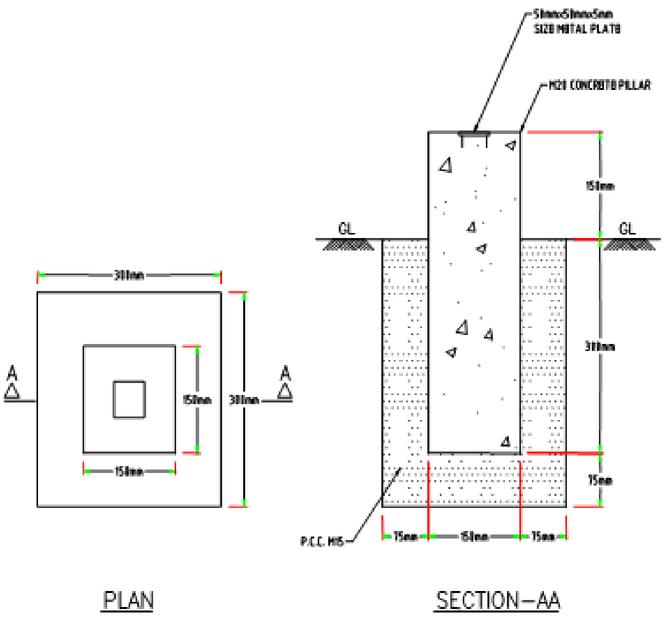


Figure 3-2 : Details of Secondary Control Pillars

3.2.2.2 Differential Global Positioning System (DGPS)

3.2.2.3 General

Once the installations of DGPS control pillars were done, as per the dimensions given above DGPS survey was commenced. Each GPS satellite transmits number of signals. The signal comprises of two waves (L1 and L2) and two codes (C/A on L1 and P or Y on L1 and L2) as well as satellite orbit message. The survey agency has to engage the differential GPS with dual frequency receivers. Pair of DGPS stations were established all along the project site with the inter visibility between pair.

3.2.2.4 Methodology

The survey was carried out using differential technique. Static Method was adopted for Control Survey and point positioning.

In this method, the raw GPS data from satellite was recorded and processed using Skipro/ Geo office or equivalent software. Two GPS receiver has been used to form a base line which had to measure from a fixed point (a reference station) to unknown station (a rover station). Base station was been established in the beginning of the project, and had tracked signals continuously without break from the satellite till, Rover Stations GPS work completes. Thus, reference station tracks continuously on a known point and rover receiver spends a short period on each point.

Simultaneously, Rover Stations shall also track signals from the satellite for a minimum period of one hour, which has been established at the outer boundary of the project area. The observation time was proportional to the length of baseline. During DGPS survey the following points has been recorded in the field book for better accuracy of the survey:

- Availability of number of satellites (minimum four nos.)
- Mask angle (Elevation, cut off angle)
- Range determination by code and phase observation
- Dilution of precision was an indicator as the geometric strength of satellite being tracked at the time of measurement. The values of precision shall not be more than 4.
- Geometrical Dilution of Precision
- Positional Dilution of Precision
- Horizontal Dilution of Precision
- Vertical Dilution of Precision

The raw data in rinex format should be submitted and processed data in WGS 84 Ellipsoid and Mercator projection. And the following survey parameters have been submitted along with the survey report:

- Semi major axis
- Semi minor axis

- Flattening 1/f values
- Central Meridian
- Scale factor at Central Meridian
- Zone code for the surveyed area to be submitted

DGPS control pillars and secondary pillars have been located, free from bushed, trees, water bodies and also avoiding any high raised structures.

3.2.2.5 Traverse Survey

GPS traverse survey was conducted from Main DGPS Control Pillar to another DGPS control pillar established at every 5-km interval. Electronic total station was used to traverse between DGPS control pillar.

The traverse closer was more than 1:20,000 and was distributed. If the error is more (i.e. accuracy was less than 1:20,000), the entire traverse was repeated till accuracy was more than 1:20,000 was obtained. All computation complied with the following:

- Traverse adjustment by Bowditch Method
- Least square adjustment

Cross sections were taken at every 50 m intervals, and at each cross-section the survey extended beyond 75m on either side of the proposed road centre line with survey points at 5-10 m apart and at all variations in the natural ground or breaks in level.

The topographic survey thus carried out contains the details of all physical and topographical features within the survey corridor such as roads, rivers, streams, rail crossings, electric / telephone lines, high /low tension lines and their offsets from the road edge, buildings, trees (girth more than 300mm), etc. The width of the survey corridor is extended appropriately to accommodate the proposed alignment.

The survey data thus collected by the topographic survey was processed and converted to graphic files using Highway Design software called “MX ROAD”, for ascertaining quantities, grid levelling was utilised.

Figure 3-3 : Observation by Total Station

Figure 3-4 : Observation by Real Time Kinematic (GPS by RTK)

3.3 ROAD INVENTORY AND CONDITION SURVEY

3.3.1 Road Inventory

An inventory of the Project Highway has been carried out by visual observations supplemented with sample measurements using tape etc. Kilometer wise features like terrain, land-use, surfacing type and width, shoulder, curve details, intersectional details, retaining structures details, location of water bodies, location of forest areas height of embankment or depth of cut, ROW, CD structures, road side arboriculture, existing utility services, Existing Railway crossings, cross roads, structures, junctions and general drainage conditions etc., were recorded. The road inventory has been referenced to the existing km posts established along the roadside. DetailED road inventory is given as **Appendix B.**

3.3.1.1 Start and End points

This report covers the pojrect section of NH-29 (Old NH-150) from existing Km 30.474 (Design Ch. 30+000) to Km 53.220 (Design Ch. 52+000) - Construction Package – II" only.

3.3.1.2 Terrian

The entire Project Highway passes through hilly Terrain.

3.3.1.3 Alignment

The existing alignment comprises of many sharp horizontal and deficient vertical curves which require geometric corrections.

3.3.1.4 Land use

The land use patterns along the Project Highway can be categorized as Agricultural, Barren and Urban/Built-up.

3.3.1.5 Built-up Areas

The villages/towns through which the project highway passes are listed in table below

Table 3-1 Villages/Towns along Project Highway

Name of Town / Village	Existing Location (km)
Chikabama	30+600
RD Block, Kiruma	49+000

3.3.1.6 Carriageway and Roadway width

The existing carriageway of the Project Highway has predominantly single lane carriageway with earthen shoulder configuration except few locations where it has intermediate lane and 2-Lane with earthen shoulder carriageway configuration.

3.3.2 Pavement Condition

The survey on general pavement condition was primarily a visual exercise undertaken by means of slow drive-over survey, and supplemented with measurements wherever necessary. Visual assessment was carried out from a vehicle, with speed not exceeding 15 km/hr and stopping at various locations at suitable intervals and wherever necessary, depending on variations in pavement conditions. Aspects of pavement conditions assessed include surface defects, rut depth, cracking, potholes, patched areas, shoulder condition etc. An overall assessment of performance serviceability of the road was also done to qualitatively rate the existing pavement and shoulder condition.

The pavement condition was recorded under the following sub-heads:

- Shoulder
    - Composition / Condition / material Loss

  - Riding Quality (Good / Fair / Poor / Very Poor)

- Pavement Condition (surface distress type &extent)

  - Cracking (%)
  - Raveling (%)
  - Potholes (%)
  - Patching (%)
  - Rut depth (mm)
  - Edge break (m)
  - Pavement edge Drop (mm)

- Embankment Condition (Good / Fair / Poor)
- Road Side Drain (Non Existing / Partially Functional / Functional)
- Drainage condition

The existing pavement of the Project Highway is bituminous but in many locations bituminous layers are either has been washed out or in fair to poor condition.

The width of earthen shoulder varies from 0.5 m to 2.0 m on both sides, and condition of the earthen shoulders is poor to very poor. The detailed pavement condition survey detailes are given as Appendix-C.

*3.3.3 **Benkelman Beam Deflection (BBD) Tests***

The evaluation of structural strength of existing flexible pavement was carried out using a Benkelman Beam in accordance with the procedure given in IRC 81-1997.

For measuring pavement deflection, the CGRA procedure that is based on testing under static load was adopted. A standard truck having a rear axle weighing 8200 kg fitted with dual tyre inflated to a pressure of 5.60 kg/sq.cm was used for loading the pavement. The beam was calibrated using metal plates of known thickness prior to testing. The dual wheels of the truck are centred above the selected point.

The deflection tests have been carried out at every 50m interval in staggered manner. The selection of homogeneous segment shall be carried out based on pavement condition survey. Pavement temperature was recorded at every one hour during the testing period by inserting a thermometer in a hole (approximately 5 cm deep and 10 mm diameter) drilled in the pavement and filled with glycerol. At any deviation of the pavement temperature during measurements from the standard temperature of 35^{o} C, correction has been applied to the deflection measured in accordance with the procedure described in IRC: 81-1997. Seasonal correction was carried out using the moisture correction factors given in Figures 2 to 7 in IRC: 81-1997. PI and moisture content of the sub-grade were established from test pit excavations carried out simultaneously with Benkelman Beam tests. The Benkelman Beam Deflection data is presented in **Appendix D1.** Characteristic deflection varries from 1.3mm to 3.3mm.

The observed characteristic deflections for the Project Highway have been given in table below;

Table 3-2: Observed Characteristic Deflections

S. No.	From (km)	To (km)	Characteristic Deflection Value (mm)
1	30.00	31.00	3.2
2	31.00	32.00	3.1
3	32.00	33.00	3.2
4	33.00	34.00	3.3
5	35.00	36.00	1.6
6	36.00	37.00	3.3
7	37.00	38.00	2.5
8	38.00	39.00	1.8
9	39.00	40.00	1.6
10	40.00	41.00	1.6
11	41.00	42.00	2.0
12	42.00	43.00	1.7
13	43.00	44.00	1.5
14	44.00	45.00	1.4
15	45.00	46.00	1.3
16	46.00	47.00	1.9
17	47.00	48.00	1.4
18	48.00	49.00	1.9
19	49.00	50.00	1.5
20	50.00	51.00	1.5
21	51.00	52.00	1.8

3.3.4 Roughness Survey

The Vehicle Mounted Bump Integrator (VMBI) is a component of the Road Measurement Data Acquisition System (ROMDAS) which is a response-type road unevenness meter mounted in a vehicle to monitor pavement unevenness. It records the displacement of the vehicle chassis relative to the rear axle per unit distance travelled, usually in terms of counts/km or m/km. Since each vehicle responds differently to unevenness due to its own unique springs and shocks, as these changes over time with wear, it is necessary to calibrate each vehicle against a standard unevenness measure.

From km30+474 to km 40+000 of the project road is poor to very poor in condition with complete bituminous layer is washed out. Hence, roughness survey is not carried out on this part of project road section.

Two runs, one on each direction of wheel path have been carried out by maintaining a running speed of 30 kmph. The Kilometer values of roughness in BI values and International Roughness Index (IRI) observed on Project Highway are present in **Appendix D2**. IRI values varies between 3.11 to 3.61 and corresponding BI values are generally in between 2245.04 mm/km to 2652.40 mm/km.

3.3.5 Axle Load Surveys

The vehicle damage factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as the equivalent number of standard axles per commercial vehicle. Universally accepted standard axle load weighs 8,160 Kg. ESAL is determined by the relationships recommended in IRC: 37-2001 & IRC: 37-2012 'Tentative guidelines for the design of Flexible Pavements'. An excerpt is presented here.

1) Single axle with single wheel on either side:
   Equivalency Factor = $(\text{Axle load in tones } /6.6)^4$
2) Single axle with dual wheels on either side:
   Equivalency Factor = $(\text{Axle load in tones } /8.16)^4$
3) Tandem axle with dual wheels on either side:
   Equivalency Factor = $(\text{Axle load in tones } /15.10)^4$
4) Tridem axles with dual wheels on either side:
   Equivalency Factor = $(\text{Axle load in tones } /22.85)^4$

The relationship is referred to as the 'Fourth Power Rule', which states that the damaging effect of an axle load increases as the fourth power of the weight of an axle. In order to convert axle loads from the survey data into ESAL, each axle of each category of vehicle is multiplied by the equivalency factor of that type of axle. The output is called the 'damage' caused by that particular axle on the pavement. Damages by all axles are then added to find the cumulative damage by that type of vehicle. The cumulative damage is divided by the number of vehicles of that category surveyed to obtain the average damage, which is also called the Vehicle Damage Factor (VDF) of that category of vehicle.

$$\text{VDF} = \frac{\text{Cumulative Damage}}{\text{Sample Size}}$$

Axle Load Survey was carried out at 2 locations along the project highway. The main purpose for carrying out the survey was to assess the loading pattern on the highway and to estimate Vehicle Damage Factor (VDF) based on the commercial (Heavy) vehicle volume which is using the road.

During the survey, Axle load of commercial vehicles, i.e. LCVs, 2-Axle, 3-Axle, Multi Axle Trucks and Buses, were weighed on random sampling basis. The vehicles were stopped with the help of police and the drivers were directed to stop their vehicles in such a way that wheel of each axle can be weighed using portable Axle Load Weighing

Pad. Vehicle damage factor (VDF) observed on Project Highway are present in **Appendix D3**. The schedule of axle load surveys are given in table below;

Table 3-3: Schedule of Axle Load Survey

Location (km)	Name of the Location	Date	Remarks
13.000	Chidema	06.10.2015	Cosnidered for Package-2
107.000	Losami	01.10.2015	

The summary of calculated VDF values for the project highway are given in table below;

Table 3-4: Summary of Calculated Vehicle Damage Factors (VDFs)

Vehicle type	Calculated VDF values				Recom mended VDFs
	Direction Location km 13.000		Direction Location km 107.000		
	Chanditala to Champadang (UP)	Champadanga to Chandital (DN)	Chanditala to Champadang (UP)	Champadanga to Chandital (DN)	
LCV	0.18	0.25	0.32	0.19	0.5
BUS	0.43	0.43	0.43	0.43	0.5
2 Axle	1.12	0.67	1.29	0.80	0.5

3.4 Sub-grade MATERIAL INVESTIGATIONS

3.4.1 Existing Ground & Construction Materials Surveys

3.4.1.1 Introduction

In highway design the identification and study of materials suitable for use in embankments, pavements and for structural foundations forms an integral part of the design process. Field surveys are carried out to understand the geo-physical and geo-morphological characteristics and material properties of project stretch, and make a general assessment on the quality, quantity and suitability of the available materials based on visual observation followed by an appropriate test to determine its character.

The material and sub-grade investigations study for this project are divided into three parts as:

- Part I–Soil Investigations- along the proposed alignment.
- Parts II –Test Results of TEST PIT.
- Part III–construction materials.

3.4.2 Soil Investigation

3.4.2.1 Methodology (Test Pits)

Investigations have been carried out by digging test pits to assess the adequacy of existing pavement layers including sub-grade soil properties to establish the strengthening/ reconstruction requirements to cater for design traffic during service life. Test pits were excavated at the pavement-shoulder interface, extending through the pavement layers and down to the level of the sub-grade. Test pits made were of two types – large pits and small pits for the investigation along the project road.

Large Test Pits - 1.0m x 1.0m at every 5 Km or at change of soil strata.
Small Test pits - 0.5m x 0.5m at every 0.5 Km.

The details and test results are provided in the subsequent paragraphs.

3.4.2.2 Large Pits (1.0 m x 1.0 m)

Large pits were dug at 5 km interval at the pavement-shoulder interface extending through the pavement layers. Pits were made in such a way that one third of the pit (30 cm) was within the carriageway and the remaining two third (70 cm) in the shoulder, ensuring minimum damage to the original pavement and disruption to the traffic. The pits were backfilled and compacted after completion of work. The sequence of operations for large pits was as follows:

- Manual excavation of 1.0 m x 1.0 m pit down to sub-grade level. After reaching the sub-grade level, the thickness of the different pavement layers were measured and type of material examined. Sub-grade soil samples were collected and field moisture content was determined at site by using moisture meter method as per IS 2720: Part 2.
- One sample of 40 kg sub-grade soil was collected from the top 100 mm of sub-grade for the following laboratory tests:

  - Field moisture content : As per IS: 2720
  - Grain size analysis : As per IS: 2720
  - Atterberg limits : As per IS: 2720
  - Free swell index : As per IS: 2720
  - Moisture-Density test (Heavy Compaction) : As per IS: 2720
  - CBR (un- soaked, and 4 days soaked at three Energy levels of 10, 35, 65 blows) : As per IS: 2720

- Photographs of the pavement layers were obtained at few test pits.

3.4.2.3 Small Pits (0.5 m x 0.5 m)

Small pits were dug in between the large pit locations staggered left/right along the pavement edge in line with the principles of large pits at every 500m. The pits were dug such that at least 20 cm was within the carriageway and the rest on the shoulder. The pits were backfilled and compacted properly after completion of the work. The sequences of operation for small pits were as follows:

- Manual excavation of 0.5 m x 0.5 m size pit down to the sub-grade level.
- Thickness of each pavement layer was measured and type of materials was examined, soil samples were collected and field moisture content was determined at site by using moisture meter method as per IS 2720: Part 2.
- Photographs were taken of the pavement layers at a few locations.

3.4.2.4 Pavement Composition

For each test pit, the following information was recorded:

- Test pit reference (Identification number, location):
- Pavement composition (material type and thickness)
- Sub-grade type (textural classification) and condition (dry, wet)

Broad variation in pavement thickness was observed along the project road. However, the pavement composition of the existing pavement is generally same as bituminous, Base and Sub-base. The wearing coat (Bituminous) varies from 70 mm to 92 mm and from km34+090 to km34+275 top bituminious layer is washed away and having poor condition, base course varies from 86 mm to 181 mm and Subbase course varies from 198 mm to 264 mm. The bituminous course consists of one layer and appears to be fair to poor in condition. The base course material was moderately strong and dry in general. The sub-grade below the base course was observed to be fine grained clay and silty soil at some locations. The survey photos are shown in Figure 7.11. The existing pavement crust composition and thicknesses is presented in Table 7.2.

Table 3-5 Exisiting crust composition

Identification No.	Location (Chainage) km	Existing Crust Composition Details	mm	Total Thickness (mm)	Type of Sub-Grade Soil (Visual Identification)	Field Moisture Content (%) by Rapid Moisture Meter
30/49	30+810 (R/S)	BT	92	481	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	12.72
		WBM	175			
		Boulder	214			
31/50	31+325	BT	90	460	Reddish / Light Yellowish,	14.64

Identification No.	Location (Chainage) km	Existing Crust Composition Details	mm	Total Thickness (mm)	Type of Sub-Grade Soil (Visual Identification)	Field Moisture Content (%) by Rapid Moisture Meter
	(R/S)	WBM	134		Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	
		Boulder	236			
31/51	31+815 (L/S)	BT	73	425	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.64
		WBM	137			
		Boulder	215			
32/52	32+310 (L/S)	BT	73	382	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	14.00
		WBM	111			
		Boulder	198			
32/53	32+805 (L/S)	BT	73	434	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.64
		WBM	141			
		Boulder	220			
33/54	33+285 (L/S)	BT	76	443	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	11.45
		WBM	152			
		Boulder	215			
33/55	33+790 (L/S)	BT	79	465	Yellowish, Silty Clay / Clayey Silt with some Shale Pieces / Silt Stone / Clay Stone mixed.	12.09
		WBM	152			
		Boulder	234			
34/56	34+090 (L/S)	BT	0	320	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	15.27
		WBM	86			
		Boulder	234			
34/57	34+275 (L/S)	BT	0	334	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.36
		WBM	95			
		Boulder	239			
34/58	34+780 (L/S)	BT	84	452	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	14.64
		WBM	134			
		Boulder	234			
35/59	35+295 (R/S)	BT	78	475	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.36
		WBM	146			
		Boulder	251			
35/60	35+810	BT	73	444	Reddish, Silty Clay / Clayey	14.00

Identification No.	Location (Chainage) km	Existing Crust Composition Details	mm	Total Thickness (mm)	Type of Sub-Grade Soil (Visual Identification)	Field Moisture Content (%) by Rapid Moisture Meter
	(L/S)	WBM	140		Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	
		Boulder	231			
36/61	36+310 (L/S)	BT	72	449	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	11.45
		WBM	139			
		Boulder	238			
36/62	36+820 (L/S)	BT	77	484	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	12.09
		WBM	150			
		Boulder	257			
37/63	37+330 (R/S)	BT	84	478	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	12.09
		WBM	135			
		Boulder	259			
37/64	37+810 (L/S)	BT	73	450	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.36
		WBM	142			
		Boulder	235			
38/65	38+260 (L/S)	BT	74	471	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	11.45
		WBM	141			
		Boulder	256			
38/66	38+745 (L/S)	BT	76	473	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.81
		WBM	151			
		Boulder	246			
38/67	38+985 (L/S)	BT	74	479	Yellowish, Clayey Silt / Silty Clay with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.81
		WBM	151			
		Boulder	254			
39/68	39+220 (L/S)	BT	91	467	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	11.45
		WBM	161			
		Boulder	215			
39/69	39+700 (L/S)	BT	76	455	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.81
		WBM	145			
		Boulder	234			
40/70	40+150	BT	84	493	Light Yellowish / Light Grey,	9.54

Identification No.	Location (Chainage) km	Existing Crust Composition Details	mm	Total Thickness (mm)	Type of Sub-Grade Soil (Visual Identification)	Field Moisture Content (%) by Rapid Moisture Meter
	(R/S)	WBM	145		Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	
		Boulder	264			
40/71	40+715 (R/S)	BT	70	433	Light Yellowish / Light Grey, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.17
		WBM	143			
		Boulder	220			
41/72	41+180 (L/S)	BT	72	454	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	8.90
		WBM	144			
		Boulder	238			
41/73	41+700 (L/S)	BT	78	468	Yellowish, Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.17
		WBM	156			
		Boulder	234			
42/74	42+275 (R/S)	BT	84	433	Yellowish, Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.81
		WBM	143			
		Boulder	206			
42/75	42+765 (L/S)	BT	71	437	Yellowish, Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	9.54
		WBM	143			
		Boulder	223			
43/76	43+250 (R/S)	BT	73	457	Yellowish, Clayey Silt with some Shale Pieces/Silt Stone /Clay Stone mixed.	10.17
		WBM	156			
		Boulder	228			
43/77	43+730 (L/S)	BT	92	504	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	8.26
		WBM	181			
		Boulder	231			
43/78	43+980 (R/S)	BT	73	457	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	10.81
		WBM	147			
		Boulder	237			
44/79	44+175 (L/S)	BT	76	442	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.17
		WBM	146			
		Boulder	220			
44/80	44+660 (R/S)	BT	71	467	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.81
		WBM	158			
		Boulder	238			
45/81	45+140	BT	78	465	Yellowish, Silty Clay / Clayey	11.45

Identification No.	Location (Chainage) km	Existing Crust Composition Details	mm	Total Thickness (mm)	Type of Sub-Grade Soil (Visual Identification)	Field Moisture Content (%) by Rapid Moisture Meter
	(L/S)	WBM	151		Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	
		Boulder	236			
45/82	45+625 (L/S)	BT	85	461	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.36
		WBM	142			
		Boulder	234			
46/83	46+100 (L/S)	BT	79	424	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	14.00
		WBM	140			
		Boulder	205			
46/84	46+580 (R/S)	BT	73	402	Yellowish, Clayey Silt with some Shale Pieces / Silt Stone / Clay Stone mixed.	10.17
		WBM	125			
		Boulder	204			
47/85	47+075 (L/S)	BT	78	459	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	14.64
		WBM	143			
		Boulder	238			
47/86	47+560 (L/S)	BT	90	427	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	9.54
		WBM	134			
		Boulder	203			
48/87	48.050 (R/S)	BT	75	449	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.36
		WBM	138			
		Boulder	236			
48/88	48+525 (R/S)	BT	74	450	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	10.17
		WBM	146			
		Boulder	230			
48/89	48+825 (R/S)	BT	73	409	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	10.17
		WBM	132			
		Boulder	204			
49/90	49+010 (L/S)	BT	73	439	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	12.09
		WBM	138			
		Boulder	228			
49/91	49+475 (R/S)	BT	76	465	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	10.17
		WBM	155			
		Boulder	234			

Identification No.	Location (Chainage) km	Existing Crust Composition Details	mm	Total Thickness (mm)	Type of Sub-Grade Soil (Visual Identification)	Field Moisture Content (%) by Rapid Moisture Meter
49/92	49+985 (R/S)	BT	77	467	Yellowish, Clayey Silt with good % of Shale Pieces / Silt Stone / Clay Stone mixed.	9.54
		WBM	141			
		Boulder	249			
50/93	50+475 (R/S)	BT	74	455	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	12.72
		WBM	144			
		Boulder	237			
50/94	50+935 (R/S)	BT	76	417	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	13.36
		WBM	143			
		Boulder	198			
51/95	51+415 (L/S)	BT	77	465	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	12.72
		WBM	153			
		Boulder	235			
51/96	51+900 (R/S)	BT	71	449 481	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed. Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	14.64 12.72
		BT	92			
		WBM	175			

3.4.2.4.1 SUB-GRADE INVESTIGATIONS

The material used in sub-grade shall be soil, moorum, gravel or a mixture of these. The materials satisfying the density requirements given in Table 300-1 of MORT&H specification shall be employed for the construction of sub-grade. The material to be used in sub-grade should also satisfy design CBR at the dry unit weight applicable as per Codal provisions. Materials for sub-grade layers shall be considered from the identified borrow areas.

3.4.2.4.1.1 Objective

The objective of the investigations is to (i) understand the composition and characteristics of the existing pavement / sub-grade, (ii) establish the engineering characteristics of material available for inclusion in various types of pavements viz. pavements and (iii) be aware of about the materials for the proposed sub-grade as materials of shoulders.:

- Field investigation on exiting pavement & collection of secondary and primary data regarding the composition of existing pavement and its characteristics.
- Existing sub-grade type and sub-soil conditions.
- Local soil investigation for new pavement.

3.4.2.4.1.2 Field and Laboratory Investigations

The field and laboratory tests are carried out as described below:

3.4.2.4.1.3 Test Pits on Existing Pavement

Test pits of approx. 1.0 m x 1.0 m size staggered on both sides of the pavement are excavated upto sub-grade level at an interval of 5.0 km along the project road alignment and test pits at 500m interval. These pits are excavated on shoulders extending about 20 cms into the pavement. The following field and laboratory tests have been carried out on each test pit as described below:

- The thickness and type of the pavement layers are measured and noted on all the three exposed faces of the pavement.
- The bottom surface is leveled by scrapping the sub-grade by about 25 mm. Field density and natural moisture content of the sub-grade are determined in-situ by core-cutter and rapid moisture meter methods, conducted on one corner of the pit. The results are given in Table 6.0.
- DCP tests are conducted in the pit at a depth of approx. 1.0 m below the sub-grade level. The DCPT equipment used is standard TRL penetrometer with 8 kg hammer, 575 mm drop height and 60°C cone, having a diameter of 20 mm.
- Approx. 50 kg of the disturbed samples from existing sub-grade is collected from each test pit and brought to the laboratory for testing index properties of sub-grade soil and field soaked CBR test on remolded sample.

3.4.2.4.1.4 DCP test on the Existing Sub – grade

The test pits of size 1mx1m have been excavated in staggered way at five km interval upto depth till the existing sub-grade is reached. DCPT has been performed on the sub-grade soil upto a depth of 500mm to evaluate the field CBR value. The field moisture content has been calculated by rapid moisture meter and field dry density and bulk density has been calculated by Core-Cutter method.

The Dynamic Cone Penetration test is an instrument designed to provide a measure of the in-situ strength of sub-grade. A schematic diagram of DCPT instrument has been shown in Figure 1. The depth of penetration is measured after each blow, the output of the DCP test is in mm/blow. The benefits of using DCPT is evaluate sub-grade strength in quick succession, and large amount of data can be calculated in a short time, though, being a correlation method it may not give the laboratory soaked CBR values. Therefore, this gives a comparative strength of sub-grade at different locations.

The field dry density and bulk density has been calculated by the core cutter (As per IS-2720 PART-29) method and the field moisture content has been calculated by the Rapid moisture meter. The core-cutter method is consists of a steel rammer of 9.8 kg weight with solid mild steel foot 140mm diameter and 75mm height with a concentrically screwed 25mm diameter solid mild steel staff. The Schematic diagram of DCPT equipment is shown as Figure 7.4.

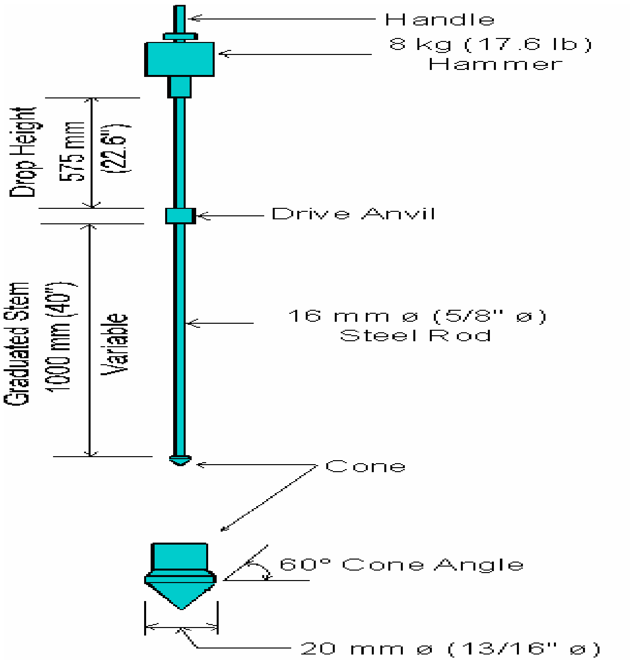


Figure 3-5 : Schematic of DCP

The penetration for each blow has been noted down in the field data sheet and after that the field CBR from DCPT test has been calculated using correlation between CBR and PI (Penetration Index), the correlation has been given in the Table 7.5.

Table 3-6: Correlation between CBR and PI (after Harison 1987 and Gabr et al. 2000)

Author	Correlation	Field or Laboratory based Study	Material Tested
Kleyn(1975)	log(CBR)=2.62-1.27log(PI)	Laboratory	Unknown
Harison(1987)	log(CBR)=2.56-1.16log(PI)	Laboratory	Cohesive
Harison(1987)	log(CBR)=3.03-1.54log(PI)	Laboratory	Granular
Livneh et. Al.(1994)	log(CBR)=2.46-1.12log(PI)	Field and Laboratory	Granular and Cohesive

Author	Correlation	Field or Laboratory based Study	Material Tested
Ese et. Al.(1994)	log(CBR)=2.44-1.07log(PI)	Field and Laboratory	Aggregate base course(ABC)
NCDOT(1998)	log(CBR)=2.60-1.07log(PI)	Field and Laboratory	ABC and Cohesive
Coonse(1999)	log(CBR)=2.53-1.14log(PI)	Laboratory	Piedomont residual soil
Gabr(2000)	log(CBR)=1.40-0.55log(PI)	Field and Laboratory	Aggregate base course(ABC)

The correlation for cohesive soil has been used to convert the DCPT into CBR. For the existing sub-grade soil is appraised as cohesive soil by visual means, CBR has been calculated by formulas given by Kleyn (1975) and Livneh et al (1994) and Harrison (1987) formula to compare the CBR values. The summery of the field test result are given in table below.

Table 3-7: Summary of DCP Test Results

Sl no	Chainage	Direction	Visual classification of soil	FMC (%)	Field Bulk Density(gm/cc)	Field Dry Density(gm/cc)	DCPT inferred CBR
1	34+090	L/S	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	15.27	2.067	1.793	3
2	38+985	L/S	Yellowish, Clayey Silt / Silty Clay with little Shale Pieces / Silt Stone / Clay Stone mixed.	10.81	1.967	1.775	5
3	43+730	L/S	Yellowish, Clayey Silt with Some Shale Pieces / Silt	8.26	1.984	1.832	62

			Stone / Clay Stone mixed.				
4	48+825	R/S	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	10.17	2.022	1.835	37

- **Field dry density test:**

Field dry density has been performed for soil samples in accordance with the method described in IS: 2720 (Part 29). This standard covers the method for the determination of the in-place density of fine-grained natural or compacted soils free from aggregates using a core-cutter. For the purpose of the tests described in this standard, a soil shall be termed as fine-grained soil if not less than 90 percent of it passes a 4.75mm IS Sieve.

Field dry density and moisture content of sub-grade soil were measured at every pit at sub-grade level with the modern equipment available with the team. It has been observed that the average compaction of the existing sub-grade is 96.43.

3.4.2.4.1.5 Laboratory Investigations of Soil Samples

The following tests were carried out on soil samples collected from each test pit.

- Gradation tests (As per IS: 2720 –Part 4).
- Atterberg's limits test (As per IS: 2720-Part 5).
- Modified proctor tests (As per IS: 2720-Part 8).
- Soaked & Un-soaked CBR tests (As per 2720-Part 16).
- Free Swell index test (As per 2720-Part 40).
- Field dry density test (As per 2720-Part 29).
- Gradation tests:

The grain size distribution analysis has been carried out for soil samples in accordance with the method described in IS: 2720 (Part 4). Compliance with the Standard, with respect to minimum sample quantity is dependent on the maximum significant grain size and the method of sampling. Two methods are given for finding the distribution of grain sizes; the first method, wet sieving shall be applicable to all soils and the second, dry sieving, shall be applicable only to soils which do not have an appreciable amount of clay.

- **Atterberg's limits test:**

The Atterberg's Limits comprising liquid limit, plastic limit and plasticity index were determined for soil samples in accordance with the methods described in IS: 2720 (Part 5). The liquid limit has been determined by three methods (namely, mechanical method, one point method and cone method) most popularly method is mechanical method by Casagrande apparatus. The soil sample preparation, in accordance with the code of practice, included removal of soil particles retained on the 425micron sieve. Accordingly, where a significant quantity of coarser particles was present, it is imperative that the Atterberg Limits results are representative of the relatively fine soil fraction, and not of the complete soil sample.

- **Modified proctor tests:**

The Modified proctor test, to determination of water content - dry density relation using heavy compaction, has been carried out for soil samples in accordance with the method described in IS: 2720 (Part 8).

- **Soaked & Unsoaked CBR tests:**

Soaked & Unsoaked California Bearing Ratio has been performed for soil samples in accordance with the method described in IS: 2720 (Part 16). The CBR value of a soil can be considered to be an index which in some fashion is related to its strength. The value is highly dependent on the condition of the material at the time of testing. The CBR values are usually calculated for penetrations of 2.5 and 5 mm.

California Bearing Ratio = PT/PS x 100
PT= Test load
PS= Standard load

Generally, the CBR value at 2.5 mm penetration will be greater than that at 5 mm penetration and in such a case; the former shall be taken as the CBR value for design purposes. If the CBR value corresponding to a penetration of 5 mm exceeds that for 2.5 mm, the test shall be repeated. If identical results follow, the CBR corresponding to 5 mm penetration shall be taken for design.

- **Free Swell index test:**

Free Swell index test of soil, can be determine with the help of IS:2720 (Part-40), helps to identify the potential of a soil to swell which might need further detailed investigation regarding swelling under different field conditions. Samples use for this test must be passes through 425-micron IS Sieve.

3.4.2.4.1.6 Laboratory Test Results of Existing Sub-grade

Gradation, Atterberg's limit test, soil classifications, OMC, MDD and CBR tests are carried out for the samples collected from the test pits. Laboratory CBR tests are carried out on pit samples as per IS: 2720 (Part- 16). CBR moulds are prepared by compacting the soil in five layers. CBR moulds are prepared at three energy levels (18, 35 & 60 blows for each layer of sample). CBR at FDD has been determined to verify the current CBR at present condition.

From the lab result, it can be seen that Liquid Limit varies from 30.2 to 34.3, Plastic Limit varies from 20.22 to 24.16 and Plasticity index varies from 6.04 to 13.98. The existing sub-grade CBR results show that the average value is 4.29, Maximum value is 4.81 and the minimum is 3.93. The CBR values with respect to the road section are Table 7.7.

Table 3-8: Minimum, Average and Maximum CBR values

Road Section	Existing Sub-grade CBR Values		
	Minimum	**Average**	**Maximum**
Km 30+474 to km 53+220	3.89	4.43	5.29

3.4.3 Sub-grade Soil Laboraotry Test Results

At every 5km interval about 40 kg of soil sample have been collected from test pit for testing purposes. The identification mark and location of the sample have been recorded and sent to the laboratory for conducting the tests.

Free Swell Index (FSI) test on the samples show that it varies from 5.26% swell to 15% swell with average value of 10.25%.

Soaked CBR varies from 3.89% to 5.29%.

The results of laboratory tests are given below in table below:

Table 3-9: Laboratory Tests Results - Existing Soil (TEST PIT)

Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level					Free swell Index	FIELD DRY DENSITY (CORE - CUTTER METHOD)		(%) OF COMPACTION (FDD vs. MDD)
											Un soaked		Soaked						
		GRAVEL (%)	SAND (%)	SILT & CLAY (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	CBR (%) 2.5 MM	CBR (%) 5.0 MM	EXPANSION RATIO	CBR (%) 2.5 MM	CBR (%) 5.0 MM		FMC (%) BY RAPID MOISTURE METER	FDD (gm/cc)	
34+090 (L/S)	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	0.00	21.78	78.22	39.34	21.25	18.09	CI	12.20	1.885	7.53	6.44	2.41	3.93	3.43	13.04	15.27	1.793	95.12
38+985 (L/S)	Yellowish, Clayey Silt / Silty Clay	0.00	22.65	77.35	39.60	24.21	15.39	CI	12.20	1.869	7.67	6.70	1.93	3.89	3.37	15.00	10.81	1.775	94.97

	with little Shale Pieces / Silt Stone / Clay Stone mixed.																		
43+7 30 (L/S)	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	3. 1 6	38. 55	58. 29	31. 25	24. 42	6.8 3	ML	11. 00	1.90 3	10. 69	9.7 8	1.78	4. 61	4. 02	5.2 6	8.26	1.8 32	96.27
48+8 25 (R/S)	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	1. 8 2	34. 06	64. 12	30. 20	23. 15	7.0 5	ML	10. 80	1.91 3	13. 31	12. 14	1.43	5. 29	4. 70	7.6 9	10.17	1.8 35	95.92

3.4.4 Construction Materials

3.4.4.1 Introduction

The objective is to locate suitable materials for the construction of embankment, sub-grade and top layers of pavement and bridge structures. Also the objective is to determine the engineering properties of the following materials, which are to be used in construction.

- Borrow areas for locating suitable soils for use in embankment and sub-grade.
- Quarries for locating hard stone/granular materials for use in sub bases, bases, bituminous mixes and concrete works
- Source of fine aggregate for use in DBM/BC layers and cement concrete works.

3.4.4.2 Fill / Embankment

The survey of soil from borrows areas for use in embankment and sub-grade layer was conducted along the proposed alignment. Soil samples of 40kg in weight from each borrow area were collected in gunny bags and after proper identification tag for location, sent to laboratory for testing. The location of borrow areas with their distances from the proposed alignment and the quantity available are given in table below:

3.4.4.2.1 of Borrow Area Soil

Earth/soil for construction of embankment fill and sub-grade is available in sufficient quantities from the land adjacent to the road and certain prominent potential extraction areas, which have been identified. These are at Chainage 1+400km, 6+650km, 12+060km, 17+650km, 24+335km, 27+240km, and 32+030km etc along NH-150. This soil is mainly available from cultivated Lands and Hillock lands along the stretch as given in table below;

Table 3-10: Location of Borrow Area for Soil

Sl No.	Chainage (km)		Borrow Area Number	Type of Borrow Area	Location	Direction	Distance from project road (m)	Quantity Available (Cum)
	From	To						
1	1+400	1+425	BRW-1	Hillock	kohima	L/S	3	3600
2	6+650	6+670	BRW-2	Hillock	kohima	R/S	1.5	2880
3	12+060	12+035	BRW-3	Hillock	kohima	L/S	3	3000
4	17+650	17+680	BRW-4	Hillock	kohima	L/S	2	4320
5	24+335	24+370	BRW-5	Agricultural Field	kohima	R/S	3.5	5040
6	27+240	27+265	BRW-6	Hillock	Chakabama	L/S	1	3600
7	32+030	32+050	BRW-7	Hillock	Chakabama	R/S	1.5	2880
8	38+375	38+400	BRW-8	Hillock	Chakabama	R/S	3	3800

Sl No.	Chainage (km)		Borrow Area Number	Type of Borrow Area	Location	Direction	Distance from project road (m)	Quantity Available (Cum)
	From	To						
9	42+010	42+035	BRW-9	Hillock	R.D Block, Kikruma	R/S	1.5	3600
10	49+500	49+520	BRW-10	Hillock	R.D Block, Kikruma	R/S	1.5	2900
11	50+735	50+765	BRW-11	Hillock	Kikruma	L/S	1.5	4400
12	58+650	58+675	BRW-12	Hillock	Kikruma	L/S	1	3530
13	63+000	63+025	BRW-13	Hillock	Pfutsero	L/S	1.5	3615
14	67+679	67+719	BRW-14	Open Field	Pfutsero	L/S	3	5760
15	74+800	74+820	BRW-15	Hillock	Pfutsero	R/S	1.5	2905
16	77+000	77+030	BRW-16	Hillock	Mesulumi	R/S	1.5	4050
17	82+000	82+025	BRW-17	Hillock	Mesulumi	R/S	1.5	3610
18	86+980	87+005	BRW-18	Hillock	Chizami	R/S	1.5	3670
19	93+350	93+370	BRW-19	Hillock	Chizami	L/S	1	2880
20	97+500	97+525	BRW-20	Hillock	Chizami	L/S	1	3800
21	103+595	103+615	BRW-21	Hillock	Chizami	L/S	1	3100
22	107+450	107+475	BRW-22	Hillock	Losami	L/S	1	3600
23	116+500	116+520	BRW-23	Hillock	Losami	L/S	1.5	2890
24	120+100	120+200	BRW-24	Agricultural Field on both Left Hand Side & Right Hand Side	Losami	L/S & R/S	2	3200
25	121+700	121+730	BRW-25	Hillock	Jessami	R/S	2	4300
26	129+800	129+840	BRW-26	Hillock	Jessami	R/S	1	5500

The representative soil samples collected from above borrow areas have been tested for Gradation, Atterberg's limits, Modified Proctor Density, Soaked and Unsoaked CBR and Free swell index tests. All these test results are tabulated in Table 1.8 and the variation in CBR values is shown in Figure 7.2.

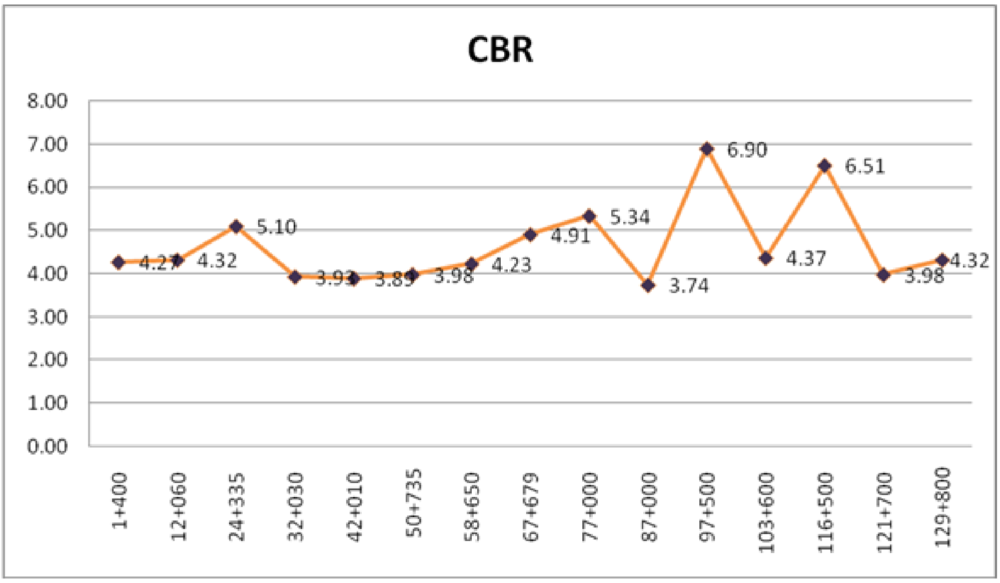


Figure 3-6: CBR values for Borrow Areas on NH-150

The area along the project road was surveyed for the selection of borrow areas. The survey revealed that adequate materials are available in the borrow areas along the project road. Borrow area lead chart for the road construction is shown in Figure 7.3.

Table 3-11**: Laboratory Test Results of Borrow Area soil for NH-150 from km 3.100 to km 132.00 (Collected from Borrow Pit)**

Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg's Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level (Soaked			Free swell Index
		Gravel (%)	Sand (%)	Silt & Clay (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	Expansion Ratio	CBR (%) 2.5 mm	CBR (%) 5.0 mm	

Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg's Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level (Soaked			Free swell Index
		Gravel (%)	Sand (%)	Silt & Clay (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	Expansion Ratio	CBR (%) 2.5 mm	CBR (%) 5.0 mm	
1+400 L/S	Yellowish, Clayey Silt / Silty Clay with little Shale Pieces / Silt Stone / Clay Stone mixed.	1.88	29.32	68.80	33.50	21.22	12.28	CL	11.60	1.905	2.03	4.27	3.63	7.69

Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg's Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level (Soaked			Free swell Index
		Gravel (%)	Sand (%)	Silt & Clay (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	Expansion Ratio	CBR (%) 2.5 mm	CBR (%) 5.0 mm	
12+060 L/S	Yellowish, Clayey Silt / Silty Clay with some Shale Pieces / Silt Stone / Clay Stone mixed.	0.00	31.84	68.16	32.80	21.21	11.59	CL	12.00	1.904	2.17	4.32	3.76	10.00

Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg's Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level (Soaked			Free swell Index
		Gravel (%)	Sand (%)	Silt & Clay (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	Expansion Ratio	CBR (%) 2.5 mm	CBR (%) 5.0 mm	
24+335 R/S	Grey / Light Yellowish, Clayey Silt with some Shale Pieces / Silt Stone / Clay Stone mixed.	4.22	41.02	54.76	29.60	24.16	5.44	ML	10.90	1.926	1.59	5.10	4.31	5.26
32+030 R/S	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	0.00	23.66	76.34	33.50	20.22	13.28	CL	11.30	1.899	2.70	3.93	3.46	7.69
42+010 R/S	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	1.58	25.62	72.80	36.60	22.21	14.39	CI	12.70	1.864	2.52	3.89	3.24	12.64

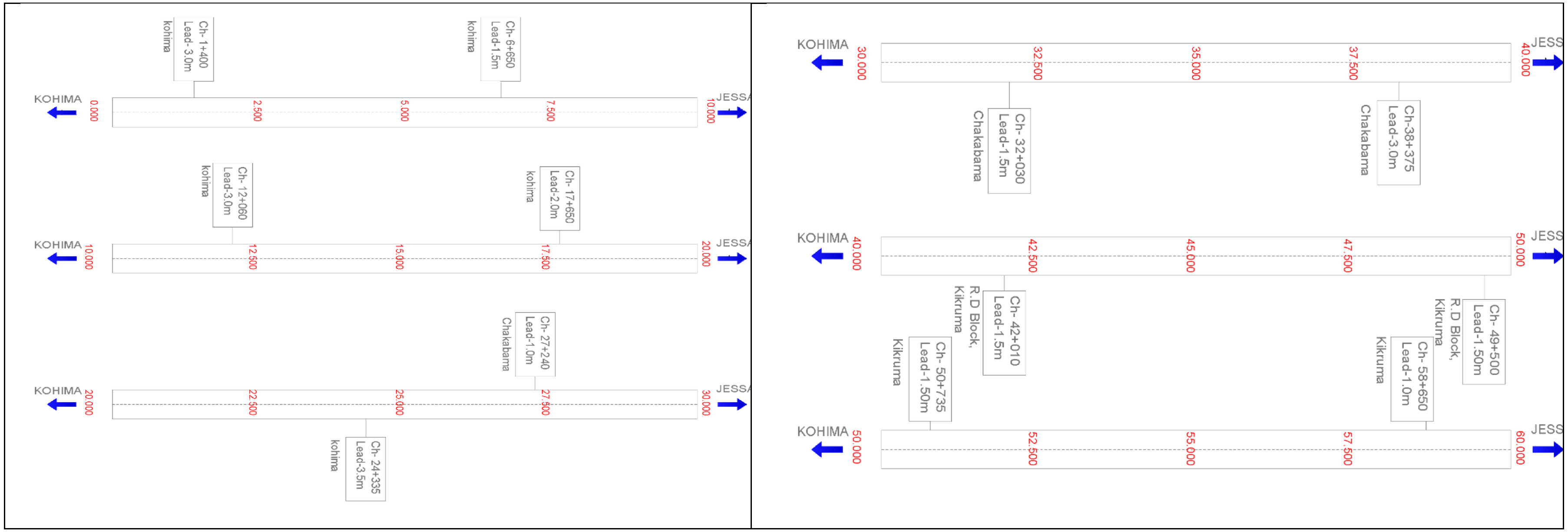
Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg's Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level (Soaked			Free swell Index
		Gravel (%)	Sand (%)	Silt & Clay (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	Expansion Ratio	CBR (%) 2.5 mm	CBR (%) 5.0 mm	
50+735 L/S	Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	0.00	24.36	75.64	37.30	21.25	16.05	CI	12.10	1.886	2.49	3.98	3.40	13.04
58+650 L/S	Yellowish, Clayey Silt / Silty Clay with some Shale Pieces / Silt Stone / Clay Stone mixed.	5.12	26.62	68.26	33.60	22.21	11.39	CL	12.30	1.902	2.27	4.23	3.56	10.00
67+679 L/S	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	4.14	36.62	59.24	30.80	24.42	6.38	ML	9.50	1.928	1.31	4.91	4.18	5.26
77+000 R/S	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	3.29	35.89	60.82	30.10	23.22	6.88	ML	8.50	1.906	1.35	5.34	4.73	5.26

Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg's Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level (Soaked			Free swell Index
		Gravel (%)	Sand (%)	Silt & Clay (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	Expansion Ratio	CBR (%) 2.5 mm	CBR (%) 5.0 mm	
87+000 R/S	Yellowish / Light Reddish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	1.24	22.26	76.50	36.80	21.75	15.05	CI	12.10	1.894	2.67	3.74	3.17	13.64
97+500 L/S	Grey, Clayey Silt with good % of Shale Pieces / Silt Stone / Clay Stone mixed.	8.92	59.92	31.16	29.60	23.55	6.05	SC-ML	8.70	1.948	1.24	6.90	5.73	5.26
103+600 L/S	Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed.	0.00	37.69	62.31	33.60	22.12	11.48	CL	11.40	1.901	2.32	4.37	3.69	9.09
116+500 L/S	Grey, Clayey Silt with good % of Shale Pieces / Silt Stone / Clay Stone mixed.	4.52	57.22	38.26	29.80	24.22	5.58	SC-ML	10.00	1.945	1.15	6.51	5.38	5.26

Location (Km)	Visual Classification of soil	Sieve Analysis % Passing			Atterberg's Limit			Type of soil as per IS Classification 1498 of 1970	Mod. Proctor Test		CBR at 97% compaction level (Soaked			Free swell Index
		Gravel (%)	Sand (%)	Silt & Clay (%)	LL	PL	PI		OMC (%)	MDD (gm/cc)	Expansion Ratio	CBR (%) 2.5 mm	CBR (%) 5.0 mm	
121+700 R/S	Yellowish, Silty Clay / Clayey Silt with little Shale Pieces / Silt Stone / Clay Stone mixed.	0.00	23.35	76.65	33.20	22.81	10.39	CL	11.90	1.879	2.13	3.98	3.37	13.64
129+800 R/S	Dark Grey, Clayey Silt with some Shale Pieces / Silt Stone / Clay Stone mixed.	1.12	32.81	66.07	33.50	22.23	11.27	CL	11.60	1.900	2.16	4.32	3.66	10.00

LL – Liquid Limit; PI – Plasticity Index; CBR – California Bearing Ratio; MDD – Maximum Dry Density; OMC – Optimum Moisture Content; PL – Plastic Limit

The test results indicate that the soils in the potential borrow areas fall in CL, CI, SC, SM and SC-ML classes and visualy can be identified as Yellowish, Clayey Silt with Some Shale Pieces / Silt Stone / Clay Stone mixed. Their CBR values ranges from 3.74 to 6.9. Pavement design shall be based on 90th percentile CBR value.


KOHIMA
JESS
Ch- 1+400
Lead- 3.0m
kohima
Ch- 6+650
Lead-1.5m
Kohima
Ch- 12+060
Lead-3.0m
kohima
Ch- 17+650
Lead-2.0m
kohima
Ch- 27+240
Lead-1.0m
Chakabama
Ch- 24+335
Lead-3.5m
kohima
Ch- 32+030
Lead-1.5m
Chakabama
Ch-38+375
Lead-3.0m
Chakabama
Ch- 42+010
Lead-1.5m
R.D Block,
Kikruma
Ch- 49+500
Lead-1.50m
R.D Block,
Kikruma
Ch- 50+735
Lead-1.50m
Kikruma
Ch- 58+650
Lead-1.0m
Kikruma

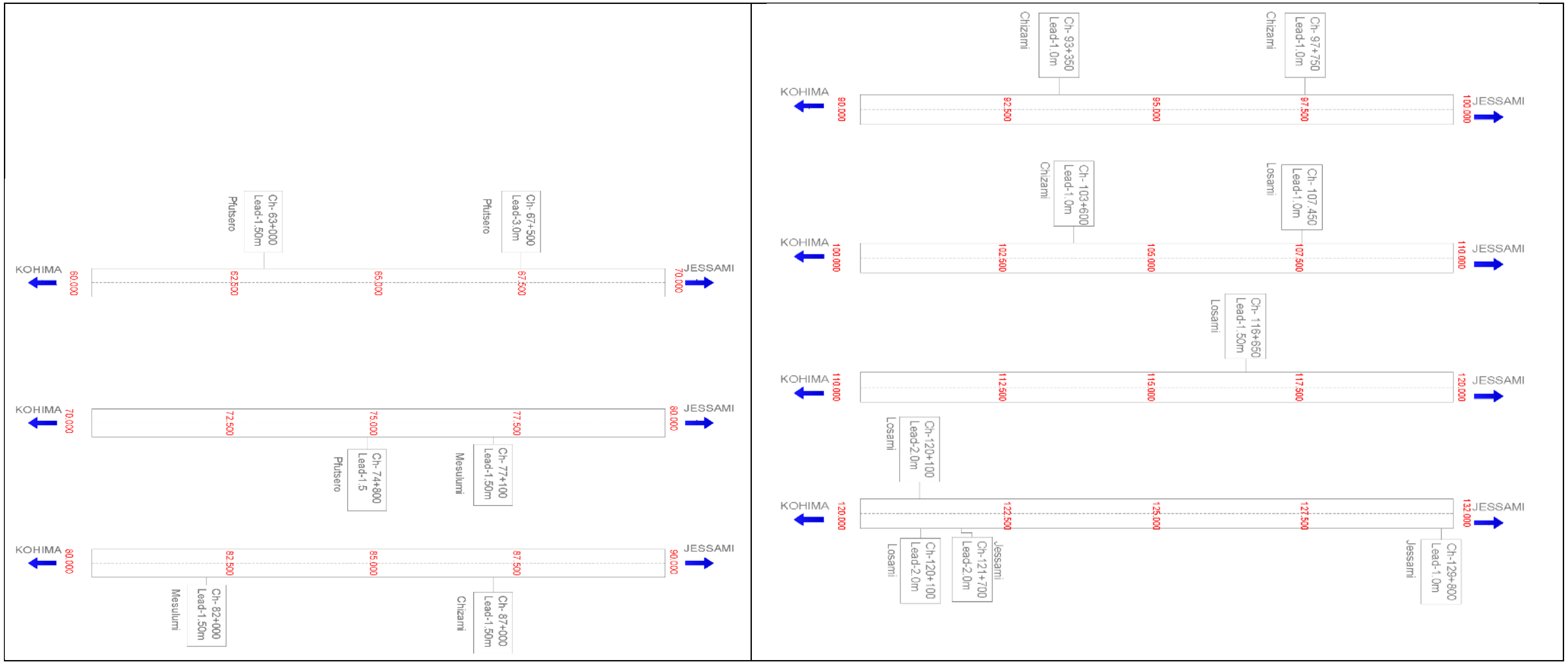


Figure 3-7: Borrow Area Lead Chart

Some exhibits of the investigations along the project highway are shown below;

	
KM 29+675 RS Pit Excavation Is In Progress For Existing Sub-grade Testing	Borrow area on hillock at Km 116+500 on LHS
	
Test Pit at Km 29+675 on RHS	DCPT at Km 43+730 on RHS
	
Measuring the existing crust composition at Km 43+730 on RHS	Test pit & DCPT at Km 48+825

Field Dry Density Test at Km 54+140

DCPT at Km 54+140

Measurement of pavement thickness at Km 59+000 LHS

DCPT at Km 63+150 on RHS

Measurement of existing crust at Km 63+150 on RHS

DCPT at Km 86+025 on LHS

Measurement of Dry Density at Km 86+025 on LHS

Measurement of Pavement Crust thickness at Km 95+450 on RHS

Test pit at Km 95+450 on RHS

Test pit at Km 101+600 on RHS

Measurement of existing crust composition at KM 101+600 on RHS

DCPT at KM 107+500 on RHS

Measurement of crust composition at Km 107+500 on RHS

DCPT at Km 114+960 on RHS

Measurement of existing crust composition at Km 114+960 on RHS

3.4.4.3 Sub-base

The material to be used for the work shall be gravel and / or crushed stone or a combination there of. The material shall be free from organic and other deleterious constituents and conform to grading given in Table 400-1 of MORT&H specification. Material for Sub-base will be available from stone/gravel quarries. Crushed stone samples were collected from different locations to establish their suitability for use in construction as sub-base material.

Stone materials:

Since, Nagaland the state has huge caches of unutilized & unexploited Natural Minerals. Vast deposits of stone are found in Chakabama, Pfutsero and Jessami which is used as construction materials. Summary of quarry locations of stone material is given in Table 7.10. The test results summary of the stone material is given in Table 7.11.

Stone Quarries in Chakabama Area:

Inventory survey reveals that Chakabama, with a minimum average distance of 36km from Kohima - the nearest end of the project corridor has 1 no, of major quarry location as tabulated in Table 11 with the quantity and lead distance. The Rate of 40mm is 105/Cft, 25mm is 100/Cft, 20mm is 99/Cft, 10mm is 101.54/Cft but as per the local enquiry from the quarry owner the rate of 40mm, 25mm, 20mm, & 10mm is 44/Cft, 38/Cft, 36/Cft & 35/Cft & the Owner of the quarry Pay tax to govt.. The Quarry location from the stock yard is 10km from the project road. The quarry owner shall charge Rs 6000 for 30km as transportation cost. The lead map is given in figure below;

Figure 3-8: Stockyard of Chakabama stone quarry at Km. 36+000 on LHS

Stone Quarries in Pfutsero Area :

Inventory survey reveals that Pfutsero, with a minimum average distance of 67km from Kohima - the nearest end of the project corridor has 4 no, of major quarry location as tabulated in Table 11 with the quantity and lead distance. The Rate of 40mm is 105/Cft, 25mm is 100/Cft, 20mm is 99/Cft,10mm is 101.54/Cft but as per the local enquiry from the quarry owner the rate of 40mm, 25mm, 20mm, & 10mm is 42/Cft, 37/Cft, 36/Cft & 37/Cft in the four nos of quarry location & the Quarry Owner was not interested to share the Royalty. The lead map is given in Figure 7.13.

Stone Quarries in Jessami Area

Inventory survey reveals that Pfutsero, with a minimum average distance of 132km from Kohima - starting point of the project corridor has 1 no, of major quarry location as tabulated in Table 11 with the quantity and lead distance The Rate of 40mm is 115/Cft, 25mm is 112/Cft, 20mm is 111/Cft, 10mm is 113/Cft, but as per the local enquiry from the quarry owner the rate of 40mm, 25mm, 20mm, & 10mm is 40/Cft, 39/Cft, 36/Cft & 37/Cft & the Quarry Owner was not interested to share the Royalty .The lead map is given in Figure below; The summary of Identified Quarry/Crusher Locations is given in table below;

Table 3-12: Quarry Location of Stone Material

Sl No	Chainage (Km)	Quarry name/ Owner Name	Available Course Aggregate (mm)	Capacity (Cum)	Quantity (cum)	Distance from the project road (m)
1	36+000	Chakabama/ Mr V.Puro	40,25, 20,10, Stone Dust	10800	6000	20
2	64+000	Pfutsero/ Mr. Azo	25, 20,12.5, stone dust	12500	7500	50
3	65+800	Pfutsero/ Mr. Kezo	40,25, 20,10, stone dust	11300	6300	50
4	67+600	P futsero/ Mr. Niba	40,25, 20,10, stone dust	10500	4300	50
5	69+500	Pfutsero/ Mr. Dhanecho	25, 20,10, stone dust	13200	7600	40
5	121+000	Jessami/ Mr Azo Minister	40,25, 20,10, Stone Dust	11000	7800	20

Table 3-13: Test Result of Coarse Aggregate

Identification Number	Quarry Name / Location (km)	Size of Aggregate (mm)	Gradation Test % of Passing 40 mm	20 mm	12.50 mm	10 mm	4.75 mm	2.36 mm	1.18 mm	0.600 mm	0.300 mm	0.150 mm	0.075 mm	Sp. Gravity	Water Absorption (%)	Aggregate Impact Value (%	Flakiness Index (%)	Elongation Index (%)	Index + Elongation	Striping Value (%)	Soundness (%)
CA/01	Chakabama / 36+000	20	98.1	73.8	-	8.26	1.15	-	-	-	-	-	-	2.69	1.26	13.88	15.39	27.55	42.94	Area Coated >85%	6.1
		10	-	-	96.35	73.7	5.86	1.15	-	-	-	-	-	2.656	1.5	15.13	21.66	35.52	57.18	Area Coated >90%	7
		Stone Dust	-	-	-	100	92.4	80.8	68	47.53	37.01	25.58	18.29	2.641	1.67	-	-	-	-	-	-
CA/02	Pfutsero / 64+000	20	100	74.6	-	9.32	1.02	-	-	-	-	-	-	2.695	1.39	14.68	13.55	24.56	38.11	Area Coated >90%	6.88
		10	-	-	98.81	70.2	8.68	2.22	-	-	-	-	-	2.663	1.41	14.66	18.82	30.22	49.04	Area Coated >85%	6.45
		Stone Dust	-	-	-	98.8	94.6	85.3	73.3	51.24	38.63	26.62	19.12	2.629	1.66	-	-	-	-	-	-

Identification Number	Quarry Name / Location (km)	Size of Aggregate (mm)	Gradation Test											Sp. Gravity	Water Absorption (%)	Aggregate Impact Value (%)	Flakiness Index (%)	Elongation Index (%)	Index + Elongation	Striping Value (%)	Soundness (%)
			% of Passing																		
			40 mm	20 mm	12.50 mm	10 mm	4.75 mm	2.36 mm	1.18 mm	0.600 mm	0.300 mm	0.150 mm	0.075 mm								
CA/03	Pfutsero / 65+800	20	95.1	82.9	-	6.99	0.97	-	-	-	-	-	-	2.672	1.29	14.21	18.62	17.22	35.84	Area Coated >85%	6.33
		10	-	-	93.89	72	6.32	1.55	-	-	-	-	-	2.646	1.49	15.35	24.26	33.32	57.58	Area Coated >90%	7.51
		Stone Dust	-	-	-	100	94	81.2	70.7	48.96	39.65	23.32	15.69	2.631	1.75	-	-	-	-	-	-
CA/04	Pfutsero / 67+600	20	100	81.2	-	10.1	1.88	-	-	-	-	-	-	2.706	1.5	15.65	15.52	20.32	35.84	Area Coated >90%	7.67
		10	-	-	100	80.9	3.68	0.89	-	-	-	-	-	2.681	1.68	16.21	19.96	27.16	47.12	Area Coated >90%	7.11
		Stone Dust	-	-	-	100	91.9	85.7	71.3	49.63	40.09	25.62	17.25	2.652	1.76	-	-	-	-	-	-

Identification Number	Quarry Name / Location (km)	Size of Aggregate (mm)	Gradation Test % of Passing 40 mm	20 mm	12.50 mm	10 mm	4.75 mm	2.36 mm	1.18 mm	0.600 mm	0.300 mm	0.150 mm	0.075 mm	Sp. Gravity	Water Absorption (%)	Aggregate Impact Value (%)	Flakiness Index (%)	Elongation Index (%)	Index + Elongation	Striping Value (%)	Soundness (%)
CA/05	Pfutsero / 69+500	20	100	75.9	-	10.1	1.15	-	-	-	-	-	-	2.683	1.4	12.21	16.62	23.15	39.77	Area Coated >91%	6.59
		10	-	-	97.52	77.9	4.96	1.33	-	-	-	-	-	2.663	1.33	11.65	15.52	30.33	45.85	Area Coated >87%	7.01
		Stone Dust	-	-	-	100	95.9	86.6	73.6	49.66	38.35	26.65	18.66	2.642	1.65	-	-	-	-	-	-

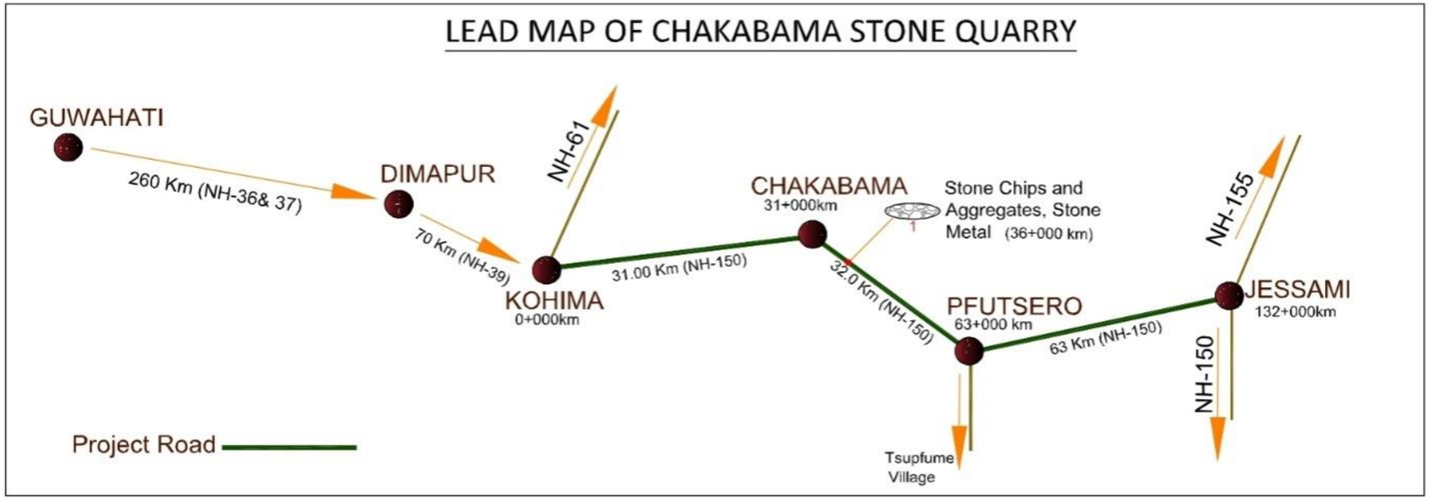


Figure 3-9:: Chakabama Lead map

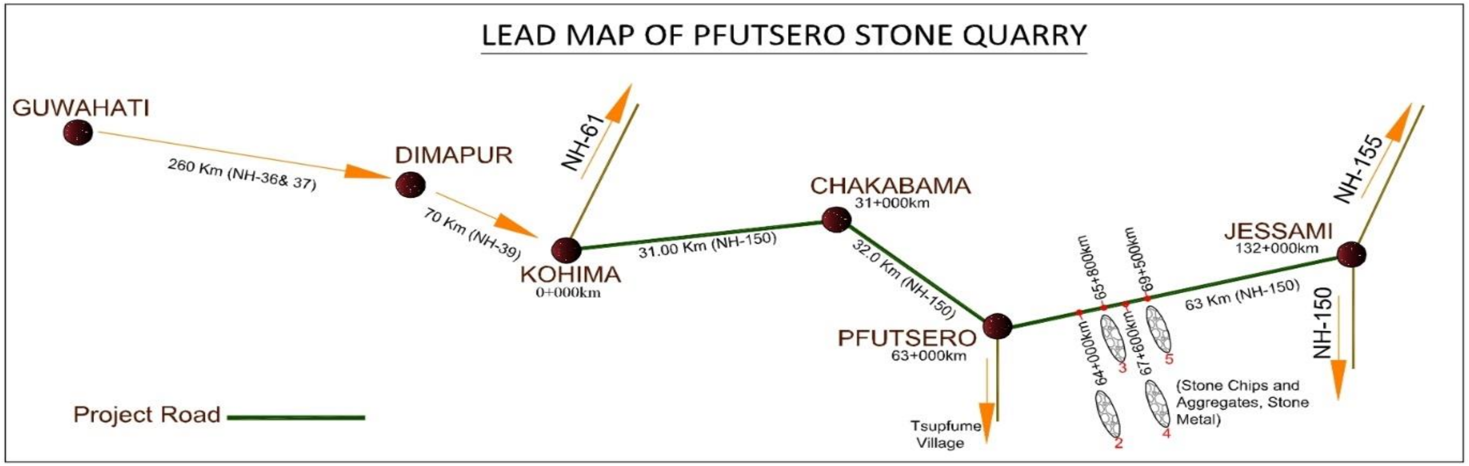


Figure 3-10: Pfutsero Lead Map

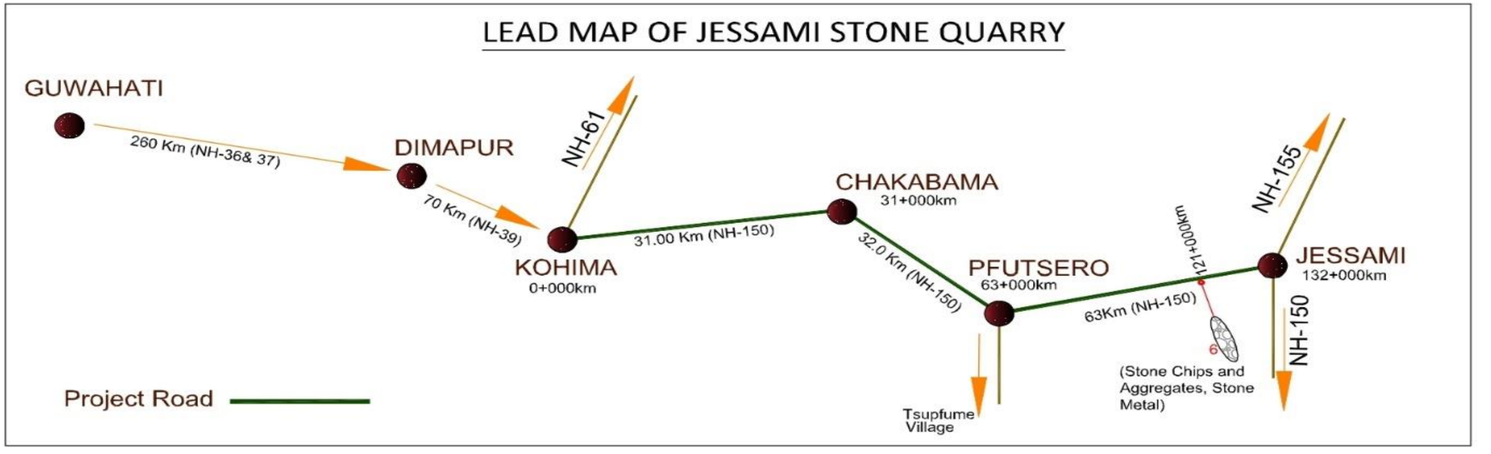


Figure 3-11: Jessami Lead Map

3.4.4.4 Base

The material to be used for base shall be mixture of coarse aggregates and fine aggregates. The coarse aggregates shall consist of crushed rock and conform to physical requirements and grading as given in table 400-12 and 400-13 respectively of MORT&H specification.

Extensive survey was conducted to locate the availability of stone metal near the project site. As a result of local enquiries and discussion with the local PWD official's stone metal was identified at various locations. The samples from the crusher were collected from quarries and tested in the laboratory for the following tests:

Los Angeles Abrasion Test	:	As per IS: 2386 (Part-4)
Aggregate Impact value	:	As per IS: 2386 (Part-6)
Combined Flakiness and Elongation Indices	:	As per IS: 2386 (Part-7)
Soundness	:	As per IS: 2386 (Part-5)
Water absorption	:	As per IS: 2386 (Part-3)

3.4.4.5 Sand

River is the main source of course sand. Sand quarry locations are given in table below;

3.4.4.5.1 Sand Quarries:

Good quality coarse / fine sand is available beyond the project road, which is Dhansiri River area, Dimapur. This river area is having the major sand quarries. Sand quarries operate steadily all along the year, however, with monsoon and river water level there are slight variation in this trend. We have collected samples from 5 major quarries & the test results of those samples are given in Table 7.12. The total quantity available is more than 100000 Cum in this river area, with a distance from the nearest end of the project road Kohima is 72km.The Rate of Fine Sand is 10/- per Cft & for Coarse sand is 36/- per Cft.

Table 3-14: Test results of Fine Aggregate

Identification Number	Quarry Name / Location	Gradation Test % of Passing							Zone Classification	Fineness Modules	Sp. Gravity	Water Absorption (%)	Bulk Density (Loose Weight) kg/lit	Bulk Density (Compacted Weight) kg/lit	Moisture Content (%) at Bulk Density Test Time
		10 mm	4.75 mm	2.36 mm	1.18 mm	0.600 mm	0.300 mm	0.150 mm							

FA/ 01	Dhansiri River/ Dimapur	100.00	97.89	86.85	59.62	29.21	12.32	0.89	I	3.132	2.641	1.16	1.479	1.649	0.98
FA/ 02	Dhansiri River / Dimapur	100.00	98.12	86.25	63.36	22.32	10.02	0.75	I	3.192	2.638	1.12	1.475	1.612	0.92
FA/ 03	Dhansiri River / Dimapur	100.00	100.00	91.55	75.20	38.20	15.36	1.33	II	2.784	2.623	1.28	1.441	1.623	1.02
FA/ 04	Dhansiri River / Dimapur	100.00	96.12	80.55	63.25	29.32	10.02	0.91	I	3.198	2.646	1.10	1.486	1.608	0.97
FA/ 05	Dhansiri River / Dimapur	100.00	100.00	93.25	81.24	42.35	14.26	1.02	II	2.679	2.632	1.19	1.462	1.613	1.05

Dhansiri river in Dimapur which is located beyond the project road with an abundance of sand.

Stockyard of sand in Dimapur with a distance of 70 Km from the nearest end of the project road Kohima.

3.4.4.6 Flyash

Fly Ash is a lightweight material, which may be used for construction of embankment, sub-grades etc. singly or by mixing with suitable admixtures. The flyash is laid in alternate layers with soil and earth blankets are also provided on the side slopes for the confinement of the materials as per IRC: SP: 58 – Guidelines for use of Flyash in Road Embankment. The guidelines regarding design / construction of embankments are given in IRC SP: 58-2001.

Fly ash is readily available in Guwahati in sufficient quantity. The Lead distance of Guwahati from the nearest end Kohima, of the project corridor is 330km. The lead chart is given in Figure 7.15. Summary of fly ash test results are given in table below;

Table 3-15:Summary of Fly Ash Test Results

Identification Number	Source of Place / Location	Gradation Test													Sp. Gravity	Proctor Density		Consolidation			Permeability
		% of Passing									Gravel Size Particles (%)	Sand Size Particles (%)	Silt Size (%)	Clay Size (%)		OMC (%)	MDD (gm/cc)	EO	CC	Coefficient of Consolidation Cv	
		10 mm	4.75 mm	2.00 mm	1.18 mm	0.600 mm	0.425 mm	0.300 mm	0.150 mm	0.075 mm											
Flyash/01	Guwahati	100	100	100	100	100	100	97.81	94.22	86.02	0	14	83	3	2.11	26	1.189	0.71	0.0137	6.10×10-7	3.30×10-7
Flyash /02	Guwahati	100	100	100	100	100	100	99.35	95.25	88.02	0	12	84	4	2.13	27.6	1.194	0.58	0.0185	5.6×10-7	4.1×10-7

3.4.4.7 Bitumen

Inventory survey reveals that Guwahati, with a distance of 330 km from Kohima-the nearest end of the project corridor where Bitumen is available in good quantity. The lead map is given in Figure 7.15.

3.4.4.8 Cements

Cement of all varieties/types i.e. Ordinary Portland, Portland Slag, and Portland Pozzolona confirming to relevant IS standards are readily available in the market in sufficient quantity, and also, would be directly supplied by the manufacturer to the project site for such a huge quantum of work and may be at rebated price.

3.4.4.9 Moorum:

Inventory survey reveals that good quality moorum is available near Tsupfume village beyond the project corridor on NH-150. Tsupfume with a 300m distance from Pfutsero town on the project road. The lead chart is given in Figure 7.15.

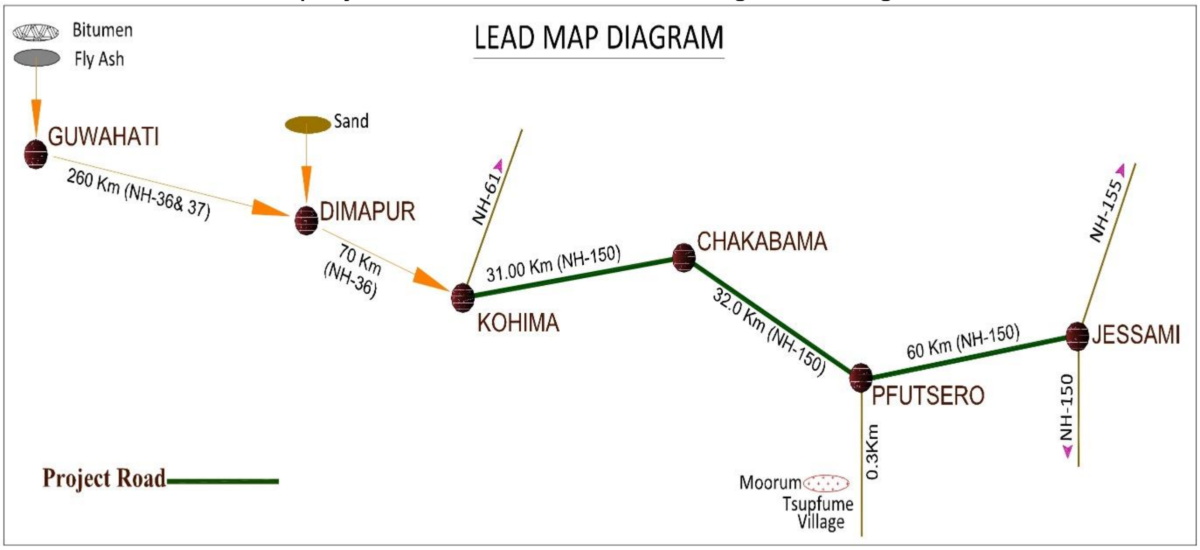


Figure 3-12: Lead map of Sand, Moorum, Bitumen, Fly ash

3.4.4.10 Conclusion and Recommendations

- Construction materials are available with in economical lead;
- Construction materials can be obtained/exploited without any hassles during the implementation of the project

3.5 Structures Inventory and Condition Survey

There is 1 Existing Bridge and 1 Bridge is Newly Constructured. There are 102 nos. existing culverts out of which 74 nos. are pipe arch culverts and 28 nos. are slab culverts. Details of the existing Bridges are in Appendix-E & Culverts are in Appendix-F.