

**KINGDOM OF CAMBODIA
MINISTRY OF PUBLIC WORKS AND TRANSPORT
PROJECT MANAGEMENT UNIT 3**

**CAMBODIA NORTHWEST PROVINCIAL ROAD
IMPROVEMENT PROJECT
EDCF LOAN NO. KHM-9**

Contract Name: Improvement of National Road No. 56 from km 29 to Samraong



GEOTECHNICAL INVESTIGATION

MAY 2011



**Korea Consultants International
Yooshin Engineering Corporation**

KINGDOM OF CAMBODIA
Nation Religion King

MINISTRY OF PUBLIC WORKS AND TRANSPORT

PROJECT MANAGEMENT UNIT.3 (PMU.3)

PROCUREMENT OF CIVIL WORKS

FOR

THE CAMBODIA NORTH-WEST PROVINCIAL ROAD

IMPROVEMENT PROJECT.

DETAILED DESIGN FOR IMPROVEMENT OF NR.B

EDCF LOAN No. KHM-9.

MATERIALS REPORT

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Subsurface investigation report

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1. Introduction

Soil and materials investigation is the TOR requirements for detailed engineering design of the Cambodia North-West Provincial Road Improvement Project and covers the materials investigation, finding, evaluation, analysis, pictures and recommendations necessary for the design of highway pavement structure, investigation of available materials sources, borrow and embankment materials, and aggregate materials.

Sakor Cambodia Company was commissioned to undertake materials investigation for this particular project on December 27, 2010 for the determination of subsoil condition, its relative soil characteristics and its texture, consistency, classification and characteristics of soil types, especially geologic and subsoil condition of the materials beneath the Project Site for the construction design.

2. Geology and Landform

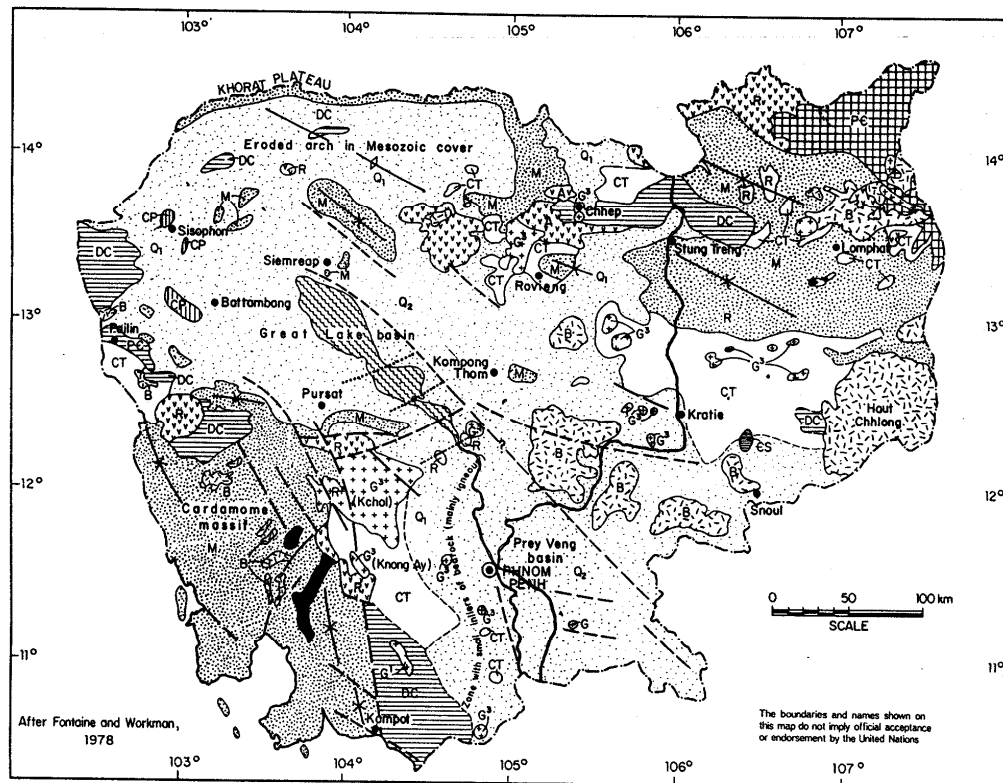
The geology of the project area and its immediate environments are shown in Figure 2.

Cambodia is geologically composed of three different structures; they are mostly Triassic, Jurassic-Cretaceous and Quaternary. The Triassic period covers a large area in the east, Jurassic-Cretaceous Era forming important highlands in the west and, between them, the Quaternary basin occupy the whole central plain of the country.

The area of the site is situated within a belt of recent lacustrine sediments. Near the river shore, a belt of organic deposit is overlying alluvial of the Holocene period. In the flat area of the main Tonle Sap, they are reported to comprise gray silts, sands, clay and organic soils. The geological map also shows the alluvial sediments of the project area, where it flows from vicinity high land and upper Mekong River to fulfill low land and flat plain. Therefore the project area occurred historically from year after years, era after era by deposited layer by layers the sediment from the high land area.

The other site is situated within a folds-belt of indochinian of high land sediments of Precambrian-Silurian medium to high grade metamorphics. Near the mountain area, a belt of hilly deposit is overlying eluvia of the Devonian-Carboniferous rocks. In the flat area of the main land, they are reported to comprise gray silts, sands, and clay soils. The geological map also shows the sediments of the project area, where it is coming from vicinity high land and upper hilly to fulfill flat plain, as a deposit of recent origin.

Figure 1. Geology Map of Cambodia



LEGEND

TERRANES

UNDEFORMED OR GENTLY FOLDED COVER STRATA

- Q Quaternary sedimentary rocks and unconsolidated sediments. 1: Pleistocene; 2: Holocene. Includes some small Neogene basins
- B Neogene - Quaternary platform basaltic rocks
- M Mesozoic sedimentary units (upper Triassic-Cretaceous)
- Volcano-sedimentary units (mainly Triassic, some Paleozoic). A: andesitic; R: rhyolitic.
- C-P Paleozoic sedimentary units (mainly Carboniferous-Permian).

ZONES OF INDOSINIAN FOLDING

- CT Synclinal zones in Indosinian fold-belts (mainly Carboniferous-Triassic).
- DC Anticlinal zones in Indosinian fold-belts (Precambrian-Silurian medium to high-grade metamorphics; Devonian-Carboniferous rocks, deformed and slightly metamorphosed).

EXPOSED BASEMENT ROCKS OF THE KONTUM MASSIF

- PC Precambrian-Early Paleozoic granites and high-grade metamorphics.

INTRUSIVE ROCK GROUPS

- G Acid - Intermediate intrusive suites
- G₁ - Pre-Carboniferous
- G₂ - Carboniferous
- G₃ - Triassic-Jurassic
- G₄ - Cretaceous

STRUCTURE SYMBOLS

- Regional faults, known and inferred
- Geographical lineament
- Axes of Cenozoic epirogenic folding
- Limits of terranes, known and inferred
- Axis of swell in buried pre-Tertiary basement
- Intramontane grabens (Neogene)

3. Objective and Scope

The objective of soil and materials investigation is contributed to analyzing various subsoil conditions including their characteristics and composition status of strata distributed beneath the project area. The scopes and the objectives of the subsurface investigation included the following tasks:

- Make an actual field observation and inspection.
- Test pitting in-situ CBR test and DCP tests along the road alignment.
- Retrieve samples collection, preservation and transportation to the laboratory.
- Investigation and field survey of available materials sources borrow and embankment materials, aggregate materials for use of road construction project.
- Interpret and evaluate of the field testing; and Laboratory testing of soil samples from test pits, materials and aggregate sources.
- Determination of the factual characteristics of sub-grade soil and existing sub-base for the purpose of getting conclusive data to support our recommendation for the pavement new design and construction.
- Determination of the actual existing pavement condition.
- Determination of the potential materials and aggregate sources for the construction.
- Confirm the location, hauling distance and road condition of the material sources to be availed during construction stage.
- Confirm the available volume and quantities and classification of materials at the chosen locations.

4. Materials Investigation

The subcontractor commissioned to undertake materials investigation for this particular road project for the determination of general sub-soil condition and its physical and mechanical characteristics of soil and materials and its classification that may compose of the road alignment, pavement structure and embankment foundations.

Materials sources, quarry sites, aggregate sources, and borrow sources were also investigated. Field investigation such as test pitting, DCP tests, and in-situ CBR by samples cutting edge on the road alignment, together with laboratory testing of soil samples gathered were conducted.

5. Field Investigation Methodology

5.1 Road Alignment

Pit Dig

In order to identify the different type of soil encountered along the road alignment of the project, Pit Tests were conducted on existing road sections with intervals of 5.00 Km and on the realignment road with intervals of 1.00 Km by a maximum depth of 0.70 m with an area of 1.00m x 1.00m. The texture and type of soil were described and made the pit log at every changed stratum. Soil samples along the road were brought to routine laboratory to identify characteristics of soil along road alignment of the construction project. The results of test pits provide information on road alignment, existing pavement condition, soil profile as recorded in the field. Each retrieved samples was conducted in laboratory in according with the AASHTO standard methods and its results are shown in the appendix.

DCP Test

DCP tests were performed at the every dug pit of 5.00 Km intervals for existing road sections with intervals of 5.00 Km and every dug pit of 1.00 Km intervals for the realignment road to get information of CBR in-situ along project. It is carried out by using free dropping hammer at constant height. The test shall be used 8 Kg drive weight at free fall height of 760 mm to drive the hammer at every 5 blows or 10 blows. The interpreted CBRs conducted on road site are shown in the DCP appendix attached.

5.2 Materials Sources

Investigation was undertaken for borrow materials, sub-base, base and aggregated materials along the sketch of the road section. Test pit were dug to the depth of 0.70m depth for each designated source (location). Composite samples were extracted from each test pit and subjected to require physical and mechanical testing. The quantity of material was estimated, hauling and accessibility considered. Laboratory test results, location plan and accessibility are shown in the appendix.

5.3 Laboratory Tests

Soil samples extracted to present the different strata from pits tests along the road alignment were subjected to standard laboratory soil testing for

evaluation and analysis in accordance with AASHTO standard methods and specification to classify them for their engineering values. The quantity and type of tests performed were also in accordance with the TOR and contract agreement for the project.

All tests performing in following standard procedures:

- Natural Water content AASHTO T-93
- Moisture Density Relation AASHTO-T180,
- Plastic and Liquid Limit AASHTO-T89 and T90,
- Particle Size Distribution AASHTO-T88,
- Specific Gravity AASHTO-T100 and AASHTO T-84/ T-85
- California Bearing Ratio CHR AASHTO-193

Bulk samples taken from test pits on the existing sub-grade were subject to Procter Test under AASHTO-T80 testing procedure. Method B or D was adopted depending on the gradation of the soil or aggregate material. A (4.54Kg) hammer was used. Five trials were performed for each compaction test.

The sub-grade, sub-base, base strength and other engineering characteristics were determined using the California Bearing Ratio (CBR) tests. The three points CBR method was adopted, where the specimens were soaked for 96 hours. The method allows interpolating the CBR values at various dry densities of soil. Three points obtained from CBR test represented the different compaction energies at 10, 30 and 65 blows using 4.54 Kg hammer dropped at a height of 0.457m for five layers of soil in the compaction cylinder mould.

The borrow materials, sub-base, base and aggregated materials were subjected to conduct physical and mechanical tests as following:

- Gradation Test AASHTO T-27,
- Atterberg Limits AASHTO T-89/ T90,
- Moisture Density Relation AASHTO-T180,
- California Bearing Ratio CHR AASHTO-193,
- Specific gravity and Absorption AASHTO T-85,
- Unit Weight AASHTO T-19,
- Los Angeless Abrasion Test AASHTO T-96,
- Soundness Test AASHTO T-104,
- Organic Impurity Test AASHTO T-21,
- Flakiness and Elongation Test BS.812

6 Finding (Test results):

6.1 Road Alignment (Soil)

The project road NR-56B Connect from NR-56A in km 29 to Sam Raong in km 113. At present there is 29 km of road from the starting point of NR 56B toward Sam Raong having Laterite surfacing with fairly good trafficable surface condition but the standard requires by this project design and hence need to be dismantled and recycle material for sub-grade/sub-base construction depending on quality of salvage materials and also have 11.15km for Re-Alignment from Km 53+600 to Km 64+750 at Benteay Chhmar Temple. To avoid traffic hazards and excavation difficulties within the length of sealed surface area, Test Pit was excavated just next to sealed surface at every 5km for Existing Road and Every 1km for Re-Alignment New Road By-Passing. Total 26 test pits were dug, tested and sampled for 84km length of project road. To obtain representative test information and adequate samples, each test pits were dug to the size of 1.0m x1.0m x0.7m. Existing road sub-grade soil field investigation conducted from 30.12.10 to 10.02.11 and Laboratory tests continued till 25th February 2011 by the detail design and supervision consultant team. In-Place Dynamic Cone Penetrometer (DCP) test were conducted using TRL DCP, at an interval of 5 km. DCP test performed at two points per test pit and one undisturbed CBR sample was taken from each of the test pits for 96 hours soaked CBR test (AASHTO T-193). Disturbed samples were also taken from each test pits and tested for physical properties like Natural Moisture Content, Atterberg Limits, Particle Size analysis, Specific Gravity etc of the soils. To compare the In-Situ CBR with DCP test data, one side of the undisturbed CBR specimens were tested in the laboratory before soaking. Test results demonstrate remarkable variation between In-Situ DCP and Laboratory Unsoaked CBR test values for the same location and depth of undisturbed sample and hence laboratory unsoak CBR values will be prefer for comparison with DCP In-Situ CBR values. However soaked CBR values obtained from undisturbed samples are considered to be used for pavement design review purposes. During dry condition of road surface, driving of DCP cone through top 25 to 40 cm except Re-Alignment Road, driving of DCP cone carried out from top layer to 0.5m in depth only. Layer of lateritic material were not possible for most of the instances and hence DCP test carried out on existing embankment sub-grade soil removing the top lateritic materials. Existing road sub-grade soil test results are presented in Table 2-1.

Table: 2-1:Existing Sub-grade Test Report (Existing NR-56B)						
Test Pit location	CBR values (in %)for undisturbed Samples obtained from Test Pits				In-Situ CBR by (DCP)	Natural moisture content at same depth of In-Situ CBR Samples and DCP tests
	Un-soaked test at Penetration level of		Soaked test at penetration level of			
	2.54mm	5.08 mm	2.54 mm	5.08mm		
Test Pit No.1: 31+500(RHS 1.4m)	37.19	46.17	7.92	9.00	106	at depth 32-61cm MC= 6.17 %
					56	at depth 32-61cm MC= 6.32 %
Test Pit No.2; 36+500(LHS 1.0m)	16.88	23.55	1.03	1.39	66	at depth 46-75cm MC= 2.98 %
					108	at depth 46-75cm MC= 2.48 %
Test Pit No.3: 41+500 (RHS 1.9m)	22.39	27.47	11.02	12.93	42	at depth 41-70cm MC= 7.75 %
					22	at depth 41-70cm MC= 7.92 %
Test Pit No.4: 46+500 (LHS 1.9m)	9.64	11.54	1.38	3.00	25	at depth 20-49cm MC= 10.47 %
					49	at depth 20-49cm MC= 11.02 %
Test Pit No.5: 51+550 (RHS 0.8m)	31	28.62	9.99	11.77	43	at depth 22-50.4cm MC= 5.61 %
					42	at depth 22-50.4cm MC= 6.3 %
Test Pit No.6: 67+500 (LHS 0.7m)	19.97	23.08	11.37	12.00	35	at depth 28-56.4cm MC= 4.2 %
					38	at depth 28-56.4cm MC= 5.0 %
Test Pit No.7: 72+500 (RHS 1.0m)	46.84	39.71	0.69	0.69	15	at depth 31-60cm MC= 14.99 %
					14	at depth 31-60cm

						MC= 13.44 %
Test Pit No.8: 77+500 (LHS 0.8m)	24.8	25.85	2.41	2.31	16	at depth 20-50cm MC= 7.54 %
					10	at depth 20-50cm MC= 6.08 %
Test Pit No.9: 82+500 (RHS 1.0m)	18.6	20.78	3.44	4.16	11	at depth 20-48.4cm MC= 9.9 %
					12	at depth 20-48.4cm MC= 10.57 %
Test Pit No.10: 87+500 (LHS 1.0m)	18.6	17.08	2.07	2.08	11	at depth 22-50.5cm MC= 6.4 %
					24	at depth 22-50.5cm MC=5.58 %
Test Pit No.11: 92+500 (RHS 0.8m)	38.23	41.09	9.3	10.16	19	at depth 14-42.5cm MC=9.7 %
					17	at depth 14-42.5cm MC=10.35 %
Test Pit No.12: 97+500 (LHS 0.7m)	22.39	24.01	3.79	4.16	22	at depth 15-44cm MC=11.87 %
					16	at depth 15-44cm MC=10.87 %
Test Pit No.13: 102+400 (RHS 0.8m)	14.46	12.93	3.79	3.69	11	at depth 21-49.4cm MC=9.34 %
					11	at depth 21-49.4cm MC=11.66 %
Test Pit No.14: 107+400 (LHS 0.7m)	7.23	6.46	9.64	8.54	11	at depth 24-52.6cm MC=12.3 %
					25	at depth 24-52.6cm MC=11.57 %
Test Pit No.15: 111+500 (RHS 1.0m)	41.33	56.79	7.23	8.08	39	at depth 22-50.6cm MC=6.99 %
					50	at depth 22-50.6cm MC=5.72 %

Source: Detail Design & Supervision Consultant's Geotechnical Study.

Table: 2-1-a:Existing Embankment Test Report (Re-Alignment NR-56B)

Test Pit location	CBR values (in %)for undisturbed Samples obtained from Test Pits				In-Situ CBR by (DCP)	Natural moisture content at same depth of In-Situ CBR Samples and DCP tests
	Un-soaked test at Penetration level of		Soaked test at penetration level of			
	2.54 mm	5.08 mm	2.54 mm	5.08 mm		
Test Pit No.1: 54+100 (RHS 0.7m)	17.56	12.7	3.44	3.69	11	at depth 5-22.7cm MC= 2.78 %
					8	at depth 5-22.7cm MC= 2.82 %
Test Pit No.2; 55+100 (RHS 0.6m)	11.37	14.31	0.34	0.46	12	at depth 5-22.7cm MC= 5.89 %
					13	at depth 5-22.7cm MC= 5.46 %
Test Pit No.3: 56+100 (LHS 0.8m)	24.45	24.47	1.38	1.15	18	at depth 5-22.7cm MC= 2.54 %
					10	at depth 5-22.7cm MC= 2.49 %
Test Pit No.4: 57+100 (RHS 0.4m)	14.12	11.31	0.69	0.69	20	at depth 5-22.6cm MC=1.85 %
					34	at depth 5-22.6cm MC=12.75 %
Test Pit No.5: 58+100 (LHS1.9m)	11.71	13.85	1.38	1.39	35	at depth 5-22.6cm MC=8.24 %
					37	at depth 5-22.6cm MC=8.5 %
Test Pit No.6: 59+100 (RHS 0.4m)	11.37	14.77	2.41	2.31	17	at depth 5-22.6cm MC=9.0 %
					9	at depth 5-22.6cm MC=9.38 %

Test Pit No.7: 60+100 (LHS 0.2m)	24.45	22.85	2.41	2.77	26	at depth 5-22.8cm MC=3.81 %
					24	at depth 5-22.8cm MC=3.86 %
Test Pit No.8: 61+100 (RHS 0.85m)	22.04	18.24	0.69	0.69	6	at depth 5-22.6cm MC=7.71 %
					6	at depth 5-22.6cm MC=5.63 %
Test Pit No.9: 62+100 (LHS 0.4m)	25.83	27.24	1.03	0.92	29	at depth 5-22.7cm MC= 4.91 %
					27	at depth 5-22.7cm MC= 4.86 %
Test Pit No.10: 63+100 (RHS 0.5m)	40.64	36.01	1.72	1.62	18	at depth 5-22.7cm MC= 8.56 %
					20	at depth 5-22.7cm MC=8.24 %
Test Pit No.11: 64+100 (LHS 0.5m)	13.43	12.23	3.1	2.77	7	at depth 5-22.7cm MC=14.44 %
					6	at depth 5-22.7cm MC=15.04 %

Table: 2-1-b : Embankment /Sub-base Borrow Pits/Rock Quarry

Descriptions	Project	Number	Location/Station	Remarks
Emban./Sub-grade Borrow Pits	ADB	BP1	4+500 LHS 1500m from NR 56	Soaked CBR not less than 2%.Further testing for extended area can be done once UXO/Mine survey & clearing is done.
		BP2	7+300 LHS 100m from NR 56	Soaked CBR 2.8 to 2.9 % and PI 15 to 16%.
		BP3	19+400 LHS 4.5km from NR 56	Soaked CBR at 95% of MDD=43% and PI = 21%
		BP4	28+616 LHS 100m from NR 56	Once UXO/Mine survey & clearing done then sampling & testing may be possible
		BP5	28+600 RHS 1000m from NR 56	Once UXO/Mine survey & clearing done then sampling & testing may be possible
	EDCF	BP6	33+976 LHS 100m from NR 56	Soaked CBR 9 to 15.8% and PI 7 to 15%
		BP7	34+380 RHS 200m from NR 56	Once UXO/Mine survey & clearing done then sampling & testing may be possible
		BP8	52+250 LHS 500m from NR 56	Soaked CBR =2~3% and PI = 15.06%.
		BP9	60+100 LHS 100m from Re-Alignment NR-56	Soaked CBR =45% and PI =0.....
		BP10	61+800 RHS 500m from NR-56	Soaked CBR =14~28% and PI =10.14%
		BP11	69+100 RHS 2500m from NR-56	Soaked CBR =38~75% and PI =10.3%
		BP12(TA)	Ou Smanch, 23km from Ending Pointof of NR-56	110+000 RHS 3km from NR-68
		BP13(TA)	Chang KAL Moun, 28km from Ending Point of NR-56	49+000 RHS 4km from NR-68
Sub-base Borrow Pits	ADB	SB1	5+00 LHS 3.3 km from NR 56(Kongva Mountain)	Soaked CBR 46 %, PI 10%. Crushed aggregate mixed with borrow pit material
		SB2	20+000 LHS 5 km from NR 56	Soaked CBR 34 to 36 %, PI 19%, LAA coefficient 38%
	EDCF	SB3	51+800 RHS 10.5 km from NR-56 (Phnom Dey)	Soaked CBR =128% and PI =9.93%, and LAA=32.83%

		SB4	77+150 LHS 1.5km from NR-56	Soaked CBR at 95% of MDD 26.5%, Plasticity Index(PI) = 8.69%
		SB5	79+250 RHS 200m from NR-56	Soaked CBR=30% and PI =13.0% and LAA=65.07%
		SB6	97+200 LHS 5.2km (Tonlea Sar)	Soaked CBR=138% and PI =0% and LAA=47.15%
		SB7(TA)	Ou Smanch, 23km from Ending Point of NR-56	110+000 LHS 3km from NR-68
		SB8(TA)	Both sides of NR68 at between km 3.6 and km 5.2, 1.0m depth.	
		SB9(TA)	Both sides of NR68 at between km 18.0 and km 28.0, 1.0m depth.	
Rock Quarry	ADB	Q1	4+900 LHS 1.0km (AKH, ASIA)	
		Q2	Quarry Sla Kram(future) 19+400 LHS 5 km	Soaked CBR at 95% of MDD=43%, Plasticity Index 21%.
	EDCF	Q3	Phnom Phkom and Bay Sar Moun, 42+000 RHS 18km	
		Q4	Chong Kran Yeak Moun, 42+000 RHS 12km	
		Q5(TA)	52+250 LHS 500m	
		Q6	Ou Smanch, 23km from Ending Point of NR-56	100+000 LHS 3km from NR-68
		Q7	Chang KAL Moun, 28km from Ending Point of NR-56.	49+000 RHS 4km from NR-68
		Q8(TA)	About 2.4km north of Kralanh	
		R1(TA)	At Krasang Village. Otdor Meanchey province.	Rock

Considering the soaked CBR for penetration level 2.54mm or 5.08 mm (Table 2-1) existing road sub-grade soil it is clear that the sub-grade soil soaked CBR values, except Test Pit No.2, 7, 8, 10 are safe enough to select the Sub-grade Strength Class S 2 which requires minimum soaked CBR value between 3 to 4%. Possibly during transportation one end of the in-situ CBR specimen for Test Pit No.2, 7, 8, 10 became loose and resulted doubtful soaked CBR values. The CBR values for existing embankment-test results (Re-alignment NR-56B) are ranging from 0.34 to 3.69. In the future when civil work contract is awarded and contractors mobilized to job site, further confirmatory testing of sub-grade soil may be performed by the contractors with an interval of 250m along the road alignment.

6.2 Construction Material Surveys

Base, Sub-base and Borrow Materials

From the CRIP project record it is observed that only 11.15km Re-Alignment were constructed within 84 km length of this project road and not much information available for embankment and sub-base borrow pit because there was not much involvement of embankment and sub-base borrow pit material for bridge site backfilling and approach construction. Identification, sampling and investigation of new embankment and sub-base borrow pits were difficult during existing road material testing/sampling because of UXO/Mine suspicion to the approach road of borrow pit areas. However some locations of embankment and sub-base borrow pits were identified and tested during CRIP and detail design and Supervision Consultant's study and are shown in Table 2-2 as reference below:

Table: 2-2 : Embankment /Sub-grade and Sub-base Borrow Pits		
Descriptions	Location/Station	Remarks
Embankment./Sub-grade Borrow Pits	52+250 LHS 500m from NR 56	Soaked CBR = 2~3%. And PI = 15.06%
	60+100 LHS 100m from Re-Alignment NR-56	Soaked CBR = 45% and PI = 0
	61+800 RHS 500m from NR-56	Soaked CBR 14~ 28% and PI = 10.14%
	69+100 RHS 2500m from NR-56	Soaked CBR 38 ~ 75% and PI 10.30%
Sub-base Borrow Pits	51+800 RHS 10.5 km from NR-56 (Phnom Dey)	Soaked CBR 128%, PI = 9.93% and, LAA = 32.83%
	79+250 RHS 200 m from NR-56	Soaked CBR =30%, PI = 13.02% and LAA = 65.07%
	97+200 LHS 5.2km (Tonlea Sar)	Soaked CBR = 138%, PI = 0 and LAA = 47.15%
Source: CRIP record and Detail Design and Supervision Consultant's Study		

6.3 Aggregate Materials

During the existing road soil investigation, consultant's team also visited functioning stone quarries and 1 under process of installing crushing plant. Visited the sites to identify sources and check availability of stone crushed aggregate for Base Course, Concrete works and DBST surfacing. 3 quarries as cited above are A. K. H Rock Construction located beside NR 56 at station 5+000(LHS 1.8km), Rock Asia is located at station 5+000(LHS 3.3 km) and 3rd one located at station 3+000(LHS 1.5 km). The representative physical properties of the quarry stone crushed aggregates sampled and tested by detail design and supervision consultant's team are presented in Table: 2-3 and Table: 2-4 below and in Table 2-5 and 2-6 shows test reports obtained from CRIP records.

Rock Quarry for EDCF were investigated at Chong Kran Yeak Moun at station 42+000 of NR 56 offset RHS 14km and Chang KAL Moun 28km from Ending Point of NR-56 and Ou Smanch 23km from Ending Point of NR-56. Contractor for Road No. 56B may need to check and investigated the possibility to procure aggregates from those quarries in the future.

Table : 2-3 Typical properties of Stone Crushed Aggregate for Quarry Rock Asia									
Specific Gravity of Aggregate			Absorption (%)	Unit weight(g/cc)		LAA Abrasion (%)	S Sulfate Soundness (%)	F.I Index (%)	E.L Index (%)
				Loose	Rodded				
Bulk	SSD	Apparent							
Test results for 19mm Nominal Size Aggregate									
2.650	2.675	2.713	0.841	-	-	18.91	3.2	-	-
MDD, CBR, Plasticity Index and S. Sulfate Soundness for Aggregate Mix Materials									
MDD g/cc	OMC %	CBR (%)	P.I (%)	S. Sulfate Soundnes s	Grading				
2.235	4.9	115	N.P	3.2%	OK				
Source : Detail design and Supervision Consultants Study									

Table : 2-4 Typical properties of Stone Crushed Aggregate for AKH Rock Quarry									
Specific Gravity of Aggregate			Absorption (%)	Unit weight(g/cc)		LAA Abrasion (%)	S Sulfate Soundness (%)	F.I Index (%)	E.L Index (%)
Bulk	SSD	Apparent		Loose	Rodded				
Coarse Aggregate 19mm Nominal Size									
2.688	2.703	2.730	0.572	-	-	25.85	1.1	-	-
MDD, OMC, CBR, Plasticity Index and Grading for Aggregate Mix Materials									
MDD g/cc	OMC %	CBR (%)	Grading						
2.250	7	95	OK						
Source : Detail design and Supervision Consultants Study									

Table : 2-5 Typical properties of Stone Crushed Aggregate for Quarry Rock Asia									
Specific Gravity of Aggregate			Absorption (%)	Unit weight(g/cc)		LAA Abrasion (%)	S Sulfate Soundness (%)	F.I Index (%)	E.L Index (%)
				Loose	Rodded				
Bulk	SSD	Apparent							
Test results for 19mm Nominal Size Aggregate									
2.605	2.648	2.722	1.65	1.374	1.499	17.7	0.43	18.4	12.6
Test results for 12.5 mm Nominal Size Aggregate									
2.600	2.636	2.695	1.35	1.362	1.492	21.9	1.07	26.6	15.1
Test results for 9.5 mm Nominal Size Aggregate									
2.676	2.698	2.737	0.84	1.428	1.55	26	0.41	34.9	1.8
Source : CRIP Laboratory Test records									

Table : 2-6 Typical properties of Stone Crushed Aggregate Khla Korn Quarry									
Specific Gravity of Aggregate			Absorption (%)	Unit weight(g/cc)		LAA Abrasion (%)	S Sulfate Soundness (%)	F.I Index (%)	E.L Index (%)
Bulk	SSD	Apparent		Loose	Rodded				
Test results for 19.0 mm Nominal Size Aggregate									
2.620	2.643	2.682	0.88	1.397	1.54	23.73	0.4	26	
Test results for 12.5 mm Nominal Size Aggregate									
2.600	2.632	2.685	1.126	1.339	1.467	24.76	0.5	29	
Test results for 9.5 mm Nominal Size Aggregate									
2.636	2.656	2.690	0.752	1.38	1.512	27.51	0.7	38	
Source: CRIP Laboratory Test records									

All the test results tabulated above appears that the crushed rock aggregates are appropriate for use in the construction of Base Course, Concrete and Double Bituminous Surface Treatment (DBST). Required particle size to comply specific grading of crushed aggregates to be adjusted by placing order with the crushing plant owner as and when needed.

The crushing plant owners informed that in the near future the A.K.H Rock Construction and Rock Asia quarry sites are being shut down their sites at present locations due to local authority policy to save the environment or other reasons. However the owner of the above mentioned crushing plant confirmed that they are installing their new crushing plant at Slor Kram at station 19+800 of NR 56 offset 5 km LHS. At the new quarry site the owner is expecting to commence trial production in February 2011.

Rock Asia quarry owner also planning to relocate their crushing plant to Phnom Touch in Mongkul Borai district beside NR5 about 20km away from Sisophon when travel toward Battambang. Contractors for NR 56B therefore will have the options to procure crushed rock aggregates from the new quarries in the future.

There is information about a new rock quarry located at station 60+000 RHS 20 km from NR 56 (Village-Bang Vieng, Banteay Ample district in

OdorMeanchey Province). This quarry still not opened but very soon the proprietor may be explore and install crushing plant.

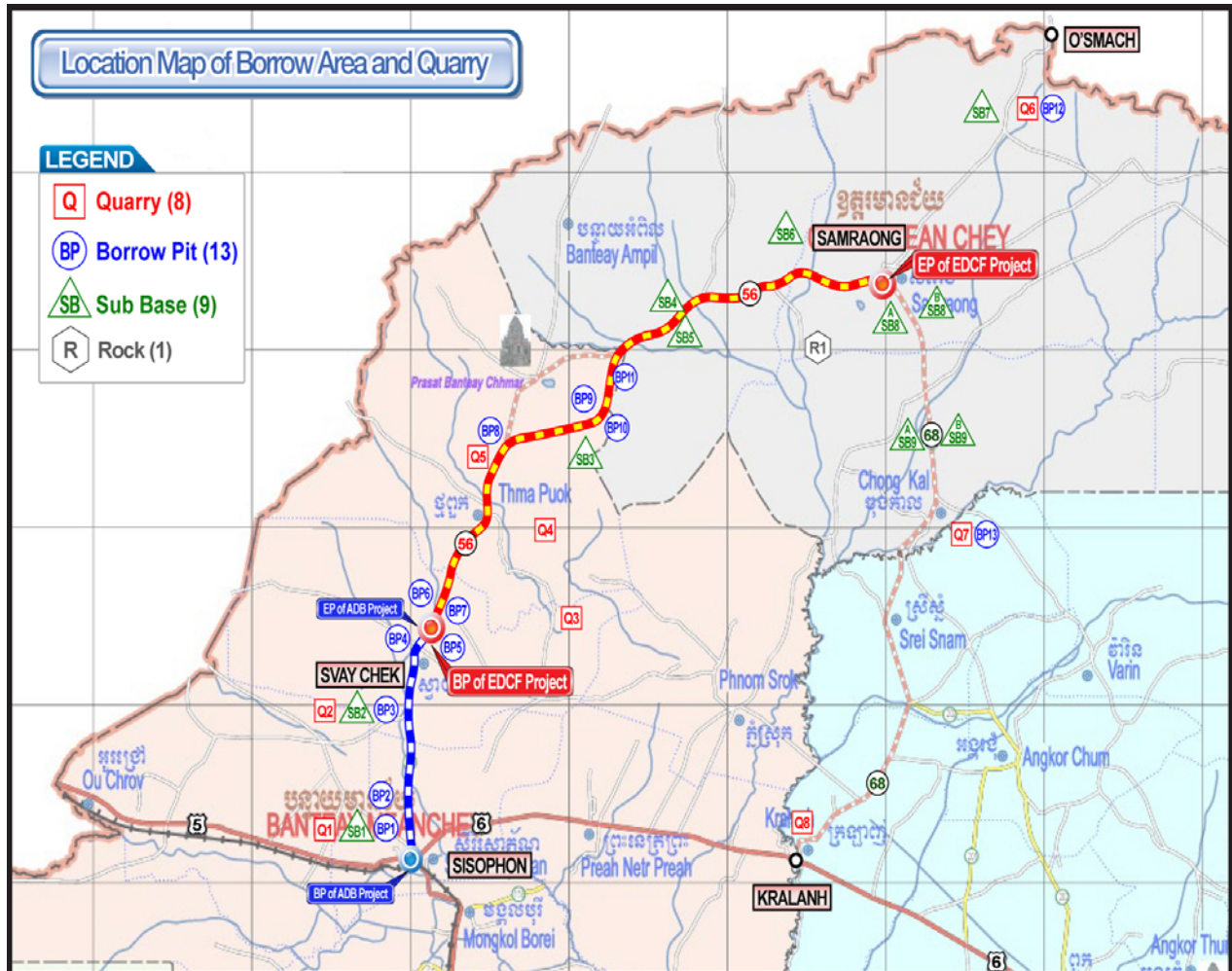
Location Map to Borrow Pits & Quarries

Borrow Pits & Quarries:

No.	BP/ Quarry	Name	Province	Village	Material	For Road	By Road			Approx. Require amount m³	Approx. available amount m³	Description of Materials
							PK	Road Left/right	Offset			
							Km		m			
1	Crushing plant	Crushing Plant Rock Asia Company	Banteay Meanchey	Kong War	Base Course, DBST & Concrete Aggregate	NR 56.ADB Loan No.2539-CAM (SF)	5+000	NR.56, Left	2+700	100,000.00	Unlimited	Base Course, Sub-base, DBST & Concrete Aggregate (Limestone).
2	Crushing plant	Crushing Plant AKH Company	Banteay Meanchey	Kong War	Base Course, DBST & Concrete Aggregate	NR 56.ADB Loan No.2539-CAM (SF)	6+000	NR.56, Left	1+600	50,000.00	Unlimited	Base Course, Sub-base, DBST & Concrete Aggregate (Limestone).
3	Crushing plant	Crushing Plant AKH Company	Banteay Meanchey	Slorkram	Base Course, DBST & Concrete Aggregate	NR 56.ADB Loan No.2539-CAM (SF)	19+400	NR.56, Left	4+500	15,000.00	Unlimited	Base Course, Sub-base, DBST & Concrete Aggregate (Metamorphic stone).
4	Crushing plant	Crushing Plant AKH Company	Banteay Meanchey	Slorkram	Embankment, Subgrade, Subbase Course	NR 56.ADB Loan No.2539-CAM (SF)	19+400	NR.56, Left	4+500	250,000.00	Unlimited	Embankment, Sub-grade, Sub-base, (Metamorphic stone).
5	Borrow Pit	Sub-Base Borrow Pit Phnom Dey	Oddor Meanchey	Phnom Dey	Sub-base Borrow Pits	RN 56B/EDCF	51+800	NR.56B, RHS	10+500	60,000.00	Unlimited	Sub-base materials
6	Borrow Pit	Sub-Base, Sub-Grade Borrow Pits	Oddor Meanchey	-	Sub-base, Sub-Grade Borrow Pits	RN 56B/EDCF	79 + 250	NR.56B, RHS	0+200	30,000.00	Unlimited	Sub-Grade, Sub-base materials
7	Borrow Pit	Sub-Base Borrow Pits	Oddor Meanchey	Tonlea Sar	Sub-base Borrow Pits	RN 56B/EDCF	97 + 200	NR.56B, LHS	5+200	37,500.00	Unlimited	Sub-base materials
8	Borrow Pit	Sub-Base Borrow Pits	Oddor Meanchey	-	Sub-base Borrow Pits	RN 56B/EDCF	69 +100	NR.56B, RHS	2+500	20,000.00	Unlimited	Sub-base materials
9	Borrow Pit	Embank., Subgrade Borrow Pit	Oddor Meanchey	-	Embankment, Subgrade Materials	RN 56B/EDCF	61+800	NR.56B, RHS	0+500	20,000.00	Unlimited	Embankment, Sub-Grade materials
10	Borrow Pit	Sub-Base Borrow Pits	Oddor Meanchey	Banteay Chhmar	Sub-base Borrow Pits	RN 56B/EDCF	60+100	NR.56B, LHS	0+100	40,000.00	Unlimited	Sub-Grade, Sub-base materials
11	Borrow Pit	Embank. Borrow Pit	Oddor Meanchey	-	Embankment Materials	RN 56B/EDCF	52+250	NR.56B, LHS	0+500	30,000.00	Unlimited	Embankment materials

Notes: - The estimated available quantity is calculated based on the estimated area only, the possibility of area extension are to be investigated by the contractor

Figure. 2 Location Map of Borrow Area and Quarry



7 Conclusion and Recommendation

Existing Sub-grade or Road Foundation

The site investigation along the existing roadbed was undertaken by three kind of test methodology to compare and accurately check in order to ensure the test results are confidence and believable. All three testing conduct on site is DCP test, In-situ CBR test by cutting edge, and CBR test at laboratory. The result test of DCP test results on site showed the CBR values ranging from 10 to 108 for the depth of top surface down to 0.20 meter depth and from 6 to 37 for the depth of 0.20 m depth of re-alignment section.

The CBR values referring to CBR in-situ by cutting edge method indicated that the test results for the starting point to the end point of the project are ranging from 9.64 to 56.79 in natural condition. Moreover the soil samples retrieved from the dug pits were subjected to routine laboratory to quality test. The test results of soaking CBR value ranging from 0.69 to 12.93 for existing road section and from 0.34 to 3.69 for realignment section. According to the above test results, it is recommend that the existing sub-grade layer could be a layer of new sub-grade layer of 10% CBR for the new construction road project for existing road condition. And the embankment layer may be omitted for more workability because during site investigation along the construction road, there is not encountered any sub-grade materials of 15%. But for the realignment road section, the existing soil layer should be the layer of embankment and then follow the suggestion of existing road section. That mean the layer of sub-grade should be omitted if necessary.

Sub-grade, Sub-base, Base Course and Borrow Materials

Potential borrow site along the project road were investigated. Materials suitable for sub-grade and sub-base were founded for the CBR values ranging between 27 and 140 at PK.19+800 (5.0 Km LHS), PK.60+100 (0.1 Km LHS), PK.61+800 (0.5 Km RHS), PK.79+250 (0.2 Km RHS), PK.51+800 (10.5 Km RHS), PK.69+100 (2.5 Km LHS), PK.97+200 (5.2 Km LHS). These materials can be used as both sub-grade and sub-base materials to meet technical specification standard.

CBR test results of base course materials indicated that the classification is not in the specification standard required at Phnom Slorkram Quarry (AKH Quarry PK.19+800, 5 Km LHS), but mechanical analysis can be corrected to fulfill technical specification.

If possible, a new rock quarry located at station 60+000 RHS 20 km from NR 56 (Village-Bang Vieng, Banteay Ample district in OdorMeanchey

Province) will be produced base aggregate for the requirement of construction project. This quarry still not opened yet, but very soon the proprietor may be explore and install crushing plant.

Aggregate Materials

Potential aggregate sources site were investigated along project road section mostly aggregate materials. On each site samples were taken and subjected to quality tests. The results of the test showed that aggregate materials satisfy the AASHTO standard specification requirement except for grading. Mechanical analysis of materials can be corrected to meet specification standards by blending. Materials classification and materials specification are all within technical specification standard. It is recommended that all materials be crushed and processed to meet standard requirements.

If possible, a new rock quarry located at station 60+000 RHS 20 km from NR 56 (Village-Bang Vieng, Banteay Ample district in OdorMeanchey Province) will be produced aggregate for the requirement of construction project. This quarry still not opened yet, but very soon the proprietor may be explore and install crushing plant.

8 Appendix

**KOREA CONSULTANTS INTERNATIONAL IN ASSOCIATION WITH : KHMER CONSULTANT ENGINEERING CORPORATION LT.
ADB LOAN 2539-CAM (SF) : GMS CAMBODIA NORTHWEST PROVINCIAL ROAD IMPROVEMENT PROJECT.**

Detailed design and Construction Supervision

Date : 15.03.2011

SUMMARY OF LABORATORY TEST RESULTS OF TEST PITS ALONG PROJECT SECTION.																
Lab Reference		Sample Location (Pk)	Offset	Test completion Date	Sample discription	Test Results									Approximate Volume	Remarks
No.	Date					Soil Classification	MDD(g/cc)	OMC(%)	CBR(%)	LL(%)	PI(%)	# 0.425mm	# 0.075mm	Abras. (%)		
009	03.01.2011	31+500 Km	1.50 m RHS	22.01.2011	Exist-Subgr	-	2.061	17.90	38.00	None	None	74	29	-	-	Existing
010	03.01.2011	36+500 Km	1.00 m LHS	24.01.2011	Exist-Subgr	-	-	-	1.39	None	None	87	38	-	-	Existing
011	04.01.2011	41+500 Km	1.90 m RHS	24.01.2011	Exist-Subgr	-	-	-	12.93	None	None	89	41	-	-	Existing
012	04.01.2011	46+500 Km	1.30 m LHS	21.01.2011	Exist-Subgr	A-7-6	-	-	3.00	47.10	28.29	90	87	-	-	Existing
013	04.01.2011	52+550 Km	0.80 m RHS	21.01.2011	Exist-Subgr	-	-	-	11.77	None	None	66	27	-	-	Existing
014	04.01.2011	67+500 Km	0.70 m LHS	21.01.2011	Exist-Subgr	-	-	-	12.00	None	None	90	39	-	-	Existing
015	05.01.2011	72+500 Km	1.00 m RHS	22.01.2011	Exist-Subgr	A-7-5	1.792	23.20	1.50	49.6	30.97	81	76	-	-	Existing
016	05.01.2011	77+500 Km	1.00 m LHS	21.01.2011	Exist-Subgr	A-4	-	-	2.41	20.50	7.10	68	40	-	-	Existing
017	05.01.2011	82+500 Km	0.90 m RHS	27.01.2011	Exist-Subgr	A-4	-	-	4.16	19.70	8.35	93	61	-	-	Existing
018	05.01.2011	87+500 Km	1.00 m LHS	24.01.2011	Exist-Subgr	-	-	-	2.07	None	None	93	28	-	-	Existing
019	06.01.2011	92+500 Km	0.70 m RHS	27.01.2011	Exist-Subgr	-	-	-	10.16	None	None	91	49	-	-	Existing
020	06.01.2011	97+500 Km	1.50 m LHS	27.01.2011	Exist-Subgr	A-4	-	-	4.16	19.80	10.21	95	64	-	-	Existing
021	06.01.2011	102+400 Km	0.80 m RHS	24.01.2011	Exist-Subgr	A-4	-	-	3.79	16.80	5.28	92	62	-	-	Existing
022	06.01.2011	107+400 Km	1.00 m LHS	27.01.2011	Exist-Subgr	-	-	-	9.64	None	None	84	29	-	-	Existing
023	06.01.2011	111+500 Km	1.00 m RHS	27.01.2011	Exist-Subgr	-	1.960	18.60	5.50	None	None	86	39	-	-	Existing

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Detailed design and Construction Supervision

Date : 15.03.2011

SUMMARY OF LABORATORY TEST RESULTS OF TEST PITS ALONG PROJECT SECTION.																
Lab Reference		Sample Location (Pk)	Offset	Test completion Date	Sample discription	Test Results									Approximate Volume	Remarks
No.	Date					Soil Classification	MDD(g/cc)	OMC(%)	CBR(%)	LL(%)	PI(%)	# 0.425mm	# 0.075mm	Abras. (%)		
024	04.02.2011	54+100 Km	1.30 m RHS	13.02.2011	Exist-Subgr	-	-	-	3.44	None	None	86	16	-	-	Existing
025	04.02.2011	55+100 Km	1.25 m LHS	13.02.2011	Exist-Subgr	-	-	-	1.15	None	None	83	16	-	-	Existing
026	04.02.2011	56+100 Km	0.80 m LHS	08.02.2011	Exist-Subgr	-	1.998	7.70	47.00	None	None	88	20	-	-	Existing
027	04.02.2011	57+100 Km	0.40 m RHS	14.02.2011	Exist-Subgr	-	-	-	1.03	None	None	86	22	-	-	Existing
028	04.02.2011	58+100 Km	1.90 m LHS	14.02.2011	Exist-Subgr	-	-	-	1.39	None	None	83	35	-	-	Existing
029	04.02.2011	59+100 Km	1.00 m RHS	14.02.2011	Exist-Subgr	-	-	-	2.41	None	None	76	30	-	-	Existing
030	05.02.2011	60+100 Km	0.20 m LHS	12.02.2011	Exist-Subgr	-	2.120	6.60	42.00	None	None	93	47	-	-	Existing
031	05.02.2011	61+100 Km	0.85 m RHS	14.02.2011	Exist-Subgr	A-4	-	-	1.38	20.20	7.58	90	51	-	-	Existing
032	05.02.2011	62+100 Km	1.50 m LHS	15.02.2011	Exist-Subgr	-	-	-	1.03	None	None	89	50	-	-	Existing
033	05.02.2011	63+100 Km	0.50 m RHS	10.02.2011	Exist-Subgr	A-6	-	-	1.72	25.55	12.37	89	62	-	-	Existing
034	06.02.2011	64+100 Km	0.50 m LHS	13.02.2011	Exist-Subgr	A-6	-	-	3.10	30.60	16.19	91	59	-	-	Existing

**KOREA CONSULTANTS INTERNATIONAL IN ASSOCIATION WITH : KHMER CONSULTANT ENGINEERING CORPORATION LT.
ADB LOAN 2539-CAM (SF) : GMS CAMBODIA NORTHWEST PROVINCIAL ROAD IMPROVEMENT PROJECT.**

Detailed design and Construction Supervision

Date : 15.03.2011

[illegible]

Detailed design and Construction Supervision

Date : 15.03.2011

**SUMMARY OF LABORATORY TEST RESULTS OF COARSE & FINE AGGREGATES FOR CONCRETE
ADB APPENDIX)**

[illegible]

Detailed design and Construction Supervision

Date : 15.03.2011

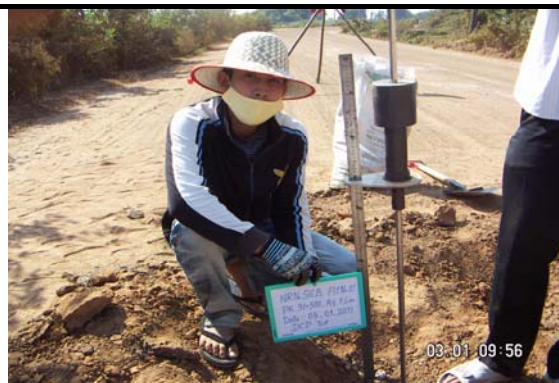
SUMMARY OF LABORATORY TEST RESULTS OF COARSE & FINE AGGREGATES FOR SURFACE TREATMENT AND/OR ASPHALT(RN.No.56A, ADB APPENDIX)

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Figure 7 Photograph of Trial Pits and DCP Tests



DCP & Pit No.1 (STA.31+500)



DCP & Pit No.1 (STA.31+500)



Trial Pit No.2 (STA.36+500)



Trial Pit No.2 (STA.36+500)



Trial Pit No.4 (STA.41+500)



DCP Test No.6 (STA.67+500)



Trial Pit No.7 (STA.72+500)



Trial Pit No.9 (STA.28+200)

Figures

Photograph of Trial Pits and DCP Tests

Photograph of Trial Pits and DCP Tests



Borrow Pit (STA.19+800) 5.0 Km LHS



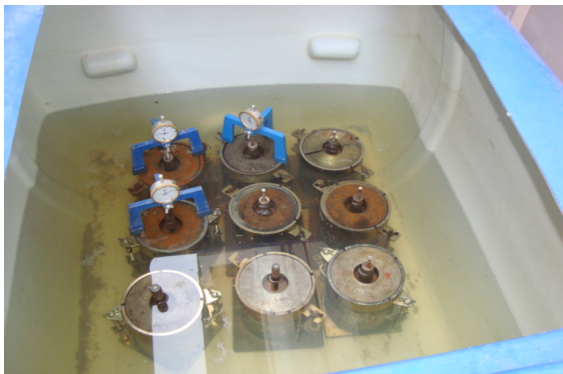
Quarry (STA.05+300) 3.3 LHS



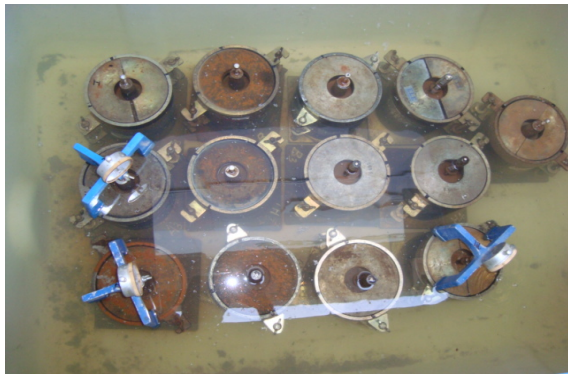
Quarry (STA.19+800) 5.0 Km LHS



Laboratory Testing Activities



Sample soaking at laboratory



Sample soaking at laboratory



Laboratory testing activities



Laboratory testing activities

Figures

Borrow Pits & Laboratory Testing Activities