Republic of the Union of Myanmar
Ministry of Construction, PW

The Project for Improvement of Road Technology in Disaster Affected Area in Myanmar

Completion Report on Pilot Project

(Phase Ⅱ-1)

Road Stabilization Work at Road No.6, Bogale Township

July 2015

Japan International Cooperation Agency
（JICA）

Pegasus Engineering Corporation
Oriental Consultants Global Co., Ltd.

EI
JR
15-151

Completion Report
on
Pilot Project (Phase-2)

Vol. 1 of 2: Main Text

July 2015

The Project for Improvement of Road Technology in Disaster Affected Area in Myanmar

Department of Highway, Ministry of Construction	JICA Expert Team


Project Location Map
Kyaw Chan Ye Kyaw Br.
High Embank. monitoring Sec.
2/0
Project Section 3furlong=600m
1/5
Rd No.10
Kan Nyi Naung
Kantawgyi Lake
BOGALE
ဘိုကလေး
18th St
Nat Chaung
0/0
Borrow pit
Bogale Br.
Rd No.5
Temporary Yard (Plant)
Sand pit
Google

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0. Report Summary

0.1 Background and the Purpose of the Project

Road network in the Ayeyarwady Region indicates its fragility because there is no effective alternative route and absence of appropriate material for road construction work in the Region. Resulting above, frequent road closures have been occurred in many locations due to severe deformation on the embankment in the rainy season.

PW and JICA implemented the Pilot Project (Phase-2) (PP-2) on Road No. 10 in Bogale Township in Ayeyarwady Region. PW/JICA attempted the capacity development of PW through the OJT and the workshop during the project period. Major targets of the capacity development are as follows.

- ✓ To enhance the capability of quality control in case of applying chemically stabilized soil material.
- ✓ To enhance the capability of site supervision work and the overall project management
- ✓ To obtain comprehensive knowledge of the soil stabilization work and the project management.
- ✓ To obtain appropriate skill for operation and maintenance of the soil mixing plant newly imported from Japan.

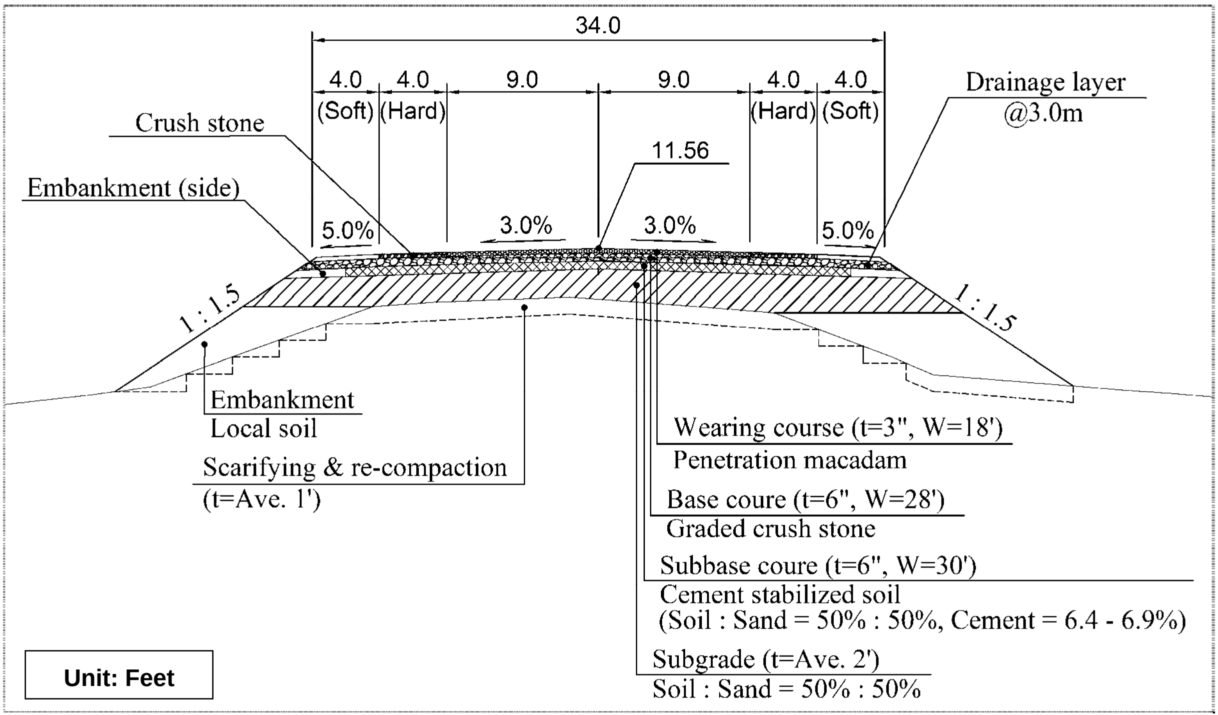
0.2 Contents of the Project Implementation

0.2.1 Current Work Implementation Status

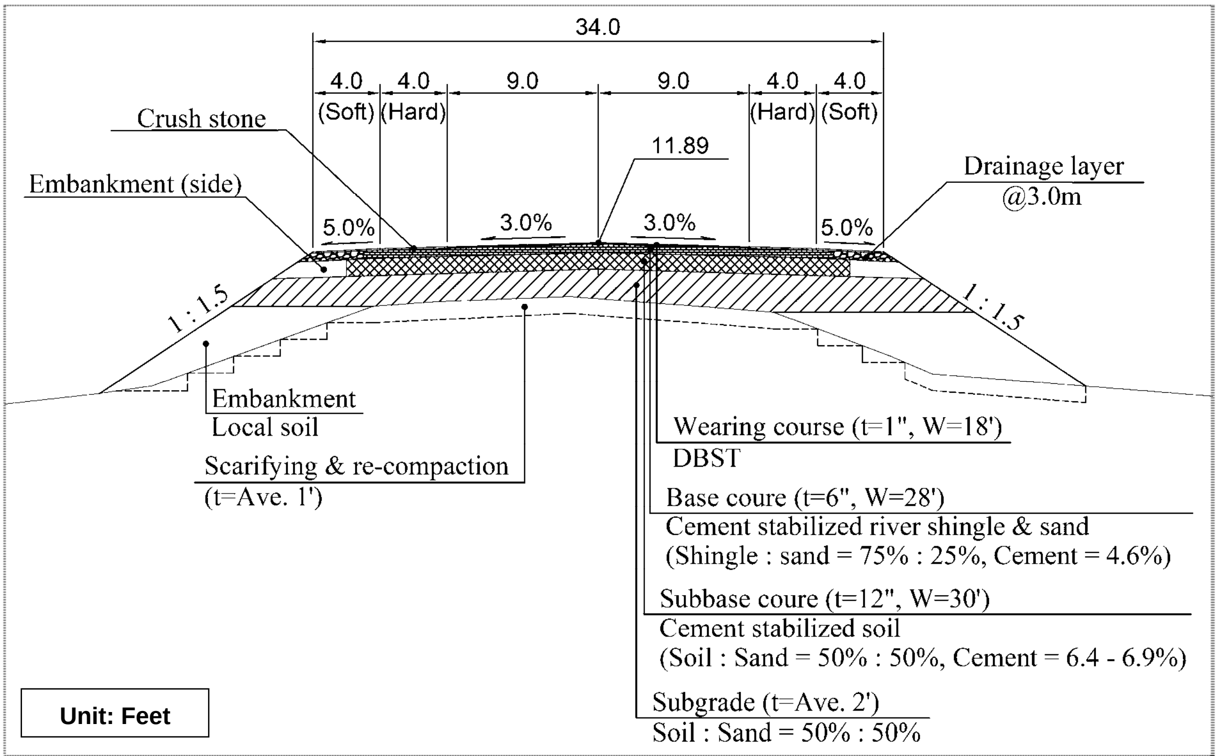
Currently the work is still progressing on the site. The status as of 24/July/2015 is summarized in the following table. Detail is described in 2.5 in the main chapters.

No.	Work Item	Status	Remarks
1	Scarifying & re-compaction on existing embankment	Completed	
2	Widening of existing embankment	Completed	
3	Subgrade construction	Completed	
4	Cement stabilized subbase course	Completed	
5	Cement stabilized base course	Completed	
6	Crush stone base course	Progressing	Bad weather hinders the work execution.
7	Wearing course (Penetration macadam)	Not started yet	Bad weather hinders the work execution.
8	Wearing course (DBST)	Completed	
9	Drainage layer (crush stone)	Completed	

0.2.2 Typical Cross Sections



Section-1 (1/5 – 1/6.5: L = 300m)



Section-2 (1/6.5 – 2/0: L = 300m)

0.2.3 Project Implementation Team

PW and JICA Expert Team jointly worked for the project implementation. Major tasks, number of assigned engineers in PW and the JICA Experts in charge are illustrated in the following table. Detail of the assignment is as shown in Table 2.4.1 in the main chapter.

Task	Nos. of PW	JICA Expert
Planning & design	4	Kobayashi, Miyamoto
Project management & work supervision	4	Kobayashi, Miyamoto, Akmar
Material control	2	Miyamoto
Machinery work	3	Kobayashi, Akmar

0.2.4 Work Implementation Procedures

The work was commenced on 18th February, 2015. The work procedure is listed below in order of the implementation. Detailed contents are described in 2.5 in the main chapter.

(1) Initial Work Stage (Off-site Work)

- ✓ Engineering survey
- ✓ Preparation of temporary construction yard
- ✓ Construction of foundation concrete of the soil plant
- ✓ Mobilization and installation of the soil plant

(2) Road Rehabilitation Work

1) Earthworks

- ✓ Scarifying and re-compaction of existing embankment
- ✓ Widening of the embankment
- ✓ Subgrade construction work

2) Pavement Works

- ✓ Cement stabilized subbase course
- ✓ Base Course (Graded crush stone & cement stabilized river shingle & sand)
- ✓ Wearing Course (Penetration macadam & DBST)

Hard Shoulder (Crush stone)

3) Drainage Layer

0.2.5 Quality Assurance of the Work

The approaches for quality assurance of the work Project are outlined as below. Detailed contents are described in 2.6 in the main chapter.

(1) Dimension control of the work

- ✓ Measurement of finishing level by applying the survey pegs installed on road sides and recording of the measurement result in the inspection form.

(2) Quality control of stabilized material

- ✓ Filed density test to confirm the compaction degree after the compaction work
- ✓ Elution test of the hexavalent chromium from the cement mixture

(3) Project management

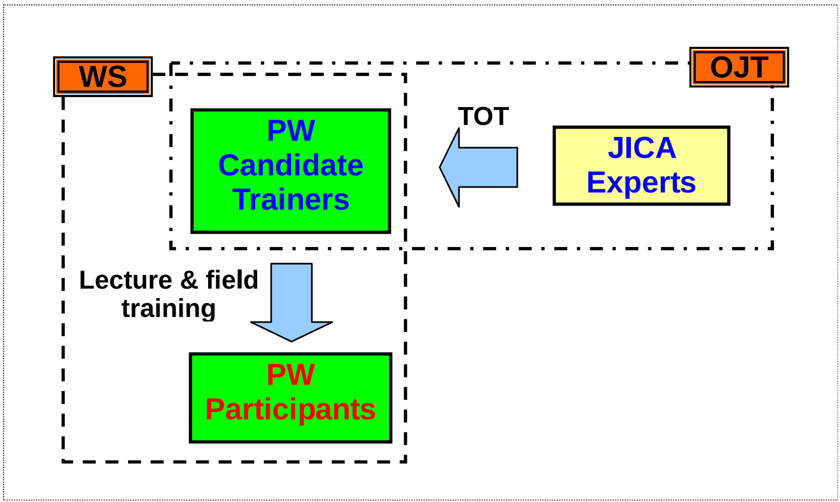
- ✓ Establishment of communication system
- ✓ Recording the field activities in the report form
- ✓ Hold meeting to share the common understandings

0.3 Technical Transfer Program

0.3.1 Contents and Implementation System

The program consisted of On-the-Job-Training (OJT) and the Workshop (WS) in principle. PW engineers trained through the OJT carried out lecture and field training for the participants in the WS. Frame of the program and themes of the WS are illustrated below.

- ✓ Pavement design
- ✓ Mix design of stabilized material
- ✓ Material quality control on site
- ✓ Operation & maintenance method of sol mixing plant



Frame of Technical Transfer Program

0.4 Key Notes for Improvement of Work Approach

Following notes shall be applied for improvement of work approach in the prospective project in accordance with the analysis result of findings and issues through the overall period. Details are described in 4. in the main chapter.

0.4.1 Project Management

(1) Application of International System of Units (SI)

So far, PW conventionally applied “Imperial Unit” composed of ‘yard’ and ‘pound’ for the road engineering field. PW should apply the SI system to prevent numerical confusion in case of implementing international project such as the Asian Highway Project.

(2) Schedule Control to Complete the Project before Rainy Season

Preparation of the project implementation program including procurement schedule of the equipment in early stage is crucial for smooth project implementation.

(3) Continuous Staffing of the Quality Control Team in the Construction Site

Confirmation and examination of the test result is fundamental approach for the quality assurance during the project. Arrangement of the staffing schedule should be appropriately considered prior to the project.

(4) Flexibility of Work Method and Approach

Flexibility with certain consideration and examination is highly required ability to the person in charge of the project management.

0.4.2 Soil Mixing Plant

(1) Construction of Foundation Concrete of the Soil Plant

Site engineer should pay attention to quality assurance of the construction work to prevent collapse accident due to poor work quality.

(2) Daily Inspection and Maintenance Activity of the Plant

Routine activities such as inspection, maintenance and cleaning will be the most effective approach for sustaining good condition and preventing malfunction of the plant.

(3) Material Feeding into the Plant

Feeding work of clayey material should be executed slowly and gradually in case of applying clayey soil to the material because the soil still may contain large lump of clay. Watchman should be assigned beside the feeder unit.

0.4.3 Soil Stabilization Work

(1) Material Preparation of the Soil Stabilization Work

Excavated soil in borrow pit should be placed in the pit or the yard a few days for drying purpose instead of instant application for construction work.

(2) Examination of Mixing Degree of the Stabilized Material

Site engineer should examine the degree every plant operation day by spraying “Phenolphthalein solution”. The color turns pink in case the solution touches alkaline object including cement.

0.4.4 Road Construction Work

(1) Equipment for Compaction Work by Soil Type

Sheep-foot roller should be used for initial compaction work of clayey soil as well as tire roller to be used for finishing surface level.

1. Introduction

1.1 Background of the Technical Cooperation Project

Road network in the Ayeyarwady Region indicates its fragility because there is no effective alternative route in case that the one road becomes impassable. Furthermore, the road embankment had been constructed by applying local soil classified clay and/or silt due to locally absence of the appropriate material (e.g. rock aggregate and coarse sand) in the region. The local soils are inappropriate for road construction because of their physical characteristics. Resulting above, frequent road closures have been occurred in many locations due to severe deformation on the embankment in the rainy season. Consequently, this technical cooperation project has been working for transferring technology in the application of suitable remedial methods for the stabilization of the local soils.

1.2 Purpose of Pilot Project (Phase-2)

PW and JICA implemented the Pilot Project (Phase-2) (PP-2) on Road No. 10 in Bogale Township in Ayeyarwady Region. PW/JICA attempted the capacity development of PW through the OJT and the workshop during the project period. Major targets of the capacity development are as follows.

- ✓ To enhance the capability of quality control in case of applying chemically stabilized soil material.
- ✓ To enhance the capability of site supervision work and the overall project management
- ✓ To obtain comprehensive knowledge of the soil stabilization work and the project management.
- ✓ To obtain appropriate skill for operation and maintenance of the soil mixing plant newly imported from Japan.

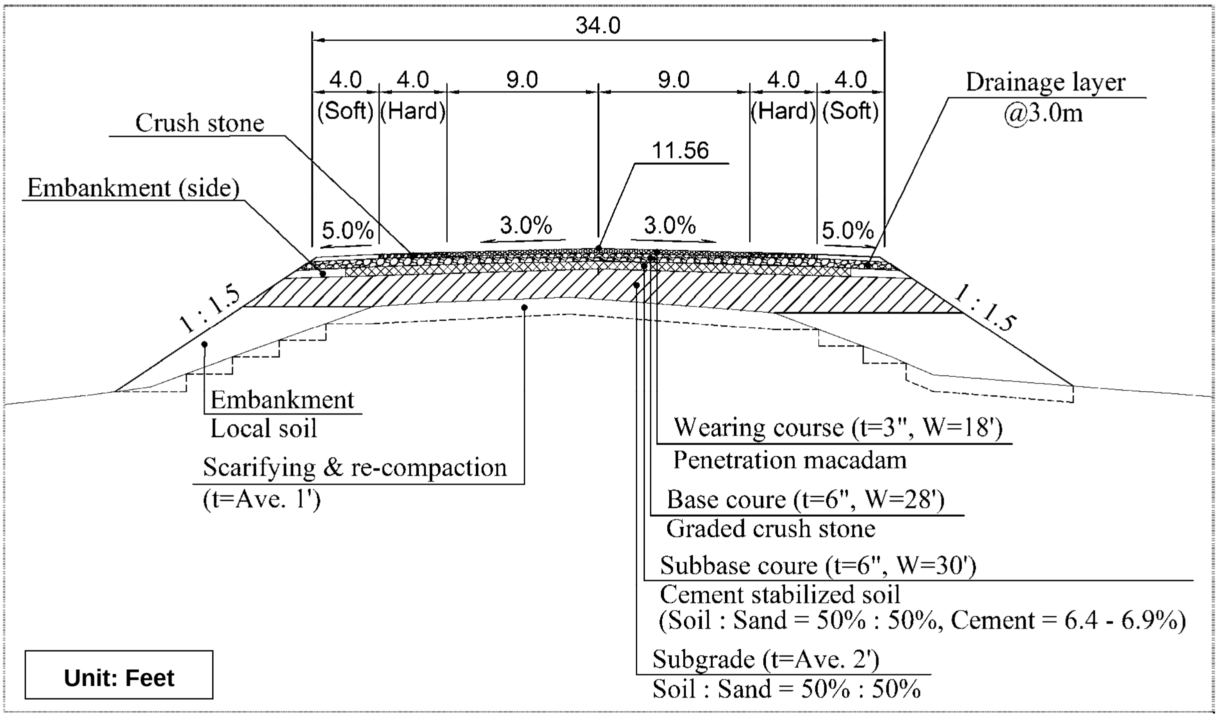
2. Contents of the PP-2

2.1 Project Outline

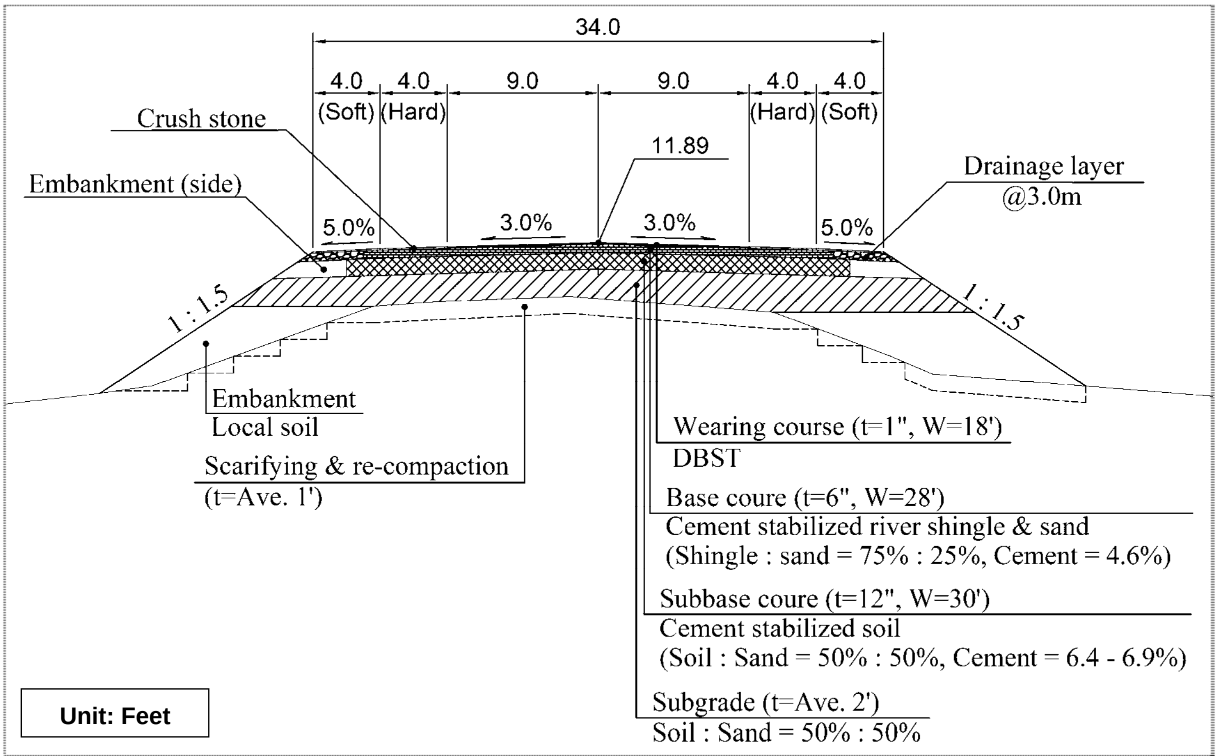
Outline of the PP-2 is described below.

- Location : 1/5 – 2/0 on Road No.10, Bogale Township (see Location Map)
- Length : 3 Furlongs = 600m
- Period : 15/Feb/2015 – continued as of 24/Jul/2015
- Major works :
  - ✓ Scarifying and re-compaction on existing embankment
  - ✓ Widening of existing embankment
  - ✓ Subgrade construction
  - ✓ Cement stabilized subbase course
  - ✓ Cement stabilized base course
  - ✓ Dense graded crush stone base course
  - ✓ Wearing course (Penetration macadam)
  - ✓ Wearing course (DBST)
  - ✓ Drainage layer (crush stone) on road shoulder

➢ Typical cross sections :

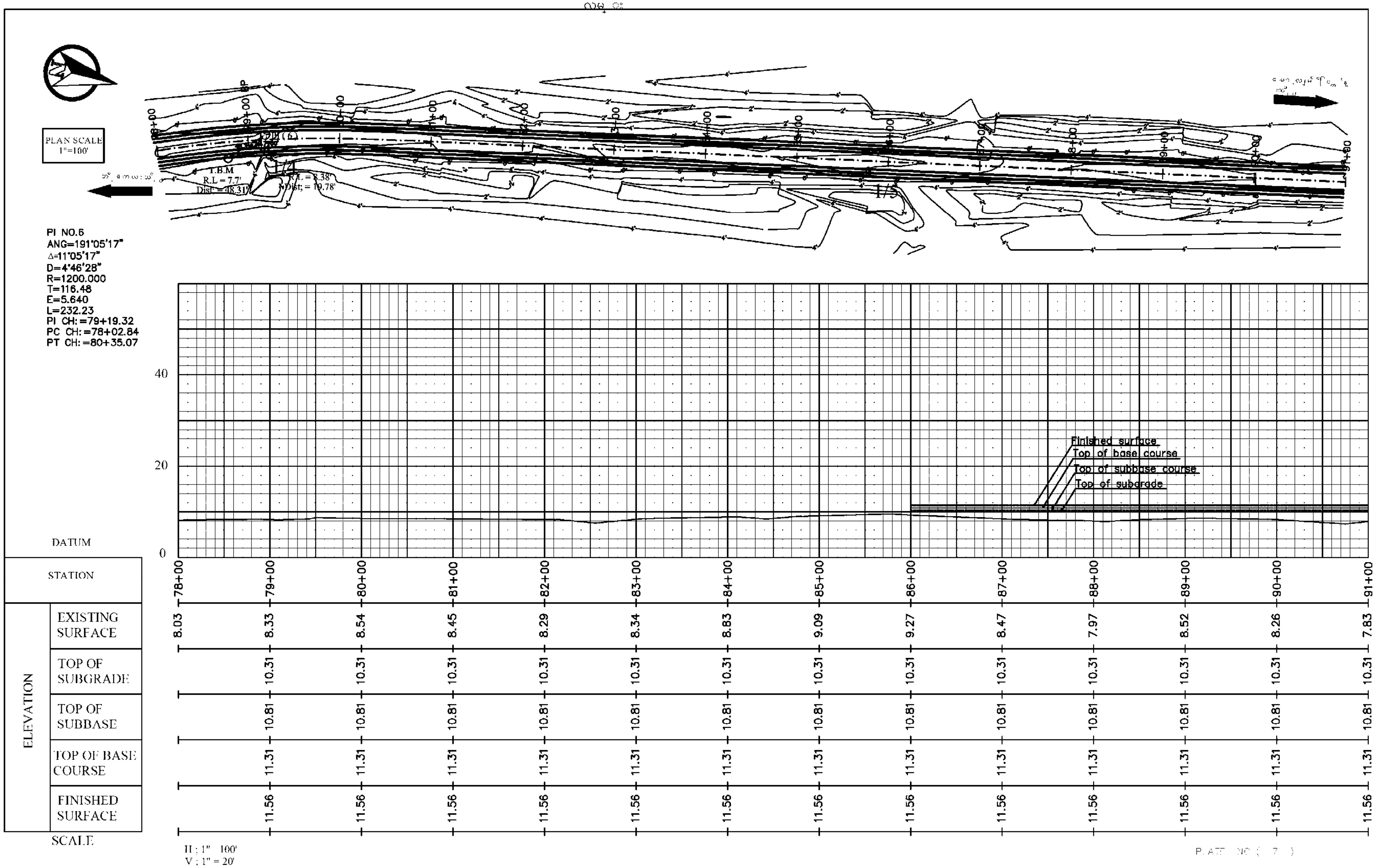


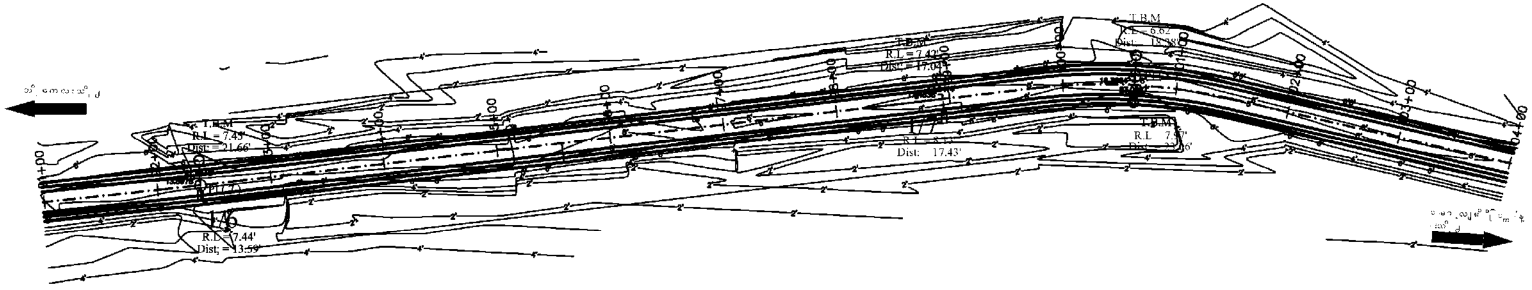
Section-1 (1/5 – 1/6.5: L = 300m)



Section-2 (1/6.5 – 2/0: L = 300m)

- Plan & profile:





PI NO.7
ANG=179°25'43"
Δ=0°34'17"
D=0°52'53"
R=6500.000
T=32.42
E=0.081
L=64.83
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PC CH: =92+05.37
PT CH: =92+70.20

PI NO.8
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D=11°27'33"
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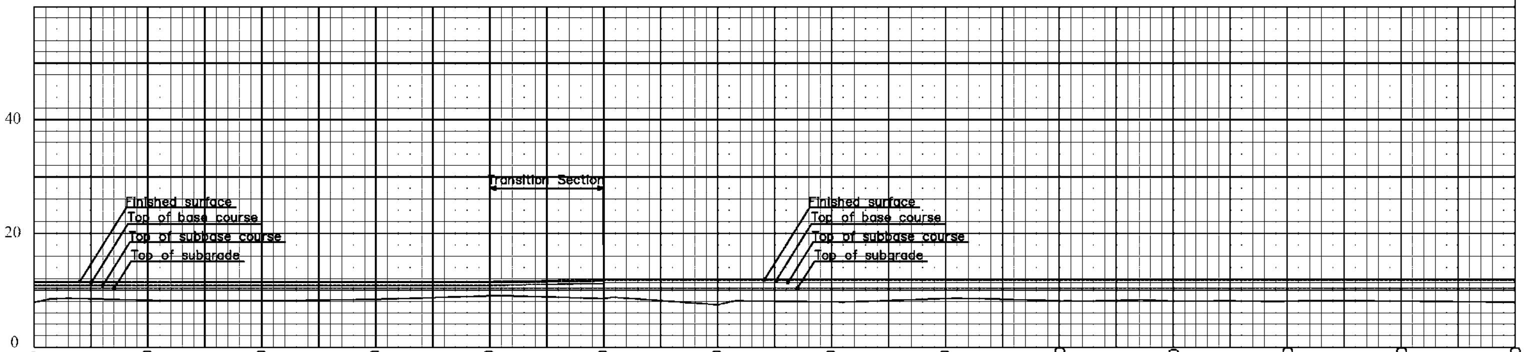
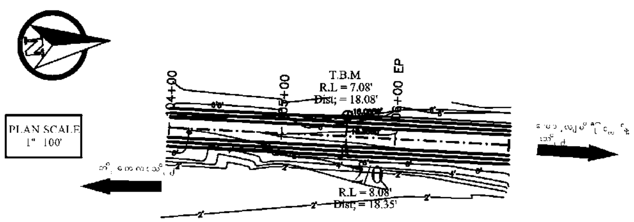
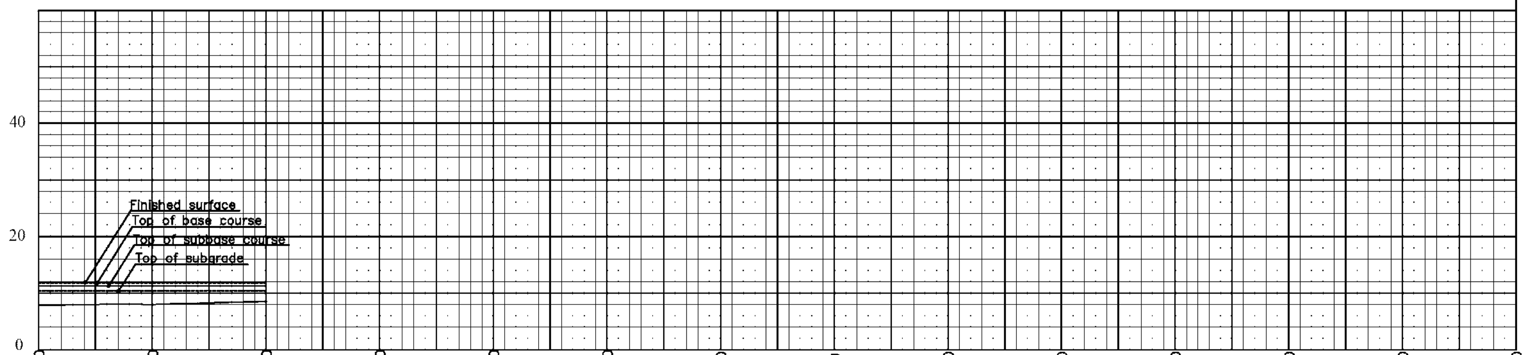
E=7.469
L=171.78
PI CH: =100+63.82
PC CH: =99+77.07
PT CH: =101+48.85



STATION		91+00	92+00	93+00	94+00	95+00	96+00	97+00	98+00	99+00	100+00	101+00	102+00	103+00	104+00
ELEVATION	EXISTING SURFACE	7.83	8.21	8.13	8.37	8.95	8.52	7.44	7.93	8.49	8.10	8.10	8.06	8.06	7.84
	TOP OF SUBGRADE	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31
	TOP OF SUBBASE	10.81	10.81	10.81	10.81	10.81	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31
	TOP OF BASE COURSE	11.31	11.31	11.31	11.31	11.31	11.81	11.81	11.81	11.81	11.81	11.81	11.81	11.81	11.81
	FINISHED SURFACE	11.56	11.56	11.56	11.56	11.56	11.89	11.89	11.89	11.89	11.89	11.89	11.89	11.89	11.89

SCALE
H : 1" = 100'
V : 1" = 20'





STATION		104+00	105+00	106+00	107+00	108+00	109+00	110+00	111+00	112+00	113+00	114+00	115+00	116+00	117+00
ELEVATION	EXISTING SURFACE	7.84	7.93	8.51											
	TOP OF SUBGRADE	10.31	10.31	10.31											
	TOP OF SUBBASE	11.31	11.31	11.31											
	TOP OF BASE COURSE	11.81	11.81	11.81											
	FINISHED SURFACE	11.89	11.89	11.89											

SCALE

H : 1" =100'
V ; 1" = 20'

PLATE NO (9)

➢ Implementation schedule (achievement as of 24/July/2015) :

No.	Work item		Work status (as of 24/Jul)	February						March						April						May						June						July					
				5	10	15	20	25	28	5	10	15	20	25	31	5	10	15	20	25	30	5	10	15	20	25	31	5	10	15	20	25	30	5	10	15	20	25	31
I.	Construction work																																						
1.	Earthwork																																						
	1.1 Scarifying & re-compaction		Completed																																				
	1.2 Embankment		Completed																																				
	1.3 Subgrade		Completed																																				
	1.4 Slope trimming		Completed																																				
2.	Pavement																																						
	2.1 Wearing course	(1) Penetration macadam	Not started																																				
		(2) DBST	Completed																																				
	2.2 Base course	(1) Crush stone	Progressing																																				
		(2) Cement stabilized	Completed																																				
	2.3 Subbase course	Cement stabilized	Completed																																				
	2.4 Hard shoulder	Crush stone	Progressing																																				
3.	Apparatus work																																						
	3.1 Drainage layer		Completed																																				
II.	Off-site work																																						
1.	Temporary yard & borrow pit																																						
	1.1 Site opening		Completed																																				
	1.2 Site clearance		Not started																																				
	1.3 Plant foundation RC concrete		Completed																																				
	1.4 Plant assembling & setting		Completed																																				
2.	Engineering survey																																						
	2.1 Training for survey work		Completed																																				
	2.2 Road survey		Completed																																				
3.	Training																																						
	3.1 Plant operation and maintenance		Completed																																				
	3.2 Workshop for soil stabilization work		Completed																																				

➢ Dispatch schedule of JICA Experts :

No.	Name	Task	Dispatch schedule (2015)
1	H. Kobayashi (Mr.)	Leader in PP-2, design, construction planning & project management	12/Feb – 12/Apr 23/Apr – 09/May
2	H. Miyamoto (Mr.)	Material quality control	08/Mar – 11/Apr 23/Apr – 16/May
3	N. Akmar (Mr.)	Construction supervision	11/Feb – 12/Apr
Ref.	*2 local assistants*	*Construction supervision, work monitoring & liaison*	*12/Feb – 12/Apr* *23/Apr – 23/May*

2.2 Planning and Design Work

2.2.1 Pavement Design

PW/JICA designed pavement structure to be applied for the PP-2 in 2 steps namely (i) AASHTO empirical method and (ii) Structural Number (SN) principle in ORN31. The design result is summarized in Table 2.2.1 (Section-1) and 2.2.2 (Section-2) respectively. Note the detailed design procedure is described in Appendix-A.

Table 2.2.1 Pavement Formation of Section-1 (P-Macadam)

Layer	Material	Layer coefficient (a_n)	Thickness (inch)	SN
Wearing course	P-macadam	0.30	3.00	0.90
Base course	Graded crush stone	0.14	6.00	0.84
Sub-base course	Cement stabilized soil	0.12	6.00	0.72
Total SN				**2.46**

Table 2.2.2 Pavement Formation of Section-2 (DBST)

Layer	Material	Layer coefficient (a_n)	Thickness (inch)	SN
Wearing course	DBST	-	1.00	-
Base course	Cement stabilized river shingle & sand	0.16	6.00	0.96
Sub-base course	Cement stabilized soil	0.12	12.00	1.44
Total SN				**2.40**

2.2.2 Mix Design of Material Stabilization

One of the main themes of the PP-1 and 2 is the application of chemically stabilized local soil composed of silt and clay to the pavement layers such as base course, subbase course and subgrade. Therefore, PW/JICA conducted trial mixing test for determination of mixing ratio of the each layer. The test result is as shown in 2.2.3. Furthermore, the detailed design procedure is described in Appendix-B.

Table 2.2.3 Result of Trial Mixing Test (Weight Basis)

Layer	Material					Target test value	
	Local	Import			Chemical	CBR (%)	UCS (MPa)
	Soil	Sand	River shingle	Graded stone	Cement		
Base	-	-	-	100%	-	80	-
	-	25%	75%	-	4.6%	-	1.50 – 3.00
Subbase	50%	50%	-	-	6.4 – 6.9%	-	0.75 – 1.50
Subgrade	50%	50%	-	-	-	3	-

(Note) % of cement is excluded from soil and imported materials.

2.2.3 Drainage Layer

Water being infiltrated into the pavement structure should be promptly drained for protection of the structure. In particular, the soil material shows higher deterioration level to the water than the granular one. Therefore, PW/JICA decided to install buried drain called as “drainage layer” at both sides of the base course with intervals of every 3meters. Related figures are as shown in Figure 2.2.1 – 2.2.3.

Note PW/JICA set up the 2 sections namely “drainage section” and “non-drainage section” to evaluate the effect of the layer. PW will be able to examine the deterioration level of the sub-base course in the both sections at the end of the rainy season (Oct or Nov, 2015). The examination result will indicate how much the drainage layer serves for protection in the lower part of the structure.

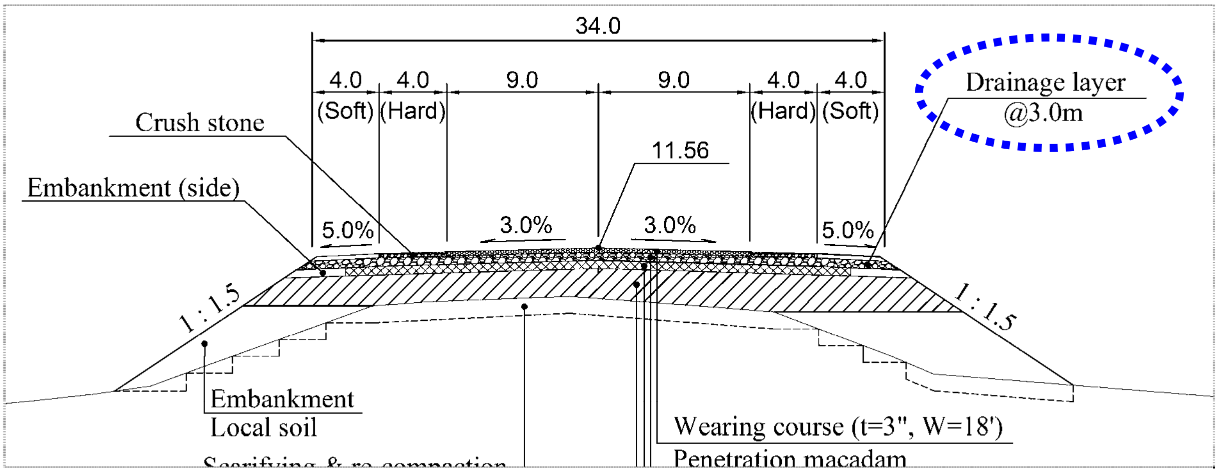


Figure 2.2.1 Typical Cross Section of Drainage Layer

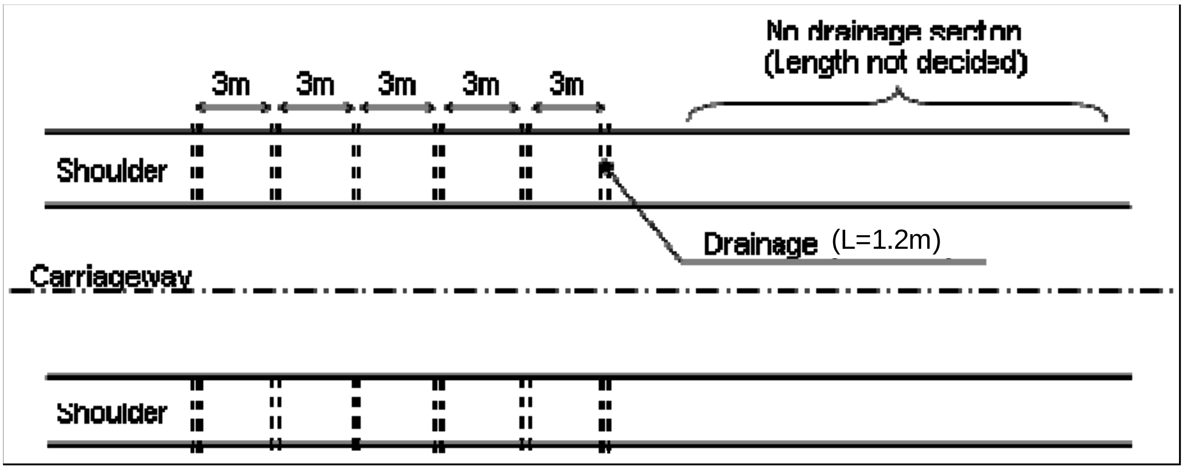


Figure 2.2.2 Layout of Drainage Layer (Not to Scale)

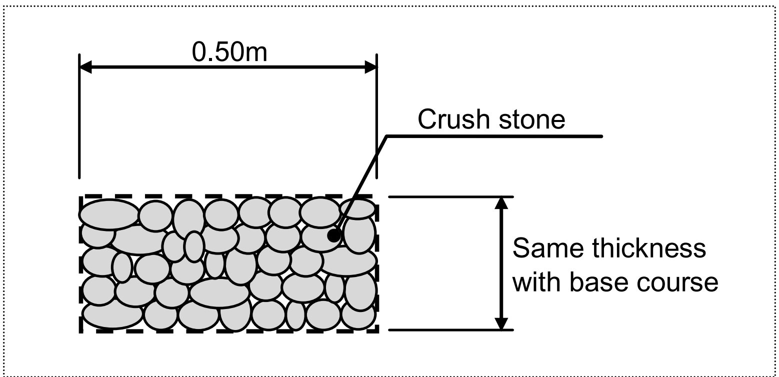


Figure 2.2.3 Dimension of Drainage Layer (Not to Scale)

2.3 Work Quantities

The work quantities of the PP-2 namely construction work and off-site work were calculated on the basis of the design result. The quantities are summarized in Table 2.3.1 – 2.3.2. Breakdown of the quantities is attached in Appendix-C.

Table 2.3.1 Total Work Quantities (1 of 2)

I. Construction work **Total length =** **600** **m (1/5 - 2/0)**

Category	Work item		Specification	Quantity	Unit
1. Earthwork	1.1 Scarifying & re-compaction		t=Ave. 1ft	2,453.3	cu.m
	1.2 Embankment	(1) Lower	Local soil	1,785.5	cu.m
		(2) road side	Local soil	431.5	cu.m
	1.3 Subgrade		t=Ave.2ft, Soil : Sand = 50% : 50% (weight basis)	5,358.6	cu.m
	1.4 Slope trimming			5,592.6	sq.m
2. Pavement	2.1 Wearing course	(1) Penetration macadam	t=3in, w=18ft	1,645.9	sq.m
		(2) DBST	t=1in, w=18ft	1,645.9	sq.m
	2.2 Base course	(1) Crush stone	CBR=80%, t=6in, w=28ft	390.2	cu.m
		(2) Cement stabilized	River shingle : Sand = 75% : 25%, Cement=4.6% (weight basis), t=6in, w=28ft	390.2	cu.m
	2.3 Subbase course	(1) Cement stabilized	Soil : Sand = 50% : 50%, Cement=6.4-6.9% (weight basis), t=6in, w=30ft	418.1	cu.m
		(2) Cement stabilized	Soil : Sand = 50% : 50%, Cement=6.4-6.9% (weight basis), t=12in, w=30ft	836.1	cu.m
	2.4 Hard shoulder		Graded crush stone, t=3in, w=8ft	1,463.0	sq.m
3. Apparatus work	3.1 Drainage layer		Crush stone, L = 1.2m, t=0.15m, w=0.5m	200	No.
				18.0	cu.m

II. Off-site work

Category	Work item	Specification	Quantity	Unit
1. Temporary yard	1.1 Site opening	Bush cut, grading, removal of surface soil (t=0.3m)	20,000.0	sq.m
	1.2 Site clearance	Grading	20,000.0	sq.m

Table 2.3.2 Total Work Quantities (2 of 2)

III. Import materials

Item	Work to be applied		Specification	Quantity	Unit
1. Cement	1.1 Subbase course		Material=1.8t/cu.m, **Cement=6.4-6.9%**, Loss=10%	170.0	ton
	1.2 Base course		Material=1.8t/cu.m, **Cement=4.6%**, Loss=10%	40.0	ton
			Total	**210.0**	**ton**
2. Sand	2.1 Subbase course		Material=1.8t/cu.m, **Sand=50%**, Loss=10%	1,250.0	ton
	2.2 Base course		Material=1.8t/cu.m, **Sand=25%**, Loss=10%	200.0	ton
	2.3 Subgrade		Material=1.8t/cu.m, **Sand=50%**, Loss=10%	5,310.0	ton
			Total	**6,760.0**	**ton**
3. Crush stone	3.1 Base course	(1) Graded stone	Material=2.0t/cu.m, Loss=10%	860.0	ton
		(2) River shingle	Material=2.0t/cu.m, **Stone=75%**, Loss=10%	650.0	ton
	3.2 Hard shoulder		Weight=2.0t/cu.m, Loss=10%	250.0	ton
	3.3 Wearing course	(1) P-macadam	Weight=2.0t/cu.m, Loss=10%	280.0	ton
		(2) DBST	Weight=2.0t/cu.m, Loss=10%	100.0	ton
	3.3 Drainage layer		Weight=2.0t/cu.m, Loss=10%	40.0	ton
			Total	**2,180.0**	**ton**
4. Straight asphalt (80/100)	4.1 Prime coat		1 - 1.5ltr/sq.m, Loss=10%	4,600.0	ltr
	4.2 Wearing course	(1) P-macadam	0.7 - 2.3ltr/sq.m (2layers), Loss=10%	5,500.0	ltr
		(2) DBST	0.7 - 2.3ltr/sq.m (2layers), Loss=10%	5,500.0	ltr
			Total	**15,600.0**	**ltr**
5. Fuel	Operation of equipment	Diesel		N/A	ltr

2.4 Work Implementation Team

PW and JICA Expert Team jointly worked for implementation of the PP-2. PW Pyapon District Office was in charge of the overall project management by having substantial cooperation from the other departments in PW and JICA. Members of the work implementation team (the Team) are listed in Table 2.4.1.

Table 2.4.1 Member List of Work Implementation Team

No.	Task	Name	Position	JICA Expert
0	Total project management	U Aung Myint Oo	Deputy chief engineer (planning)	
1	Planning & design stage			
1.1	Road & pavement design	Daw Mya Mya Win	Deputy superintending engineer, RRL	H. Kobayashi
1.2	Soil investigation & material mix design	U Nyi Nyi Kyaw	Assistant engineer, RRL	H. Miyamoto
1.3	Topographic survey & drawing preparation	Daw Aye Aye Thwin	Executive engineer, Road design Dept. HQ	
1.4	Implementation program	U Thet Zaw Win	Executive engineer, Pyapon District office	H. Kobayashi
2	Work implementation stage			
2.1	Project management	U Thet Zaw Win	Executive engineer, Pyapon District office	H. Kobayashi
2.2	Mobilization of soil plant	U Nyi Nyi Win	Assistant engineer, Mechanical Dept.	H. Kobayashi
2.3	Site management	U Win Naing	Assistant engineer, Bogale Township	N. Akmar
2.4	Construction supervision work	U Tun Tun Hlaing	Junior engineer, Bogale Township	N. Akmar
2.5	Material quality control	U Tint Lwin Oo	Assistant engineer, RRL	H. Miyamoto
2.6	Field material test	U Han Lin Aung	Technician, RRL	H. Miyamoto
2.7	Plant operation work	U Dawei	Mechanic, Mechanical Dept.	H. Kobayashi
2.8	General equipment operation work	U Hlaing Min Zaw	Junior engineer, Mechanical Dept.	N. Akmar
2.9	Dimension control	U Myo Min Win	Junior engineer, Bogale Township	N. Akmar

(Note) Position of PW personnel is as of Feb/2015.

2.5 Work Implementation Procedures

2.5.1 Initial Work Stage (Off-site Work)

Work implementation team (the Team) commenced the work as categorized off-site work on 16th February, 2015. Principal work items and their brief explanations are described below. Furthermore, photos of the work views are as shown in Figure 2.5.1.

- **Engineering survey**

  The Team installed wooden stakes at each station (per 30m interval with mid pegs per 15m interval) to check the elevation of existing road and set out the base height of each pavement layer.

- **Preparation of temporary construction yard**

  The Team opened a temporary yard beside Bogale Bridge by considering transportation of construction material and soil plant through water-transport. Borrow pit was also opened at adjacent land to the bridge. The borrow pit was able to accommodate total volume of soil to be applied in the project. Note excavated soil possessed high moisture contents. Therefore, the soil was left on the pit for decreasing the moisture contents to satisfy for application.

- **Construction of foundation concrete of the soil plant**

  The Team constructed foundation concrete of the plant prior to the arrival. The foundation has 8 columns as shown in Figure 2.5.1 (v). Note engineer and/or surveyor should carefully check top level of each column to secure same elevation for the plant installation horizontally. Drawings of the foundation are attached in Appendix-D.

- **Mobilization and installation of the soil plant**

  The Team installed the plant in cooperation with 2 engineers from the manufacturer. The plant arrived at the yard by barge on 03/Apr. Brief schedule for the installation work is as follows.

  - 03/Apr : Plant arrived at the yard
  - 04 – 07/Apr : Unloading and assembling work
  - 08 – 10/Apr : Trial operation and training for operation and maintenance.

  PW recorded all procedures of the assembling work and the training by video camera for future application by own resources.

(i) Engineering survey

(ii) Soil drying work in borrow pit

(iii) Assembling re-bar for of the foundation

(iv) Checking top level of each column

(v) Completed foundation

(vi) Arrival of the plant

(vii) Setting base frame on the foundation

(viii) Setting main control box

	
(ix) Setting feeder unit	(x) Cement Silo
	
(xi) Completed plant	(xii) Generator unit
	
(xiii) Instruction of operation method of control panel	(xiv) Instruction of mixing mechanism
	
(xv) Training of soil feeding work	(xvi) Loading cement stabilized soil

Figure 2.5.1 Work Views of Off-site Work

2.5.2 Road Rehabilitation Work

(1) General

The Team executed the following work items in the PP-2. Detailed work sequences are described in the following sub-clauses.

- ✓ Earthworks
- ✓ Pavement work
- ✓ Drainage layer work

(2) Earthworks

1) Scarifying and Re-compaction of Existing Embankment

Soil properties of the existing embankment indicated insufficient bearing strength for road construction work. Therefore, the Team executed scarifying and re-compaction of the embankment in average 30cm depth by applying the bulldozer with ripper unit. Note large size boulders were removed by manpower to secure uniformity of compaction degree. Photos of the work views are as shown in Figure 2.5.2.

	
(i) Scarifying work	(ii) Re-compaction work

Figure 2.5.2 Work Views of Scarifying and Re-compaction of Existing Embankment

2) Widening of the Embankment

Dimension of the existing embankment was not able to accommodate the design cross section (total width = 10.2m). Therefore, the team executed the widening work by filling local soil hauled from the borrow pit. Photos of the work views are as shown in Figure 2.5.3.

	
(i) Unloading local soil	(ii) Grading and leveling work
	
(iii) Compaction work	

Figure 2.5.3 Work Views of Widening work of the Embankment

3) Subgrade Construction Work

The Team considered mitigation approach against affect of the flood. As a result, the Team raised top level of subgrade 3 feet higher than the previous high water level in accordance with the regulation of PW as illustrated in Figure 2.5.4.

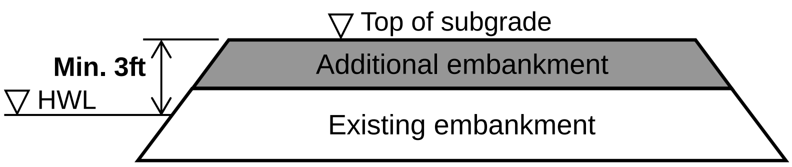


Figure 2.5.4 Image Cross Section of Embankment & Subgrade in PP-2

The Team executed the construction work by applying mixed material of soil (50%) and sand (50%). Mixing work was done by backhoe in the borrow pit. Thickness of the subgrade was determined to 60cm (= 2 feet) in average. Note the Team planned execution of compaction work every 30cm thickness initially. However, it was difficult to achieve the designated dry density in case of 30cm thickness. Therefore, the Team changed the thickness to 15cm for the improvement. As a result, the Team obtained the sufficient dry density. Photos of the work views are as shown in Figure 2.5.5.

(i) Loading mixed material in the borrow pitl

(ii) Unloading the material on the embankment

(iii) Grading & leveling work

(iv) Initial compaction by sheep foot roller

(v) Final compaction by tire roller

(vi) Check surface elevation

Figure 2.5.5 Work Views of Subgrade Construction

(3) Pavement Works

1) Installation of Cement Stabilized Subbase Course

The Team executed the work in accordance with the following sequences.

(i) Mixing work of the base material consisted of soil (50%) and sand (50%) by backhoe
(ii) Production or the stabilized material by the plant
(iii) Transporting and unloading the material on the subgrade
(iv) Grading and compaction
(v) Field dry density test (FDT)
(vi) Curing work

Note feeding work of the base material should be done slowly and gradually in case of applying clayey soil because the material still may contain large lump of clay. Sudden collision of the lump may harm vibration device of the feeder unit. Watchman should be assigned beside the feeder unit in case of the feeding work.

Compaction work was done every 15 cm thickness to achieve the sufficient dry density. Furthermore, the Team executed one work cycle within 4 hours by considering hardening time of the cement. Photos of the work views are as shown in Figure 2.5.6.

	
(i) Mixing base material by backhoe	(ii) Feeding base material into the plant

(iii) Unloading the material on the subgrade

(iv) Grading & leveling work

(v) Control of moisture contents

(vi) Initial compaction by sheep foot roller

(vii) Final compaction by tire roller

(viii) Field density test

(xvi) Check surface elevation

(x) Water spraying for curing purpose

Figure 2.5.6 Work Views of Cement Stabilized Subbase Course Installation

2) Installation of Base Course

2)-1 Section-1 (Graded Crush Stone)

The work was commenced on 08/Jun by PW. The work has been going on according to the site report as of 24/Jul. Photos of the work views are as shown in Figure 2.5.7. The work description is so far unavailable. Self-updating and finalizing work by PW will be expected after the 1st submission of this report from JICA Expert to JICA/HQ.

	
(i) Work completion on one lane	(ii) Work completion on whole width

Figure 2.5.7 Work Views of Base Course Installation (Crush Stone)

2)-2 Section-2 (Cement Stabilized River Shingle and Sand)

The work had been executed from 07/Jun to 06/Jul by PW. Photos of the work views are as shown in Figure 2.5.8. The work description is so far unavailable. Self-updating and finalizing work by PW will be expected after the 1st submission of this report from JICA Expert to JICA/HQ.

	
(i) Unloading material on subbase surface	(ii) Work completion on whole width

Figure 2.5.8 Work Views of Cement Stabilized Base Course Installation

3) Installation of Wearing Course

3)-1 Section-1 (Penetration Macadam)

The work is not commenced due to bad weather according to the site report as of 24/Jul. The work description and the photos are so far unavailable. Self-updating and finalizing work by PW will be expected after the 1st submission of this report from JICA Expert to JICA/HQ.

3)-2 Section-1 (DBST)

The work was commenced on 15/Jun by PW. The work has been going on according to the site report as of 24/Jul. Photo of the work view is as shown in Figure 2.5.9. The work description is so far unavailable. Self-updating and finalizing work by PW will be expected after the 1st submission of this report from JICA Expert to JICA/HQ.

Figure 2.5.9 Work Views of Wearing Course (DBST)

4) Hard Shoulder (Crush Stone)

The work was commenced on 07/Jun by PW. The work has been going on according to the site report as of 24/Jul. Photo of the work completion view is as shown in Figure 2.5.10. The work description is so far unavailable. Self-updating and finalizing work by PW will be expected after the 1st submission of this report from JICA Expert to JICA/HQ.

Figure 2.5.10 Work Completion View of Hard Shoulder

(4) Drainage Layer

The work was commenced on 07/Jun by PW. The work has been going on according to the site report as of 24/Jul. Photo of the work completion view is as shown in Figure 2.5.11. The work description is so far unavailable. Self-updating and finalizing work by PW will be expected after the 1st submission of this report from JICA Expert to JICA/HQ.

Figure 2.5.11 Work Completion View of Drainage Layer

2.6 Quality Assurance of the Work

The Team attempted following approaches for quality assurance of the works in the PP-2.

2.6.1 Dimension Control of the Work

The Team measured elevation at each layer by applying the survey pegs installed during the engineering survey work whether it complied with the designed thickness. Contents of the measurement work are stipulated in Table 2.6.1. Form of inspection sheet (subbase course) is as shown in Figure 2.6.1.

Table 2.6.1 Item/Interval/Tolerance of Measurement Work

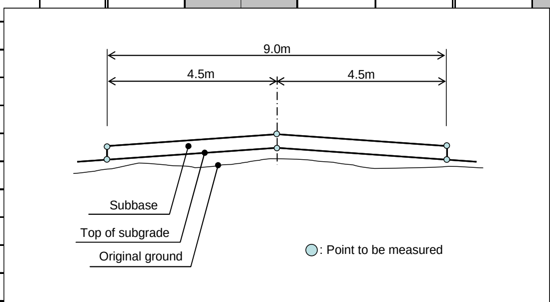
Layer	Measure Item	Interval	Tolerance
Sub-grade	Elevation (Center & both side)	Every 30m	±5cm
	Width		−10cm
Sub-base course	Elevation (Center & both side)	Every 30m	±4cm
	Thickness		−4.5cm
	Width		−5cm
Base course	Thickness	Every 30m	−3cm
	Width		−5cm
Wearing course	Thickness	Every 30m	−1.5cm

Inspection Sheet for Road Works (Subbase Course)

Location: Road No.6, Bogale Township, Ayeyarwady Region
Section: 1/5 - 2/0 (L=600m)
Thickness tolerance: -0.045m

Inspection Date:
Measured by:
Checked by:

Pavement type	Station	Curve element	Elevation Level Data														
			Left side 4.5m Offset					Center line					Right side 4.5m Offset				
			Top of subgrade	Design		Measurement	Thickness	Top of subgrade	Design		Measurement	Thickness	Top of subgrade	Design		Measurement	Thickness
			m	Ft	m	m	m	m	Ft	m	m	m	m	Ft	m	m	m
			(a)		(b)	(c)	(c) - (a)	(a)		(b)	(c)	(c) - (a)	(a)		(b)	(c)	(c) - (a)
Penetration macadam	86			10.32	3.15				10.81	3.29				10.32	3.15		
	87			10.32	3.15				10.81	3.29				10.32	3.15		
	88			10.32	3.15				10.81	3.29				10.32	3.15		
	89			10.32	3.15				10.81	3.29				10.32	3.15		
	90			10.32	3.15				10.81	3.29				10.32	3.15		
	91			10.32	3.15				10.81	3.29				10.32	3.15		
	92			10.32	3.15				10.81	3.29				10.32	3.15		
	93			10.32	3.15				10.81	3.29				10.32	3.15		
	94			10.32	3.15				10.81	3.29				10.32	3.15		
	95			10.32	3.15				10.81	3.29				10.32	3.15		
	96			10.32	3.15				10.81	3.29				10.32	3.15		
DBST	97			10.82	3.30				11.31	3.45				10.82	3.30		
	98			10.82	3.30				11.31	3.45				10.82	3.30		
	+27	BTS		10.82	3.30				11.31	3.45				10.82	3.30		
	99			11.30	3.44				11.31	3.45				10.82	3.30		
	+02			11.31	3.45				11.31	3.45				10.82	3.30		
	+77	BCS		11.80	3.60				11.31	3.45				10.82	3.30		
	100			11.80	3.60				11.31	3.45				10.82	3.30		
	101			11.80	3.60				11.31	3.45				10.82	3.30		
	+49	ECS		11.80	3.60				11.31	3.45				10.82	3.30		
	102			11.47	3.50				11.31	3.45				10.82	3.30		
	+24			11.31	3.45				11.31	3.45				10.82	3.30		
	+99	ETS		10.82	3.30				11.31	3.45				10.82	3.30		
	103			10.82	3.30				11.31	3.45				10.82	3.30		
	104			10.82	3.30				11.31	3.45				10.82	3.30		
	105			10.82	3.30				11.31	3.45				10.82	3.30		
	106			10.82	3.30				11.31	3.45				10.82	3.30		



BTS: Beginning point of **Transition section**
BCS: Beginning point of **Curve section**
ECS: End point of **Curve section**
ETS: End point of **Transition section**

Figure2.6.1 Form of Inspection Sheet of Elevation & Thickness (Subbase Course)

2.6.2 Quality Control of Stabilized Material

(1) Field Density Test (FDT)

The Team implemented field dry density test (FDT) at each station whether the result achieved target value to examine the compaction degree of the soil material. Target densities and their moisture contents of each layer are summarized in Table 2.6.2. Note the Team also implemented the 2nd test after re-compaction work, in case if former test was failed. Test results were summarized in Table 2.6.3 – 2.6.6. Note the test results are partially or wholly absent in case the JICA Expert Team did not confirm the results for those parts. Self-updating and finalizing work by PW will be expected after the 1st submission of this report from JICA Expert to JICA/HQ.

Table 2.6.2 Target Values of FDT

Layer type	Material mixing ratio	Target value	
		Dry density (kg/cm3)	Moisture content (%)
Embankment (scarifying & re-compaction) + (widening)	Scarifying & re-compaction: existing embankment soil = 100% Widening part: borrow soil = 100%	1.67	13.50
Subgrade (bucket mixing in borrow pit)	Soil : Sand = 50% : 50% (weight basis),	1.69	6.00
Subbase course (plant mixing in yard)	Soil : Sand = 50% : 50% & 6.4 – 6.9% of (soil + sand) for cement (weight basis)	1.63	11.00
Base course (section-2) (plant mixing in yard)	River shingle : Sand = 75% : 25% & 4.6% of (r-shingle + sand) for cement (weight basis)	2.24	6.50

Table 2.6.3 Summary of Field Density Test Result (Embankment)

Test	Station	86		87		88		89		90		91		92	
	R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st	Date	11.Apr		6.Apr		6.Apr								8.Apr	
	Density (g/cm3)	1.70		1.27		1.64								1.64	
	OK or NG	OK		NG		OK								OK	
2nd	Date														
	Density (g/cm3)														
	OK or NG														

Test	Station	93		94		95		96		97		98		99	
	R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st	Date	5.Apr				5.Apr					5.Apr			5.Apr	
	Density (g/cm3)	1.51				1.71					1.60			1.63	
	OK or NG	NG				OK					NG			NG	
2nd	Date														
	Density (g/cm3)														
	OK or NG														

Test	Station	100		101		102		103		104		105		106	
	R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st	Date									2.Apr		2.Apr		2.Apr	
	Density (g/cm3)									1.38		1.64		1.64	
	OK or NG									NG		OK		OK	
2nd	Date														
	Density (g/cm3)														
	OK or NG														

Table 2.6.4 Summary of Field Density Test Result (Subgrade)

Layer	Test	Station	86		87		88		89		90		91		92	
		R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st Layer	1st	Date	21.Apr		30.Apr		30.Apr		21.Apr						22.Apr	
		Density (g/cm3)	1.67		1.60		1.60		1.68						1.70	
		OK or NG	NG		NG		NG		NG						OK	
	2nd	Date	22.Apr						22.Apr		22.Apr			22.Apr		
		Density (g/cm3)	1.71						1.72		1.72			1.72		
		OK or NG	OK						OK		OK			OK		
2nd Layer	1st	Date		3.May	3.May		3.May	3.May		1.May					5.May	
		Density (g/cm3)		1.60	1.67		1.52	1.58		1.61					1.65	
		OK or NG		NG	NG		NG	NG		NG					NG	
	2nd	Date	11.May			11.May	11.May			11.May	11.May		11.May		9.May	
		Density (g/cm3)	1.73			1.71	1.65			1.61	1.67		1.62		1.61	
		OK or NG	OK			OK	NG			NG	NG		NG		NG	

Layer	Test	Station	93		94		95		96		97		98		99	
		R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st Layer	1st	Date	21.Apr	23.Apr			7.May	7.May	21.Apr		22.Apr	5.May			21.Apr	
		Density (g/cm3)	1.62	1.72			1.77	1.68	1.65		1.72	1.70			1.63	
		OK or NG	NG	OK			OK	NG	NG		OK	OK			NG	
	2nd	Date	22.Apr		22.Apr				22.Apr							
		Density (g/cm3)	1.71		1.70				1.73						1.71	
		OK or NG	OK		OK				OK						OK	
2nd Layer	1st	Date	5.May	1.May	5.May					1.May				30.Apr	6.May	30.Apr
		Density (g/cm3)	1.67	1.62	1.67					1.69				1.69	1.732	1.69
		OK or NG	NG	NG	NG					NG				NG	OK	NG
	2nd	Date	7.May	9.May			9.May	9.May			5.May			8.May	8.May	6.May
		Density (g/cm3)	1.66	1.63			1.77	1.73			1.69			1.76	1.80	1.74
		OK or NG	NG	NG			OK	OK			NG			OK	OK	OK

Layer	Test	Station	100		101		102		103		104		105		106	
		R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st Layer	1st	Date	4.Apr	23.Apr	30.Apr	1.May	5.Apr		5.Apr		5.Apr				4.Apr	
		Density (g/cm3)	1.69	1.70	1.67	1.64	1.72		1.44		1.60				1.67	
		OK or NG	NG	OK	NG	NG	OK		NG		NG				NG	
	2nd	Date				4.May			9.Apr		30.Apr		7.Apr		7.Apr	
		Density (g/cm3)				1.80			1.64		1.76		1.34		1.53	
		OK or NG				OK			NG		OK		NG		NG	
2nd Layer	1st	Date		30.Apr		5.May	8.Apr		1.May	1.May			8.Apr		8.Apr	
		Density (g/cm3)		1.70		1.75	1.53		1.60	1.69			1.61		1.60	
		OK or NG		OK		OK	NG		NG	NG			NG		NG	
	2nd	Date	6.May	4.May	4.May	8.May	1.May		2.May	7.May						
		Density (g/cm3)	1.73	1.77	1.76	1.71	1.79		1.75	1.68						
		OK or NG	OK	OK	OK	OK	OK		OK	NG						

Table 2.6.5 Summary of Field Density Test Result (Subbase Course)

Test	Station	86		87		88		89		90		91		92	
	R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st	Date														
	Density (g/cm3)														
	OK or NG														
2nd	Date														
	Density (g/cm3)														
	OK or NG														

Test	Station	93		94		95		96		97		98		99	
	R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st	Date			17.May		17.May		14.May		14.May		13.May		12.May	12.May
	Density (g/cm3)			1.64		1.64		1.60		1.62		1.60		1.61	1.65
	OK or NG			OK		OK		OK		OK		OK		OK	OK
2nd	Date														
	Density (g/cm3)														
	OK or NG														

Test	Station	100		101		102		103		104		105		106	
	R/L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1st	Date	10.May			7.May	4.May	8.May	4.May	3.May	1.May	29.Apr		16.May	15.May	8.Apr
	Density (g/cm3)	1.60			1.65	1.60	1.70	1.65	1.71	1.53	1.55		1.64	1.61	1.58
	OK or NG	OK			OK	OK	OK	OK	OK	NG	NG		OK	OK	NG
2nd	Date														29.Apr
	Density (g/cm3)														1.58
	OK or NG														NG

Table 2.6.6 Summary of Field Density Test Result (Base Course in Section-2)

(N/A)

(2) Control of Hexavalent Chromium

Road agency should be cautious in case of applying cement for mixing with soil because there is a risk of elution of a heavy metal called as “hexavalent chromium (Cr^{6+})” from the mixture. Therefore, the agency should examine the elution in advance to the project.

The Team applied “Alkaline Digestion Method” to examine the existence of Cr^{6+} in the cement itself (see Figure 2.6.2) applied in the PP-2. Work flow of this approach is illustrated in Figure 2.6.3. The test result indicated 15mg/kg of Cr^{6+} was extracted from the sample. This value is lower than the allowable value (20mg/kg) regulated in Japan Cement Association (JCA). Therefore, the Team was able to apply this cement in the PP-2. The test report is attached in Appendix-E.

Figure 2.6.2 Cement to be applied in the PP-2

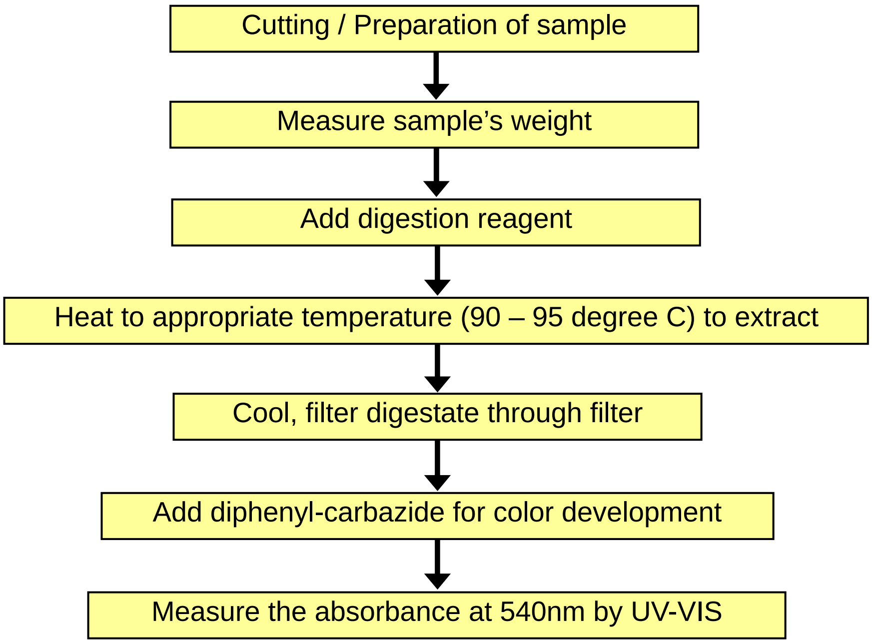


Figure 2.6.3 Work Flow of Alkaline Digestion Method

2.6.3 Approach for Project Management

Close communication between the site and the management level is one of the key elements for successful implementation of the project. The Team applied the following approaches to accomplish smooth communication and sufficient common understanding through the PP-2.

(1) Establishment of Communication System

Communication system between the site and the management level by clarifying the role each group through the PP-2 is illustrated in Figure 2.6.4. The Team also prepared report forms namely daily report and weekly report for use at the site. The site group noted work record and identified issues down to the forms for the submission to the management group. And then the management group reviewed the reports for consideration of the appropriate project implementation. Form of the daily report is as shown in Figure 2.6.5.

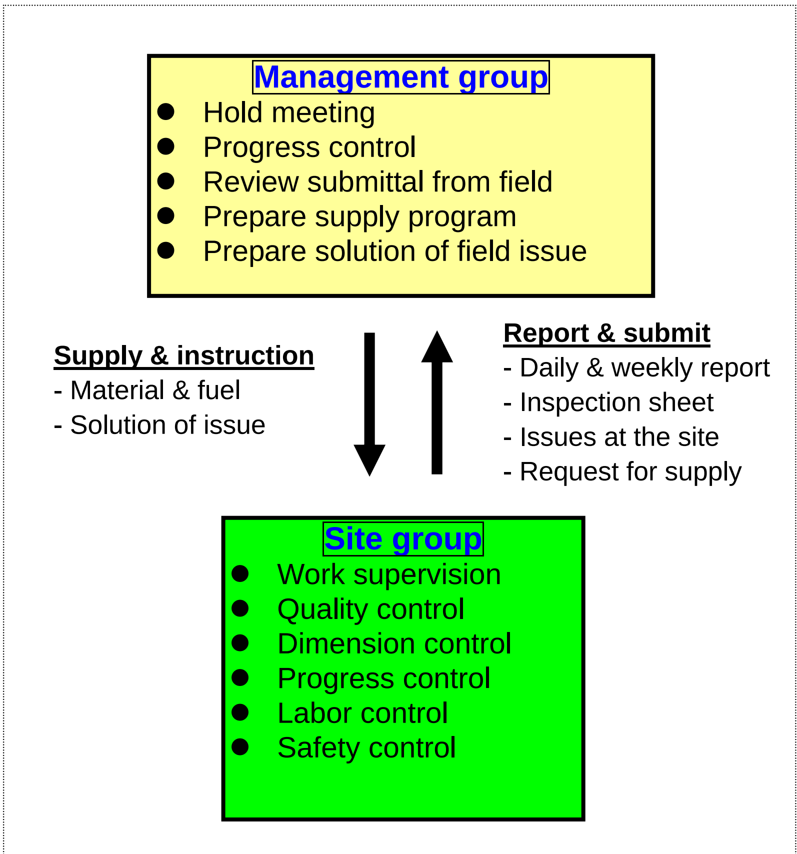


Figure 2.6.4 Communication System and Roles of Each Groups in the PP-2

Pilot Project (Phase-2) on Road No.10, Bogale Township, Aeyarwaddy Region

Date:

Weather

Contract/Force account

Temparature: ______ *C*

Section: 1/4 - 2/0 (L=800m)

Humidity ______ *%*

Construction :Public Works (PW)

DAILY PROGRESS REPORT

No.	Work items	Station	Description of Works	Remarks

EQUIPMENTS				Materials		MAN POWERS			
Type	No.	Type	No.	Type	Quantity	Type	No.	Type	No.
						Project Manager		Oprerator	
						Deputy PM		Worker	
						Site Engineer			
						Foreman			
						Surveyor			

Confirmed by: ____________ Date : Approved by: ____________ Date :

PW Engineer (PW Resident Representative)

Figure 2.6.5 Form of Daily Progress Report

(2) Hold Meeting

The Team held several meetings prior to commencement of the construction work at the site. The attendants confirmed and shared the information related to principal considerations and rules through the project as stated below.

- Each role of key person
- Work implementation schedule
- Procurement and supply program of material and equipment
- Specific caution and requirement during the work
- Environmental mitigations
- Traffic safety control
- Frequency and type of test and inspection
- Format of sheet for inspection and test to be used

The Team also held weekly meeting to share common understanding regarding current site condition and the issues to be solved among key persons for the project management. Major agenda are listed below.

- Confirm work progress in this week and work program in next week
- Confirm resources (i.e. material, fuel, labor and equipment) spent in this week and consider supply program for next week
- Mobilization schedule of the equipment
- Confirm issues occurred at the site and discuss for the solution

The work progress report and the work program are as shown in Table 2.6.6 and 2.6.7 respectively.

Table 2.6.6 Weekly Work Progress Report (4/May – 10/May)

I. Road Works

Category	Work item	May 4 Mon	5 Tue	6 Wed	7 Thu	8 Fri	9 Sat	10 Sun	Actual work description	Total quantity	Unit	Progress Weekly	Progress Total	Progress (%)	Issues & remarks
1. Earthwork															
1.1 Scarifying & re-compaction									Used motor grader scrafying existing embankment, recompaction by tire roller.	600	m		600	100.0%	
1.2 Embankment	(1) Lower								Use dump truck carry borrow soil and leveling by motor grader, and then compaction by Sheep foot roller.	600	m		600	100.0%	
	(2) Road side									600	m		0	0.0%	
1.3 Subgrade		■	■	■	■	■	■	■	Use Excavator mixing soil and sand, and carry by dump trucks to road section, then leveling and grading by motor grader, and then compaction by sheep foot roller.	600	m	420	540	90.0%	Total thickness for subgrade layer=600 mm, From STA:88~103 section finish (600)mm tk; and from STA:86~88 section finish (300) mm tk. Only
1.4 Slope trimming										600	m		0	0.0%	
2. Pavement															
2.1 Wearing course	(1) P-macadam									300	m		0	0.0%	
	(2) DBST									300	m		0	0.0%	
2.2 Hard shoulder										600	m		0	0.0%	
2.3 Base course	(1) Graded stone									300	m		0	0.0%	
	(2) Stabilized material									300	m		0	0.0%	
2.4 Subbase course				■	■	■	■	■	Use soil plant mixing soil, sand and cement, and carry by dump trucks to road section,then leveling and grading by motor grader, and then compaction by tire roller.	600	m	155	200	33.3%	Total thickness of subbase layer=300 mm for DBST section, only done the tk: (150 mm) of subbase layer from STA:99~105.
3. Drainage layer										300	m		0	0.0%	

II. Works in Yard

Category	Work item	May 4 Mon	5 Tue	6 Wed	7 Thu	8 Fri	9 Sat	10 Sun	Actual work description	Total quantity	Unit	Progress Weekly	Progress Total	Progress (%)	Issues & remarks
1. Temporary yard	(1) Site opening	■	■	■	■	■	■	■	Used bulldozer remove top muddy soil and dry up, with excavator loading soil & mixing soil and sand at Borrow pit.	20,000	sq.m	5500	13000	65.0%	
	(2) Site clearance									20,000	sq.m		0	0.0%	
2. Diversion road										600	m		600	100.0%	Diversion for truck until (6.5.2015), and after then not provide diversion way for truck. Only allow motorbike passing.
3. Material production	(1) Subgrade	■	■	■	■	■	■	■	Produce borrow dry soil from borrow pit and carry sand by boat to stock yard.	7,000	cu.m	650	6300	90.0%	
	(2) Subbase			■	■	■	■	■	Produce borrow dry soil from borrow pit and carry sand by boat to stock yard.	1,100	cu.m	200	550	50.0%	
	(3) Base (stone)								Carry crush stone from boat to stock yard.	1,100	cu.m		330	30.0%	Crush stone (6" * 9")=120 sud already arrive site stock yard, but need to crushing to required size.
	(4) Base (stabilized)								Carry river shrinckle from boat to stock yard	700	cu.m		254	36.3%	River shringle =90 sud already arrived to site stock yard.
	(5) Hard shoulder (stone)	■	■	■					Manually collecting stone from existing road embankment after scarifying of road surface by bulldozer.	200	cu.m	60	120	60.0%	Collecting crush stone from road section, and storage near 1/4 Mile Post.
	(6) P-macadam								Carry crush stone from boat to stock yard.	400	cu.m		110	27.5%	Crush stone (1/2" * 3/4")=40 sud already arrive site stock yard
	(7) DBST								Carry crush stone from boat to stock yard.	250	cu.m		0	0.0%	

III. Other works (if any)

Category	Work item	May 4 Mon	5 Tue	6 Wed	7 Thu	8 Fri	9 Sat	10 Sun	Actual work description	Total quantity	Unit	Progress Weekly	Progress Total	Progress (%)	Issues & remarks
1. Engineering survey	Road alignment and levelling	■	■	■	■	■	■	■	Continuted carried out level survey for subgrade layer and subbase layer.	600	m	250	450	75.0%	
2. Soil Plant	Produce mixing materials (Soil + Sand + Cement)			■	■	■	■	■	Setting up & Assembling for soil plant completed; producing mixing materials (soil & sand & cement) for subbase course carried on.	836	cu.m	263	270	32.3%	
3. Borrow pit	Dry up soils/ access road	■	■	■	■	■	■	■	Use excavator do access, dry up soil and mixing soil and sand, and then loading soil to dump trucks, use bulldozer scrafying and dry up soil.	7,768	cu.m	1500	5,400	69.5%	
4. Elevated Water Tank	Build frame and install water tank								Construct elevated water tank and joint with tube well pipe for supply fresh water to soil mixing plant was completed.	1	nos.		1	100.0%	
5.Gravel stock yard	Gravel stock yard								Unloading gravel from boat to stock yard by using man power.	2,560	ton		750	29.3%	
6.Sand stock yard	Pumping up sand	■	■	■	■	■	■	■	Unloading sand from boat to stock yard by using pump	7,910	ton	800	3,300	41.7%	

Table 2.6.7 Weekly Work Program (11/May – 17/May)

I. Road Works

Category	Work item	May 11 Mon	12 Tue	13 Wed	14 Thu	15 Fri	16 Sat	17 Sun	Actual work description	Total quantity	Unit	Progress Weekly	Progress Total	Progress (%)	Issues & remarks
1. Earthwork															
1.1 Scarifying & re-compaction									Used motor grader scrafying existing embankment, recompaction by tire roller and sheep boot roller.	600	m		600	100.0%	
1.2 Embankment	(1) Lower								Will be used dump truck carry borrow soil and leveling by motor grader, and then compaction by sheep foot roller.	600	m		600	100.0%	
	(2) Road side									600	m		0	0.0%	
1.3 Subgrade									Will be use JCB mixing soil and sand, and carry by dump trucks to road section, then leveling and grading by motor grader, and then compaction by sheep foot roller and tire roller.	600	m		600	100.0%	Total thickness for subgrade layer=600 mm, From STA:103~106 section finish (600)mm tk; and from STA:86~103 section finish (300) mm tk. Only
1.4 Slope trimming										600	m		0	0.0%	
2. Pavement															
2.1 Wearing course	(1) P-macadam									300	m		0	0.0%	
	(2) DBST									300	m		0	0.0%	
2.2 Hard shoulder										600	m		0	0.0%	
2.3 Base course	(1) Graded stone									300	m		0	0.0%	
	(2) Stabilized material									300	m		0	0.0%	
2.4 Subbase course									Will be use soil plant mixing soil, sand and cement, and carry by dump trucks to road section,then leveling and grading by motor grader, and then compaction by sheep foot roller and tire roller.	600	m		400	66.7%	Total thickness of subbase layer=300 mm for DBST section, only done the tk: (180 mm) of subbase layer from STA:105~106.
3. Drainage layer										300	m		0	0.0%	
II. Works in Yard															
1. Temporary yard	(1) Site opening								Will use bulldozer scarifying and dry up soil, and then loading by ecavator to dump trucks.	20,000	sq.m		16,000	80.0%	
	(2) Site clearance									20,000	sq.m		0	0.0%	
2. Diversion road										600	m		600	100.0%	
3. Material production	(1) Subgrade								Produce borrow dry soil from borrow pit and carry sand by boat to stock yard.	7,000	cu.m		7000	100.0%	
	(2) Subbase								Produce borrow dry soil from borrow pit and carry sand by boat to stock yard.	1,100	cu.m		733	66.6%	
	(3) Base (stone)								Carry crush stone from boat to stock yard.	1,100	cu.m		330	30.0%	Crush stone (6" * 9")=120 sud already arrive site stock yard, but need to crushing to required size.
	(4) Base (stabilized)								Carry river shrinckle from boat to stock yard	700	cu.m		254	36.3%	River shringle =90 sud already arrived to site stock yard.
	(5) Hard shoulder (stone)								Will be continue manully collecting stone from existing road emabnkment after scarifying of road surface.	200	cu.m		120	60.0%	Collecting crush stone from road section, and storage near 1/4 Mile Post.
	(6) P-macadam								Carry crush stone from boat to stock yard.	400	cu.m		110	27.5%	Crush stone (1/2" * 3/4")=40 sud already arrive site stock yard
	(7) DBST								Carry crush stone from boat to stock yard.	250	cu.m		0	0.0%	
III. Other works (if any)															
1. Engineering survey	Road alignment and levelling								Will be continuted carried out level survey for emabnkment layer and subgrade layer.	600	m		450	75.0%	
2. Soil Plant	Produce mxing materials for subbase course								Produce mixing materials for subbase course	836	cu.m		557	66.6%	
3. Borrow pit	Dry up soils/ access road								Will use excavator do access and loading soil to dump trucks , use bulldozer scarifying and dry up soil.	7,768	cu.m		5,826	75.0%	
4.Gravel stock yard	Gravel stock yard								Will be continued carry gravel to stock yard.	2,560	ton		750	29.3%	
5.Sand stock yard	Pumping up sand								Will be continued pumping up sand from boat to stock yard.	7,910	ton		5,537	70.0%	

3. Technical Transfer Program

3.1 Approach and Methodology

Technical transfer program in the PP-2 consisted of On-the-Job-Training (OJT) and the Workshop (WS). JICA Experts attempted training of trainers (TOT) to the engineers appointed as candidate trainers by PW through the OJT in the implementation period of the PP-2. As a result of the TOT, the trainers of PW carried out training to the participants in the WS. Note the participants of the WS were also dispatched from PW. Frame of the technical transfer approach is illustrated in Figure 3.1.1. Furthermore, list of the trainers in the WS is as shown in Table 3.1.1. The OJT had been implemented from the commencement of the PP-2 (15/Feb) to the implementation date of the Workshop (29/Apr).

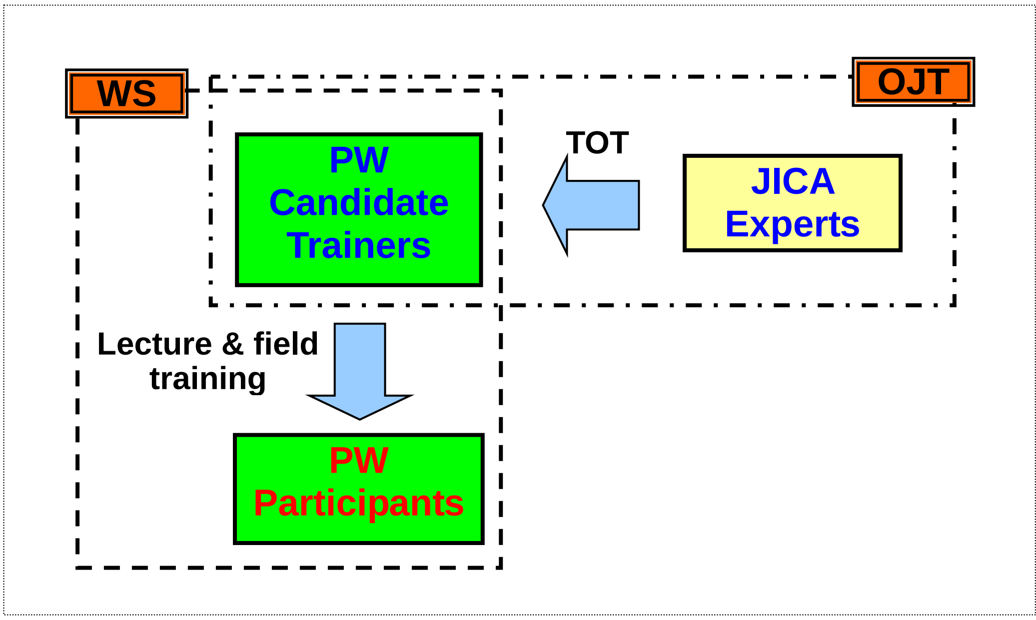


Figure 3.1.1 Frame of Technical Transfer Approach in the PP-2

Table 3.1.1 Trainers in the WS

No.	Name	Position	JICA Expert	Subject
1	Daw Hnin Yu Aung	Senior Sub-Assistant Engineer, RRL	H. Kobayashi)	Pavement design
2	U Nyi Nyi Kyaw	Assistant Engineer, RRL	H. Miyamoto	Mix design of stabilized material
3	U Min Thu	Assistant Engineer, JICA Expert Team	H. Miyamoto	Material quality control on site
4	U Nyi Nyi Win	Assistant Engineer (Mechanical)	H. Kobayashi	Operation & maintenance method of sol mixing plant

3.2 Contents of the Workshop

3.2.1 Outline of the Workshop

Trainers, who were nominated by PW and trained through the OJT in the PP-2, implemented the lecture and field session with support of the JICA Experts. The participants dispatched from PW learned comprehensive knowledge of pavement design, soil stabilization work and application method of the soil plant. Outline of the program is as shown below.

- Date : 29/April, 2015
- Venue : Bogale Bridge Office and work site of the PP-2
- Timetable :

Time	Contents	Presenter
08:30 – 09:00	Registration of the participants	
09:00 – 09:15	Opening remarks	U Aung Myint Oo Chief Engineer, Dept. of Highway
09:20 – 09:40	**Presentation-1** Pavement design in the PP-2	Daw Hnin Yu Aung Senior Sub-Assistant Engineer, RRL
09:40 – 09:50	Question & Answer	
09:50 – 10:20	**Presentation-2 (1)** Mix design of stabilized material	U Nyi Nyi Kyaw Assistant Engineer, RRL
10:20 – 10:40	**Presentation-2 (2)** Outline of material quality control	U Min Thu Project Engineer, JICA
10:40 – 10:50	Question & Answer	
10:50 – 11:00	*Tea break*	
11:00 – 11:30	**Presentation-3** Operation & maintenance method of the sol mixing plant	U Nyi Nyi Win Assistant Engineer (Mechanical)
11:30 – 11:40	Question & Answer	
11:40 – 12:00	Move to restaurant	
12:00 – 13:00	*Lunch break*	
13:00 – 13:15	Move to temporary yard	
13:20 – 13:50	**Field session-1** Material production by the plant	U Nyi Nyi Win Assistant Engineer (Mechanical)
13:50 – 14:00	Move to road construction site	
14:00 – 14:40	**Field session-2** Installation work of the stabilized subbase course	PW & JICA
14:40 – 15:00	Move to the office	
15:10 – 15:30	Filling the questionnaires	
15:30 – 15:45	Closing remarks	U Aung Myint Oo Chief Engineer, Dept. of Highway

- The number of participants : 53 participants
- Photos in the program

	
(i) Opening remark by PD	(ii) Lecture of pavement design
	
(iii) Lecture of material mix design	(iv) Lecture of plant operation
	
(v) Session of question and answer	(vi) Field session of plant operation

(vii) Field session of plant operation

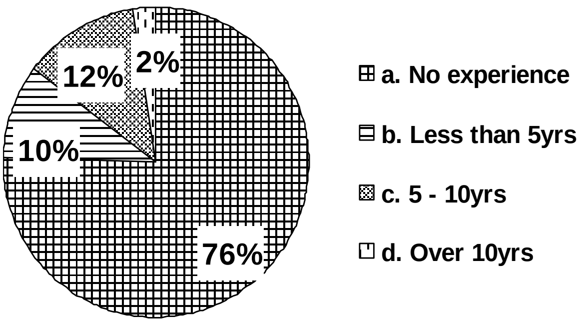
(viii) Field session of stabilized subbase course

3.2.2 Evaluation of Effectiveness of the Program

The Team applied evaluation approach called as “Self-evaluation” for examination of the effectiveness of the WS. This evaluation was carried out at pre-WS and post-WS stage respectively in order to confirm the improvement of knowledge and skill of the participants through the WS. Evaluation result is described in the following sub-clauses.

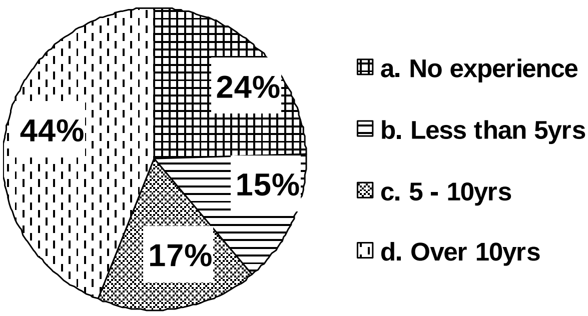
(1) Background of the Participants

The Team observed technical background of the participants namely design work and construction work. Figure 3.2.1 indicates the work experiences as well as Figure 3.2.2 indicates participation experiences of capacity development programs such as training, workshop and/or seminar. It seems that the participants were familiar with construction work rather than design work.



Memo
76% of the participants have no experience of design work.

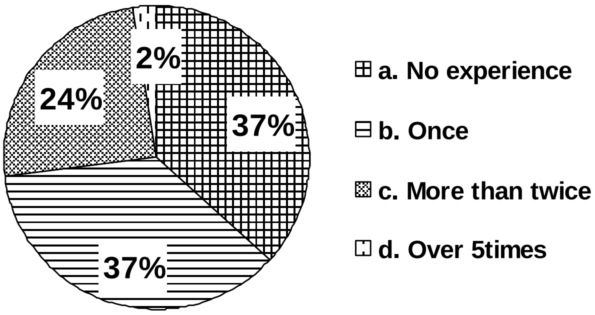
Experience of Design Work



Memo
61% of the participants have work experience more than 5years.

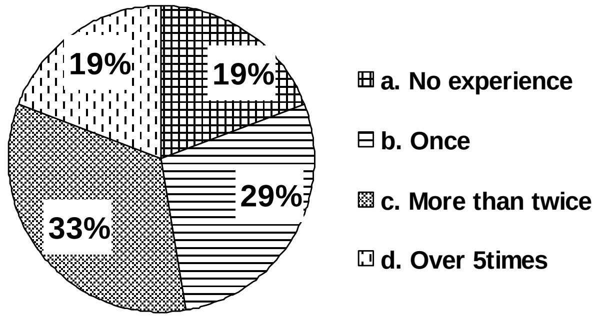
Experience of Construction Work

Figure 3.2.1 Background of the Participants (Work Experience)



Memo
74% of the participants have experience less than once.

Workshop Experience of Design Work



Memo
52% of the participants have experience more than twice.

Workshop Experience of Construction Work

Figure 3.2.2 Background of the Participants (Workshop Experience)

(2) Evaluation Result

1) Self-Evaluation of Technical Capacity Level

Filling questionnaires for self-evaluation of technical capacity level were carried on each theme among the participants. The result is summarized as shown in Table 3.2.1. Average of the level was obviously increased from 2.15 to 2.85 **(+0.70)**.

Table 3.2.1 Comparison of Self-evaluation between Pre and Post

Evaluation Item	Technical Capacity Level		
	Pre-workshop	Post-workshop	Difference (Post) - (Pre)
P1: Pavement design	2.19	2.90	0.71
P2 (1): Material mix design	2.13	2.83	0.70
P2 (2): Material quality control	2.28	2.88	0.60
P3: Operation & maintenance of plant	2.10	2.83	0.73
F1: Production of stabilized material by plant	2.14	2.79	0.65
F2: Installation of subbase course	2.05	2.86	0.81
Average	**2.15**	**2.85**	**0.70**

Remarks (Technical capacity level)

Level 1 : I cannot or do not know how to achieve the results even with support provided by other skilled staffs / manuals.

Level 2 : I can or know how to achieve the results with fully support provided by other skilled staffs / manuals.

Level 3 : I can or know how to achieve the results with occasionally or proper support by skilled staffs

/ manuals.
Level 4 : I can or know how to achieve the results without any support / manuals.
Level 5 : I am able to train other staffs.

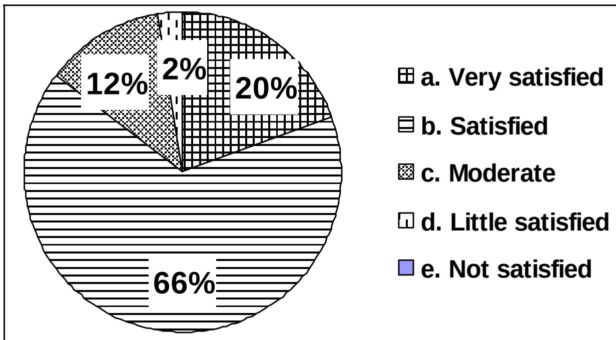
2) Evaluation of the Workshop Contents

Evaluation of the contents (e.g. textbook, lecture and fieldwork) was carried out to apply the result for next training opportunities. The details are described below.

(i) Satisfaction and Understanding

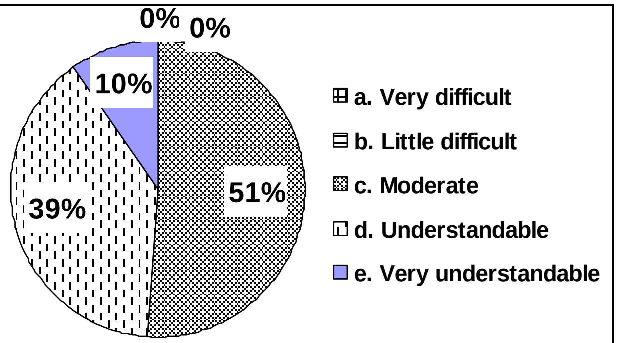
(a) Comprehensive Evaluation

Evaluation result of satisfaction and understanding of the WS contents is indicated in Figure 3.2.3. 86% of the trainees answered "Satisfied" or "Very satisfied" as well as 49% of the trainees answered "Understandable" or "Very understandable" according to the figure. Considering above, the contents were prepared on the satisfactory level to match with the interest. However, the contents seemed slightly difficult by comparing with the technical capacity of the participants.



Memo
86% of the participants answered "satisfied" or "very satisfied".

Satisfaction Level



Memo
49% of the participants answered "understandable" or "very understandable".

Understanding Level

Figure 3.2.3 Evaluation Result of Satisfaction & Understanding of the Workshop

(b) Evaluation of Understanding Level by Theme

Understanding level by theme is indicated in Table 3.2.2. First majority group of the participants answered "moderate" and second majority group answered "understandable" in all themes. The level may improve in case applying the following approaches in the future training opportunities.

- ✓ Prepare sufficient time for the lecture and the Q&A
- ✓ Distribution of the textbook in advance to the workshop date
- ✓ Selection of the participants according to their technical field

Table 3.2.2 Evaluation Result of Understanding Level by Theme

Understanding level	a. Very difficult		b. Little difficult		c. Moderate		d. Understandable		e. Very understandable		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	
P1: Pavement design	0	0%	8	22%	**17**	**46%**	10	27%	2	5%	37
P2 (1): Material mix design	0	0%	2	5%	**29**	**74%**	6	15%	2	5%	39
P2 (2): Material quality control	1	3%	6	15%	**20**	**50%**	11	28%	2	5%	40
P3: Operation & maintenance of plant	3	7%	8	19%	**23**	**53%**	9	21%	0	0%	43
F1: Production of stabilized material by plant	0	0%	5	13%	**28**	**70%**	7	18%	0	0%	40
F2: Installation of subbase course	1	3%	5	13%	**28**	**70%**	6	15%	0	0%	40

(ii) Interested Themes to Learn More

The result of question and answer regarding the interested themes to learn more is shown in Table 3.2.3. The participants tend to learn skill and knowledge of material matters of the soil stabilization work in accordance with the table. The feedback will be utilized for the future training opportunities.

Table 3.2.3 Interested Themes to Learn More

Which theme do you want learn more?	No.
P1: Pavement design	16
P2 (1): Material mix design	**33**
P2 (2): Material quality control	**35**
P3: Operation & maintenance of plant	7
F1: Production of stabilized material by plant	10
F2: Installation of subbase course	14

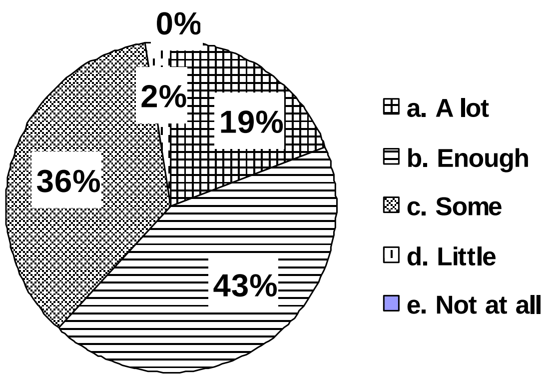
(iii) Benefit of the Workshop

Benefit of the WS is evaluated in accordance with the questions stated below.

(i) “Did you get information on what you expected?”

(ii) “Can you apply what you learned to your work?”

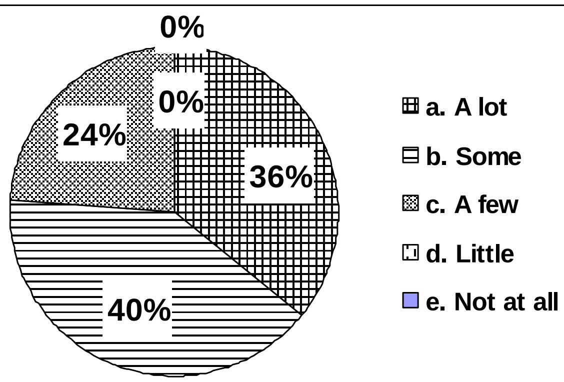
The result is indicated in Figure 3.2.4. 62% of the participants answered “A lot” or “Enough” for question-(i) as well as 76% of the participants answered “Apply a lot” or “Apply some” for question-(ii). Considering above, the contents of the WS achieved satisfactory level to match with the interest and the demand of the participants comprehensively.



Memo

62% of the participants answered “a lot” or “enough”.

Useful Information



Memo

76% of the participants answered “a lot” or “some”.

Applicability

Figure 3.2.4 Benefit of the Workshop

4. Key Notes for Improvement of Work Approach

4.1 Purpose

Following activities will be effective for improvement of work approach in the prospective project in Myanmar.

- To record findings and issues observed through the project implementation.
- To review and analyze the observed findings.
- To share outcome of the review and the analysis among concerned parties.

Following statements made by the Team in accordance with the work outcome through the PP-2 will be utilized in case of considering the project implementation in future.

4.2 Key Notes

4.2.1 Project Management

(1) Application of International System of Units (SI)

So far, PW conventionally applied “Imperial Unit” composed of ‘yard’ and ‘pound’ for the road engineering field. Figure 4.2.1 is standard cross section of class D-III and D-IV road indicating width by feet. However, currently “International System of Unit (SI)” has been applied in the most of the countries including neighboring countries. Therefore PW should apply the SI system to prevent numerical confusion in case of implementing international project such as the Asian Highway Project.

(2) Schedule Control to Complete the Project before Rainy Season

In principle, road construction work should not be executed during rainy season because the water deteriorates the soil material. Therefore, a lot of road projects have been intensively implemented in the dry season (Jan – May) to assure the work quality. However, it also causes shortage of the resources owned by PW (e.g. equipment and labor) to distribute all of the work sites. Prioritization of the project due to the importance and preparation of the project implementation program including procurement schedule of the equipment in early stage will mitigate this difficulty.

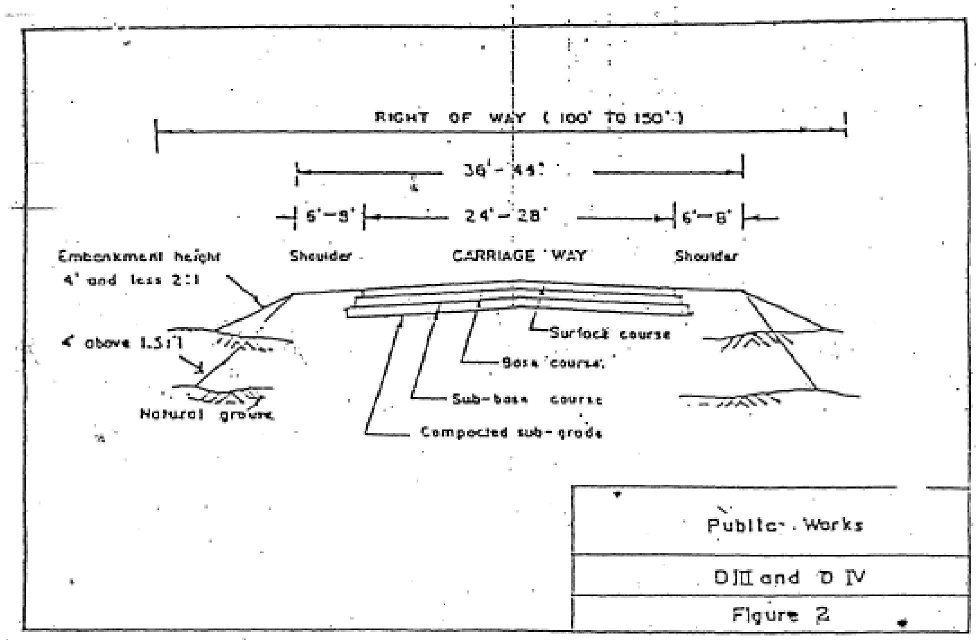


Figure 4.2.1 Standard Cross Section of Road Class D-III and D-IV

(3) Continuous Staffing of the Quality Control Team in the Construction Site

There are many absences in the Table 2.6.3 to 2.6.5 those are indicating the field dray density test because the tests were not implemented due to absence of the material technician(s) on the site. Confirmation and examination of the test result is fundamental approach for the quality assurance during the project. Arrangement of the staffing schedule should be appropriately considered prior to the project.

(4) Flexibility of Work Method and Approach

In principle, site engineer and his staffs should implement the construction work by complying with the design outcome, the specification and the required test value those were determined prior to the work commencement. However, unforeseen events are often occurred on site during the work execution period. For example, if the field density test results frequently indicated less than the required values even though the compaction work was appropriately executed, the engineer should consider a possibility whether the required value does not match with the actual site condition. In such a case material test should supplementary be done for re-examination. Furthermore, the engineer has to deal with shortage of material and/or equipment by adjusting construction schedule and/or work methodology for minimizing the negative impact as much as possible. In this way, flexibility with certain consideration and examination is highly required ability to the person in charge of the project management.

4.2.2 Soil Mixing Plant

(1) Construction of Foundation Concrete of the Soil Plant

The foundation (RC concrete) is composed of a basement slab and 8 columns, and sidewall. The plant must be set on the columns in totally horizontal. Therefore, the columns must be built in perpendicular and same height. The site engineer shall check top of the column whether they are indicating the same elevation by survey instrument (e.g. total station or auto level). Furthermore, the foundation has to bear weight of the plant (approximately 18 tons) in comparatively long-term. Therefore, site engineer should pay attention to quality assurance of the construction work to prevent collapse accident due to poor work quality. Relevant photos are as shown in Figure 4.2.2.

	
(i) Curing work of concrete columns	(ii) Checking elevation of tops of the columns

Figure 4.2.2 Work Views of the Foundation Work

(2) Daily Inspection and Maintenance Activity of the Plant

Routine activities such as inspection, maintenance and cleaning will be the most effective approach for sustaining good condition and preventing malfunction of the plant. The engineer should pay attention to continuous implementation of the activities. Monitoring daily inspection record is one of the tasks to be done by the engineer.

(3) Material Feeding into the Plant

Base material composed of soil and sand will be prepared by backhoe mixing prior to feeding work into the plant. Feeding work of the material should be executed slowly and gradually in case of applying clayey soil to the material because the soil still may contain large lump of clay even after the backhoe mixing. Sudden collision of the lump may harm vibration device of the feeder unit. Watchman should be assigned beside the feeder unit in case of the feeding work. Related photo (training for the material feeding work) is as shown in Figure 4.2.3.

Figure 4.2.3 Training for Material Feeding Work

4.2.3 Soil Stabilization Work

(1) Material Preparation of the Soil Stabilization Work

Excavated soil in borrow pit still contains high moisture content even in during the mid-dry season in Ayeyarwady delta area. In particular, soil to be applied for the stabilized material requires adjustment of the moisture content determined in accordance with the material test. Therefore, the soil should be placed in the pit or the yard a few days for drying purpose instead of instant application for construction work. Site engineer in charge of material quality control shall examine the applicability of the soil by referring the test result. Related photo is as shown in Figure 4.2.4.

Figure 4.2.4 Soil Drying Work in Yard

(2) Examination of Mixing Degree of the Stabilized Material

Mixing degree of the stabilized material varies depending on soil property such as PI, moisture content, grain size distribution and so on. Therefore, site engineer should examine the degree every plant operation day. JICA Expert Team recommends a simplified examination method by applying "Phenolphthalein solution". The solution is often used as an indicator in acid–base titrations. For this application, the color turns pink in case of touching alkaline object including cement (see Figure 4.2.5). Therefore, the engineer is able to confirm the degree by spraying the solution on surface of the mixture several times. The degree is supposed to be sufficient if all sprayed spots turn pink in uniform.

Figure 4.2.5 Turned Color of the Material due to Acid-Base Reaction

4.2.4 Road Construction Work

(1) Equipment for Compaction Work by Soil Type

Sheep-foot roller should be used for initial compaction work of clayey soil because warty wheel is efficient to squash remaining air-void in the soil. Note vibration function should not be used to prevent over-compaction of the clayey soil. Subsequently, tire roller shall execute compaction work on finishing surface level. Related photos are as shown in Figure 4.2.6.

	
(i) Compaction on finishing surface	(ii) compaction on clayey soil by sheep foot roller

Figure 4.2.6 Compaction Equipment by Soil Type

Completion Report
on
Pilot Project (Phase-2)

Vol. 2 of 2: Appendices

July 2015

The Project for Improvement of Road Technology in Disaster Affected Area in Myanmar

Public Works, Ministry of Construction	**JICA Expert Team**

Appendix-A: Pavement Design Report in the PP-2

Pavement Design Report in the PP-2

1. Introduction

The project implementation team composed of PW and JICA Experts conducted pavement design work to be applied for the PP-2 on Road No. 10 in Bogale Township. The PP-2 will be commenced in February, 2015. Approach and conditions for the design work are described in the following chapters.

2. Design Approach

PW/JICA designed pavement structure to be applied for the PP-2 in 2 steps namely (i) AASHTO empirical method and (ii) Structural Number (SN) principle in ORN31. The design procedures will be described in the following chapters.

3. Design Conditions

3.1 Estimated Traffic Volume in Design Period

(1) Diverted and Generated Traffic

Currently, there is 6 numbers of heavy vehicles in the PP-2 section on Road No. 10 based on the estimate of the District Engineer in PW Pyapon District Office. They have been applied for construction work of Kyaw Chan Ye Kyaw Bridge (KCYK-B). The bridge will be opened in 2017 on the basis of the recent construction schedule. PW/JICA made assumption that the traffic will be certainly increased in the PP-2 section through the following routes once the bridge opens.

- ✓ Traffic of Maubin-Pyapon-Bogale will be diverted to Maubin-Kyaikpi-Bogale.
- ✓ Traffic of Mawgyun-Bogale will be generated.

Current daily traffic volume (heavy vehicle only) on the related routes are as shown in Table 3.1.1. Furthermore, road network related to the PP-2 is as shown in Figure 3.1.1.

Table 3.1.1 Daily Traffic Volume of Heavy Vehicle (2014)

Route	Road No.	Traffic volume (both directions)
Maubin-Pyapon-Bogale		29
Maubin-Kyaikpi(KYCK-B)-Bogale	Rd-1 & Rd-10	6
Mawgyun-(KYCK-B)-Bogale	Rd-10	0

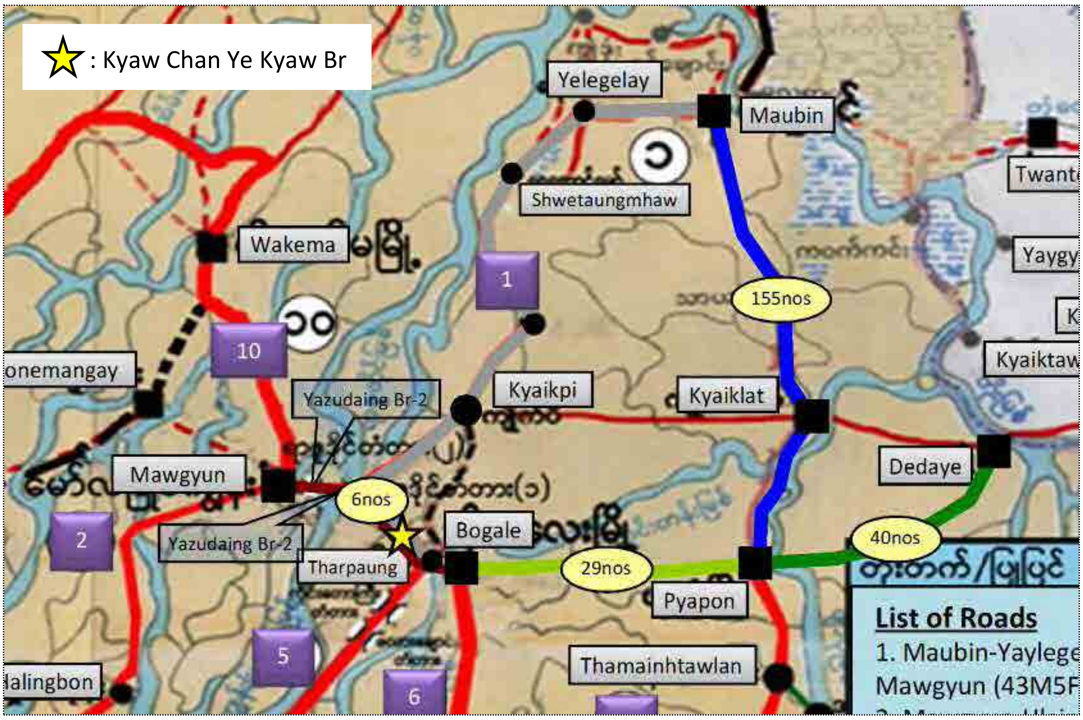


Figure 3.1.1 Road Network Map related to the PP-2

(2) Traffic Growth Ratio

PW/JICA set up the traffic growth ratio in the design period (2015 – 2024) as follows.

- ✓ 2015 – 2016 : 4.5 % per year (Middle value (3.0 – 6.0%) of the design manual)
- ✓ 2017 – 2024 : 6.0 % per year (The ratio will be increased after opening of KYCK bridge)

(3) Cumulative Traffic Volume in the Design Period

PW/JICA estimated the cumulative traffic volume in the PP-2 section during the design period by considering diverted/generated traffic and traffic growth ratio stated above. Result of the estimate is summarized in Table 3.1.2. Note PW/JICA made the following assumptions for the estimate.

- ✓ Numbers of construction vehicles for KCYK-B construction work will not be increased by applying the traffic growth ratio because of their specific purpose to use. Furthermore, they will be removed once the construction work is completed (2017).
- ✓ Traffic volume via Maubin-Pyapon-Bogale will be diverted once KYCK-B opens (2017).
- ✓ Traffic volume via Mawgyun-(KYCK-B)-Bogale also will be generated once KYCK-B opens (2017). 10 numbers were set up as the traffic volume in 2017.

Table 3.1.2 Cumulative Traffic Volume in the PP-2 Section in the Design Period (Nos.)

Year	Maubin-Kyaikpi-(KCYK-B)-Bogale Rd1+Rd10	Mawgyun-(KYCK-B)-Bogale Rd10	Maubin-Pyapon-Bogale
2014	*6.00*	*0.00*	*29.00*
2015	*6.00*	0.00	*30.31*
2016	*6.00*	0.00	*31.67*
2017	*33.09*	**10.00**	
2018	35.08	10.60	
2019	37.18	11.24	
2020	39.42	11.91	
2021	41.78	12.62	
2022	44.29	13.38	
2023	46.94	14.19	
2024	49.76	15.04	
Total (per day)	339.54	98.97	
	438.52		
10 years (x365)	**160,059.68**		

Exist till KYCK-B opening

Generated

Diverted

3.2 Estimated Cumulative Equivalent Standard Axle Loads (ESAL) in Design Period

(1) Vehicle Type, Distribution Ratio and Damage Factor (DF)

PW/JICA set up the target vehicle types and their distribution ratio in accordance with the PW regulation as follows.

(i) 16tons, 2-axles : 15%

(ii) 13tons, 2-axles : 29%

(iii) <13tons, 2-axles : 56%

DF will be slightly varied depending on the design manual to be applied. Calculated DFs by the manual namely ORN31 and AASHTO are listed in Table 3.2.1. The values of AASHTO will be applied for the PP-2.

Table 3.2.1 DF by the Manual

Vehicle type	ORN31	AASHTO
(i) 16tons, 2-axles	2.74	**2.41**
(ii) 13tons, 2-axles	2.00	**1.86**
(iii) <13tons, 2-axles	0.50	**0.55**

(2) Lane Distribution Factor

Proposed lane formation is as shown in Figure 3.2.1. Carriageway is composed of 2 lanes (9 feet per lane). This formation is designated as 1.5 lanes in accordance with the PW regulation. Therefore, cumulative ESAL (both directions) will be multiplied by **0.75**.

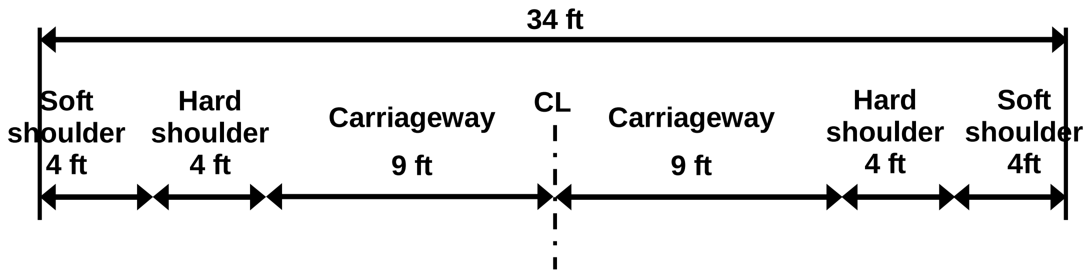


Figure 3.2.1 Proposed Lane Formation in the PP-2

(3) Estimate of Cumulative ESAL in the Design Period

PW/JICA estimated the cumulative ESAL by considering the above stated factors. The result is summarized in Table 3.2.2. The value of **145,122** will be applied for the PP-2.

Table 3.2.2 Cumulative ESAL in the Design Period

Vehicle type	i. 16t, 2-axles	ii. 13t, 2-axles	iii. <13t, 2-axles
Percentage	15%	29%	56%
DF (PW/ORN31)	2.74	2.00	0.50
DF (AASHTO)	2.41	1.86	0.55
Cummulative vehicle numbers	24,009	46,417	89,633
Cummulative ESAL (PW/ORN31)	65,785	92,835	44,817
Total ESAL (2-directions)			203,436
Total ESAL per direction (x 75%)			**152,577**
Cummulative ESAL (AASHTO)	57,862	86,336	49,298
Total ESAL (2-directions)			193,496
Total ESAL per direction (x 75%)			**145,122**

3.3 Reliability (R)

Reliability (R) is the probability that the pavement structure will fulfill the desired performance under the estimated traffic volume and environment in the design period. R is classified according to required function (i.e. importance) of the road in the AASHTO method. Table 3.3.1 indicates the recommended values of R. Further, Reliability coefficient (Z_R) is determined according to the classified R as shown in Table 3.3.2.

PW/JICA assumed Road No. 10 would be categorized to “Local road” in accordance with the American Classification. Therefore, **R = 70%** and **Z_R = -0.524** will be applied. Furthermore, standard deviation (S_0) in case of flexible pavement will be between 0.40 and 0.50 also in accordance with AASHTO. Therefore, **S_0 = 0.45** will be applied.

Table 3.3.1 Recommended R by Road Function

Function	Recommended R (%)	
	Urban	Rural
Interstate road & freeway	85 – 99.9	80 – 99.9
Principal arterial	80 – 99	75 – 95
Collectors	80 – 95	75 – 95
Local	50 – 80	50 – 80

Table 3.3.2 Reliability Coefficient (Z_R) by Determined R

R (%)	Z_R
50	0.000
60	-0.253
70	-0.524
75	-0.674
80	-0.841
85	-1.037
90	-1.282
95	-1.645
99.9	-3.090

3.4 Serviceability

The team determined 2 types of serviceability values namely initial serviceability (**P_0 = 4.2**) and terminal serviceability (**P_t = 2.0**) in accordance with AASHTO.

3.5 Material Coefficient of Each Layer

Strength (e.g. UCS, CBR) of the each layer is able to convert to layer coefficient (a_n) the following graphs (Figure 3.5.1 to Figure 3.5.3). The determined coefficients are summarized in Table 3.5.1.

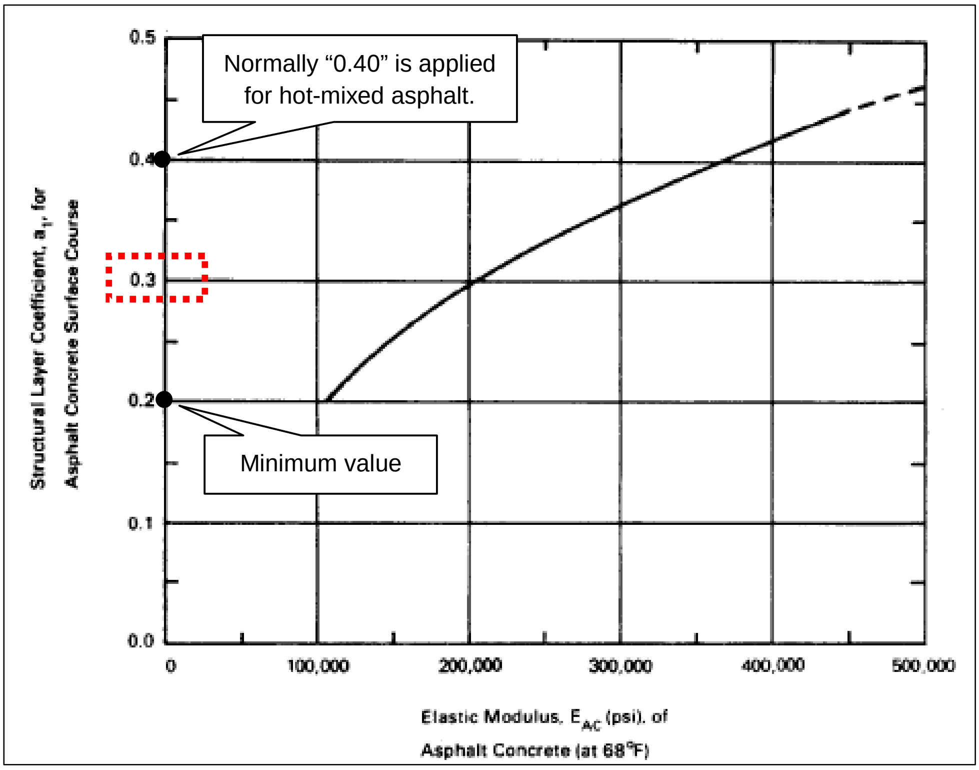


Figure 3.5.1 Correlations between Elastic Modulus & Layer Coefficient in Asphalt Concrete

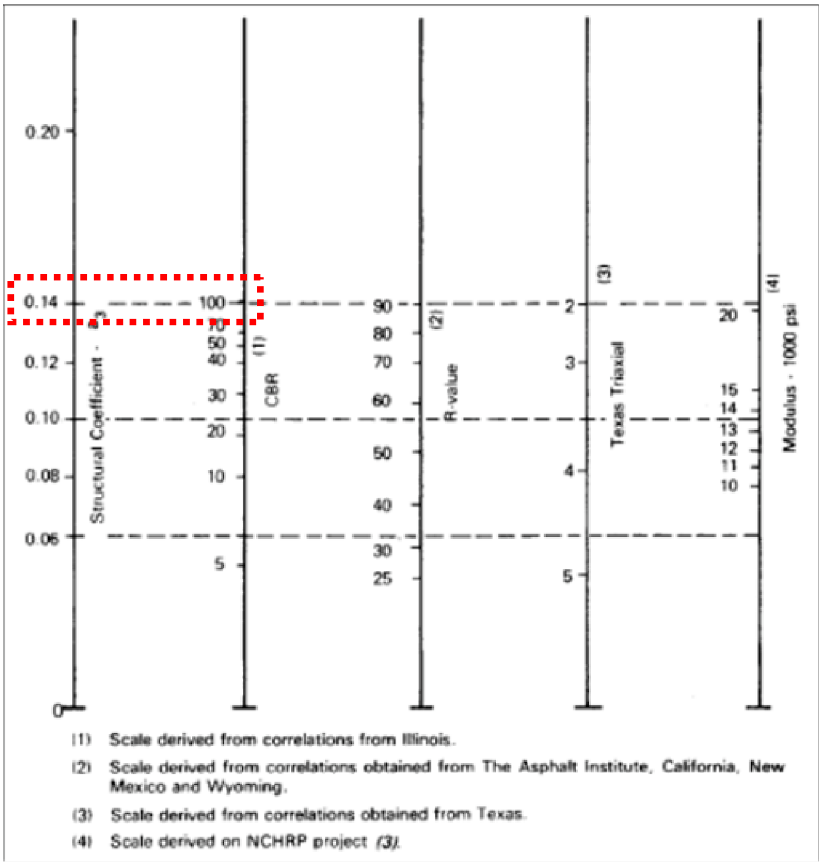


Figure 3.5.2 Correlations between CBR & Layer Coefficient in Granular Base

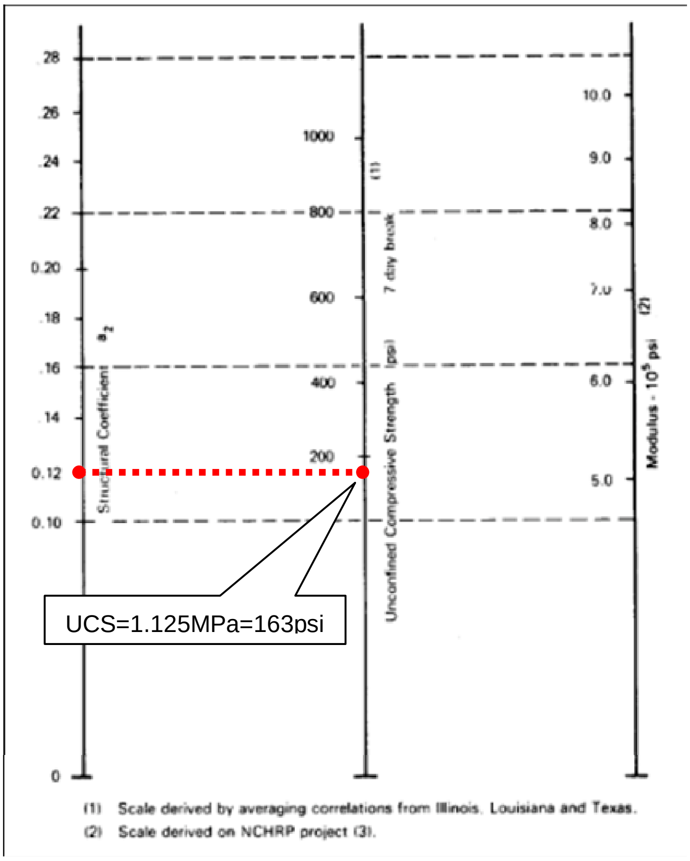


Figure 3.5.3 Correlations between UCS & Layer Coefficient in Cement Treated Base

Table 3.5.1 Layer Coefficient in AASHTO

Layer	Material	Strength	Coefficient (a_n)	Remarks
Wearing	P-macadam	Not available in numeral	0.30	Interim value in Fig.3.5.1
Base	Graded crush stone	CBR=100%	0.14	See Fig.3.5.2
Subbase	Cement stabilized soil	UCS=1.125MPa	0.12	See Fig.3.5.3

(Note) 1.0psi = 0.0069MPa

3.6 Drainage Coefficient of Each Layer

Bottom of subbase course will be set on 3feet higher than previous high water level in accordance with the PW regulation. Therefore, drainage coefficients (m_n) of subbase course and base course will not be considered (i.e. m_n=1.00).

4. Determination of Pavement Formation

4.1 Determination Approach in AASHTO

Required strength of whole pavement structure, which is called the Structure Number (SN), will be calculated by the following formula and the conditions determined in above sections.

$$\log_{10}(W18) = Z_R \times S_0 + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

W18 : Estimated cumulative ESAL (=145,122)

M_R : Resilient coefficient of subgrade (CBR × 1,500 = 4 × 1,500 = 6,000)

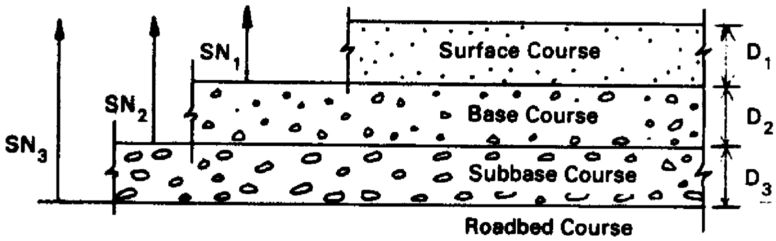
SN : Structure Number (Required strength of whole pavement structure = 2.38)

Z_R : Reliability coefficient (= -0.524 in case of R = 70%)

S_0 : Standard deviation (= 0.45)

⊿PSI : $P_0 - P_t$ (Difference between initial serviceability index and terminal serviceability index of pavement (initial: P_0=4.2, terminal: P_t=2.0)

Furthermore, each layer's thickness should be determined by fulfilling the correlations as illustrated in Figure 4.1.1. Consequently, pavement formation was determined as shown in Table 4.1.1.



$$D^*_1 \geq \frac{SN_1}{a_1}$$

$$SN^*_1 = a_1 D^*_1 \geq SN_1$$

$$D^*_2 \geq \frac{SN_2 - SN^*_1}{a_2 m_2}$$

$$SN^*_1 + SN^*_2 \geq SN_2$$

$$D^*_3 \geq \frac{SN_3 - (SN^*_1 + SN^*_2)}{a_3 m_3}$$

1) a, D, m and SN are as defined in the text and are minimum required values.

2) An asterisk with D or SN indicates that it represents the value actually used, which must be equal to or greater than the required value.

Figure 4.1.1 Procedure for Determining Thickness of Layers by a Layered Analysis Approach

Table 4.1.1 Pavement Formation in AASHTO

Layer	Material	a_n	m_n	Min. thickness (inch)	D_n (inch)	D_n* (inch)
Wearing	P-macadam	0.30		2.00	4.17	**4.50**
Base	Graded crush stone	0.14	1.00	4.00	-1.86	**4.00**
Subbase	Cement stabilized soil	0.12	1.00		3.92	**4.00**

(Note) D_n: minimum required value, D_n^*: actually applied value

4.2 Thickness Modification by ORN31

PW/JICA considered reduction of the wearing course thickness from 4.5" to 3.0" to conform to the previous projects of PW. PW/JICA applied the SN principle stipulated in ORN31 for this approach. That is, the strength of reduced thickness will be substituted by increment of the lower layers' thicknesses (i.e. base and subbase). SN of modified pavement structure (SN_m) will be calculated by the following formula. Furthermore, SN_m should exceed SN of whole pavement structure (=2.38) stated in section 4.1.

$$SN_m = a_1 \times D_1 + a_2 \times D_2 \times m_2 + a_3 \times D_3 \times m_3$$

SN_m : Structure Number of modified pavement structure

a_n : Material coefficient of each layer

D_n : Thickness of each layer (inch)

m_n : Drainage coefficient of each layer

Modified pavement formation to be applied in the PP-2 is as shown in Table 4.2.1.

Table 4.2.1 Modified Pavement Formation

Layer	Material	a_n	m_n	D_n (inch)	SN_m
Wearing	P-macadam	0.30		**3.00**	0.90
Base	Graded crush stone	0.14	1.00	**6.00**	0.84
Subbase	Cement stabilized soil	0.12	1.00	**6.00**	0.72
				Total SN_m	**2.46**

Appendix-B: The Report on Stabilized Material Test at RRL

The Report on Stabilized Material Test at RRL

March, 2014

The Project for Improvement of Road Technology in Disaster Affected Area in Myanmar

Public Works, Ministry of Construction	**JICA Expert Team**

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APPENDIX

1. INTRODUCTION

(1) Overview

Based on the results of mixing tests conducted until now(refer Figure-1.2), the cases that comply with site conditions where the required strength can be anticipated will be identified, and the relationship that exists between the quantities of stabilizer required for test mix design and the manifested strength will be sought.

Because the paving cross-sectional composition in the pilot works is uncertain and it is necessary to investigate the potential of each stabilization method, the following stabilized roadbeds are examined:

・Subgrade stabilization (lime treatment)

・Subbase course stabilization (in-situ soil, in-situ sand mixture + cement): Target improvement strength qu ≧ 0.75 ～1.5 Mpa

・Base course stabilization (in-situ soil, in-situ sand, local crushed stone + cement): Target improvement strength qu ≧ 1.5～3.0 Mpa

(2) Test Method

At RRL, laboratory test methods for compaction testing and so on have been conducted according to BS, and the compaction tests and CBR tests conducted so far have also been performed according to BS.

As for stabilized soil testing, there is a minor difference regarding the unit for measuring mold diameter (centimeters as opposed to inches), but the number of layers and the drop energy on striking (3 layers, 2.5 kilogram rammer, 30 centimeter drop, 25 times for each layer) are the same as in JIS.

In view of the above points, the compaction testing and CBR will be conducted basically according to BS (with mold diameter altered from 10 to 15 centimeters (15.2 centimeters)) while also listening to the opinions of RRL.

Meanwhile, since it is not desirable to become confused with the Sakai manual in the case of stabilized soil testing, this will be conducted according to JIS using a 10 (10.5) centimeter mold., the curing period for samples will be set according to the two cases of JIS and BS.

(3) Mixing Test

1) Stabilization of Existing Sub-grade (Ground)

(a) CBR Test of Existing Sub-grade (Ground)

The existing roadbed (ground) on the target section consists of CL (lean clay) and SM (silty sand). Since it is forecast that compaction will be fairly low during the works, CBR testing with altered compaction (corrected CBR) will be conducted and CBR will be sought according to the site conditions. Moreover, because in-situ density testing hasn’t been conducted (only water content comparison), it is scheduled to implement this as part of the re-consigned geological survey.

(b) Mixing Test on Stabilized Materials

The following table shows the way to use lime and cement based on the BS plasticity index (PI). Since a figure of 20 or more applies to the target area, lime treatment will be targeted. In conventional testing, stable quality Yangon lime has been used, however, the cheaper Phyapon lime, which has question marks regarding the stability of quality, will be tried here.

2) Sub base Course Stabilization (ONR 31, CS)

Cement will be added to in-situ soil + sand mixture, which is anticipated to provide the required strength.

The sand is ocean sand that can be extracted from the nearby coast, although it is extremely fine particle sand. In order to reduce PI to 10 or less, it is necessary to mix in almost 50%, however, because the required strength can be anticipated with a blend ratio of 30%, tests will be implemented with a 30% sand mixture and differing amounts of added cement.

3) Base Course Stabilization (ONR 31, CB2)

The base course consists of a mixture of in-situ sand and crushed stones extracted locally from Myaung Mya (in-situ soil: in-situ sand; C/R=0.15: 0.15: 0.7), and it was confirmed that this generally satisfies the scope of granularity indicated in the BS (the recommended scope is roughly the same in the BS and the Japanese paving standard).

Accordingly, testing on the amount of cement addition will be implemented with respect to this granularity blend. Concerning lime-added blending, consideration will be given to adding good quality lime and crushed stone in future, however, first priority will be given to addition of cement.

Table-1.1 Guide to the type of stabilization likely to be effective

Type of stabilization	Soil Properties					
	More than 25% passing the 0.075 mm sieve			Less than 25% passing the 0.075 mm sieve		
	PI≦10	10<PI<20	PI≧20	PI<6 PP<60	PI≦10	PI>10
Cement	Yes	Yes	-	No	Yes	Yes
Lime	-	Yes	Yes	No	-	Yes
Lime-P0zzolan	Yes	-	No	Yes	Yes	-

Source: ORN 31

STEP1: The combination study of use materials to ensure the necessary strength.

1) Testing of additive mixing suited to the sub-grade accordance with soil physical properties ＝＞Select Slaked Lime for

2) Mixing testing of additives suited to sub-road ＝＞Select Sand 30% and

3) Mixing testing of additives suited to road base materials
＝＞ Select Sand15 %, aggregate 70 % and Cement for

↓

STEP2: The mixing test to determine the design additive content of stabilizer.

1) Mixing test to determine Lime content for stabilized Road base
＝＞For Sub-grade 3.6%(=1.2×3%)
(Targeting Modified CBR is 20%)

2) Mixing test to determine cement content for stabilized Base
＝＞For Sub-base 6.3%(=1.2×5.2%)
For Road-base 6.8%(=1.2×5.6%)

Figure-1.1 Testing Procedure and Results

Table-1.2 RRL Preliminary TEST Result (Step 1) Summary

No	Material	C.B.R (%)	Specified CBR (%)	USC (Mpa)	Specified UCS (Mpa)	Consistency			O.M.C (%)	M.D.D (g/cm^3)
						L.L(%)	P.L(%)	PI(%)		
For Capping Layer (For Sub-grade)										
1	CLSoil (CBR 3%)+ Lime 4 %	19	> 15			43.0	27.8	15.2	14.0	1.674
2	CLSoil (CBR 4%)+ Lime 4 %	20	> 15			39.0	25.1	13.9	13.0	1.690
3	SM Soil (CBR 6%)+ Lime 4 %	27	> 15			37.5	24.4	13.1	10.6	1.834
For Sub-base Course										
1	Cement 4% + Soil	40	>70			50.0	25.0	25.0	12.0	1.724
2	Cement 6% + Soil	50	>70			48.0	25.0	23.0	9.0	1.733
3	Soil + Sand 10% + Lime 4 %			0.6	0.75 - 1.5	34.8	24.0	10.8	12.0	1.740
4	Soil + Sand 10% + Lime 6%			0.72	0.75 - 1.5	32.0	23.3	8.7	11.9	1.733
5	Soil 70%+ Sand 30% + Lime 8%			0.69	0.75 - 1.5	34.0	23.0	11.0	14.7	1.751
6	Soil 70%+ Sand 30% + Lime 10%			0.65	0.75 - 1.5	35.0	24.0	11.0	13.2	1.725
7	Soil + C/R (30: 70) + Lime 4%			0.7	0.75 - 1.5				25.0	1.458
8	Soil + C/R (25: 75) + Lime 6%			0.9	0.75 - 1.5				11.6	1.724
9	Soil + C/R (30: 70) + Lime 6%			0.78	0.75 - 1.5				15.0	1.850
10	Soil + Sand 10% + Cement 4 %			0.76	0.75 - 1.5	32.0	21.0	11.0	11.6	1.828
11	Soil + Sand 10% + Cement 6 %			1.11	0.75 - 1.5	37.0	30.0	7.0	11.7	1.879
12	Soil 50% + Sand 50% + Cement 6%			1.4	0.75 - 1.5	26.0	20.0	6.6	10.5	1.816
13	Soil + C/R (25: 75) +Cement 4%			1.00	0.75 - 1.5				10.0	1.898
14	Soil + C/R (25: 75) +Cement 6%			1.25	0.75 - 1.5				13.0	1.818
15	Soil + C/R (25: 75) +Lime 6%	46.5			0.75 - 1.5					
16	Soil + C/R (30: 70) +Lime 6%	50.0			0.75 - 1.5					
17	Soil + C/R (25: 75) +Lime 10%	49.8			0.75 - 1.5					
For Road-base Course										
1	Soil + C/R (25 : 75) + Lime 8%			0.8	0.1.5 – 3.0				18.9	1.943
2	Soil + C/R (25 : 75) + Lime 10%			0.7	0.1.5 – 3.0				18.0	1.762
3	Soil 15% + Sand 15% + C/R (70%) + Cement 8%			3.6	0.1.5 – 3.0				14.0	1.954
4	Soil 15% + Sand 15% + C/R (70%) + Cement 10%			3.9	0.1.5 – 3.0				12.6	1.983

2. CBR TEST TO EVAUETE THE EXISTING SUB GRADE

(1) Objective

In order to find out the compaction degree and the CBR existing sub-grade or filled up ground, we shall execute a compaction test and some CBR test that numbers of blows to make specimen are changed in some cases.

(2) Type of soil

・CL-Soil

Figure-2.1 shows the sieve distribution of CL-soil and SM-soil.

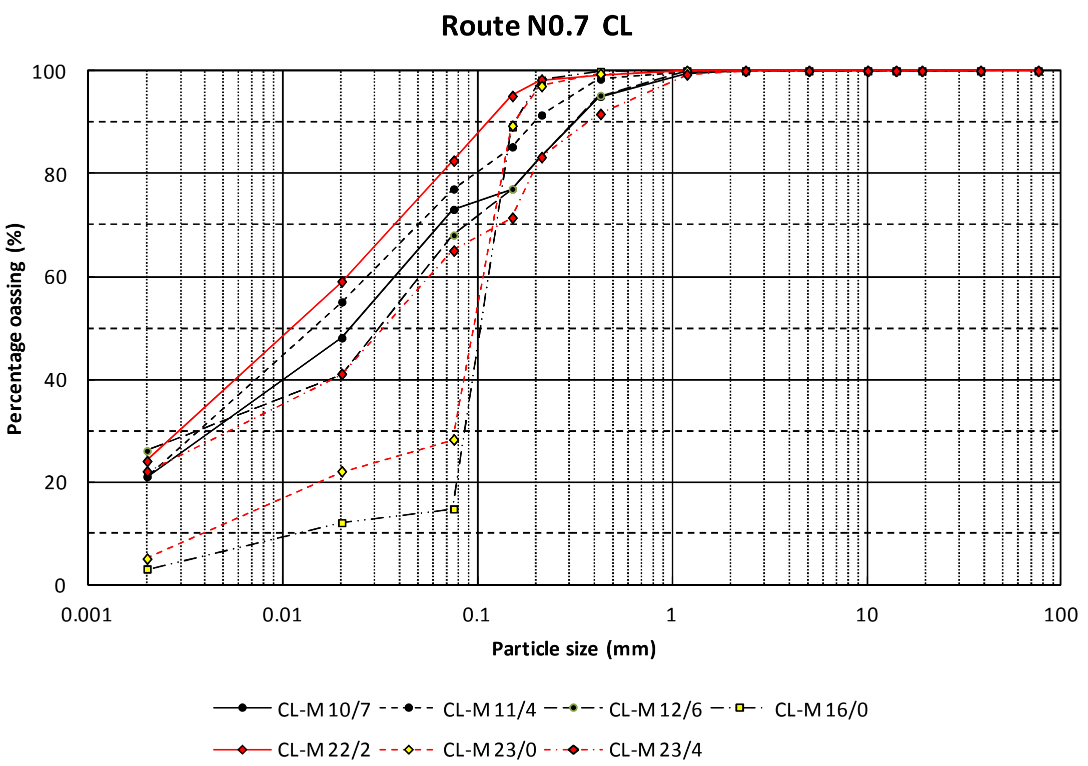


Figure-2.1 The Sieve Distribution of CL, SM soils

Photo-2.1 Taking sample soil for laboratory test

(3) Compaction Test

RRL used 105mm mold and 4.5 kg rammer with ϕ 105mm mold for compaction test at last test. In this case, we shall use 152 mm mold and 4.5kg rammer as same as CBR test

Table-2.1 Compaction Test (Sub-grade)

British Standard (BS) RRL						Remarks (JIS D-method)
Inside Diameter Of Mold (cm)	Rammer Weight (kg)	Impact Height (cm)	Number of Tamping Layer	Tamping Numbers per each layer	Allowable Maximum particle Size	
15.2	4.5kg	45	5	62	(20mm)	ϕ 15cm 5 layer 55 each layer

(4) CBR Test

We shall hold four cases CBR test changed compaction energy to compact soil.

The moisture content using for compacting soil are same as the optimum moisture content or slightly more than optimum moisture content.

Table-2.2 CBR TEST (Sub-grade)

	British Standard (BS) RRL						Remarks (JIS Modified CBR)
	Inside Diameter Of Mold (cm)	Rammer Weight (kg)	Impact Height (cm)	Number of Tamping Layer	Number of blows per layer	Soaked Duration	
1 2 3	15.2	4.5	45	5	15/layer 30/layer 62/layer	4 days	
4	15.2	4.5	45	3	67/layer	4 days	Additional case JIS Design CBR

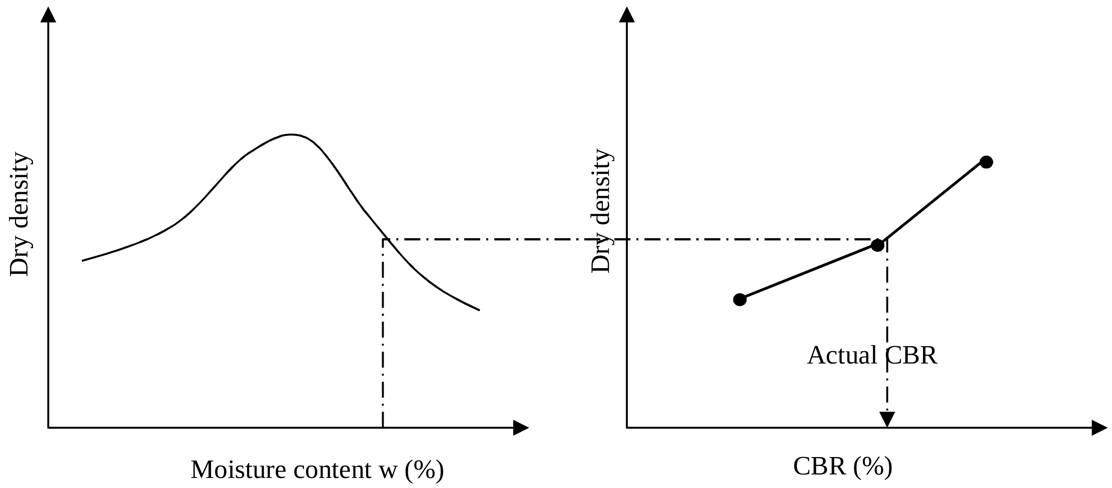


Figure-2.2 Evaluation method of existing subgrade CBR

(5) The evaluation of existing sub-grade CBR

The CBR at the existing sub-grade can be estimated as following

Step 1: Survey the dry density in-situ.

Step 2: Examine three point method specified BS 1377-part4 in order to get the relationship between dry density and CBR.

Step 3: Seek CBR matched the dry density by using Figure-2.4.

The relationship CBR values and dry density in specimens for CBR test is shown in Figure-A.1.4.

The compaction degree of existing subgrade was 85% at the density test results carried out in situ,Therefore, it is reasonable to be considered that the existing subgrade is 2% as following.

・Maximum dry density ρ_d = 1.96 (g/cm^3)
・Dry density in-situ = = 1.66 (g/cm^3)
・Degree of Compaction = 85%
・CBR in-situ = 2% at dry density is 1.66 (g/cm^3)

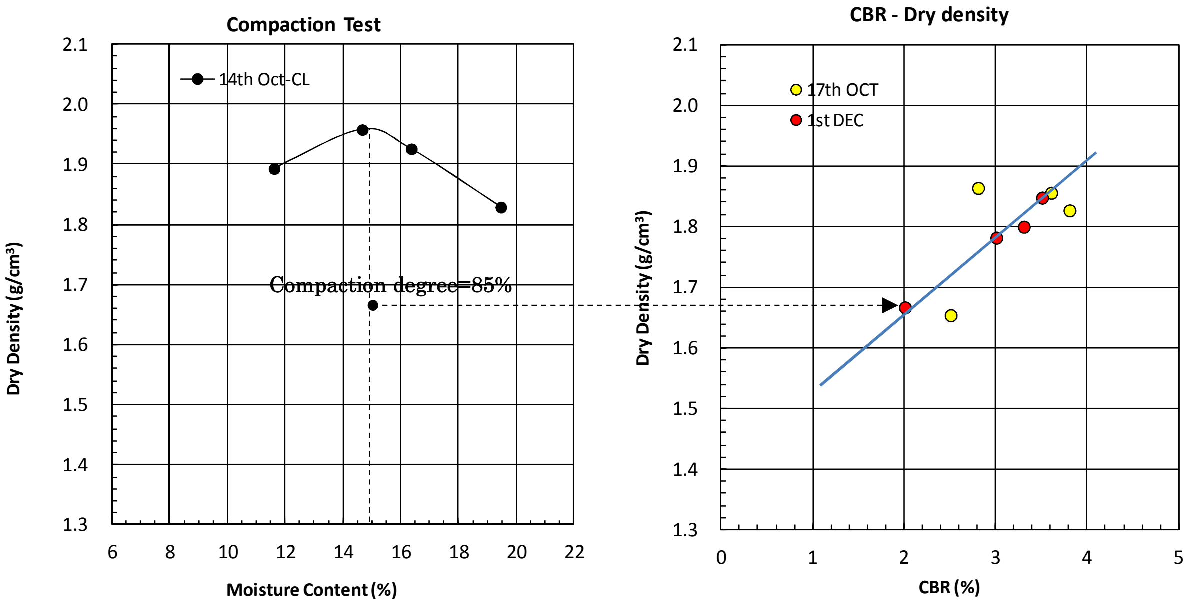


Figure-2.3 Relationship between CBR values and dry density

Table-2.3 Dry Density of Existing-Sub grade (the testing date 12/02/2014)

Location		Dry Density		Moisture content
		(g/cm^3)	(g/cm^3)	w_n (%)
1	0m	16.97	1.73	16.0
2	45m	15.55	1.59	17.0
3	75m	16.49	1.68	17.5
4	120m	16.65	1.7	17.0
5	150m	16.34	1.67	15.0
6	195m	15.55	1.59	15.0
7	225m	16.9	1.72	15.0
8	270m	16.2	1.65	16.0
9	330m	16.7	1.7	16.2
10	390m	16.5	1.68	16.3
11	435m	15.9	1.62	16.0
12	480m	16.3	1.66	16.4
13	525m	16.1	1.64	16.0
15	570m	16.2	1.65	16.0
15	615m	15.8	1.61	16.4
16	660m	16	1.63	16.7
17	720m	16.5	1.68	15.9
18	780	16.8	1.71	16.3
Average		16.30	1.66	16.15
Standard deviation		0.418	0.041	0.662

Photo-.22 Dry Density Test of Existing Subgrade in situ

3. MIXING TEST OF STBILIZED MATERIALS

3.1 Stabilization of Sub grade

(1) Type of soil

・CL-Soil, ~~SM-Soil, two patterns~~

(2) Type of stabilizer

We shall use lime for stabilized sub-grade according to following reasons.

- The soil property at Ayeyarwady delta has high plasticity(PI) and high moisture content(w_n). In that case, Lime is seemed to be more effective than cement for stabilizer from experiences especially in Japanese.
- Last test data executed by RRL have indicated that Lime stabilization improved the soil's strength sufficiently (refer table-3.1)

But in this time, we shall use Phyapon Slaked Lime instead of Yangon Slaked Lime.

Table-3.1 The Existing Test Result by RRL

No	Type of Soil	Unified soil	O.M.C(%)	MDD	CBR (%)
1	Soil (CBR 3%)+Lime 4%	CL	14.0	104.5 pcf (1.675 g/cm^3)	19
2	Soil (CBR 3%)+Lime 4%	CL	13.0	105.5 pcf (1.691 g/cm^3)	20
3	Soil (CBR 3%)+Lime 4%	CM	10.6	114.5 pcf (1.835 g/cm^3)	27

(3) CBR Test

We shall do the test according to Japanese manual excluding curing period of specimen basically.

Natural moisture content shall be used to CBR test.

・ w_n = 17～18 %

Table-3.2 Compaction Test and CBR Test for Sub-grade Stabilization Design

	JIS					Remarks
	Inside Diameter Of Mold (cm)	Rammer Weight (kg)	Impact Height (cm)	Number of Tamping Layer	Number of blows per layer	
Compaction test	15.2	4.5	45	3	67/layer	Water content 3case
Design CBR	15.2	4.5	45	3	67/layer	

We shall take into two type curing period of the specimen as follows,

Table-3.3 Comparison of Curing Period for Specimen

		CASE 1 (JIS)		CASE 2 (BS)		Test method
		Indoor curing	Immersion curing	Moist curing	Immersion curing	
Road Base	Lime Stabilized	9 days	1 day	21 days	7 days	Unconfined compression test
	Cement Stabilized	6 days	1 day	7 days	7 days	
Sub-Base	Lime Stabilized	9 days	1 day	21 days	7 days	
	Cement Stabilized	6 days	1 day	7 days	7 days	
Subgrade	Lime Stabilized	6 day	4 day	21 days	7 days	CBR
	Cement Stabilized	3 day	4 day	7 days	7 days	
Remarks		~~20℃~~ 25℃	~~20℃~~ 25℃	25℃	25℃	

(4) Combination of lime

We shall consider three or four cases of combination in according to additive lime content.

Table-3.4 Test Case for Stabilized Sub-grade

	Lime additive content				Moisture content
	2%	4%	6%	8%	Depend on the time of pilot project Maybe w_n = 17～18 %
CL-Soil	○	○	○	○	
~~SM-Soil~~	~~○~~	~~○~~	~~○~~		

(5) Mixing test results

Table-3.5 and Figure-3.1 show the testing result of stabilized sub-grade.
Photo-3.1 shows some situations of the laboratory test.

Table-3.5 Test results of stabilized sub-grade

Additive content				2%	4%	6%	8%	Remarks
Stabilized sub-grade	Lime	Dry density(g/cm^3)		1.63	1.68	1.80	1.65	
		Water content (%)		12	14	17	14	
		CBR	6day+4day	15	20	30	31	JIS
			21day+5day	18	22	32	34	BS
	Cement	Dry density(g/cm^3)		1.67	1.71	1.86	1.92	
		Water content (%)		17	17	17	17	
		CBR	6day+1day	29	35	45	55	JIS
			7day+7day	34	46	52	65	BS

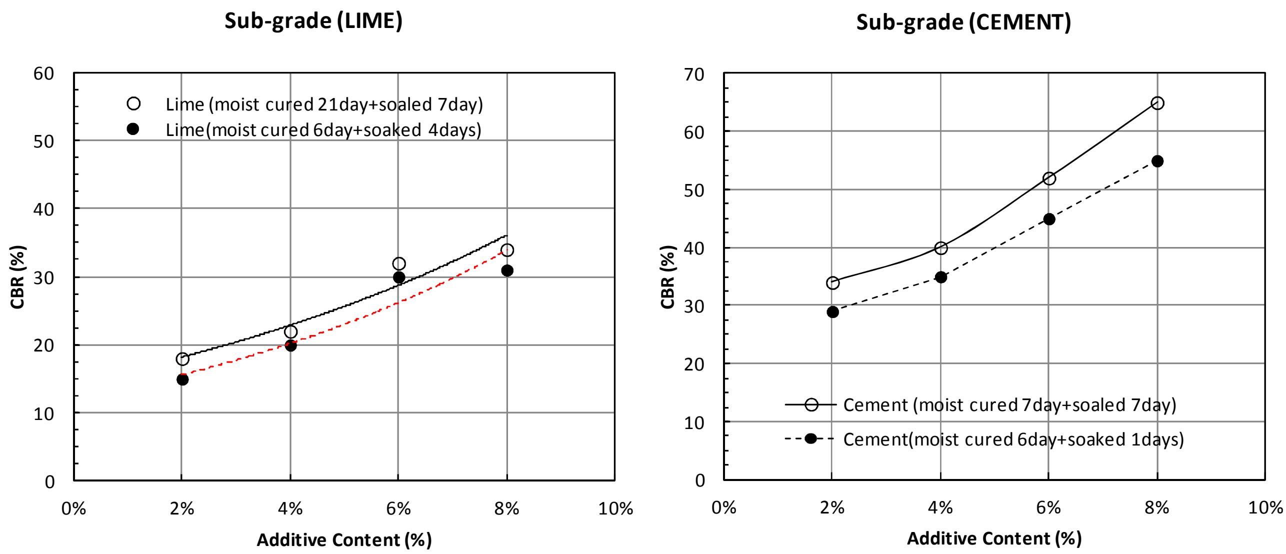


Figure-3.1 Stabilized sub-grade Mixing testing results

Photo-3.1 CBR Test On Stabilized Subgrade Material

3.2 Stabilization of Sub base (CS)

(1) Type of stabilization

We shall select soil, sand and cement mixed stabilization because the onset of strength of this type seems to be enough for required strength and to be more economical than other type.

Table-3.6 Existing Testing Case for Stabilized Sub-base (CS, CB2)

Cement stabilization UCS (Mpa)								Requirement
				Additive content of stabilizer				
				4%	6%	8%	10%	
Cement	Soil 90%	Sand 10%		0.76	1.1			CS: 0.75-1.5(0.98Mpa) CB2: 1.5-3.0(2.9Mpa)
	Soil 50%	Sand 50%			1.4			
	Soil 25%		C/R 75%	1.0	1.25			
	Soil 15%	Sand 15%	C/R70%			3.6	3.9	
Lime	Soil 70%	Sand 30%				0.69		CS: 0.75-1.5(0.7Mpa) CB2: 1.5-3.0(0.9Mpa)
	Soil 70%	Sand 30%				0.65		
	Soil 30%		C/R 70%	0.7	0.78			
	Soil 25%		C/R 75%		0.9	0.8	0.7	
Remarks								( ) JIS

(2) Consistency test

First, some consistency tests in accordance with mixed sand amount shall be executed to select the suitable plasticity index (PI), it seems PI is better less than ten in order to be performed good workability mixing soil, sand and cement, and to obtain higher strength.

(3) Compaction test

We shall do compaction test to obtain optimum water content of the mixed soil, we may select one case that cement additive content is 4 %.
The compaction method is as following,

- Mold diameter 105mm (100mm)
- Mold height 115.5mm (127mm)
- Rammer weight 2.5kg
- Impact height =30cm
- Number of layers =3 layer
- Tamping number of each layers 27(25) times

( ) indicates JIS size

(4) Preparing the specimen and unconfined compression test

The specimen with optimum water content shall be made the same way as the compaction test.

But, if we don't have enough number of molds the modification shown in Table-3.8 is reasonable.

Notes) The stabilizing additive amount is shown as percentage of the dry mass of soil materials.

The water content of the stabilizing additive compound mixture is shown as percentage of the stabilizing additive and specimen dry mass.

In this test, we shall take into two type curing period of the specimen as follows,

・6 days for indoor curing and 1day for water immersion, total 7 day (in case of JIS).

・7 day for indoor curing and 7 days for water immersion, total 14 days (in case of BS).

Table-3.7 Test Case for Stabilized Sub-base (CS)

		Consistency Test PI (%)	Cement blending test				Remarks
			Cement additive cement				
			2%	4%	6%	8%	
Sand blending	0%	20.0					
	10 %	15.0		0.76	1.1		
	20%	13.0					
	30%	12.0	○	○	○	○	Candidate case
	40%						
	50%				1.4		
Remarks							Cement is made in Thailand

Table-3.8 Mold Size and Compaction Energy

Mold Type	Mold size		Rammer Weight (kg)	Impact Height (cm)	Number of Layer	Tamping Numbers per each layer	Compaction Energy Ec (KJ/m^3)
	Diameter (mm)	Height (mm)					
BS Mold	105	115.5	2.5	30	3	27	595.6
JIS Mold	100	127	2.5	30	3	25	552.9
Other Mold ϕ 100mm h=200mm	100	200	2.5	30	5	24	561.8

$$\text{CompactionEnergy} \quad E_c = \frac{W \times H \times \text{Layer} \times \text{Browtimes}}{\text{Volume}}$$

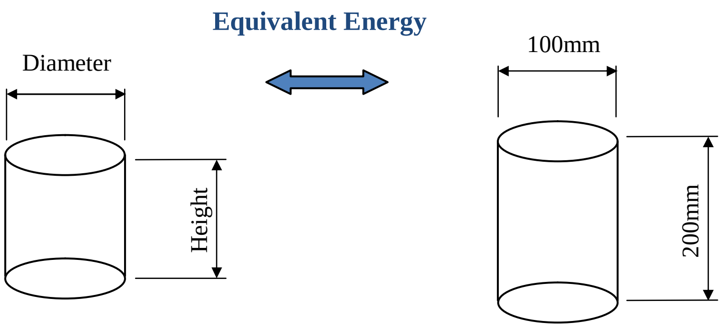


Figure-3.2 Equivalent Compaction Energy

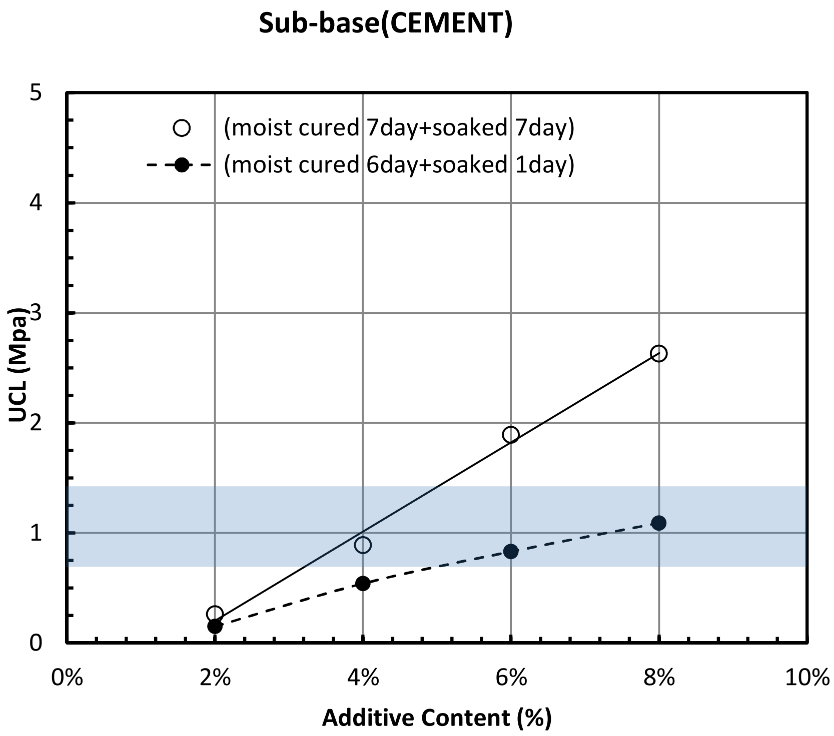
(5) Mixing test results

Table-3.9 and Figure-3.3 show the testing result of stabilized sub-base (CS).

Table-3.9 Test results of stabilized sub-base (CS)

Additive content				2%	4%	6%	8%	Remarks
Stabilized sub-base (CS)	Cement	Dry density(g/cm^3)		1.62	1.66	1,67	1.69	
		Water content (%)		12	14	18	19.5	
		UCS (Mpa)	6day+1day	0.12	0.43	0.66	0.87	JIS
			7day+7day	0.21	0.71	1.89	2.63	BS
		×1.25*	6day+1day	0.15	0.54	0.83	1.09	
			7day+7day	0.26	0.89	2.36	3.28	

Note: ×1.25* Correction Factor accordance with specimen type (ORN31 pp29)



(include the correction factor accordance with specimen type)

Figure-3.3 Stabilized sub-base (CS) Mixing testing results

Photo-3.2 Mixing Test of Stabilized Materials for Subbase

3.3 Stabilization of Rad base (CB2)

(1) Test case for Stabilized Road-base

Table-5.1 shows the existing test case for stabilized Road base at step one

From in these test cases, we selected the Cement for stabilizer, testing material is mixing soil with soli, sand and crusher run which mixing ratio is 15%: 15* 70%.

Figure-3.10 shows the sieve distribution the mixing material used in this test.

Table-3.10 Test Case for Stabilized Road-base (CB2)

				PI (%)	Cement blending test					Remarks
					additive cement					
Stabilizer	Soil	Sand	C/R		2%	4%	6%	8%	10%	
Lime	25%	0	75%				(0.9)	(0.8)	(0.7)	CB2: 1.5-3.0 Mpa
	30%	0	70%			(0.7)	(0.76)	△	△	
Cement	25%	0	75%			(1.0)	(1.25)			CB2 :1.5-3.0 Mpa
	15%	15%	70%			○	○	○ (3.6)	(3.9)	
Remarks				Soil: CL, in situ Sand: sea sand near the site C/R: Myaung mya						

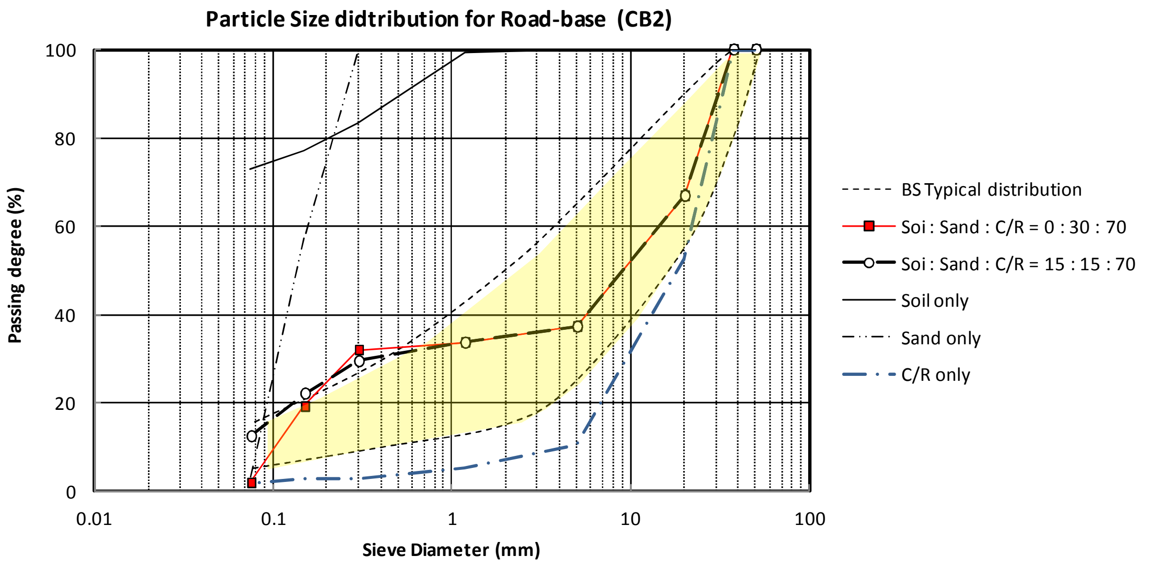


Figure-3.4 Sieve Distribution of Mixing Soil Materials

(2) Preparing the specimen and unconfined compressive test

That is same as stabilized sub-base test.

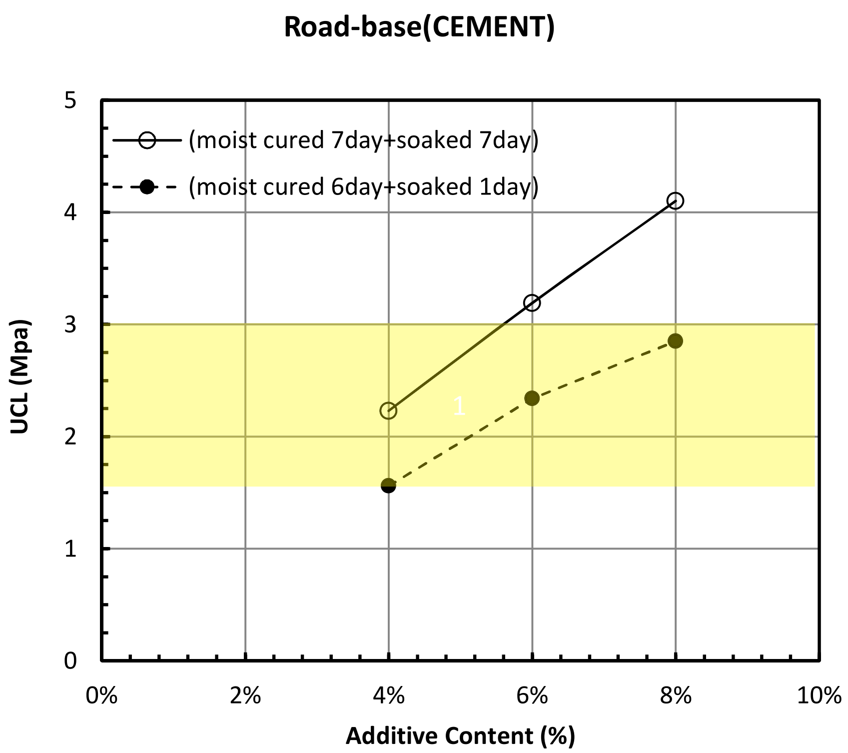
(3) Mixing test results

Table-3.11 and Figure-3.5 show the testing results of stabilized Road-base.

Table-3.11 Test Results of Stabilized Road-base (CB2)

Additive content				4%	6%	8%	Remarks
Stabilized RoadBase (CB2)	Cement	Dry density(g/cm^3)		2.02	2.00	1.96	
		Water content (%)		9.5	11.7	14	
		UCS (Mpa)	6day+1day	1.25	1.87	2.28	JIS
			7day+7day	1.78	2.55	3.28	BS
		×1.25*	6day+1day	1.56	2.34	2.85	
			7day+7day	2.23	31.9	4.10	

Note: ×1.25* Correction Factor accordance with specimen type (ORN31 pp29)



(including the correction factor accordance with specimen type)

Figure-3.5 Stabilized Road-base (CB2) Mixing Testing Results

Photo-3.3 Mixing Test of Stabilized Materials for Road base

4. DESIGN STABILIZED SUBGRADE AND SUBBASE

4.1 Design additive Ratio

In accordance with the preliminary laboratory mixing test results, which were executed from this July to September, RRL have selected the cases that would seem to be satisfied the specimen strength specified in ORN31, the tested items in detail mixing test (Step2) are shown in Table-4.1

Table-4.1 The mixing test contents in detail mixing test (Step2)

Layer	Materials content			PI (%)	Additive	Remarks
	Soil	Sand	C/R			
Sub-grade	100%	0%	0%	20	Lime	PI is more than 20 (from ORN31, pp28)
Sub-base (CS)	70%	30%	0%	13	Cement	use sea sand
Road-base (CB2)	15%	15%	70%	10	Cement	Use sea sand and Myang Mya crushed rock

C/R: Crusher-run, PI: Plasticity Index

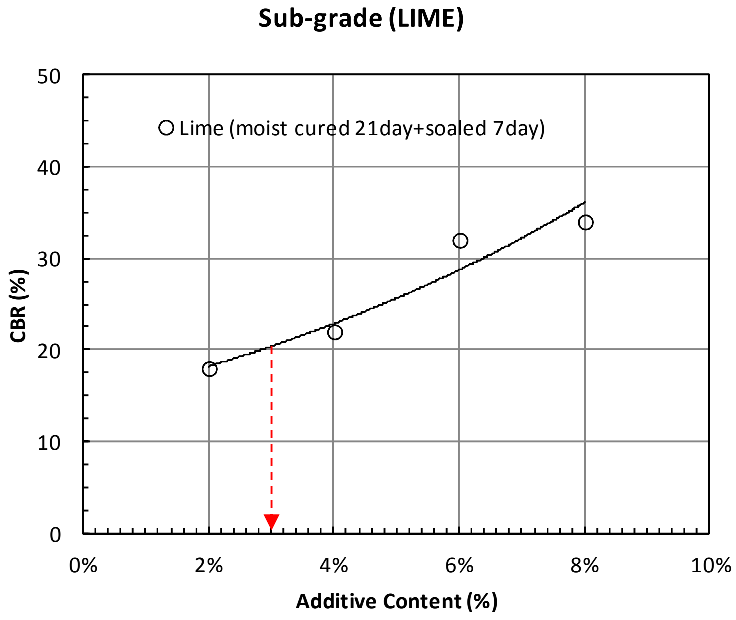
The relationships between stabilizer additive content and the specimen strength are shown Figure-4.1, the strength shown in this Figure is already included the correction coefficient corresponding to the shape of the specimen as showing in Table-4.2.

On the basis of these testing results, we shall take account of the rate of premium as shown in Table-4.3 in order to deal with some uncertainty of field works.

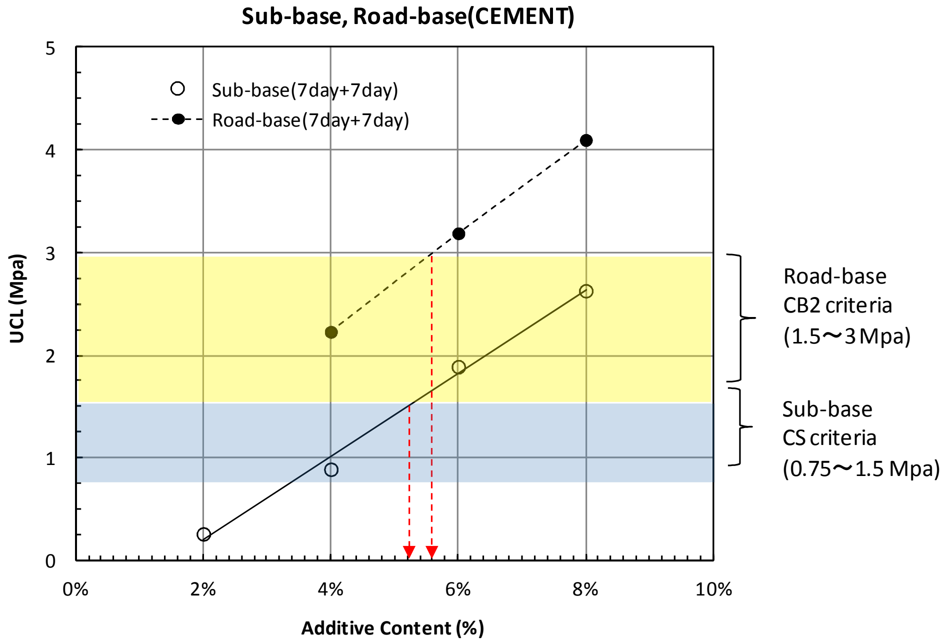
RRL has carrying out the tests on relationship between the strength of stabilized materials and compaction degree now and so it is necessary to consider the appropriate premium rate taking into account These test results and the field test data in the pilot project-1.

Rate of Premium α =Function (agitation・compaction degree, soil property in situ, etc.)

Design additive content = $(1+\alpha)\times$ Laboratory additive content



(a) Stabilized sub-grade by LIME



(b) Stabilized sub-base, road-base by CEMENT

(include the correction factor accordance with specimen type)

Figure-4.1 Relationship between Additives Content and Strength

Table-4.2 Correction Factors to calculate Equivalent Cube Strengths

Test piece type	Correction Factor
150 mm cubes	—
200 mm×100 mm diameter	1.25
115.5 mm×105 mm diameter	1.04
127 mm×152 mm diameter	0.96

Table-4.3 Rate of Premium for In-situ Stabilized Materials

Depth Stabilized Layer D(cm)	Soil Type	Rate of Premium α	Remarks
D < 50cm	Sandy Clay Cohesive Soil	15 ～ 20%	used α=20%
D ≧ 50cm	Sandy Clay	20 ～ 40%	
	Cohesive Soil	30 ～ 50%	

Source: Japanese manual

The construction unit prices of each pavement structures are shown in Table-4.4, it is noted that these construction unit prices were estimated according to Japanese construction estimate manual.

Table-4.4 Unit Cost of Each Pavement Structures (Direct Cost)

(Currency: Kyat)

Item	Sub-base		Road-base		Remarks
	Stabilized materials (CS)	Granular (GS)	Stabilized Material (GB2)	Granular (GB)	
Material	15,130	36,460	30,880	47,680	
Machinery	17,590	4,140	17,590	5,520	Rental fee include fuel, operator
Worker	140	40	140	50	
Sum(kyat/m^3)	32,860	40,650	48,610	53,250	
Remarks	Cement= 1.2×5.2=6.3%	Produced in Mandalay	Cement= 1.2×5.6=6.8%	Produced in Mandalay	

4.2 Evaluation of CBR on Subgrade Considering Stabilized Subgrade

(1) Average CBR for a location

Each value of the CBR, obtained from several kinds of the materials shall be calculated according to the following formula and the CBR calculated can be defined as the average CBR for a location in question:

$$CBR_m = \left(\frac{h_1 CBR_1^{1/3} + h_2 CBR_2^{1/3} + \qquad + h_n CBR_n^{1/3}}{100} \right)^3$$

CBR_m : Average CBR of a location in question

$CBR_1, CBR_2, \cdot\cdot\cdot\, CBR_n$: CBR value of soil layers No.1,2,・・・・n

$h_1, h_2 \cdot\cdot\cdot\, h_n$: Thickness (cm) of soil layers No.1,2,・・・n, $h=h_1+h_2+\cdot\cdot\cdot\, h_n=100cm$

(2) Average CBR in consideration of stabilized sub-grade

If the existing sub-grade is weak there is a possibility that can not be mixed soil and stabilizer, and compacted stabilized materials sufficiently at near the bottom of n stabilized layer.

Considering such the phenomenon, it should be noted that the calculation method of average CBR is not same between CBR is three or more and less than three in Japanese pavement design standard.

If the sub-grade which existing CBR is less than three is stabilized, the depth of effective stabilized layer shall become the thickness obtained by subtracting 20cm from stabilized depth. And then the CBR for 20cm thickness from the bottom of stabilized sub-grade is taken the average value of existing sub-grade CBR and the CBR at stabilized sub-grade.

On the other hand, if the CBR at existing sub-grade is three or more, it does not need to perform such the reduction.

$$CBR_m = \left(\frac{h_1 CBR_1^{1/3} + 20\left(\frac{CBR_{improve} + CBR_1}{2} \right)^{1/3} + (h_2 - 20) CBR_{improve}^{1/3}}{100} \right)^3$$

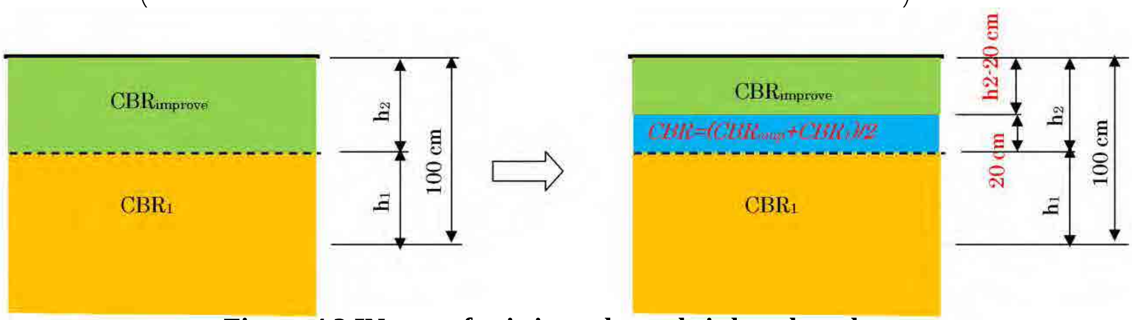


Figure-4.2 IN case of existing sub-grade is less than three

(3) Example of calculating average CBR at stabilized and existing sub-grade

The examples of calculating average sub-grade CBR are shown bellow.

1) Existing sub-grade CBR is two and stabilized sub-grade CBR is fifteen

$$CBR_m = \left(\frac{55 \times 2^{1/3} + 20 \times \left(\frac{2+15}{2} \right)^{1/3} + (45-20) \times 15^{1/3}}{100} \right)^3 = 5.07$$

2) Existing sub-grade CBR is three and stabilized sub-grade CBR is fifteen

$$CBR_m = \left(\frac{73 \times 3^{1/3} + 27 \times 15^{1/3}}{100} \right)^3 = 5.07$$

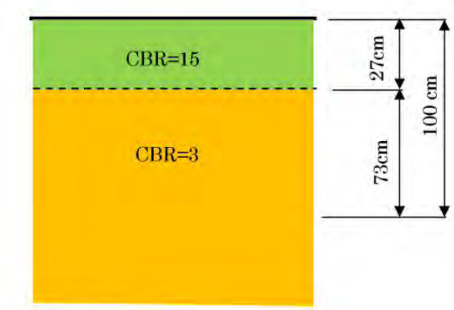


Figure-4.3 IN case of existing sub-grade CBR is three or more

For target average CBR , the relationship derived by above equations between CBR at existing sub-grade and the depth required to be stabilized are shown in Figure-6.4

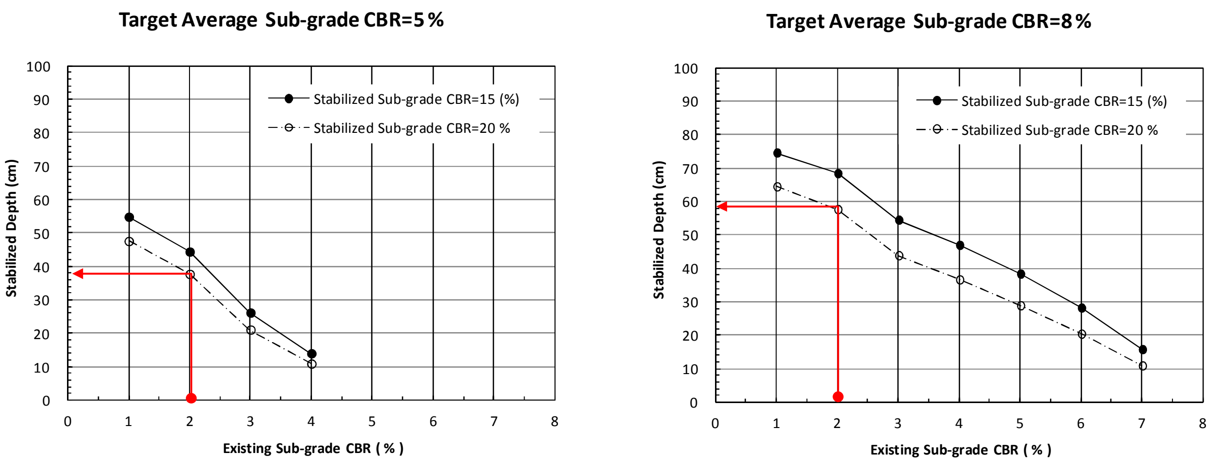


Figure-4.4 The relationship between CBR and necessary stabilized

5. CONTROL OF HEXAVALENT CHROMIUM

5.1 Simplified Hexavalent Chromium Test

(1) General

Cement is often used as a method to contain deleterious materials physically so that it has superior capacity to fix material.
Although depending on the type of soil and mineral mixed with cement, the hydration reaction to be related with the capacity to fix material is inhibited, and accordance with this phenomenon some hexavalent chromium contained in the cement will be eluted into water.
Thus, when using improved soil and stabilized pavement with cement, it is necessary to confirm the safety by testing a hexavalent chromium in laboratory before construction in-situ. It is necessary to be careful especially if we use a volcanic cohesive soil and highly organic soil.

It is noted that even if hexavalent chromium reference value or higher is detected it is possible to reduce the hexavalent chromium leaching amount depending on the type of cement even in the same mixed soil. Therefore, if hexavalent chromium reference value or higher is detected, it will make a re-tested in the following order.

1. Change of cement type
2. Change of mixed soil
3. Changes to the other method, such as lime stabilization

(2) Test method

Test method described below shows a simple method that can be tested easily in situ, but to inspect accurate hexavalent chromium elution amount is difficult by using simple kit shown herein.

Therefore, hexavalent chromium is detected by this simple testing ,and if we need to check the exact hexavalent elution amount the detail testing shown in appendix-3 shall be executed in order to comparison with the Myanmar national environmental standards.

(a) create a sample soil

After air-drying gathered soil, we pick out fine material less than 2mm from gathered soil without crushing process.

(b) Preparation of the sample solution

After weighing the sample of 2mm or less, put the sample into a container for shaking, subsequently, and then put the solvent by weight of 4-times of the sample into the container. The solvent is made by mixing pure water and hydrochloric acid, and it is required that Hydrogen-ion concentration of the solvent is more than 5.8 and less than 6.3.

(c) Shaking

Shake the container vigorously for 5 minutes by hand or by using suitable equipment.

(d) Still standing

Leave the container quietly for five minutes.

(e) filtration

Suck out the supernatant water by using a syringe after standing. Then, attach a membrane filter with 0.45 μm to the syringe, filter the supernatant and keep the filtered supernatant in a beaker.

(f) Analysis of hexavalent chromium

Using a simple kit for detecting hexvalent chromium, analyze the concentration of hexavalent chromium.

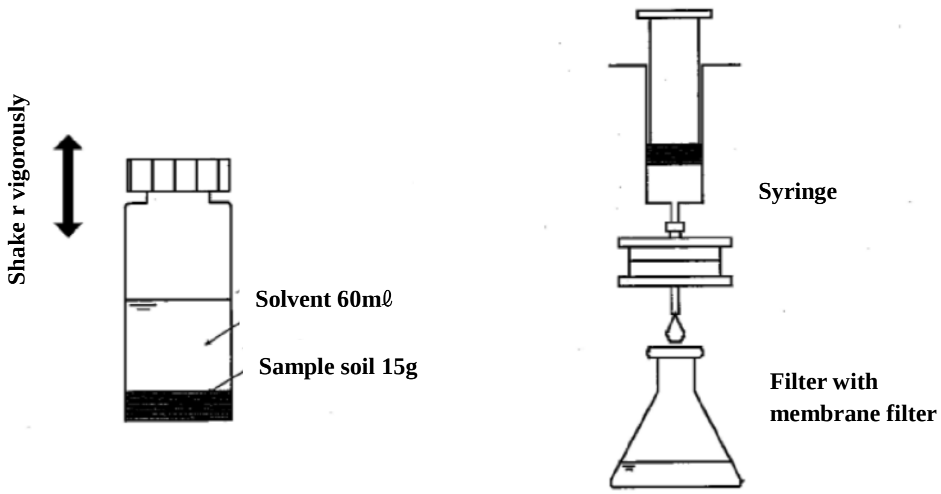


Figure-5.1 The procedure for eluting hexavalent chromium

(3) The Results of Simplified Hexavalent Chromium Test

Photo-5.1 Simplified Hexavalent Chromium Test

5.2 Detail Hexavalent Chromium Test

(1) Scope of Application

This sub-clause shall be used to dissolve hexavalent chromium for improved soil mixed with soil and cement or solidified material using cement at plant and/or in situ.

(2) Method and Type of Test

Dissolved hexavalent chromium test in this guideline is composed by the following method.

1) Trial of the case to be used for ground improvement of cement solidifying material and/or cement

This case targets a ground improvement which is constructed by mixing with ground soil and cement or solidified material using cement.

a. Dissolved hexavalent chromium test to be executed at the mixing design stage (hereinafter referred to as "Test Method 1")
   This test shall be executed for the elution which is shaken continuously for six hours using crushed soils less than 2mm or equal with a solvent. This test is carried out with the aim to confirm solidifying material is correct.
b. Dissolved hexavalent chromium test to be executed after construction (hereinafter referred to as "Test Method 2")
   This test shall be performed in order to confirm the amount of dissolved hexavalent chromium in the improved soil using a sample.
c. Tank test carried out after construction (hereinafter referred to as "Test Method 3")
   Tank test is a method for measuring the hexavalent chromium elution volume in solvent water tank in which the soil sampled as clod is left still standing. This test shall be executed for only improvement work in-case of which the volume is at least about 5,000 m3, or the number of improved soil columns is 500 or so more.

For the places elution volume was the highest in test method 2, this test should be executed in order to confirm the amount of dissolved hexavalent chromium.

d. The case not to be required the implementation of test method 2 and/or test method 3. When a cement or cement solidifying material which amount of dissolved hexavalent chromium does not exceed the environmental quality standards in test method 1, for soil improvement, it is not required to be executed test method 2 and 3.

However, if the implementation agency wants to improve the **volcanic cohesive soil**, test method 2 and 3 have to be done regardless of the results of test method 1.

2) The test for reusing improved soil by cement

This test shall be executed for recycling improved soil as follows;

a. For recycling construction generated soils and construction sludge, cement or cement solidifying material are used as stabilizer.
b. In case of reusing improved soil which had been stabilized by mixing cement or cement solidifying material.

3) How to Prepare Test-liquid for Experiment on Hexavalent Chromium

The test liquid for cadmium, total-cyanide, lead, hexavalent chromium, arsenic, total-mercury, alkyl-mercury, PCB, and selenium shall be made as follows;

(a) Deal with gathered soils

The gathered soils are put into a glass container or a specified container to avoid the soils adhere a container. The experiment should be executed immediately. If the experiment is not executed immediately, the gathered soils should be kept in a dark place, and the experiment shall be executed as soon as possible.

(b) Create a sample

After air-drying gathered soil, small-to-medium gravels and chips of wood are removed, and then clods and crumbs are crushed. Mix sufficiently the soil which passes the sieve of the 2-mm which are made from nonmetal.

(c) Preparation of the sample solution

The sample solution shall be made by mixing the above sample (unit g) and a solvent at the rate with 10% of weight volume ratio, the sample solution is needed more than 500 mm-litters. The solvent is made by mixing pure water and hydrochloric acid, and it is required that Hydrogen-ion concentration of the solvent is more than 5.8 and less than 6.3.

(d) Elution

The samples shall be shaken continuously for 6 hours by using a shaking machine under the condition that temperature is about 20 degree Celsius, and normal pressure. The shaking machine should be adjusted that the shaking number of time per minutes is 200 times, and the shaking width is from 4 cm to 5cm.

(f) Create a test liquid for experiment

The sample liquid created by the procedure above (a) to (d) is leaved still-standing from ten to thirty minutes. A supernatant liquid is used as experiment liquid after insoluble substance is removed by centrifugation for twenty minutes by three thousands turns per minute. The supernatant liquid is filtrated to obtain a filtration by using a membrane filter with 0.45μm. Measure the quantity of filtration needed in experiment.

The analytical method and the point to note

Preparation a test-liquid (how to elute)

Treatment of soil

1) The gathered soils are put into a glass container to avoid the soils adhere a container.

   If the experiment is not executed immediately, the gathered soils should be kept in a dark place.

Make a sample

2) After air-drying gathered soil, Small-to-medium gravels and chips of wood are removed, and then clods and crumbs, are crushed.

   Mix sufficiently the soil which passes the sieve of the 2-mm which are made from nonmetal.

Regulation for the solvent

3) Mix the gathered soils (unit g) and a solvent at t1he rate with 10% of weight volume ratio.

   The solvent is made by mixing pure water and hydrochloric acid, and it is required that Hydrogen-ion concentration of the solvent is more than 5.8 and less than 6.3.

4) the sample solution is needed more than 500 mm-litters

Elution

5) The samples shall be shaken continuously for 6 hours by using a shaking machine under the condition that temperature is about 20 degree Celsius, and normal pressure.

   The shaking machine should be adjusted that the shaking number of time per minutes is 200 times, and the shaking width is from 4 cm to 5cm.

still-standing

6) The sample liquid is leaved still-standing from ten to thirty minutes.

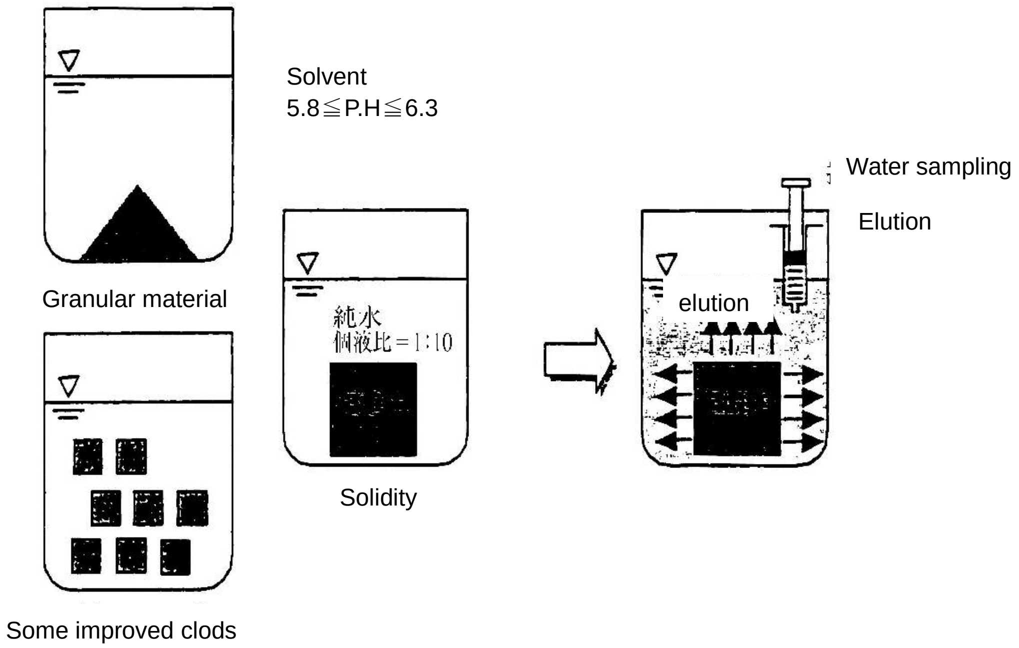
The filtration

7) A supernatant liquid is used as experiment liquid after insoluble substance were removed by centrifugation for twenty minutes by three thousands turns per minute.

   The supernatant liquid is filtrated to obtain a filtration by using a membrane filter with 0.45μm.

The experiment-liquid

<u>Tank test</u>



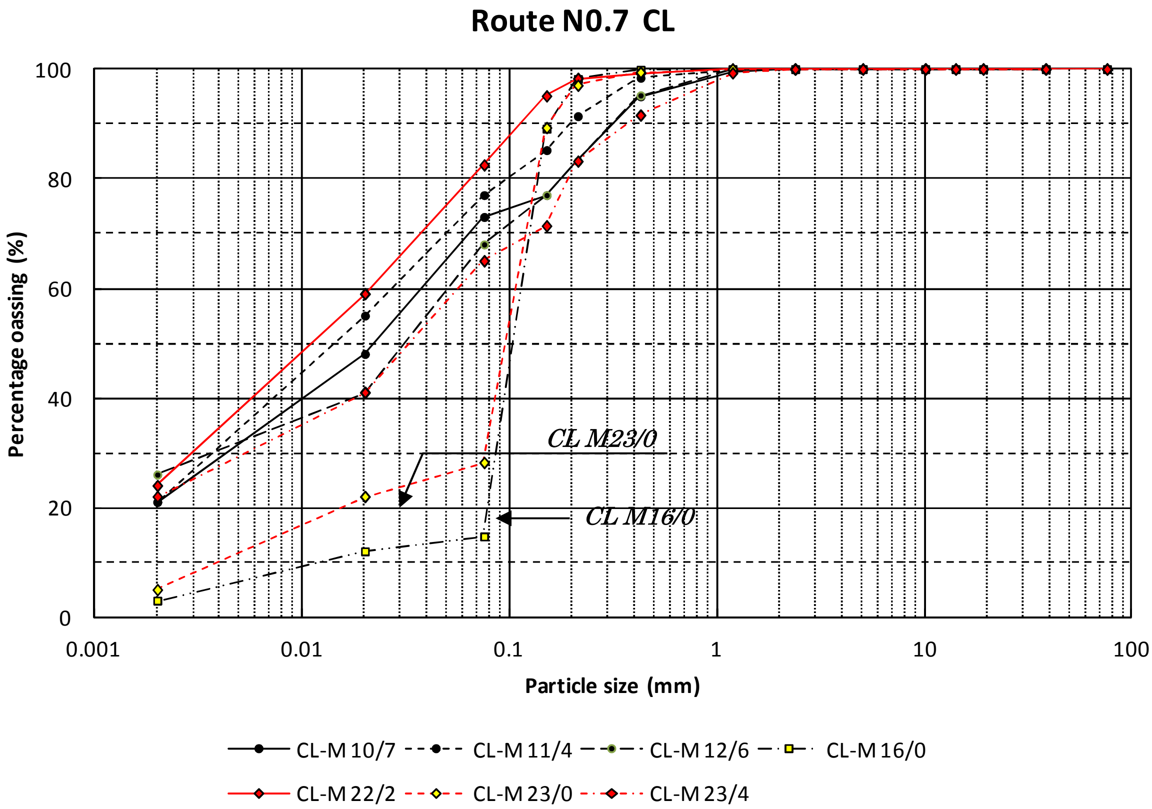
Immerse the stabilized material that had been curing for predetermined period in pure water (Solid and liquid ratio =1:10)

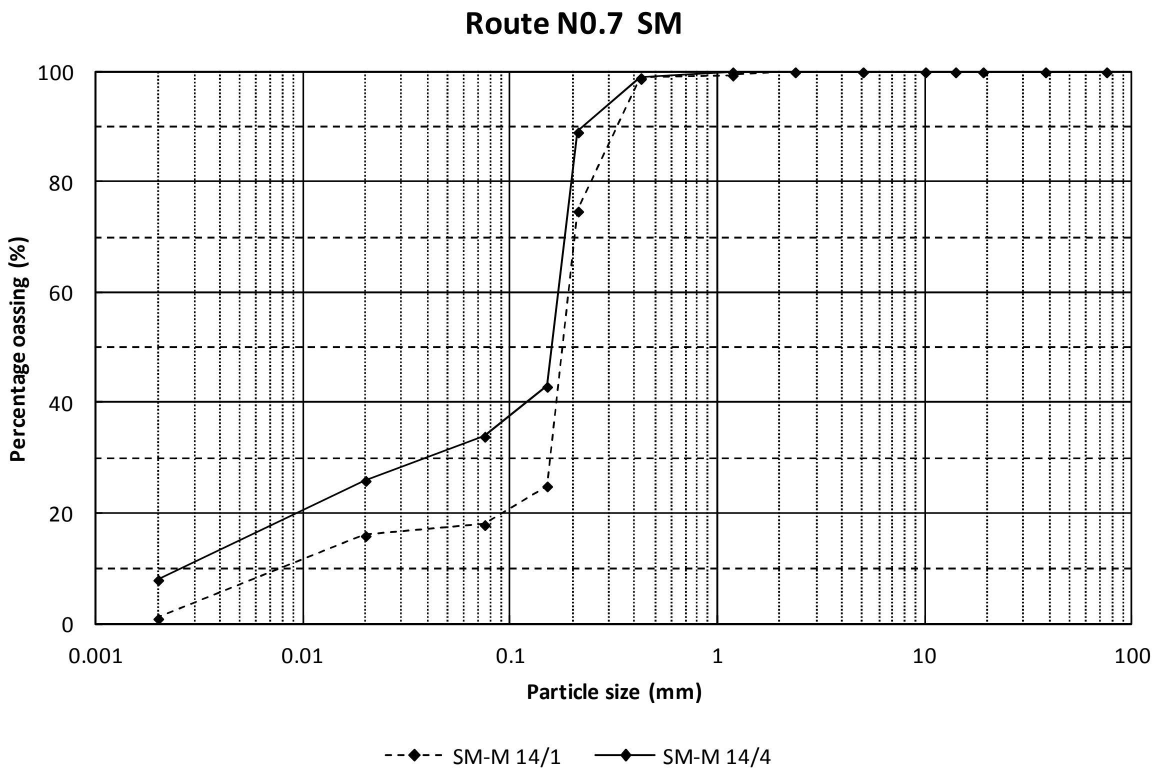
Take the water sample after predetermined period immersing in the water (for 28 days) Carry out elution test.

APPENDIX -1

PRELIMINARY TEST RESULT AT RRL

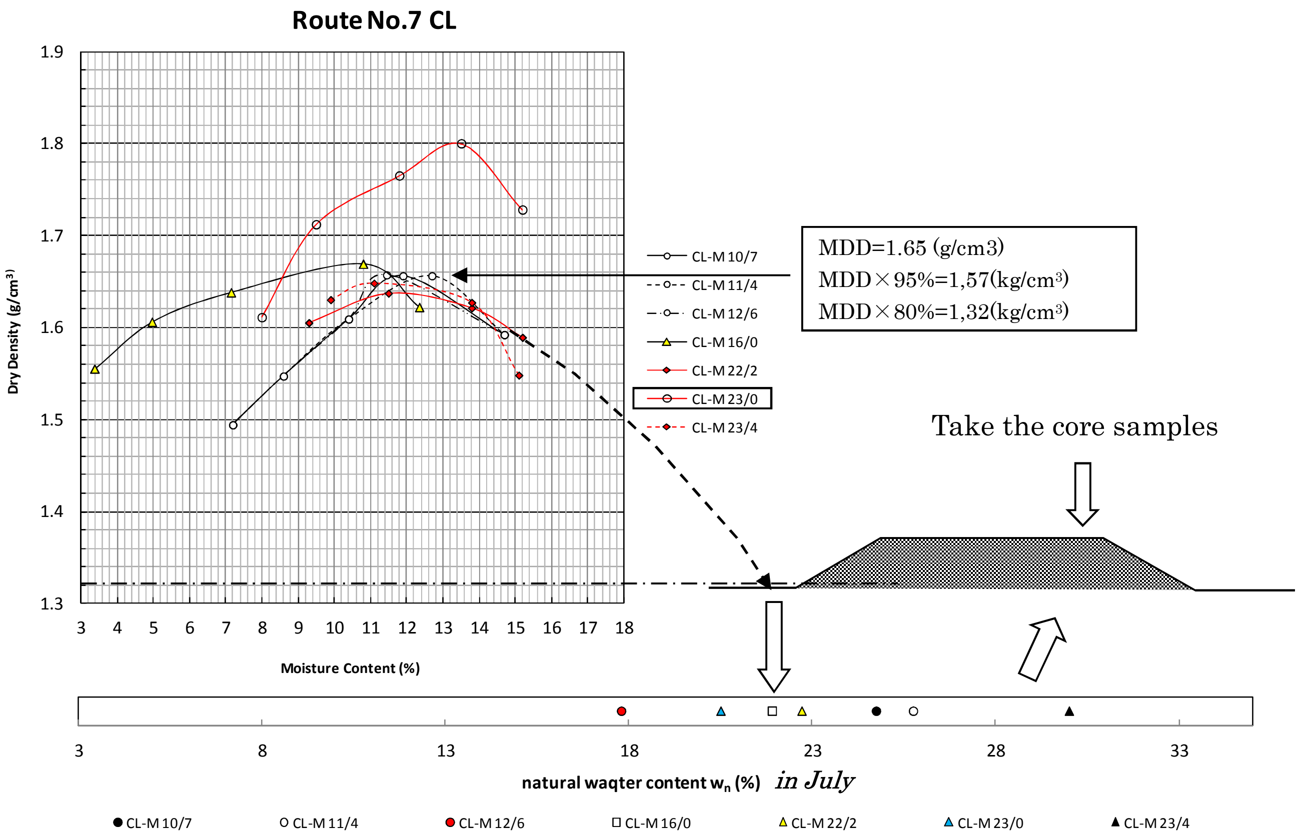
1. Sieve Distribution soil in-situ

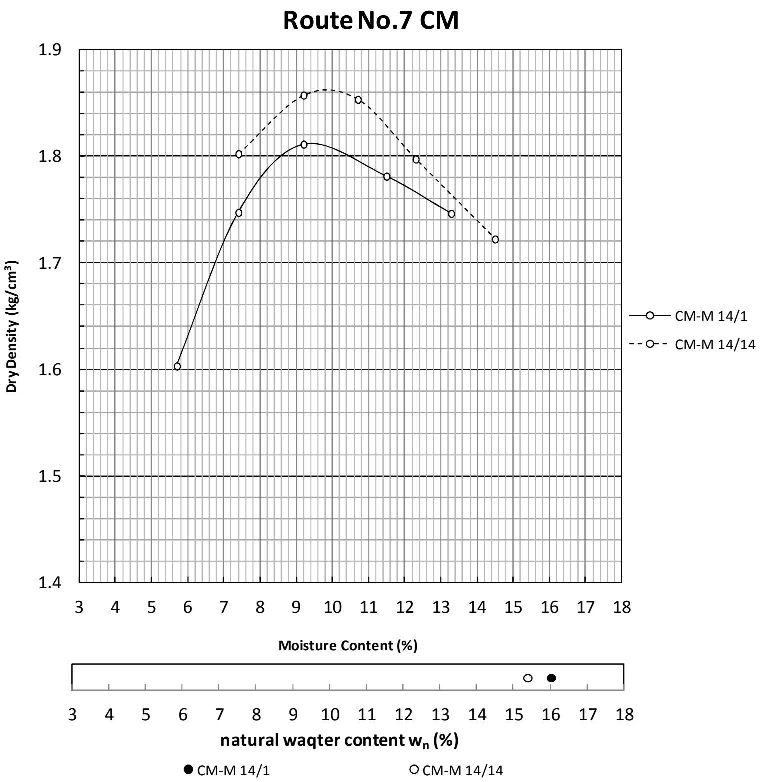




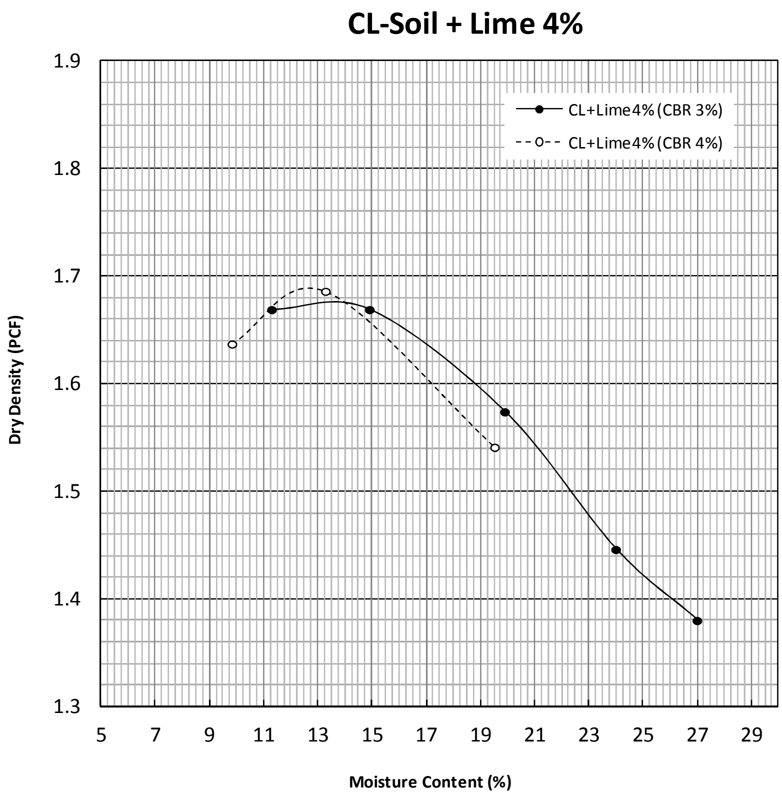
2. COMPACTION TEST

(1) CL-Soil, SM-Soil





(2) CL-Soil + Lime (4%)

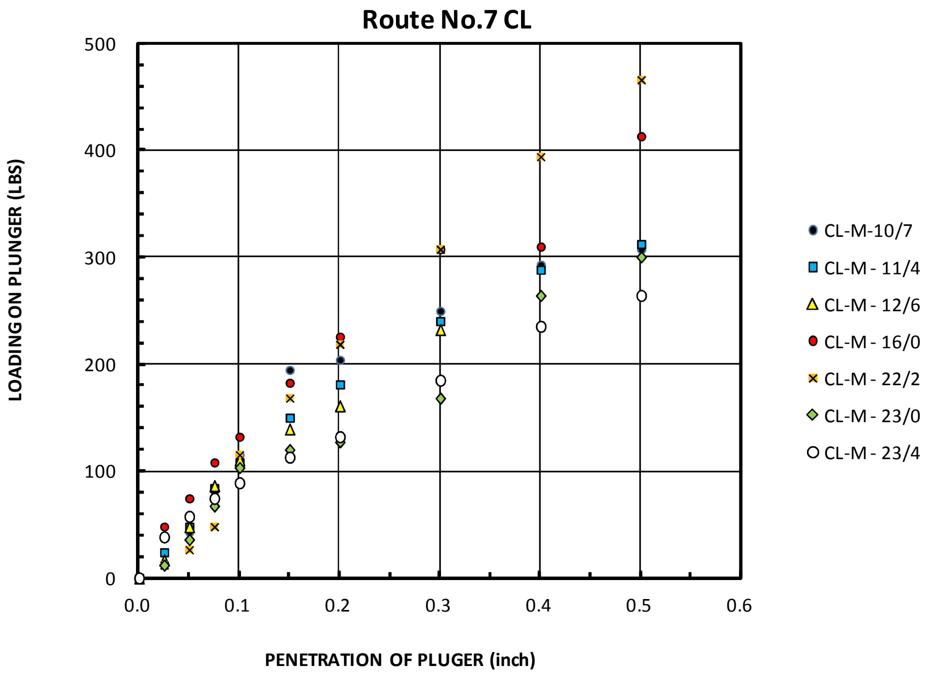


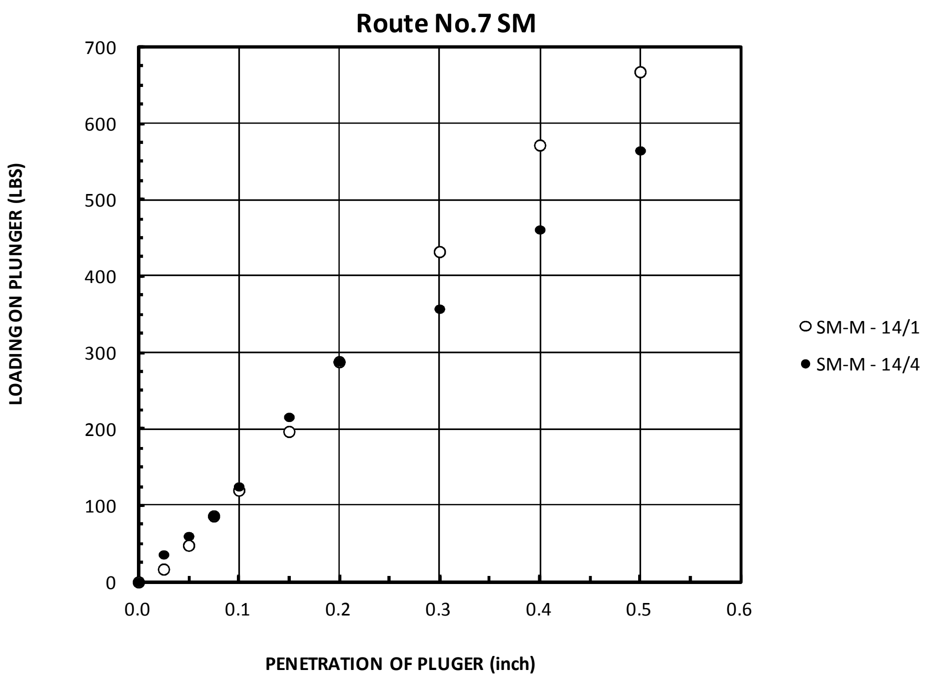
Condition of compaction test

- Mould ϕ 105 mm
- Rammer 4.5 kg, h=45 cm
- 5 layer
- 27 times / layer

3. CBR test for existing sub-grade

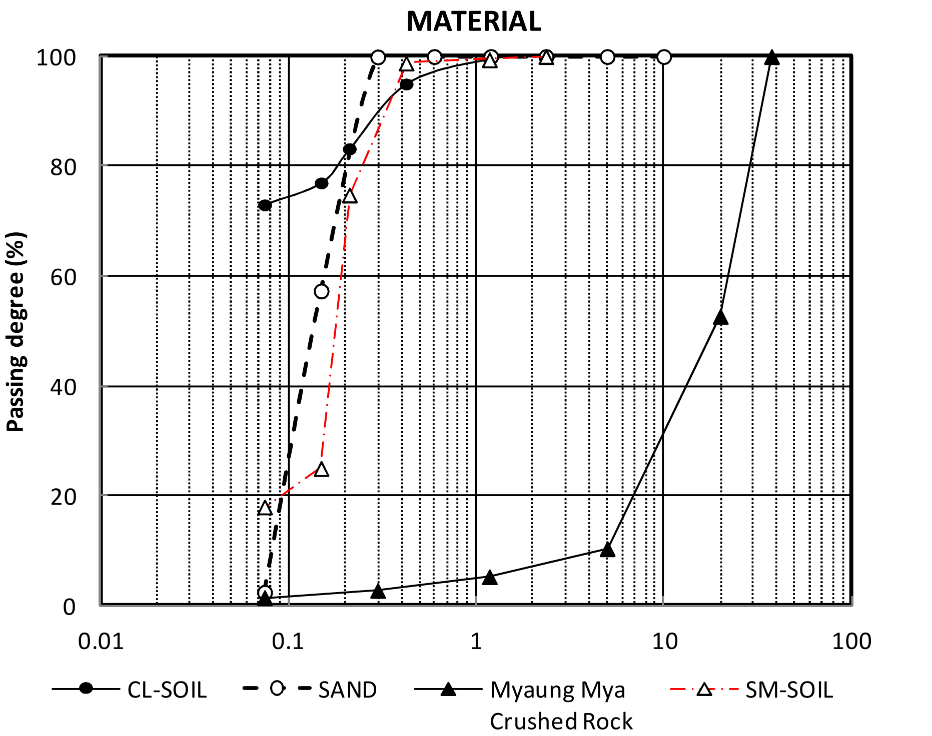
	CL							SM	
	M 10/7	M 11/4	M 12/6	M 16/0	M 22/2	M 23/0	M 23/4	M 14/1	M 14/4
moisture content wn (%)	11.9	12.7	11.4	10.8	11.5	13.5	11.1	9.15	9.15
Top	5.3%	4.2%	3.7%	4.5%	3.8%	3.4%	3.0%	4.3%	5.0%
Bottom	5.0%	3.3%	3.2%	3.7%	2.8%	2.8%	4.2%	6.0%	5.0%
Average	5.2%	3.8%	3.5%	4.1%	3.3%	3.1%	3.6%	5.2%	5.0%
	3.8%							5.1%	





4. PROPERTY OF AGGREGATE

(1) Grain Distribution



(2) Property

1) Sample Sand

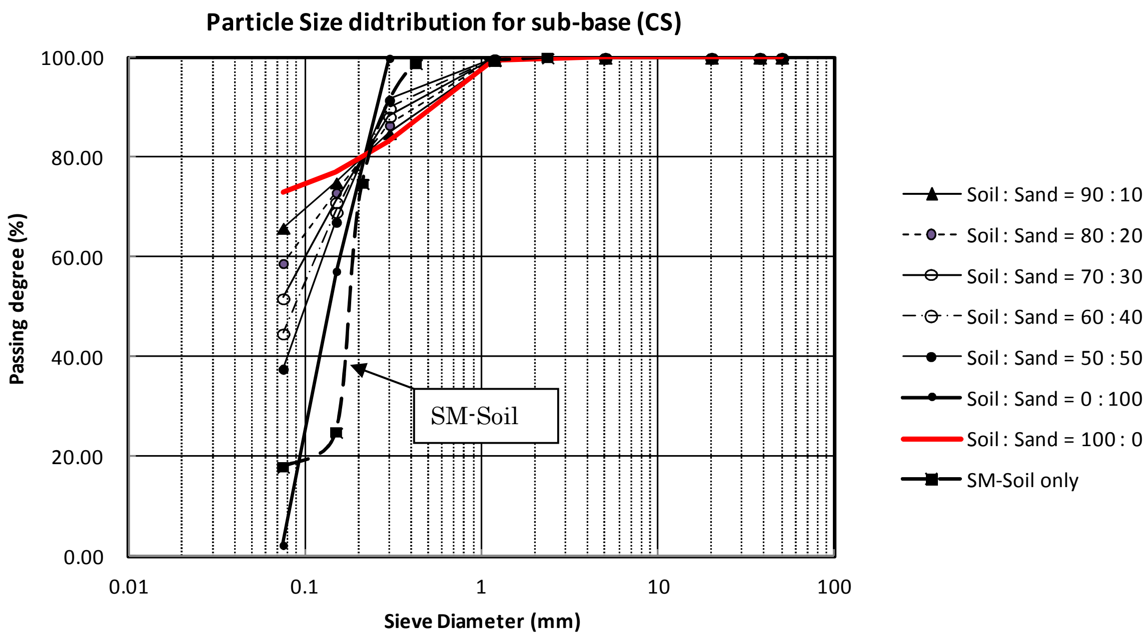
Sea Sand near the site

Particulars	Specific Gravity	Absorption	Clay Lump (%)	Fineness Modulus	Loosed Density lb/ft^3
Sand sample	2.52	＜ 3.0	＜ 3.0	1.4	76.8 (1.23 g/cm^3)
B.S specification for Concrete	2.6 – 2.8	3.0	3.0	2.3 – 3.6	

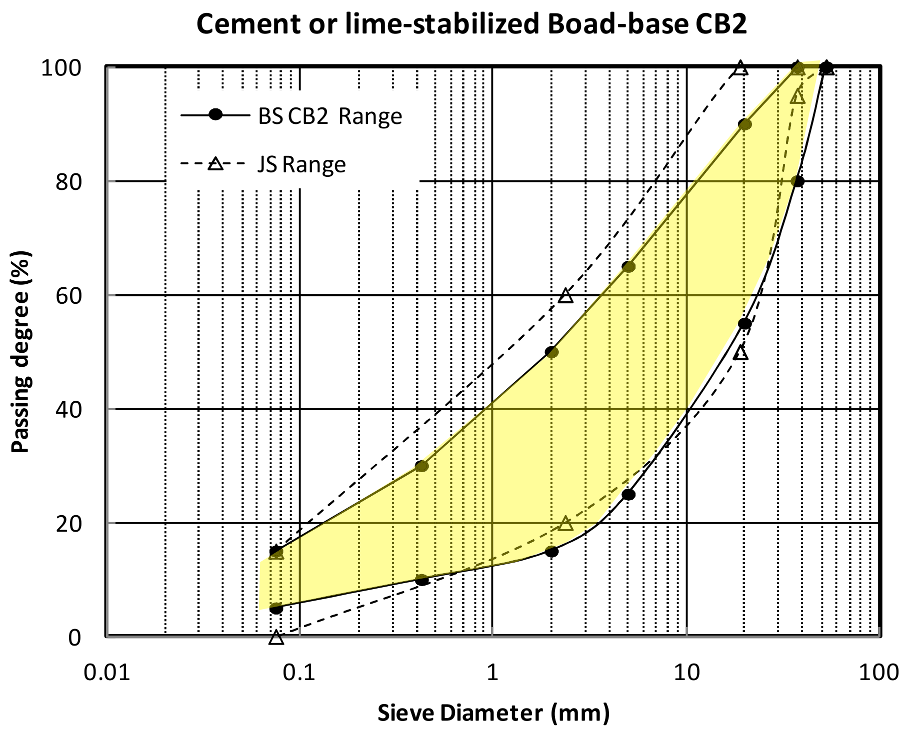
2) Crushed Rock

	Location	Specific Gravity	Absorption (%)	Clay Lump (%)	Crushing Value (%)	Los-Angeles Abrasion values
1	Myaung mya crushed rock	2.2	17.6	5.85	40.5	35.1
BS Specification	For surface course	2.5 – 3.0	2.0 (Max)	2.0 (max)	30.0 (Max)	40.0 (Max)
	For Base course	2.5 – 3.0	4.0 (Max)	4.0 (max)	30.0 (Max)	50.0 (Max)
	For Sub-base course	2.5 – 3.0	4.0 (Max)	4.0 (max)	40.0 (Max)	50.0 (Max)

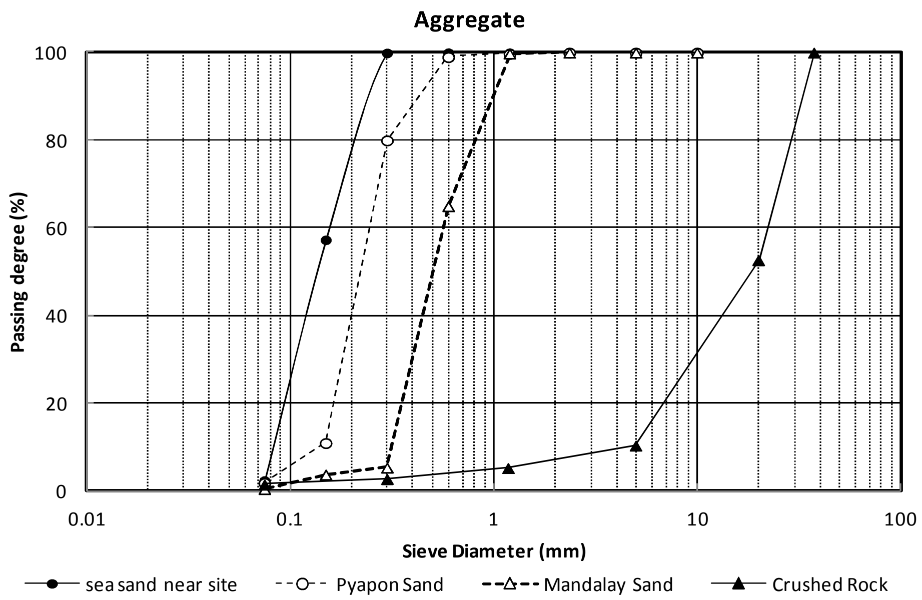
5. SIZE CONTROL TEST FOR STABILEZED SUB-BASE (CS)



6. SIZE CONTROL TEST FOR STABILEZED RODA-BASE (CB2)



7. Grain distribution of other sand



APPENDIX-2

COMPARISON ON TESTING METHOD WITH BS AND JIS

1. Compaction Test

(1) BS 1377: Part4

British Standard (BS1377-Part4)) RRL						
	Rammer Weight (kg)	Impact Height (cm)	Inside Diameter Of Mold (cm)	Number of Layer	Tamping Numbers per each layer	Allowable Maximum particle Size
1*1	2.5kg	30	10.5	3	27	20
2*2	2.5kg	30	15.2	3	62	37.5
3*3	4.5kg	45	10.5	3～5	27	20
4*4	4.5kg	45	15.2	3～5	62	37.5
RRL	4.5kg	45	10.5	**5**	27	

*1 for soils with particles up to medium-gravel size

*2 for soils with soils with some coarse gravel-size particles

*3 for soils with particles up to medium-gravel size

*4 for soils with soils with some coarse gravel-size particles

(2) JIS

Japanese Standard (JIS)						
Type	Rammer Weight (kg)	Impact Height (cm)	Inside Diameter Of Mould (cm)	Number of Layer	Tamping Numbers per each layer	Allowable Maximum particle Size
A	2.5kg	30	10	3	25	19
B	2.5kg	30	15	3	55	37.5
C	4.5kg	45	10	5	25	19
D	4.5kg	45	15	5	55	19
E	4.5kg	45	15	3	92	37.5

(3) ASTM, AASHOTO

ASTM D 1883						
	Inside Diameter of Mold (cm)	Rammer Weight (kg)	Impact Height (cm)	Number of layer	Tamping Numbers per each layer	Soaked Duration
Compaction	15.2	1.49 kg (5 lb)	30.5 (12 inches)	3	56	s
CBR Test	15.2	4.54kg (10 lb)	45.7 (18 inches)	5	56	4 days

AASHOTO T 193						
	Inside Diameter of Mould (cm)	Rammer Weight (kg)	Impact Height (cm)	Number of layer	Number of blows per layer	Soaked Duration
Compaction	15.2	2.49 kg (5 lb)	30.5	3	56	
CBR	15.2	2.49 kg (5 lb)	30.5	3	10 30 65	4 days
Only 5 lb rammer is used.						

2. CBR TEST

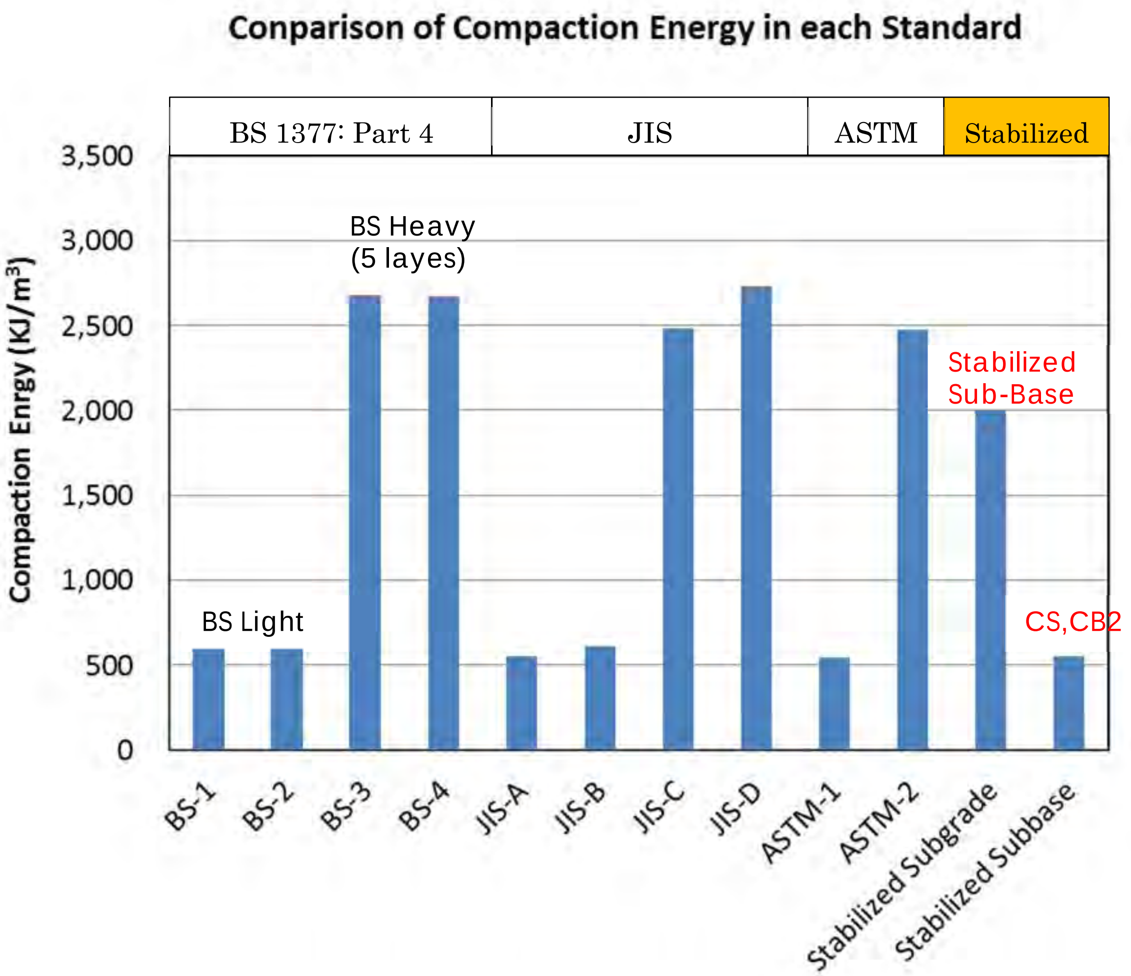
(1) BS 1377: Part 4

British Standard (BS) RRL						
	Inside Diameter of Mold (cm)	Rammer Weight (kg)	Impact Height (cm)	Number of layer	Tamping Numbers per each layer	Soaked Duration
1	15.2	2.5	30	5 layer	*1 undefined	4 days
2	15.2	4.5	45	5 layer		
	*1: Depending on the degree of compaction required. *2: RRL used 62 times per layer to compact soil in last test					

(2) JIS

Japanese Standard (JIS)							
		Inside Diameter of Mould (cm)	Rammer Weight (kg)	Impact Height (cm)	Number of layer	Number of blows per layer	Soaked Duration
1	Design CBR Test	15	4.5	45	3 layer	67	4 days
2	Modified CBR Test	15	4.5	45	3 layer	17 42 92	

3. Comparison of Compaction Energy



APPENDIX-3

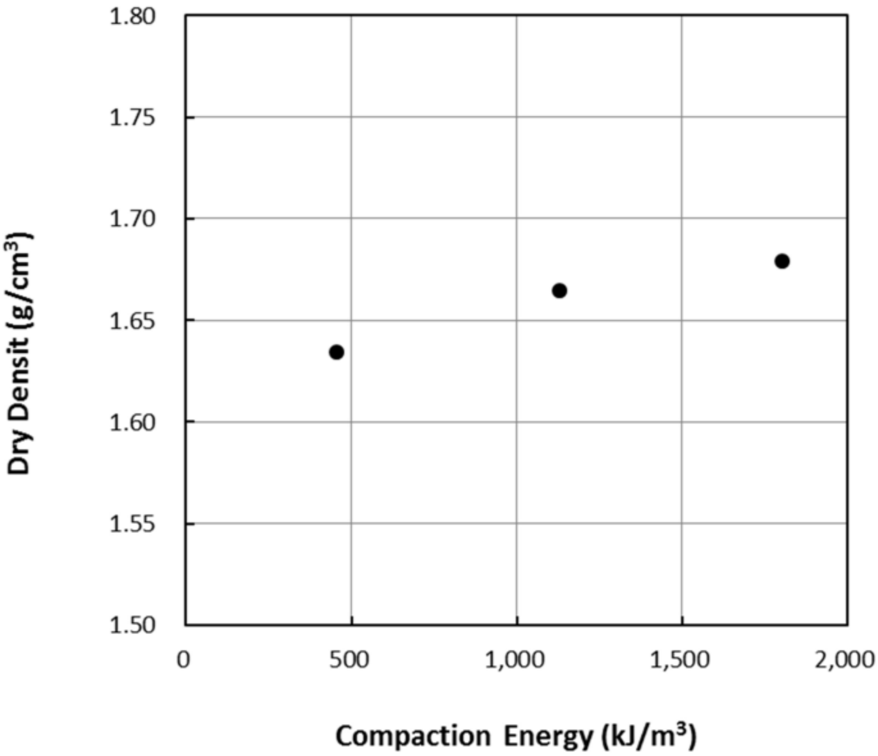
ADDITONAL TESTING ON STABILIZED MATERIALS

Considering the on-site environment, it may be necessary to conduct testing with differing blends of in-situ soil and stabilizer (currently mixed according to the test guidelines) and differing degree of compaction.

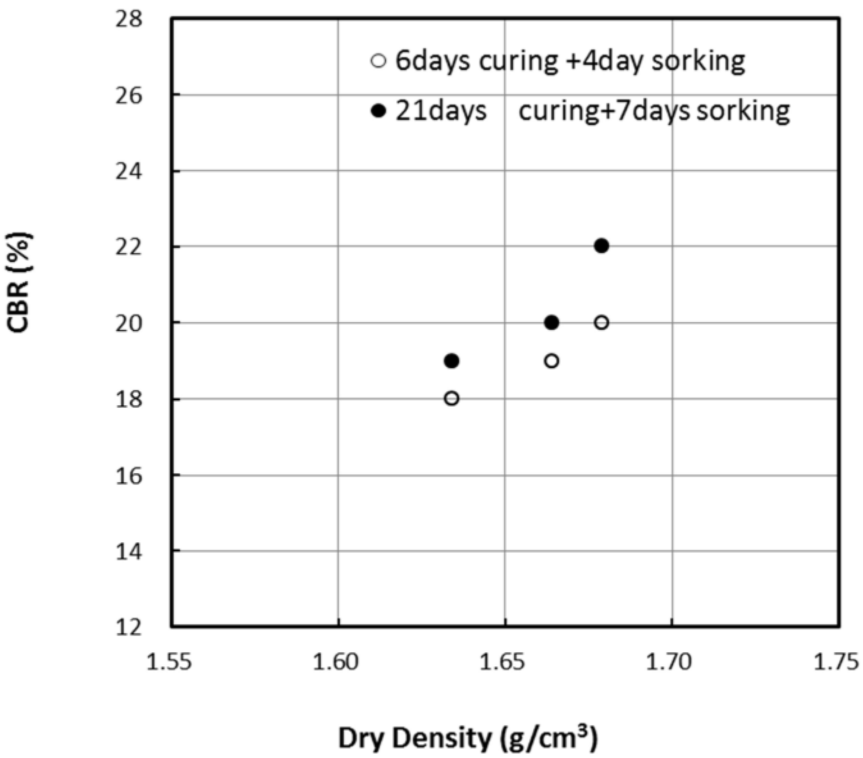
It was scheduled to first determine the design blend upon giving priority to the test (stabilizer blending) indicated in section **3. Mixing Test Stabilized Materials**, but after that, according to the necessity, it is scheduled to conduct additional testing aimed at confirming the impact that compaction has on improved road strength (durability).

1. Stabilized Sub-grade

Sub-grade (Lime 4%) BS ϕ 15.2cmMold						
Testing Case			1	2	3	Remarks
compaction		layer	17	42	67	55
		Blow timed	3	3	3	5
Compaction Energy(KJ/m^3)			458	1,132	1,806	2,471
6days Curing + 4days Soaking	O.M.C (%)		15.0	15.0	14.0	(BS-Heavy)
	M.D. D	(pcf)	102.0	103.9	104.8	
		(g/cm^3)	1.634	1.664	1.679	
		ratio	0.97	0.99	1.00	
	C.B..R (%)		18.0	19.0	20.0	
	(ratio)		0.90	0.95	1.00	
21days Curing + 7days Soking	O.M.C (%)		15.0	15.0	14.0	
	M.D. D	(pcf)	102.0	103.9	104.8	
		(g/cm^3)	1.634	1.664	1.679	
		ratio	0.97	0.99	1.00	
	C.B..R (%)		19.0	20.0	22.0	
	(ratio)		0.86	0.91	1.00	



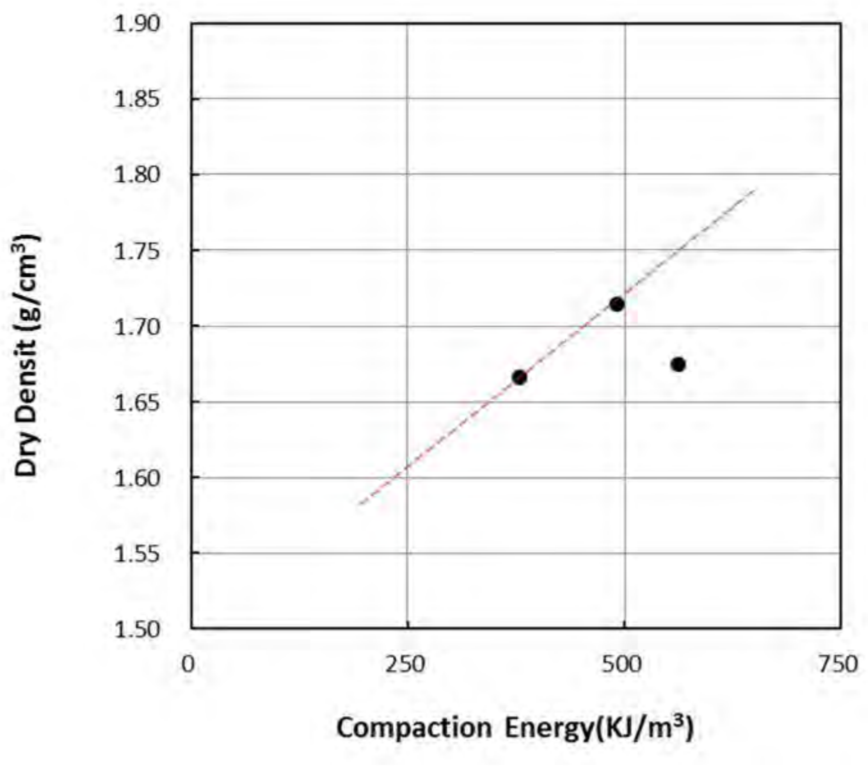
1.80
1.75
1.70
1.65
1.60
1.55
1.50
0
500
1,000
1,500
2,000
Dry Densit (g/cm3)
Compaction Energy (kJ/m3)

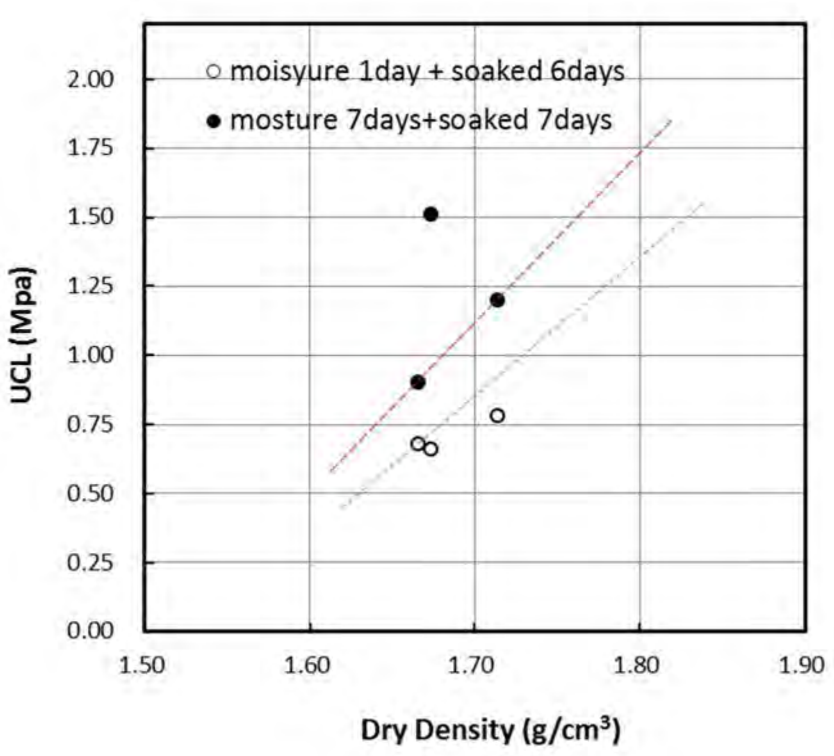


28
26
24
22
20
18
16
14
12
1.55
1.60
1.65
1.70
1.75
6days curing +4day sorking
21days curing+7days sorking
CBR (%)
Dry Density (g/cm3)

2. Stabilized Sub-base (CS)

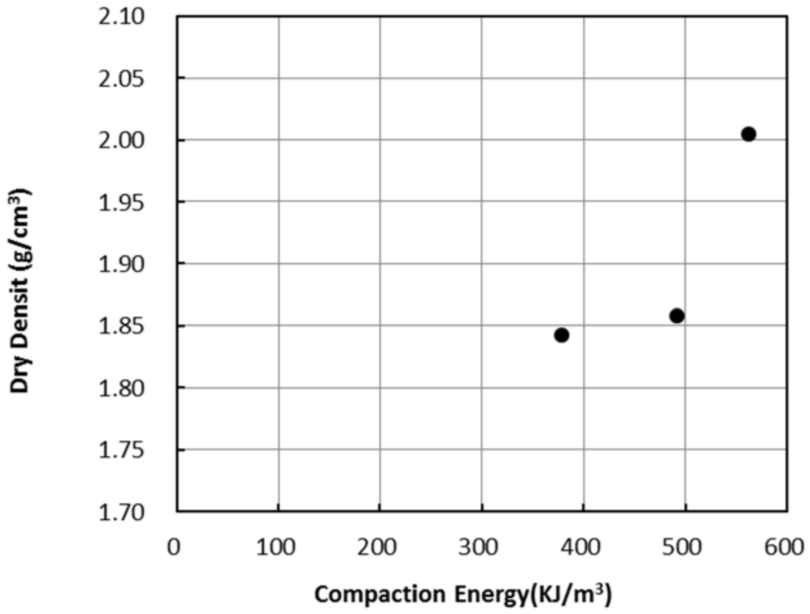
Sub-base(Soil:Sand=0.3:0.7) Cement 6% ϕ 10cm,h=20cm Mold						
Testing Base			1	2	3	Remarks
compaction	layer		3	3	5	3
	Blow timed		27	35	24	25
Compaction Energy(KJ/m³)			379	492	562	551
1 days Curing + 6days Soaking	O.M.C (%)		17.0	17.0	18.0	(BS Light)
	M.D. D	(pcf)	104.0	107.0	104.5	
		(g/cm³)	1.666	1.714	1.674	
		ratio	1.00	1.02	1.00	
	U.C.S (Mpa)		0.68	0.78	0.66	
	(ratio)		1.03	1.18	1.00	
7days Curing + 7days Soaking	O.M.C (%)		17.0	17.0	18.0	
	M.D. D	(pcf)	104.0	107.0	104.5	
		(g/cm³)	1.666	1.714	1.674	
		ratio	1.00	1.02	1.00	
	U.C.S (Mpa)		0.90	1.20	1.51	
	(ratio)		0.60	0.79	1.00	
				V=1570(cm³)		1000 (cm³)



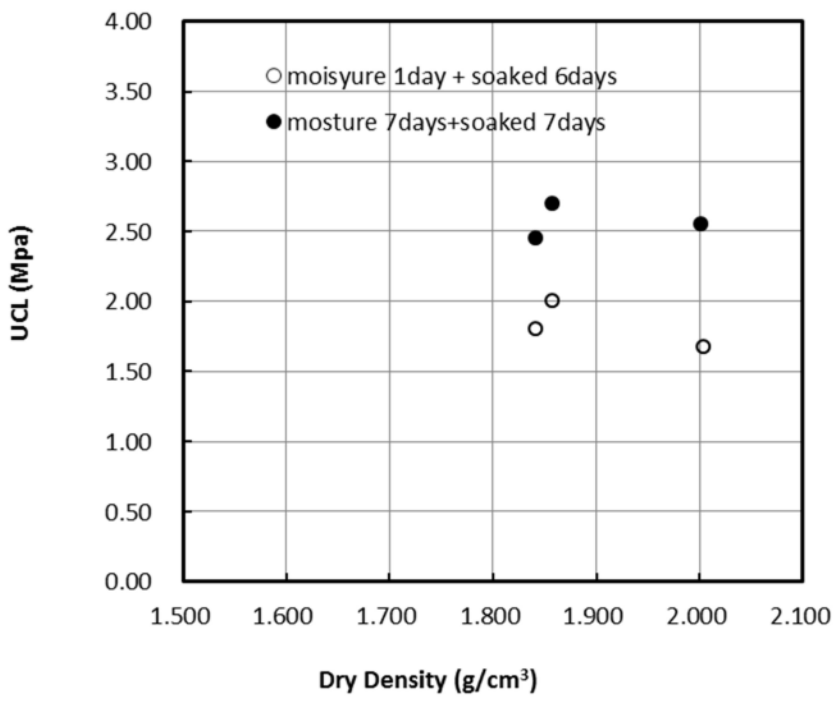


3. Stabilized Road-base(CB2)

Road-base(Soil:Sand:C/R=0.15:0.15:0.7) Cement 6%					
Testing Case			1	2	3
compaction		layer	27	35	24
		Blow timed	3	3	5
Compaction Energy(KJ/m3)			379	492	562
1 days Curing + 6days Sorking	O.M.C (%)		16.0	13.0	11.7
	M.D. D	(pcf)	115.0	116.0	125.1
		(g/cm3)	1.842	1.858	2.004
		ratio	0.92	0.93	1.00
	U.C.S (Mpa)		1.80	2.00	1.67
	(ratio)		1.08	1.20	1.00
7days Curing + 7days Sorking	O.M.C (%)		16.0	13.0	11.7
	M.D. D	(pcf)	115.0	116.0	125.0
		(g/cm3)	1.842	1.858	2.002
		ratio	0.92	0.93	1.00
	U.C.S (Mpa)		2.45	2.70	2.55
	(ratio)		0.96	1.06	1.00



2.10
2.05
2.00
1.95
1.90
1.85
1.80
1.75
1.70
Dry Densit (g/cm³)
0
100
200
300
400
500
600
Compaction Energy(KJ/m³)



4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
UCL (Mpa)
moisyure 1day + soaked 6days
mosture 7days+soaked 7days
1.500
1.600
1.700
1.800
1.900
2.000
2.100
Dry Density (g/cm³)

APPENDIX-4

DETAIL HEXVALENT CHROMIUM TEST RESULT

RRL don't have the necessary equipment for the detail hexavalent chromium, and we could not get the equipment in Myanmar.

Therefore, in order to confirm the validity of the simplified test results, JICA expert Team performed The results of detail test are less than 0.05mg/ℓ as following, the validity of the simple test results was approved,

The Report on Analysis Results

報告番号	24-07

分析試験報告書

御依頼事業所　株式会社エイト日本技術開発　御中

採取場所　Soil + Cement 6%　　採取者　貴社担当

試料名　No. 1　土+セメント6%

御依頼年月日　平成２５年１１月１２日　　採取年月日　平成２５年１１月　日

上記供試品についての分析試験結果は下記のとおりであることを報告いたします。

項目	単位	溶出試験 測定値	計量の方法
六価クロム (Cr^{6+})	mg/L	検出せず (0.02未満)	ＪＩＳ Ｋ０１０２ ６５．２．１ (2008) 吸光光度法
Hexavalent Chromium		以下余白	
		Not detected	
		Less than 0.02mg/ℓ	

備考	
	１．業務名：「ミ」国 道路技プロ ２．計量の方法：平成３年環境庁告示第４６号による ３．測定値は検液中での値。

濃度計量証明事業　岡山県登録第６－１４号
音圧レベル計量証明事業　岡山県登録第７－５号
振動加速度レベル計量証明事業　岡山県登録第８－３号

株式会社 エクスラン・テクニカル・センター
〒704-8194　岡山市東区金岡東町３丁目３番１号
ＴＥＬ　（０８６）　９４３－７２５３
ＦＡＸ　（０８６）　９４３－９１０５

平成２５年１１月１５日

環境計量士
桑田　康幸

The Report on Analysis Results

報告番号	24-09

分 析 試 験 報 告 書

御依頼事業所　株式会社エイト日本技術開発　御中

採 取 場 所　　　採 取 者　貴社担当

試 料 名　No. 3　土50%+砂50%+セメント6%

御依頼年月日　平成２５年１１月１２日　　採取年月日　平成２５年１１月　日

上記供試品についての分析試験結果は下記のとおりであることを報告いたします。

項　　目	単 位	溶出試験 測定値	計量の方法
六価クロム (Cr^{6+})	mg/L	検出せず (0.02未満)	JIS K0102 65.2.1 (2008) 吸光光度法
Hexavalent Chromium		以下余白	
		Not detected	
		Less than 0.02mg/ℓ	
	Soil 50% + Sand 50% + Cement 6%		
備　　考	1. 業務名：「ミ」国 道路技プロ 2. 計量の方法：平成３年環境庁告示第４６号による 3. 測定値は検液中での値。		

濃度計量証明事業　岡山県登録第６－１４号
音圧レベル計量証明事業　岡山県登録第７－５号
振動加速度レベル計量証明事業　岡山県登録第８－３号

株式会社 エクスラン・テクニカル・センター
〒704-8194　岡山市東区金岡東町３丁目３番１号
TEL　(086)　943-7253
FAX　(086)　943-9105

平成２５年１１月１５日
環境計量士
桑 田 康 幸

The Report on Analysis Results

報告番号	24-08

分 析 試 験 報 告 書

御依頼事業所　株式会社エイト日本技術開発　御中

採 取 場 所　　　　採 取 者　貴社担当

試 料 名　No. 2　砕石70%＋土15%＋砂15%＋セメント10%

御依頼年月日　平成２５年１１月１２日　　採取年月日　平成２５年１１月　　日

上記供試品についての分析試験結果は下記のとおりであることを報告いたします。

項　目	単 位	溶 出 試 験 測 定 値	計 量 の 方 法
六価クロム (Cr^{6+})	mg/L	0. 04	ＪＩＳ Ｋ０１０２ ６５. ２. １ (2008) 吸光光度法
Hexavalent Chromium		以下余白	
		0.04 mg/ℓ	
	C/R 70%+Soil 15% + Sand 15% + Cement 10%		

備　考	１．業務名：「ミ」国 道路技プロ ２．計量の方法：平成３年環境庁告示第４６号による ３．測定値は検液中での値。

濃度計量証明事業　岡山県登録第６－１４号
音圧レベル計量証明事業　岡山県登録第７－５号
振動加速度レベル計量証明事業　岡山県登録第８－３号

株式会社 エクスラン・テクニカル・センター

〒704-8194　岡山市東区金岡東町３丁目３番１号
ＴＥＬ　(０８６)　９４３－７２５３
ＦＡＸ　(０８６)　９４３－９１０５

平成２５年１１月１５日

環境計量士

桑 田 康 幸

Appendix-C: Work Quantity of the PP-2

Total Work Quantities in PP-2

I. Construction work **Total length =** **600** **m (1/5 - 2/0)**

Category	Work item		Specification	Quantity	Unit
1. Earthwork	1.1 Scarifying & re-compaction		t=Ave. 1ft	2,453.3	cu.m
	1.2 Embankment	(1) Lower	Local soil	1,785.5	cu.m
		(2) road side	Local soil	431.5	cu.m
	1.3 Subgrade		t=Ave.2ft, Soil : Sand = 50% : 50% (weight basis)	5,358.6	cu.m
	1.4 Slope trimming			5,592.6	sq.m
2. Pavement	2.1 Wearing course	(1) Penetration macadam	t=3in, w=18ft	1,645.9	sq.m
		(2) DBST	t=1in, w=18ft	1,645.9	sq.m
	2.2 Base course	(1) Crush stone	CBR=80%, t=6in, w=28ft	390.2	cu.m
		(2) Cement stabilized	River shingle : Sand = 75% : 25%, Cement=4.6% (weight basis), t=6in, w=28ft	390.2	cu.m
	2.3 Subbase course	(1) Cement stabilized	Soil : Sand = 50% : 50%, Cement=6.4-6.9% (weight basis), t=6in, w=30ft	418.1	cu.m
		(2) Cement stabilized	Soil : Sand = 50% : 50%, Cement=6.4-6.9% (weight basis), t=12in, w=30ft	836.1	cu.m
	2.4 Hard shoulder		Graded crush stone, t=3in, w=8ft	1,463.0	sq.m
3. Apparatus work	3.1 Drainage layer		Crush stone, L = 1.2m, t=0.15m, w=0.5m	200	No.
				18.0	cu.m

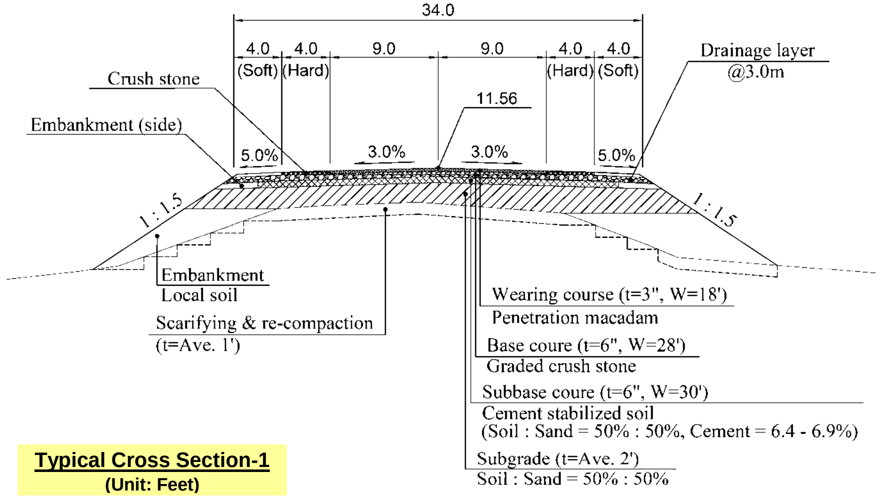
II. Off-site work

Category	Work item	Specification	Quantity	Unit
1. Temporary yard	1.1 Site opening	Bush cut, grading, removal of surface soil (t=0.3m)	20,000.0	sq.m
	1.2 Site clearance	Grading	20,000.0	sq.m

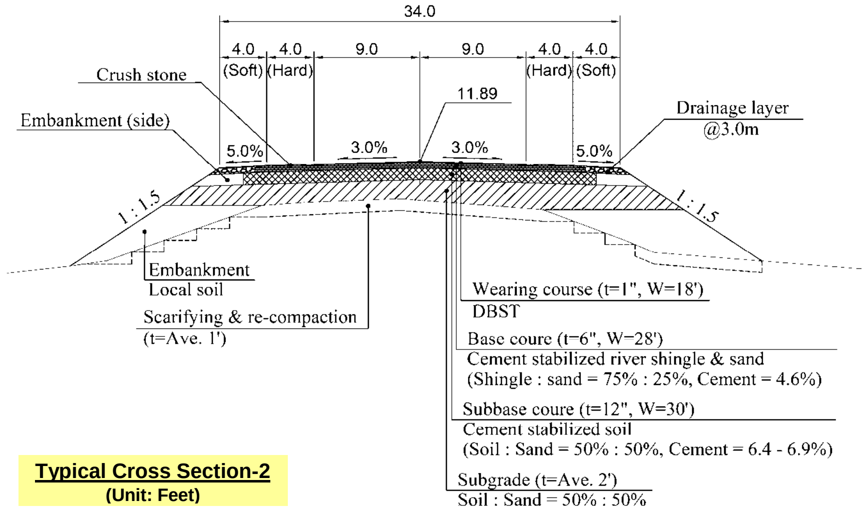
III. Import materials

Item	Work to be applied		Specification	Quantity	Unit
1. Cement	1.1 Subbase course		Material=1.8t/cu.m, **Cement=6.4-6.9%**, Loss=10%	170.0	ton
	1.2 Base course		Material=1.8t/cu.m, **Cement=4.6%**, Loss=10%	40.0	ton
			Total	**210.0**	**ton**
2. Sand	2.1 Subbase course		Material=1.8t/cu.m, **Sand=50%**, Loss=10%	1,250.0	ton
	2.2 Base course		Material=1.8t/cu.m, **Sand=25%**, Loss=10%	200.0	ton
	2.3 Subgrade		Material=1.8t/cu.m, **Sand=50%**, Loss=10%	5,310.0	ton
			Total	**6,760.0**	**ton**
3. Crush stone	3.1 Base course	(1) Graded stone	Material=2.0t/cu.m, Loss=10%	860.0	ton
		(2) River shingle	Material=2.0t/cu.m, **Stone=75%**, Loss=10%	650.0	ton
	3.2 Hard shoulder		Weight=2.0t/cu.m, Loss=10%	250.0	ton
	3.3 Wearing course	(1) P-macadam	Weight=2.0t/cu.m, Loss=10%	280.0	ton
		(2) DBST	Weight=2.0t/cu.m, Loss=10%	100.0	ton
	3.3 Drainage layer		Weight=2.0t/cu.m, Loss=10%	40.0	ton
			Total	**2,180.0**	**ton**
4. Straight asphalt (80/100)	4.1 Prime coat		1 - 1.5ltr/sq.m, Loss=10%	4,600.0	ltr
	4.2 Wearing course	(1) P-macadam	0.7 - 2.3ltr/sq.m (2layers), Loss=10%	5,500.0	ltr
		(2) DBST	0.7 - 2.3ltr/sq.m (2layers), Loss=10%	5,500.0	ltr
			Total	**15,600.0**	**ltr**
5. Fuel	Operation of equipment	Diesel		N/A	ltr

1. Earthwork



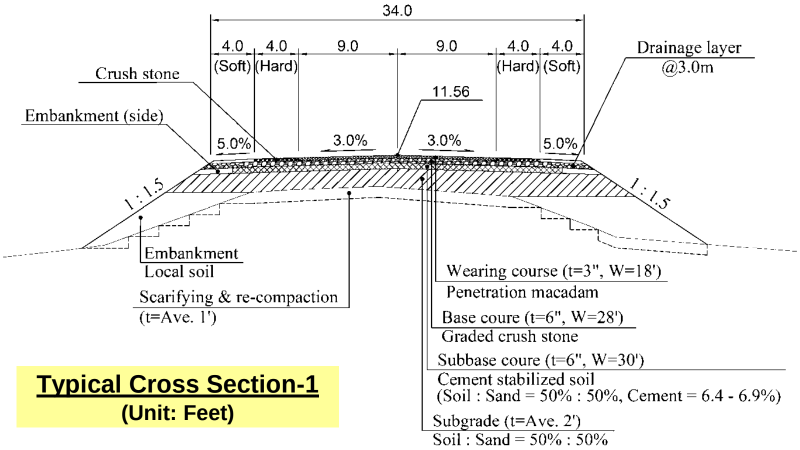
Typical Cross Section-1
(Unit: Feet)



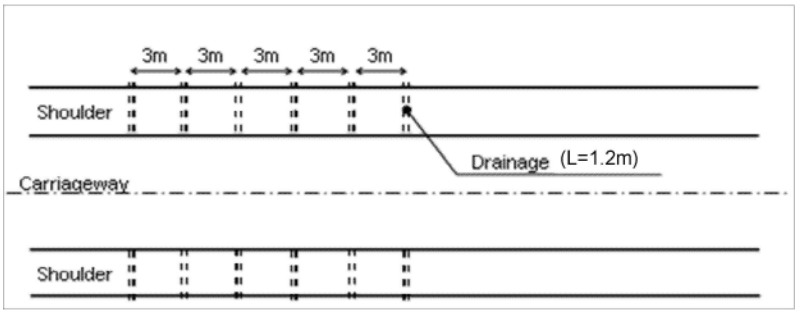
Typical Cross Section-2
(Unit: Feet)

Section	Station	Distance	1.1 Scarifying & re-compaction				1.2 (1) Embankment (local soil)				1.2 (2) Embankment (road side)				1.3 Subgrade				1.4 Slope trimming			
		(ft)	Sq.Ft	Ave.Sq.Ft	Ave.sq.m	Cu.m	Sq.Ft	Ave.Sq.Ft	Ave.sq.m	Cu.m	Sq.Ft	Ave.Sq.Ft	Ave.sq.m	Cu.m	Sq.Ft	Ave.Sq.Ft	Ave.sq.m	Cu.m	L (Ft)	Ave.L (Ft)	Ave.L (m)	sq.m
	86.0	0.0	43.11			0.0	26.30			0.0	7.62			0.0	54.21			0.0	24.40			0.0
	87.0	100.0	46.87	44.99	4.18	127.4	46.35	36.33	3.37	102.9	7.62	7.62	0.71	21.6	72.74	63.48	5.90	179.7	23.80	24.10	7.35	285.2
	88.0	100.0	46.02	46.45	4.31	131.5	54.87	50.61	4.70	143.3	7.62	7.62	0.71	21.6	97.50	85.12	7.91	241.0	25.20	24.50	7.47	299.4
	89.0	100.0	46.83	46.43	4.31	131.5	22.34	38.61	3.59	109.3	7.62	7.62	0.71	21.6	81.86	89.68	8.33	253.9	23.60	24.40	7.44	298.0
	90.0	100.0	44.42	45.63	4.24	129.2	19.51	20.93	1.94	59.3	7.62	7.62	0.71	21.6	115.25	98.56	9.16	279.1	25.90	24.75	7.54	297.1
1	91.0	100.0	45.20	44.81	4.16	126.9	41.85	30.68	2.85	86.9	7.62	7.62	0.71	21.6	94.26	104.76	9.73	296.6	25.80	25.85	7.88	304.7
	92.0	100.0	42.48	43.84	4.07	124.1	36.76	39.31	3.65	111.3	7.62	7.62	0.71	21.6	94.93	94.60	8.79	267.9	24.40	25.10	7.65	289.5
	93.0	100.0	45.00	43.74	4.06	123.9	19.78	28.27	2.63	80.1	7.62	7.62	0.71	21.6	101.45	98.19	9.12	278.0	22.10	23.25	7.09	267.5
	94.0	100.0	38.51	41.76	3.88	118.2	54.92	37.35	3.47	105.8	7.62	7.62	0.71	21.6	94.96	98.21	9.12	278.1	28.60	25.35	7.73	278.5
	95.0	100.0	37.87	38.19	3.55	108.1	46.82	50.87	4.73	144.0	7.62	7.62	0.71	21.6	73.46	84.21	7.82	238.5	24.50	26.55	8.09	266.7
	96.0	100.0	41.90	39.89	3.71	112.9	21.40	34.11	3.17	96.6	7.62	7.62	0.71	21.6	87.59	80.53	7.48	228.0	23.20	23.85	7.27	250.2
	97.0	100.0	47.43	44.67	4.15	126.5	34.97	28.19	2.62	79.8	7.62	7.62	0.71	21.6	106.24	96.92	9.00	274.4	23.30	23.25	7.09	273.2
	98.0	100.0	42.20	44.82	4.16	126.9	31.16	33.07	3.07	93.6	7.62	7.62	0.71	21.6	104.00	105.12	9.77	297.7	24.90	24.10	7.35	284.1
	99.0	100.0	42.31	42.26	3.93	119.7	16.58	23.87	2.22	67.6	7.62	7.62	0.71	21.6	98.40	101.20	9.40	286.6	22.40	23.65	7.21	262.9
	100.0	100.0	44.11	43.21	4.01	122.4	14.25	15.42	1.43	43.7	7.62	7.62	0.71	21.6	103.21	100.81	9.37	285.4	22.90	22.65	6.90	257.5
2	101.0	100.0	43.93	44.02	4.09	124.7	24.22	19.24	1.79	54.5	7.62	7.62	0.71	21.6	100.24	101.73	9.45	288.1	27.30	25.10	7.65	290.7
	102.0	100.0	47.68	45.81	4.26	129.7	21.26	22.74	2.11	64.4	7.62	7.62	0.71	21.6	106.66	103.45	9.61	292.9	22.70	25.00	7.62	301.3
	103.0	100.0	41.79	44.74	4.16	126.7	20.47	20.87	1.94	59.1	7.62	7.62	0.71	21.6	97.01	101.84	9.46	288.4	24.70	23.70	7.22	278.9
	104.0	100.0	44.50	43.15	4.01	122.2	40.22	30.35	2.82	85.9	7.62	7.62	0.71	21.6	91.77	94.39	8.77	267.3	22.90	23.80	7.25	270.1
	105.0	100.0	34.44	39.47	3.67	111.8	32.07	36.15	3.36	102.4	7.62	7.62	0.71	21.6	106.85	99.31	9.23	281.2	29.10	26.00	7.92	270.0
	106.0	100.0	42.63	38.54	3.58	109.1	35.19	33.63	3.12	95.2	7.62	7.62	0.71	21.6	73.77	90.31	8.39	255.7	23.60	26.35	8.03	267.1
	Total	2,000.0	1.1 Scarifying & re-compaction			2,453.3	1.2 (1) Embankment (local soil)			1,785.5	1.2 (2) Embankment (road side)			431.5	1.3 Subgrade			5,358.6	1.5 Slope trimming			5,592.6

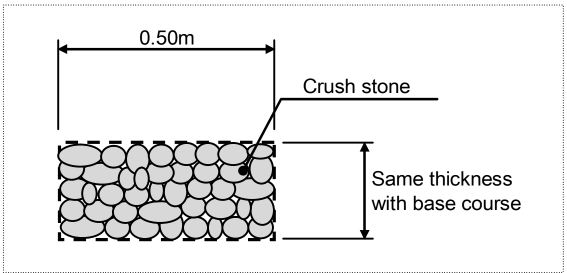
3.1 Drainage layer



Typical Cross Section-1
(Unit: Feet)



Layout of Drainage Layer (out of scale)



Dimension of Drainage Layer (out of scale)

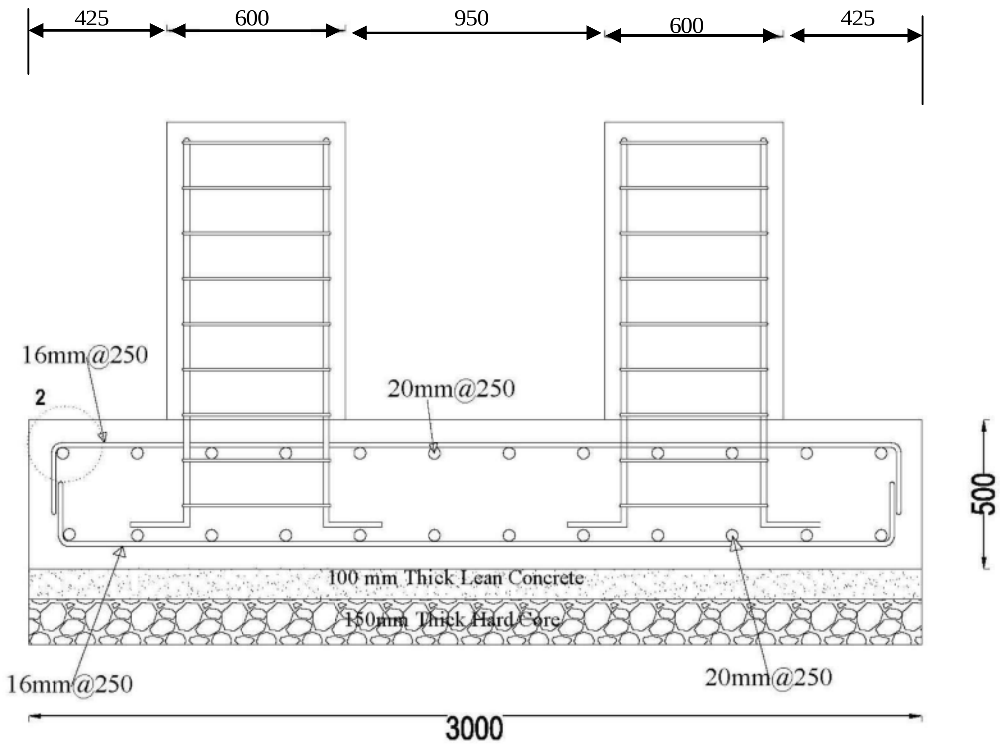
Locations

Station					
Section-1			Section-2		
86 + 0	88 + 0	90 + 0	101 + 0	103 + 0	105 + 0
86 + 10	88 + 10	90 + 10	101 + 10	103 + 10	105 + 10
86 + 20	88 + 20	90 + 20	101 + 20	103 + 20	105 + 20
86 + 30	88 + 30	90 + 30	101 + 30	103 + 30	105 + 30
86 + 40	88 + 40	90 + 40	101 + 40	103 + 40	105 + 40
86 + 50	88 + 50	90 + 50	101 + 50	103 + 50	105 + 50
86 + 60	88 + 60	90 + 60	101 + 60	103 + 60	105 + 60
86 + 70	88 + 70	90 + 70	101 + 70	103 + 70	105 + 70
86 + 80	88 + 80	90 + 80	101 + 80	103 + 80	105 + 80
86 + 90	88 + 90	90 + 90	101 + 90	103 + 90	105 + 90
87 + 0	89 + 0		102 + 0	104 + 0	
87 + 10	89 + 10		102 + 10	104 + 10	
87 + 20	89 + 20		102 + 20	104 + 20	
87 + 30	89 + 30		102 + 30	104 + 30	
87 + 40	89 + 40		102 + 40	104 + 40	
87 + 50	89 + 50		102 + 50	104 + 50	
87 + 60	89 + 60		102 + 60	104 + 60	
87 + 70	89 + 70		102 + 70	104 + 70	
87 + 80	89 + 80		102 + 80	104 + 80	
87 + 90	89 + 90		102 + 90	104 + 90	
Nos. 20	Nos. 20	Nos. 10	Nos. 20	Nos. 20	Nos. 10

Dimension & Quantity

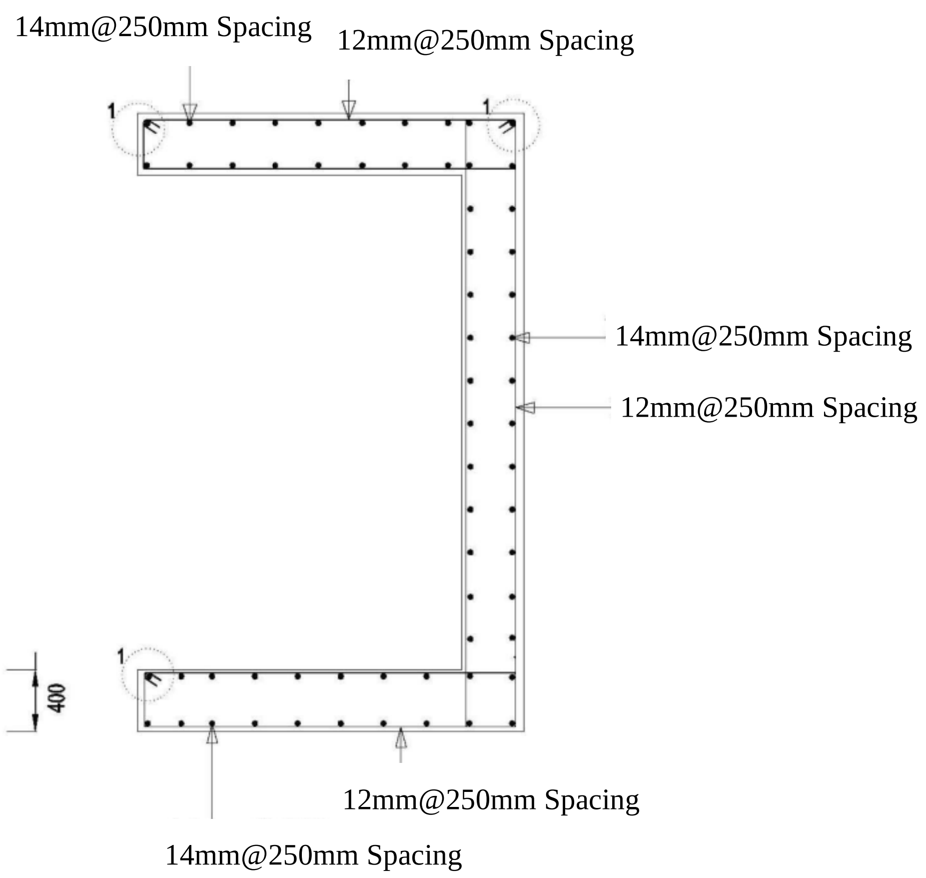
Unit L (m)	1.20
Unit W (m)	0.50
Unit D (m)	0.15
Unit V (cu.m)	0.09
Total Nos.	200
Total V (cu.m)	18.00

Appendix-D: Drawings of the Soil Plant Foundation

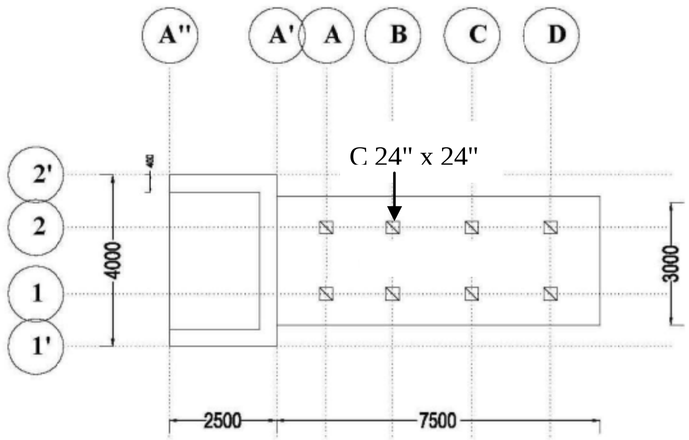


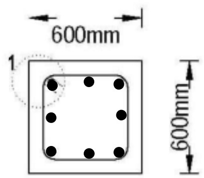
SECTION D-D

PROJECT	JICA		
	BLOCK NO		
	LOT NO		
PROJECT			
SCALE	AS SHOWN	PROJECT	
L.S			
L.C			
OWNER			



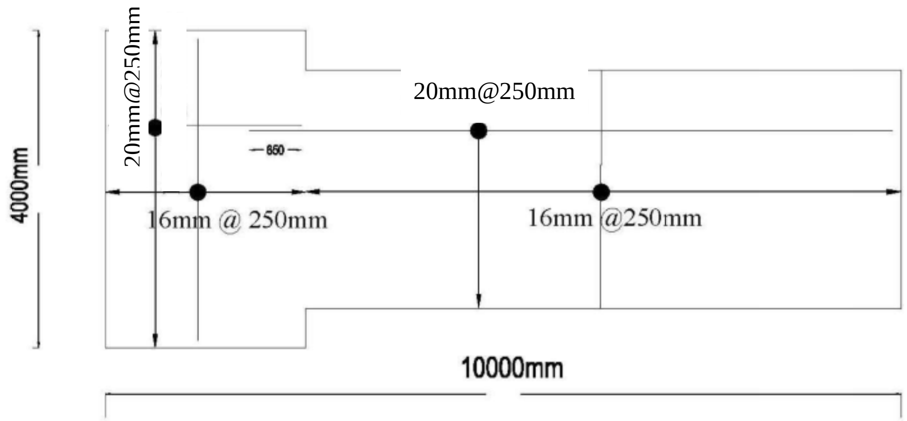
PROJECT
JICA
BLOCK NO
LOT NO
PROJECT
SCALE
AS SHOWN
PROJECT
LS
LC
OWNER



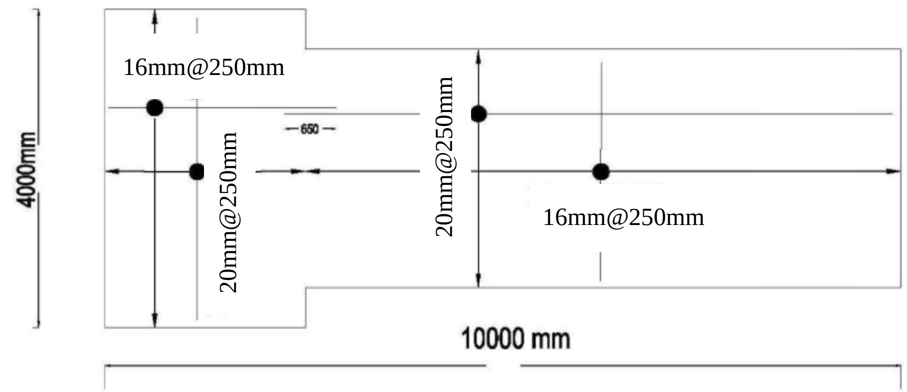


Longitudinal Steel – 8- 16mm
Shear Steel – 10mm@150mm
Spacing

PROJECT	JICA	
	BLOCK NO	
	LOT NO	
PROJECT		
SCALE	AS SHOWN	PROJECT
L.S		
L.C		
OWNER		



Top Steel Footing Plan



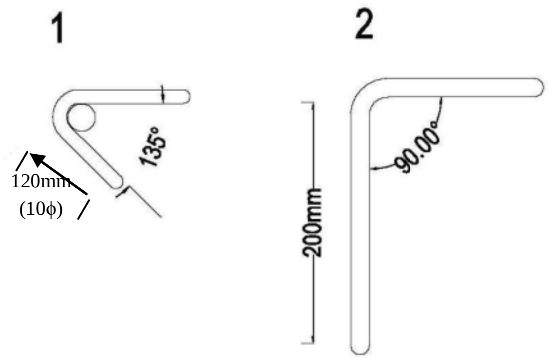
Bottom Steel Footing Plan

PROJECT	JICA	
	BLOCK NO	
	LOT NO	
PROJECT		
SCALE	AS SHOWN	PROJECT
L.S		
L.C		
OWNER		

Material

concrete cylinder strength,f'c = 3000 psi (fc=21N/mm^2)

reinforcing yield strength = 40000 psi (fy=275N/mm^2



Concrete cover = 1.5"

PROJECT	J.	
	BLOCK NO	
	LOT NO	
PROJECT		
SCALE	AS SHOWN	PROJECT
LS		
LC		
OWNER		

II

Appendix-E: Test Report of Alkaline Digestion Method

SGS

Test Report

No. : CE/2014/B2406 Date : 2014/11/24 Page : 1 of 4

ORIENTAL CONSULTANTS GLOBAL CO., LTD. *CE/2014/B2406*
12-1, HONMACHI 3-CHOME, SHIBUYA-KU, TOKYO, 151-0071, JAPAN

The following sample(s) was/were submitted and identified by/on behalf of the applicant as :

Sample Description	:	PORTLAND CEMENT
Style/Item No.	:	TIS15-PART1-2555
Sample Receiving Date	:	2014/11/17
Testing Period	:	2014/11/17 TO 2014/11/24

===

Test Requested	:	As specified by client, with reference to RoHS Directive 2011/65/EU Annex II to determine Cr(VI) content in the submitted sample.
Test Method	:	Please refer to next pages.
Test Result(s)	:	Please refer to next page(s).
Conclusion	:	Based on the performed tests on submitted samples, the test result of Cr(VI) comply with the limit as set by RoHS Directive 2011/65/EU Annex II; recasting 2002/95/EC.

Troy Chang / Manager – Tech
Signed for and on behalf of
SGS TAIWAN LTD.
Chemical Laboratory – Taipei

SGS

Test Report

No. : CE/2014/B2406 Date : 2014/11/24 Page : 2 of 4

ORIENTAL CONSULTANTS GLOBAL CO., LTD. *CE/2014/B2406*
12-1, HONMACHI 3-CHOME, SHIBUYA-KU, TOKYO, 151-0071, JAPAN

Test Result(s)

PART NAME No.1 : GRAY POWDER

Test Item(s)	Unit	Method	MDL	Result	Limit
				No.1	
Hexavalent Chromium Cr(VI)	mg/kg	With reference to IEC 62321: 2008 and performed by UV-VIS.	2	15	1000

Note：

1. mg/kg = ppm；0.1wt% = 1000ppm
2. n.d. = Not Detected
3. MDL = Method Detection Limit

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Test Report

No. : CE/2014/B2406 Date : 2014/11/24 Page : 3 of 4

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12-1, HONMACHI 3-CHOME, SHIBUYA-KU, TOKYO, 151-0071, JAPAN

Hexavalent Chromium Cr(VI) Analytical flow chart

1) Name of the person who made measurement: Climbgreat Yang
2) Name of the person in charge of measurement: Troy Chang

Cutting / Preparation
↓
Sample Measurement
↓ (Note**)
Add appropriate amount of digestion reagent
↓
Heat to appropriate temperature to extract
↓
Cool, filter digestate through filter
↓
Add diphenyl-carbazide for color development
↓
measure the absorbance at 540 nm by UV-VIS

Note** (For IEC 62321)
(1) For non-metallic material, add alkaline digestion reagent and heat to 90~95℃.
(2) For metallic material, add pure water and heat to boiling.

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Test Report

No. : CE/2014/B2406 Date : 2014/11/24

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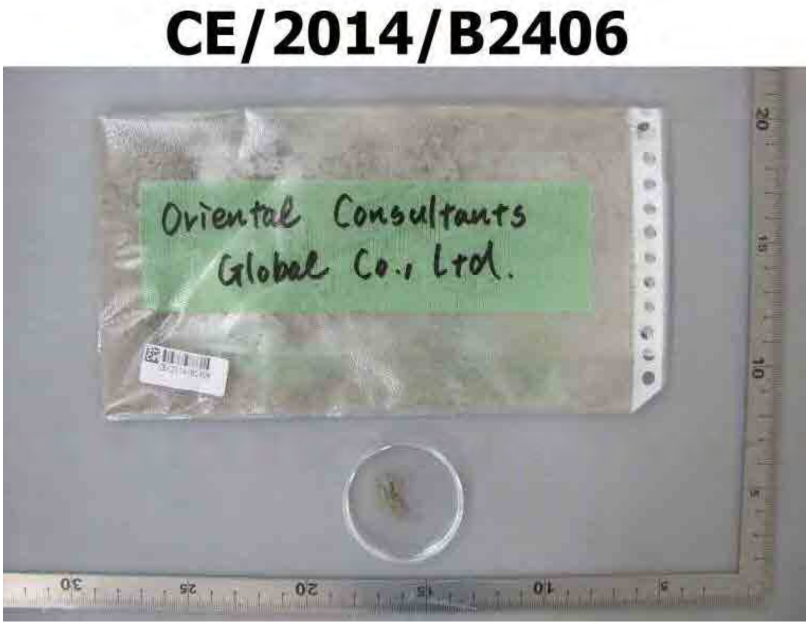
*The tested sample / part is marked by an arrow if it's shown on the photo. *



** End of Report **

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