Republic of Tajikistan
Ministry of Transport (MOT)

Ex-Post Situation Survey for the Project for the Improvement of Dusty-Nizhniy Pyandzh Road

Ex-Post Situation Survey Report

March 2015

Japan International Cooperation Agency (JICA)

CTI Engineering International Co., Ltd.

GL
JR
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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the ex-post situation Survey for the Project for the improvement of Dusty-Nizhniy Pyandzh Road and entrust the survey to CTII Engineering International Co., Ltd.

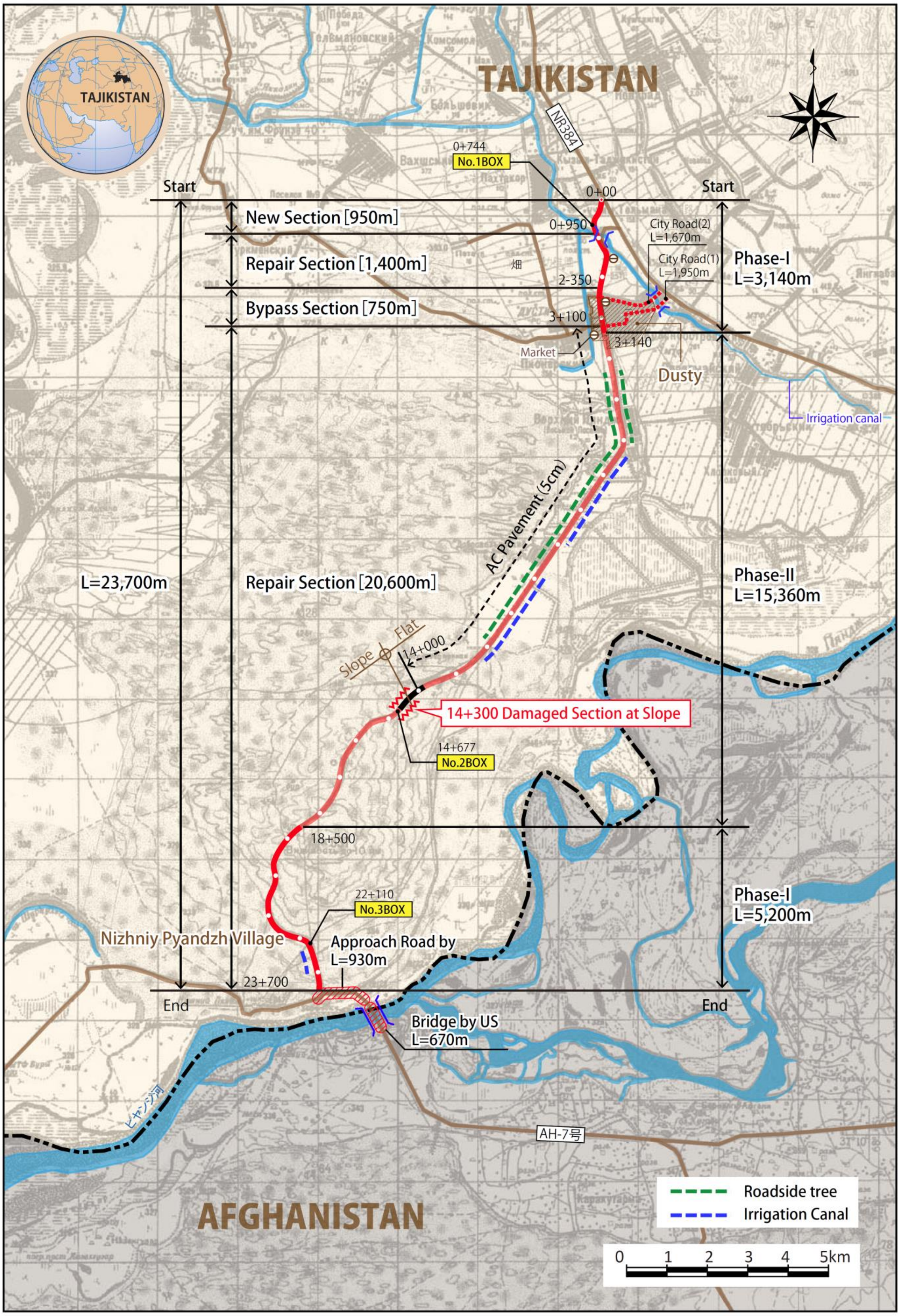
The survey team held a series of discussions with the officials concerned of the Government of the republic of Tajikistan, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the maintenance work of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the republic of Tajikistan for their close cooperation extended to the survey team.

Mar. 20, 2015

Takahiro SASAKI
Director General
Financial Cooperation Implementation Department
Japan International Cooperation Agency



Project Location Map

Preface Photos

Road Defects/Survey Condition

Sliding of AC Pavement

Alligator Crack on AC Pavement/
Exposure of AS Stabilized Base Course

Alligator Crack on AC Pavement

Repair by Cold Mixture at AC Pavement Defect Location

Meeting with MOT

Meeting with SEHM Chairwoman

Survey of Adhesion between AC Pavement and Cement-Stabilized Base Course on Steep Section

Easy CBR Test

Easy Dynamic Penetration Test

Measurement of Rutting

Traffic Survey

MOT Laboratory Room

Urgent Repair Location

Steep Location-1

Steep Location-2

Flat Location-1

Flat Location-2

Flat Location-3

Flat Location-4

Flat Location-5

Flat Location-6

Flat Location-7

Contents

Attachments

Attachment-1 List of Received Quality Related Documents

Attachment-2 Record of Minute of Meeting with JICA and MOT

Attachment-3 Result of Pavement Inventory Survey

Attachment-4 Result of Axle Load Measurement

Attachment-5 Technical Note-1

Attachment-6 Record of Meeting about the Selection of the Urgent Repair Work

Attachment-7 Letters of Request for the Selection of Repair Method

Attachment-8 Table of Result of Soil Test

Abbreviation

AC	:	Asphalt Concrete
AS	:	Asphalt
CBR	:	California Bearing Rate
CIST	:	Clegg Impact Soil Tester
DCP	:	Dynamic Cone Penetration
E/N	:	Exchange of Note
ESAL	:	Equivalence Single Axial Load
FWD	:	Falling Weight Deflectometer
G/A	:	Grant Agreement
JICA	:	Japan International Cooperation Agency
LL	:	Liquid Limit
MOT	:	Ministry of Transport
PI	:	Plasticity Index
PL	:	Plastic Limit
SEHM	:	State Enterprise on Highway Maintenance
SN	:	Structural Number

1. Outline of Project

About 90% of the Republic of Tajikistan (hereafter referred to as Tajikistan) is mountainous area. The main roads between the capital city and local cities or to the neighboring countries are the most important infrastructures. However, many main roads were constructed before 1991 during the soviet era. The remarkable deterioration and the damages of the infrastructures have caused the bottleneck of the economy development due to the shortage of the budget for the maintenance which was the result of the economy slowdown and civil war after the independence.

The target road of the project is Dusty-Nizhniy Pyandzh Road with distance of 23.7km, which is the main road connecting both capital cities of Tajikistan and Afghanistan and considered the priority road for the long-term transportation development plan in Tajikistan. Also, It is positioned as a large-covered area corridor (AH7) of the Asian Highway. Moreover, since logistical vitalization and increase of traffic volume were expected due to the bridge at the border of Afghanistan built by assistance of US, Tajikistan had requested to the Japanese Government for the assistant to build road along the same section.

Based on the request of Tajikistan, 8.3km from both sides of the road among the target roads of the project (3.1km from the start point at Dusty, 5.2km from Nizhniy Pyandzh), 3.7km(road in the Dusty city) has been chosen for the improvement under the Grant Aid [the Project for the Improvement of Dusty-Nizhniy Pyandzh Road(1/2 phase)](hereafter referred to as the First Phase), which the Exchange of Note(E/N) was signed in September 2006 and the road improvement was completed in June 2008. The improvement review study of the remaining section of 15.4km had been conducted in August 2008, the Exchange of Note (E/N) and Grant Aid had been signed in January 2009 for [the Project for the Improvement of Dusty-Nizhniy Pyandzh Road(2/2 phase)](hereafter referred to as the Second Phase), and the road improvement had been completed in November 2011.

During the monitoring after the project completed, defects on the sections where AC pavement in the Second Phase was thin(5cm) and the steep section near the Sta. 14+300 defects had been reported. Tajikistan had expressed the necessity for the overlay and the early repairmen.

In response to this request, Japan International Cooperation Agency (hereafter referred to as JICA) had been conducted the study of the ex-post situation survey(preliminary study). As a result, the following confirmation had been made at the sections with pavement thickness of 5cm in the second phase project having low bearing capacity which caused AC pavement defects and large cracks of AC pavement along the steep section. And it was confirmed that overloaded vehicles of more than 70 tons had been passed through everyday according to the hearing survey.

The purpose of this project is to clarify the mechanism and condition of pavement defects in response to the above results and to give recommendations to Tajikistan on the Urgent repair in future and provide the technical assistance for the required repair and maintenance of the target road sections in Tajikistan.

2. Content of Survey

2.1 Survey Method

The work was done in accordance with the following flowchart.

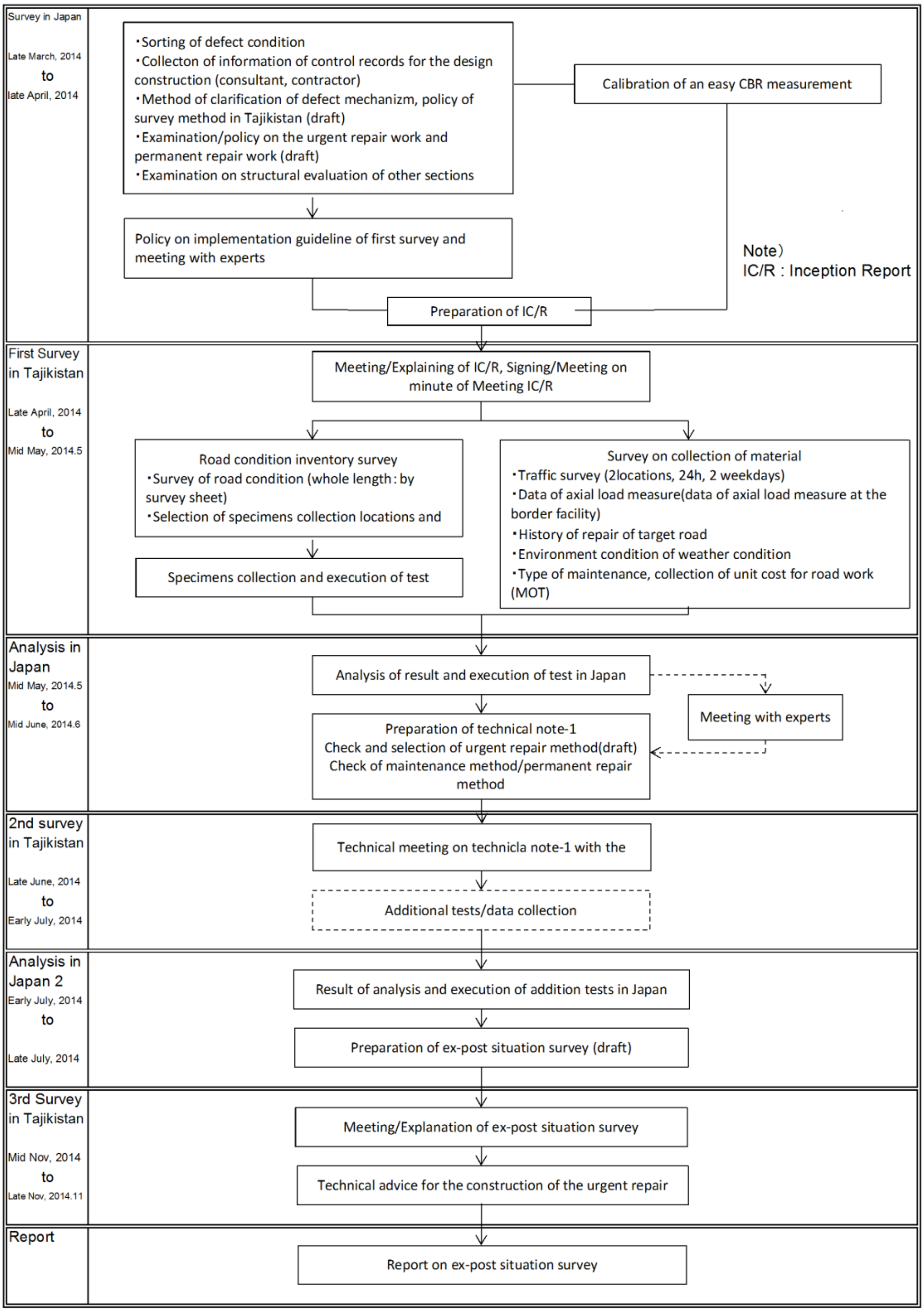


Figure 2.1-1 Flowchart of Survey

（**Survey in Japan**）

2.2 Collection of Design/Construction Documents

The quality related documents of the design/construction phases for the project had been collected. Among the collected documents (Attachement-1), as-built drawings to show the elevation of the existing road and height of subgrade fill, the records to explain material/mixture, the construction plan to explain quality control method, the records of quality control about the cement stabilized sub-base work, related quality control records to analyze the pavement defects mechanism had not been found.

2.3 Meeting with Pavement Experts

Consultation with the pavement experts (engineers from two pavement companies) about the survey and the test methods in order to explain the factors causing defects and defect condition of the pavement in this project was done. The contents of the discussion are as follows :

Table 2.3-1 Meeting with Pavement Experts

Related Issues	Survey Items to Be Conducted
Traffic volume exceeding the design traffic volume (heavy vehicle) can cause defects.	The analysis of the traffic load and the design traffic volume shall be done by examining the weight of heavy vehicles from the truck scale records taken from the device installed at the custom facility at the border with Afghanistan while the traffic survey shall be executed along with in the survey. The factor of increasing traffic volume will be also investigated such as the development around the surrounding area.
The bearing strength of the subgrade can be lower than its design value due to high underground water level .	The underground water level shall be checked by excavation work in May during the rainy season, or a peak farming season in Tajikistan. Also, the water content of the subgrade material shall be measured. In regards to the bearing strength, the in-situ test shall be done by using CIST (an easy CBR test device), dynamic cone penetration test device, and the laboratory test will be done to confirm it.
In regards to the sliding of the pavement at the steep section, there is an adhesive problem between AC pavement and the cement stabilized sub-base.	Tajikistan is responsible to execute the Urgent Repair Work in regards to the survey at the steep section. As for the repair method, the repair plan will be proposed based on the survey results taken from the survey in Tajikistan.
The deterioration of the bearing strength of the cement stabilized material and its defect can cause the defect to the pavement.	The bearing strength of the cement-stabilized sub-base at the defect location and good condition location shall be examined at site.
There is possibility that frost could cause damages to the cement- stabilized sub-base.	The existing stabilized sub-base materials shall be collected and frost-thaw test will be executed in Japan to inspect the destruction. Also, the depth of frost penetration shall be confirmed and the temperature data after the road were open shall be collected.
Low quality of AC pavement is one of the defect factors.	In regards to the defects of AS mixture, the deformation point and the penetration test of the straight AS shall be done. However, according to the experts, it is impossible to check its original quality due to the deterioration of the material of the straight AS. Therefore, its qualities can be only checked from the mixtures and particle size distribution of aggregate.

2.4 Calibration of CIST (Easy CBR Test Device)

2.4.1 Outline

The acceleration is recorded as Impact Value (IV) of the impact on the ground by falling of hammer 4.5kg from a specific height, where the CIST (Clegg Impact Soil Tester) is setting. The fourth value of the Impact Value (IV4) are conversed to the CBR value which displayed on the test device. The results of number of five(5) IVs and its latitude/longitude can be imported to PC. There is no limit of the target ground for the test according to the manual.

CIST Photo

2.4.2 Approximation from the Manual

The relationship between the %CBR and IV4 are computed based on 200 data and calculated the Approximation as in Figure 2.4-1. The manual also recommended that user can compute approximation under specific soil condition by themselves for the higher accuracy purpose.

Approximation	$\%CBR = ((0.24 \times IV_4)+1)^2$
Correlation coefficient	$r = 0.957$

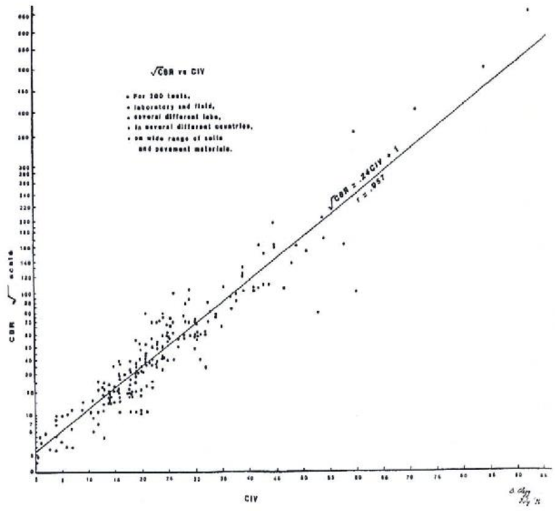


Figure 1 – IV_4 and %CBR Correlation

Figure 2.4-1 IV_4 and %CBR

2.4.3 Calibration Method

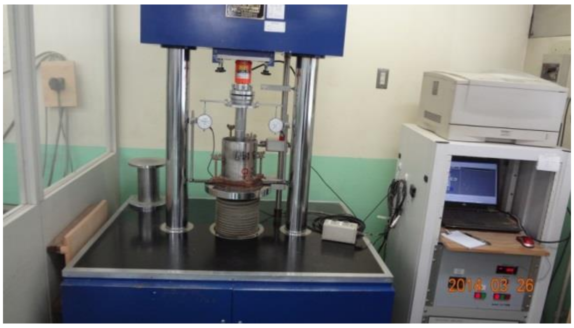
The calibration of CBR value by CIST according to the following two types of method had been made. In the method of in-situ CBR by using method-1, where some ground are too hard or having small rock in it, the measurement by CIST is impossible. In response to this, the calibration had been made by using CBR mold in the method-2.

Method-1
Test Item : Compacted road
Method : CBR value by in-situ CBR and CBR value by CIST

Method-2
Test Item : Material compacted in CBR mold
Method : CBR value by CBR test device and CBR value by CIST

In-Situ CBR Measurement

Compaction Test



Measuring by CBR Test Device

Test of Material Compacted by CIST

2.4.4 Result-1 (Calibration by using approximation in the manual)

The results of CBR value of 3 types of materials in method-2 are shown in Table 2.4-1, Figure 2.4-2,Figure 2.4-3. The result from CIST for RC-40 which has high CBR value is lower in comparison to the regular method. The result from CIST for sandy soil which has low CBR value is higher in comparison to the regular method. Since the measuring item in this survey is subgrade material which has CBR value less than 10%, the correlation which passes through point(0,0) shall be computed with the results from the regular method of the five(5) types of sandy materials.

Approximation %CBR = %CBR (by an easy measuring device)/ 1.3437

Correlation coefficient r^2=0.8758

Table 2.4-1 Results of Calibration of CBR Value by Approximation in the Manual

	RC-40 (26 March)			Sand+ Silt（28 March)		Fine sand used for pavement(28 March)		
CBR(by regular 5mm) :a	55.80	101.00	165.90	13.70	8.90	15.90	40.50	48.60
CBR(Manual) :b	60.00	84.00	139.00	21.00	17.00	28.00	43.00	71.00
b/a	1.08	0.83	0.84	1.53	1.91	1.76	1.06	1.46

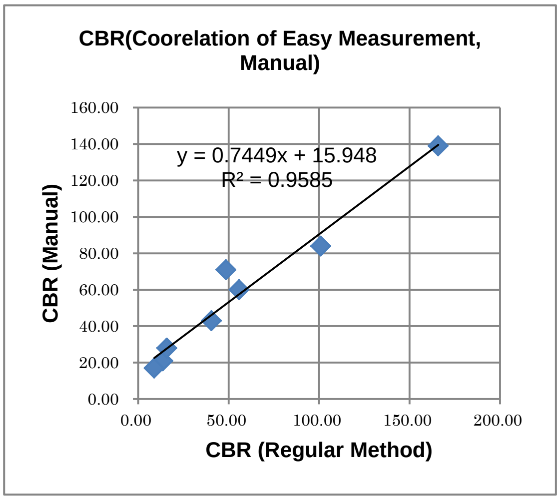


Figure 2.4-2 Correlation with CIST (All Result)

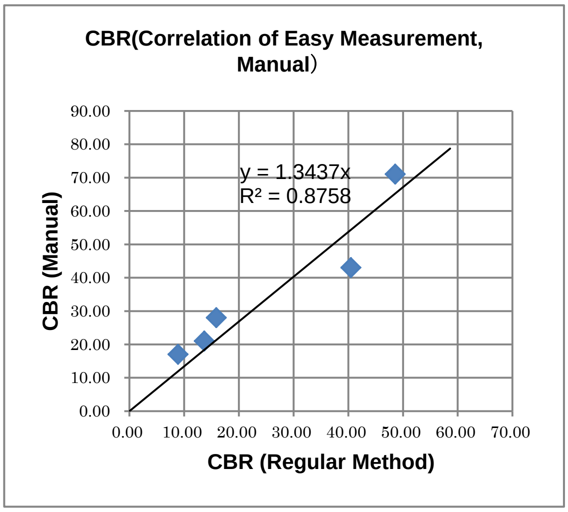


Figure 2.4-3 Correlation with CIST (Sandy Soil)

2.4.5 Result-2 (Calibration by using new approximation)

The following formula was introduced in 2002 in the Journal of Materials in Civil Engineering of American Society of Civil Engineers, the thesis « Clegg Hummer-California-Bearing Ratio Correlation ».

New Approximation $\%CBR = 0.1691 \times (IV_4)^{1.695}$

Correlation with the result of the regular method same as described in section 2.4.4 was computed as in Table 2.4-2, Figure 2.4-4,Figure 2.4-5.

Table 2.4-2　Result of Calibration of CBR Value by New Approximation

	RC-40（26 March）			Sand＋ Silt（28 March)		Fine sand used for pavement(28 March）		
CBR(by regular 5mm）:a	55.80	101.00	165.90	13.70	8.90	15.90	40.50	48.60
IV_4	28.11	34.02	44.96	14.93	13.01	17.88	23.16	30.94
CBR(Approx.）:b	48.30	66.75	107.06	16.52	13.09	22.44	34.77	56.84
b/a	0.87	0.66	0.65	1.21	1.47	1.41	0.86	1.17

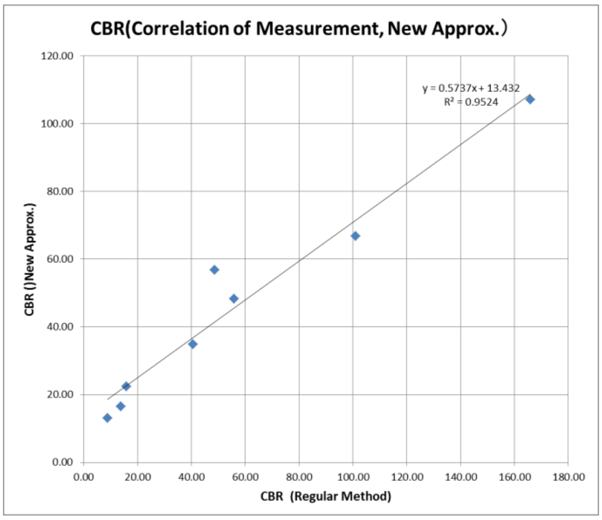


Figure 2.4-4 Correlation-2 with CIST (All result)

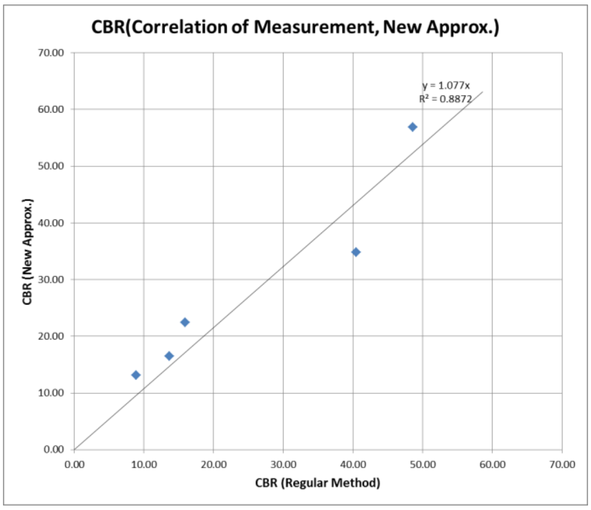


Figure 2.4-5 Correlation-2 with CIST (Sandy soil)

Approximation　　　　　%CBR = New %%CBR/1.077

Correlation coefficient　　r^2=0.8758

In comparison to the result-1 of 1.3437, the value of 1.077 is extremely small. It is found that the new approximation has high accuracy.

2.4.6 Calibration of CIST and an Easy FWD Device

The results of CBR measured by using the 2 types of method (Easy FWD and CIST) of the sandy soil were compared. The result by CIST is 10 times of the result by an Easy FWD, because the accuracy of the computed %CBR from the ground elastic modulus by an Easy FWD is not clear. CIST calibration by an Easy FWD Device was abandoned.

Measurement by an Easy FWD Device

2.5 Weather Data Survey and Examination of Frost Depth

The frost depth index computed from the result of the weather data analysis is shown in Table 2.5-1. Though the result is high due to the frost depth index in 2007, it may occur only once in 12 years and it is considered that the impact on the AC pavement by the frost after the completion of the construction is limited. The relationship between frost index and frost depth is shown Figure 2.5-1.

Table 2.5-1 Table of Frost Index

No	Location	Period	Low temperature (℃)	Frost Index (day ℃)
1		Jan , Feb 2011	-6.4	30.6
2		Dec 2001, Jan, Feb 2002	-6.4	20.3
3	Qurgonteppa	Dec 2002, Jan, Feb, 2003	-9.5	27.9
4		Dec 2003, Jan, Feb, 2004	-6.5	19.7
5		Dec 2004, Jan, Feb 2005	-2.8	2.8
6		Dec 2005, Jan, Feb 2006	-3.2	13.8
7		Dec 2006, Jan, Feb, 2007	-3.6	12.9
8	Qomsangil	Dec 2007, Jan, Feb 2008	-13.5	232.3
9		Dec 2008, Jan, Feb 2009	-4.7	8.6
10		Dec 2009, Jan, Feb 2010	-7.3	14.7
11	Field	Jan, Feb 2010	-2.9	5.8
12	Qomsangil	Dec 2010, Jan, Feb 2011	-5.6	14.9
13	Field	Dec 2010, Jan, Feb 2011	-2.1	4.7
14	Qomsangil	Dec 2011, Jan, Feb 2012	-9.3	38.3
15		Dec 2012, Jan, Feb 2013	-11.7	90.5

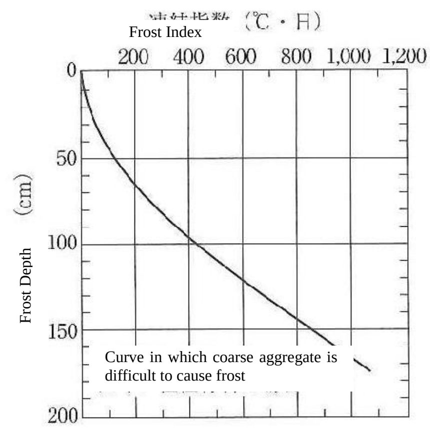


Figure 2.5-1 Relationship between Frost Index and Frost Depth (Ref: Pavement design standard)

（**First Survey in Tajikistan**）

2.6 IC/R Explanation/Meeting, Minute of Meeting/Signing

The Study Team and the Ministry of Transport (hereafter referred to as MOT) of Tajikistan had discussed about the inception report (IC/R). The MOT had signed the minute of meeting. (Attachement-2) The major undertakings for both the Government of Japan and the MOT are shown as follows:

Major undertakings of the Government of Japan

- The survey team will bring "Technical Report 1" including the result of the first field survey and proposals of methods for repair works for the damaged sections on the middle of June at the beginning of the second field survey to have technical discussion with MOT for selection of methods of the repair works.
- The Survey team will send "The Technical Report 2" including repair techniques and methods, quantity and cost of the repair works to MOT by the end of mid-July 2014, which will make MOT able to prepare for the repair works.
- The Survey team will send "Technical Report 3" including technical consideration of the result of the repair work and the final result of the Survey to MOT by the end of mid-September 2014, which will make MOT be able to comment of technical issues. The Survey team will reflect the comments and send a final report to MOT by the end of October 2014.

Major undertakings of MOT

- Assistance of obtaining necessary permission for the various tests on the survey road,
- Provision of weather data,
- Provision of vehicle type loading data,
- Provision of unit price and suppliers of materials and equipment for the Urgent repair work,
- Provision of unit price of work items,
- Implementation of traffic census,
- Lending tools (shovel, pickaxe, etc.) for sampling,
- Tests of pavement materials in MOT Lab.,
- Recovery of trial pits,
- Assistance of sampling pavement materials,
- Ensuring traffic safety measures for the on-road survey works, and
- Provision of other necessary data

2.7 Survey of Pavement Defect Condition

The defect condition was grasped from the inventory survey of the whole target roads. The defect condition had been classified as follows:

- Transverse crack (Cross section direction)
- Longitudinal crack (Profile direction)
- Alligator crack (Record into 3 steps as Big/Medium/Small)
- Defect by the flow of the AC pavement
- Crescent-shaped gaps/cracks considered to be the initial stage of the flow of AC

Defect condition of each section and its characteristics are shown in the attachment-3.

2.8 Collection of Soil Samples and Result of Trial Excavation

In order to grasp the factors causing defects, the confirmation of the subgrade and the cement-stabilized base course at the severe defect location and no defect location had been done. The material tests of the collected samples were also conducted. The details are as follows:

① Test location: Sta. 12+607 (on shoulder on Afghan direction) good road surface condition section (Test date: 6th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	3cm	3cm	—	—	
Base course	15cm	15cm	30	Cement stabilized surface CBR: 300,578,590	Material: Sand + pebble Collection of sample
Subgrade	—	30cm	5.9	Subgrade surface CBR: 15,9,12	Clay: yellow Collection of sample
	—	—	5.9	Surface－50cm CBR: 28,9,13	Clay: dark brown Collection of sample

② Test location: Sta. 6+352 (on shoulder on Afghan direction) good road surface condition section
(Test date: 9th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	3cm	3cm	—	—	—
Base course	15cm	15cm	30	Cement stabilized surface CBR: 118,128,118	Material: Sand + pebble Collection of sample
Subgrade	—	40cm	8.7	Subgrade surface CBR: 12,19,12	Clay: yellow Collection of sample
				Surface－50cm CBR: 7,9,13	
		62cm	8.7		Base course of old road: sand mixed pebble
				Surface－110cmCBR：31	Subgrade of old road: sand Collection of sample

Rutting depth: 1.3cm, no underground water

③ Test location: Sta.4+480 (on lane on Dushanbe direction) defect section (Test date: 9th May 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	5cm	5cm	—	—	—
Base course	25cm	13cm	30	Cement stabilized surface CBR: 118,26,21	Material: Sand + pebble Collection of sample (the above gravel?)
		9cm	30	Cement stabilized surface CBR: 10,10,10	Material: clay(yellow) Collection of sample
Existing AS pavement		10cm	—	—	—
Subgrade	—	—	8.7	Surface −46cm CBR: 80,112,112	Base course of old road: sand mixed boulder Collection of sample

④ Test location: Sta. 2+416 (on lane on Dushanbe direction) defect section(Test date: 10th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	10cm	8cm	—	—	Collection of sample
Base course	—	9cm	—	—	Material: gravel
	35cm	12cm	30	Cement stabilized base course Surface of base course CBR: 118,112,128	Material: sand + pebble Collection of sample
		18cm	30	Cement stabilized base course Surface - 29cm CBR: 23,63,49	Material: sand + pebble
Subgrade	—	—	3	Surface - 46cm CBR: 21,21,21	Sand

Rutting depth of carriageway: Middle lane side 0.8cm、shoulder side 3.6cm (Causes are not clear)

Middle lane side 0.6cm、shoulder side 3.9cm

⑤ Test location: Sta. 2+425 (on shoulder on Afghan direction) defect section(Test date: 10th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	3cm	4.5cm	—	—	—
Base course	15cm	12cm	30	Cement stabilized base course Surface CBR: 26,23,43,34	Material: sand + pebble
Subgrade	—	40cm	3	Subgrade surface, CBR: 12,13,10	Clay: yellow(fill)
		55cm	3	Surface -110cm CBR: 6,6	Sand(mixed with dust)

No underground water (-110cm from the road surface)

⑥ Test location: Sta. 15+458(on lane on Dushanbe direction) defect (pavement sliding) section(Test date: 10th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	10cm	10cm	—	—	Grooving process according to the repair record but cannot confirm
Base course	30cm	Not measured	30	Cement stabilized base course Surface CBR: too hard to measure	Material: sand + pebble

⑦ Test location: Sta. 5+030(Middle of lane) defect section(Test date: 10th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	5cm	5cm	—	—	—
Base course	25cm	16.5cm	30	Cement stabilized base course Base course surface CBR: 21,31,34	Material: sand + Pebble
		3.5cm	30	Cement stabilized base course Surface CBR: 13,17,36	Material: Clay(yellow) Collection of sample
Existing AS pavement		—	—	—	—

⑧ Test location: Sta. 1+317(Middle of lane) defect section (Test date:12th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	8cm	8cm	—	—	—
Base course	30cm	15.0cm	30	Cement stabilized base course Base course surface CBR: error, error, 566%	Material: sand +pebble Collection of sample
		15.0cm	30	Cement stabilized base course	Material: sand + pebble
Subgrade		27cm	5.2	Surface CBR: 17,19,19	Clay: light brown
		—	5.2	Surface CBR: 60,67,52	Clay: red Collection of sample

⑨ Test location: Sta. 5+028 (Middle of lane), good section (next to defect section) (Test date: 12th May, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Measure	Design	Measure value	
AS pavement thickness	5cm	5cm	—	—	—
Base course	25cm	17.5cm	30	Cement stabilized base course Base course surface CBR: 195%, 209%, error	Material: sand + pebble
		4.0cm	30	Cement stabilized base course CBR:18%	Material: clay (yellow)

The CBR value above was measuring by using CIST (an easy CBR test device).

2.9 Traffic Volume Survey

The traffic volume survey was conducted at the Sta.2+400 and Sta. 3+300 for two days on May 8th, 9th. The results are shown in Table 2.9-1, Table 2.9-2.

Table 2.9-1 Traffic Survey Result Sta.2+400

	To Dushanbe	To Afghan	Total (per two days)	Total (per one day)
Car	3,993	3,700	7,693	3,846
Pick-up	2	3	5	2
Bus/Mini Bus	128	219	347	173
Truck	160	186	346	173
Trailer	122	104	226	113
Total	4,405	4,212	8,617	4,307

Table 2.9-2 Traffic Survey Result Sta.3+300

	To Dushanbe	To Afghan	Total (per two days)	Total (per one day)
Car	1,842	1,941	3,783	1,891
Pick-up	18	14	32	16
Bus/Mini Bus	30	36	66	33
Truck	166	196	362	181
Trailer	114	95	209	104
Total	2,170	2,282	4,452	2,226

2.10 Axle Load Survey

In Tajikistan, the installation of an easy vehicle weight measuring device since 2011 in front of gate at the border with Afghanistan has been made to measure the over load of large vehicles. The truck scale was installed since 2014 and the measurement is conducting 24 hours. Nevertheless, the measurement of the vehicle weight started in 2006.

Truck scale installed in front of the border gate

Vehicles Waiting for Night Driving

Currently, a load limit restriction has been being carried out on road MD9 (Dushanbe-Kurgan Tyube lower Pianj border) in Tajikistan as shown in the Table 2.10-1. According to the hearing survey at the weight measuring control station, it is said that overweight vehicles have to unload the cargos.

Table 2.10-1 Load Limit on MD9

Period	All seasons (except summer)	Summer(May to August/ 10AM to 8PM) ※At day where the temperature is exceeding 25℃
Total Load	< 40t	
Axle Load	2 axles: 7.2t to less than 10.8t 3 axles: 9.6 t to less than 13.5t	Axle load: < 6t

Vehicles from Afghanistan are waiting near the border gate until night. The heavy vehicles are usually driving at daytime from Tajikistan side at present. The vehicles waiting for the night driving are usually loading cement from the Afghanistan side. Fuel and agriculture products were transporting from Tajikistan. The transports from Afghanistan side are more than from Tajikistan.

The survey was conducted 24 hours. As a result, the load limit as described above is abiding until now. However, it is mentioned in the defect liability inspection report that the overload vehicles of about 70tones were driving on the target road.

The results of vehicle weight measurement (total weight, axle number) are shown in the attachment-4.

2.11 Maintenance/Construction Unit Cost and Procurement Survey

Procurement survey was conducted in regards to the materials and equipment required for the Urgent repair.

<u>Crusher Run (Rumi Quarry)</u>

Crusher run is producing from the river gravel in Rumi village 30km north of the target road at the start point by the private company. The crusher run product has only size with the dimension of 5mm×15mm, 5mm×20mm. The production volume of 300t to 400t/days is possible throughout the year. The prices are shown in the Table 2.11-1.

Table 2.11-1 Prices of Crusher Run-1

Material	Price(m3)	Remark
5mm×15mm	80Somoni	Transportation fee of 25 Somoni/km is calculated.
5mm×20mm	60Somoni	Possess 3 dump trucks can load up to 16m3 each.

Plant

Aggregate

Crusher Run （Jirikuru quarry）

Crusher run is produced from the river gravel along the river 14km South-West of Rumi village 30km north of the target road at the start point by the private company. The crushing plant was purchased from the World Kaihatsu Kogyo, which was subcontracted from Dai Nippon Construction by the private company.

The product of crusher run has only 3 types of size with the dimension of 0mm to 5mm, 0mm to 15mm, 0mm to 25m. Size of 40mm is available only by order. The product volume is 100t to 120t per hour and it can produce year round. The prices are shown in Table 2.11-2.

Table 2.11-2 Price of the Crusher Run-2

Material	Price(m3)	Remark
0mm to 5mm	45Somoni	Pick-up unit price is excluding the transportation fee.
0mm to 15mm	45Somoni	
0mm to 25mm	35Somoni	

Plant-1

Plant-2

Collection of Aggregate

Straight Asphalt

Straight Asphalts can be procured from the Qumsangir Salosa Company, near Dusti city of the target road.

Construction Equipment / Plant

It was confirmed that the Rohid Tajik Company owns the following construction equipment / plant as shown in Table 2.11-3.

Table 2.11-3 List of Equipment / Plant owned by Rohid Tajik Company

Name of Equipment / Plant	Specifications
Asphalt Plant	1260 t / day
Milling Machine	120 t / hr
Asphalt finisher	
Macadam Roller	16 t
Tire Roller	13 t
Small Roller	4 t
Motor Grader	

2.12 Budget of Qumsangir Road Maintenance Office (SEHM)

The budget and the expenses for the road maintenance for three(3) years from 2011 to 2013 are 260,222Somoni (or 5,200,000¥).

2.13 Results of Laboratory Tests in MOT

The soil tests of base course material and subgrade material were conducted in MOT laboratory. The results are shown in Table 2.13-1. It was found that all CBR values were exceeding the design CBR. Though there have large amount of silts in most part of the subgrade soil, the PI was considered to be NP, which is different with the expectation of the study team and the test result is questionable.

Table 2.13-1 Results of Laboratory Test in Tajikistan (MOT)

(First Survey in Tajikistan)

Sta.	12+607		6+352		4+ 476	2+ 425	5+029		1+ 317
Structure	Subgrade		Subgrade		Subgrade	Subgrade	Cement Stabilized Base Course		Subgrade
Depth(m)	-0.3	-0.5	-0.5	-1.1	-0.46	-0.5	Upper layer	Sub-base	-0.7
Maximum dry density (g/cm^3)	1.879	1.926	1.817	1.997	1.927	1.815	-	-	1.810
Optimum moisture content (%)	7.7	10.4	11.8	6.4	8.7	10.2	-	-	10.8
CBR (%)	11.9	16.7	11.4	19.6	19.6	10.3			18.9
PL	NP	NP	32.4	NP	21.8	NP	NP	32.7	NP
LL	NP	NP	20.8	NP	17.2	NP	NP	20.3	NP
PI	NP	NP	11.6	NP	4.6	NP	NP	12.4	NP
Moisture content (%)	11.9	10.9	11.8	4.0	6.5	15.7	5.7	12.5	4.5
Grade (pass through %)									
19mm	80.6	98.0	100	83.9	100	97.1	96.4	100	100
9.5mm	67.9	95.3	81.2	71.4	99.1	81.5	78.9	87.4	100
4.75mm	57.3	94.0	72.0	68.2	98.0	77.1	66.3	75.6	98.8
2.00mm	48.1	93.0	61.0	64.8	97.4	74.5	60.3	63.7	98.3
1.00mm	41.3	91.9	52.4	59.6	96.5	71.8	54.6	50.7	97.3
0.425mm	38.5	90.6	49.2	55.5	95.8	70.0	49.8	43.8	96.8
0.075mm	23.9	60.9	40.6	17.2	81.9	48.9	4.16	22.6	70.3

Note) NP: non-plastic

The comparison of CBR value from the test above and from CIST is shown in Table2.13-2.

Table2.13-2 Comparison of Clegg Hummer and CBR Value

Test Location		Clegg Hammer	CBR (%)
12+607	-30cm	12(15,9,12)	11.9
	-50cm	16.6(28,9,13)	16.7
6+352	-50cm	16.6(28,9,13)	11.4
	-110cm	31(31)	19.59
4+480	-46cm	101(80,112,112)	19.59
2+425	-50cm	11.6(12,13,10)	10.3
1+317	-70cm	62(67,67,52)	18.9

（**Analsyis-1 in Japan**）

2.14 Results of Laboratory Tests and its Analysis in Japan

Test of cement stabilized base course material, permeable test of rice field soil, test of asphalt material had been conducted at the Laboratory of Japan Road Contractors Association (Hereafter referred to as JRCA Laboratory). The results are shown in the Table 2.14-1, Table 2.14-2. In regards to the cement volume of the cement stabilized base course material at Sta.5+029, the quantitative test were conducted by calcium ion-selective electrode. But the cement mixture volume could not be detected because the base material taken from quarry did not match the cement stabilized base material.

It was found that the base material of cement-stabilized base course was not satisfied with the required specification and the material from the borrow pit was not satisfied with the specifications of the subgrade fill and cement stabilized base course. Design specifications of the material are shown in the Table 2.14-3.

Since the value of permeable coefficient of soil at the roadside was having extremely low, it is understandable that there is low possibility that the irrigation water penetrated to the road structure.

Table 2.14-1 Results of Tests of Rice Field Soil and Cement Stabilized Base Course Material (First Survey in Tajikistan)

Sta.	4+476	4+476	5+029	5+029	STA22	5+029
Structure	Base course	Sub-base course	Base course	Sub-base course	Borrow Pit	Rice field at the side of road
PL	NP	37.4	NP	37.2	48.0	
LL	NP	18.1	NP	17.8	22.9	
PI	NP	19.3	NP	19.4	25.1	
Grade (Passing %)						
Rock 2 to 7.5mm	30.5	42.3	48.9	45.5	16.0	
Sand 0.075 to 2mm	45.4	21.7	34.9	17.4	17.8	
Silt <0.075mm	24.1	36.0	16.2	37.1	66.2	
Max grading mm	26.5	37.5	26.5	37.5	26.5	
Soil classification	Sand mixed with fine particles	Rock mixed with fine particle				
Penetration Coefficient (m/sec)						1.44E-7

Note) NP: non-plastic

Table 2.14-2 Table of Asphalt Tests (First Survey in Tajikistan)

	2+416	2+416	Average
AS volume (%)	3.35	3.36	3.36
Grade			
19.0mm	100	100	100
13.2mm	99.2	99.2	99.2
4.75mm	40.3	39.5	39.9
2.36mm	30.3	30.1	30.2
600μm	19.6	19.6	19.6
300μm	7.8	14.9	14.9
150μm	4.8	7.7	7.7
75μm	4.8	4.9	4.9

Table 2.14-3 Design Specifications of Materials

	Subgrade Fill	Cement Stabilized Base Course
LL	<40%	<25%
PI	<20	<9
<0.075mm	10% to 30%	
CBR	>15%	

2.15 Differences in Traffic Load

2.15.1 Traffic Load (W_{18}) of Dusti-Nizhniy Pyandzh Road Plan

The value of traffic load of the approach road of Nizhniy Pyandzh Bridge (open to the public in Spring 2005) which is located at the end of the project has been adopted as a design traffic load (w18) for this project as shown in Table 2.15-1.

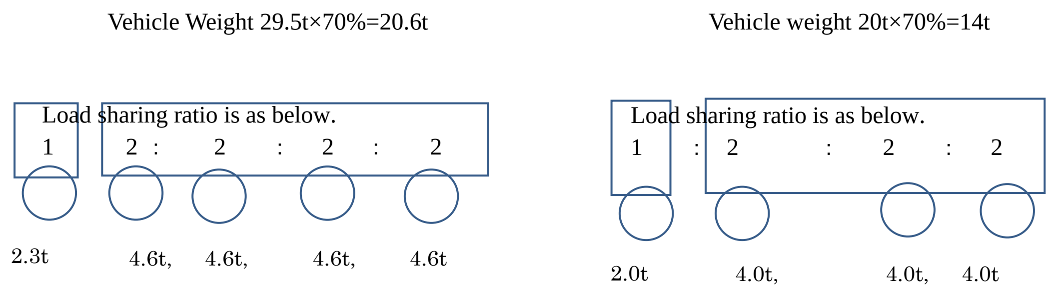
Table 2.15-1 Traffic Load Condition of the Project

Day Traffic Volume	1,000 vehicles/day
Heavy Vehicle Ratio	7% → 1,000×7% = 70 vehicles/day
Equivalent Single Axle Load (ESAL)(18kip) of heavy vehicle	0.931
Service period (10 years) ESAL	70/2×0.931×365day×10years =118,940

2.15.2 Traffic Load Estimated from the Current Traffic Volume

1) Estimation of ESAL (18kip) Value of Trailer and Truck

The ESAL values of trailer and truck (18kip) were calculated by using the result of axle load survey in June 10th, 11th, 2014, with truck of 1.67 and trailer of 3.67. (Attachment-2) Because the target axle survey vehicles were having large amount of freight, thus the weight of vehicle with small amount of freight are assumed to be 70% of the weight of the trailer and truck with large amount of freight in the survey. And the ESAL values of trailer and truck with small amount of freight which are were calculated 0.423 and 0.182 as in Figure 2.15-1.



ESAL value of Trailer excluding the axle load survey

: $(2.3/8.1)^4+(4.6/8.1)^4\times4 = 0.423$

ESAL value of Truck excluding the axle load survey

: $(2.0/8.1)^4+(4.0/8.1)^4\times3 = 0.182$

Figure 2.15-1 Estimation Method of the Equivalent Single Axle Load (18kip)

2) Estimation of Cumulative ESAL (18kip) Value of Trailer and Truck

Traffic volume and cumulative ESAL values from 2009 to 2018 as shown were estimated by the traffic survey result conducted on 8th and 9th May, 2014 and the economic growth rate in Table 2.15-2, Figure 2.15-2. ESAL(18kip) values of truck and trailer 1.67 and 3.67 are adopted to half of the total traffic volume and 0.182 and 0.43 are adopted to another half of the total traffic volume for the calculation.

Table 2.15-2 Estimated ESAL Value from Year 2009 to Year 2018

	Economic Grow Rate (%)	Day Traffic Volume(Heavy Vehicle)	Annual Traffic Volume(Heavy Vehicle)	Truck Mixed Rate (0.634)	Trailer Mixed Rate(0.366)
2009	3.9	208	75,815	48,067	27,748
2010	6.5	216	78,722	49,941	28,831
2011	7.4	230	83,892	53,188	30,704
2012	7.5	247	90,100	57,123	32,977
2013	7.4	265	96,858	61,408	35,450
2014	6.2	285	104,025	65,952	38,073
2015	6.2	303	110,475	70,041	40,434
2016	6.2	321	117,324	74,383	42,941
2017	6.2	341	124,598	78,995	45,603
2018	6.2	363	132,323	83,893	48,430
Sub total			1,014,181	642,991	371,190
		Result of an axle load survey		×1.63/2/2	×3.67/2/2
		Not an axle load survey		×0.182/2/2	×0.423/2/2
Total ESAL	1,342,190(11.3times/ original plan)			582,550	759,640

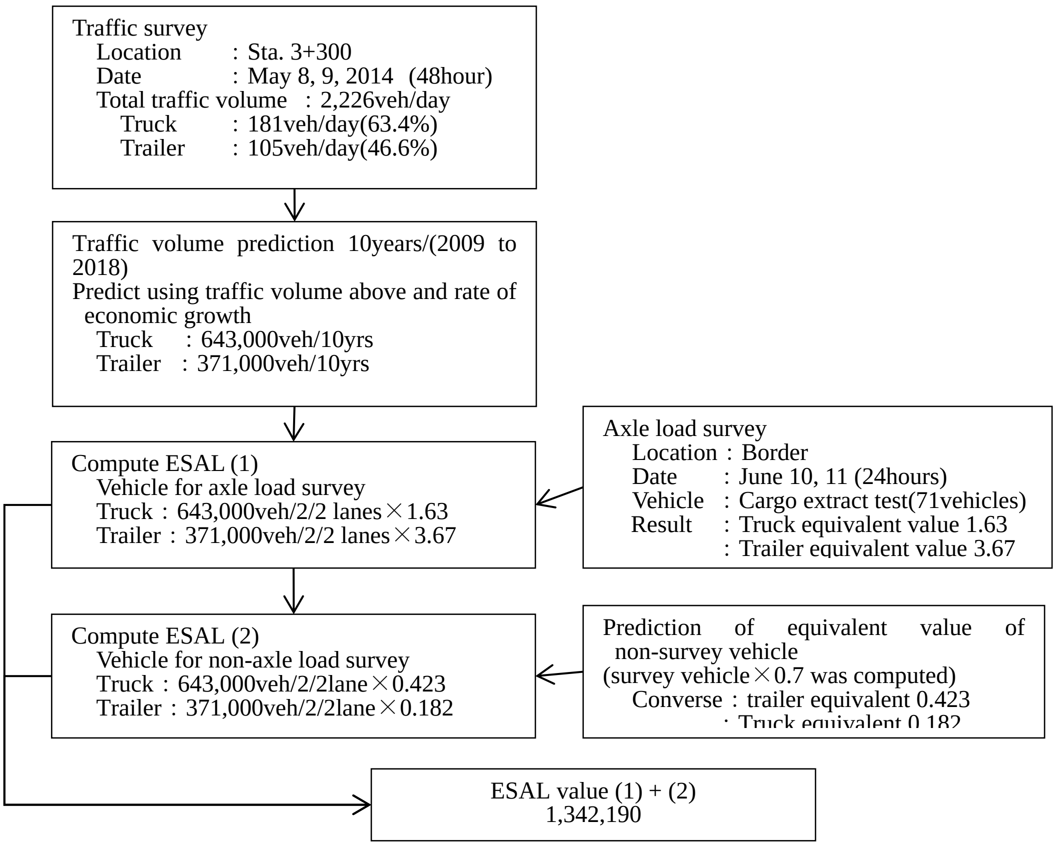


Figure 2.15-2 Flow of Estimate of Cumulative ESAL Value from 2009 to 2018

2.15.3 Comparison of Traffic Load of Qurghonteppa-Dusty Road Improvement Project

The comparison of traffic load of Qurghonteppa- dusty road improvement project is shown in Table 2.15-3 and Table 2.15-4. It is found that the actual cumulative 18 kip ESAL values in 10 years is 11 times, the cumulative 18kip ESAL values of Qurghonteppa- Dusty (K/D) road is 138 to 171 times of the planned value.

Table 2.15-3 Comparison between Plan and Actual on the Dusty-Nizhniy Pyandzh(D/N) Road

		Dusty-Nizhniy Pyandzh (D/N)Road		(Ref.) Qurghon Tyube-Dusty (K/D) Road	Remark
		Plan	Actual		
Year of basic design survey		Period I：Sep. 2006 E/N Period II：Jan. 2009 E/N		Period I：May 2008 E/N Period II : Dec. 2011 E/N	
Year of completion (Delivery)		Period I：June 2008 Period II：Nov. 2010 (First repair: Oct. to Dec. 2011 Second repair: Apr. to June 2012)		Period I：2012 Period II：2013	
Length		Period I：8,340m Period II：15,360m		Total length：59,900ｍ	
Day traffic volume (vehicle/day)		1,000 vehicle/day (2007 Border)	2,226vehicle/day (2012, St.3+300)	5,740 to 9,671veh/day (in service)	Nizhniy Pyandzh, completed in Aug, 2007
Vehicle equivalent axle load(18kip)		Truck：0.931	truck：1.63 Trailer：3.67	—	
ESAL (Equivalent single axle load)		**0.119×10^{6}**	**1.34×10^{6} (11 times)**	16.5 to 20.4×10^{6} **(138 to171 times)**	ESAL：Equivalent Single Axle Load
Pavement thickness	AC layer	5 to10cm		10cm	
	Base course	25 to 30cm Cement stabilized	15cm cement stabilized	20cm graded crushed run	
	Sub-base course		15 to 20cm cement-stabilized	35cm to 51cm Crushed run	
	total	30 to 45cm		65 to 81cm	

Table 2.15-4 Traffic Load of the Kurgan Tyube – Dusti Road

Day traffic volume	Kurgan Tyube city	9,671veh/day
	Kurgan Tyube – Rumi	5,740veh/day
	Rumi – Dusti	6,920veh/day
Service period (10years) ESAL	Kurgan Tyube city	20,400,000(※176 times)
	Kurgan Tyube - Rumi	16,500,000(※139 times)
	Rumi – Dusti	20,100,000(※169 times)

※ 118,940 in comparison

2.16 Evaluation of Factors causing Pavement Structural Defect

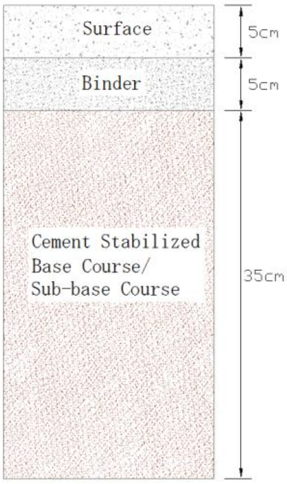
2.16.1 Current Condition of Pavement Structures

The initial design of pavement structures is shown in Table 2.16-1 to Table 2.16-4.

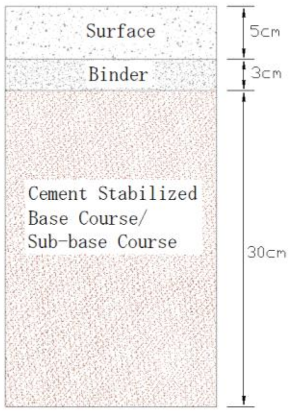
Table 2.16-1 Initial Required Pavement Structure Number (SN)

	1,3	2	4	5	6	7
Accumulated 18kip Equivalent Single Axle Load (W18)	118,940					
Standard Deviation (Z0)	-0.841					
Standard Deviation (S0)	0.45					
Performance Service Index ΔPSI	1.7					
Mp	4,500	7,800	13,050	8,850	5,700	6,150
CBR	3.0	5.2	8.7	5.9	3.8	4.1
Required Structural Number(SN)	2.755	2.288	1.819	2.121	2.515	2.442

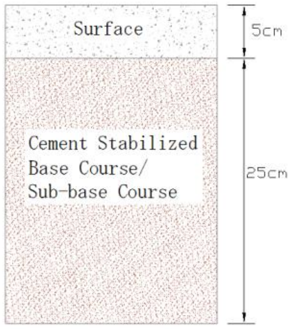
Table 2.16-2 Initial Design of Pavement Structure



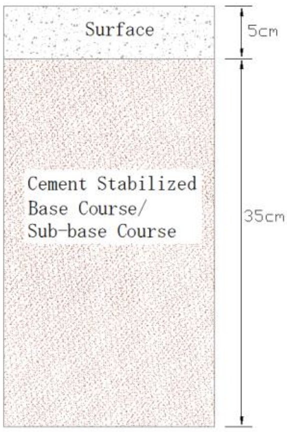
Section1,3



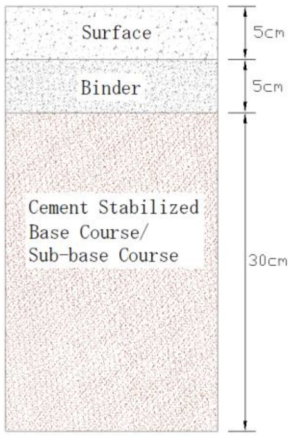
Section 2



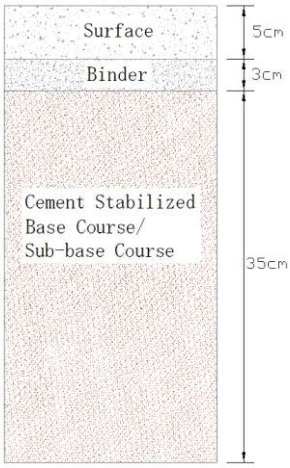
Section 4



Section 5



Section 6



Section 7

Table 2.16-3 Layer Coefficient of Pavement

Pavement material	Layer Coefficient
AC pavement surface	0.390
AC pavement binder	0.300
Cement Stabilized base course	0.108

Table 2.16-4 Pavement Structure Number

	Required Pavement Structure Number(SN)	Available Pavement Structure Number(SN)	Check
Section – 1,3	2.755	2.846	OK
Section – 2	2.288	2.398	OK
Section – 4	1.819	1.831	OK
Section – 5	2.121	2.256	OK
Section – 6	2.515	2.634	OK
Section – 7	2.442	2.610	OK

The repair was done by using the six(6) repair types as shown in **Table 2.16-5**, since the defects had been found during the defect liability period. The criteria for the selection of the repair types heard from the contractor are shown in **Table 2.16-6**.

Table 2.16-5 List of Repair Type during the Defect Liability Period

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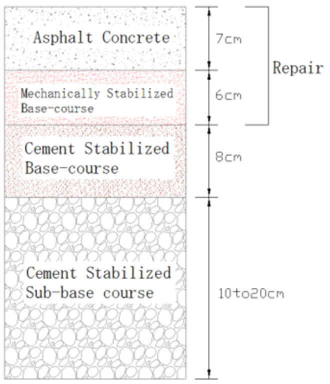
<td>
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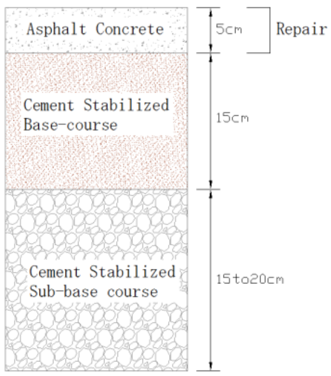
<td>
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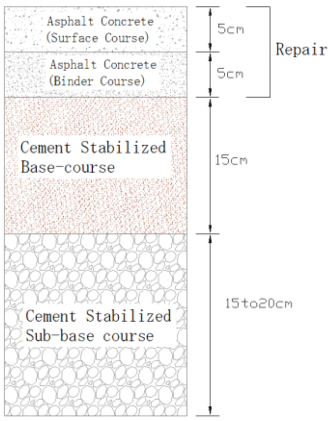
<td>
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<tr>
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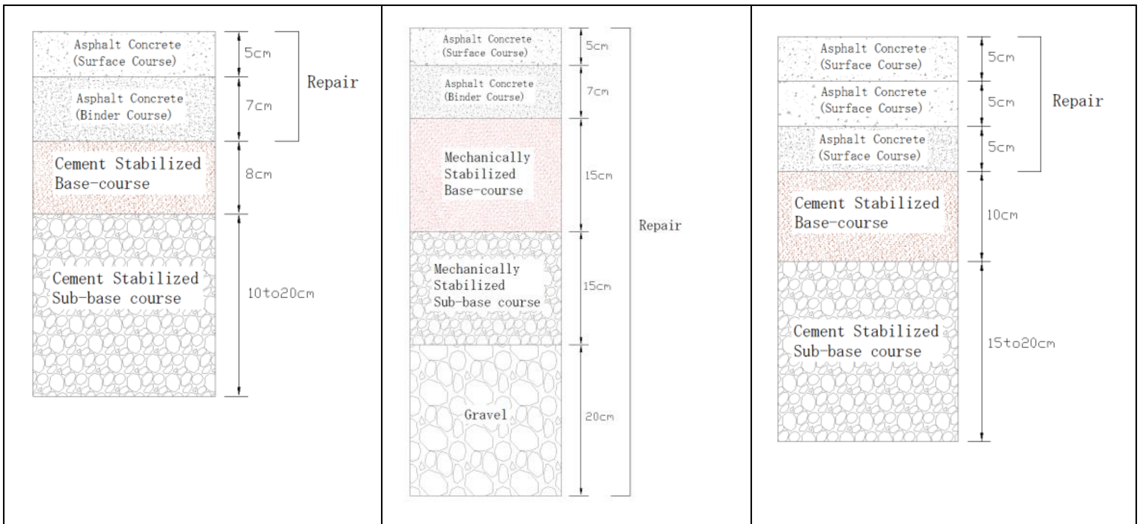


Type-4 Type-5 Type-6

Table 2.16-6 Criteria for the Selection of Repair Type

Type	Repair period	Location	Initial design of pavement structure	Defect condition	Countermeasure
Type-1	October 2011	AC pavement 1 layer	Section4,5	Sliding between base course surface and AC pavement	Adding 6cm of crushed run base course under the AC pavement Add extra 2cm of the AC pavement
Type-2				Transverse sliding of AC pavement	Replacement of AC pavement (reduce Asphalt volume, use large size of aggregate)
Type-3		AC pavement 2 layers	Section 6,7	Sliding between base course surface and AC pavement	Replace 2 layers of AC pavement. Construct grooving to prevent the sliding on the base course
Type-4	May 2012	Repair location for Type-2	Section 4,5	Sliding between base course surface and AC pavement	Making into 2 layers by adding 1 layer of AC pavement
Type-5		AC pavement 1 layer	Section 4,5	Deformation of pavement surface	Repair all from subgrade layer
Type-6		AC pavement 2 layers	Section 6,7	Sliding between base course surface and AC pavement	Making into 3 layers by adding 1 layer of AC pavement

2.16.2 Pavement Service Life from the SN Value and the Current Traffic Volume

Firstly, allowable cumulative 18kip ESAL values are calculated based on CBR values and SN values of each repair type. And, the number of years to attain the allowable cumulative 18 kip ESAL values for each section and repair type are calculated as shown in Table 2.16-7. For the current traffic volume, the design life is within 5 years for the repair section excluding some sections . However, it was confirmed that the CBR value of base course of the good section is more than 110% which is more than 3 times of the design value of 30% was secured. Thus, the longer service life to some degree is expected.

Table 2.16-7 Pavement Service Period Estimated from SN Value and Current Traffic Volume

Type of Subgrade	Pavement type &SN Value	Unrepair	Type-1	Type-2	Type-3	Type-4	Type-5	Type-6
Section1,3 CBR:3.0	SN value	2.85	2.69	2.47	2.85	3.00	3.72	3.40
	ESAL Value	146	103	62	146	198	735	423
	Service Period	2 years	1 year	1 year	2 years	2 years	7 years	4 years
Section 2 CBR:5.2	SN value	2.40	2.39	2.17	2.55	2.70	3.72	3.10
	ESAL Value	186	181	102	267	377	2,634	867
	Service Period	2 years	2 years	1 year	3 years	4 years	16years	7 years
Section 4 CBR:8.7	SN value	1.83	2.05	1.83	2.21	2.36	3.72	3.19
	ESAL Value	123	239	123	374	554	8,692	3,400
	Service Period	2 years	3 years	2 years	4 years	5 years	31 years	19 years
Section 5 CBR:5.9	SN value	2.26	2.48	2.26	2.63	2.79	3.72	3.19
	ESAL Value	174	303	174	431	616	3,531	1,381
	Service Period	2 years	3 years	2 years	4 years	6 years	19 years	10 years
Section 6 CBR:3.8	SN value	2.63	2.48	2.26	2.63	2.79	3.72	3.19
	ESAL Value	155	109	63	155	222	1,272	498
	Service Period	2 years	1 year	1 year	2 years	3 years	10 years	5 years
Section 7 CBR:4.1	SN value	2.61	2.61	2.38	2.76	2.91	3.72	3.32
	ESAL Value	177	177	102	248	341	1,518	756
	Service Period	2 years	3 years	1 year	3 years	4 years	11 years	7 years

Note) ESAL value (×1000)

2.16.3 Differences of Pavement Strength between Design and Actual condition

The following items were confirmed by the excavation survey of two locations at Sta.4+480, Sta.5+029 in regards to the cement stabilized base course as for the first survey in Tajikistan.

- The design strength of cement stabilized sub-base course at the defect section was not secured. The loose condition of the sub-base/base course was confirmed.
- The moisture content of cement stabilized sub-base course mixed with clayey material is high and has only strength same as base material. The cement stabilized base course at defect sections of flat area have two layers, which are sandy gravel layer and clayey layer.

Cement Stabilized Base course of Sand + Gravel

Cement Stabilized Sub-base of Clay

Soil test results of base course/sub-base course in MOT laboratory has shown as in Table 2.16-8.

Table 2.16-8 Comparison of Soil Test Results between the Base/Sub-base Course Layer(MOT)

Test Item	Base course	Sub-base course
PL, LL, PI	Non plastic	32.7, 20.3, 12.4
Moisture content	5.7	12.5
Silt(<0.075mm)	4.16%	22.6%

The base course is completely sandy soil. The PL, the moisture contents of the sub-base course are 32.7%, 12.5% each, which is comparatively high. Silt contents is 22.6%, which is also comparatively high.

The subgrade is low cost asphalt seal road which is extremely firm. The average 3 times of Clegg hammer is over 100%. Thus, the defect at these two locations seems to be caused by the heavy traffic load, which is exceeding its design value. It is considered that the reduction of the strength of the pavement had been progressed and the increased moisture contents from the outside water destroyed the pavement at some section.

Based on the hearing survey from the contractor, base / sub-base material were collected from the same borrow pit (Sta. 13), which is clearly different with the result of the excavation survey. The cause of the contamination of fine material into the sub-base course is not clear whether the incident was happened during the construction works or unevenness of the quality of the borrow pit.

2.16.4 Excessive Traffic Load in the Past

There has a report in the inspection report in 2013 that the trailer with full load of cement with total weight of 69.3 tones (axle load 13.86t) were passing through the target road after the completion of road construction during the defect liability period (the First Phase was completed in June 2008, the Second Phase was completed in November 2010). The 18kip ESAL value of the trailer in Chapter 2.15.2 is only 3.67 but the ESAL value of axle load 13.86tones was 42.8, which is by far higher than the current value. This is one factor to accelerate the defect of the road surface.

2.17 Urgent Repair Works for Pavement with Defects

2.17.1 Selection of Repair Locations

Table 2.17-1、Table2.17-2 shows the target urgent repair locations.

Table 2.17-1 Urgent Repair Locations at Steep Section

	Start Point (Sta.)	End point (Sta.)	Lane	Length	Area	Remark
1	14+420	14+460	Both sides	40m	280.0m2	
2	15+448	15+463	To Dushanbe	15m	52.5m2	
Total					332.5m2	

Table2.17-2 Urgent Repair Location at Flat Section

	Start Point (Sta.)	End Point (Sta.)	Lane	Length	Area	
1	4+475	4+508	To Afghanistan	33m	115.5m2	
2	5+023	5+036	Both sides	13m	91.0m2	
3	6+895	6+912	To Afghanistan	17m	59.5m2	
4	9+204	9+216	To Afghanistan	12m	42.0m2	
5	10+610	10+620	To Afghanistan	10m	35.0m2	
6	11+860	11+870	To Afghanistan	10m	35.0m2	
7	12+050	12+060	To Dushanbe	10m	35.0m2	
Total					413m2	

2.17.2 Current Condition of Selected Urgent Repair Locations

Current condition of the selected urgent repair locations is shown in Table2.17-3.

Table2.17-3 Current Condition of Selected Urgent Repair Locations

<table>
<tr><th></th><th>No.</th><th>Start</th><th>End</th><th>Section</th><th>Pavement Structure</th><th>Condition</th></tr>
<tr><td rowspan="2">Steep Section</td><td>1</td><td>14+420</td><td>14+460</td><td rowspan="2">6</td><td rowspan="2">AC：10cm
Base course：30cm</td><td rowspan="2">Asphalt pavement is sliding significantly though the condition under the sub-base is firm.</td></tr>
<tr><td>2</td><td>15+448</td><td>15+463</td></tr>
<tr><td rowspan="7">Flat Section</td><td>1</td><td>4+475</td><td>4+508</td><td rowspan="3">4</td><td rowspan="3">AC：5cm
Base course：25cm</td><td rowspan="2">The surface is drastically deforming along with the alligator crack. Cement stabilized sub-base is spouting out which interrupts the traffic.</td></tr>
<tr><td>2</td><td>5+023</td><td>5+036</td></tr>
<tr><td>3</td><td>6+895</td><td>6+912</td><td rowspan="5">Surface is deformed along with the alligator crack which is interrupting the traffic. The deformations are expected to be progress in future.</td></tr>
<tr><td>4</td><td>9+204</td><td>9+216</td><td rowspan="4">5</td><td rowspan="4">AC：5cm
Base course：35cm</td></tr>
<tr><td>5</td><td>10+610</td><td>10+620</td></tr>
<tr><td>6</td><td>11+860</td><td>11+870</td></tr>
<tr><td>7</td><td>12+050</td><td>12+060</td></tr>
</table>

2.17.3 Examination of Urgent Repair Work

The urgent repair work (draft) shows in Table2.17-4. In regards to the sections which requires the urgent repair work, the urgent repair work methods were examined based on the practical construction method in Tajikistan and materials which can be procured locally. As for the urgent repair work, the table for repair methods is prepared from the method for the low durability (urgent repair) to the method for the high durability (permanent repair) in ascending order..

Since Hot Mix AS material was confirmed to be produced at the plant in Dushanbe, the plan to use Hot Mix AC material was adopted. It is assumed that the pavement milling machine could be procured from the contractor in Dushanbe. It is required to examine the utilization of improved AC material, the procurement of straight AS which has hard penetration value and the usage of gap grade.

Table2.17-4(1) Table of Urgent Repair Method (Draft)

(1/2)

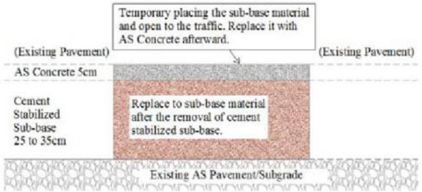
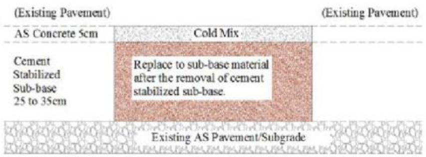
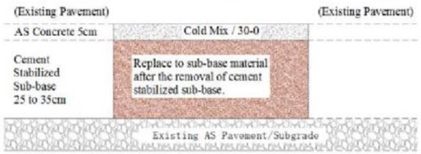
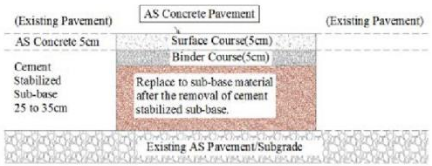
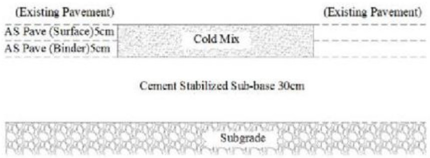
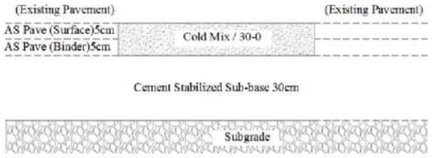
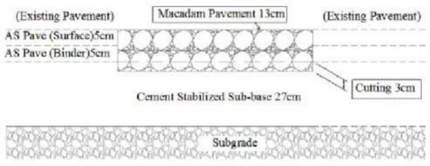
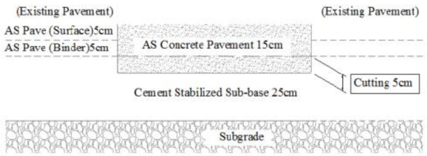
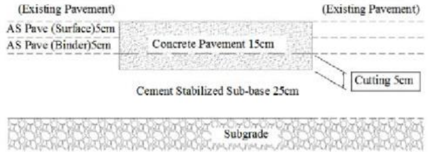
	Defect type	Location	No.	Durability	Service Period	Counter Measures	Cost (/100m2)	Method	Construction method	Material (per 100m2)	Machine	Notes	Issue/Valuation
Flat section	Repair Large scale	7 loc. 413m3	1	D	0.3 to 0.5		US$ 3,000 (M)2,000 (E)500 (L)500	Base course temporary rehab method	After removing cement stabilized base course, backfilling the base course material until it reaches the height of pavement. Open to the traffic, level the surface by filling the settlement location with base course material. Continue until the settlement is not occurring and replace the surface when the AS mixture is secured.	Base course material 40cm3	Concrete cutter, Hand guide roller	Keep supplying of the material after opening to the traffic	Necessary to reconstruct the surface layer earlier Lowest price but time consuming
			2	C	0.5 to 1.0		US$ 4,500 (M)3,000 (E)1,000 (L)500	Replacement of base course + Cold mixture pavement(5cm	Remove cement stabilized base course, backfilling it until the height of the base course and compact it. Pave the surface with cold mixture pavement.	Cold mixture 11.5t Tack coat material 50 l	Concrete cutter Mixer(pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Binder volume Particle size of the mixture Examine the finished thickness	Question of the durability of the cold mixture material
			3	C'	0.8 to 1.5		US$ 4,700 (M)3,200 (E)1,000 (L)500	Replacement of base course + Cold mixture pavement(30-0)pavement(5c m)	Remove cement stabilized base course, fill and compact the backfill until the height of the base course. Pave the surface with cold mixture (30-0) pavement.	Crusher run 30-0 13.5m3 Cold mixture 11.5t Tack coat material 50 l	Concrete cutter Dump truck Motor grader Mixer(pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Compaction of sub-base Binder volume Particle size of the mixture Examine the finished thickness The particle size of the crusher run must be continuous size	.Expect the durability since the aggregate is including
			4	B	1.5 to 2.0		US$ 5,000 (M)3,200 (E)1,000 (L)800	Replacement of base course + Permeable macadam pavement (5cm)	Remove cement stabilized base course, fill and compact the backfill well till the height of base course. Pave the surface with the permeable macadam method (5cm).	Crush run 30-20 5.0m3 Crusher run10-5 2.0m3 Crusher run 5-2.5 1.0m3 Binder 750kg (Straight AS)	Concrete cutter Macadam roller (Tire roller) (Hand guide roller) Binder spray machine (Distributor) (Engine sprayer)	It is necessary to do training one week for the crusher run spreading. Single size of the crusher run is required.	Expect the durability to some degree Preparation of spreading machine and method of heating the binder are ok?
			5	A	5		US$ 10,000 (M)7,000 (E)2,500 (L)500	Replacement of base course + Hot AS pavement	Remove cement stabilized base course, fill and compact backfill well till the depth of -10cm from the pavement surface. Pave the surface with AS mixture (10cm).	Hot AS mixture(5cm) 12 ton Tack coat material 50 l	Concrete cutter AS finisher Macadam roller Tire roller Hand guide roller Rake	Mechanical leveling Manual leveling Method to prevent sliding of the mixture	Method to procure the AS Expect the most durability
	Alligator crack	Same as the attached				Asphalt overlay 8cm to 11cm(see 4.3)		Hot Mix Asphalt Pavement					
	Crack Small scale	Same as the attached				sealing							

Table2.17-4(2) Table of Urgent Repair Method (Draft)

(2/2)

	Defect type	Location	No.	Durability	Service Period	Counter Measures	Cost (/100m2)	Method	Construction method	Material (per 100m2)	Machine	Notes	Issue/Valuation
Grade section	Repair Large scale	2loc. 332.5m2	1	C	0.5 to 1.0		US$ 3,000 (M)2,300 (E) 500 (L) 200	Cold mixture pavement(5cm)method	Pave the bare surface location with cold mixture pavement.	Cold mixture 11.5t .Tack coat material 50 l	Concrete cutter Mixer (pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Binder volume Particle size of the mixture	Question of the durability of the cold mixture Require the check of finished thickness No counter measure for sliding
			2	C'	0.8 to 1.5		US$ 3,300 (M)2,600 (E) 500 (L) 200	Cold mixture(30-0) pavement(5cm)	Pave the bare surface location with cold mixture pavement (30-0).	Crusher run 30-0 13.5m3 Cold mixture 11.5t Tack coat material 50 l	Concrete cutter Dump truck Motor grader Mixer (pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Binder volume particle size for the mixture examine the finished thickness Particle size of crusher run must be continuous particle size	Expect the durability since the aggregate is including. No counter measure for sliding
			3	B	1.5 to 2.0		US$ 7,000 (M)2,500 (E)4,000 (L) 500	Surface removal + Permeable macadam pavement (13cm)	Cut the surface 3cm as a measure to prevent sliding. Pave the surface with permeable macadam pavement (13cm).	Crusher run 30-20 15.0m3 Crusher run 10-5 5.0m3 Crusher run 5-2.5 2.5m3 Binder 2,000kg (Straight Asphalt)	Concrete cutter Road planer Macadam roller (Tire roller) (Tire roller) (Hand guide roller) (Binder spray machine) (Distributor) (Engine sprayer)	Require one week to do training for the crusher run spreading Single size of crusher run is necessary	Expect the non-sliding from the surface cutting Preparation of spreading machine and method of heating the binder are ok? Expect the durability to some degree
			4	A	5		US$ 14,000 (M)8,500 (E)2,000 (L) 500	Surface removal + hot AS pavement	Cut the surface 5cm to prevent sliding and secure the thickness of the pavement. Pave the surface with hot AS pavement.	Hot asphalt mixture(5cm) 12 t Tack coat material 50 l	Concrete cutter Road planer AS finisher Macadam roller Tire roller Hand guide roller Rake	Mechanical leveling Manual leveling Method to prevent sliding of the mixture	Expect the non-sliding from the surface cutting Method to procure the AS Expect the durability
			5	A	5		US$ 9,500 (M)2,000 (E)2,500 (L)2,000	Surface removal + Cement concrete pavement(15)	Cut the surface 5cm to prevent sliding and secure the thickness of the pavement. Pave the surface with cement concrete pavement	Cement concrete mixture 20.8m3	Concrete cutter Road planer Concrete mixer Mixture truck (one wheel) Scope prod	Security of curing time and pavement method is required	Expect the non-sliding from the surface cutting Secure the durability by concrete pavement

Note) Durability : A to E/ high to low

2.18 Method of Construction Supervision of Cement Stabilized Base Course

The comparison of technical specifications, quality control plan, actual quality control records related on cement stabilizes base/sub-base course is shown in Table2.18-1. It is confirmed that the quality control on mixture and sampling was not executed in according with the specifications.

Moreover, the comparison table was created based on the quality control records provided by the contractors and a consultant.

Table2.18-1 Comparison of Quality Control of Cement Stabilized Base/Sub-base

			Specification				Quality control/ Construction management form(by Supevisor)				Method of execution management (base on performance)	
			Standard value		Frequency		Standard value		Frequency		Standard value	Frequency
			Standard value	Speciifcation	Standard value	Specification	Standard value	Specification	Standard value	Specificaton		
Subgrade	Material	CBR at 95%	> 15%	AASHTO T180	-	No specification	>15%	JIS A 1211	before construction, change of borrow pit	No specification	>15%	Before construciton
		Grade (0.075mm)	>10%, < 30%		-		>10%,<30%	JIS A 1204	before construction, change of borrow pit		>10%,<30%	Before construciton
		LL	>40%	AASHTO T89	-		<40%	JIS A 1205	before construction, change of borrow pit		<40%	Before construciton
		PI	<20	AASHTO T90	-		<20	JIS A 1205	before construction, change of borrow pit		<20	Before construciton
	Construction	Field density test	>95%		3times/1,000m^2		>95%	JIS A 1214	3times/5,000m^2		>95%	every 40m
		Proof rollong test	whole road		whole road		whole road	TS-8	whole road		whole road	whole road
Cement stabilized sub-base	Material	Base material	Use sand	-	-	No specification	-		-	No specification	-	-
			<PL 25	-	-		<PL25	JIS A 1205	before construction, change of borrow pit		Not Plastic	First time only
			<PI 9	-	-		<PI 9	JIS A 1205	before construction, change of borrow pit		Not Plastic	First time only
			Submerged CBR >30	AASHTO T193			>submerged CBR30	AASHTO T193	before construction, change of borrow pit		no record	
		Cement	Portland cement		-		-		-		-	-
	Constructi on	Design strength	0.6N/mm^2		-		3N(mm2)(miss ?)		-		-	-
		Mix cement volume	>4%		-		-		-		Cement volume 4.5%	-
		Trial mix	Design strength 130% > (0.66N/mm^2)		-		-		-		in case of 30%: 0.74N/mm^2(123%)	First time only
		Mixture control	※		Frequently		-		-		-	-
		To confirm sub-base thickness	-		/100m		-25mm/upper layer -45mm/lower layer		/100m		-25mm/upper layer -45mm/lower layer	/100m
		Field density test	> 90%	AASHTO T180	-		>90%	AASHTO T180	3times/1,000m^2		>90%	3times/1,000m^2
		Proof rollong test	-		-		>Axle load 8tones		All sections		>Axle load 8tones	All sections
		Sampling	To confirm material	AASHTO T2	-		-		-		-	-

※: Before the construction of base course, 10 samples were collected and did laboratory test by compacting and curing. The average of the 10 samples shall exceed the design specification standard or two(2) samples only can fall below 90% of the design specification standard. ※※: Record of the thickness control is available. The standard value is -25mm (upper layer) and -45mm (lower layer), and all of locations when finish shall have plus completion structure. It found that the completion structures for this survey in Tajikistan were not sufficient at the excavation survey close to Sta.5+000.

（Second Survey in Tajikistan）

2.19 Excavation Survey and Collection of Sample

2.19.1 Survey for Factors causing Defects in Flat Section

To find the factors causing defects, and to support the first survey result in Tajikistan, the excavation survey to confirm the status of cement stabilized base course and subgrade at location with no or slight defects and sever defects where the defects. The samplings and the material tests were also conducted. The details are as follows.

① Test location : Sta.6+904 (on carriageway in Dushanbe direction) road surface defect section (Test date : June 28, 2014)

Pavement Structure			Strength Test		Remark
Structure	Design	Actual measurement	Design	Actual measurement	
AS pavement thickness	Surface course 5cm	5cm	-	-	
	Binder course 7cm	7cm	-	-	
Base course	8cm	Total 18cm	30	Cement stabilized base course Base course surface CBR(39,26,21) Could not confirm the boundary of base/sub-base course	Main material: sand + round rock
Sub-base course	10cm		30		
Subgrade	-	20cm	15	Subgrade(fill) Subgrade surface CBR(13,10,9)	Main material : Clay(yellow) Collection of samples
Existing AS pavement				Pavement surface CBR (84,107)	

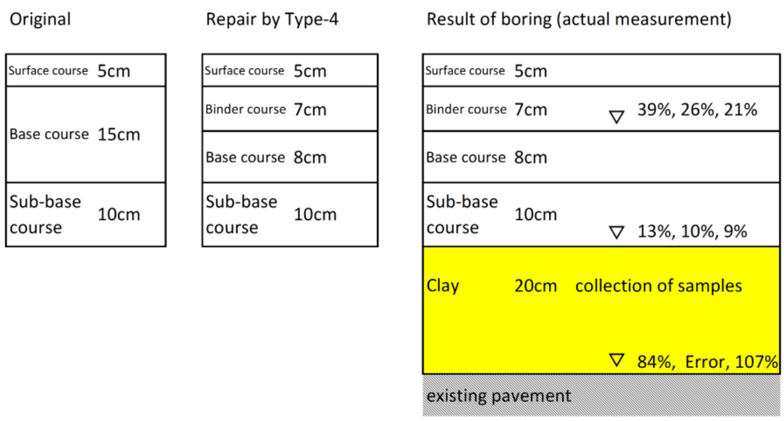
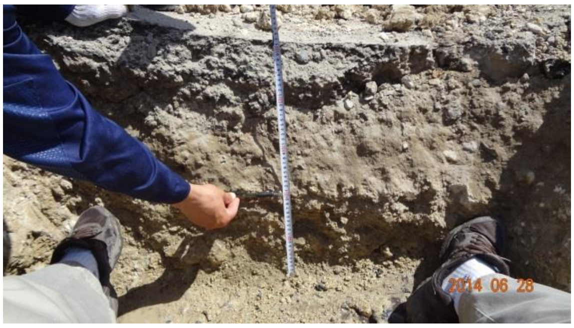


Figure 2.19-1 Excavation Cross Section (Sta.6+904)

Photos of excavation survey are shown in Figure 2.19-2. Photo ⑤ to ⑧ show the irrigator cracks and deformation of AC pavement.

① Excavation Survey

② Pavement Thickness12cm (5cm+7cm)



③ Excavation Cross Section
(Depth of 30cm, clay thickness 20cm)

④ Excavation Cross Section
(Depth of 30cm, clay thickness 20cm)

⑤ Pavement Thickness 2cm

⑥ Pavement Thickness 10mm

⑦ Pavement Thickness 13cm

⑧ Pavement Thickness 22cm

⑨ Excavation

⑩ Excavation

Figure 2.19-2 Excavation Survey (Sta. 6+904)

AC pavement surface is largely deformed, and its thickness is deformed both in the direction of the profile and the cross section. Base/sub-base are damaged and become sandy condition. The difference of the base/sub-base course was not be confirmed. 20cm of subgrade under the lower part of the sub-base course had been confirmed. Since its material was clayey, it is considered this material is causing the defects of the base/sub-base course. Laboratory test of CBR, particle size distribution, PI were executed in MOT and JRCA laboratory.

② Test location : Sta.6+960 (to「Afghanistan」traveled way) section of good road condition (test date : June 28, July 4, 2014)

Pavement structure			Strength Test		Remark
Structure	Design	Actual measurement	Design	Actual Measurement	
AC pavement thickness	Surface course 5cm	5cm	-	-	Collection of samples
Base course	15cm	Total 25cm	30	Cement stabilized base course Base course surface CBR(error, error, error) Could not confirm the base/sub-base boundary	Main material: sand+ round stone
Sub-base course	10cm		30		
Subgrade	-	33cm	15	Subgrade Mid subgrade CBR(21,12,21)	Main material: clay mix with small rock(yellow) Collection of sample
Existing AC pavement				Pavement surface CBR(error, error, error)	

Photos of excavation survey are shown in Figure 2.19-3.

Survey Location

AC Pavement (5cm)

Excavation Cross Section(Depth 63cm, Subgrade thickness 33cm)

Excavation Cross Section(Depth 63cm, subgrade thickness 33cm)

Excavation Condition

Figure 2.19-3 Excavation Survey at STA 6+960

2.19.2 Survey for Factors causing Defects at Steep Section

The sliding of AC pavement near the Sta. 14+400 is remarkably high. By checking the adhesive condition of the cement-stabilized base course and AC pavement at normal section and the sliding section near the station above, the causes of sliding shall be clarified. The surface conditions of target locations are shown in Figure 2.19-4 and Figure 2.19-5.

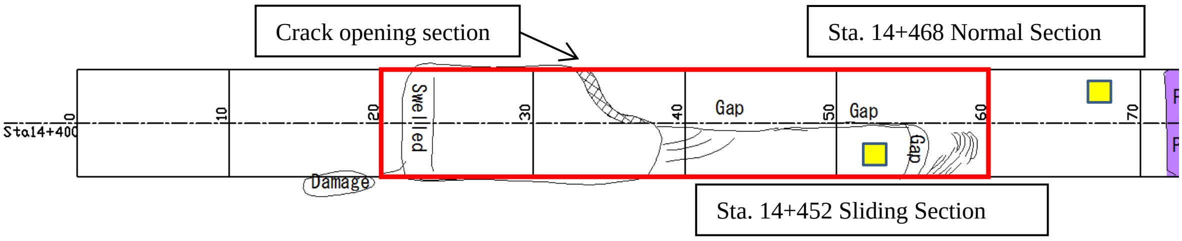


Figure 2.19-4 Measurement of Sliding Surface at Steep Section

Crack Opening Section	Sliding Section
	
It was confirmed the surface of the cement-stabilized base course was sliding. The prime coat looks peeling and adhered on the AC pavement.	The prime coat on the cement-stabilized base course surface was completely adhered on AC pavement. It was confirmed the aggregate of the cement-stabilized base course was sliding under the AC pavement.

Normal Section

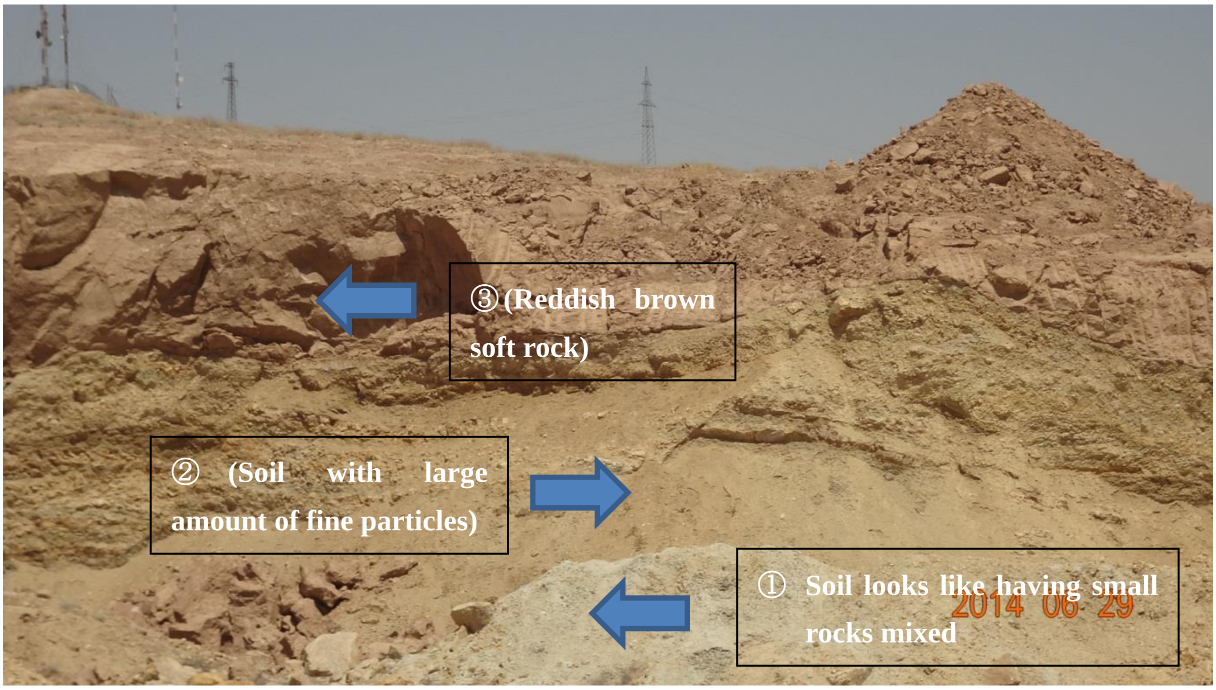
It was confirmed that the AC pavement and cement-stabilized base course were adhered together completely. The aggregate of the cement-stabilized base course is completely adhered at the AC pavement side.

Figure 2.19-5 Condition of AS Pavement Adhesive Surface

The differences of the characteristics of the adhesive surface between the asphalt and cement-stabilized base course at sliding section and normal section, had been confirmed. Though there were less irregularities of the aggregate of the surface of the cement-stabilized base course at the crack opening and sliding section, there were big irregularities of the aggregates at the normal section. It is considered that the irregularities of the aggregates has a preventive effect on the sliding of the AC pavement. The prime coat was peeled from the cement-stabilized base course at the sliding section but it was completely adhered with the cement-stabilized base course at the normal section. Prime coat and cement-stabilized base course were adhered at the peeled AC pavement side.

2.20 Survey of Borrow Pit

At the borrow pit for subgrade fill close to the Sta.22, three kind s of materials which are ① white soil with rock ② light brown soil with lots of fine particles ③ reddish brown soft rock have been confirmed. Since the ③ reddish brown soft rock was not found in the fill material, only ① and ② were collected. It is considered that ② material was mainly used for the construction because there have much ②soil in the borrow pit. ②soil was also collected at the first survey in Tajikistan. And the fine sand was also collected from the borrow pit close to Sta.13.



①

② (Sand at the slope, having large amounts of sandy soil)

Figure 2.20-1 Borrow Pit Close to Sta.22

Figure 2.20-2 Borrow Pit Close to Sta.13 (Fine Sand)

2.21 Survey for Selection of the Locations for Urgent Repair Work

Field inspection for the repair location has been conducted, and the extent of repair works has been marked. There were locations where the defects were progressed compared to the first survey (in early May). It is required to determine the final repair locations when the repair works start.

Steep Location-1

Steep Location-2

Flat Location-1

Flat Location-2

Flat Location-3

]

Flat Location-4

Flat Location-5

Flat Location-6

Flat Location-7

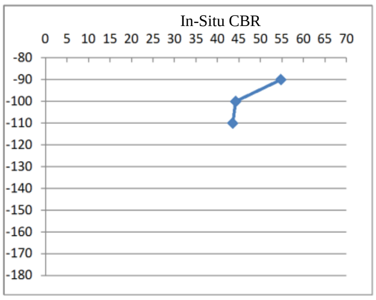
Figure 2.21-1 Condition of Selected Locations for Urgent Repair Work (on June 29, 2014)

2.22 Survey for Bearing Strength by Dynamic Cone Penetration Test (DCP)

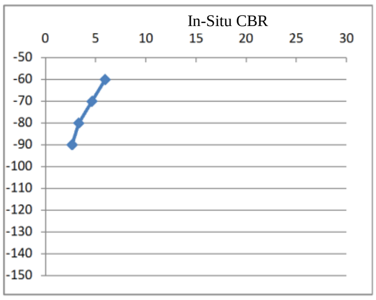
Since there is a limit of number of locations for the material samplings and excavation survey of subgrade section, the CBR value of the subgrade of the target road was also computed based on the values of dynamic cone penetration test. The computed CBR and measured DCP values are shown in Table2.22-1 . Photos of DCP test are shown in Figure 2.22-2.

Table2.22-1 Result of Easy Cone Penetration Test and Predicted CBR Value

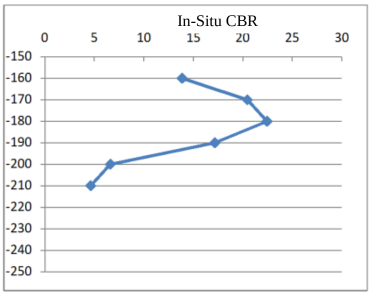
Sta.	Type (Road)	Design CBR	Position (from center)	Penetration depth (depth from pavement height)	Blow number/10cm	Computed CBR value	
						Laboratory	Field
0+400	Field	3.0	Outbound 8.5m	-1.1m	72	72.6	43.6
1+600	Field	5.2	Inbound 13.5m	-0.9m	10	4.4	2.6
2+770	Empty land	3.0	Outbound 13.5m	-1.5m	Impossible to measure(penetration)		
2+820	Empty land	3.0	Outbound 13.5m	-1.6m	27	23.1	13.9
				-2.1m	13	7.7	4.6
4+200	Field	8.7	Outbound 9.5m	-1.7m	22	17.6	10.6
5+020	Empty land	8.7	Inbound 15.0m	±0.0m	Impossible to measure(penetration)		
5+500	Grass land	8.7	Inbound 12.0m	-1.2m	38	35.2	21.1
9+200	Grass land	5.9	outbound 13.5m	-1.4m	11	5.5	3.3
12+700	Field	5.9	Inbound 20.5m	-1.1m	Impossible to measure(penetration)		
15+700	Desert soil	3.8	Outbound 10.5m	-0.6m	63	62.7	37.6
19+900	Desert soil	3.8	Outbound 20.5m	-2.8m	Impossible to measure(penetration)		



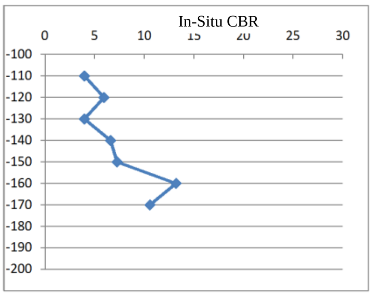
Sta. 0+400 R



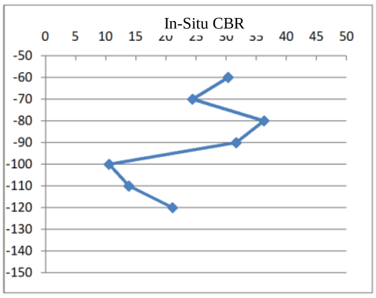
Sta. 1+600 L



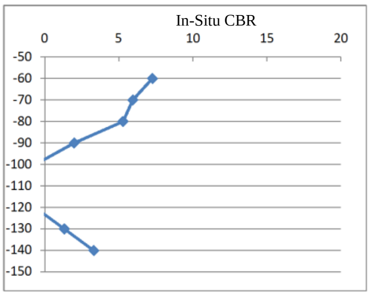
Sta. 2+820 R



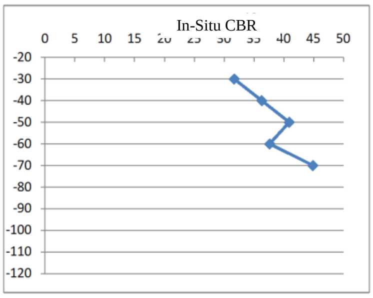
Sta. 4+200 R



Sta. 5+500 L



Sta. 9+200 L



Note） R：To Afghanistan

L：To Dushanbe

Sta. 15+700 R

Figure 2.22-1 Computed CBR Values at Each Survey Location

Sta. 0+400

Sta. 4+200

Sta. 5+020

Sta. 5+500

Sta. 9+200

Sta. 15+700

Sta. 19+900

Figure 2.22-2 Photos of DCP Test

The design CBR value and the predicted CBR value from the dynamic cone penetration in this survey were not correlated at all. There was a big gap at the depth direction and profile length direction at the flat section. The extreme weak location was also confirmed. In future, attention must be paid for these variations for design. At the steep section, there were two locations with very high value of CBR which is 3.8 times of the design value in this project. It is considered there is possibility that CBR values at steep section was under-evaluated during the design stage.

2.23 Result of Soil Test

2.23.1 Result of Laboratory Test in MOT Laboratory

The results at MOT laboratory for the collected material at the second survey in Tajikistan are shown in Table2.23-1. The tests of the same materials at Laboratory of JRCA laboratory was also conducted and the significant differences have been observed. The details are described afterward in section 2.24.2

Table2.23-1 Results of Laboratory Test in MOT Laboratory (Second Survey)

Sta.	6+904
Material	Subgrade
CBR	18.9%
PL	25.8%
LL	19.4%
PI	6.4
Particle size distribution (passing %)	
19mm	100.00
12.5mm	87.00
9.5mm	80.40
4.75mm	68.50
2.36mm	60.30
0.075mm	43.60
Soil classification	Sandy loam

（Analysis in Japan II）

2.24 Result of Laboratory Test in Japan

2.24.1 Test of Cement Content of Cement Stabilized Base Course

Since cement content of the sampling of collected material(cement stabilized base course material near Sta.5+029) at the first survey in Tajikistan could not be confirmed (section 2.14) at the JRCA laboratory, it has been again measured by the method of Calcium oxide in Japan Testing Center for Construction Materials (JTCCM). But due to the large amounts of and varied Calcium content in the base material, it could not be confirmed.

2.24.2 Results of Material Test of Subgrade Materials Collected from Borrow Pit

Grain micronizing of material-①(near Sta.22) was confirmed by submergible test before laboratory test. Results of laboratory test are shown in Table2.24-1. It is found that the material-①,② do not satisfy the design specifications for subgrade which are PI and CBR and for cement stabilized base course material which are LL, PI. The material-③ satisfies the design specifications for the cement stabilized base course material. Table2.24-2 shows the design specifications of the material for cement stabilized base-sub / base course.

The test results of subgrade material of PL, LL, PI and silt contents at Sta.6+904 at MOT and JRCA Laboratory have been confirmed. As for the several test results of subgrade materials at MOT laboratory, PL, LL, PI are NP as shown in Table 2.13-1, where there is doubt about the accuracy of the test result of MOT laboratory.

Grain micronizing of material-① after 18 hours of absorbing of water and swelling

Grain micronizing of material-② after 18 hours of absorbing of water and swelling

Table2.24-1 Result of Laboratory Test of Soil Characteristics (Analysis in Japan II)

Location			Near STA22 Material-1	Near STA22 Material-2	Near STA13 material-3	STA 6+904
PL			85.3	54.0	NP	31.9
LL			29.1	25.7	NP	16.2
PI			56.2	22.3	-	15.7
Particle size (passing %)						
Rock 2 to 7.5mm			17.1	12.0	0.0	42.6
Sand 0.075 to 2mm			42.4	65.7	95.6	49.0
Silt <0.075mm			40.5	22.3	4.4	8.4
Max grade mm			9.5	9.5	0.85	26.5
Soil classification			Clay	Sand mix rock mix clayish sand	Sand	clay mix rocky sand
CBR	Non-submerged	2.5mm	23.6	41.3	12.2	
		5.0mm	23.5	39.5	15.3	
	4days submerged	2.5mm	2.2	2.5	3.1	
		5.0mm	2.7	3.0	3.8	

Table2.24-2 Design Specification of Material(Re posting)

	Subgrade fill	Cement-stabilized sub-base
LL	>40%	> 25%
PI	>20	> 9
>0.075mm	10% to 30%	
CBR	>15%	

2.24.3 Correlation between PI and Uniaxial Compressive Strength

Various test pieces of materials collected from the borrow pit in Tajikistan, and the similar soil materials collected in Japan with different PI mixed with 4.5% cement were prepared. And the compressive tests were conducted under the two conditions of 7 days unsubmerged, 6 days unsubmerged/ 1 day submerged, then its correlation has been confirmed. As the correlation of uniaxial compressive strength and plasticity index is shown in Table2.24-3, Figure 2.24-1, it is understood that the PI value and uniaxial compressive test value are having trend of inverse proposition.

In the test of material 3, though the result which is over the design value requested in the design specifications of 0.6N/mm2, it is extremely low. However, at field, it has been confirmed that the cement stabilized base course is very hard by excavation survey and CIST (easy CBR test device). It is considered that the appropriate measures such as mixing of gravels had been executed.

Table2.24-3 Result of Uniaxial Compression Test of Cement Stabilized Material (Analysis in Japan 2)

No.	Material		PI	7 days unsubmerged	6 days unsubmerged・1 day submerge
①	Near Sta. 22 Material-1	Soil from borrow pit	56.2	1.10 N/mm^2	0.87 N/mm^2
②	Near Sta. 22 Material-2	Soil from borrow pit	28.3	1.08 N/mm^2	0.97 N/mm^2
③	Near Sta. 13 Material-3	Sand from borrow pit	NP	0.67 N/mm^2	0.62 N/mm^2
④	Decomposed granite soil (Taken from Kasama)	Decomposed granite soil for comparison	NP	4.53 N/mm^2	3.81 N/mm^2
⑤	Decomposed granite soil : Material① = 85:15	PI adjusted material for comparison	8.2	3.35 N/mm^2	2.90 N/mm^2
⑥	Decomposed granite soil : Material① = 70:30	PI adjusted material for comparison	11.5	2.57 N/mm^2	2.42 N/mm^2

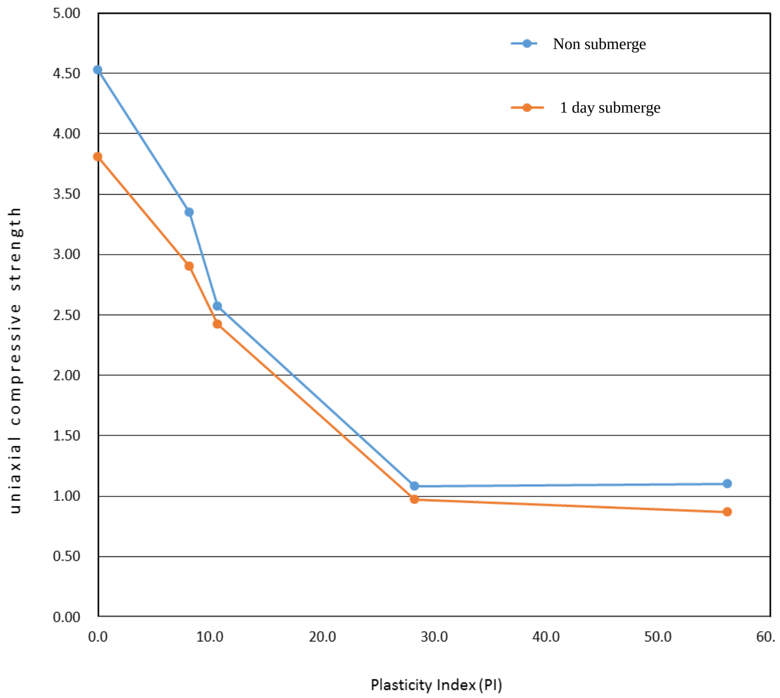


Figure 2.24-1 Correlation of Strength from Axial Compressive Test and Plasticity Index

2.24.4 Marshal Stability Test of Cold Mixtures

Since the samples taken from MOT Dusty SESM were collapsed with the 60 degree Celsius water for 30 minutes, the Marshal Stability test was executed lowering the water temperature 60 to 20 degree Celsius water. So, the result is only for the reference as shown in Table2.24-4.

It is considered that the hardness was not sufficient because there low volatile additive was contained in the cold mixtures. Further, due to the usage of round gravel in the aggregates, the bite of aggregates is extremely bad.

Table2.24-4 Result of Marshal Stability Test (Analysis in Japan II)

Material		No.1	No.2	No.3	Average
Diameter	mm	101.6	101.7	101.6	
Thickness	mm	62.5	62.7	62.8	
Dry mass	g	1122.7	1123.5	1123.0	
Density	g/cm3	2216	2206	2206	2209
Stabilized value	KN	6.61	6.28	5.28	6.06
Flow value	1/100cm	13	13	13	13

(Third Survey in Tajikistan)

2.25 Third Survey in Tajikistan

The third Survey in Tajikistan was cancelled because the budget for the Urgent Repair Work was not secured by Tajikistan.

3. Technical Data-1

3.1 Budget and Selection of Urgent Repair Method

The technical data-1 has been prepared based on the First Survey in Tajikistan in order to explain the actual pavement defect condition, urgent repair locations, repair methods and its cost and to confirm the future's policy of MOT. (Attachemnt-5)

The list of the proposed repair methods and the costs are shown in Table 3.1-1.

According to the Implementing Agency(MOT) , the costs for the urgent repair work was not allocated in this year's budget (January to December 2014) . However, it is proposed that the budget for urgent repair works is prepared from MOT budget for 2014. If it is not fulfilled, it will be prepared from MOT budget for 2015. (Attachment-6)

The official documents describing the details of the budget to be prepared based on the selection of urgent repair work method has been prepared and sent to MOT by the Study Team. (Attachment-7)

Table 3.1-1(1)　Table of Urgent Repair Method (Draft)　(Re posting)

(1/2)

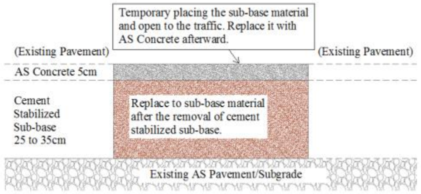
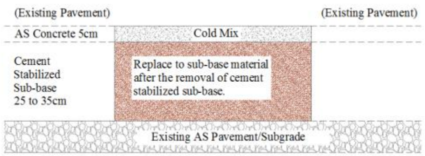
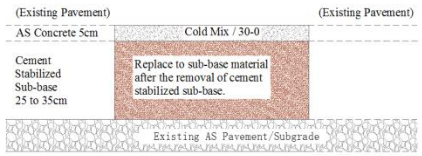
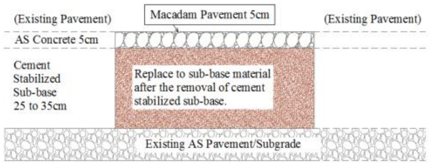
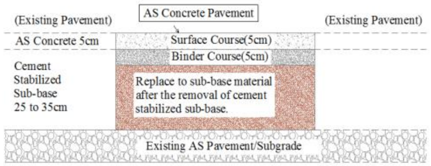
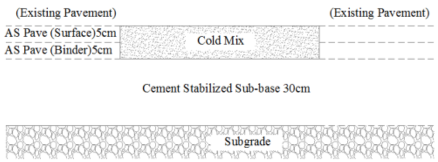
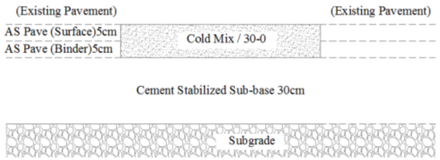
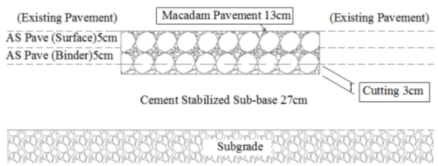
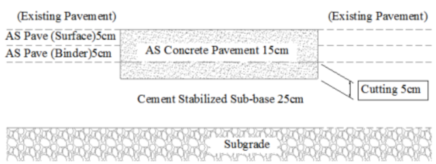
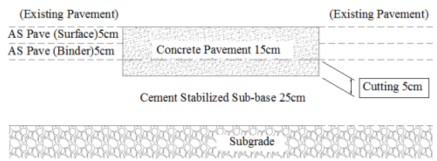
	Defect type	Location	No.	Durability	Service Period	Counter Measures	Cost (/100m2)	Method	Construction method	Material (per 100m2)	Machine	Notes	Issue/Valuation
Flat section	Repair Large scale	7 loc. 413m3	1	D	0.3 to 0.5		US$ 3,000 (M)2,000 (E)500 (L)500	Base course temporary rehab method	After removing cement stabilized base course, backfilling the base course material until it reaches the height of pavement. Open to the traffic, level the surface by filling the settlement location with base course material. Continue until the settlement is not occurring and replace the surface when the AS mixture is secured.	Base course material 40cm3	Concrete cutter, Hand guide roller	Keep supplying of the material after opening to the traffic	Necessary to reconstruct the surface layer earlier Lowest price but time consuming
			2	C	0.5 to 1.0		US$ 4,500 (M)3,000 (E)1,000 (L)500	Replacement of base course + Cold mixture pavement(5cm	Remove cement stabilized base course, backfilling it until the height of the base course and compact it. Pave the surface with cold mixture pavement.	Cold mixture 11.5t Tack coat material 50 l	Concrete cutter Mixer(pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Binder volume Particle size of the mixture Examine the finished thickness	Question of the durability of the cold mixture material
			3	C'	0.8 to 1.5		US$ 4,700 (M)3,200 (E)1,000 (L)500	Replacement of base course + Cold mixture pavement(30-0)pavement(5c m)	Remove cement stabilized base course, fill and compact the backfill until the height of the base course. Pave the surface with cold mixture (30-0) pavement.	Crusher run 30-0 13.5m3 Cold mixture 11.5t Tack coat material 50 l	Concrete cutter Dump truck Motor grader Mixer(pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Compaction of sub-base Binder volume Particle size of the mixture Examine the finished thickness The particle size of the crusher run must be continuous size	.Expect the durability since the aggregate is including
			4	B	1.5 to 2.0		US$ 5,000 (M)3,200 (E)1,000 (L)800	Replacement of base course + Permeable macadam pavement (5cm)	Remove cement stabilized base course, fill and compact the backfill well till the height of base course. Pave the surface with the permeable macadam method (5cm).	Crush run 30-20 5.0m3 Crusher run10-5 2.0m3 Crusher run 5-2.5 1.0m3 Binder 750kg (Straight AS)	Concrete cutter Macadam roller (Tire roller) (Hand guide roller) Binder spray machine (Distributor) (Engine sprayer)	It is necessary to do training one week for the crusher run spreading. Single size of the crusher run is required.	Expect the durability to some degree Preparation of spreading machine and method of heating the binder are ok?
			5	A	5		US$ 10,000 (M)7,000 (E)2,500 (L)500	Replacement of base course + Hot AS pavement	Remove cement stabilized base course, fill and compact backfill well till the depth of -10cm from the pavement surface. Pave the surface with AS mixture (10cm).	Hot AS mixture(5cm) 12 ton Tack coat material 50 l	Concrete cutter AS finisher Macadam roller Tire roller Hand guide roller Rake	Mechanical leveling Manual leveling Method to prevent sliding of the mixture	Method to procure the AS Expect the most durability
	Alligator crack	Same as the attached				Asphalt overlay 8cm to 11cm(see 4.3)		Hot Mix Asphalt Pavement					
	Crack Small scale	Same as the attached				sealing							

Table 3.1 1(2) Table of Urgent Repair Method (Draft) (Re posting)

(2/2)

	Defect type	Location	No.	Durability	Service Period	Counter Measures	Cost (/100m2)	Method	Construction method	Material (per 100m2)	Machine	Notes	Issue/Valuation
Grade section	Repair Large scale	2loc. 332.5m2	1	C	0.5 to 1.0		US$ 3,000 (M)2,300 (E) 500 (L) 200	Cold mixture pavement(5cm)method	Pave the bare surface location with cold mixture pavement.	Cold mixture 11.5t .Tack coat material 50 l	Concrete cutter Mixer (pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Binder volume Particle size of the mixture	Question of the durability of the cold mixture Require the check of finished thickness No counter measure for sliding
			2	C'	0.8 to 1.5		US$ 3,300 (M)2,600 (E) 500 (L) 200	Cold mixture(30-0) pavement(5cm)	Pave the bare surface location with cold mixture pavement (30-0).	Crusher run 30-0 13.5m3 Cold mixture 11.5t Tack coat material 50 l	Concrete cutter Dump truck Motor grader Mixer (pug mill or continuity) AS finisher Tire roller Macadam roller Hand guide roller	Binder volume particle size for the mixture examine the finished thickness Particle size of crusher run must be continuous particle size	Expect the durability since the aggregate is including. No counter measure for sliding
			3	B	1.5 to 2.0		US$ 7,000 (M)2,500 (E)4,000 (L) 500	Surface removal + Permeable macadam pavement (13cm)	Cut the surface 3cm as a measure to prevent sliding. Pave the surface with permeable macadam pavement (13cm).	Crusher run 30-20 15.0m3 Crusher run 10-5 5.0m3 Crusher run 5-2.5 2.5m3 Binder 2,000kg (Straight Asphalt)	Concrete cutter Road planer Macadam roller (Tire roller) (Tire roller) (Hand guide roller) (Binder spray machine) (Distributor) (Engine sprayer)	Require one week to do training for the crusher run spreading Single size of crusher run is necessary	Expect the non-sliding from the surface cutting Preparation of spreading machine and method of heating the binder are ok? Expect the durability to some degree
			4	A	5		US$ 14,000 (M)8,500 (E)2,000 (L) 500	Surface removal + hot AS pavement	Cut the surface 5cm to prevent sliding and secure the thickness of the pavement. Pave the surface with hot AS pavement.	Hot asphalt mixture(5cm) 12 t Tack coat material 50 l	Concrete cutter Road planer AS finisher Macadam roller Tire roller Hand guide roller Rake	Mechanical leveling Manual leveling Method to prevent sliding of the mixture	Expect the non-sliding from the surface cutting Method to procure the AS Expect the durability
			5	A	5		US$ 9,500 (M)2,000 (E)2,500 (L)2,000	Surface removal + Cement concrete pavement(15)	Cut the surface 5cm to prevent sliding and secure the thickness of the pavement. Pave the surface with cement concrete pavement	Cement concrete mixture 20.8m3	Concrete cutter Road planer Concrete mixer Mixture truck (one wheel) Scope prod	Security of curing time and pavement method is required	Expect the non-sliding from the surface cutting Secure the durability by concrete pavement

Note） Durability : A to E/ high to low

4. Possible Factors Causing Defects and Conclusions

4.1 Factors causing Defects at Flat Section

The first factor causing defects are considered with the increase of the traffic volume (11 times of the initial design load) due to the construction of bridge at the border with Afghanistan and the road improvements.

In regards to the cement-stabilized base course at the defect locations, it was confirmed that the strength of the cement-stabilized base course didn’t attain the design strength. It is considered that the deterioration of the cement-stabilized base course is triggered by the cracks due to the above mentioned excessive traffic load and worsened by the seepage water through the cracks.

A weak layer at the sub-base course of the defect locations around Sta.5 has been found and has been examined. Though, cement contents of the cement-stabilized sub-base course have not been confirmed due to large contents of calcium in the base material, it has been found that particle size distribution and PI of the base material of the cement-stabilized sub-base course are not in accordance with the specifications. It is also found that the material taken from the borrow pit is not in accordance with the specifications and the material is fined down with soaking in water. Though it is not clear whether cement has been mixed in the sub-base course or not, it is considered that the portion with low quality material is fined down and clayey with soaking in water due to the inconsistent quality of the borrow pit materials.

A weak layer at sub-grade of defect location around Sta. 7 has been also examined. The material is not in accordance with the specifications of sub-grade material as well as sub-base course of Sta. 5. It is considered that the portion with low quality material has been deteriorated by the seepage water due to inconsistent quality of the materials as well as base material of cement stabilized sub-base course around Sta. 5.

The result of the cement trial mix with the material taken from the borrow pit near Sta. 13 which was used for soil cement stabilization didn’t attain the enough strength. It is considered that proper counter measures to secure the higher strength has been taken in order to obtain the required strength by mixing gravel at the site. It has been confirmed that the strength of cement stabilized base course at sections without any defects is very high during the excavation survey.

Furthermore, in regards to section where no defect was found, high CBR value, which is three times of the design value (30%) was secured, and its life time could be longer. However, the water infiltrated from surface’s crack to the base/sub-base course may weaken the layer, thus, it is necessary to take measures to prevent the water infiltration.

4.2 Factors causing Defects at Steep Section

Since the stability was able to confirmed at location where the aggregate on soil cement stabilization surface is having remarkable irregularities, it is considered that preventive effect of sliding at some degree can be expected providing irregularities on the surface of cement stabilization base-course.

Since defects except the sliding of asphalt were not able to be confirmed, the subgrade and sub-base can be expected to be stable.

Further, since there are curves near the sections with defects, it is considered that the breaks of heavy vehicles can be one of the factors.

4.3 Determination of Urgent Repair Locations

Urgent repair locations are increasing due to the excessive traffic loads day by day. Since the repair methods are depending on the budget amount & the timing, it is required to make detailed work plan as soon as it is approved.

After the completion of the repair works at urgent repair locations, it is considered that other sections can be maintained at some time. However, it is worried that the other sound sections might be also damaged soon or later due to the excessive traffic load.

Table 4.3-1 shows the design period for each repair type based on the allowable 18 kip ESAL value (computed from CBR of sub-grade, SN) and actual traffic loads.

Table 4.3-1 Pavement Service Period from SN Number and Current Traffic Volume (re-posting)

Type of Subgrade	Pavement type &SN Value	Unrepair	Type-1	Type-2	Type-3	Type-4	Type-5	Type-6
Section1,3 CBR:3.0	SN value	2.85	2.69	2.47	2.85	3.00	3.72	3.40
	ESAL Value	146	103	62	146	198	735	423
	Service Period	2 years	1 year	1 year	2 years	2 years	7 years	4 years
Section 2 CBR:5.2	SN value	2.40	2.39	2.17	2.55	2.70	3.72	3.10
	ESAL Value	186	181	102	267	377	2,634	867
	Service Period	2 years	2 years	1 year	3 years	4 years	16years	7 years
Section 4 CBR:8.7	SN value	1.83	2.05	1.83	2.21	2.36	3.72	3.19
	ESAL Value	123	239	123	374	554	8,692	3,400
	Service Period	2 years	3 years	2 years	4 years	5 years	31 years	19 years
Section 5 CBR:5.9	SN value	2.26	2.48	2.26	2.63	2.79	3.72	3.19
	ESAL Value	174	303	174	431	616	3,531	1,381
	Service Period	2 years	3 years	2 years	4 years	6 years	19 years	10 years
Section 6 CBR:3.8	SN value	2.63	2.48	2.26	2.63	2.79	3.72	3.19
	ESAL Value	155	109	63	155	222	1,272	498
	Service Period	2 years	1 year	1 year	2 years	3 years	10 years	5 years
Section 7 CBR:4.1	SN value	2.61	2.61	2.38	2.76	2.91	3.72	3.32
	ESAL Value	177	177	102	248	341	1,518	756
	Service Period	2 years	3 years	1 year	3 years	4 years	11 years	7 years

Note）18kip ESAL loading number（×1000）

5. Recommendations and Repair Plan

5.1 Recommendations

Recommendations for this project and future’s overseas road construction projects based on the results of tests executed in Tajikistan and in Japan had been summarized as follows:

- Due to the big differences of the current traffic load from the design stage, it is expected that the defects will increase in future. It is recommended that the repair plan of the entire road section should be prepared and the repair work should be executed at an earlier stage. Moreover, it is important allowable accumulative ESAL(18kip) value during the service period shall not be under estimated, expecting future’s traffic volume based on the traffic survey and setting the ESAL(18kip) of trucks and trailer properly. The repair plan will be mentioned in the next section.
- To secure the adhesion between AC surface and cement-stabilized base course surface, it is desired that the soil cement stabilization should be placed upto the sub-base course. Moreover, in case the soil cement stabilization is adopted to base course, base course material should not be mainly composed of sand but mainly composed of crushed-run.
- It desired that thickness of AC pavement shall be at least 10cm to ensure to prevent the surface water from penetrating down below because of the inconsistent quality of the construction materials and the different construction method in foreign countries.
- In foreign countries, AC and concrete batching plant have to be self-operated for each project due to the limitation of the procurement condition. In this case, it is desired that the organization who can operate and maintain the plant and who can conduct proper quality control should be established. It also desired that the records of quality control documents should be kept to ensure the traceability in the future.
- It is necessary to select carefully the materials for use and confirm its quality regularly.
- It was confirmed the differences of laboratory test results of the same material in Japan and in Tajikistan. In future, when the tests are conducted in foreign country, it is desired that someone should supervise the test process or the test instruments from Japan should be brought to the laboratory if necessary.
- The frost protection layer was not considered in this design. If the soil cement stabilization was adopted in cold place, the frost protection layer should be considered confirming the weather data in the past.

5.2 Recommendations on Urgent Repair Plan and Future’s Repair Plan

It was planned in the begging stage that MOT executed the repair works in accordance with the urgent repair plan proposed by the consultant targeting the steep sections and flat section which was proposed by MOT during the survey under supervision of the consultant team. However, MOT has been faced the situation that the execution of the repair works cannot be executed because of the shortage of the budget. The plan for the urgent repair works is shown as in Table 3.1-1 Table of urgent repair method.

5.2.1 Purpose and Execution Plan of Urgent Repair Works(1)

Urgent repair is required to execute as soon as possible to secure the safety and smoothness of traffic flow for all road users at present. It is necessary to pay attention that the plans whose durability are A as shown in Table 3.1-1 only have the structure that has the durability of the initial design and respond to the future traffic volume at present.

As for the urgent repair method, it is economically effective to execute the method which generates enough durability in respond to the future traffic volume. It is possible to execute more economically in comparison to the initial plan by using the equipment which was provided by Grant Aid from the Government of Japan at present.

Accordingly, due to the budget issue of MOT at present, it is recommended that the equipment should be utilized to lower the cost.

Table 5.2-1, Table 5.2-2, Table 5.2-3 shows the comparison of construction unit cost in case of using the Grant Aid equipment in regards to the proposed urgent repair method. MOT is only responsible for the labor cost and pavement equipment.

Table 5.2-1 List of Road Maintenance Equipment by Grant Aid

No	Name of Equipment	Specifications	G	K	計
1	Asphalt Cutter	Air Cooled Gasoline, 8.0kw, 150mm 以上	4	6	10
2	Vibration Compactor	Air Cooled Gasoline, 2.5kw, 60kg	4	6	10
3	Hand Breaker	Air type, 7kg	4	6	10
4	Air Compressor	5m3/min, 0.65Mpa, 35kw	2	3	5
5	Asphalt Sprayer	350lit tank, Air Cooled Gasoline, 3.0kw	2	3	5
6	Hand Guide Roller	600kg, 4.0kw	2	3	5
7	Asphalt Distributer	6000 lit, 130kw,	1	1	2
8	Asphalt Finisher	4.5m width, 45 kw	1	1	2
9	Road Roller	9,500kg, 50kw	1	1	2
10	Tier Roller	Max 15 ton, 65 kw	1	1	2
11	Water Tank Truck	7,500 lit, 130kw	1	1	2
12	Motor Grader	Blade 3,700, 100kw	4	6	10
13	Crawler Excavator	0.8m3, 98kw	3	3	6
15	Wheel Roader	2.5m3, 115kw	1	2	3
16	Bull Dozer	18 ton, 130 kw	1	1	2
17	Dump Truck	14 ton, 190kw	6	8	14
18	Asphalt Plant	35 ton/hour,	1	1	2
19	Aggregate Plant	35 ton/hour	1	1	2
20	Multipurpose Vehicle	150 kw	1	1	2
21	Snow Plough	Blade width 3m	1	1	2
22	Rotary Snow Blower		1	1	2
23	Salt Spreader		1	1	2
24	Truck with crane	Lifting capacity 3ton, Loading capacity 6ton	1	1	2
25	Truck Trailer	25 ton, 250 kw	1	1	2
26	Pick up truck	Loading capacity 900kg	2	2	4
27	Line Marker		1	0	1
28	Mobile workshop Ban	Loading capacity 3ton	1	1	2
29	Maintenance Equipment	Welding machine, Generator, etc	2	2	4
30	Measuring of axle load	Max 70ton	0	1	1

Note) G:Gisar K:Grugantyupe

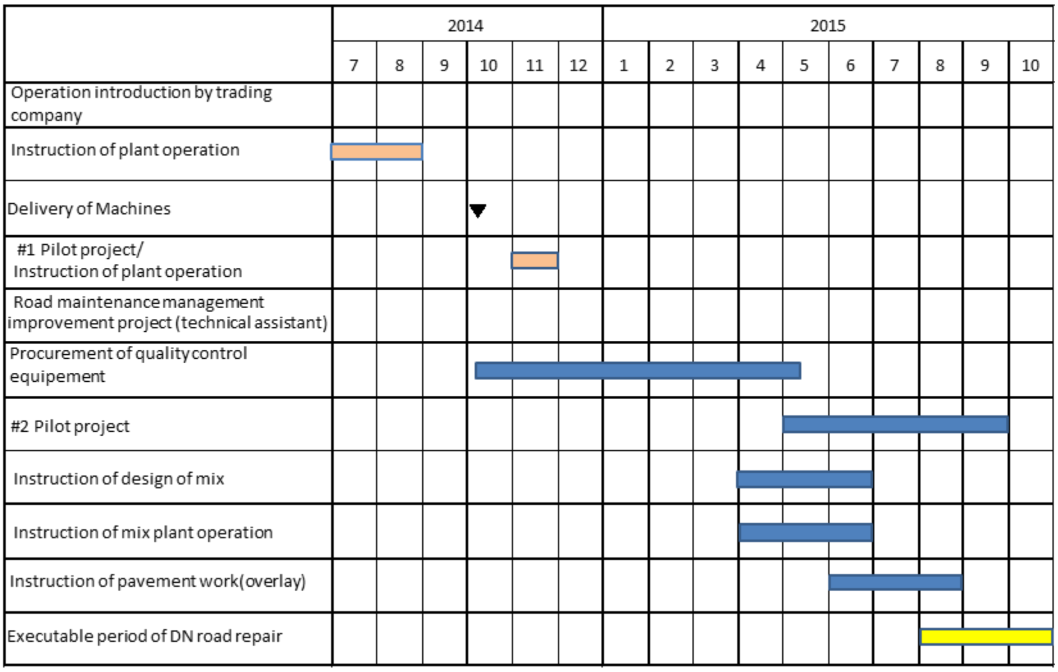


Figure 5.2-1 Delivery of Equipment/ Technical Transfer Schedule

Table 5.2-2 Cost for Urgent Repair Work (Flat Section)

		Original		New Plan		
		Unit : US$ (per 100m²)	Unit : US$ (per 413m²)	Burden for JICA/MOT	Unit : US$ (per 100m²)	Unit : US$ (per 500m²)
1	Method of temporary rehab of sub-base	3,000	12,390	MOT	100	500
				JICA	2,100	10,500
2	Replacement of base course+ cold mixture pavement method	4,500	18,580	MOT	100	500
				JICA	3,000	15,000
3	Replacement of base course+ cold mixture pavement method(30-0)	4,700	19,410	MOT	100	500
				JICA	3,200	16,000
4	Replacement of Crushed run + Macadam pavement(5cm)	5,000	20,650	MOT	400	2,000
				JICA	3,200	16,000
5	Replacement of base course + Hot AS pavement(10cm)	10,000	41,300	MOT	300	1,500
				JICA	5,000	25,000

Note）Repair location is estimated to be increasing to 500m².

Table 5.2-3　Cost for Urgent Repair Work (Steep Section)

		Original		New project		
		Unit : US$ (per 100m²)	Unit : US$ (per 332.5m²)	Burden for JICA/MOT	Unit : US$ (per 100m²)	Unit : US$ (per 400m²)
1	Cold mixture pavement (10cm)	3,000	9,975	MOT	100	400
				JICA	2,300	92,000
2	Cold mixture pavement(30-0) (10cm)	3,300	10,973	MOT	200	800
				JICA	2,600	10,400
3	Surface cutting + Permeable macadam pavement（13cm）	7,000	23,275	MOT	400	1,600
				JICA	4,500	18,000
4	Surface cutting + Hot AS pavement（15cm）	14,000	46,550	MOT	500	2,000
				JICA	8,500	35,000
5	Surface cutting＋Cement concrete pavement（15cm）	9,500	31,588	MOT	1,800	7,200
				JICA	5,000	20,000

Note）Repair location is estimated to be increasing to 400m².

Based on the above study, Implementation plan to execute the urgent repair work under follow-up project after completion of this project has been examined. As for the examination, two kinds of the project scale of ¥50,000,000 and ¥100,000,000 were assumed. It is also assumed that the implementing agency is MOT as agreed in the First Survey. In regards to the cost of the technical assistant of the consultants, labor cost for three months, indirect cost and travel cost and accommodation/daily allowance based on the unit cost of JICA are considered.

Table 5.2-4　Expenses for Technical Assistant of Consultant（Estimated Cost）

Item	Expense(1,000¥)	Remark
Expense	10,800	
Direct expense	5,700	Two flights
Direct labor expense	2,300	Labor expense(rating 3)×3 months
Other expense	2,800	Direct labor expense of 120%
General expense	2,000	(direct labor expense＋other expense)×40%
Sub-total	12,800	
Tax	1,024	
Total	13,824	About 14,000,000¥

The possible quantities (length) to be implemented for both cases are shown in Table 5.2-5.

Table 5.2-5 Possible Length for the Urgent Repair Work

Location	Method	Unit cost	Case of 50,000,000¥		Case of 100,000,000¥	
			US$ 330,000 (36,000,000¥/110¥)		US$ 780,000 (86,000,000¥/110¥)	
		US$ /100m²	m²	m	m²	m
Flat section	Method of temporary rehab of base course	2,100	15,700	2,200	37,100	5,300
	Replacement of base course + cold mixture pavement method	3,000	11,000	1,500	26,000	3,700
	Replacement of base course + cold mixture pavement method (30-0)	3,200	10,300	1,400	24,300	3,400
	Surface Cutting + Hot AS pavement(15cm)	3,200	10,300	1,400	24,300	3,400
	Surface cutting + Cement concrete pavement(15cm)	5,000	6,600	600	13,200	1,200
Steep section	Cold mixture pavement (10cm)	2,300	14,300	2,000	33,900	4,800
	Cold mixture pavement (30-0) (10cm)	2,600	12,700	1,800	30,000	4,200
	Surface cutting + Permeable macadam pavement(13cm)	4,500	7,300	1,000	17,300	2,400
	Surface cutting + Hot AS pavement(15cm)	8,500	3,900	550	7,800	1,100
	Surface cutting＋Cement concrete pavement(15cm)	5,000	6,600	900	15,600	2,200

5.2.2 Execution of Urgent Repair Works(2)

This plan assumed that MOT are responsible for all of the expenses except the equipment from the Grant Aid. Unit cost is the sum of MOT and JICA unit rate in Table 5.2-6, Table 5.2-7. The expense to be shouldered by MOT for each combination of repair works at the flat section and the slope section are shown in Table 5.2-8. Moreover, blue cells assume that that AS mixtures will be provided by MOT plant from June 2015.

Table 5.2-6 Cost for Urgent Repair Work (Flat Section)

		Original		New Plan	
		Unit : US$ (per 100m2)	Unit : US$ (per 413m2)	Unit : US$ (per 100m2)	Unit : US$ (per 500m2)
1	Method of temporary rehab of sub-base	3,000	12,390	2,200	11,000
2	Replacement of sub-base+ cold mixture pavement method	4,500	18,580	3,100	15,500
3	Replacement of sub-base+ cold mixture pavement method (30-0)	4,700	19,410	3,300	16,500
4	Replacement of Crushed run + Macadam pavement (5cm)	5,000	20,650	3,600	18,000
5	Replacement of sub-base+ Hot AS pavement(10cm)	10,000	41,300	5,300	26,500

Note）Repair location is estimated to be increasing to 500m².

Table 5.2-7 Cost for Urgent Repair Work (Sloe Section)

		Original		New Plan	
		Unit : US$ (Per 100m2)	Unit : US$ (Per 332.5m2)	Unit : US$ (Per 100m2)	Unit : US$ (Per 400m2)
1	Cold mixture pavement (10cm)	3,000	9,975	2,400	9,600
2	Cold mixture pavement (30-0) (10cm)	3,300	10,973	2,800	12,200
3	Surface cutting + Permeable macadam pavement（13cm）	7,000	23,275	5,000	20,000
4	Surface cutting + Hot AS pavement（15cm）	14,000	46,550	9,000	36,000
5	Surface cutting ＋ Cement concrete pavement（15cm）	9,500	31,588	6,800	27,200

Note） Repair location is estimated to be increasing to 400m2.

Table 5.2-8 List of Costs shouldered by MOT

	Flat Section-1 11,000	Flat Section-2 15,500	Flat Section-3 16,500	Flat Section-4 18,000	Flat Section-5 26,500
Steep section-1 9,600	20,600	25,100	26,100	27,600	36,100
Steep section-2 12,200	23,200	27,700	28,700	30,200	38,700
Steep section-3 20,000	31,000	35,500	36,500	38,000	46,500
Steep section-4 36,000	47,000	51,500	52,500	54,000	62,500
Steep section-5 27,200	38,200	42,700	43,700	45,200	53,700

Note） location painted in blue is assumed to be the usage of MOT plant from July.

5.2.3 Future Repair

It is confirmed that there is a big difference of traffic volume between design and actual. It is also confirmed that there is clayey lump in the cement stabilized sub-base course, thickness and strength of sub-base/base course is not uniform and not enough at some sections by excavation survey.

As described above, the purpose for the Urgent repair of locations where there are severe defects is to secure the smooth traffic flow and the safety of all road users. It is also necessary to examine to secure the sufficient service life by expecting the future traffic volume in the sections where is less defects or no defects at present. Moreover, it is necessary to conduct repair works for all the remaining sections with defects because the defects might worsen near future as shown in Table 4.3-1 and the repaired section might get damages again in case of the wrong selection of repair type.

The study for the remaining bearing capacity for entire target road is impossible in this project though the study of remaining bearing capacity is indispensable for appropriate and economical design. FWD (deflection measurement device) survey is strongly recommended to survey the underground structure and the bearing capacity for the entire section. The details of FWD will be mentioned in the following section.

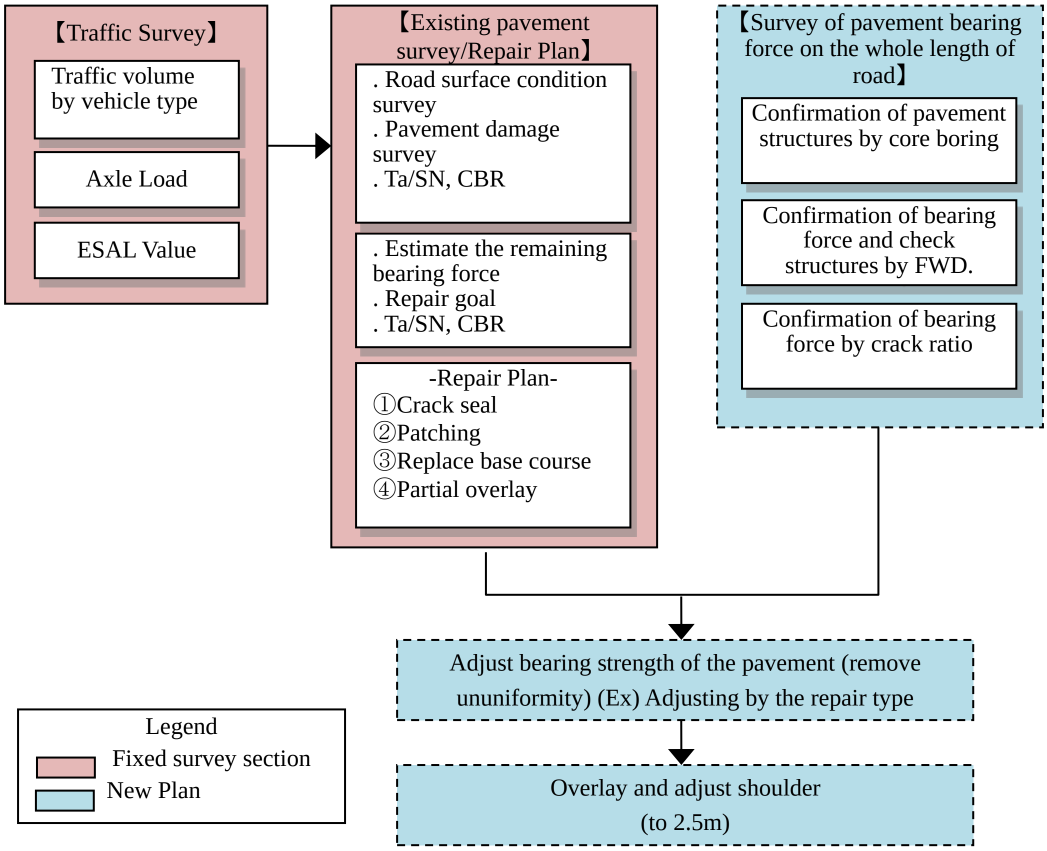
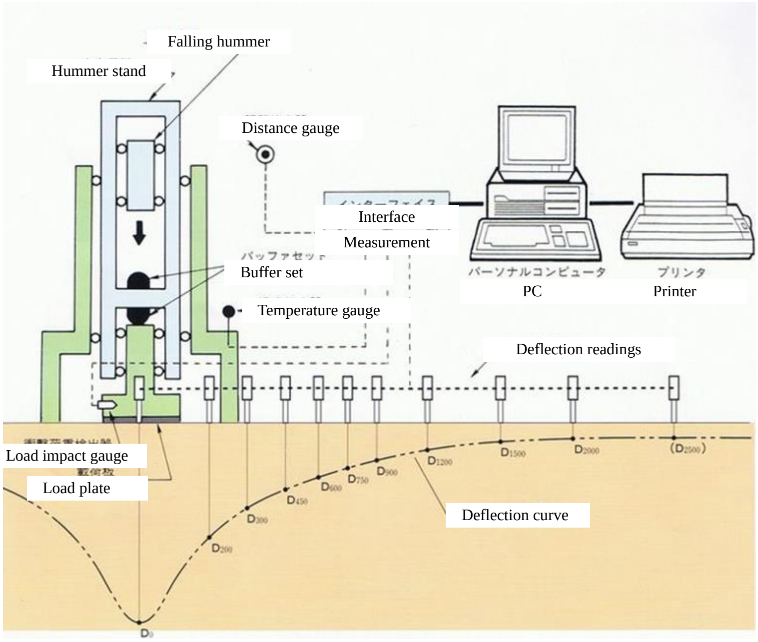


Figure 5.2-2 Flowchart of the Future Repair Plan

5.3 Examination of Pavement Bearing Capacity Survey and Repair Method for the entire section

5.3.1 Outline of FWD（Deflection Measurement Device）

FWD (Falling Weight Deflectometer, deflection measurement device) is a device to measure the deflection values of the road surface by various censors when the hammer is fallen down on the road surface. It measures the deflections values at multiple points on the surface of road at once. How the pavement deformed around the falling point can be detected. The soundness of the pavement can be analyzed by the value of the deflection value and deflection curve. Main equipment/instruments and measurement method of FWD are shown in Figure 5.3-1.



Automatic FWD vehicle

Traction FWD vehicle

Figure 5.3-1 Measurement method and main structures of FWD

The evaluation shall be done by based on the results of the 10 to 11 types of the deflection volumes (D_0 to D_{2000}, D_{2500}) obtained from FWD. There are two types of evaluation methods as shown in Figure 5.3-2. One method is to evaluate simply based on the characteristics of the deflections. Another method to evaluate by computing the destruction number by the multi-layer elasticity theory based on the elastic modulus of each layer which was obtained from the back analysis using also multi-layer elasticity theory. The obtained deflection values shall be normalized with the standard condition (20℃, 49kn) because the dynamical characteristic of the road is affected by the temperature.

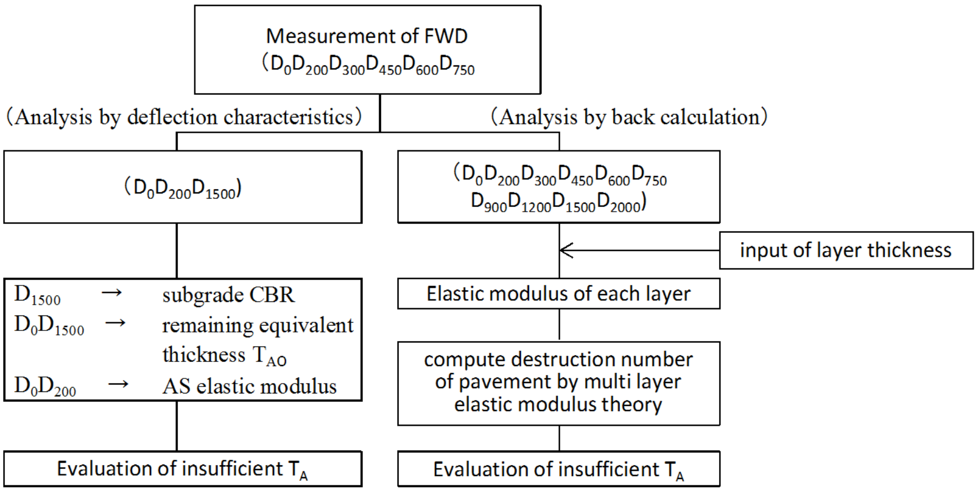


Figure 5.3-2 Method of Pavement Survey by FWD

The special feature of the survey by FWD are as following :

・Complete the survey in a short time of 3 to 4 min per one location.
・Not require a repair work after the survey because it is a non-destruction test.
・Possible to confirm the characteristics of pavement without excavation.
・Possible to shorten the traffic control hour

5.4 Comparison of Survey Method

5.4.1 Comparison with Benkelman Beam

Comparison of tests by Benkelman Beam to survey the pavement deflection as same as FWD is shown inTable 5.4-1.

Table 5.4-1 Comparison of the Surveys between FWD and Benkelman Beam

	FWD		Benkelman Beam	
Speed of measurement	○	3min to 4min per one measurement at one location	×	20min to 30min per one measurement at one location
Range of Measurement	○	Able to confirm maximum 11 locations of strain at once	×	Able to confirm only one location of strain at once
Accuracy of measurement	○	Error is small because the measurement is done by various censors and record to the PC	∆	Human error can happen by visual confirmation.
Analysis Range	○	Able to measure the elastic modulus of each layer including the whole pavement	×	Able to evaluate the soundness only of the whole pavement
Cost	×	Cost is expensive, popularity is low	○	Very simple device and low cost.

5.4.2 Comparison with Open-Cut Method

As a method to confirm the characteristics of pavement and subgrade as same as FWD by executing the open-cut and collect the materials and do laboratory test. Table of comparison for the survey by open-cut method and FWD is shown in Table 5.4-2.

Table 5.4-2 Comparison of the Surveys between FWD and Open-Cut Method

	FWD		Open Cut Method	
Survey Speed	○	Record automatically the measurement at 3 min. to 4 min. per 1 location.	×	Require long hour for 1 location measurement and great effort.
Complexity of analysis	○	Analysis work is by computation process of data.	×	Require laboratory test of the material. Analysis is complicated.
Analysis Speed	○	Fast because of computation process of data only	×	Require time for the analysis and laboratory test.
Environment	○	Excellent in environmental conservation because of non-destruction test	×	Problem with the environmental conservation for the pavement has to be destroyed and need rehab afterward.
Analysis of the whole pavement	○	It is possible to confirm high accuracy of soundness of the whole pavement from the deflection volume.	∆	It is difficult to analysis the whole pavement.
Analysis of each pavement layer	∆	Operation of analysis by the back calculation but could not match the method of collecting material directly.	○	Accuracy is high due to the laboratory examination of the direct collection of the material.
Procurement time	×	Take time due to the procurement from Japan or a third country.	○	Possible to do survey by using the local procurement material
Cost	∆	It is cheaper in large number compare to the open cut method.	×	Cost for 1 location is too expensive.

5.5 Actual Execution Method of FWD

5.5.1 Selection of Analysis Method

There are two analysis methods, one is analysis by deflection characteristic and another is by back calculation as described above. The analysis by the deflection characteristic is recommended in this project according to the following reasons:

- The surrounding deflection were affected by the nearby repaired section. Thus, It is considered the elastic modulus of each layer could not be correctly computed by the back calculation.
- There are sections whose repair records including sections are not secured.
- The elevation and condition of the exiting pavement is unknown..

5.5.2 Execution Method for the Selection of the Repair Method

Execution method for the selection of the repair method is shown in Figure 5.5-1. If there is abnormality discovered during the deflection measurement, the visual confirmation of pavement cross section and the material will be conducting by excavation survey.

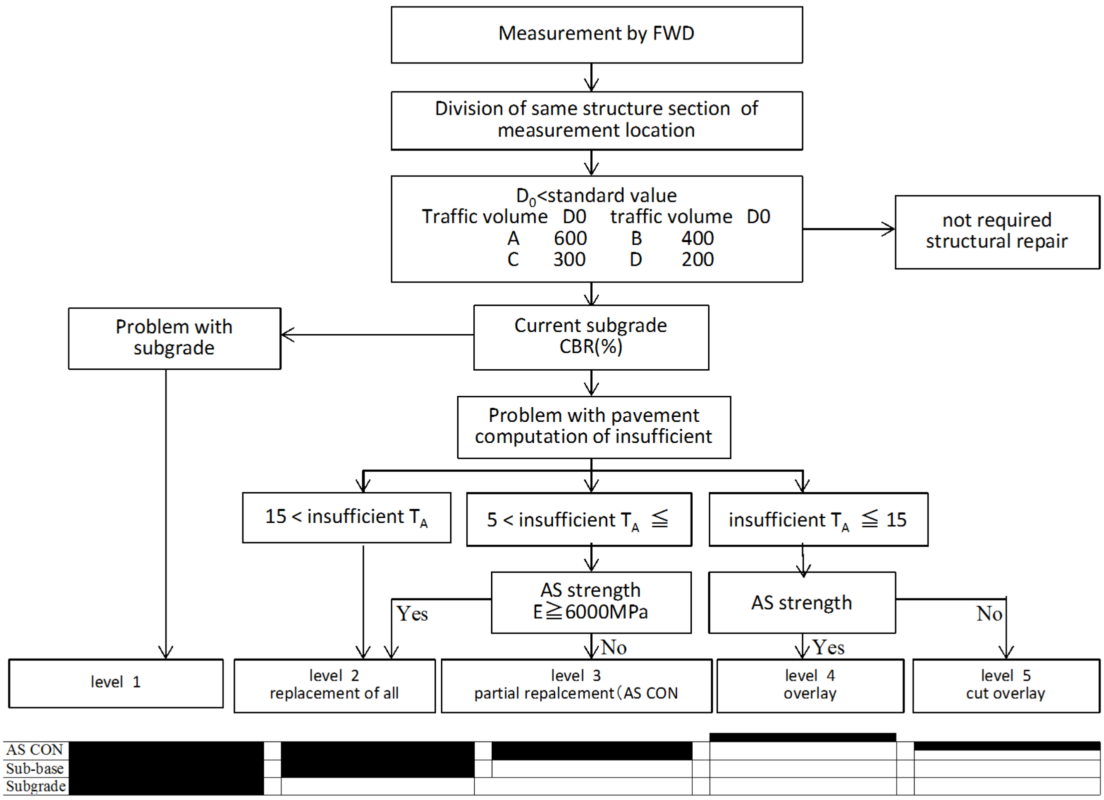


Figure 5.5-1 Example of the Selection of Repair Method by FWD