Annexes

Annex-3.1

Operational Guideline for Working Group

JICA
Data Collection Survey on Water Resources Management
in
Haor Area of Bangladesh

OPERATIONAL GUIDELINE FOR WORKING GROUP

1. General

JICA decided to conduct the "Data Collection Survey on Water Resources Management in Haor Area of Bangladesh (the Study)" in Bangladesh by dispatching the JICA Study Team (the Study Team) headed by Mr. Koji KAWAMURA from 27 November 2012. The objectives of the Study are:

(1) To review "Master Plan of Haor Areas (the M/P), 2012, BHWDB" as well as other plans on water resources management in the haor areas,
(2) To conduct basic study on matters having hardly been addressed so far in these plans, and
(3) To identify possible JICA cooperation projects for flood and river management in the haor areas.

JICA understands that the M/P has identified priority projects reflecting the local peoples' needs and is considered to be an overarching plan for future JICA cooperation in the haor areas. However, JICA has some concern that the detailed selection process including background information and the evaluation of possible impact of these prioritized projects have not fully been explained in the M/P. It is crucial to verify these points through the Study to consider future JICA cooperation.

Under such situations, the Working Group (WG) has been formed for the Study.

This operational guideline for the WG shall address the following:

i) the purpose,
ii) the final outputs,
iii) the members,
iv) the activities,
v) the time schedule, and
vi) the operation.

2. Purpose

The purpose of the WG is to review the detailed formulation process and backgrounds of the M/P and to clarify the matters having hardly been addressed yet in the M/P, which are subject to "basic study" in the Study so as to consider future JICA cooperation in the haor areas.

3. Final Output

The final outputs of the WG are the scope of the "basic study" to be carried out in the Study.

4. Members

The WG is composed of the members presented in Table 1.

Table 1 Members of Working Group

Positions	Organizations/Personnel Assigned		
	BWDB	**CEGIS**	**JICA Study Team**
Group Leader*	Director, Planning-1	-	-
Deputy Group Leader	Executive Engneer, Office Chief Planning	-	Team Leader
Water Resources Management	-	Director, Climate Change Study Division	Team Leader
Flood Measures	-	Flood Measures Expert	Deputy Team Leader
Facility Plan/Design	-	Facility Plan/Design Expert	Facility Plan/Design Expert

Note: the group leader shall be a chairperson of the WG meeting.

5. Activities

The activities of the WG are:

1) To identify and compile the items to be reviewed,
2) To collect and scrutinize the data used and analysis results regarding each review item,
3) To confirm and assess project selection criteria and results, and
4) To provide items and their contents of the “basic study”.

It is noted that the items and their contents of the “basic study” need to be finalized with an approval of JICA.

The items to be reviewed by the WG are itemized below at this initial stage of the Study, which are subject to change in the curse of the review work of the M/P:

(1) Item 1: Process for project prioritization and selection, and technical/environmental/social data and information used in water resources sector,

(2) Item 2: Clarification of applied method and data used to hydrological and hydraulic analysis,

(3) Item 3: Verification of the consistency and reliability of exiting hydrologic, hydraulic, and sediment data,

(4) Item 4: Selection process of WR-01 to WR-09 in Table 2,

(5) Item 5: (i) Selection process of subprojects in WR-01 to WR-09, including confirmation of peoples’ needs and selection criteria, and (ii) planning process of such structures as submergible embankments, sluices, platforms, etc. from a technical viewpoints, particularly hydrologic, hydraulic, geomorphic, and geotechnical ones,

(6) Item 6: Basis of cost estimation, and

(7) Item 7: Possible project impacts.

Table 2 Projects Identified in the M/P for Water Resources Sector

(Duration in year and Cost in lakh taka)

DA Code	Project Title	Duration Year	Short Term	Medium Term	Long Term	Total cost
	Water Resources		(lakh taka)			
WR-01	Pre-Monsoon Flood Protection and Drainage Improvement in Haor Areas	5	12,550	-	-	12,550
WR-02	Flood Management of Haor Areas	7	28,575	53,068	-	81,643
WR-03	River Dredging and Development of Settlement	5	44,073	4,897	-	48,970
WR-04	Development of Early Warning System for Flash Flood Prone Areas in Haor and Dissemination to Community Level	20	353	215	200	768
WR-05	Village Protection against Wave Action of Haor Area	3	31,046			31,046
WR-06	Monitoring of the Rivers in Haor Area	4	450	450	-	900
WR-07	Impact Study of the Interventions of Transboundary River System	5	1,350	150	-	1,500
WR-08	Study of the Climate Change Impact of Haor Area	4	400	400	-	800
WR-09	Strengthening and Capacity Development of BHWDB	2	197	-	-	197
	Total		118,994	59,180	200	178,374

Source : "Master Plan of Haor Area (2012)"

Notes: DA: Development Area
Short Term (FY 2012-13 ～ FY 2016-17)
Medium Term (FY 2017-18 ～ FY 2021-22)
Long Term (FY 2022-23 ～ FY 2031-32)

6. Time Schedule

	Time Schedule*
Item 1	December 2012
Item 2	
Item 3	
Item 4	
Item 5	
Item 6	January 2013
Item 7	December 2012

Note: * If the items to be reviewed are changed, the time schedule shall be reset.

7. Operation of the WG

(1) The WG will hold their regular progress meeting every two weeks as a rule on a pre-set date determined by the Chairperson. (Note: more discussions shall be required between the Study Team and CEGIS).

(2) The WG will hold any extraordinary meeting when necessary based on a proposal by any of the WG members and the decision of the Chairperson.

(3) The Chairperson shall chair all the meetings. The Study Team shall record the minutes of meetings and any other issues that may arise in the meetings.

(4) All the records will be kept and maintained by the Study Team.

Annex 3-2
Minutes of Discussion

Annex-3.2.1

Minutes of Discussion on the Inception Report

Annex

Minutes of Discussion on the Inception Report Presentation Meeting on "JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh" held on 10th December, 2012 at 3:00 pm in Conference of Director General, BWDB and agreed upon between Bangladesh Water Development Board of People's Republic of Bangladesh and Japan International Cooperation Agency (JICA) Study Team .

Introduction

The Government of Japan (hereinafter referred to as "the GOJ") through Japan International Cooperation Agency (JICA) conducted the "Preparatory Planning Study for Meghan River Basin Management" between September 2010 and March 2011 (the JICA 2010 Study). After that the JICA conducted "Preparatory Survey on Cooperation Program for the Disaster Management in Bangladesh" between September 2011 and June 2012 (the JICA 2011 Study) to formulate JICA cooperation program for flood related disaster management in the Upper Meghna River basin and to work out preliminary plans of promising projects incorporated into the said cooperation program. The JICA 2011 Study was essentially based on the "Haor Master Plan" prepared by the Bangladesh Haor and Wetland Development Board (hereinafter referred to as "BHWDB").

JICA understands that the Master Plan of Haor Areas (the M/P, BHWDB, 2012) has identified priority projects reflecting the local peoples' needs, and is considered to be an overarching plan for future JICA cooperation in the haor areas. However, JICA has some concern that (i) the detailed selection process including background information and (ii) the evaluation of possible impact of these prioritized projects have not fully been explained in the M/P. Since it is crucial to verify these points in order to consider future JICA cooperation, JICA has decided to conduct "Data Collection Survey on Water Resources Management in Haor Area of Bangladesh" (the Study).

To conduct the Study, JICA thus dispatched the Study Team (hereinafter referred to as "the JICA Study Team"), headed by Mr. Koji Kawamura of Nippon Koei Co., Ltd., to Bangladesh from 27 November 2012.

The JICA Study Team held this meeting on 10th December 2012 at Bangladesh Water Development Board (hereinafter referred to as "BWDB"), WAPDA Bhaban to explain the contents of the Inception Report covering the Study area, background, outlines, approach to implementation of the Study, Study schedule, plan of operation, staffing schedule and reporting to the officials of BWDB, BHWDB and other Bangladeshi stakeholders concerned (hereinafter referred to as "the Bangladeshi side") to share information and exchange opinions with the Bangladeshi side about the study approach and operation strategy in order to obtain maximum effectiveness.

The Bangladeshi side and the JICA Study Team had a discussion after the presentation by the JICA Study Team. The list of participants is attached hereto in Annex-1.

Results of Discussions:

The Bangladeshi side basically accepted the contents of the Summary Inception Report presented in the meeting, and mentioned some comments and requests in the discussion as follows:

1. **Comments from DG, BWDB**

   - The submerged embankments constructed in the haor areas need to be repaired almost on a yearly basis after the rainy season even after 90 % compaction. Director General, BWDB requested the Study Team to come up with some ideas so that such yearly repairs are not or less required. One of the possibilities is to fix the height of embankment at selected locations lower than the designed embankment crest with causeways/runoff bridges (like an un-gated spillway). In this way, it might be possible to use less O&M money.

2. **Request from the JICA Study Team**

   - The JICA Study Team requested the BWDB and other concerned agencies to provide support to assist in data/information collection and to assist the Study Team in arrangements for the field survey. The DG assured that the Study Team will get every assistance and support from BWDB in any respect and in anywhere.

3. **Closing Remarks by the DG, BWDB**

   - The DG thanked the JICA Study Team for their hard work. He also thanked the participants for their presence.

(K A M SHAHIDUZZAMAN)
Director General
Bangladesh Water Development Board
Dhaka.

List of Participants

List of participants attended the meeting on Inception Report of "JICA Data Collection survey on Water Resources Management in Haor Area of Bangladesh" held on 10th December, 2012 at 3:00 P.M. at the DG's Conference room of BWDB, WAPDA Building (2rd Fl.), Motijheel , Dhaka.

Sl.No.	Name and Designation	Organization	Contact no./email	Signature
1.	Md. Abdul Mazhan ADG (ER)	BWDB	01753303133	
2.	Md. Afzal Hossain ADG (PP)	BWDB	9562293	
3.	Mallah Ruhul Alam Water Resources Expert.	CEGIS.	01715406565	
4.	Md. Humayun Kabir Senior Specialist	IWM	01713041830	
5.	GILBERTO CANALI	NHC JICA STUDY TEAM	gcanali@nhc web.com.	
6	Yasuhiro AZUMA	JICA STUDY TEAM	01982292808	
7.	KOJI KAWAMURA	"	017-62001580	
8	NURUL ISLAM	"	017-1312145	
9	Michio OTA	JICA Expert	01713-043122	太田道男
10.	Md. Sarfaraz Wahed.	CEGIS.	01712209364	
11.	S.M. ATAUR RAHMAN	BWDB EE / Hydrology	01729788425	
12	Dr. Dilruba Ahmed	CEGIS	—	
13.	Md Ansar Ali Meal CE/Hydrology	BWDB	01726-064204	10/12/12
14.	Md. Ferdous CE, NEB Comilla	BWDB	01715292824	10/12/12
15	Md. Abul Kalam Azad/SE	BWDB	01711384988	10.12.12
16.	Md. Abdul Hye/EE Sunamganj	BWDB	01716094096	10.12.12.
17.	Md. Mustafizur Rahman Xen, BWDB, Moulvi bazar	BWDB	01714-00306,	10/12/12

List of Participants

List of participants attended the meeting on Inception Report of "JICA Data Collection survey on Water Resources Management in Haor Area of Bangladesh" held on 10th December, 2012 at 3:00 P.M. at the DG's Conference room of BWDB, WAPDA Building (2rd Fl.), Motijheel , Dhaka.

Sl.No.	Name and Designation	Organization	Contact no./email	Signature
18.	Musa Nurur Rahman	XEN, BWDB	01715 440505	10.12.12
19	Dr. Shayamal Chandra Das XEN, Office of the C.P.	BWDB	01759693375 shamal1967@yahoo.com	10.12.12
20	FAZLUR RASHID Executive Engineer	BWDB	01711151652 fazlur64@gmail.com	10.12.12
21	TANVIR SAIF AHMED Asst. Engr.	BWDB	01716483997	10.12.12
22	Tania Mostafa	BWDB	01553562001	10.12.12
23	Md. Mustabizur Rahman	BWDB	01736790168	10.12.12
24.	Md. Akhtar Hossain	Planning-I, BWDB	01818-614543	
25	Naoki Matsumura	JICA Bangladesh office	01714138411	

Annex-3.2.2

Minutes of Discussion for the First Working Group Meeting

BANGLADESH WATER DEVELOPMENT BOARD
Directorate of Planning-I
WAPDA Building (6th Floor), Motijheel C/A
Dhaka-1000

Ph. No: 9551088
Fax :+880-2-9564702
email:dplanning1@gmail.com

Memo No. WDB/P-I/ 1290 Dated : 31.12.2012

Subject: Minutes of Discussion for the First Working Group Meeting on "JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh".

Distribution: (Not as per seniority)

1. Director, Planning-1, BWDB and Group Leader of the Working Group.
2. Dr. Shamal Chandra Das, Executive Engineer, Office of Chief Planning, BWDB and Deputy Group Leader of Working Group.
3. Mr. Koji KAWAMURA, Team Leader, JICA Study Team and the Deputy Group Leader of Working Group.
4. Mr. Yasuhiro AZUMA, JICA Study Team and the member of Working Group.
5. Ms. Nazneen Aktar, Sr. Professional, CEGIS, House No. 6, Road No. 23C, Gulshan-1, Dhaka.
6. Mr. Md. Sahadat Hossain Choudhury, Professional, CEGIS, House No. 6, Road No. 23C, Gulshan-1, Dhaka.

C.C.

1. Additional Director General, Planning, BWDB, Dhaka.
2. The Chief Planning, BWDB, Dhaka.
3. CSO to Director General, BWDB, Dhaka.

31.12.12
(Musa Nurur Rahman)
Executive Engineer
Planning-I, BWDB,

Minutes of Discussion for the First Working Group Meeting on the JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh held on 10 December 2012 at 12:00 noon in the Office-room of Director, Planning-1.

The first meeting of the Working Group(WG) set up under the "JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh" was held at the office of the Director, Planning -1 of Bangladesh Water Development Board (BWDB) on 10th December 2012 at 12:00 noon under the chairmanship of Mr. Fazlur Rashid, Executive Engineer, Planning -1. Mr. Fazlur Rashid presided over the meeting as Director, Planning-1 and Team Leader of Working Group was not present in the meeting. The list of participants is shown in the **Annex-A**.

It was clarified at the beginning that participants from the CEGIS are representing the WG members nominated from CEGIS in their absence. The chairperson requested them to brief the original members regarding this meeting outcome.

At the outset of the meeting the Chairperson welcomed the participants and requested Mr. Koji Kawamura, the Team Leader of the JICA Study Team to explain the operational guideline of the WG. Mr. Kawamura explained the background of the Study and the purpose of setting the WG. He also explained activities of the WG and the final expected output.. The operational guideline for WG was presented by Mr. Kawamura is shown in the **Annex-B**.

The Chair thanked the presenter for his nice presentation. The Chair then opened the floor and requested the participants to give their comments on the presentations.

Mr. Kawamura proposed that on 12th December 2012 the JICA Study Team would visit CEGIS and hold detail technical discussion with concerned CEGIS staffs for the Haor Master Plan review. The CEGIS representatives agreed to convey this request. The probable discussion points are:

(1) Item 1:Process for project prioritization and selection, and used technical data and information,

(2) Item 2:Selection process of WR-01 to WR-09 in Haor MP,

(3) Item 3:(i) Selection process of subprojects in WR-01 to WR-09, including confirmation of peoples' needs and selection criteria, and (ii) planning process of such structures as submergible embankments,

sluices, platforms, etc. from a technical viewpoints, particularly hydraulic and geotechnical ones

Mr. Kawamura mentioned that CEGIS Executive Director was eager to provide a room for the Study Team to conduct their review work. The CEGIS representatives were requested to convey it to the concerned authorities.

The chairperson requested CEGIS to provide 2 sets of Haor MP (hard and soft copies), one to BWDB and one to JICA Study Team.

The WG wanted to know the project selection process used in the Haor MP. The representatives of CEGIS explained the process. It was concluded that more discussion would be held on 12th December at CEGIS.

Mr. Kawamura requested CEGIS to provide all background information regarding Haor Master Plan in documented form on 12th December, 2012. .

The Chairperson thanked all the members of the WG for their excellent presentation & valuable observation and comments on the study. He hoped that in due consideration of the comments and opinions expressed the WG will achieve its objective.

The next meeting of the WG was set at 10-30 AM on 23rd December, 2012.

As there was no other agenda to discuss, the meeting ended with a vote of thanks from the Chair.

31.12.12
(Fazlur Rashid)
Executive Engineer, Planning -1
BWDB, Dhaka.

List of Participants

List of participants attended in the meeting of Working Group for the review of "Master Plan of Haor Areas, 2012, BHWDB" under "JICA Data Collection survey on Water Resources Management in Haor Area of Bangladesh" held on 10th December, 2012 at 12:00 Noon at the office of the Planning-I, BWDB, WAPDA Building (6th Fl.), Motijheel Dhaka.

Sl.No.	Name and Designation	Organization	Contact no./email	Signature
1	Dr. Shamal Chandra Das Executive Engr.	BWDB	01759693375 shamal1967@yahoo.com	
2	Koji Kishi MLIT Team Leader	JICA Study Team	017-6200-1507/ a2737@n-koei.co.jp	
3	Faslur Rashid	BWDB	9551088 faslurc4@gmail.com	
4	Nurul Islam	JICA Study Team	017-13121427 a4980@n-koei.co.jp	
5	Yasuhito AZUMA	JICA study Team	019-8227808 a3769@n-koei.co.jp	
6	Gilberto Camilli	JICA STUDY Team	gcamilli@hotmail.com	
7	Michio Ota	JICA Expert	monarbo7810@gmail.com	
8.	Musa Nusrat Rahman	XEN, Planning-I BWDB	mnrplanning1@gmail.com	10.12.12
9.	Nazneen Akter	Sr. Professional CESD, CECATS	naktan@cecgis-bd.com	Nazneen 10.12.12
10.	M.I. Shahadat Hossain Chandly	Professional CEGIS.	loadingground@gmail.com	MSH 11.12.12
11.	TANJIR SAIF AHMED	AE, BWDB	01716453997	Tanjir Saif Ahmed 10.12.12

JICA
Data Collection Survey on Water Resources Management
in
Haor Area of Bangladesh

OPERATIONAL GUIDELINE FOR WORKING GROUP

1. General

JICA decided to conduct the "Data Collection Survey on Water Resources Management in Haor Area of Bangladesh (the Study)" in Bangladesh by dispatching the JICA Study Team (the Study Team) headed by Mr. Koji KAWAMURA from 27 November 2012. The objectives of the Study are:

(1) To review "Master Plan of Haor Areas (the M/P), 2012, BHWDB" as well as other plans on water resources management in the haor areas,
(2) To conduct basic study on matters having hardly been addressed so far in these plans, and
(3) To identify possible JICA cooperation projects for flood and river management in the haor areas.

JICA understands that the M/P has identified priority projects reflecting the local peoples' needs and is considered to be an overarching plan for future JICA cooperation in the haor areas. However, JICA has some concern that the detailed selection process including background information and the evaluation of possible impact of these prioritized projects have not fully been explained in the M/P. It is crucial to verify these points through the Study to consider future JICA cooperation.

Under such situations, the Working Group (WG) has been formed for the Study.

This operational guideline for the WG shall address the following:

i) the purpose,
ii) the final outputs,
iii) the members,
iv) the activities,
v) the time schedule, and
vi) the operation.

2. Purpose

The purpose of the WG is to review the detailed formulation process and backgrounds of the M/P and to clarify the matters having hardly been addressed yet in the M/P, which are subject to "basic study" in the Study so as to consider future JICA cooperation in the haor areas.

3. Final Output

The final outputs of the WG are the scope of the "basic study" to be carried out in the Study.

4. Members

The WG is composed of the members presented in Table 1.

Table 1 Members of Working Group

Positions	Organizations/Personnel Assigned		
	BWDB	CEGIS	JICA Study Team
Group Leader*	Director, Planning-1	-	-
Deputy Group Leader	Executive Engneer, Office Chief Planning	-	Team Leader
Water Resources Management	-	Director, Climate Change Study Division	Team Leader
Flood Measures	-	Flood Measures Expert	Deputy Team Leader
Facility Plan/Design	-	Facility Plan/Design Expert	Facility Plan/Design Expert

Note: the group leader shall be a chairperson of the WG meeting.

5. Activities

The activities of the WG are:

1) To identify and compile the items to be reviewed,
2) To collect and scrutinize the data used and analysis results regarding each review item,
3) To confirm and assess project selection criteria and results, and
4) To provide items and their contents of the "basic study".

It is noted that the items and their contents of the "basic study" need to be finalized with an approval of JICA.

The items to be reviewed by the WG are itemized below at this initial stage of the Study, which are subject to change in the curse of the review work of the M/P:

(1) Item 1: Process for project prioritization and selection, and technical/environmental/social data and information used in water resources sector,

(2) Item 2: Clarification of applied method and data used to hydrological and hydraulic analysis,

(3) Item 3: Verification of the consistency and reliability of exiting hydrologic, hydraulic, and sediment data,

(4) Item 4: Selection process of WR-01 to WR-09 in Table 2,

(5) Item 5: (i) Selection process of subprojects in WR-01 to WR-09, including confirmation of peoples' needs and selection criteria, and (ii) planning process of such structures as submergible embankments, sluices, platforms, etc. from a technical viewpoints, particularly hydrologic, hydraulic, geomorphic, and geotechnical ones,

(6) Item 6: Basis of cost estimation, and

(7) Item 7: Possible project impacts.

Table 2 Projects Identified in the M/P for Water Resources Sector

(Duration in year and Cost in lakh taka)

DA Code	Project Title	Duration Year	Short Term	Medium Term	Long Term	Total cost
	Water Resources		(lakh taka)			
WR-01	Pre-Monsoon Flood Protection and Drainage Improvement in Haor Areas	5	12,550	-	-	12,550
WR-02	Flood Management of Haor Areas	7	28,575	53,068	-	81,643
WR-03	River Dredging and Development of Settlement	5	44,073	4,897	-	48,970
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WR-05	Village Protection against Wave Action of Haor Area	3	31,046			31,046
WR-06	Monitoring of the Rivers in Haor Area	4	450	450	-	900
WR-07	Impact Study of the Interventions of Transboundary River System	5	1,350	150	-	1,500
WR-08	Study of the Climate Change Impact of Haor Area	4	400	400	-	800
WR-09	Strengthening and Capacity Development of BHWDB	2	197	-	-	197
	Total		118,994	59,180	200	178,374

Source : "Master Plan of Haor Area (2012)"

Notes: DA: Development Area
Short Term (FY 2012-13 ～ FY 2016-17)
Medium Term (FY 2017-18 ～ FY 2021-22)
Long Term (FY 2022-23 ～ FY 2031-32)

6. Time Schedule

	Time Schedule*
Item 1	December 2012
Item 2	
Item 3	
Item 4	
Item 5	
Item 6	January 2013
Item 7	December 2012

Note: * If the items to be reviewed are changed, the time schedule shall be reset.

7. Operation of the WG

(1) The WG will hold their regular progress meeting every two weeks as a rule on a pre-set date determined by the Chairperson. (Note: more discussions shall be required between the Study Team and CEGIS).

(2) The WG will hold any extraordinary meeting when necessary based on a proposal by any of the WG members and the decision of the Chairperson.

(3) The Chairperson shall chair all the meetings. The Study Team shall record the minutes of meetings and any other issues that may arise in the meetings.

(4) All the records will be kept and maintained by the Study Team.

Annex-3.2.3

Minutes of Discussion for the Second Working Group Meeting

Minutes of Discussion for the Second Working Group Meeting on the "JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh" held on 23 December 2012 at 11:00 am in the Office chamber of Director, Planning-1.

The second meeting of the Working Group (the WG) set up under the "JICA Data Collection Survey on Water Resources Management in Haor Area of Bangladesh (the Study)" was held at the office of the Director ,Planning -1, Bangladesh Water Development Board (BWDB) on 23rd December 2012 under the chairmanship of Mr. Md. Abdur Rahman Akhanda, Director, Planning -1. The list of participants is shown in the Annex-A.

At the outset of the meeting, the Chairperson welcomed the participants and requested Mr. Koji Kawamura, the Team Leader of the JICA Study Team (the Study Team) to explain briefly the operational guideline of the WG for the first-time participants. Mr. Kawamura explained the background of the Study and the purpose of setting the WG. He also explained the final expected output, members and activities of the WG, referring to the operational guideline. This guideline was attached to the minutes of discussion of the first WG meeting.

The Chairperson thanked Mr. Kawamura for his nice presentation, and then opened the floor and requested the participants to continue the proceedings.

It was pointed out that official nomination for the WG from the CEGIS was not yet confirmed. The Chairperson requested the CEGIS representatives to issue a letter with their nominations.

Mr. Kawamura reported the WG that after the first WG meeting on 10th December 2012, the Study Team had technical discussion with CEGIS on the "Master Plan of Haor Area (the M/P)" thrice, namely, on Dec. 12, Dec. 17 and Dec. 20, 2012 but unfortunately the progress was rather less than expectation. In reply, the CEGIS representative said that since one of the key members of the M/P Team was not available, there were some delays in data provision. However, he assured that from now on CEGIS will provide all their support to the Study Team in the review work of the M/P. The Study Team and CEGIS thus agreed to have another technical discussion on 24th Dec. at the CEGIS office.

It was reported by the Study Team that in line with the decision concluded in the first WG meeting, CEGIS provided the soft and hard copies of the main report and one annex of the M/P to the Study Team. The Chairperson requested CEGIS to provide the remaining annexes of the M/P to the Study Team.

One of the WG members raised a question of study area extent. It was confirmed by the Study Team that the area including the Brahmanbaria area should be considered as the study area.

Regarding the information on river cross section survey by BWDB and the design guideline for the crest elevation of submergible embankment, the Chairperson arranged appointments with the

Superintending Engineer , Morphology Circle , BWDB, Dhaka and the Superintending Engineer , Design Circle -1 , BWDB , Dhaka respectively.

It was decided that the Chairperson will issue a letter to IWM requesting sharing with the Study Team all BWDB owned data kept with IWM.

The Chairperson thanked all the members of the WG for their excellent presentation and valuable observation and comments on the Study. He hoped that in due consideration of the comments expressed the WG will achieve its objective.

The next meeting of the WG is set at 11-00 AM on 14th January, 2013.

The meeting ended with a vote of thanks from the Chair.

Sd/-

(Md. Abdur Rahman Akhanda)
Director,
Planning -1
BWDB, Dhaka.

Memo No. BWDB/P-1/78(5) Date: 23/.01.2013

Distribution : (Not as per seniority)

1. Executive Director, CEGIS, House-6, Road-23/C, Gulshan-1, Dhaka.
2. Dr. Shamal Chandra Das, Executive Engineer, Office of the Chief Planning, BWDB, Dhaka and Deputy Group Leader of the Working Group.
3. Mr. Michio Ota, JICA Expert, WAPDA Buliding, Motijheel, Dhaka.
4. Mr. Koji KAWAMURA, Team Leader, JICA Study Team and Deputy Group Leader of the Study Group.
5. Mr. Fida A. Khan, Director, CCSD, CEGIS, House-6, Road-23/C, Gulshan-1, Dhaka.

C.C.

1. Additional Director General (Planning), BWDB, Dhaka.
2. Chief Planning, BWDB, Dhaka.
3. C.S.O. to Director General, BWDB, Dhaka.

23.1.13

(Musa Nurur Rahman)
Executive Engineer
Planning -1
BWDB, Dhaka.

- 2 -

List of Participants

List of participants attended in the 2nd meeting of Working Group for the review of "Master Plan of Haor Areas, 2012, BHWDB" under "JICA Data Collection survey on Water Resources Management in Haor Area of Bangladesh" held on 23rd December, 2012 at 11:00 A.M. at the office of the Planning-I, BWDB, WAPDA Building (6th Fl.), Motijheel Dhaka. The meeting is presided over by the Director, Planning-I, BWDB.

Sl.No.	Name and Designation	Organization	Contact no./email	Signature
1.	Koji KAWAMURA (NIPPON KOEI)	JICA Study	a2717@n-koei.co.jp	
2.	(NIPPON KOEI) NURUL ISLAM	JICA Study	a4890@n-koei.co.jp	
3.	Michio Ota ← (JICA Expert)	BWDB	monarbo7810@gmail.com	
4	Mohle Fida A. Khan Director PCSD, CEGIS	CEGIS	mfkhan@cegisbd.com	
5.	Md. Shahadat Hossain Chowdhury	CEGIS	shchowdhury@cegisbd.com	
6.	Dr. Shamal 1967@yahoo.com XEN, Office of the Chief Planning	BWDB	shamal1967@yahoo.com	
7.	Musa Nurur Rahma, XEN	BWDB	01715 7405 05	23.12.12
8.	Mohammad Akbar Hossain, Research Officer.	Planning-I, BWDB	01818-614543 akbarhossain@yahoo.com	

Annex-3.2.4

Minutes of Discussion for the Third Working Group Meeting

Minutes of Discussion for the Third Working Group Meeting on the "JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh" held on 14 January 2013 at 11:00 am in the Office-room of Director, Planning-1 , BWDB, Dhaka.

The third meeting of the Working Group(the WG) set up under the "JICA Data Collection Survey on Water Resources Management in Haor Area of Bangladesh (the Study)" was held at the office of the Director , Planning -1 , Bangladesh Water Development Board (BWDB) on 14th January 2013 under the chairmanship of Mr. Md. Abdur Rahman Akhanda, Director, Planning-1. The list of participants is shown in the **Annex-A.**

At the outset of the meeting, the Chairperson welcomed the participants and requested Mr. Koji Kawamura, the Team Leader of the JICA Study Team (the Study Team) to explain briefly the progress since the last working group meeting held on 23rd December, 2012. Mr. Kawamura explained that discussions between the JICA Study Team and CEGIS were held on December 31, January 7, 9 and 13 (4 times in total), and the progress was satisfactory although many more things remained to be clarified. Mr. Azuma, the Deputy Team Leader of the JICA Study Team, then presented the summary of project and sub project selection process used in the preparation of the Haor Master Plan. He also pointed out that the selection process for the river dredging needed to be clarified. The representative of CEGIS invited the JICA Study Team to visit CEGIS to have further discussion on this on the same day (14th January). The Chairperson thanked the representative of CEGIS for prompt response.

The Chairperson thanked Mr. Azuma for his nice presentation, and then opened the floor and requested the participants to continue the proceedings.

In response to the query on the progress of Kalni-Kushiara River Management Project (KKRMP), CEGIS informed that an Inception Report was already submitted by them and the Progress Report will be presented in March 2013. The chairperson requested CEGIS to provide a copy of Inception Report to the Study Team.

In response to another query on the progress of the on-going 52 haors rehabilitation project by BWDB, CEGIS mentioned that the study for 37 haors has been completed by IWM and that for the rest 15 is now in progress by CEGIS. The Chairperson requested CEGIS to provide all reports for the 15 haors to the Study Team.

It was decided that the Chairperson will issue a letter to Chief Engineer, Central Zone, BWDB, Dhaka and Chief Engineer, North-Eastern Zone, BWDB, Comilla requesting their cooperation during the Study Team's field visit.

Regarding the requirement of some meteorological data, the Chairperson suggested that relevant data can be

found in WARPO and he advised to send a letter to BWDB in this regard.

Regarding the requirement of some topographic data, CEGIS proposed that the Study Team check the DEM available with CEGIS and if applicable, the Study Team get the DEM.
Regarding the MOD for ICR meeting, BWDB explained that the official process for issuance of the MOD is still in progress.

The Chairperson thanked all the members of the WG for their excellent presentation and valuable observation and comments on the Study. He hoped that in due consideration of the comments expressed the WG will achieve its objective.

The next meeting of the WG was not fixed. The Chairperson requested the Team Leader of the JICA Study Team to inform him whenever the next WG meeting needs to be conveyed.
The meeting ended with a vote of thanks from the Chair.

Sd/-
(Md. Abdur Rahman Akhanda)
Director,
Planning -1
BWDB, Dhaka.

Memo No. BWDB/P-1/79 (5).

Date: 23/.01.2013

Distribution : (Not as per seniority)

1. Executive Director, CEGIS, House-6, Road-23/C, Gulshan-1, Dhaka.
2. Dr. Shamal Chandra Das, Executive Engineer, Office of the Chief Planning, BWDB, Dhaka and Deputy Group Leader of the Working Group.
3. Mr. Michio Ota, JICA Expert, WAPDA Buliding, Motijheel, Dhaka.
4. Mr. Koji KAWAMURA, Team Leader, JICA Study Team and Deputy Group Leader of the Study Group.
5. Mr. Yasuhiro AZUMA, Deputy Team Leader, JICA Study Team.
6. Mr. Fida A. Khan, Director, CCSD, CEGIS, House-6, Road-23/C, Gulshan-1, Dhaka.

C.C.

1. Additional Director General (Planning), BWDB, Dhaka.
2. Chief Planning, BWDB, Dhaka.
3. C.S.O. to Director General, BWDB, Dhaka.

31.1.13
(Musa Nurur Rahman)
Executive Engineer
Planning -1
BWDB, Dhaka.

-2-

List of Participants

List of participants attended in the 3rd meeting of Working Group for the review of "Master Plan of Haor Areas, 2012, BHWDB" under "JICA Data Collection survey on Water Resources Management in Haor Area of Bangladesh" held on 14th January, 2013 at 11:00 A.M. at the office room of Director, Planning-I, BWDB, WAPDA Building (6th Fl.), Motijheel Dhaka. The meeting is presided over by the Director, Planning-I, BWDB.

Sl.No.	Name and Designation	Organization	Contact no./email	Signature
1	Koji KAWAMUK[illegible]	JICA Study Team	+880 [illegible]	[signature]
2	Tesuhiro AZUMA	JICA Study Team	a37690@n-koei.co.jp	[signature]
3.	Michio Ota	JICA Expert	monarbo7810@gmail.com	[signature]
4.	NORUL ISLAM	JICA Study Team	a4980@n-koei.co.jp	[signature]
5	Gilberto Canali	JICA STUDY TEAM	gecanali@comcast.net	[signature]
6.	Musa Nurun Rahman, XEN	BWDB	01715740505	[signature] 14.1.13
7	Malik Fida A. Khan	CEGIS	01819261279	[signature]
8.	Mohammad Akbar Hossain (Research officer)	BWDB	01818-614543	[signature]

Annex-3.2.5

Minutes of Discussion on the Draft Final Report

Minutes of the Meeting on Draft Final Report in connection with the Review meeting for **"JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh"** held on 13th November, 2013 in the conference room of JICA Bangladesh office between Bangladesh Water Development Board and JICA Study Team.

A review meeting to discuss the Draft Final Report (the DFR) on "JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh" was held on 13th November, 2013 in the conference room of JICA Bangladesh office at Gulshan, Dhaka. The meeting was presided over by Mr. Zahirul Islam, Chief Planning, BWDB, Dhaka. List of the participants who attended the meeting is attached herewith **(Annexure-1)**.

The Chairman welcomed the participants and requested Mr. Koji Kawamura, Team Leader of the JICA Study Team to present the DFR. The JICA Study Team then made a power point presentation on major essence of the DFR. After the presentation, the Chair thanked the Study Team and opened the floor for discussion. BWDB officials made comments and observations and then the Study Team responded to them.

The Bangladeshi side basically accepted the contents and outcomes of the DFR in the meeting and made some comments as discussed below to improve the Report further.

It was observed by Mr. Zahirul Islam, Chief Planning, BWDB, Dhaka that the submersible embankments used to remain under water for 5 to 6 months in the monsoon season, even after recommended by JICA for 95% compaction. The JICA Study Team replied that many earthen dams and parts of many embankments usually remain under water for a long time, but due to proper compaction there is no problem. The Chair further queried how to obtain the required compaction. The Study Team replied that it would be obtained through the use of roller compactors and bulldozers. The Chief Planning responded that it would be impossible to carry the heavy equipment to sites of poor and in most cases, little communication facilities. The Study Team replied that a competent contractor could arrange that as in the case of some gas pipe construction works currently going on in the haor areas. To the Chair, it was felt unrealistic on the ground of attenuated accessibility to the haors located in remote corners and he doubted whether the Consultant had visited all the interior locations. No satisfactory answer was found from the Consultant's side. He termed 95% compaction as an absurd imagination and opined that it would not be achieved if included in the work schedule leaving it as wastage of budget. He then observed that the wet-dry cycle test used to find out an optimum compaction level might not represent actual field conditions. The JICA Study Team proposed to include trial embankment during the succeeding detail design stage to confirm compaction level. The BWDB side agreed to this proposal, suggested to boost up pilot implementation works and select the haor in middle area of the haor region.

Related to Study Team's recommendation to carry out soil investigation to confirm existence of a super soft layer, the Chief Planning suggested that tests should also be done for a peat layer @ 500 m interval and an investigation cost should be included in the project cost. The Study Team agreed with his proposition.

Mr. Fazlur Rashid, Executive Engineer, Directorate of Planning-1, BWDB, Dhaka mentioned that the last paragraph of Page 9 in the summary of the DFR, it is mentioned that BWDB river cross-sections were not applied to hydraulic analysis due to low reliability of pillar information. He objected this statement and wanted some clarification about this. The JICA Study Team explained

that after plotting the pillar information of the cross-sections, some deviations were found mismatching. As a result, the JICA Study Team used their own first hand river cross-sections data along with some IWM data. The JICA Study Team agreed to share the soft copy of the river cross-sections with BWDB.

He then pointed out that the number of surveyed river cross-sections mentioned in Page 10 of the summary was different from that in Table 4.1.4. The JICA Study Team mentioned that this would be checked and revised in the Final Report.

He further mentioned that the total length of embankment mentioned in Page 13 seemed less than the figure actually would be. The JICA Study Team authenticated the figure and mentioned that this figure surveyed by the Study Team. However, inclusion of this explanation in the Final Report was agreed by the study team.

Mr. Rashid then pointed out that there was difference in flood depth mentioned in Page 4 and that mentioned under "flood mark" in Page 13. The JICA Study Team explained that the value shown in Page 4 is the definition of land classification for the whole area, while the value mentioned in "flood mark" was related to only haor project surveyed in this study. This explanation would be included in the Final Report.

After threadbare discussion, the following decisions were taken:

- All the comments, observations and suggestions would be replicated in the Final Report.
- Necessary explanation of quarries made in the discussions would be incorporated in the Final Report.

As there was no other agenda to discuss, the meeting ended with a vote of thanks from the Chair.

(Zahirul Islam)
Chief Planning
BWDB, Dhaka.

Memo No. BWDB/DP-1/ 1309 Date: 01 12.2013.

Distribution (not as per seniority):

1. Additional Director General (Planning), BWDB, Dhaka.
2. Chief Planning, BWDB, Dhaka.
3. C.S.O. to Director General, BWDB, Dhaka.
4. Koji Kawamura, Team Leader, JICA Survey Team.

(Md. Abdur Rahman Akhanda)
Director
Planning-1
BWDB, Dhaka.

Annexure-1

Title : Meeting on Draft Final Report, JICA Data Collection Survey on Water Resources Management in Haor Areas of Bangladesh

Venue : JICA Bangladesh Office

Date : November 13, 2013

No.		Designation
1	Zahirul Islam	Chief Planning, BWDB
2	A.M. Aminul Haque	SE, JMREMP, BWDB
3	Fazlur Rashid	Executive Engineer, PI-1, BWDB
4	Tanjir Saif Ahmed	Assistant Engineer, PI-1, BWDB
5	Michio Ota	JICA Expert, BWDB
6	Naoki Matsumura	JICA Bangladesh Office
7	Anisuzzaman Chowdhury	SPO, JICA Bangladesh Office
8	Norio Takayanagi	JICA Survey Team / Team Leader
9	Koji Kawamura	JICA Survey Team/ Team Leader
10	Junichi Fukuwatari	JICA Survey Team/ Co Team Leader
11	Tatsuhiko Hiraiwa	JICA Survey Team/ Rural Infrastructure
12	Kazuhiro Yamakawa	JICA Survey Team/ Facility Planning & Design
13	Shinsuke Hino	JICA Survey Team/ Implementation &OM
14	Takashi Shiraki	JICA Survey Team/ Agr. Promotion
15	Hikaru Sugimoto	JICA Survey Team/ O&M Planning
16	Nurul Islam	JICA Survey Team/ Social Consideration
17	Yasuhiro Azuma	JICA Survey Team/ Deputy Team Leader

Annex-4.1

River Cross Section Data from BWDB

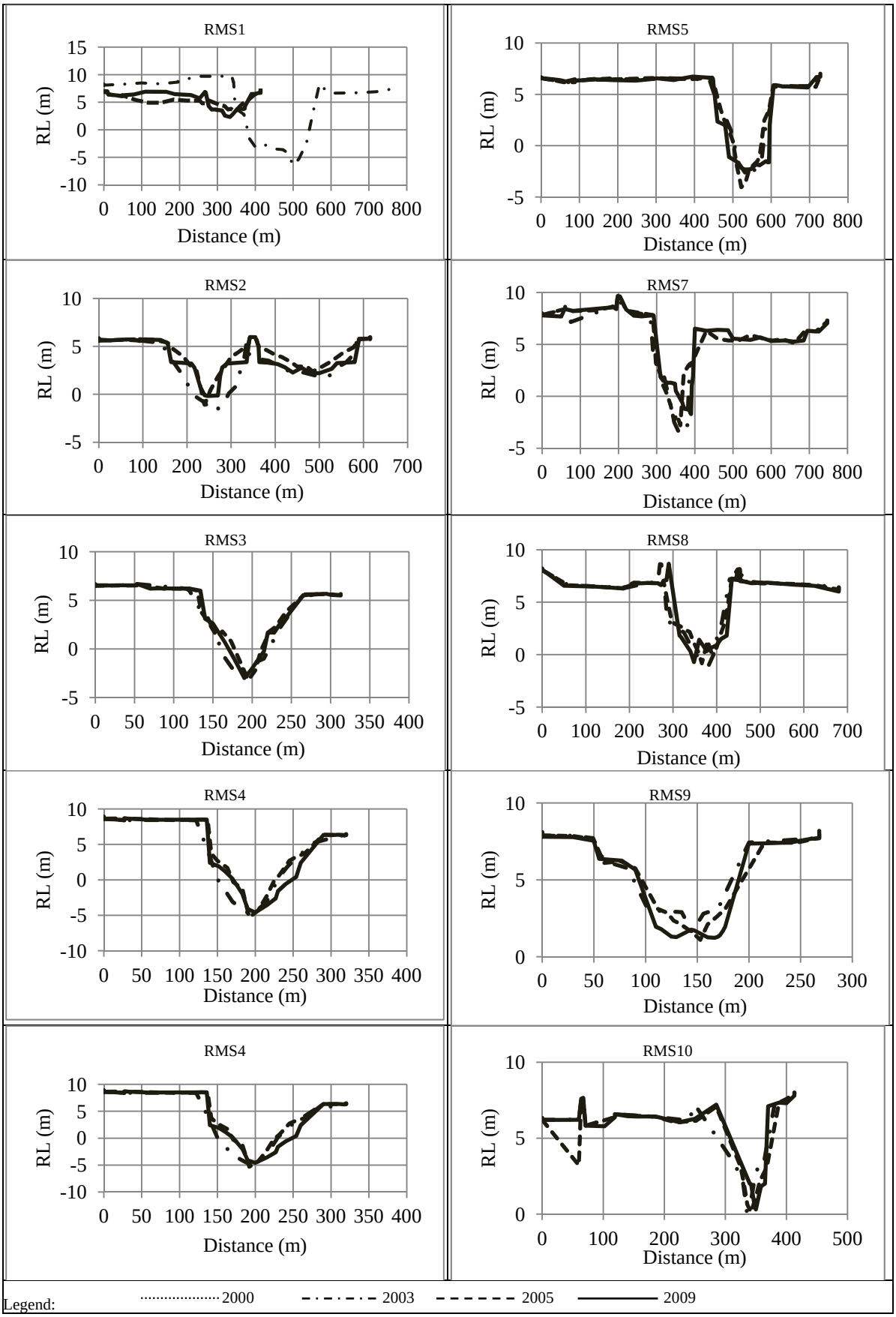


Figure A-1 Histrical River Cross Section of Surma River (1/5)

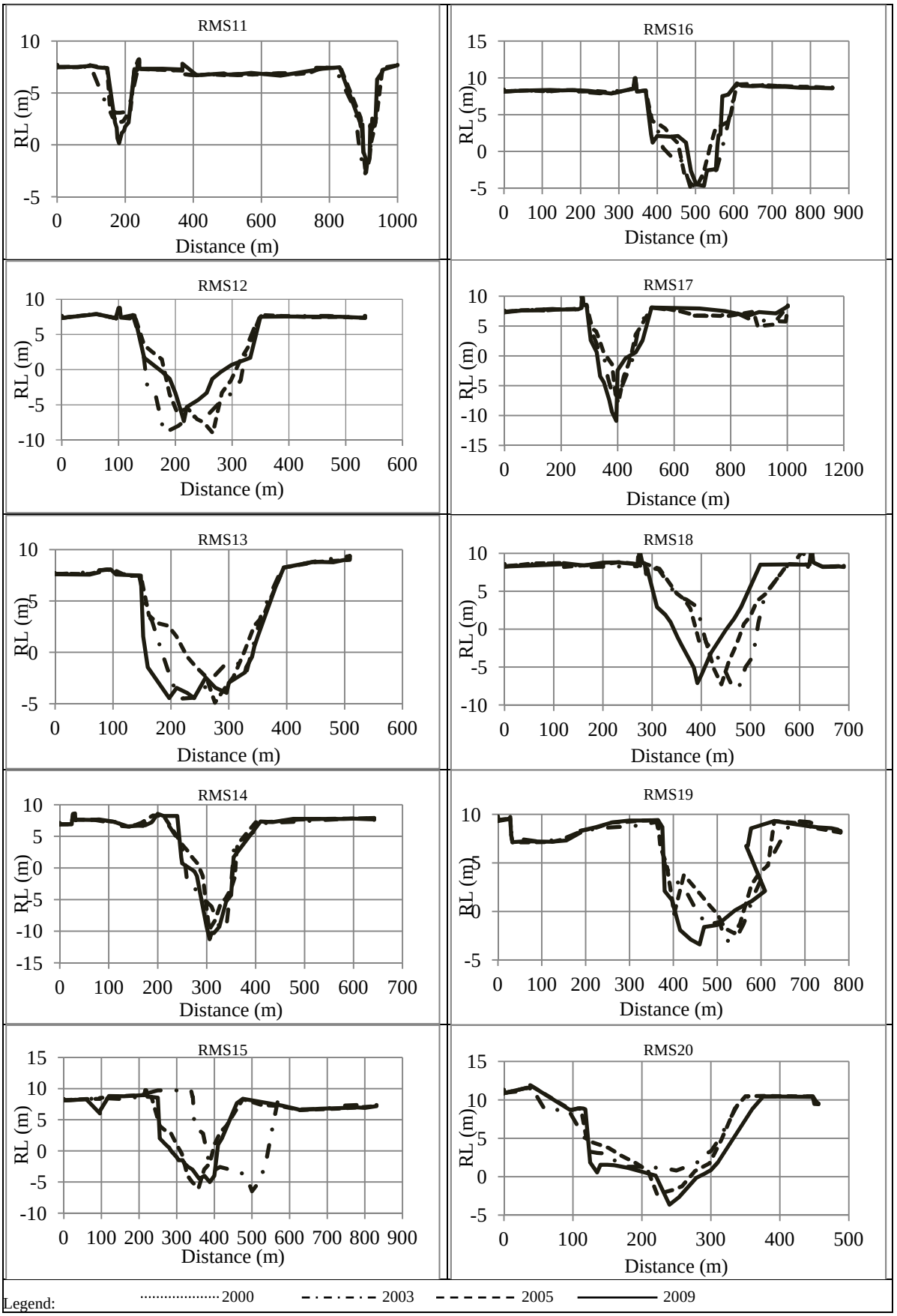


Figure A-1 Histrical River Cross Section of Surma River (2/5)

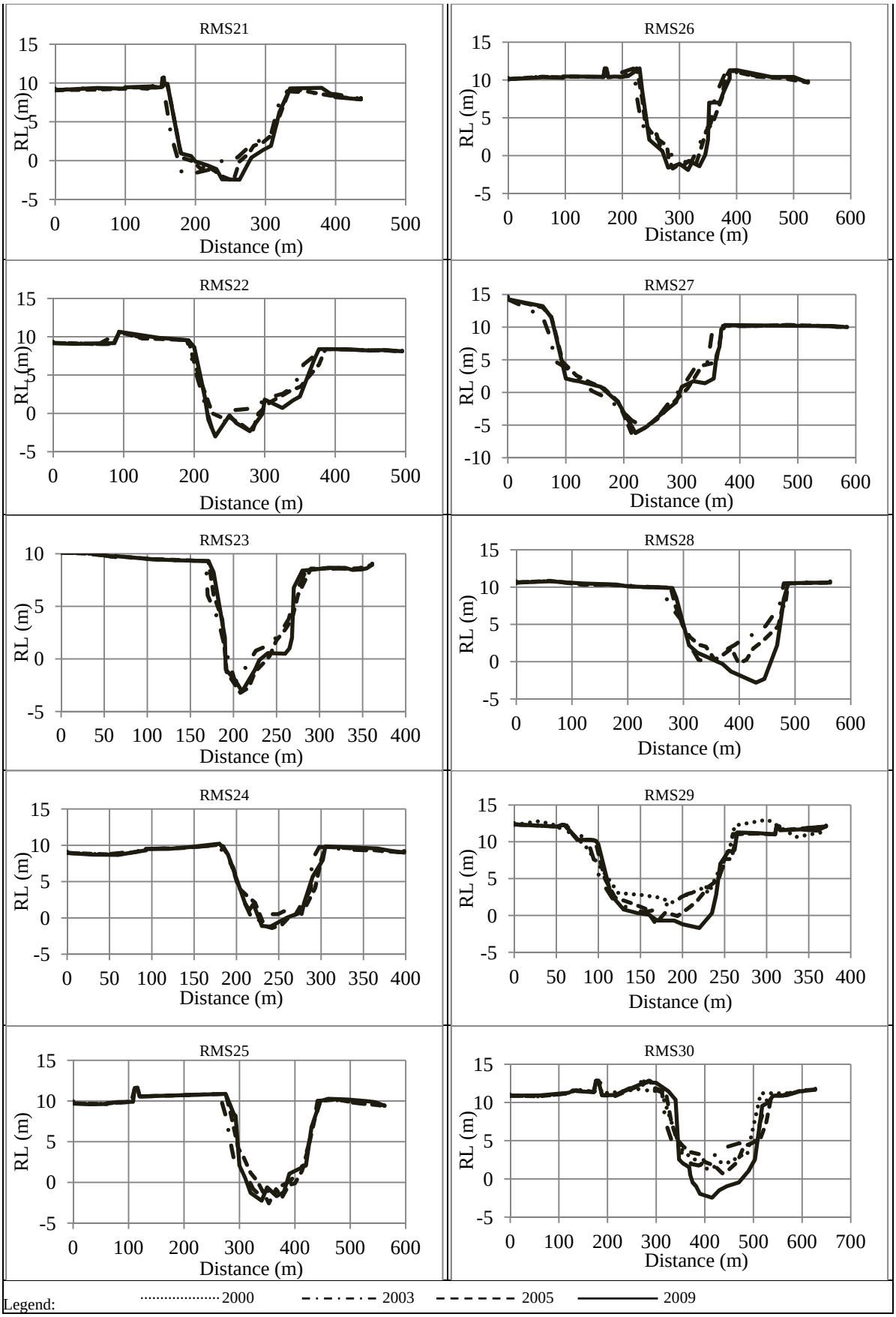


Figure A-1 Histrical River Cross Section of Surma River (3/5)

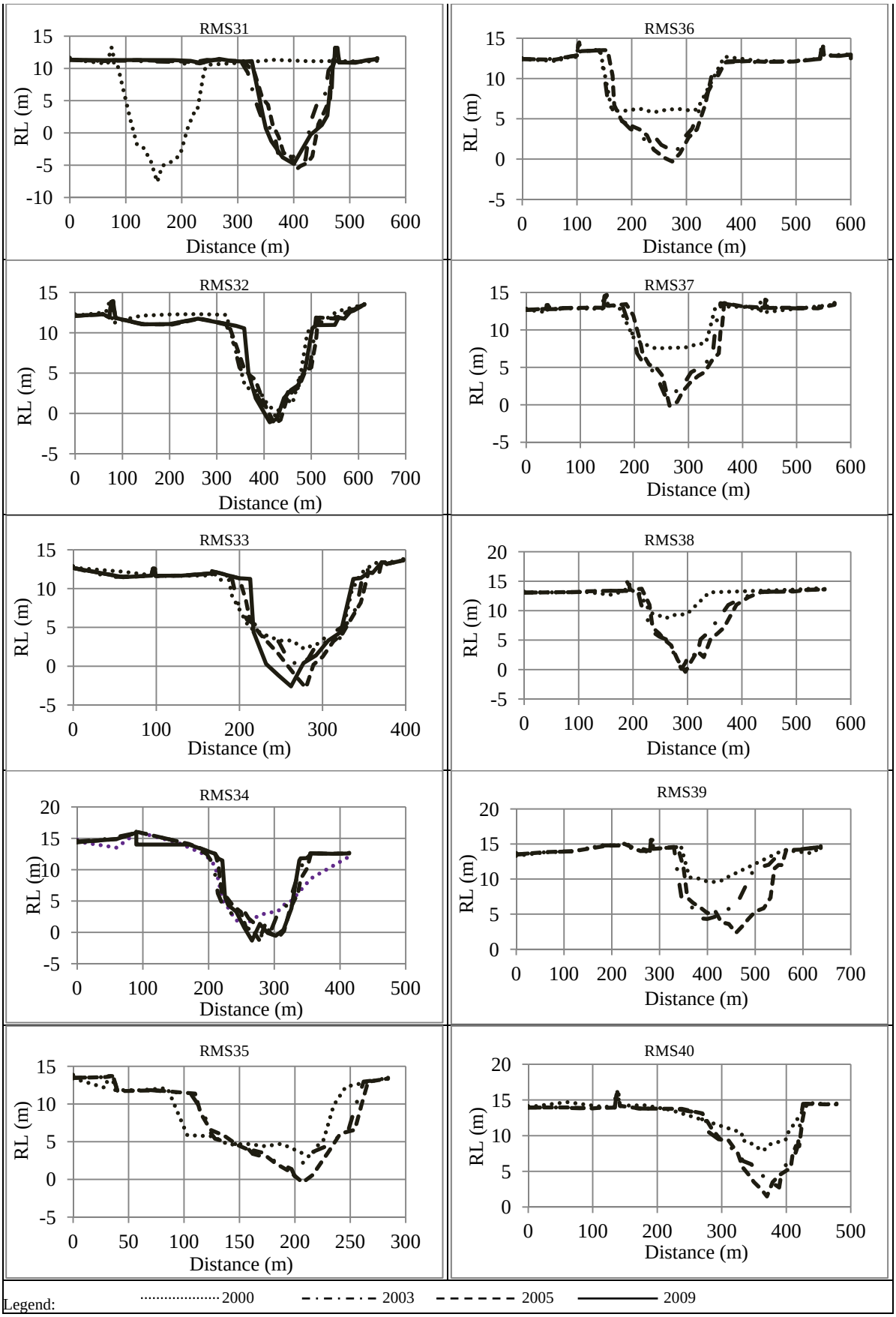


Figure A-1 Histrical River Cross Section of Surma River (4/5)

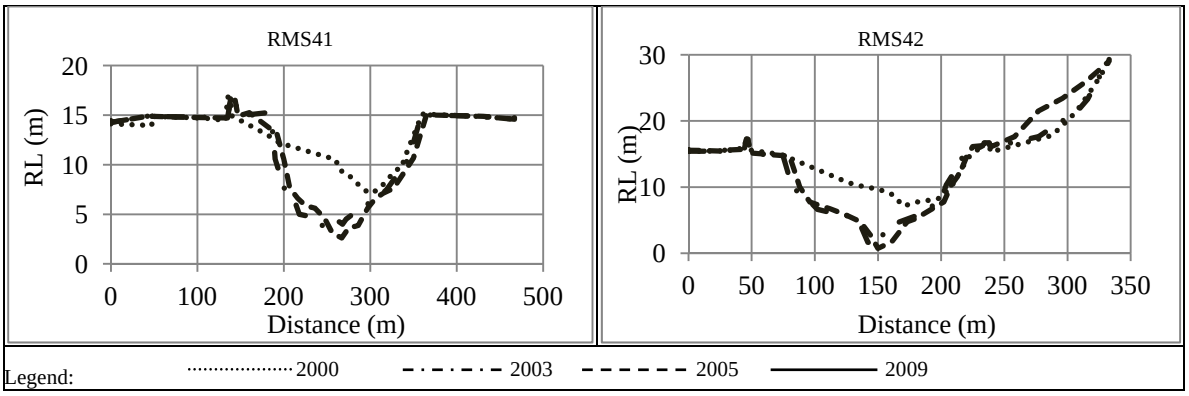


Figure A-1 Histrical River Cross Section of Surma River (5/5)

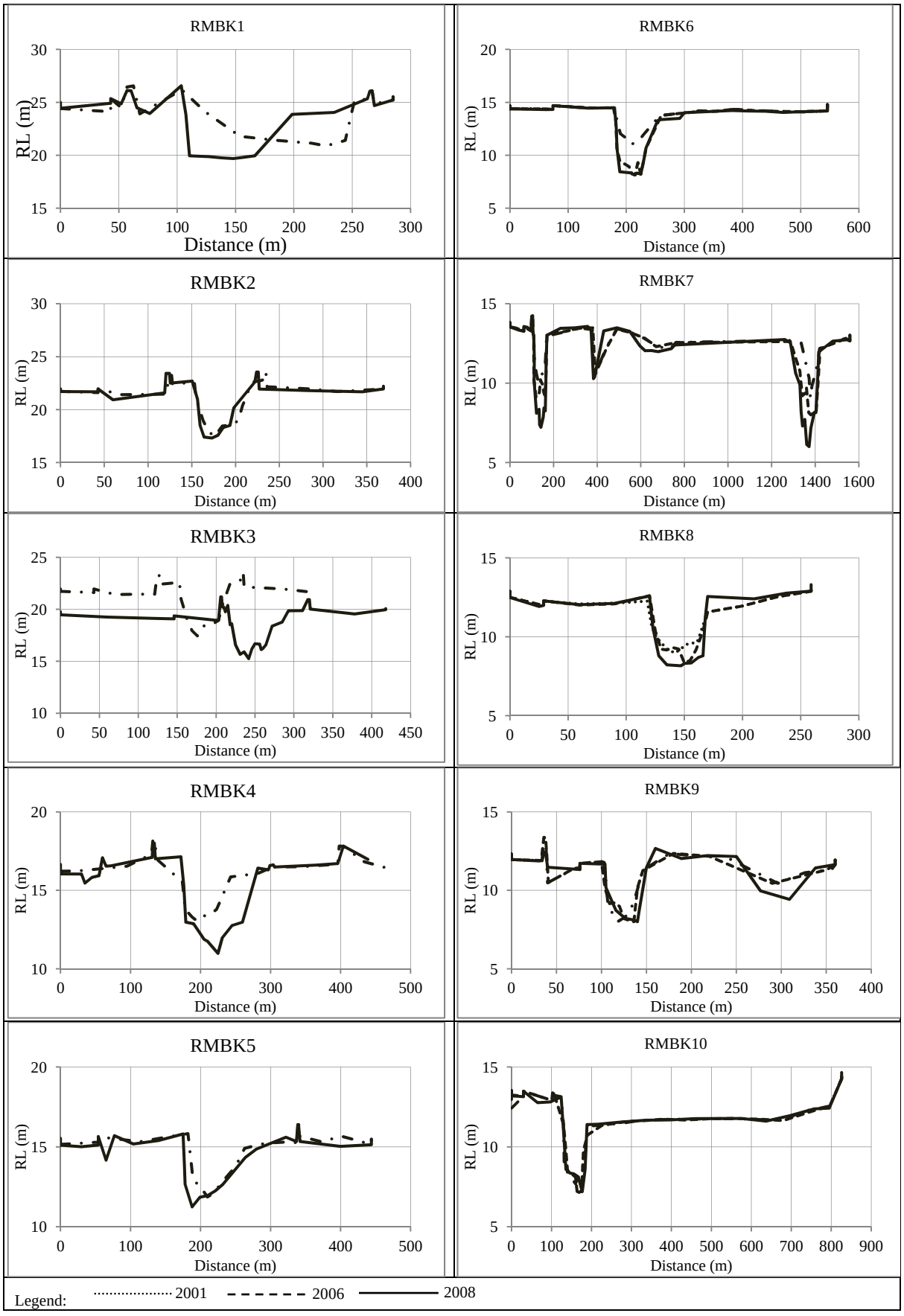


Figure A-3 Histrical River Cross Section of Bogai-Kangsha River (1/3)

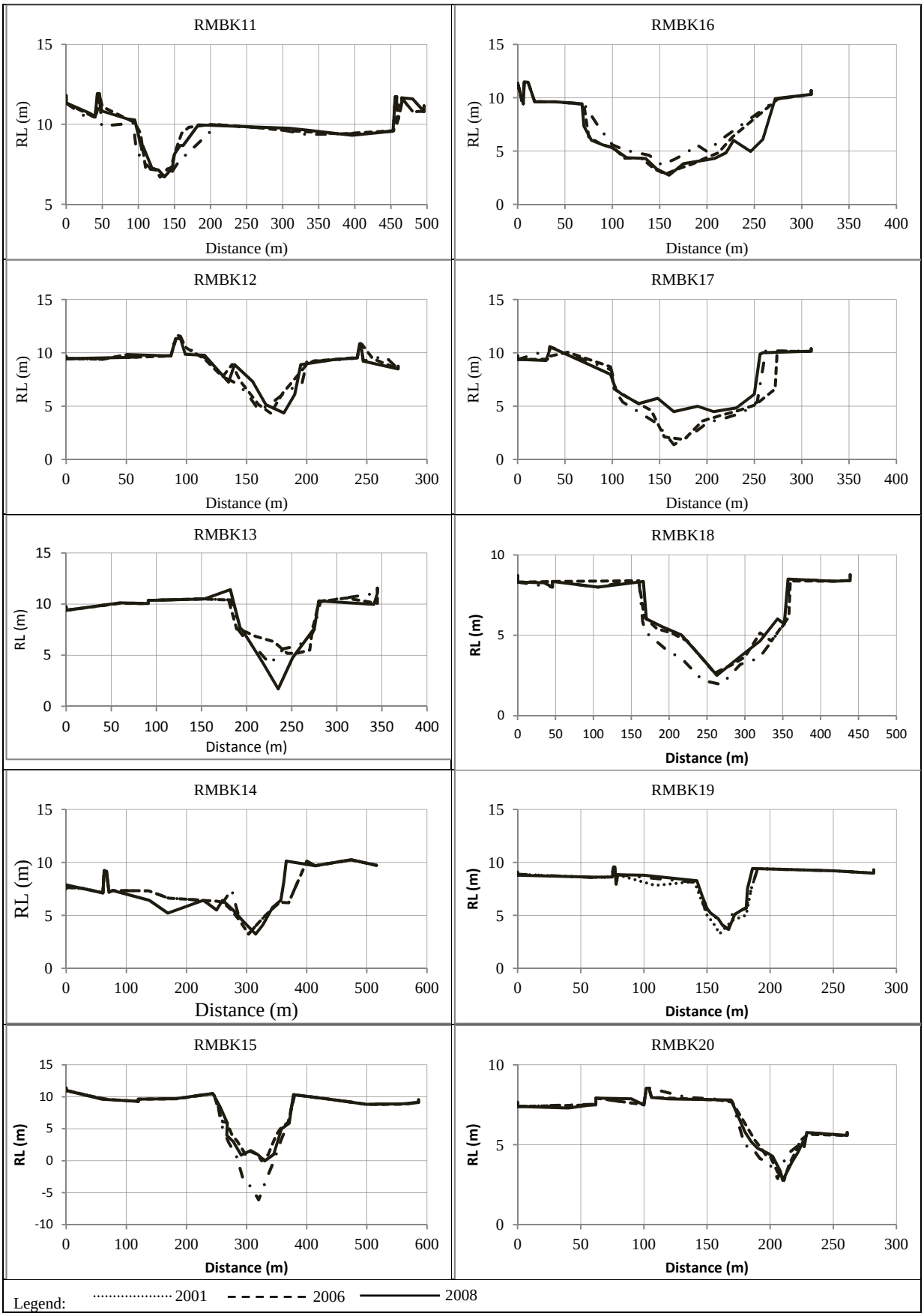


Figure A-3 Histrical River Cross Section of Bogai-Kangsha River (2/3)

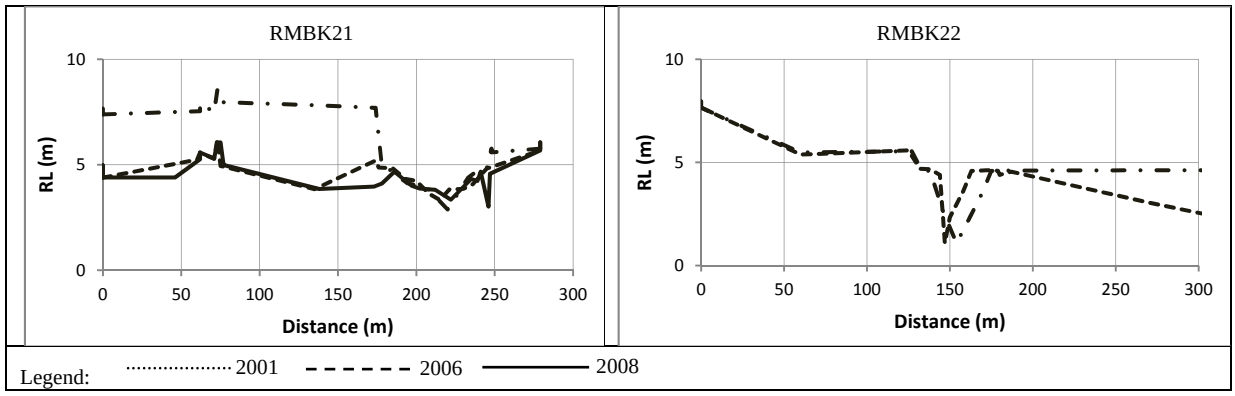


Figure A-3 Histrical River Cross Section of Bogai-Kangsha River (3/3)

Annex-4.2

Analysis of Geotechnical Investigation and Laboratory Test Result

1. Soil Classification according to Drilling Survey and Dutch Cone Test

1.1 Soil Classification by N-Value

Table 1.1 shows simplified Soil Classification by N-Value.

N-values of cohesive soil are classified to 3 categories, N≦4, N=5 to 8 and N>8 from Table 1.2. Cohesive soil of N≦4 is considered to occur problem of settlement and sliding, and of N>8 is almost problem-free layer due to stiff. Cohesive soil of N=5 to 8 is necessary for examination in case of high embankment, but has less problem if embankment height 4m. If N≧20, it is assumed as bearing layer for pile foundation.

N-values of sand are classified to 4 categories, N≦10, N=11~29, N=30~49 and N≧50, as follows from Table 1.3.

N≦10; loose sand layer
N=11~29; necessary for examination in case of high embankment
(less problem if embankment height is less than 4m in Haor)
N=30~49; assumed as bearing layer for pile foundation
N≧50; assumed as bearing layer for pile foundation

Haor area is undelain by problemless sandy ground of N-value 11~29.

Generally soft silt layer exists within GL.-3m, increasing its consistency by depth, and changes to sand layer around GL.-10m. This typical pattern is shown at n-6, n-9, n-13, n-17, n-18, r-7, r-9.

However, n-2 has loose sand and soft clay layer exists within GL.-3m, and layer below GL.-3 show the same pattern mentioned above. The borehole r-1 has medium cohesive layer in GL.-1 to -3m, and soft layer reaches to GL.-6.5m. The borehole r-8 has loose sand layer up to GL.-4m, and increases its consistency and density by depth below. No cohesive layer exists in this borehole.

It is difficult to assume the pattern of soil layers by region, because, for example there is much difference even between adjacent boreholes such as n-6 and n-13, n-9 and r-8.

Table 1.2 Consistency and Cone Resistance for Clay

Consistency	N value	Unconfined strength q_u (Mpa)	Cone resistance q_c (Mpa)
Very soft	0 ~ 2	0 ~ 25	0 ~ 0.4
Soft	2 ~ 4	25 ~ 50	0.4 ~ 0.8
Medium	4 ~ 8	50 ~ 100	0.8 ~ 1.5
Stiff	8 ~ 15	100 ~ 200	1.5 ~ 3.0
Very stiff	15 ~ 30	200 ~ 400	3.0 ~ 6.0
Hard	>30	>400	>6.0

Source: Terzaghie & Peck, Soil mechanics in engineering practice(1996)

Table 1.3 Density Index and Cone Resistance for Sand

Density index	N value	Cone resistance q_c (Mpa)	Internal friction angle φ (deg)
Very loose	0 ~ 4	0.0 ~ 2.5	29 ~ 32
Loose	4 ~ 10	2.5 ~ 5.0	32 ~ 35
Medium dense	10 ~ 30	5.0 ~ 10.0	35 ~ 37
Dense	30 ~ 50	10.0 ~ 20.0	37 ~ 40
Very dense	>50	>20	40 ~ 42

Source: Terzaghie & Peck, Soil mechanics in engineering practice(1996)
EN 1997-2 (2007) (English): Eurocode 7: Geotechnical design - Part 2: Ground investigation and testing, Annex D (informative) Cone and piezocone penetration tests, Table D.I - An example for deriving values of the effective angle of shearing resistance (qf) and drained Young's modulus of elasticity (E') for quartz and feldspar sands from cone penetration resistance (qc)

Table 1.1 Soil Classification by N-value

Depth (m)	n-2 N value	n-6 N value	n-9 N value	n-13 N value	n-17 N value	n-18 N value	r-1 N value	r-7 N value	r-8 N value	r-9 N value
0.0										
0.5										
1.0	9	4	3	4	4	6	6	5	6	3
1.5										
2.0	1	4	4	8	4	4	5	4	6	4
2.5										
3.0	12	7	5	6	5	9	4	5	7	6
3.5										
4.0	8	6	6	7	8	11	3	15	11	7
4.5										
5.0	12	6	7	5	6	25	3	18	13	10
5.5										
6.0	14	7	8	30	8	19	4	5	18	20
6.5										
7.0	31	8	10	16	9	24	14	6	21	22
7.5										
8.0	18	10	11	17	10	12	16	8	22	23
8.5										
9.0	20	13	15	19	11	29	19	18	24	33
9.5										
10.0	48	12	20	18	12	35	16	21	26	38
10.5										
11.0	43	14	21	22	15	35	18	23	29	44
11.5										
12.0	41	18	24	25	18	52	25	26	30	48
12.5										
13.0	80	19	26	28	28	61	8	28	33	51
13.5										
14.0	66	22	29	31	30	43	30	34	34	55
14.5										
15.0	43	44	31	33	32	75	32	38	35	57
15.5										
16.0	40	45	33	37	33	60	30	57	38	62
16.5										
17.0	40	46	35	39	36	71	30	59	37	65
17.5										
18.0	40	46	37	43	22	85	32	61	37	69
18.5										
19.0	66	47	40	47	27	83	35	64	39	87
19.5										
20.0	46	49	41	49	31	83	37	68	40	89
20.5										
21.0	26	42	44	55	41	82	42	69	41	88
21.5										
22.0	28	44	45	57	44	90	46	67	43	83
22.5										
23.0	27	45	47	55	49	77	46	69	45	85
23.5										
24.0	30	47	50	47	52	79	49	72	49	86
24.5										
25.0	18	47	51	53	56	33	46	76	52	89
25.5										
26.0	21	49	55	59	63	18	48	81	55	90
26.5										
27.0	9	50	58	64	87	12	47	86	57	91
27.5										
28.0	12	52	62	66	89	11	49	88	60	92
28.5										
29.0	9	55	64	69	93	9	51	89	66	92
29.5										
30.0	11	60	70	64	95	18	56	91	36	93

Remark

Clay		N=<4	Silt		N=<4	Sand		N<=10
		N>8			N=5~8			N=11~29
					N>8			N=30~49
								N>=50

Soft Grand bottom

Bearing stratum top

Source: JICA Study Team

1.2 Soil Classification by DCT (Cone Penetration Resistance)

Table 1.4 shows soil formation in each area.

Figure 1.1 shows the vertical distribution of N-value and qc (cone resistance by DCT) in the same project area. The definition of soft ground and bearing stratum in is shown in the following table.

Table 1.5 Soft ground and bearing stratum

	Soft ground	Bearing stratum
Clay layer	N=<4 q_c=<0.8Mpa	N>=20 q_c>=4Mpa
Sand layer	N=<10 q_c=<5Mpa	N>=30 q_c>=10Mpa

Source: JICA Study Team

* Division depends on those in Table 1.2/1.3
* N-value of bearing stratum is common required value for pile foundation

Table 1.4 Distribution of Soil Type by N-value and Cone Resistance

Depth (m)	n-2				Depth (m)	n-6				Depth (m)	n-9				Depth (m)	n-13				Depth (m)	n-17				Depth (m)	n-18			
	N value	DCT-1	DCT-2	DCT-3		N value	DCT-1	DCT-2	DCT-3		N value	DCT-1	DCT-2	DCT-3		N value	DCT-1	DCT-2	DCT-3		N value	DCT-1	DCT-2	DCT-3		N value	DCT-1	DCT-2	DCT-3
0.0		0.6	0.8	0.8	0.0		0.1	1.6	1.6	0.0		2.5	2.5	2.5	0.0		0.8	0.0	0.4	0.0		1.8	2.3	0.7	0.0		0.7	0.8	
0.5		0.6	0.8	0.8	0.5		0.2	2	1.3	0.5		2.5	2.5	2.5	0.5		1.5	0.1	1	0.5		1.8	1.7	0.2	0.5		0.7	0.8	
1.0	9	0.6	1	1.5	1.0	4	0.3	3.5	2.3	1.0	3	2.5	1.5	2	1.0	4	1.1	0.3	1	1.0	4	1.8	1.2	0.4	1.0	6	0.8	0.8	
1.5		0.6	1	1.5	1.5		0.2	5	2.3	1.5		2.5	1.5	1.5	1.5		1.1	0.4	1	1.5		1.4	1.2	0.5	1.5		3	1	
2.0	1	0.6	1	1.5	2.0	4	0.4	1.5	2.1	2.0	4	3	3	0.8	2.0	8	1	0.6	1	2.0	4	1.4	1.2	0.5	2.0	4	2.5	2.5	
2.5		0.6	2.5	1.5	2.5		0.4	6	3	2.5		2.5	2	2.5	2.5		1	0.7	1	2.5		1.4	0.9	0.5	2.5		3.5	3	
3.0	12	0.6	1	1.5	3.0	7	1.5	8	3	3.0	5	4	3.5	3.5	3.0	6	1	0.9	0.5	3.0	5	1.4	3.5	0.8	3.0	9	4.5	4	0.8
3.5		1.5	1	1.5	3.5		1.1	8	4	3.5		4.5	2	4.5	3.5		0.6	1.0	0.5	3.5		1.7	4.4	0.8	3.5		1.3	4	0.8
4.0	8	1.5	2.5	4	4.0	6	1.4	8	4	4.0	6	3	3	3.5	4.0	7	0.6	1.1	0.8	4.0	8	1.7	2.3	0.4	4.0	11	0.5	2.5	0.8
4.5		1	1	4	4.5		1.4	8	4	4.5		4.5	4	3.5	4.5		5	1.3	1	4.5		1.1	2.8	0.4	4.5		1	3	6
5.0	12	0.5	0.5	4	5.0	6	1.8	8	8	5.0	7	4	4	4	5.0	5	6	1.4	0.7	5.0	6	1.6	3	2.3	5.0	25	0.5	5	6
5.5		0.8	0.5	4	5.5		1.6	12	8	5.5		6	4.5	2.5	5.5		5	1.6	0.8	5.5		1.2	3	1.7	5.5		0.5	2.5	5.5
6.0	14	0.8	0.5	4	6.0	7	1	12	8	6.0	8	7	5	5	6.0	30	4.5	1.7	1	6.0	8	0.58	3	1.2	6.0	19	0.5	0.5	6.5
6.5		1	0.5	6	6.5		1.8	12	8	6.5		6.5	6	2.5	6.5		5	6	1	6.5		0.55	3.4	1.2	6.5		0.5	1	0.8
7.0	31	1	0.8	6	7.0	8	1.6		8	7.0	10	6	5	3	7.0	16	5	8	1	7.0	9	0.5	3	1.2	7.0	24	1	1	0.5
7.5		1	0.8	7	7.5		2.7		8	7.5		6.5	10	4.5	7.5		5	8	1	7.5		0.5	4	2.5	7.5		0.5	0.5	0.5
8.0	18	1	0.8	6	8.0	10	2		6	8.0	11	6	8	4	8.0	17	7	8	1.7	8.0	10	0.9	4	2.5	8.0	12	0.5	5	0.9
8.5		1	2	4	8.5		6.5		4	8.5		5	6.5	5	8.5		5	8	1.1	8.5		0.9	4	2.5	8.5		1	1	0.9
9.0	20	1	2	0.5	9.0	13	6.5		6	9.0	15	3.5	5	4	9.0	19	5		1.5	9.0	11	2.5	2.6	5	9.0	29	0.8	0.5	3
9.5		1	4	1	9.5		6.5		9	9.5		4	7	5.5	9.5		4		3	9.5			2.6	5	9.5		1.5	0.5	3.5
10.0	48	1	8	0.8	10.0	12	6.5			10.0	20	4.5	5	9	10.0	18	4.5		5	10.0	12		2.6	5	10.0	35	1	0.5	8
10.5		1	6	1.5	10.5		6.5			10.5		5	5	6.5	10.5		2		7	10.5			2.6	3.3	10.5		1	0.5	2
11.0	43	6	4	1.5	11.0	14	6.5			11.0	21	4	6.5	6.5	11.0	22	4		7	11.0	15			3.3	11.0	35	1	0.5	4
11.5		10	7	1.5	11.5		6.5			11.5		6	6.5	6	11.5		2		10	11.5				5.4	11.5		1	6	10.5
12.0	41	12	8	4	12.0	18				12.0	24	10	6	8	12.0	25				12.0	18				12.0	52	1	5	12
12.5		12	4	2	12.5					12.5		7.5	6	6.5	12.5					12.5					12.5		14	5	13
13.0	80	14	4	2	13.0	19				13.0	26	7.5	6	7	13.0	28				13.0	28				13.0	61	15	6	12
13.5		14	5	3	13.5					13.5		9	6.5	6.5	13.5					13.5					13.5		13	6.5	12
14.0	66	14	5	3	14.0	22				14.0	29	9.5	8	6.5	14.0	31				14.0	30				14.0	43	10	5	12
14.5		14	4	5	14.5					14.5		9	16	7	14.5					14.5					14.5		12	6	10
15.0	43	14	4	4	15.0	44				15.0	31	10	16	6	15.0	33				15.0	32				15.0	75	8	9	7
15.5		14	4	3	15.5					15.5		6.5	10	6.5	15.5					15.5					15.5		14	6	5
16.0	40	14	4	5	16.0	45				16.0	33	8	7	7	16.0	37				16.0	33				16.0	60	9	7	8
16.5		14	4	12	16.5					16.5		14	7	10	16.5					16.5					16.5		12	7	12
17.0	40	14	4	20	17.0	46				17.0	35	8	8.5	14	17.0	39				17.0	36				17.0	71	16	7	13
17.5		14	4	21	17.5					17.5		12	11	8	17.5					17.5					17.5		16	5	12
18.0	40	10	4	19	18.0	46				18.0	37	9	8	8	18.0	43				18.0	22				18.0	85	13	3.5	8
18.5		10	5	18	18.5					18.5		8	5	6.5	18.5					18.5					18.5		12	4	11
19.0	66	10	6	16	19.0	47				19.0	40	20	6.5	6.5	19.0	47				19.0	27				19.0	83	16	4	12
19.5		10	4	18	19.5					19.5		20	7	7	19.5					19.5					19.5		22	4	13
20.0	46	10	4	15	20.0	49				20.0	41	14	8.5	7	20.0	49				20.0	31				20.0	83	20	4	9
20.5		10	4	18	20.5					20.5		12	8	8	20.5					20.5					20.5		18	3	10
21.0	26	16	5	18	21.0	42				21.0	44	6.5	15	8	21.0	55				21.0	41				21.0	82	16	3	18
21.5		16	6	14	21.5					21.5		13			21.5					21.5					21.5		15	4	17
22.0	28	16	6	18	22.0	44				22.0	45				22.0	57				22.0	44				22.0	90	19	4	15
22.5		16	16	14	22.5					22.5					22.5					22.5					22.5		20		15
23.0	27	16	16	11	23.0	45				23.0	47				23.0	55				23.0	49				23.0	77	20		7.5
23.5		16	16	14	23.5					23.5					23.5					23.5					23.5				8
24.0	30	16	16	18	24.0	47				24.0	50				24.0	47				24.0	52				24.0	79			8
24.5		20	16	18	24.5					24.5					24.5					24.5					24.5				6
25.0	18	20	16	16	25.0	47				25.0	51				25.0	53				25.0	56				25.0	33			
25.5		20			25.5					25.5					25.5					25.5					25.5				
26.0	21	20			26.0	49				26.0	55				26.0	59				26.0	63				26.0	18			
26.5					26.5					26.5					26.5					26.5					26.5				
27.0	9				27.0	50				27.0	58				27.0	64				27.0	87				27.0	12			
27.5					27.5					27.5					27.5					27.5					27.5				
28.0	12				28.0	52				28.0	62				28.0	66				28.0	89				28.0	11			
28.5					28.5					28.5					28.5					28.5					28.5				
29.0	9				29.0	55				29.0	64				29.0	69				29.0	93				29.0	9			
29.5					29.5					29.5					29.5					29.5					29.5				
30.0	11				30.0	60				30.0	70				30.0	64				30.0	95				30.0	18			

Remark

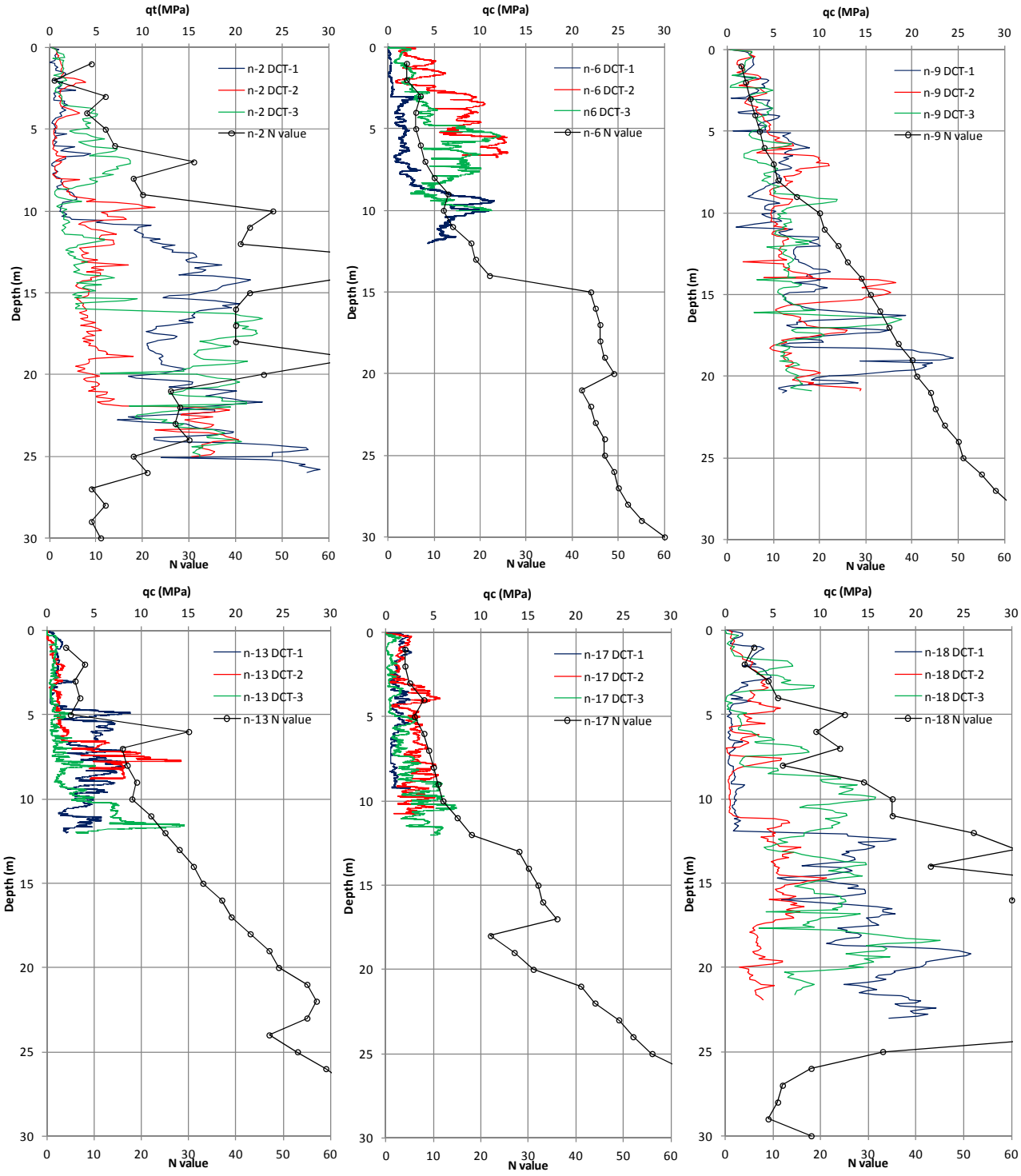
Silt		N=<4	qc<=0.8Mpa
		N=5~8	qc=0.8~3Mpa
		N>8	qc>3Mpa
Clay		N=<4	qc<=0.8Mpa
		N>8	qc>3Mpa

Sand		N<=10
		N=11~29
		N=30~49
		N>=50

qc<5Mpa
qc=5~10Mpa
qc=10~20Mpa
qc>20Mpa

Soft grand bottom
Bearing stratum top

Source: JICA Study Team



Source: JICA Study Team

Figure 1.1 Depth distribution of N-value and cone penetration resitance

2. Soil Properties

2.1 Distribution in depth direction

Figure 2.1 shows vertical distribution of drilling investigation results (N-value, cone penetration resistance and coefficient of permeability) and laboratory test results.

N-value in soft ground, intermediate layer and bearing layer, shows two patterns as step-like increasing/decreasing or linear increasing. Soft layer of less than 0.8Mpa in qc (cone resistance) is found within 10m deep, mostly less than 3m deep.

Data for wet density, dry density and void ratio are limited within depth of 5m. Wet density varies widely from 1.6 to 2.0g/cm3, dry density varies widely from 1.1 to 1.7g/cm3 as well.

Void ratio is divided into two categories such as around 0.8 and 1.2~1.4, which can be one of a parameter for an assessment of soil texture. Moisture content also varies widely as 22 to 42%.

Grain size within 5m depth consists mostly of fine fraction (<0.075mm), and that in deeper than 10m consists of much sand fraction. Cohesive soil including around 30% of sand content exists in depth from 5 to 10m, as an intermediate silt layer.

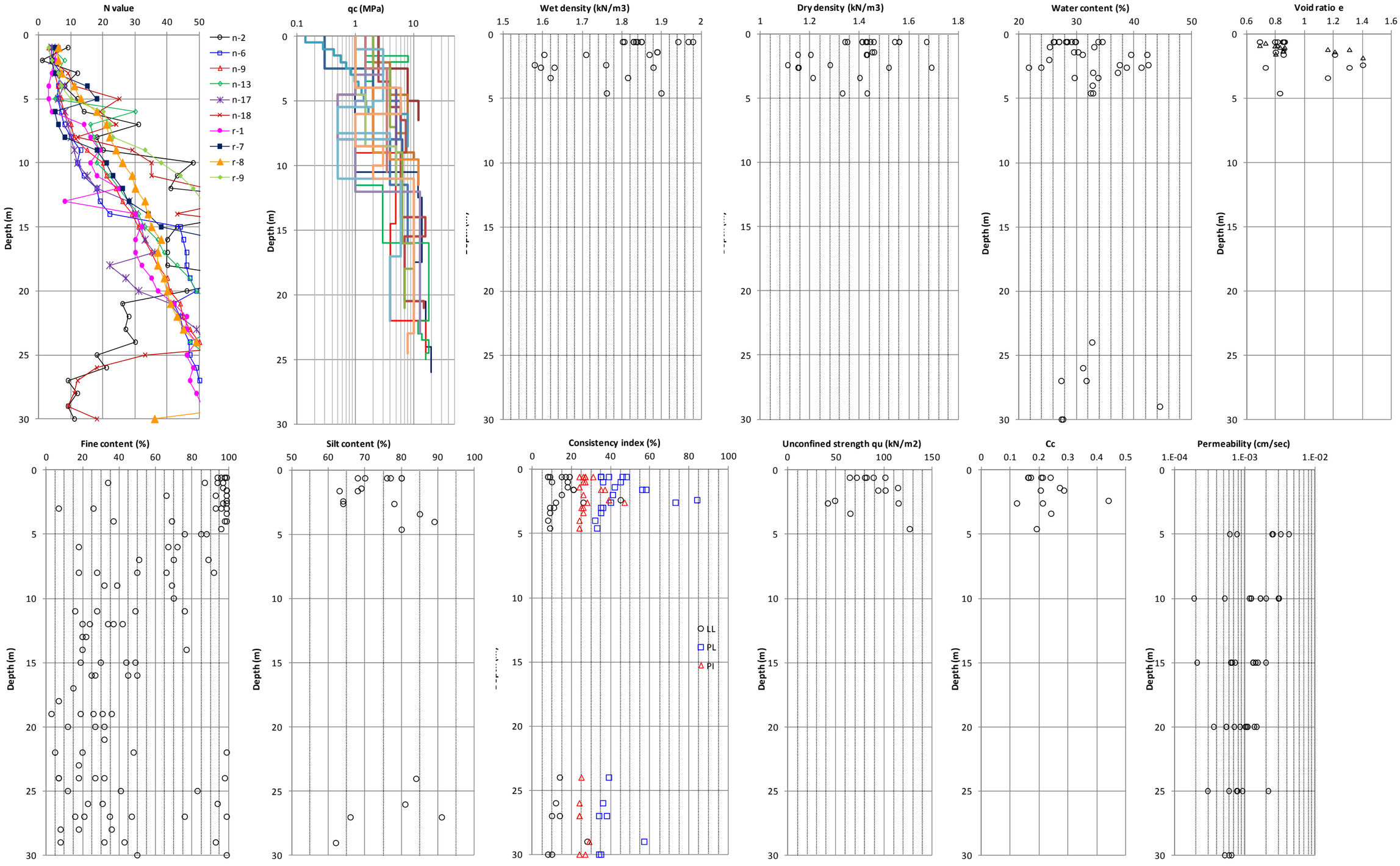
Representative physical values of silt layer within 5m depth are said as dry density 1.4g/cm3, water content of 30%, wet density of 1.8g/cm3 and void ratio of 0.85 for central value. This silt layer contains 65 to 90 % of silt fraction (0.075 to 0.002mm), and less clay fraction (under 2μ).

Liquid limit (w_L) and plastic limit (w_P) have a tendency to decrease by depth, and plastic index (PI) as those deference shows around 25% constantly. Soil class of large liquid limit is cohesive soil containing organic matter. Cohesive soil deeper than 24m shows same value as depth of 4 to 5m.

Unconfined compressive strength qu varies widely as 40~130kN/m2 and no tendency by depth is identified.

Compression index Cc varies widely as 0.12~0.3, central value (0.2) can be defined as a representative. This value is considered to be smaller than usual cohesive soil, and consolidation settlement is also considered to be smaller. Only one large value of Cc is seen for cohesive soil including organic matter.

Coefficient of permeability shows order from 10^{-4} to 10^{-3}cm/sec, and a slight tendency to decrease by depth is identified. Smaller coefficient of permeability is seen in silt fraction, and larger is seen in sand fraction.



Source: JICA Study Team

Figure 2.1 Soil Propeties in Depth Distribution

2.2 Physical Characteristics

(1) Grain size distribution

Figure 2.3 shows the gradation curve.

Grain size distribution is classified into two categories such as cohesive soil and sand.

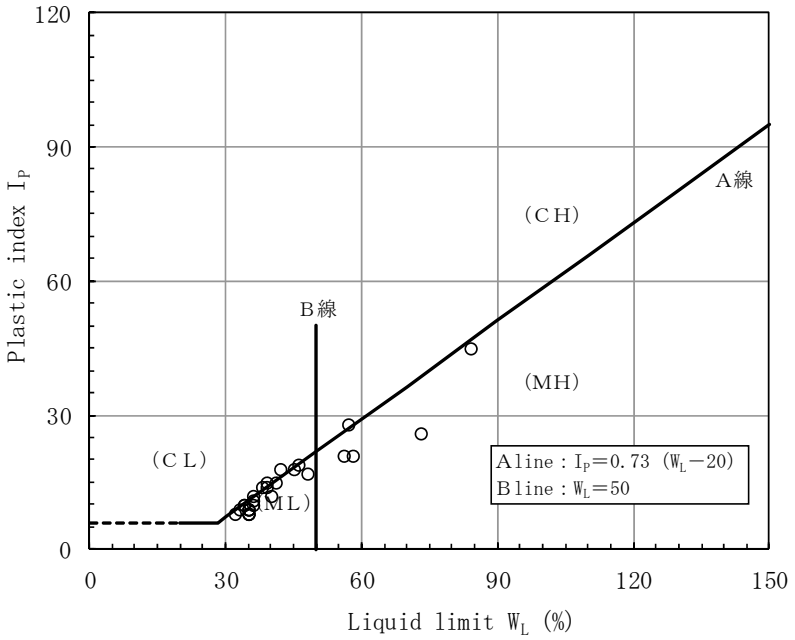
Though grain size of cohesive soil consists of fine fraction of more than 90%, the fine fraction predominantly consists of silt fraction of 0.075~0.002mm, and less clay fraction (under 2μ) of 10~40%.

Maximum grain size of sand is 2mm, however, size under 0.4mm is predominant.

Note) Above grain size classification is based on British Standard.

(2) Plasticity chart

Figure 2.4 shows plasticity chart. Soil contains mainly ML (silt with low liquid limit), partly MH (silt with high liquid limit).



Source: JICA Study Team（Plastic Chart is based on British Standard）

Figure 2.2 Plasticity chart

(3) Correlation in soil parameter

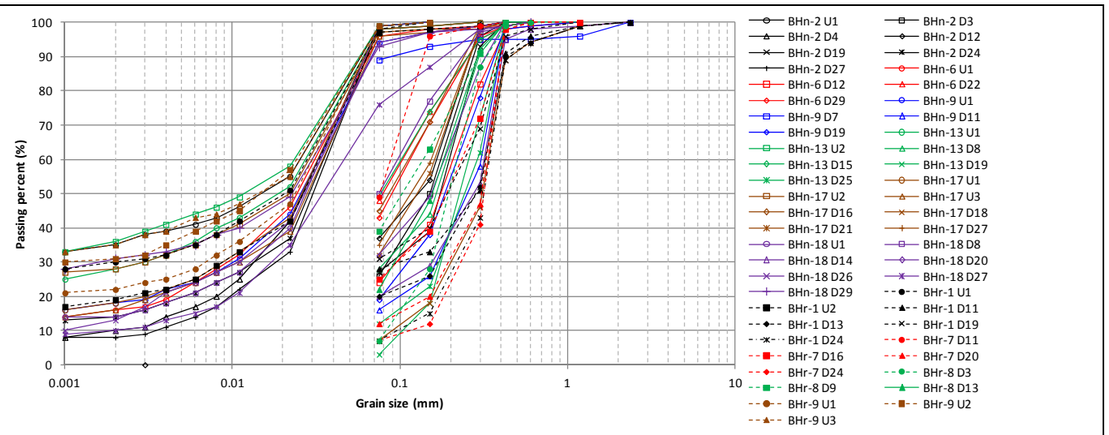
Figure 2.4 shows correlation chart in soil parameter.

Wet density has best correlation with void ratio, and next with water content. Unconfined compressive strength is identified correlation with void ratio.

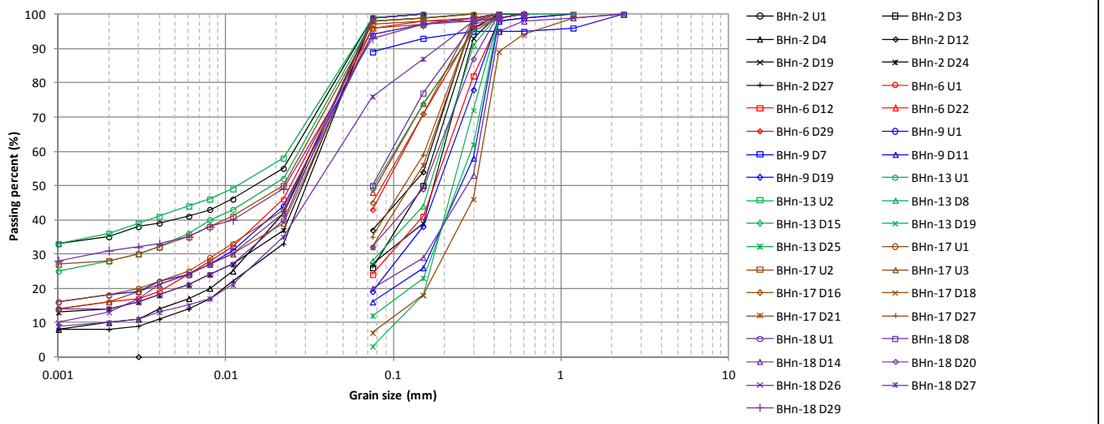
Skempton showed that compression index has correlation with liquid limit by the following formula.

$$Cc=0.009(w_L-10) \qquad \text{(Eq.1)}$$

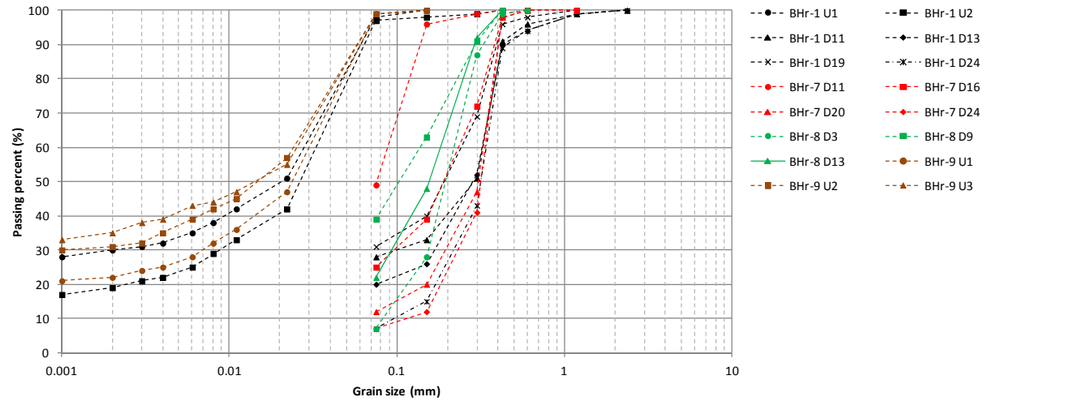
However, compression index has little correlation with liquid limit but void ratio well.



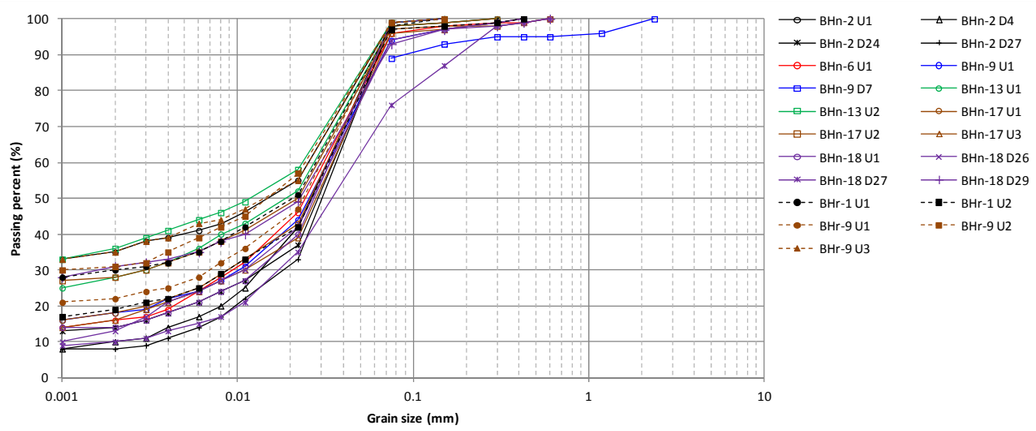
(a) All data



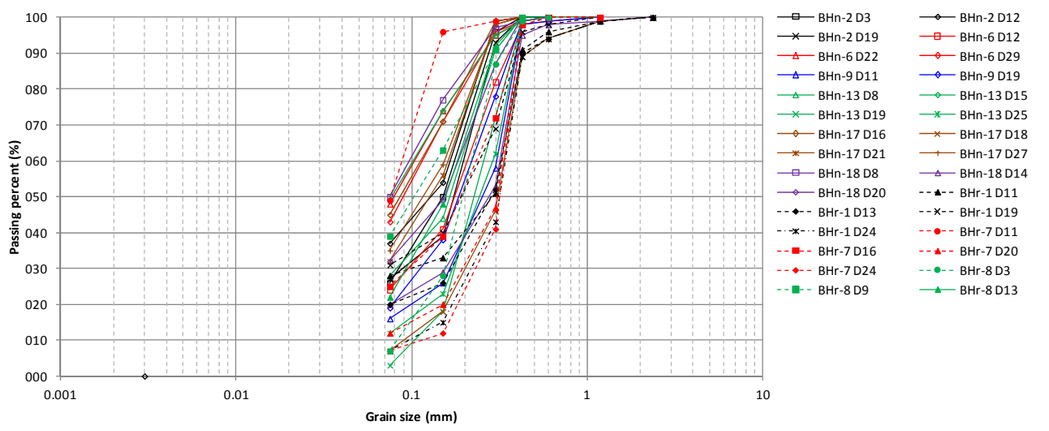
(b) New construction



(c) Rehabilitation



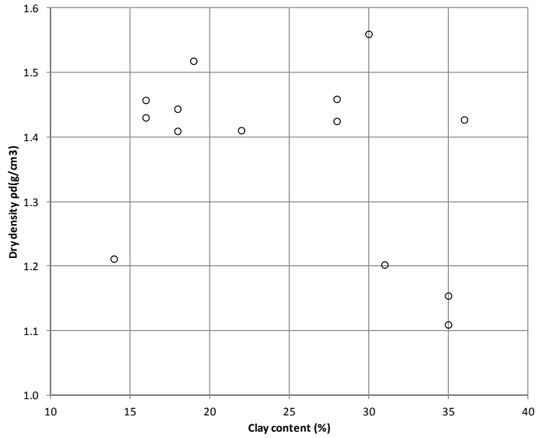
(d) Clay



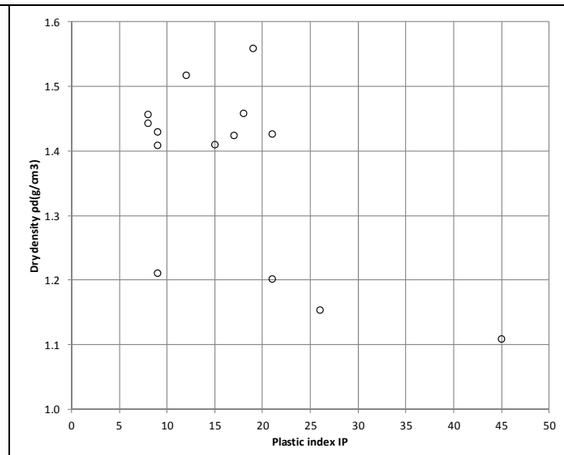
(e) Sand

Source: JICA Study Team

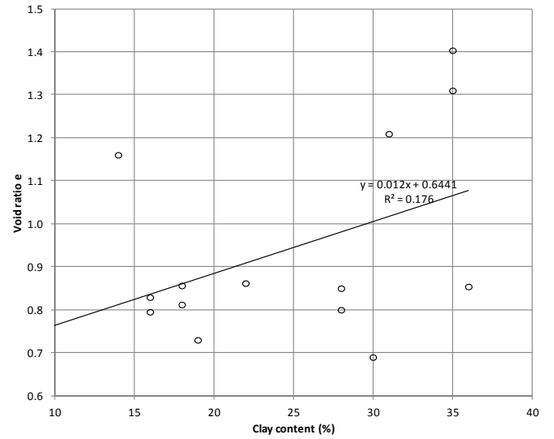
Figure 2.3 Grain size distribution



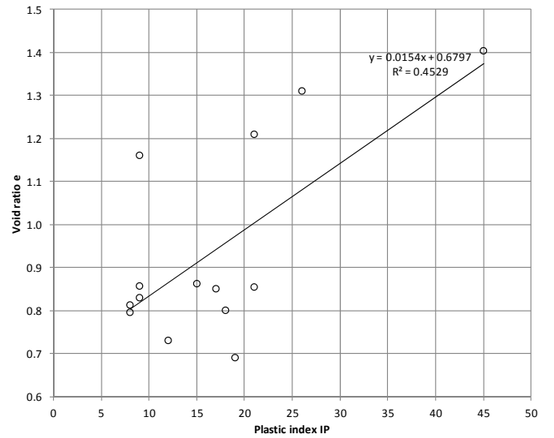
(1) Clay content and Dry density



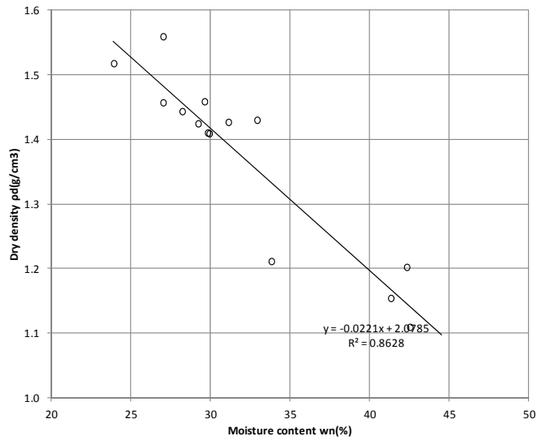
(2) Plastic index and Dry density



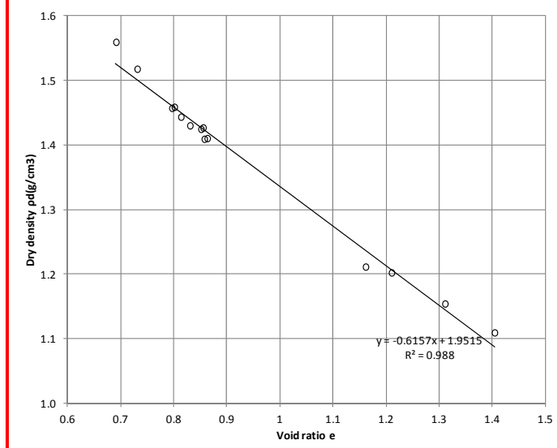
(3) Clay content and Void ratio



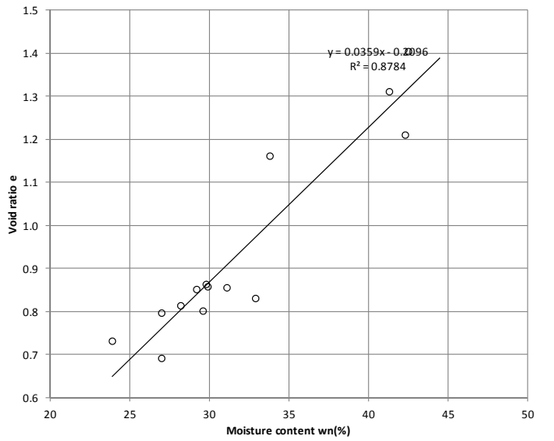
(4) Plastic index and Void ratio



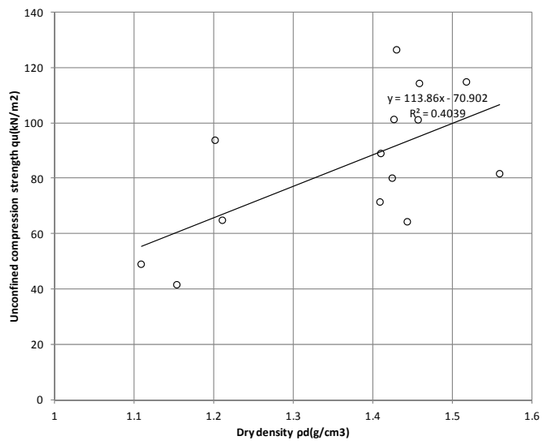
(5) Moisture content and Dry density



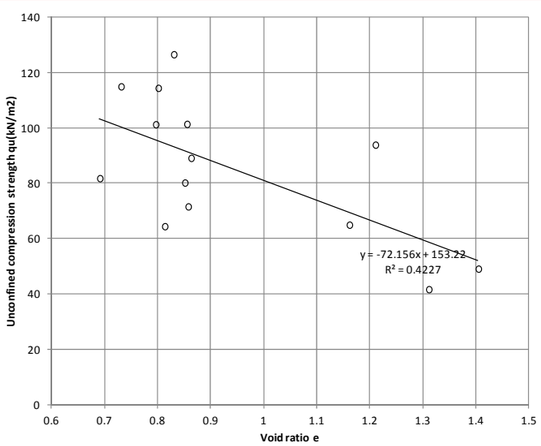
(6) Void ratio and Dry density



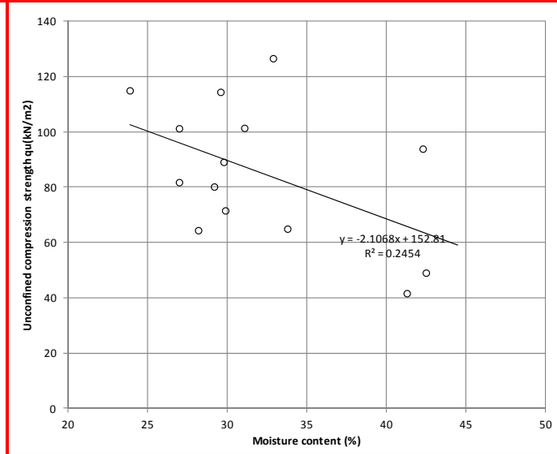
(7) Moisture content and Void ratio



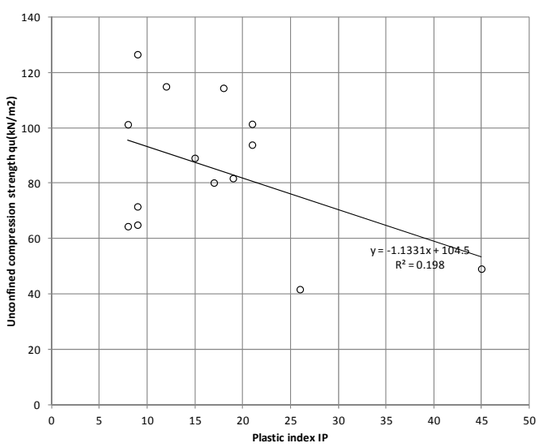
(8) Dry density and Unconfined compression strength



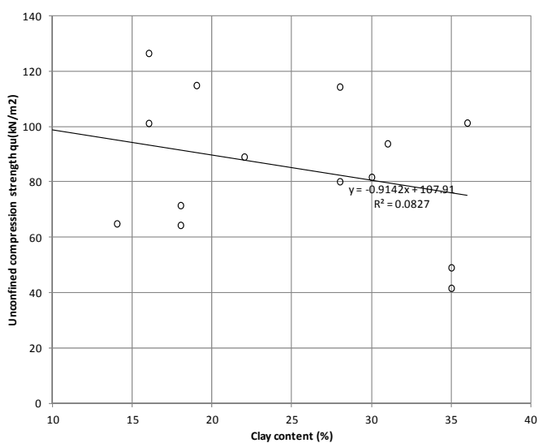
(9) Void ratio and Unconfined compression strength



(10) Moisture content and Unconfined compression strength



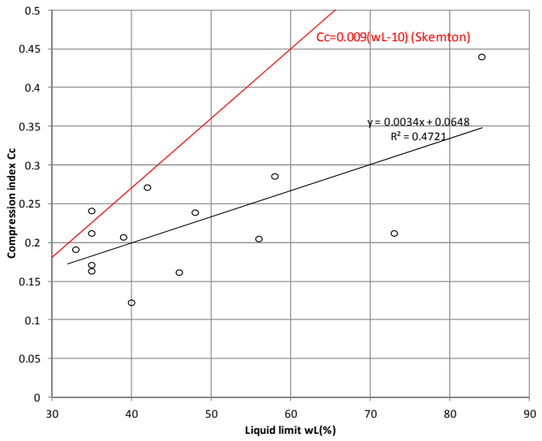
(11) Plastic index and Unconfined compression strength



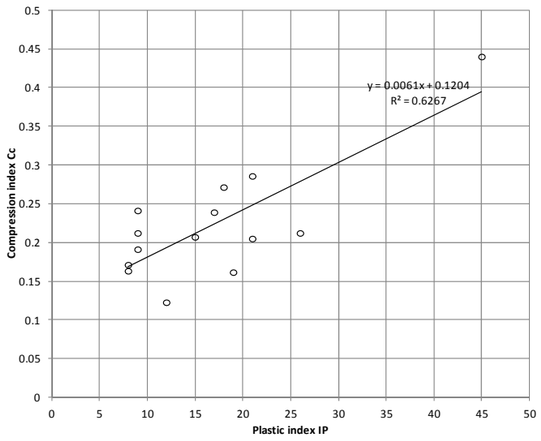
(12) Clay content and Unconfined compression strength

Source: JICA Study Team

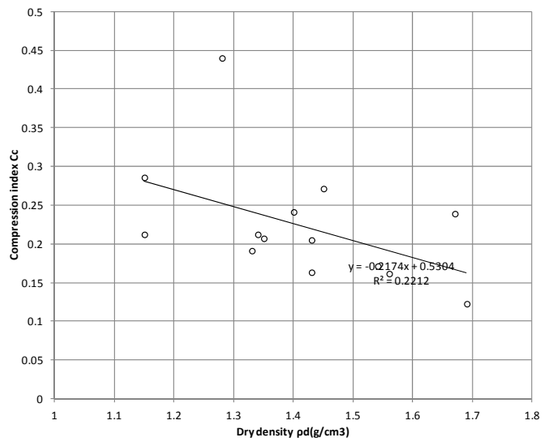
Figure 2.4(1) Correlation in Soil Parameter



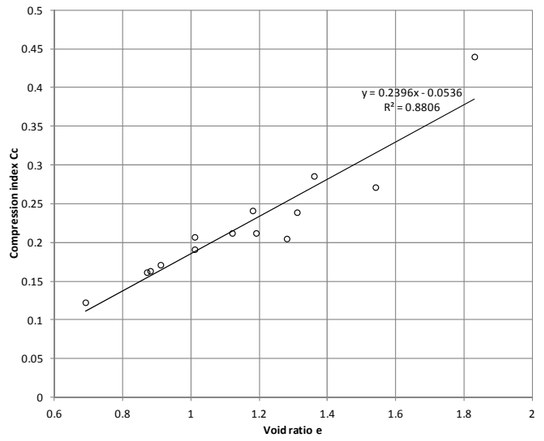
(13) Liquid limit and Compression index



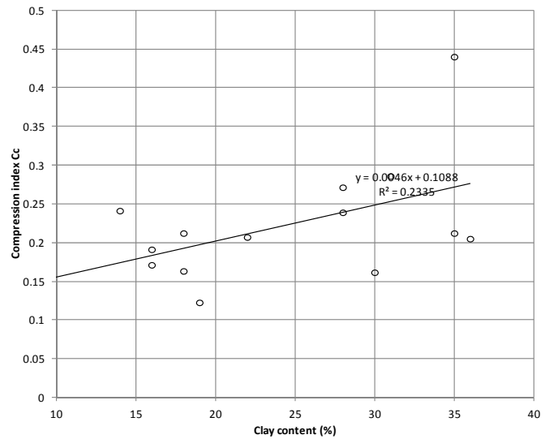
(14) Plastic index and Compression index



(15) Dry density and Compression index



(16) Void ratio and Compression index



(17) Clay content and Compression index

Source: JICA Study Team

Figure 2.4(2) Correlation inSoil Parameter

SUMMARY OF SOIL TEST RESULTS(1)

Bore Hole No.	Sample No. Tested	Depth of Sample (m)	Wet Unit Weight (kN/m^3)	NMC (%)	Dry density (g/cm3)	Void Ratio e	LL (%)	PL (%)	PI (%)	Sand (%)	Silt/ Clay (%)	Clay (%)	Specific Gravity	Classification of Soil USCS Group Symbol	Unconfined Compression Test q_u (kPa)	Unconfined Compression Test SF (%)	Consolidation Test Cc	Consolidation Test Specific Gravity	Consolidation Test Dry Density (g/cm3)	Consolidation Test Moisture Content (%)	Consolidation Test Initial Void Ratio	Organic Content by Loss-on Ignition %	Coefficient of Permeability (cm/sec)
1	2	3	4	5			6	7	8	9	10		11	12	13	14	15				16	18	19
BHn-2	D1	1.00					#N/A	#N/A	#N/A	66	34			SM									
	U1	2.40	15.8	42.50	1.11	1.404	84	39	45	1	99	35	2.72	MH	49.0	7.0	0.440	2.655	1.28	37.53	1.83		
24.89375	D3	3.00					#N/A	#N/A	#N/A	74	26			SM									
90.99114	D4	4.00		32.83			32	24	8	1	99	10	2.66	ML									
	D7	7.00					#N/A	#N/A	#N/A	30	70			ML									
	D8	8.00					#N/A	#N/A	#N/A	34	66			ML									
		10.00																					1.65E-03
	D12	12.00					#N/A	#N/A	#N/A	63	37			SM									
	D15	15.00					#N/A	#N/A	#N/A	70	30			SM									6.26E-04
	D19	19.00					#N/A	#N/A	#N/A	74	26			SM									
		20.00																					5.39E-04
	D22	22.00					#N/A	#N/A	#N/A	1	99		2.67	ML									
	D24	24.00		32.74			39	25	14	2	98	14	2.68	ML									
	D27	27.00		31.76			34	24	10	1	99	8	2.67	ML									
BHn-6	U1	0.60	18.5	27.00	1.46	0.796	35	27	8	4	96	16	2.67	ML	101.2	10.0	0.171	2.638	1.54	26.07	0.91		
	D3	3.00					#N/A	#N/A	#N/A	7	93			ML									
		5.00																					7.65E-04
24.334	D6	6.00					#N/A	#N/A	#N/A	33	67		2.66	ML									
90.993	D9	9.00					#N/A	#N/A	#N/A	31	69			ML									
	D10	10.00					#N/A	#N/A	#N/A	30	70			ML									5.12E-04
	D12	12.00					#N/A	#N/A	#N/A	76	24			SM									
	D15	15.00					#N/A	#N/A	#N/A	56	44		2.65	SM									1.30E-03
		20.00																					7.00E-04
	D22	22.00					#N/A	#N/A	#N/A	52	48		2.65	SM									
	D25	25.00					#N/A	#N/A	#N/A	59	41			SM									5.89E-04
	D27	27.00					#N/A	#N/A	#N/A	53	47			SM									
	D29	29.00					#N/A	#N/A	#N/A	57	43		2.65	SM									
		30.00																					6.41E-04
BHn-9	U1	0.60	18.3	29.90	1.41	0.857	35	26	9	6	94	18	2.67	ML	71.50	7.5	0.212	2.666	1.34	34.53	1.12		
24.19583	D1	1.00		33.10			36	26	10	6	94			ML									
90.88503	D2	2.00					#N/A	#N/A	#N/A	1	99			ML									
	D4	4.00					#N/A	#N/A	#N/A	2	98		2.66	ML									
		5.00																					6.04E-04
	D7	7.00					#N/A	#N/A	#N/A	11	89			ML									
		10.00																					1.88E-04
	D11	11.00					#N/A	#N/A	#N/A	84	16		2.65	SM									
	D15	15.00					#N/A	#N/A	#N/A	81	19			SM									2.07E-04
	D19	19.00					#N/A	#N/A	#N/A	81	19		2.65	SM									
		20.00																					3.57E-04
	D23	23.00					#N/A	#N/A	#N/A	82	18			SM									
		25.00																					2.94E-04
	D27	27.00					#N/A	#N/A	#N/A	84	16		2.64	SM									
BHn-13	UD1	0.60	18.4	29.20	1.42	0.851	48	31	17	2	98	28	2.69	ML	80.1	5.0	0.239	2.638	1.67	28.44	1.31		
	UD2	1.60	18.7	31.10	1.43	0.855	56	35	21	1	99	36	2.70	ML	101.3	8.0	0.205	2.643	1.43	1.28	1.28		
24.35675	D3	3.00		32.90			36	25	11	1	99			ML									
90.95917	D5	5.00					#N/A	#N/A	#N/A	15	85			ML									2.42E-03
	D8	8.00					#N/A	#N/A	#N/A	72	28		2.65	SM									
		10.00																					1.21E-03
	D12	12.00					#N/A	#N/A	#N/A	80	20			SM									
	D15	15.00					#N/A	#N/A	#N/A	51	49			SM									1.41E-03
	D19	19.00					#N/A	#N/A	#N/A	97	3		2.64	SP									
		20.00																					1.09E-03
	D22	22.00					#N/A	#N/A	#N/A	95	5			SP									
	D25	25.00					#N/A	#N/A	#N/A	88	12			SP-SM									9.17E-04
	D29	29.00					#N/A	#N/A	#N/A	92	8		2.65	SP-SM									
		30.00																					5.90E-04
BHn-17	UD1	0.60	18.5	28.20	1.44	0.813	35	27	8	2	98	18	2.67	ML	64.4	8.5	0.164	2.652	1.43	28.39	0.88		
24.509	UD2	1.40	18.9	29.60	1.46	0.801	42	24	18	3	97	28	2.68	ML	114.4	8.0	0.272	2.640	1.45	30.32	1.54		
91.13333	UD3	4.60	19.0	32.90	1.43	0.830	33	24	9	4	96	16	2.67	ML	126.5	7.0	0.191	2.644	1.33	32.50	1.01		
	D8	8.00					#N/A	#N/A	#N/A	8	92			ML									
		10.00																					3.05E-03
	D11	11.00					#N/A	#N/A	#N/A	24	76			ML									
	D14	14.00					#N/A	#N/A	#N/A	23	77			ML									
		15.00																					1.29E-03
	D16	16.00					#N/A	#N/A	#N/A	55	45		2.65	SM									
	D18	18.00					#N/A	#N/A	#N/A	93	7			SP-SM									
	D19	19.00					#N/A	#N/A	#N/A	64	36			SM									
		20.00																					1.05E-03
	D21	21.00					#N/A	#N/A	#N/A	68	32			SM									
	D24	24.00					#N/A	#N/A	#N/A	73	27			SM									
		25.00																					7.60E-04
	D26	26.00					#N/A	#N/A	#N/A	69	31			SM									
	D27	27.00					#N/A	#N/A	#N/A	65	35		2.64	SM									
	D28	28.00					#N/A	#N/A	#N/A	64	36			SM									
	D29	29.00					#N/A	#N/A	#N/A	68	32			SM									
BHn-18	D1	1.00					#N/A	#N/A	#N/A	13	87			ML									
24.72558	D3	3.00		37.20			35	26	9	4	96			ML									
90.91225	U1	3.40	16.2	33.80	1.21	1.161	35	26	9	1	99	14	2.67	ML	64.9	7.5	0.241	2.645	1.40	29.69	1.18		
	D5	5.00					#N/A	#N/A	#N/A	24	76			ML									3.22E-03
	D8	8.00					#N/A	#N/A	#N/A	50	50		2.66	ML									
		10.00																					1.99E-03
	D12	12.00					#N/A	#N/A	#N/A	58	42			SM									
	D14	14.00					#N/A	#N/A	#N/A	80	20			SM									
		15.00																					1.52E-03
	D20	20.00					#N/A	#N/A	#N/A	68	32			SM									1.35E-03
	D25	25.00					#N/A	#N/A	#N/A	17	83			ML									
	D26	26.00		31.17			36	24	12	6	94	13	2.67	CL									
	D27	27.00		27.39			38	24	14	24	76	10	2.68	CL									
	D29	29.00		44.50			57	29	28	7	93	31	2.70	CH									
	D30	30.00		27.45			34	24	10	50	50			SC									

SUMMARY OF SOIL TEST RESULTS(2)

Bore Hole No.	Sample No. Tested	Depth of Sample	Wet Unit Weight	NMC	Dry density	Void Ratio e	LL	PL	PI	Sand	Silt/ Clay	Clay	Specific Gravity	Classification of Soil USCS Group Symbol	Unconfined Compression Test		Consolidation Test					Organic Content by Loss-on Ignition %	Coefficient of Permeability
															q_u	SF	Cc	Specific Gravity	Dry Density	Moisture Content	Initial Void Ratio		
		(m)	(kN/m^3)	(%)	(g/cm3)		(%)	(%)	(%)	(%)	(%)	(%)			(kPa)	(%)			(g/cm3)	(%)		%	(cm/sec)
1	2	3	4	5			6	7	8	9	10		11	12	13	14	15				16	18	19
BHr-1	U1	0.60	19.8	27.00	1.56	0.691	46	27	19	2	98	30	2.69	ML	81.7	7.0	0.162	2.628	1.56	26.19	0.87		
24.36758	D1	1.00		25.40			45	27	18	3	97			ML									
91.64572	D2	2.00		25.29			41	26	15	7	93			ML									
	U2	2.60	18.8	23.90	1.52	0.731	40	28	12	3	97	19	2.68	ML	114.9	7.5	0.123	2.625	1.69	21.76	0.69		
	D8	8.00					#N/A	#N/A	#N/A	82	18			SM									
		10.00																					1.65E-03
	D11	11.00					#N/A	#N/A	#N/A	72	28		2.64	SM									
	D13	13.00					#N/A	#N/A	#N/A	80	20			SM									
		15.00																					6.26E-04
	D16	16.00					#N/A	#N/A	#N/A	73	27			SM									
	D19	19.00					#N/A	#N/A	#N/A	69	31		2.65	SM									
		20.00																					5.39E-04
	D22	22.00					#N/A	#N/A	#N/A	80	20			SM									
	D24	24.00					#N/A	#N/A	#N/A	93	7			SP-SM									
		25.00																					7.65E-04
	D26	26.00					#N/A	#N/A	#N/A	77	23		2.67	SM									
		30.00																					5.12E-04
BHr-7	D2	2.00					#N/A	#N/A	#N/A	34	66		2.66	ML									
	D4	4.00					#N/A	#N/A	#N/A	31	69			ML									
25.01478	D6	6.00					#N/A	#N/A	#N/A	28	72			ML									
		10.00																					1.22E-03
90.62486	D11	11.00					#N/A	#N/A	#N/A	51	49		2.66	SM									
		15.00																					6.55E-04
	D16	16.00					#N/A	#N/A	#N/A	75	25		2.65	SM									
	D20	20.00					#N/A	#N/A	#N/A	88	12			SP-SM									8.48E-04
	D24	24.00					#N/A	#N/A	#N/A	93	7		2.64	SP-SM									
		25.00																					7.76E-04
	D28	28.00					#N/A	#N/A	#N/A	92	8		2.64	SP-SM									
BHr-8	D3	3.00					#N/A	#N/A	#N/A	93	7		2.64	SP-SM									
		5.00																					4.21E-03
	D6	6.00					#N/A	#N/A	#N/A	82	18			SM									
24.13386	D9	9.00					#N/A	#N/A	#N/A	61	39		2.66	SM									
		10.00																					2.97E-03
90.92586	D13	13.00					#N/A	#N/A	#N/A	78	22			SM									
		15.00																					1.98E-03
	D17	17.00					#N/A	#N/A	#N/A	85	15		2.64	SM									
		20.00																					1.46E-03
	D24	24.00					#N/A	#N/A	#N/A	82	18		2.65	SM									
		25.00																					2.14E-03
	D27	27.00					#N/A	#N/A	#N/A	79	21			SM									
	D30	30.00		27.70			35	27	8	1	99		2.68	ML									
BHr-9	U1	0.60	18.3	29.80	1.41	0.863	39	24	15	1	99	22	2.68	CL	89.1	5.0	0.207	2.650	1.35	33.82	1.01		
	U2	1.60	17.1	42.30	1.20	1.210	58	37	21	1	99	31	2.71	MH	93.8	9.0	0.286	2.645	1.15	39.50	1.36		
	U3	2.60	16.3	41.30	1.15	1.311	73	47	26	1	99	35	2.72	MH	41.6	6.5	0.212	2.645	1.15	38.74	1.19		
	D4	4.00					#N/A	#N/A	#N/A	63	37			SM									
	D5	5.00					#N/A	#N/A	#N/A	12	88			ML									2.50E-03
	D7	7.00					#N/A	#N/A	#N/A	49	51			ML									
	D9	9.00					#N/A	#N/A	#N/A	68	32			SM									
		10.00																					1.15E-03
	D12	12.00					#N/A	#N/A	#N/A	66	34			SM									
		15.00																					7.21E-04
	D16	16.00					#N/A	#N/A	#N/A	50	50			SM									
	D20	20.00					#N/A	#N/A	#N/A	73	27		2.65	SM									1.01E-03
	D24	24.00					#N/A	#N/A	#N/A	68	32			SM									
	D28	28.00					#N/A	#N/A	#N/A	82	18		2.64	SM									

Source: JICA Study Team

2.3 Soil Parameter

Cohesion of soft silt layer is set from the results of laboratory test and DCT.

The relation between unconfined compressive strength (qu) and cone resistance (qc) is presented by the following formula Eq.1 according to "Road Earthwork Guideline for Countermeasures of Soft Ground, Japan Road Association".

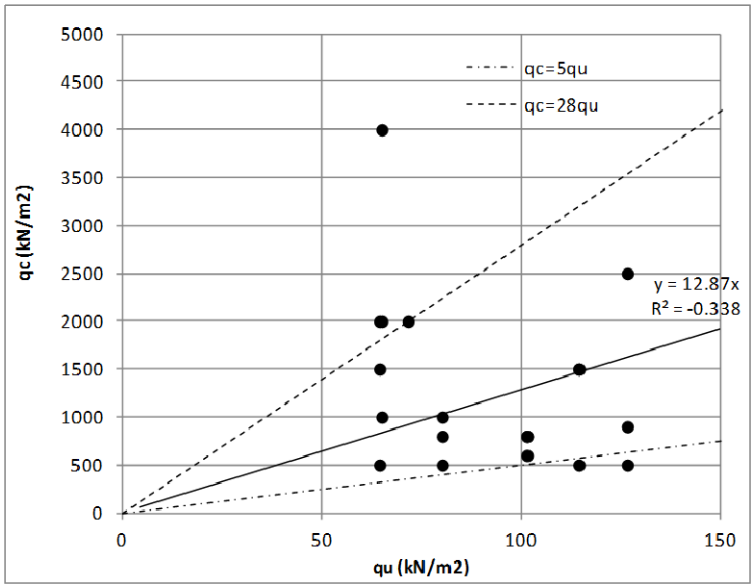
$$qu = (1/10 \text{ to } 1/15)qc \qquad \text{(Eq.1)}$$

The correlation between unconfined compressive strength and cone resistance is in the range of Eq.1, although unevenness is recognized because the drilling survey and DCT were conducted at different places.

Then, unconfined compressive strength shall be estimated from cone resistance by Eq. 2. And cohesion can be estimated by Eq.3, as cu=qu/2.

$$qu=1/15qc \qquad \text{(Eq.2)}$$

$$cu=qu/2=1/30qc \qquad \text{(Eq.3)}$$



Source: JICA Study Team

Fig. 2.5 Correlation between cone resistance (qc) and unconfined strength (qu)

The strength of intermediate and bearing layer is presumed by cone resistance for cohesive soil and empirical equation of $\varphi = (15N)^{0.5}+15$ for internal friction angle of sand. Density is supposed as typical value.

In addition, the relation between friction angle φ and cone resistance can be estimated by following Eq.4 (BS EN 1997-2:2007).

$$\varphi = 13.5 \times \log qc + 23 \qquad \text{(Eq.4)}$$

Table 2.1 Setting soil parameter

	Soft Layer	Intermediate Layer		Bearing Layer	
	Silt Layer	Silt Layer	Sand Layer	Silt Layer	Sand Layer
Specific gravity Gs	2.65	2.65	2.65	2.65	2.65
Wet density $\rho_t(kN/m^2)$	18	19	21	19	21
Dry density $\rho_d(kN/m^2)$	13	14.5	17.5	15	18
Water content $w_n(\%)$	38	30	20	25	20
Void ratio e	1.0	0.8	0.5	0.7	0.5
Cone penetration resistance $q_c(kN/m^2)$	800	1,500	—	4,500	—
N-value	—	—	20	—	30
Unconfined compressive strength $qu(kN/m^2)$	53	100	0	300	0
Cohesion $c_u(kN/m^2)$	27	50	0	150	0
Internal friction angle φ(deg)	0	0	32	0	36
Compression index Cc	0.2	0.1	—	—	—
Coefficient of compressibility cv(m2/day)	$1x10^{-2}$	$1x10^{-2}$	—	—	—

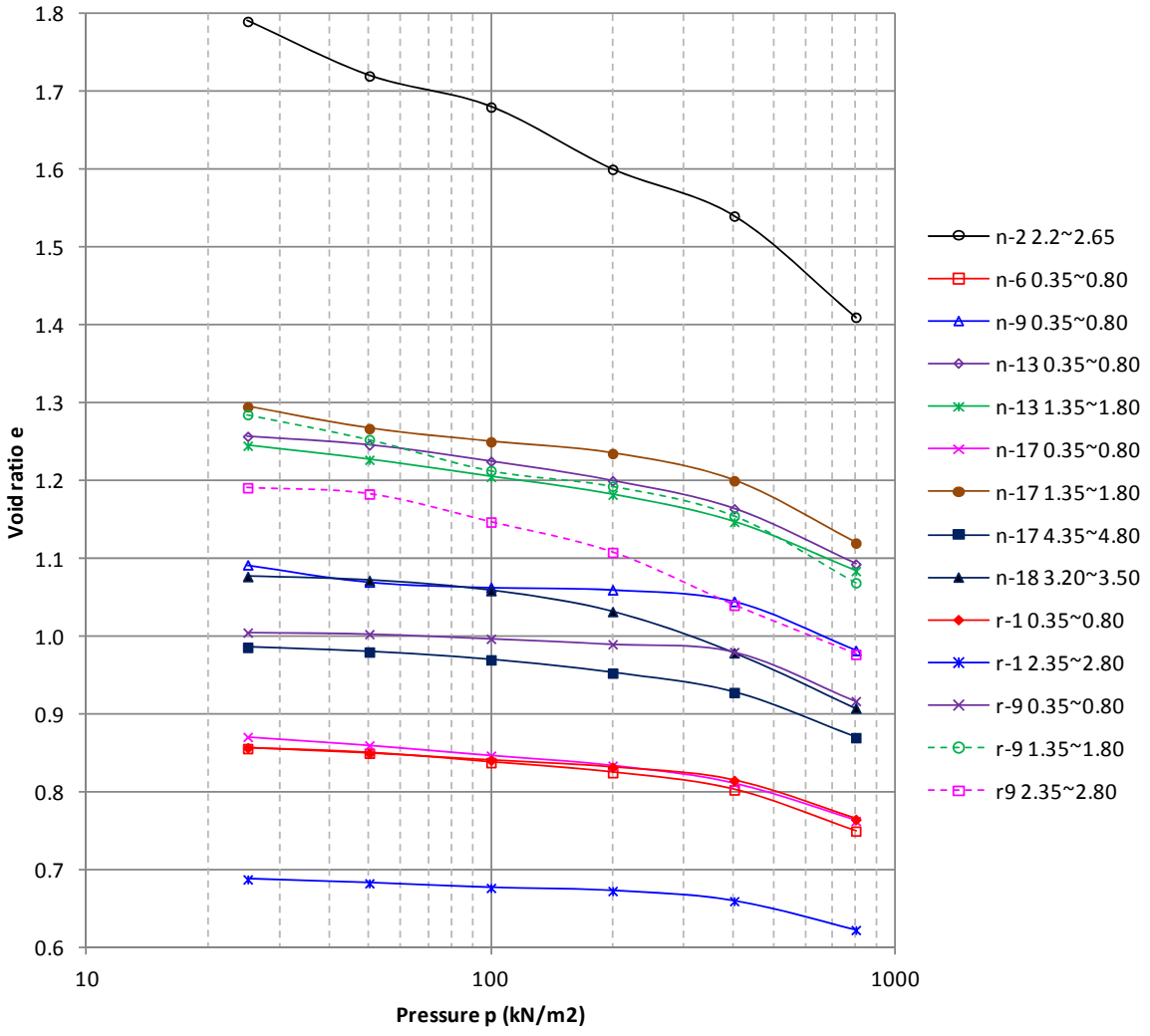
Source: JICA Study Team

3. Settlement

3.1 Consolidation Test Result

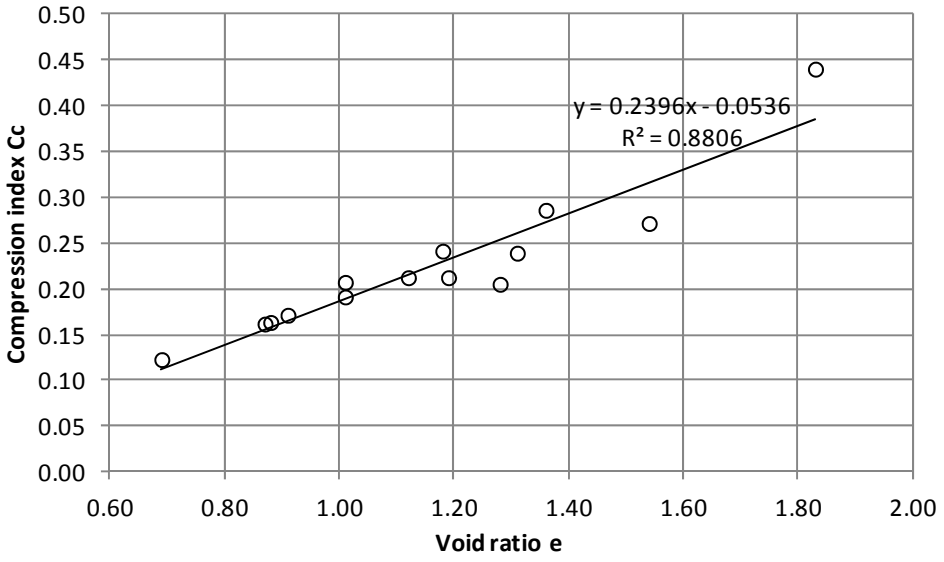
Figure 3.1 shows e ~ log(p) curves. The pre-compression load will be more than 200kN/m2 because void ratio comes down after 200kN/m2. This matter shows overburden was generally more than 20tf/m2, but it is impossible to consider the overburden like this in the project area. This is considered to be effect of drying shrinkage in dry season.

Figure 3.2 shows correlation between void ratio e and compression index Cc, indicating a extremely good correlation. The average void ratio of undisturbed samples is e=0.94, of which correspondent compression index will be Cc=0.17. This value is small due to cohesive soil of dominant silt contents.



Source: JICA Study Team

Figure 3.1 e ~ log(p) curves



Source: JICA Study Team

Figure 3.2 Correlation between Void ratio e and Compression index Cc

3.2 Setting Compression Index

As laboratory test result shows Cc=0.15~0.3, average 0.20, consolidation settlement is considerably low.

Estimate equations for Cc are as follows:

Cc = 0.009(WL - 10) Skempton

Cc = 0.017 (WL - 18) Nobi Plain

From above equations, Skempton derives Cc=0.18- 0.36 using liquid limit of 30- 50%, and Nobi Plain derives Cc=0.12- 0.29 using natural water content of 25- 35%. These results are almost same range as laboratory result.

As a result, representative compression index in the investigation area is assumed to be Cc=0.20.

3.3 Preliminary Settlement Estimation

(1) Basic condition for study of consolidation

Objective consolidation layer will be soft ground of N<4 or qc<0.8Mpa.

Thickness of soft ground is less than 6m from observed N-value, and less than 12m from observed qc. Embankment height is less than 4m, slope gradient of 1:3.0 and crest width of 4.3m. Embankment rising rate is 3cm/day as general value for soft ground.

(2) Soil parameter of soft ground

Initial void ratio is uneven but can be set as e0=0.85. Wet (saturated) density is 19.0kN/m^3. Compression index is Cc=0.2. Coefficient of consolidation can be cv=1.0x$10^{-2}$$m^2$/day as cohesive soil of dominant silt, considering common alluvial clay is 10^{-3} to $10^{-2}$$m^2$/day.

(3) Soil parameter of embankment

Maximum dry density can be set as central value of 17.0kN/m^3 from 16.7 to 17.2kN/m^3. Given compaction degree of 95%, dry density is 16.2kN/m3. If optimum moisture content is 18% as central value, wet density is 19.1kN/m^3 and saturated density is 20.2kN/m^3.

Table 3.1 Soil Properties

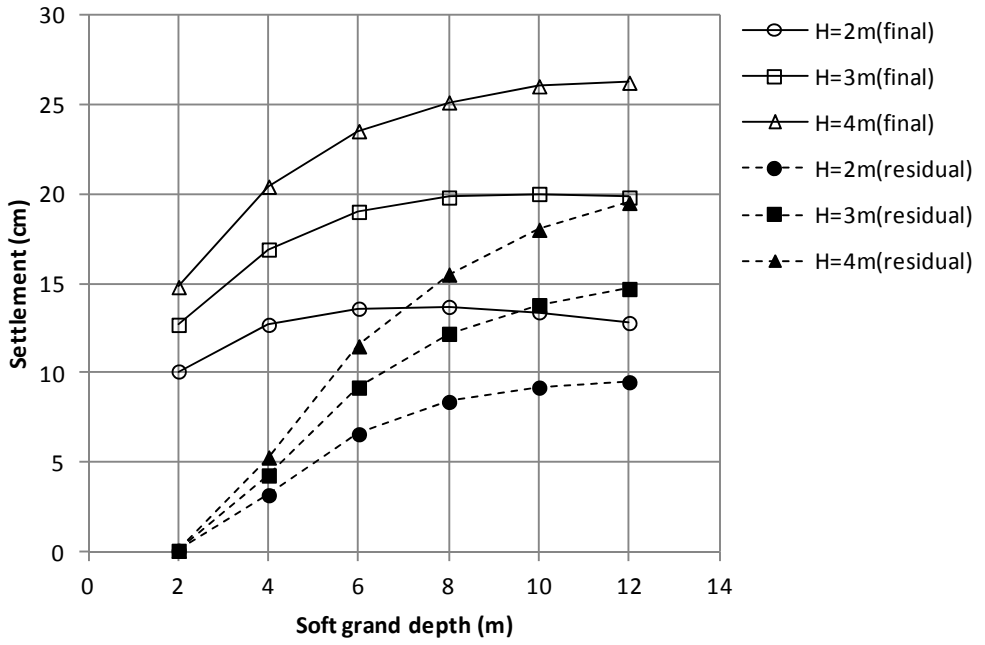
	Specific gravity Gs	Natural water content w_n (%)	Water content at satration w_{sat} (%)	Dry density ρ_d (kN/m^3)	Saturated density ρ_{sat} (kN/m^3)	Wet density ρ_t (kN/m^3)	Void ratio e	Compression index Cc	Coefficientof consolidation Cv m^2/day
Soft layer	2.66	32.0	32.0	14.4	19.0	19.0	0.85	0.2	1x10^{-2}
Embankment	2.68	18.0	24.4	16.2	20.2	19.1	0.65		

Source: JICA Study Team

(4) Settlement by Consolidation

Figure 3.3 shows estimated settlement due to consolidation.

Total settlement can be estimated as 26cm under the condition of soft ground thickness 12m and embankment height 4m. As residual settlement can be 20cm after construction of embankment, problem due to settlement will not occur. If the thickness of soft ground is smaller than 5m, residual settlement can be estimated less than 10cm.



Source: JICA Study Team

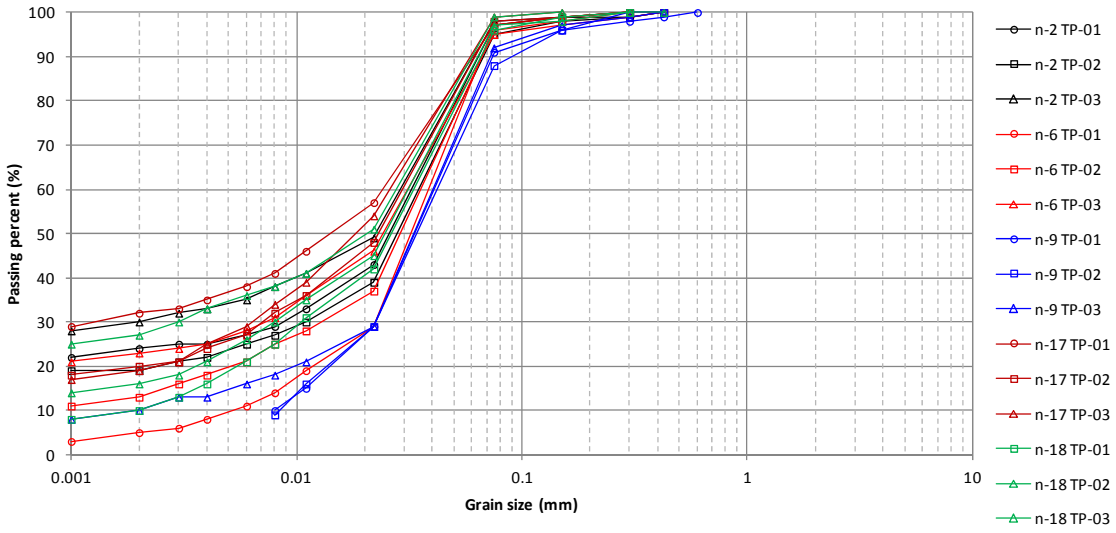
Figure 3.3 Estimated Settlement due to Consolidation

4. Embankment Material

4.1 Result of Laboratory Test for Embankment Material

(1) Physical Characteristics

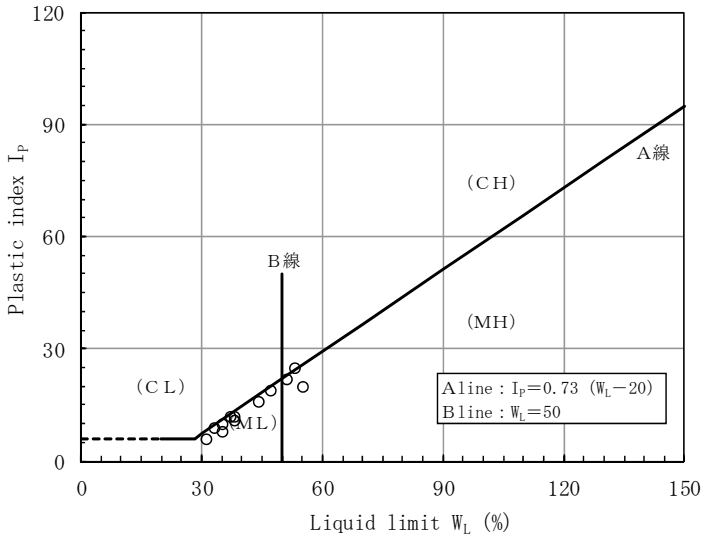
Figure 4.1 shows the gradation curve, and materials are cohesive soil mainly composed by silt with sand fraction of less than 12%. The silt fraction shows around 70 to 90% (Average 80%).



Source: JICA Study Team

Figure 4.1 Grain Size Curve

Figure 4.2 shows plasticity chart, and soil classification of materials are comprised in ML (silt with low liquid limit), partly MH (silt with high liquid limit) and CH (clay with high liquid limit).



Source: JICA Study Team (Plastic Chart is based on British Standard)

Figure 4.2 Plasticity chart

(2) Compaction Characteristics

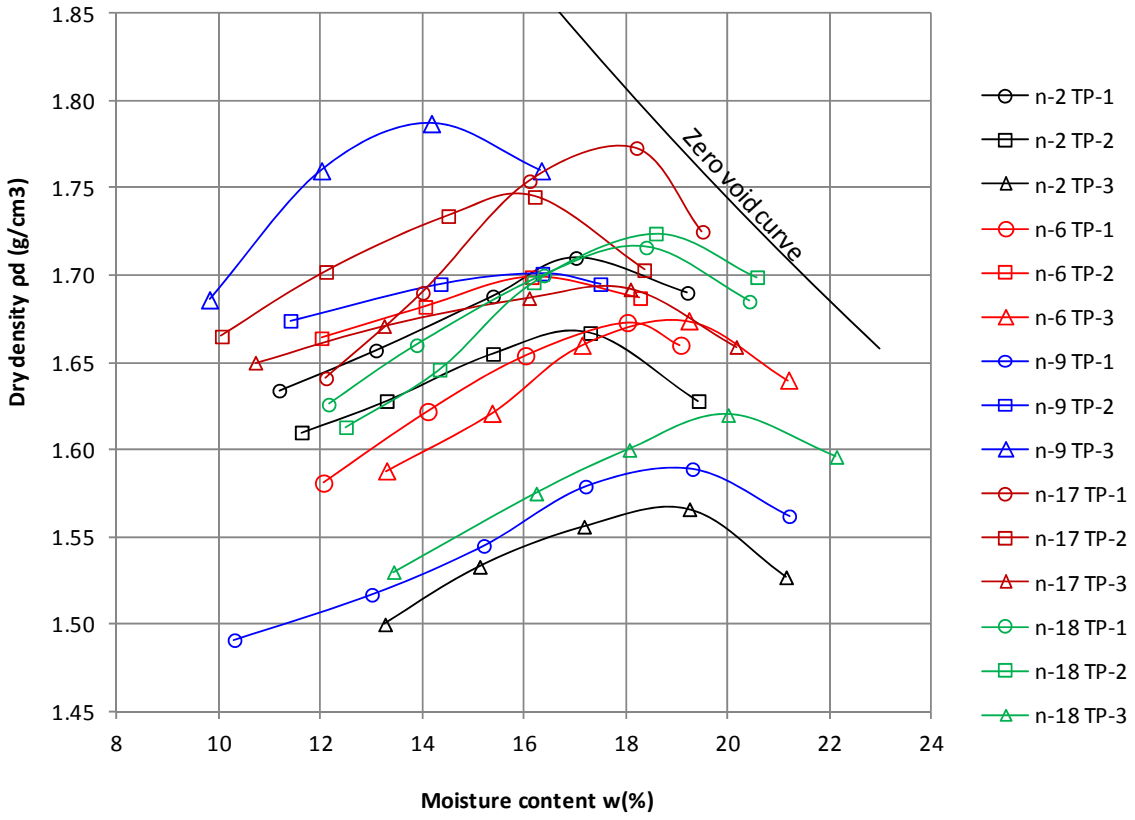
Figure 4.3 shows compaction curve.

Table 4.1 shows the relationship between optimum moisture content and dry density. This data show that optimum moisture content of 18% and dry density of around 1.7g/cm3 with unevenness.

Table 4.1 Compaction Test Result

	Maximum dry density ρ_{dmax} (g/cm^3)	Optimum moisture content W_{opt} (%)	Wet density ρ_t (g/cm^3)
Range	1.57~1.79	14.2~20.0	1.86~2.09
Average	1.69	17.6	1.99

Source: JICA Study Team



Source: JICA Study Team

Figure 4.3 Compaction Curve

(3) Soil Strength Characteristics

1) Unconfined compression strength test

Unconfined compression strength test was performed under condition of compaction degree of 90% and 95%.

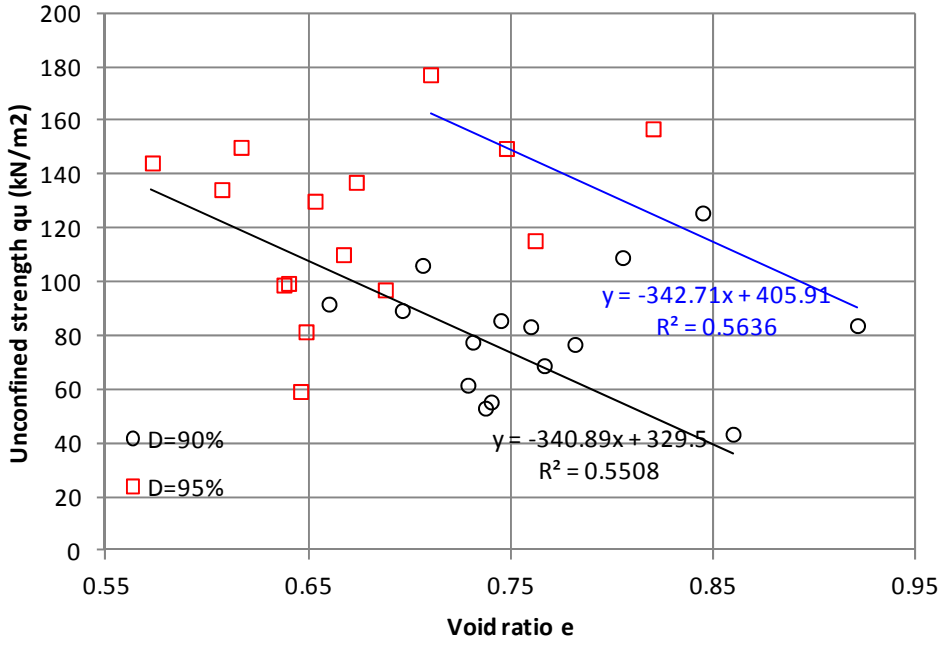
Figure 4.4 shows the correlation between void ratio (e) and unconfined compression strength (qu), with tendency of less qu in proportion as more e.

The strength of materials are classified to two categories, namely bigger strength is included in MH (silt with high liquid limit).

For D=90%, qu is expected more than 60kN/m^2, and for D=95%, qu is expected more than 100kN/m^2.

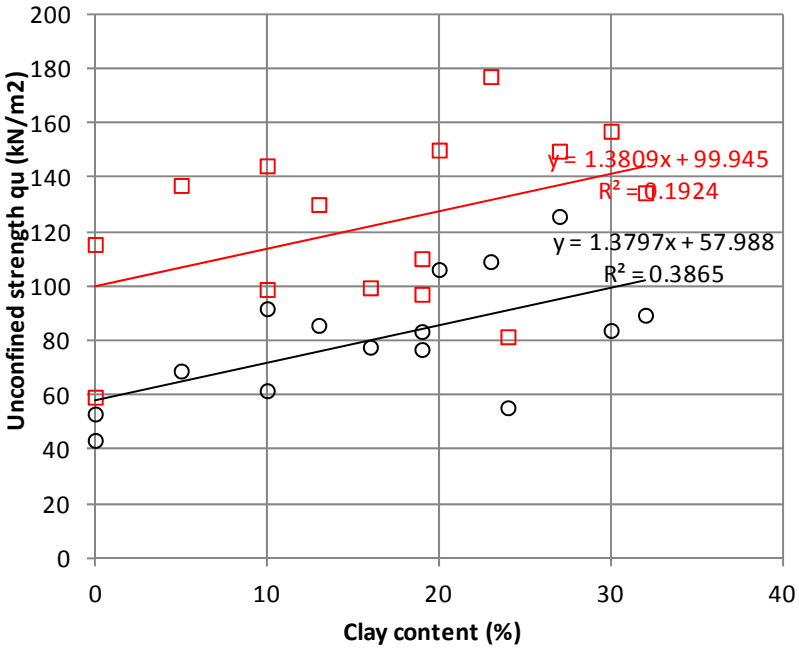
Figure 4.5 shows the correlation between clay contents and qu, with tendency of much qu in proportion as more clay content.

Figure 4.6 shows the correlation between qu of 90% and qu of 95%, with result that the latter shows 1.5 times of the former.



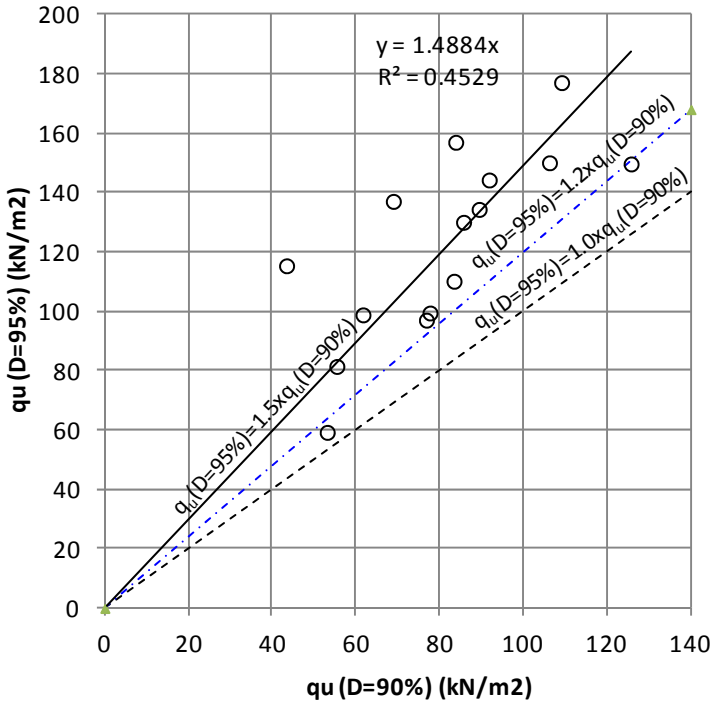
Source: JICA Study Team

Figure 4.4 Unconfined Compression Strength and Void Ratio



Source: JICA Study Team

Figure 4.5 Unconfined compression strength and clay content



Source: JICA Study Team

Figure 4.6 Relation of unconfined compression strength with D=90% and D=95%

2) Triaxial compressive strength test

The following table shows the strength of compacted material presumed from the triaxial compressive strength test results. In addition, unconfined compression test results are also evaluated comprehensively as triaxial compressive strength test as of confining pressure zero, for estimating strength parameter.

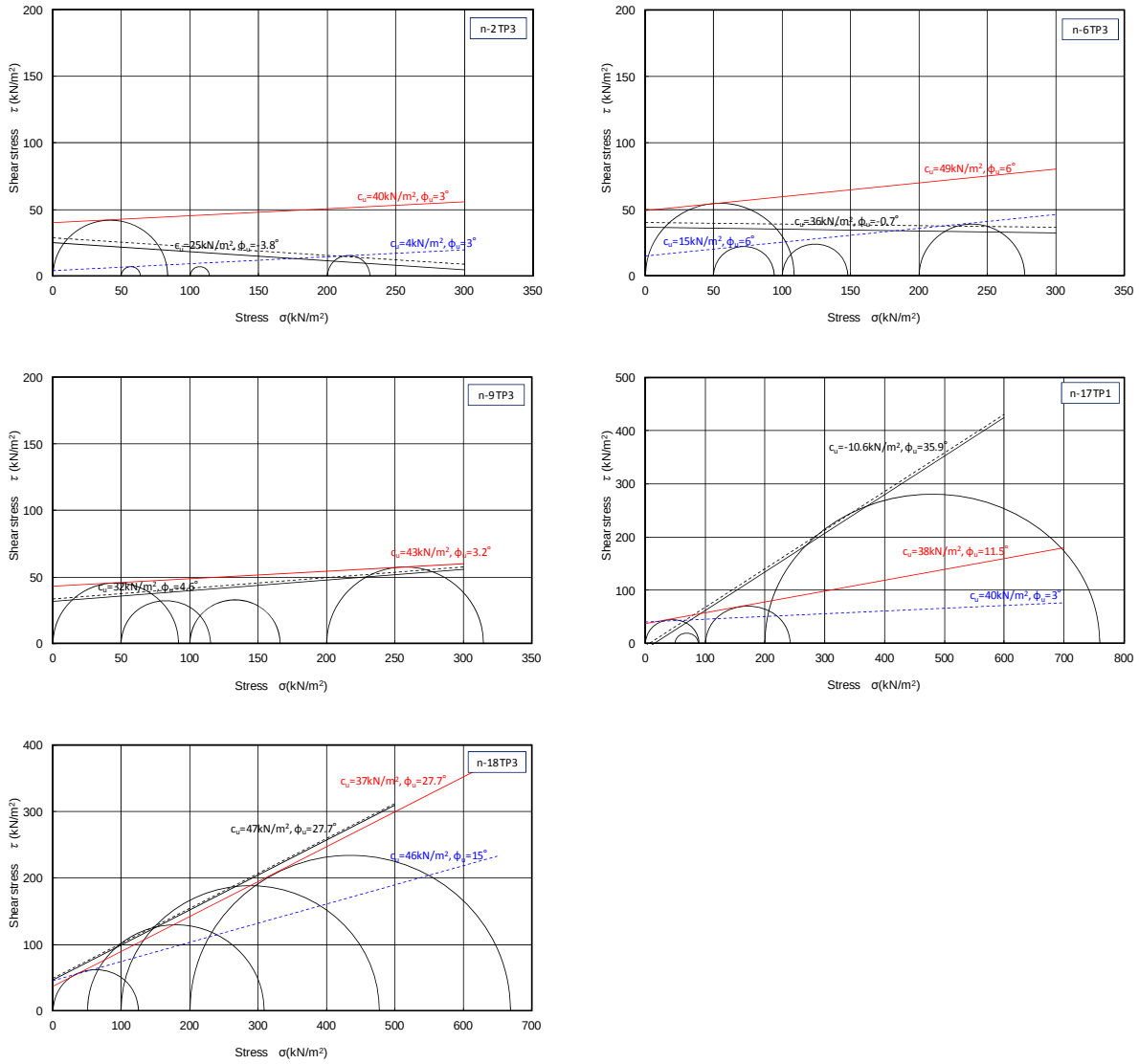
Table 4.1 Estimation for Strength Parameter from Triaxial Compression Test Result

Location	Condition*1	Dry density ρ_d (g/cm^3)	Water content w (%)	Degree of compaction D (%)	Cohesion c_u (kN/m^2)	Internal friction angle ϕ_u (deg)
n-2	Sat.	1.40~1.43 (1.418)*2	17.2~19.0 (18.2) *2	89.3~91.3 (90.5) *2	40	3
n-6	Sat.	1.51~1.53 (1.518) *2	10.8~19.0 (13.2) *2	90.2~91.4 (90.7) *2	49	9
n-9	Uns.	1.61~1.64 (1.633) *2	13.0~14.2 (13.5) *2	89.9~91.6 (91.2) *2	43	3
n-17	Uns.	1.60~1.70 (1.643) *2	14.6~18.0 (16.2) *2	90.1~95.8 (92.5) *2	38	11
n-18	Uns.	1.46~1.50 (1.480) *2	18.5~20.0 (19.6) *2	90.1~92.6 (91.4) *2	46	15

Source: JICA Study Team

*1 : Sat. is saturated and Uns. is unsaturated before triaxial compression test is done,

*2 : The values given in parentheses are mean.



Source: JICA Study Team

Figure 4.7 Results of Unconfined Compression Test and Triaxial Compression Test

(4) Advisability for Embankment Material

The embankment material should fill the following conditions according to the Manual of River Earthwork in Japan. In terms of soil classification, silt is possible to be used for embankment if moisture content is proper.

1) Grain size distribution should provide high density, and stable embankment with high shear strength.
2) Impermeable as much as possible, without seepage extending to toe of slope of protected area side.
3) Materials of no deformation and no expansivity so as not to effect to embankment body.
4) Good workability, especially easy to compact.
5) Stable and safe for sliding and clack against environmental variation such as inundation and dryness.
6) No content of deleterious organic matter and dissolving ingredient.

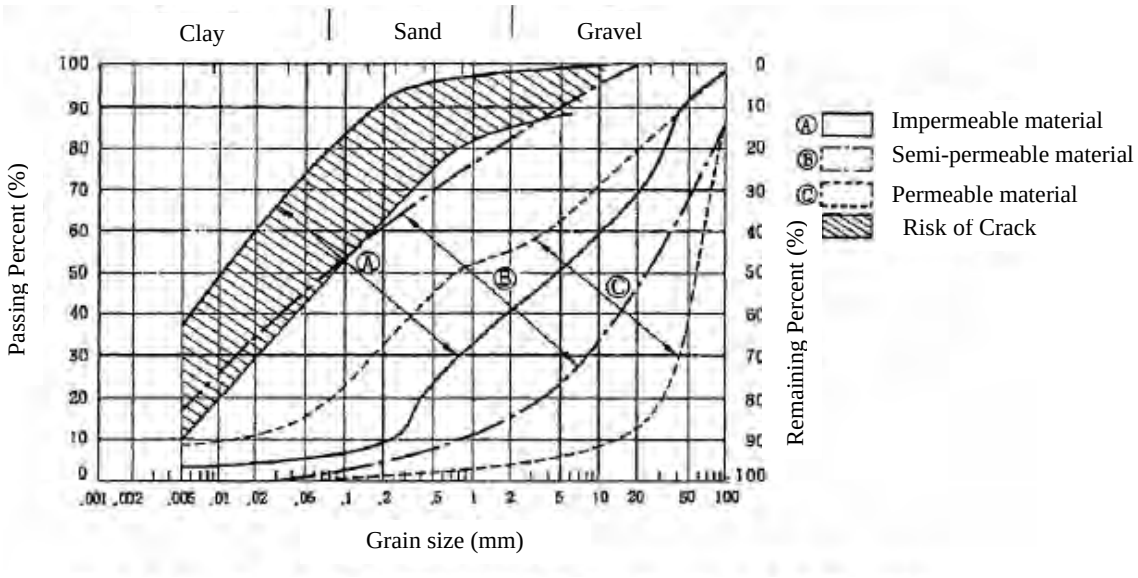
Source: The Manual of River Earthwork, Japan

The descriptions regarding expected embankment materials are as follows:

1) Soil of not much silt content: slope failure is apt to occur in the embankment of degraded shearing resistance by erosion and seepage water. Those weakened soil is considered to be affected by silt content.
2) Soil of not much content of fine grained fraction (<0.075mm): As soil of fine grained fraction of more than 50% is apt to be cracked in dry condition, it is preferable to use the soil of less than 50%.

Source: The Manual of River Earthwork, Japan

In terms of the grain size distribution, the materials with much silt content have high risk of cracks, according to the proper range for embankment materials by US Reclamation Bureau.



Source: The Manual of River Earthwork, Japan

Figure 4.8 Range Sample for Embankment Material (USRB 1974)

Therefore, if the silty materials will be used for embankment, it is important to consider the following matters;

- Take measures so as not to be cracked in embankment body.
- Take measures so as not to be eroded.
- Take consideration for slope stability in infiltration of seepage water.

Vegetation is generally effective for countermeasures against cracks and erosion. Especially *Dubra Grass* of endemic species as slope protection is widely used in this region, so this method is considered to be also effective for the slope protection of submergible embankment.

Dubra Grass will die down by submergence, however its roots survives and may prevent cracks and erosion partly. If ineffective by only vegetation, covering by high quality soil (above-mentioned blended grained soil) or geo-textile is considered to be good measures.

Table 4.2 Soil Evaluation as Embankment Material

Soil Classification			Evaluation for Embankment Material		Countermeasures
Name		Symbol (JUSCS*)	Evalu-ation	Issues to be concerned	
Coarse Grained Soil	Gravel	(GW),(GP)	○	Permeability is very high.	Measures for permeability and vegetation will be required.
	Gravelly Soil	(G-M),(G-C), (G-O),(G-V), (GM),(GC), (GO),(GV),	○		
	Sand	(SW),(SP)	○	As permeability is high, slope collapse will be apt to occur.	Measures for permeability will be required.
	Sandy Soil	(S-M),(S-C), (S-O),(S-V), (SM),(SC), (SO),(SV),	○		
Fine Grained Soil	Silt	(ML),(MH)	○	If soil is wet, it is hard to construct by machine, as compaction might not be enough. (Countermeasure will be required as the case.)	Cut down of moisture content by drying, or stabilize by soil stabilization additive.
	Cohesive Soil	(CL),(CH)	○		
	Volcanic Cohesive Soil	(OV),(VH1), (VH2)	○		
	Organic Soil	(OL), (OH)	△	As frequent high moisture content, compaction and forming by machine are difficult without modification.	Cut down of moisture content by drying, or stabilize by soil stabilization additive, or grain size control using good soil.
Highly Organic Soil		(Pt),(Mk)	×	As high moisture content, compaction is very difficult. Compressive deformation is large and stability is low for environmental variation such as flooding and drying.	

○ Possible to use as embankment material
△ Possible to use as embankment material if some countermeasures are done
× Inappropreate for embankment material

*: Japan Unified Soil classification system

Source: River Earthwork Manual

SUMMARY OF CLASSIFICATION AND COMPACTION CHARACTERISTICS

FOR EMBANKMENT MATERIAL

Scheme No.	Test Pit No.	Coordinate	Water Content	Liquid Limit	Plastic Limit	Plasticity Index	Grain Size Analysis			Specific Gravity	Classification of Soil USCS Group Symbol	Proctor Compaction Test			Unconfined Com-pression Test						Trixial Shear Test (UU)	
															D=90%			D=95%				
							Sand	Silt	Clay			MDD	Void ratio	OMC	q_u	e	SF	q_u	e	SF	q_u	SF
			(%)	(%)	(%)	(%)	(%)	(%)	(%)			(gm/cm^3)	e	(%)	(kPa)		(%)	(kPa)		(%)	(kPa)	(%)
n-2	TP-1	N-24^0 58' 06.2" E-91^0 04' 57.6"	13.4	44	28	16	3	73	24	2.68	ML	1.71	0.57	17.0	55.4	0.74	3.5	81.5	0.649	2.0		
n-2	TP-2	N- 25º 02' 35.1" E- 91º 03' 44.7"	30.9	35	25	10	5	76	19	2.67	ML	1.67	0.60	16.9	76.8	0.782	3.5	97.1	0.688	2.5		
n-2	TP-3	N- 25º 02' 59.6" E- 91º 00' 00.5"	18.8	55	35	20	2	68	30	2.71	MH	1.57	0.73	19.0	83.8	0.922	2.0	157.0	0.8	1.5		
n-6	TP-1	N-24^0 22' 49.8" E-91^0 01' 55.1"	34.1	#N/A	#N/A	#N/A	3	92	5	2.66	ML	1.67	0.59	18.0	68.9	0.767	3.5	137.1	0.674	2.5		
n-6	TP-2	N-24^0 17' 31.4" E-91^0 04' 37.8"	25.9	31	25	6	4	83	13	2.67	ML	1.70	0.57	16.1	85.7	0.7	2.5	130.1	0.7	3.5		
n-6	TP-3	N-24^0 19' 57.7" E-91^0 07' 06.4"	19.8	51	29	22	5	72	23	2.72	MH	1.67	0.62	19.0	109.1	0.805	2.0	177.1	0.71	2.5		
n-9	TP-1	N-24^0 12' 00.7" E-90^0 54' 02.4"	21.6	#N/A	#N/A	#N/A	9	91	0	2.66	ML	1.59	0.67	19.2	43.4	0.86	5.0	115.4	0.762	2.5		
n-9	TP-2	N-24^0 13' 46.2" E-90^0 52' 34.4"	16.6	#N/A	#N/A	#N/A	12	88	0	2.66	ML	1.70	0.56	16.5	53.1	0.738	5.5	59.3	0.646	4.5		
n-9	TP-3	N-24^0 12' 41.9" E-90^0 51' 20.8"	17.8	33	24	9	8	82	10	2.67	ML	1.79	0.49	14.2	91.8	0.66	2.0	144.3	0.573	3.0		
n-17	TP-1	N-24^0 30' 29.8" E-91^0 09' 26.0"	18.7	53	28	25	3	65	32	2.71	CH	1.78	0.53	18.0	89.4	0.696	7.0	134.4	0.607	7.5		
n-17	TP-2	N-24^0 30' 11.0" E-91^0 06' 58.0"	29.7	37	25	12	2	78	20	2.68	ML	1.75	0.54	16.0	106.2	0.706	2.5	150.1	0.617	3.0		
n-17	TP-3	N-24^0 27' 33.1" E-91^0 06' 53.0"	23.9	38	27	11	1	80	19	2.68	ML	1.69	0.58	17.8	83.4	0.76	2.5	110.2	0.667	2.0		
n-18	TP-1	N-24^0 46' 36.0" E-90^0 53' 46.8"	24.4	35	27	8	4	86	10	2.67	ML	1.72	0.56	18.4	61.7	0.7	2.5	98.9	0.6	3.0		
n-18	TP-2	N-24^0 25' 40.8" E-90^0 55' 16.5"	25.9	38	26	12	3	81	16	2.68	ML	1.72	0.56	18.6	77.7	0.7	2.5	99.5	0.64	3.5		
n-18	TP-3	N-24^0 44' 24.8" E-90^0 56' 36.0"	24.8	47	28	19	1	72	27	2.69	ML	1.62	0.66	20.0	125.7	0.845	2.5	149.7	0.748	2.5		

Source: JICA Study Team

4.2 Required Strength of Embankment Material

(1) Basic Condition

Embankment section is considering the most dangerous condition as follows:

- Height of embankment; 4.0m
- Slope gradient; 1: 2.0
- Seepage water; rapid rising and falling condition of flood water level
- Density of embankment; D= 95%

(2) Result of Calculation

As a result of slope stability analysis, cohesion is 14kN/m^2 to satisfy the required safety factor of 1.2 as shown in Figure 4.9.

As cohesion is expected as 38 49 kN/m^2 according to the unconfined compression tests and tri-axial tests, then the initial strength of embankment is enough. The strength must not decrease up to cu=14kn/m^2 even under the repeating submergence and dry.

Assuming that initial strength is 38kN/m^2, 14kN/m^2 is corresponding 37% (63% strength reduction). According to the dry-wet test up to 8 cycles test at present, the strength reduction is 45% from initial strength under the condition of compaction degree of 90%, and 36% under compaction degree of 98%. For compaction degree of 80%, dry-wet cyclic test is not able over 4 cycles, since any specimens cannot keep their form. The strength reduction under compaction degree of 90% is within the allowable range according to the result of dry-wet test up to 8 cycles.

Table 4.2 Slope Stability Analysis Result

Cohesion Cu (kN/m^2)	Min. safety factor	
	Rising	Drop down
10	1.003	0.919
12	1.204	1.102
13	-	1.194
14	-	1.286
20	2.006	1.837
30	3.009	2.756

Source: JICA Study Team

4.3 Shape of Embankment

(1) Study for Embankment Stability

Cohesive soil of N<4 and qc<0.8Mpa might be problem for embankment stability.

Assuming qc=0.8Mpa up to GL.-10m, stability has been examined.

1) Basic Condition

Set cohesion of cohesive soil as follows:

$$cu=1/2qu=1/30qc=1/30*0.8Mpa=26.7kN/m^2$$

Table 4.3 Analytical Parameter

Analytical parameter	Embankment	Soft ground
Saturated density ρ_{sat} (kN/m^3)	20.2	18.0
Wet density ρ_t (kN/m^3)	19.1	18.0
Cohesion c_u(kN/m^2)	10.0	26.7
Friction angle φ_u(deg)	0.0	0.0

Source: JICA Study Team

2) Water level condition

Set residual water level condition at depression head.

3) Embankment shape

Set three kinds of height as H=2.0m, 3.0m, 4.0m.

Set two kinds of slope gradient as 1: 2.0 and 1: 3.0.

Set crest width as 4.3m.

4) Result of calculation

Table 4.4 shows the result of calculation, cu=26.7kN/m^2 satisfies the required safety factor.

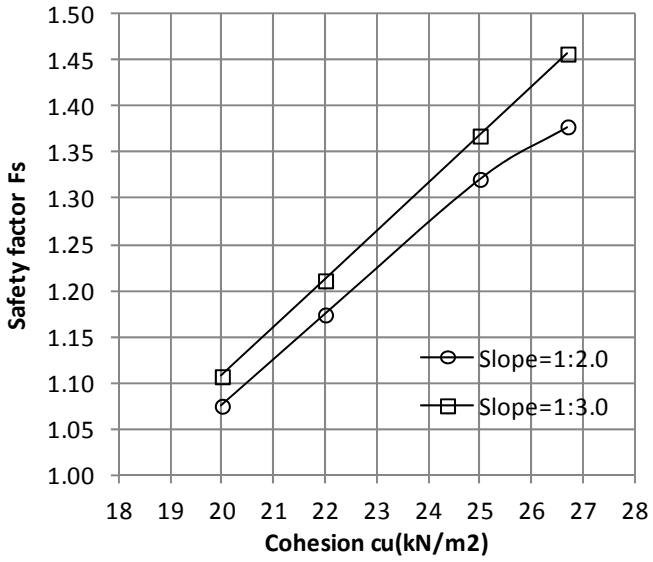
Cohesion of more than 23kN/m^2 satisfies the safety factor of 1.2 as shown in Figure 4.9.

Therefore, cone resistance of more than 0.8Mpa will be evaluated as no problem in stability.

Table 4.4 Stability Analysis Result

Embankment Height (m)	Cohesion of Grand cu (kN/m2)	Min. safety factor	
		Slope=1:2.0	Slope=1:3.0
4	26.7	1.378	1.457
4	25.0	1.321	1.368
4	22.0	1.174	1.211
4	20.0	1.075	1.107

Source: JICA Study Team



Source: JICA Study Team

Figure 4.9 Cohesion and safety factor

(2) Soft Ground

The cone resistance of less than 0.8Mpa is corresponding as soft ground.

The most soft ground is qc=0.3Mpa of GL.-3.0m at DCT-1 point in n-6 area. Embankment shape will be examined at this point.

1) Analytical parameter

The strength of soft ground at this point will be found as using foresaid formula Eq.2 and Eq.3.

Table 4.5 Analytical Parameter(2)

Parameter	Embankment	Soft grand
Saturated density ρ_{sat} (kN/m^3)	20.2	18.0
Wet density ρ_t (kN/m^3)	19.1	18.0
cohesion c_u(kN/m^2)	10.0	15.0
Internal friction angle φ_u(deg)	0.0	0.0

Source: JICA Study Team

2) Water level condition

Set residual water level condition at depression head.

3) Embankment shape

Set three kinds of height as H=2.0m, 3.0m, 4.0m.

Set two kinds of slope gradient as 1: 2.0 and 1: 3.0.

Set crest width as 4.3m.

4) Result of calculation

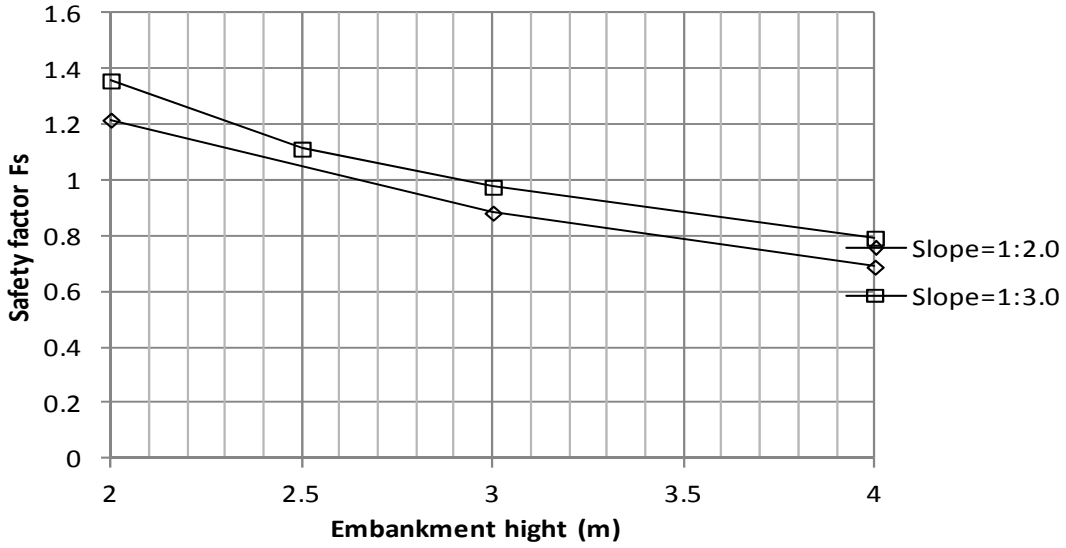
The required safety ratio of 1.2 cannot be satisfied in case of height of more than 2.0m as shown in the Table below.

Table 4.6 Minimum safety factor with embankment height on soft ground

Embankment Height (m)	Min. safety factor	
	Slope=1:2.0	Slope=1:3.0
4	0.688	0.792
3	0.882	0.975
2.5	-	1.112
2	1.216	1.357

Source: JICA Study Team

The maximum height will be 2.0m at the gradient of 1:2.0, and 2.3m at the gradient of 1:3.0 as shown in Figure 4.10. Therefore, it is required that embankment alignment shall be changed to avoid the soft ground in case of further embankment height.



Source: JICA Study Team

Figure 4.9 Embankment height and safety factor

5. Method of Dry-Wet Cycle Test for Evaluating of Decrease of Local Durability on Submergible Embankment due to Repeated Submergence

5.1 Objectives of Test

Submergible embankment will be supposed to deteriorate gradually due to decrease of surface local durability under the condition of repeated submergence and drying process. This decrease of local durability is more strongly influenced by surface density reduction due to swelling and cracks through saturation and drying process if the compaction work of embankment was not carried out sufficiently.

The purpose of this test was to examine the relation between density and durability reduction through dry-wet cycle by evaluating unconfined compression strength as an indicator, using specimens compacted

with various degree.

5.2 Condition of Test

Optimum moisture content (W_{opt}) and maximum dry density (ρ_{dmax}) of the embankment material was obtained by corresponding compaction test. Local durability of embankment was evaluated by using unconfined compression strength as an indicator, therefore unconfined compression tests (UCTs) were carried out for 2 specimens per 1 cycle. Number of tests is presented in following table.

Table 5.1 Numer of Case and Tes

Case No.	Moisture Content	Degree of Compaction	Wet and Dry Condition	Number of Specimens for UCT	
D80-0a	Wopt	80%	None (already finished by compaction test)	2	
D80-0b			Wet	2	
D80-01			Wet → (Dry → Wet) x 1 cycle	2	
D80-02			Wet → (Dry → Wet) x 2 cycle	2	14
D80-04			Wet → (Dry → Wet) x 4 cycle	2	
D80-08			Wet → (Dry → Wet) x 8 cycle	2	
D80-16			Wet → (Dry → Wet) x 16 cycle	2	
D90-0a	Wopt	90%	None (already finished by compaction test)	2	
D90-0b			Wet	2	
D90-01			Wet → (Dry → Wet) x 1 cycle	2	
D90-02			Wet → (Dry → Wet) x 2 cycle	2	14
D90-04			Wet → (Dry → Wet) x 4 cycle	2	
D90-08			Wet → (Dry → Wet) x 8 cycle	2	
D90-16			Wet → (Dry → Wet) x 16 cycle	2	
D95-0a	Wopt	95%	None (already finished by compaction test)	2	
D95-0b			Wet	2	
D95-01			Wet → (Dry → Wet) x 1 cycle	2	
D95-02			Wet → (Dry → Wet) x 2 cycle	2	14
D95-04			Wet → (Dry → Wet) x 4 cycle	2	
D95-08			Wet → (Dry → Wet) x 8 cycle	2	
D95-16			Wet → (Dry → Wet) x 16 cycle	2	
D100-0a	Wopt	100%	None (already finished by compaction test)	2	
D100-0b			Wet	2	
D100-01			Wet → (Dry → Wet) x 1 cycle	2	
D100-02			Wet → (Dry → Wet) x 2 cycle	2	14
D100-04			Wet → (Dry → Wet) x 4 cycle	2	
D100-08			Wet → (Dry → Wet) x 8 cycle	2	
D100-16			Wet → (Dry → Wet) x 16 cycle	2	
Total				56	

Source: JICA Study Team

5.3 Preparation of Specimens

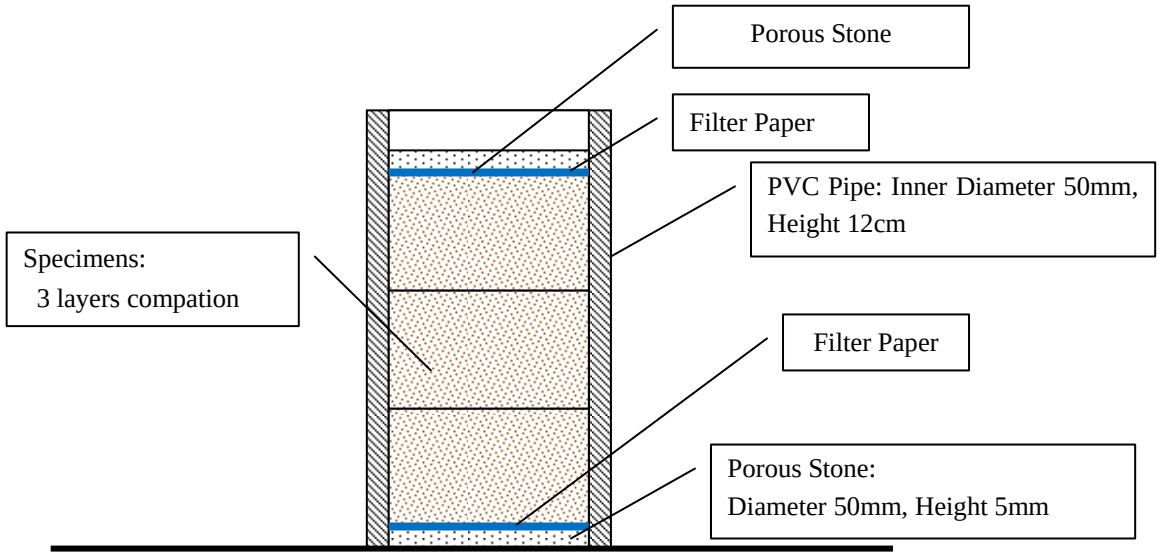
(1) PVC pipe of 50 mm diameter was cut to around 12 cm length as the mold for a specimen.

(2) Put a porous stone into the bottom of the PVC mold with a filter paper on it.

(3) Prepare embankment material which is corresponding to required density in the mold of 5 cm diameter and 12 cm height.

(4) Split the embankment material into 3 pieces and compact them inside the mold separately (4 cm thickness each x 3 layers) by a stick.

(5) Cover a filter paper with a porous stone on the specimens.



Source: JICA Study Team

Figure 5.1 Preparation of Specimens

5.4 Dry-Wet Cycle and Unconfined Compression Test

(1) The weight of the PVC pipe, porous stone and filter paper were measured before preparing specimens. Then, weight of the specimen was measured with the PVC pipe, porous stone and filter paper.

(2) The specimens were kept in water tank to be submerged for 3 days, then kept under the circumstance which is of high temperature, well ventilated and without direct sunshine to dry for 7days. A box with holes like next photograph was used for this drying.

(3) (2) and (3) were repeated as required.

(4) The specimens were thrust out from the PVC pipes and cut their upper and bottom portion by 1 cm to be formed. Then weight, height and diameter of the specimens were measured.

(5) Unconfined compression tests were carried out conforming to the standard of ASTM, and moisture contents were measured. Two specimens were tested for 1 case and 1 cycle, therefore, the unconfined compression strength was defined as the average of two specimens.

5.5 Results of Dry-Wet Cycle Test

Following table presents the relationship between unconfined compression strength and number of dry-wet cycles by degree of compaction.

Table 5.2 List of Test Results

Liquid Limit	Plasticity Index	Proctor Compaction Test		Degree of Compaction	Specimen Number	Wet and Dry Condition	Average Moisture Content	Unconfined Compression Test	
(%)	(%)	MDD (gm/cm^3)	OMC (%)	(%)			%	q_u (kPa)	Average q_u (kPa)
48	24	1.68	18.3	98%	D98-ob	Wet	25.7	97.6+97.1	**97.4**
					D98-01	1 cycle	26.0	93.9+93.7	**93.8**
					D98-02	2 cycle	26.1	91.2+87.6	**89.4**
					D98-04	4 cycle	26.6	73.7+74.6	**74.2**
					D98-08	8 cycle	26.8	64.3+59.6	**62.0**
					D98-16	16 cycle	27.9	57.4+55.8	**56.6**
				90%	D90-0b	Wet	27.5	90.8+82.1	**86.5**
					D90-01	1 cycle	28.2	63.0+65.7	**64.4**
					D90-02	2 cycle	28.7	56.5+56.0	**56.3**
					D90-04	4 cycle	29.0	51.1+52.7	**51.9**
					D90-08	8 cycle	29.5	49.2+45.2	**47.2**
					D90-16	16 cycle	30.3	36.8+36.8	**36.8**
				80%	D80-0b	Wet	33.5	70.5+70.1	**70.3**
					D80-01	1 cycle	36.0	16.2+16.3	**16.3**
					D80-02	2 cycle	36.7	14.3+14.3	**14.3**
					D80-04	4 cycle	--	Not Possible	**--**
					D80-08	8 cycle	--	Not Possible	**--**
					D80-16	16 cycle	--	Not Possible	**--**

Source: JICA Study Team