附録

附録 3-1

ワーキンググループ運営ガイドライン

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.

附録 3-2
議事録

附録 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	01753903133	
2.	Md. Afzal Hossain ADG (P)	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-we6.com.	
6	Yasuhiro AZUMA	JICA STUDY TEAM	01982272808	
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 Mead. CE/Hydrology	BWDB	01726-064204	10/12/12
14.	Md. Ferdous CE, NE & Coordn.	BWDB	01715292829	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	01714-003067	10/12/12

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Sl.No.	Name and Designation	Organization	Contact no./email	Signature
18.	Musa Nurur Rahman	XEN, BWDB	01715 440505	10.12.12
19	Dr. Shamal Chandra Das XEN, Office of the C.E.	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	Tanvir Saif Ahmed 10.12.12
22	Tania Mostafa	BWDB	01553562001	Tania 10.12.12
23	Md. Mustabizur Rahman	BWDB	01736790168	10.12.12
24.	Md. Afroz Hossain	Planning-1, BWDB	01818-614543	Afroz
25	Naoki Matsumura	JICA Bangladesh office	01714138111	

附録 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 Kohno MLIT Team Leader	JICA Study Team	017-6200-1507/ a27376@n-koei.co.jp	
3	Fazlur Rashid	BWDB	9551088 fazlurc4@gmail.com	
4	Nurul Islam	JICA Study Team	017-13121425 a49800@n-koei.co.jp	
5	Yasuhito AZUMA	JICA Study Team	019-82272808 a37698@n-koei.co.jp	
6	Gilberto Gandi	JICA STUDY Team	gandi2@hotmail.com	
7	Michio Ota	JICA Expert	monarbo7810@gmail.com	
8.	Musa Nusrat Rahma	XEN, Planning-I BWDB	mnrplanning1@gmail.com	10.12.12
9.	Nazneen Aktar	Sr. Professional CESD, CEGIS	naktar@cegisbd.com	Nazneen 10.12.12
10.	Md Shahadat Hossain Chowdhury	Professional CEGIS.	lodwing4roshul@gmail.com	MSH 11.12.12
11.	TANJIR SAIF AHMED	AE, BWDB	01716453997	10.12.12

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

OPERATIONAL GUIDELINE FOR WORKING GROUP

1. General

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(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
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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
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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.

附録 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	a2737@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	太田
4	Mohle Fida A. Khan Director, PCSD, CEGIS	CEGIS	mkhan@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 Munir Rahman, XEN	BWDB	01715 7405 05	23.12.12
8.	Mohammad Akbar Hossain, Research Officer	Planning-I, BWDB	01818-614543 akbargazi@yahoo.com	

附録 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.

31/13
(Musa Nurur Rahman)
Executive Engineer
Planning -1
BWDB, Dhaka.

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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 Kunamoto	JICA Study Team	+880-17-[illegible]157	
2.	Tesuhiro AZUMA	JICA Study Team	a37692@nkoei.co.jp	
3.	Michio Ota	JICA Expert	monarbo7410@gmail.com	
4.	[illegible]	JICA Study Team	a4980@n-koei.co.jp	
5	Gilberto Canali	JICA STUDY TEAM	gecanali@comcast.net	
6.	Musa Nurur Rahman, KEN	BWDB	01715 7405 05	14.1.13
7	Mahbub Uddin A. Khan	CEGIS	01819261274	
8.	Mohammad Akbar Hossain (Research officer)	BWDB	01818-614543	

附録 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, Pl-1, BWDB
4	Tanjir Saif Ahmed	Assistant Engineer, Pl-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

附録 **4-1**
BWDB による河川横断データ

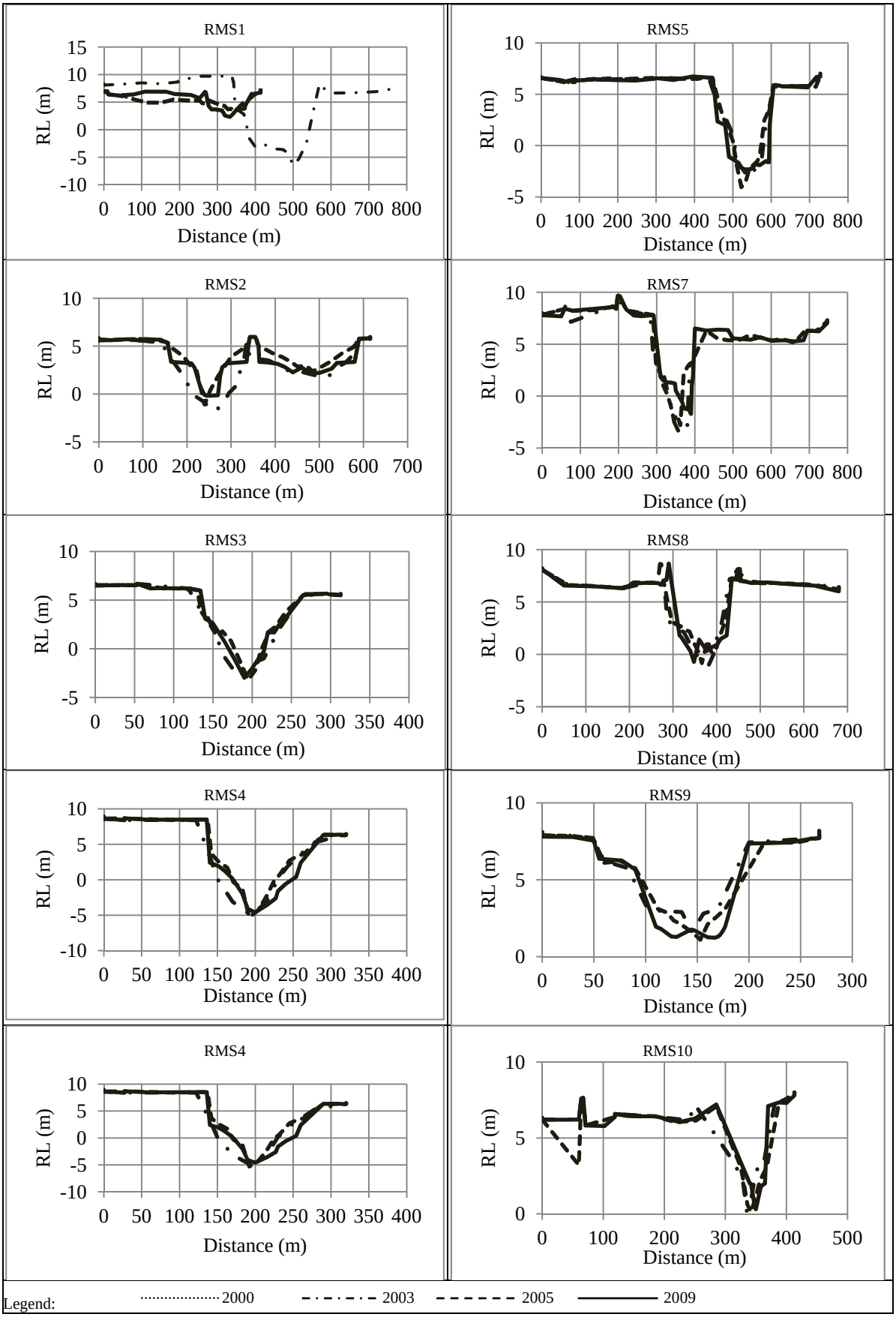


Figure A-1 Histrical River Cross Section of Surma River (1/5)

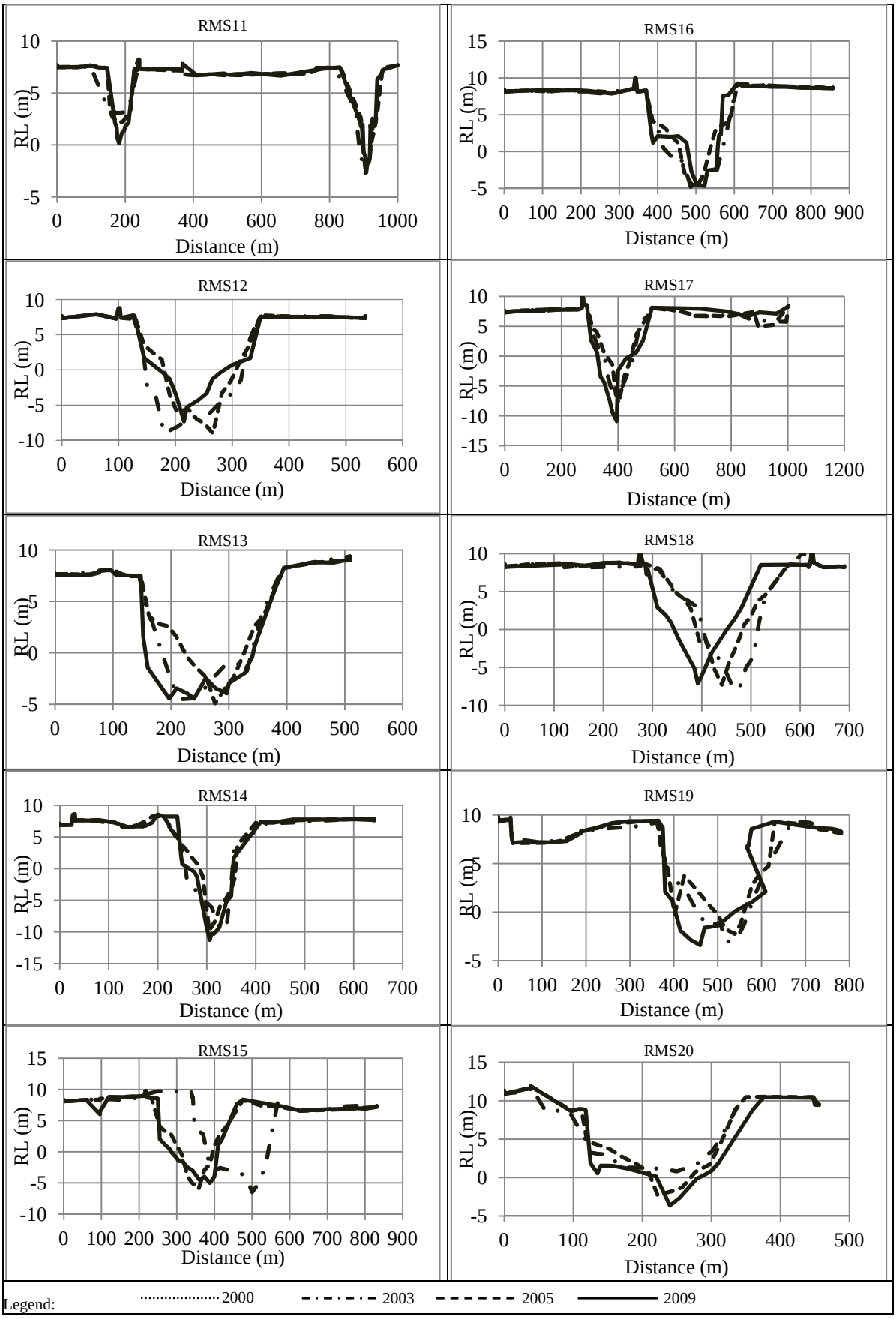


Figure A-1 Histrical River Cross Section of Surma River (2/5)

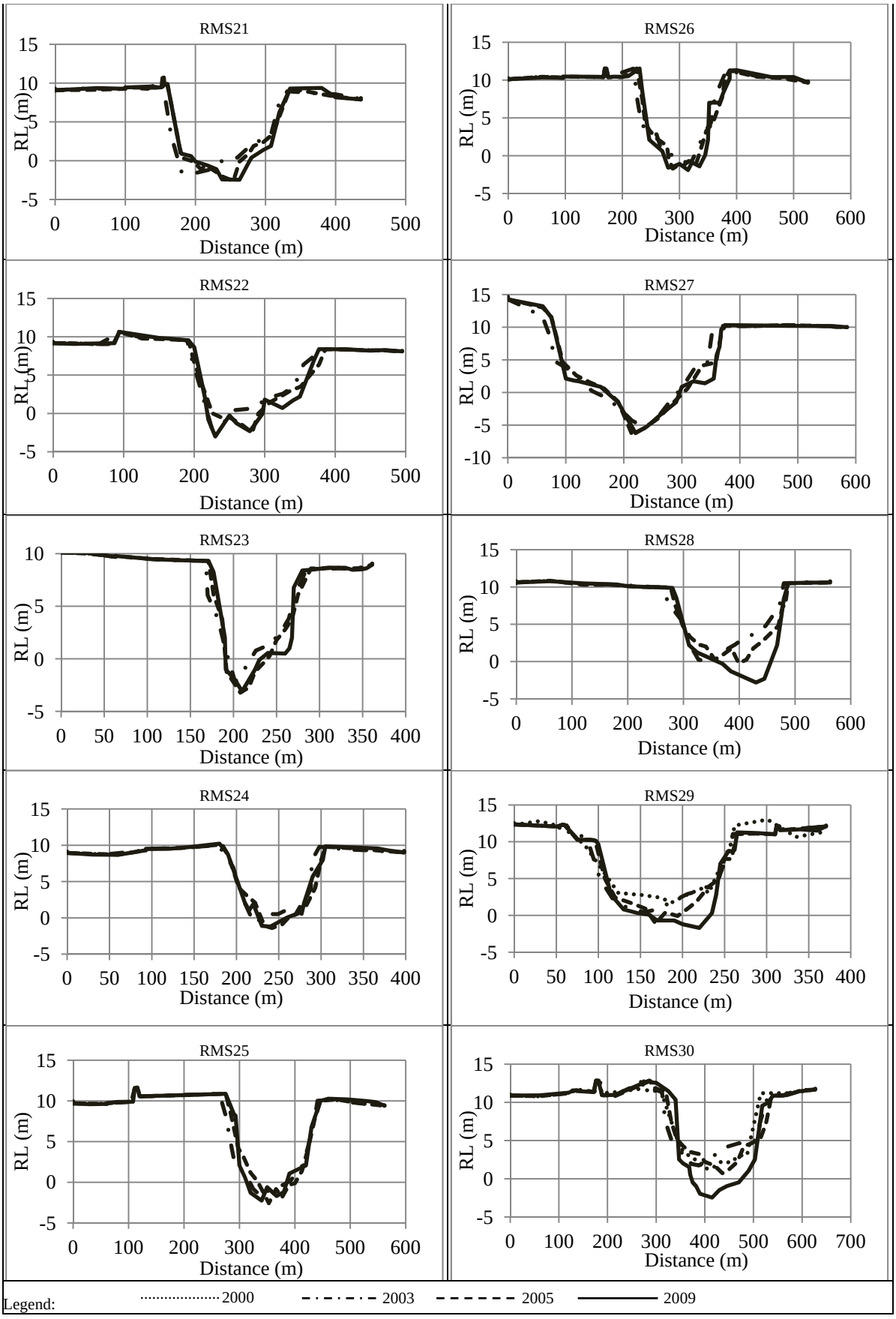


Figure A-1 Histrical River Cross Section of Surma River (3/5)

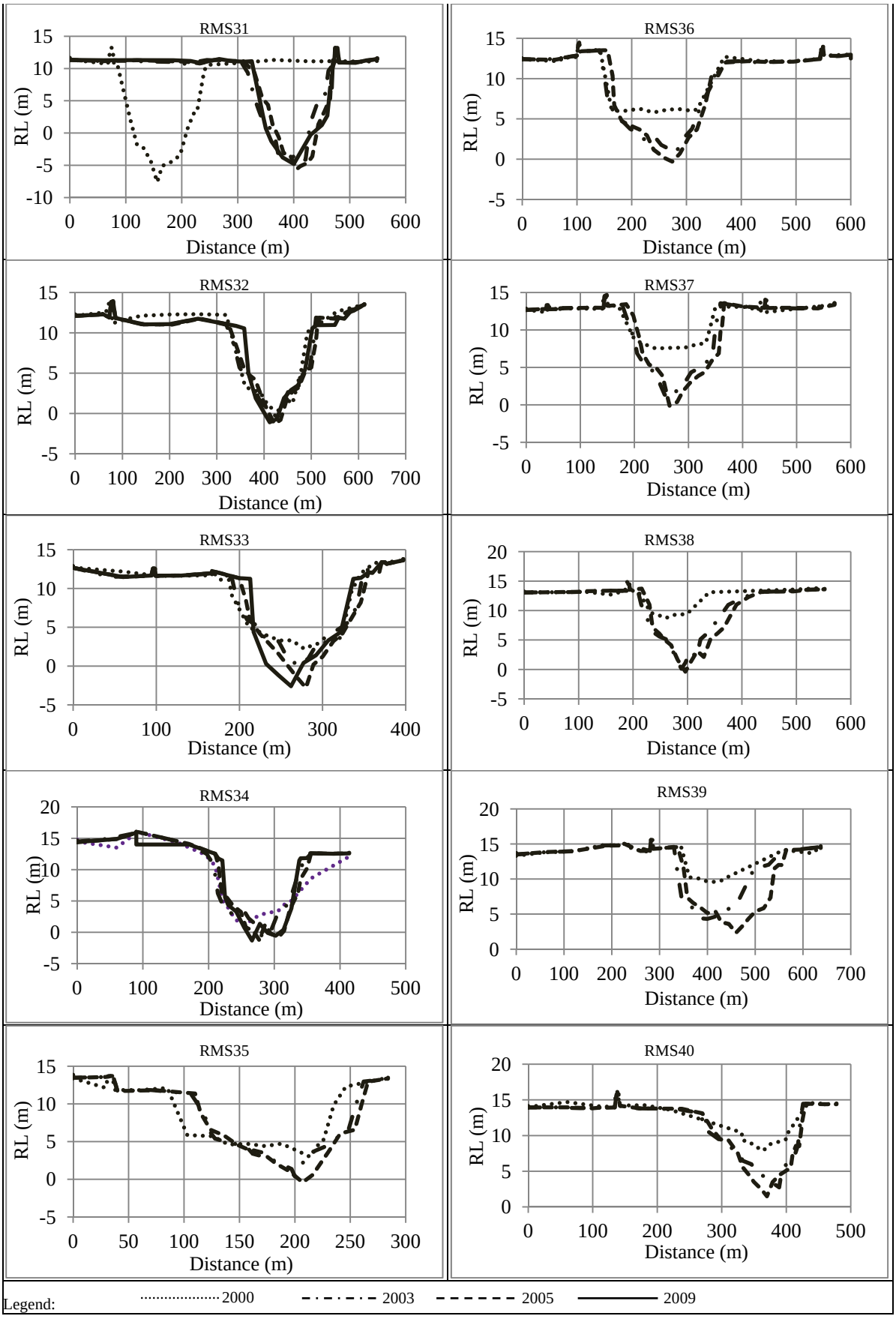


Figure A-1 Histrical River Cross Section of Surma River (4/5)

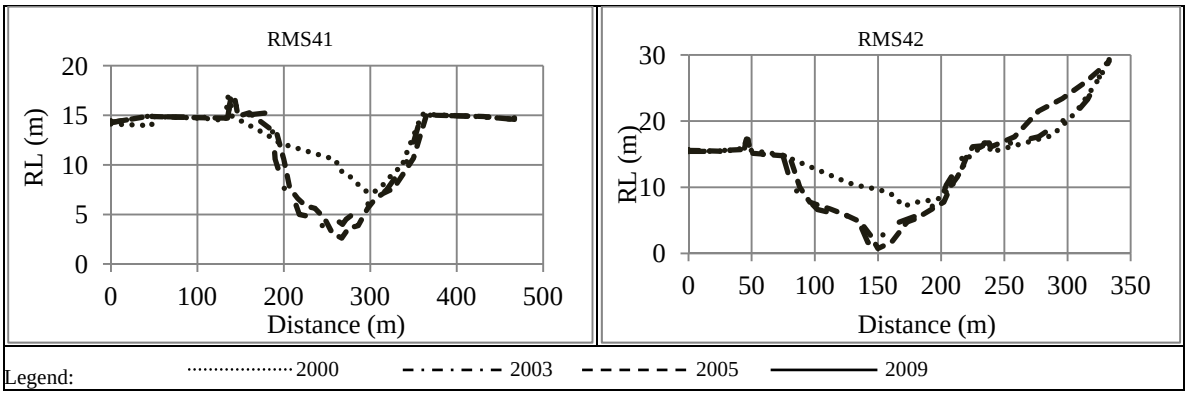


Figure A-1 Histrical River Cross Section of Surma River (5/5)

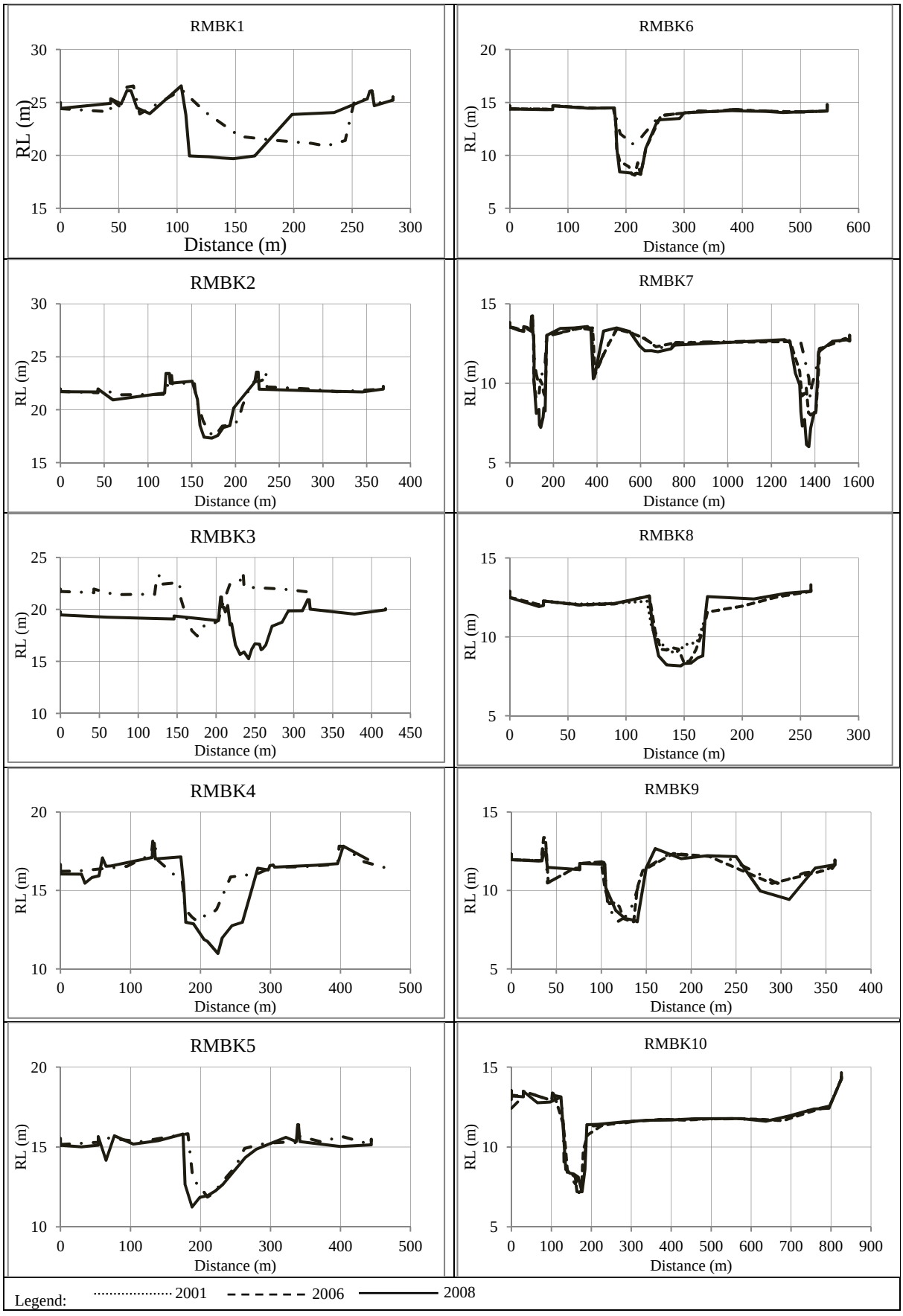


Figure A-3 Histrical River Cross Section of Bogai-Kangsha River (1/3)

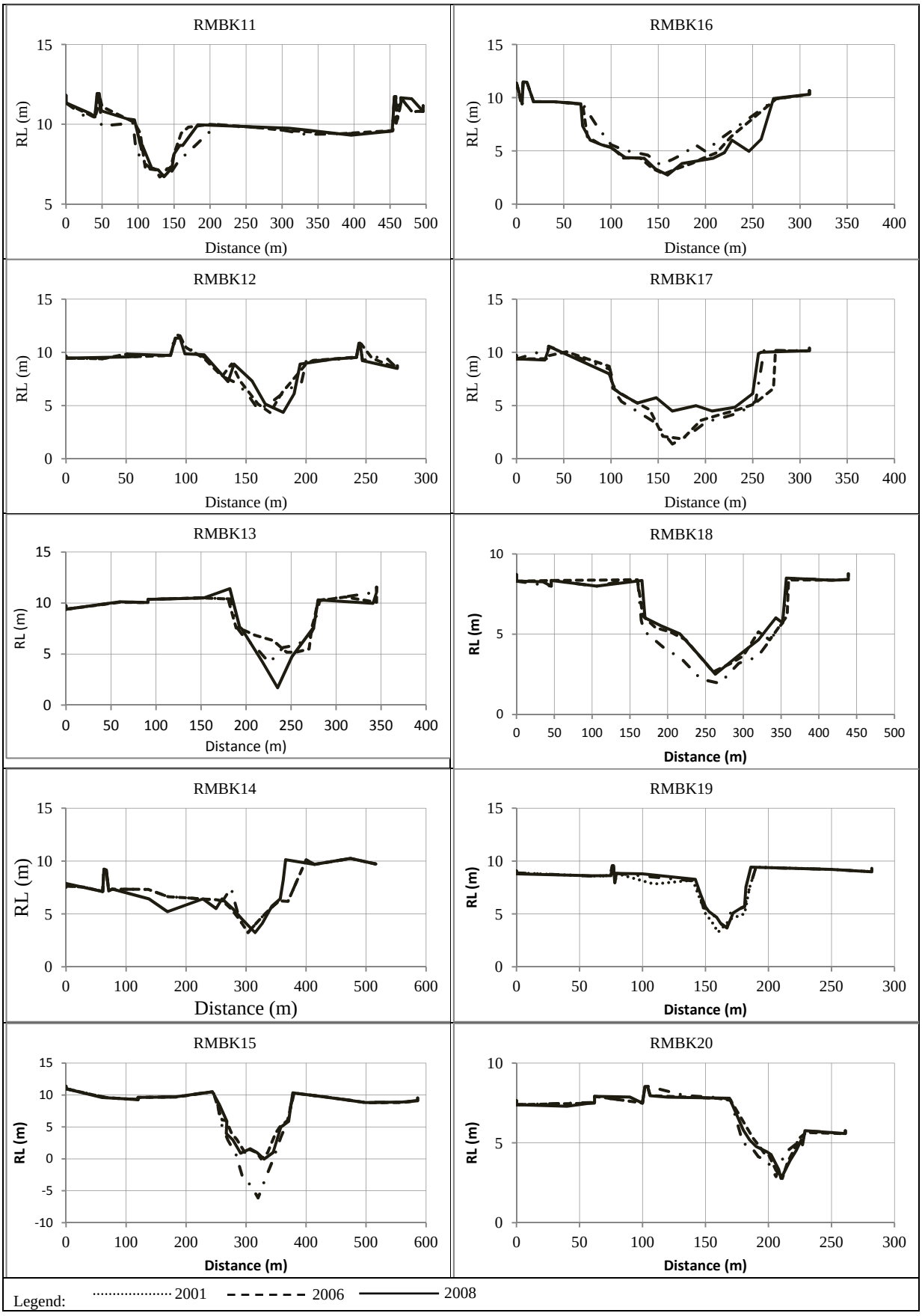


Figure A-3 Histrical River Cross Section of Bogai-Kangsha River (2/3)

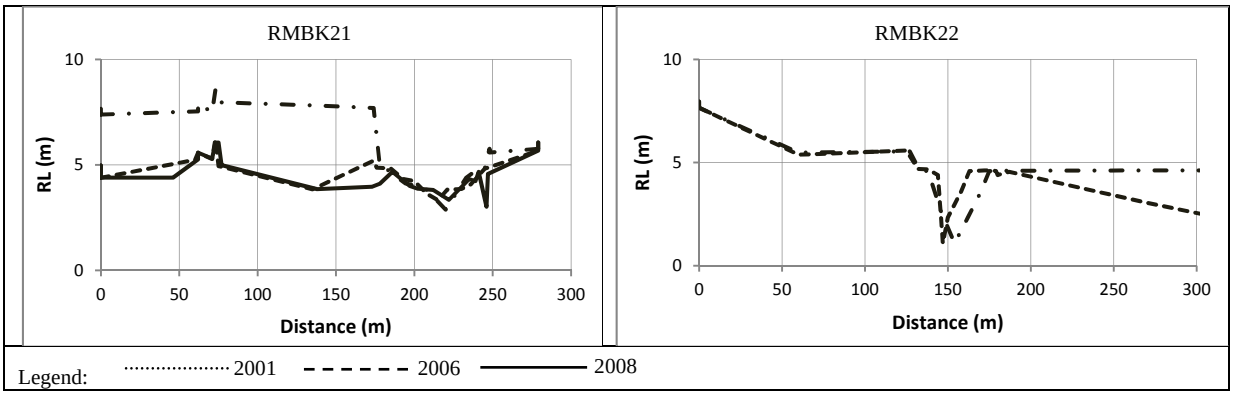


Figure A-3 Histrical River Cross Section of Bogai-Kangsha River (3/3)

附録 **4-2**

地盤調査・土質試験結果の分析

1. ボーリング調査及びオランダ式コーン試験による土質区分

1.1 N値による土質区分

表 1.1 にボーリング調査の標準貫入試験値と土質記載を簡略的に示す。

粘性土のN値の区分は表 1.2 のコンシステンシーとの関係より、N=<4、N=5~8、N>8 の 3 区分に分けた。これは、N 値が 4 以下の粘性土は圧密沈下や円弧すべりの問題が生じると考えられ、N 値８以上は固い地盤であり、土質的にあまり問題を起こさない地盤である。N値=5~8 の地盤は盛土高さが高いような場合は、N 値４以下と同様検討対象地盤としなければならないが、堤防高がほぼ４m以下ならば、問題が少ない地盤と扱うことができる。また、N値 20 以上あれば杭の支持基盤として考えることができる。

砂地盤のN値の区分は表 1.3 の密度との関係より、N=<10、N=11~29、N=30~49、N>=50 の 4 区分に分けた。N値 10 以下は軟弱な砂層であり、N 値 30 以上は杭の支持地盤と考えることができる堅固な地盤である。ハオール地域は N=11～29 の問題が少ない砂質地盤である。

ハオール地域の地盤は表層３m以内に軟弱なシルト層があり、下位になるにつれコンシステンシーが大きくなり、深度 10m前後から砂層と変わる。n-6, n-9, n-13, n-17, n-18, r-7, r-9 地点はこのような典型的な土層特性を示している。

一方、n-2 地点は深度 3m まで軟弱な砂層と粘土層があり、3m 以深は上記と同じ地層構成となっている。r-1 地域は深度 1~3m に中位のコンシステンシーの層を挟み、軟弱な地層が 6.5mまで他の地点より深い。r-8 地域は深度 4m まで軟弱な砂層で、その後深度が深くなるにつれ、堅固な地盤に変化していく、粘性土が存在しない地点である。

n-6 と n-13、n-9 と r-8 のように地域が近くても土質構成が異なり、大きな地域区分で地層構成を見ることは困難である。

表 1.2　粘性土のコンシステンシーによる区分

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

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

表 1.3　砂質土の密度区分

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

出典：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)

表 1.1　N 値による土質区分

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

出典：JICA 調査団

1.2　オランダ式コーン貫入試験（貫入抵抗値）による土質区分

表 1.4 にオランダ式コーン貫入試験からの土質分類結果を示す。図 1.1 には同一事業地域のＮ値とコーン貫入抵抗値 qc の深度分布図を示す。表 1.4 における軟弱地盤及び支持地盤の定義は表 1.5 に示すとおりである。

表 1.5　軟弱地盤と支持地盤の区分

	Soft grand	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

出典：JICA 調査団
* 表 1.2、1.3 の Soft、Loose の区分による
* Bearing statum は一般的な杭基礎の支持層に必要とされる N 値

表 1.4　N 値およびコーン貫入抵抗値による土質区分

Depth (m)	n-2 N value	n-2 DCT-1	n-2 DCT-2	n-2 DCT-3	Depth (m)	n-6 N value	n-6 DCT-1	n-6 DCT-2	n-6 DCT-3	Depth (m)	n-9 N value	n-9 DCT-1	n-9 DCT-2	n-9 DCT-3	Depth (m)	n-13 N value	n-13 DCT-1	n-13 DCT-2	n-13 DCT-3	Depth (m)	n-17 N value	n-17 DCT-1	n-17 DCT-2	n-17 DCT-3	Depth (m)	n-18 N value	n-18 DCT-1	n-18 DCT-2	n-18 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

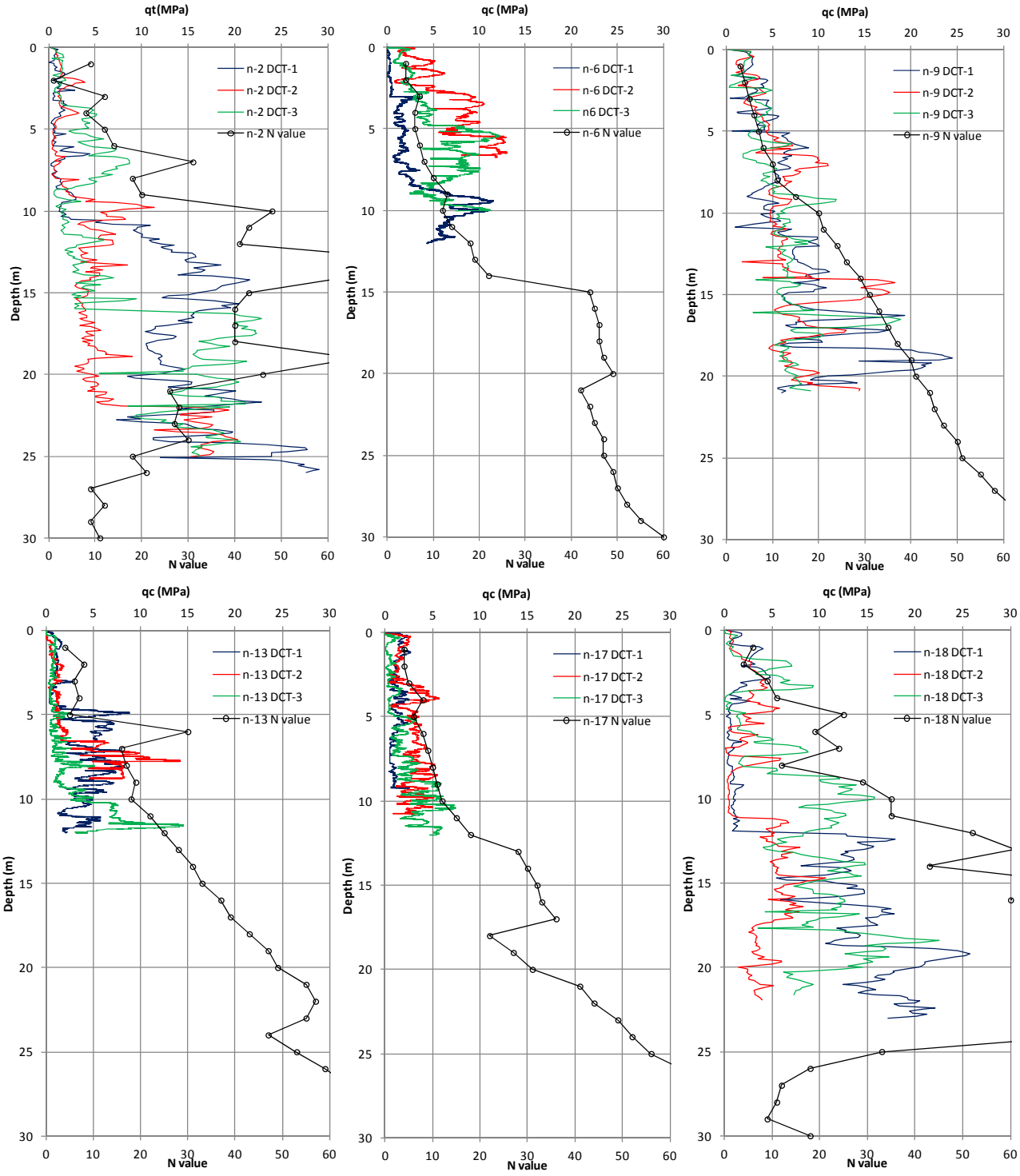
Silt		N=<4	qc<=0.8Mpa
		N=5~8	qc=0.8~3Mpa
		N>8	qc>3Mpa
Clay		N=<4	qc<=0.8Mpa
		N>8	qc>3Mpa

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

出典：JICA 調査団



出典：JICA 調査団

図 1.1　N 値とコーン貫入試験の深度分布

2. 土質特性

2.1 深度方向分布

図 2.1 にはボーリング調査(N 値、コーン抵抗値、透水係数)と室内土質試験結果の深度方向の分布を示す。

N値は軟弱地盤、中間層、支持地盤と階段状に増減するものと直線的に増加するものがある。N値４以下もしくは 10 以下の軟弱層は 10m以浅と浅い。コーン抵抗値 qc は qc<0.8Mpa の軟弱な地層は 10m以浅で、3m以浅が多い。

湿潤密度、乾燥密度、間隙比に関するデータは５m以浅に限られている。湿潤密度は 1.6～2.0g/cm3 と大きくばらついており、同様に乾燥密度も 1.1～1.7g/cm3 とばらついている。間隙比は 0.8 前後と 1.2～1.4 の２つに分類される。これから、間隙比をパラメータに土性を評価することが可能である。含水比も 22～42%とばらつきが大きい。

深度５mまでに細粒分（<0.075mm）を 100%近く含むものが多く、深度 10m以深では砂が多くなっている。深度 5～10m には 30%程度の砂分を含んだ粘性土があり、これが中間層となっているシルト層に相当する。

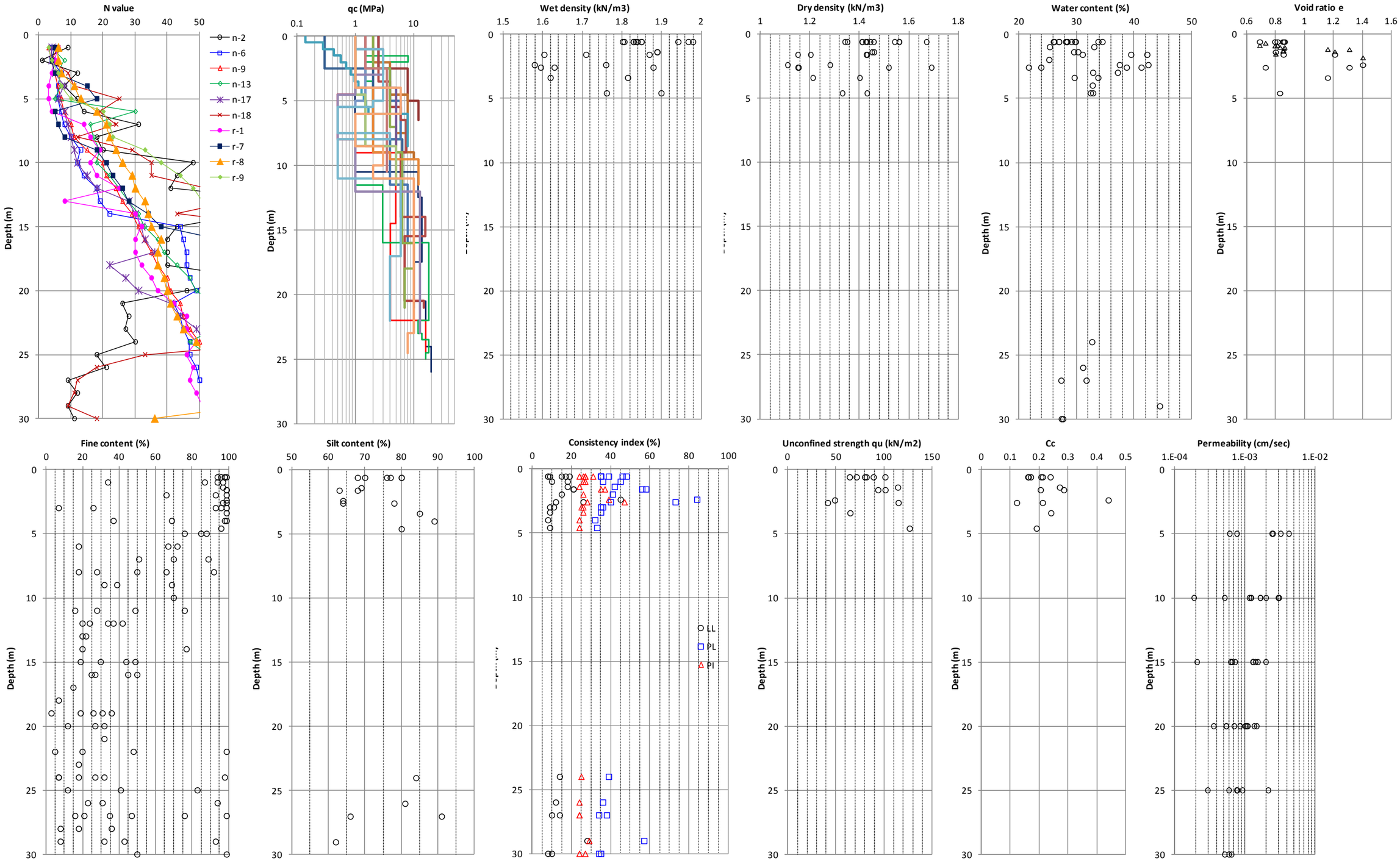
５m以浅のシルト層の密度の代表値としては、乾燥密度 1.4g/cm^3、含水比 30%、湿潤密度 1.8g/cm^3、間隙比 0.85 と設定される。シルト層はシルト分(0.075~0.002mm)を 65～90%と極めて多く含み、粘土分(2μ 以下)が少ない。

液性限界 w_L 及び塑性限界 w_P は表層から深度が深くなるにつれ小さくなる傾向があり、その差である塑性指数 PI は 25%前後の値で一定している。液性限界が大きくなっているものは有機質土を含む粘性土である。24m 以深の粘性土は深度 4~5mの粘性土と同じ値となっている。

一軸圧縮強度 qu は 40~130kN/m^2 とばらついており、深度方向の傾向が認められない。

圧縮指数 Cc は 0.12~0.3 位でばらついており、0.2 が代表値となっている。粘性土としては小さな値であり、圧密沈下量が少ないと想定される。ひとつだけ大きな Cc は有機質土を含んだ粘性土である。

透水係数は 10^{-4}~10^{-3}cm/sec 台の値であり、深度が深くなるにつれ小さくなる傾向が僅かに認められる。透水係数が小さなものはシルトが多いものでありであり、大きなものは砂が多いと考えられる。



出典：JICA 調査団

図 2.1　土質特性の深度分布

2.2　物性値

(1) 粒度分布

図 2.3 に粒度曲線を示す。

粒度は粘性土と砂の２種類に分かれる。

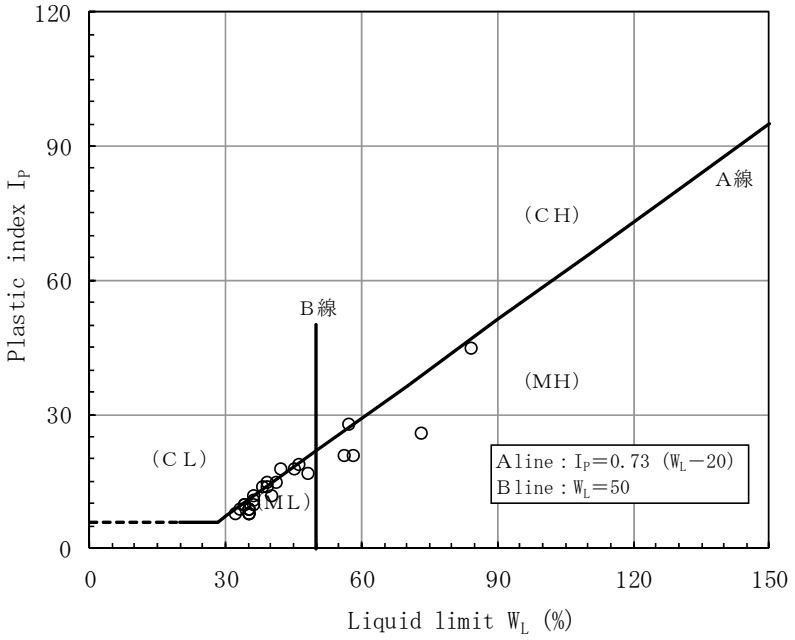
粘性土の粒度は細粒分が 90%以上と非常に多く、その中でも 0.075~0.002mm のシルトが卓越しており、粘性土分(2μ 以下)は 10~40%と少ない。

砂分は最大粒径が 2mm だが、ほとんどは 0.4mm 以下の中砂である。

注）上記の粒径区分は British Standard に基づく

(2) 塑性図

図 2.2 に塑性図を示すが、殆どの土は低液性限界のシルト(ML)であり、一部高液性限界のシルト(MH)となっている。



出典：JICA 調査団（Plastic Chart は British Standard に基づく）

図 2.2　塑性図（Plastic Chart）

(3) 土質定数間の相関

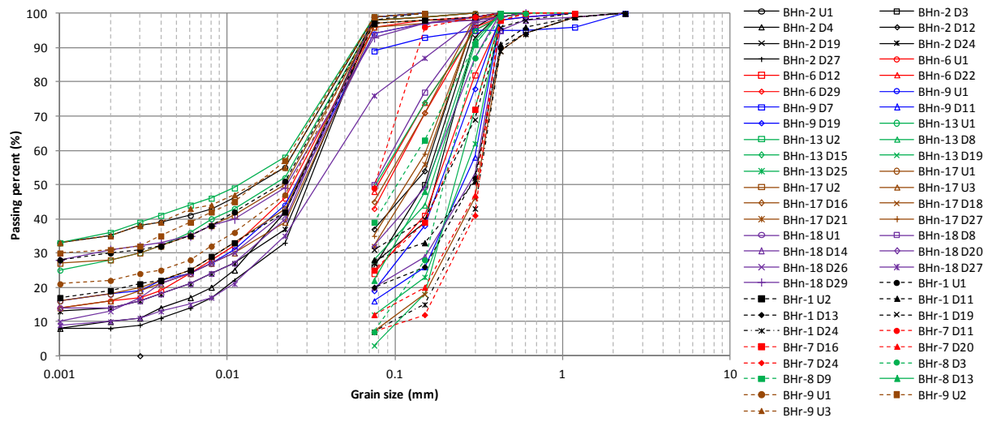
図 2.4 には各土質定数間の相関図を示す。

乾燥密度とは間隙比が一番相関が高く、次に含水比が相関が高い。一軸圧縮強度は間隙比との相関関係が認められる。

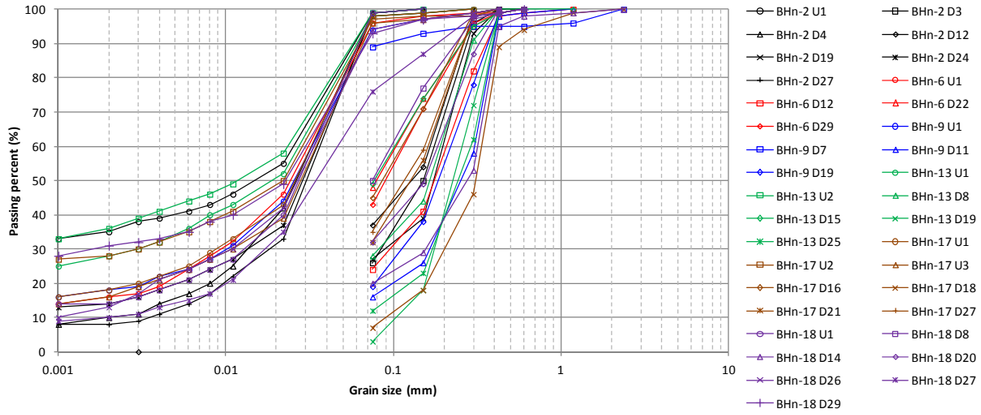
圧縮指数は Skempton が Eq.1 の液性限界との相関があるとしている。

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

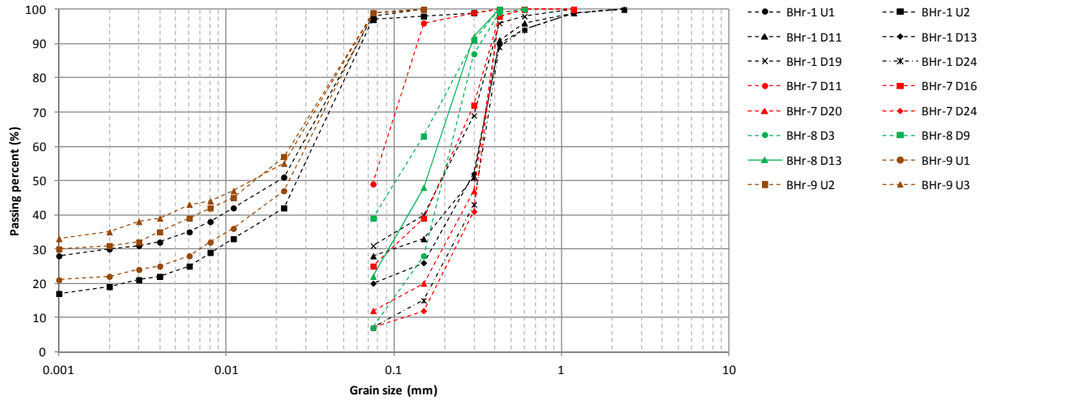
相関関係は Skempton の式よりも小さい関係となっている。圧縮指数と相関関係が高いのは間隙比である。



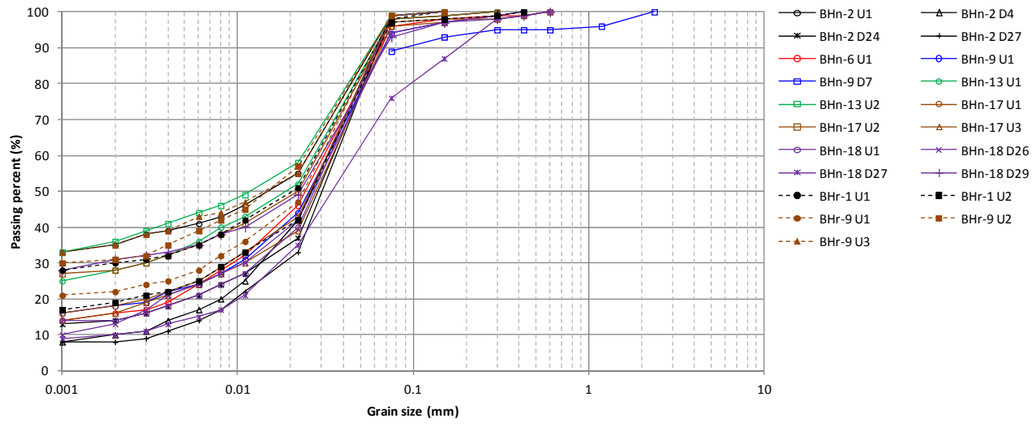
(a) All data



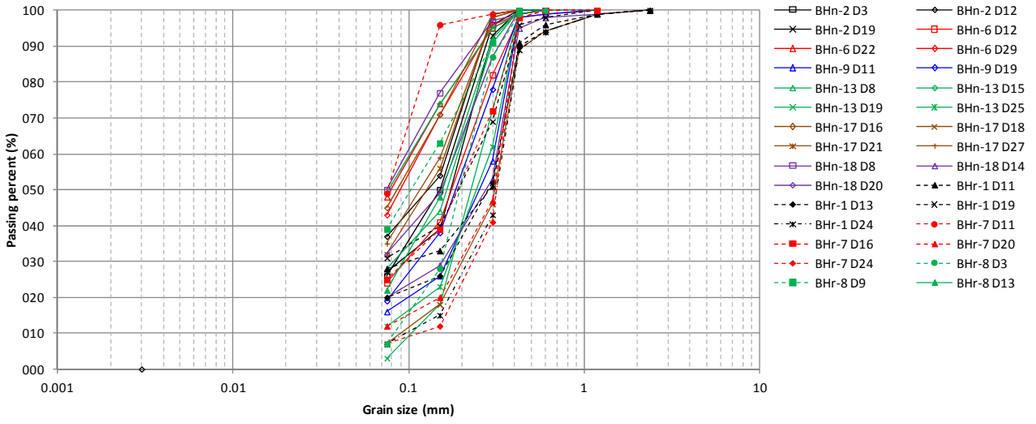
(b) New construction



(c) Rehabilitation



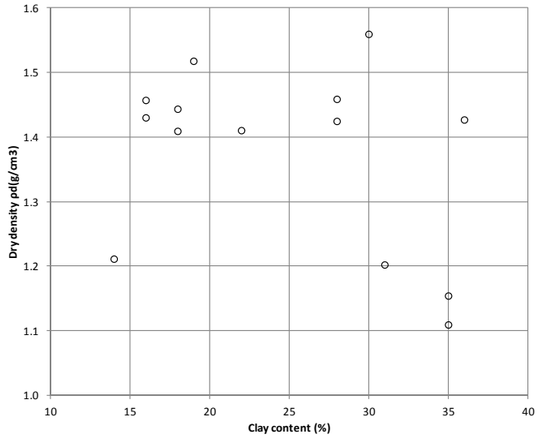
(d) Clay



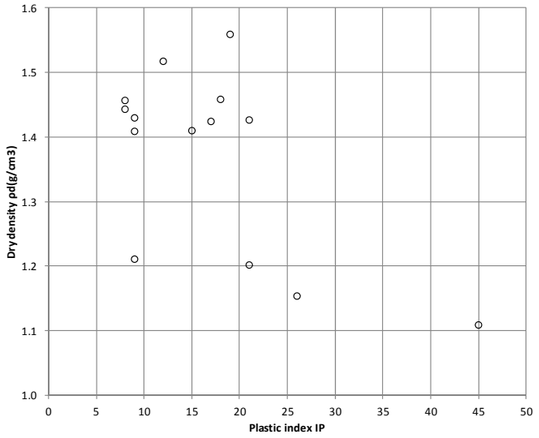
(e) Sand

出典：JICA 調査団

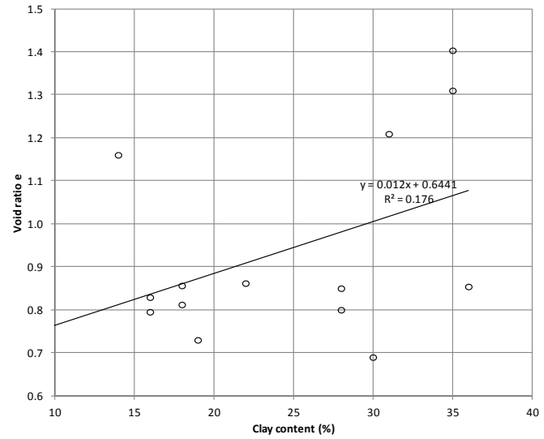
図 2.3　粒度分布



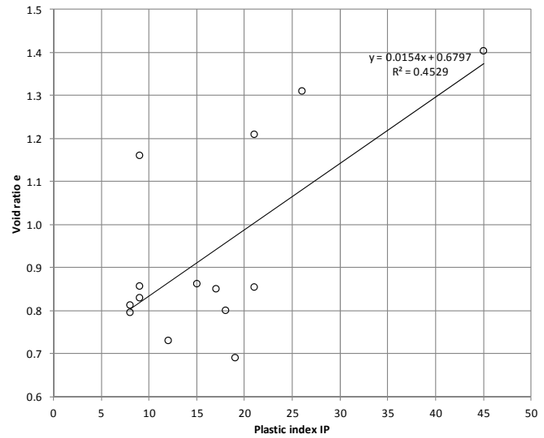
(1) Clay content and Dry density



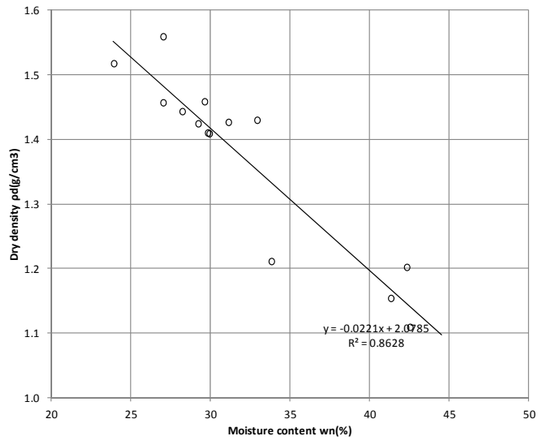
(2) Plastic index and Dry density



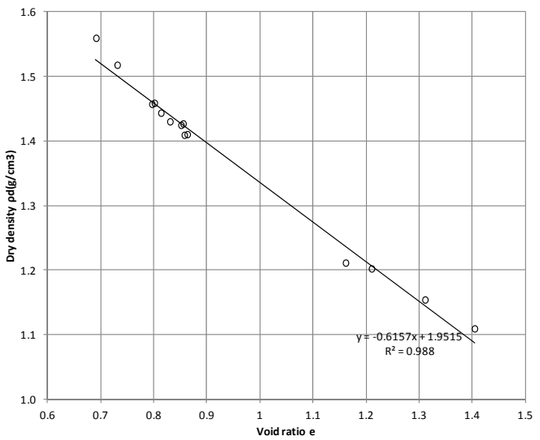
(3) Clay content and Void ratio



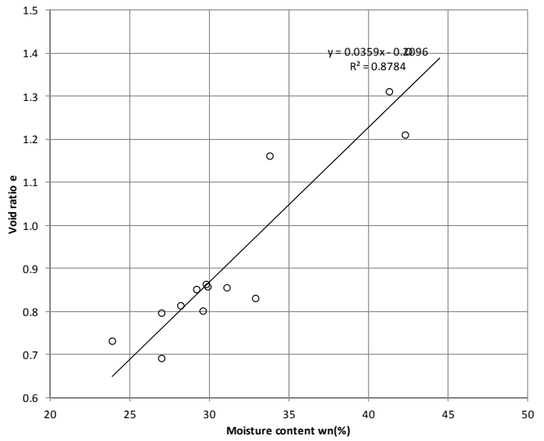
(4) Plastic index and Void ratio



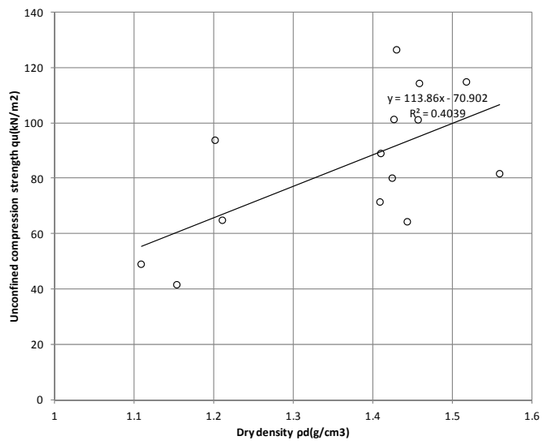
(5) Moisture content and Dry density



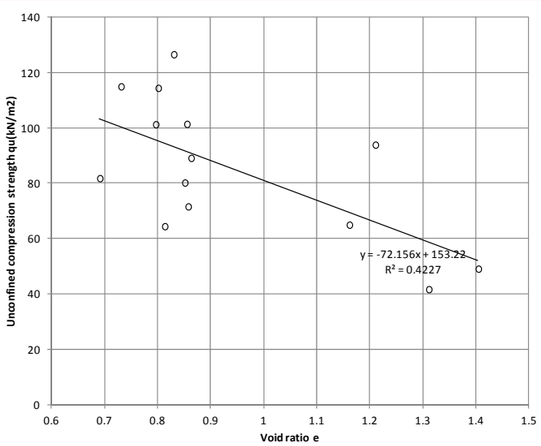
(6) Void ratio and Dry density



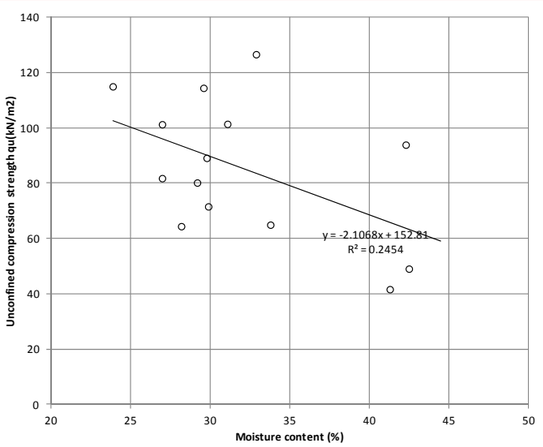
(7) Moisture content and Void ratio



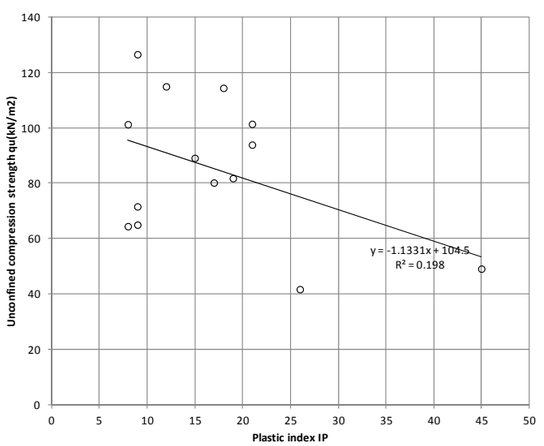
(8) Dry density and Unconfined compression strength



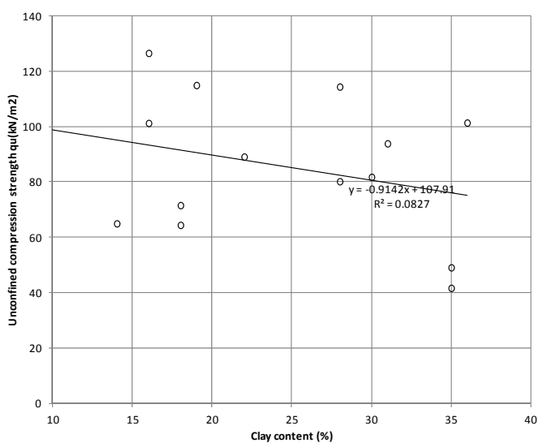
(9) Void ratio and Unconfined compression strength



(10) Moisture content and Unconfined compression strength



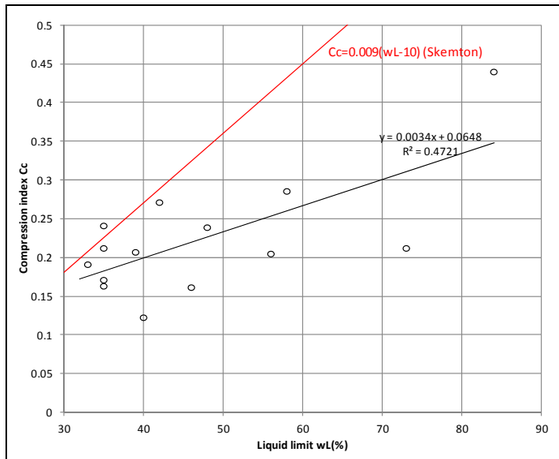
(11) Plastic index and Unconfined compression strength



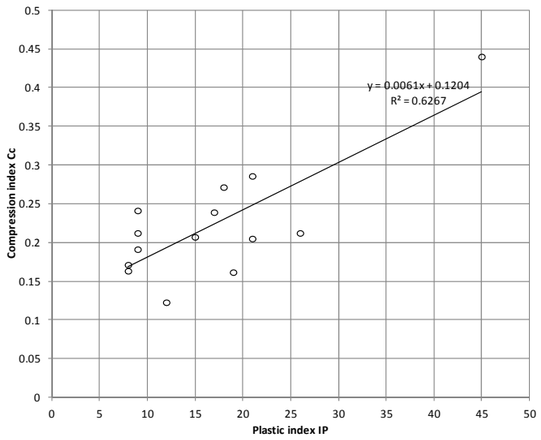
(12) Clay content and Unconfined compression strength

出典：JICA 調査団

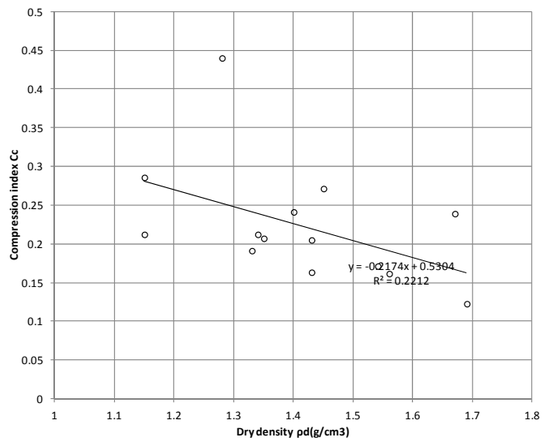
図 2.4(1)　土質定数間の相関



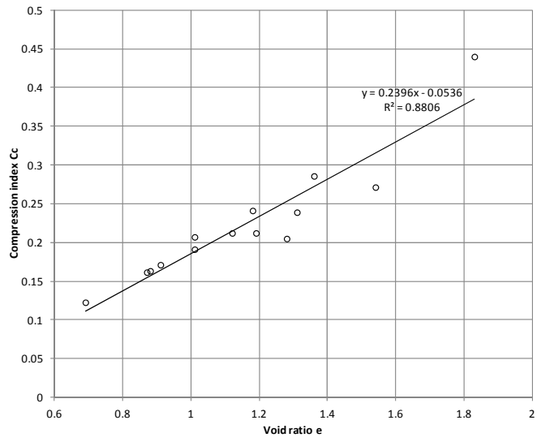
(13) Liquid limit and Compression index



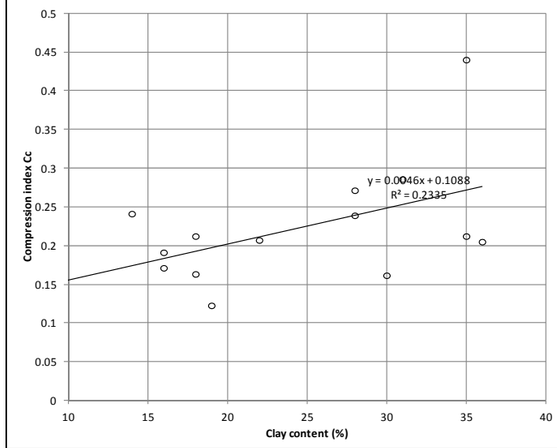
(14) Plastic index and Compression index



(15) Dry density and Compression index



(16) Void ratio and Compression index



(17) Clay content and Compression index

出典：JICA 調査団

図 2.4(2)　土質定数間の相関

SUMMARY OF SOIL TEST RESULTS(1)

Bore Hole No.	Sample No. Tested	Depth of Sample	Wet Unit Weight	NMC	Dry density	Void Ratio	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
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 (m)	Wet Unit Weight (kN/m³)	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		Consolidation Test					Organic Content by Loss-on Ignition %	Coefficient of Permeability (cm/sec)
															q_u (kPa)	SF (%)	Cc	Specific Gravity	Dry Density (g/cm3)	Moisture Content (%)	Initial Void Ratio		
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									

出典：JICA 調査団

2.3 土質定数

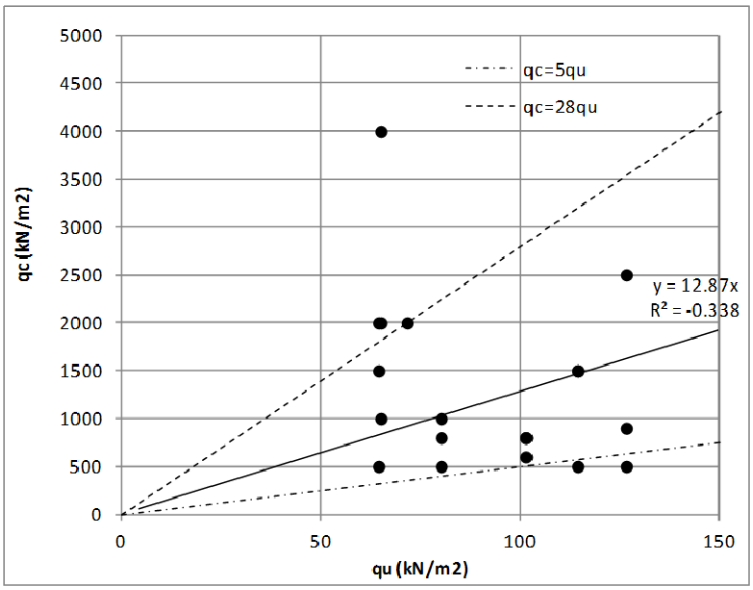
軟弱なシルト層については土質試験結果及びオランダ式コーン貫入試験値より粘着力を設定した。日本道路協会「道路土工　軟弱地盤対策工指針」によると、一軸圧縮強度 qu とコーン貫入抵抗値 qc との関係は Eq.1 となっている。

$$qu=(1/10\sim1/15)qc \qquad \text{(Eq.1)}$$

室内試験の一軸圧縮強度と同じ地区の同深度付近で実施したコーン貫入抵抗値の相関関係を求めると、同一地点での試験値でないためばらつきが大きいが、Eq.1 の範囲内となっている。そこで、コーン貫入抵抗値から得られる一軸圧縮強度の推定式は Eq.2 を用いることとした。粘着力は cu=qu/2 となるので、Eq.3 から推定する。

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

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



出典：JICA 調査団

図 2.5　コーン貫入抵抗値と一軸圧縮強度の関係性

中間層及び支持層の強度は、粘性土はオランダ式コーン貫入試験値、砂層の内部摩擦角は経験式 $\phi=(15N)^{0.5}+15$ より推定した。密度については代表的な値を仮定した。なお、内部摩擦角 ϕ とコーン抵抗値との関係は Eq.4 の推定式となる(BS EN 1997-2:2007)。

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

表 2.1　土質定数の設定

	軟弱層	中間層		支持層	
	シルト層	シルト層	砂層	シルト層	砂層
比重　Gs	2.65	2.65	2.65	2.65	2.65
湿潤密度　ρ_t(kN/m^2)	18	19	21	19	21
乾燥密度　ρ_d(kN/m^2)	13	14.5	17.5	15	18
含水比　w_n(%)	38	30	20	25	20
間隙比　e	1.0	0.8	0.5	0.7	0.5
コーン貫入値　q_c(kN/m^2)	800	1,500	―	4,500	―
N 値	―	―	20	―	30
一軸圧縮強度　q_u(kN/m^2)	53	100	0	300	0
粘着力　c_u(kN/m^2)	27	50	0	150	0
内部摩擦角　φ(deg)	0	0	32	0	36
圧縮指数　Cc	0.2	0.1	―	―	―
圧密係数　c_v(m^2/day)	1x10^{-2}	1x10^{-2}	―	―	―

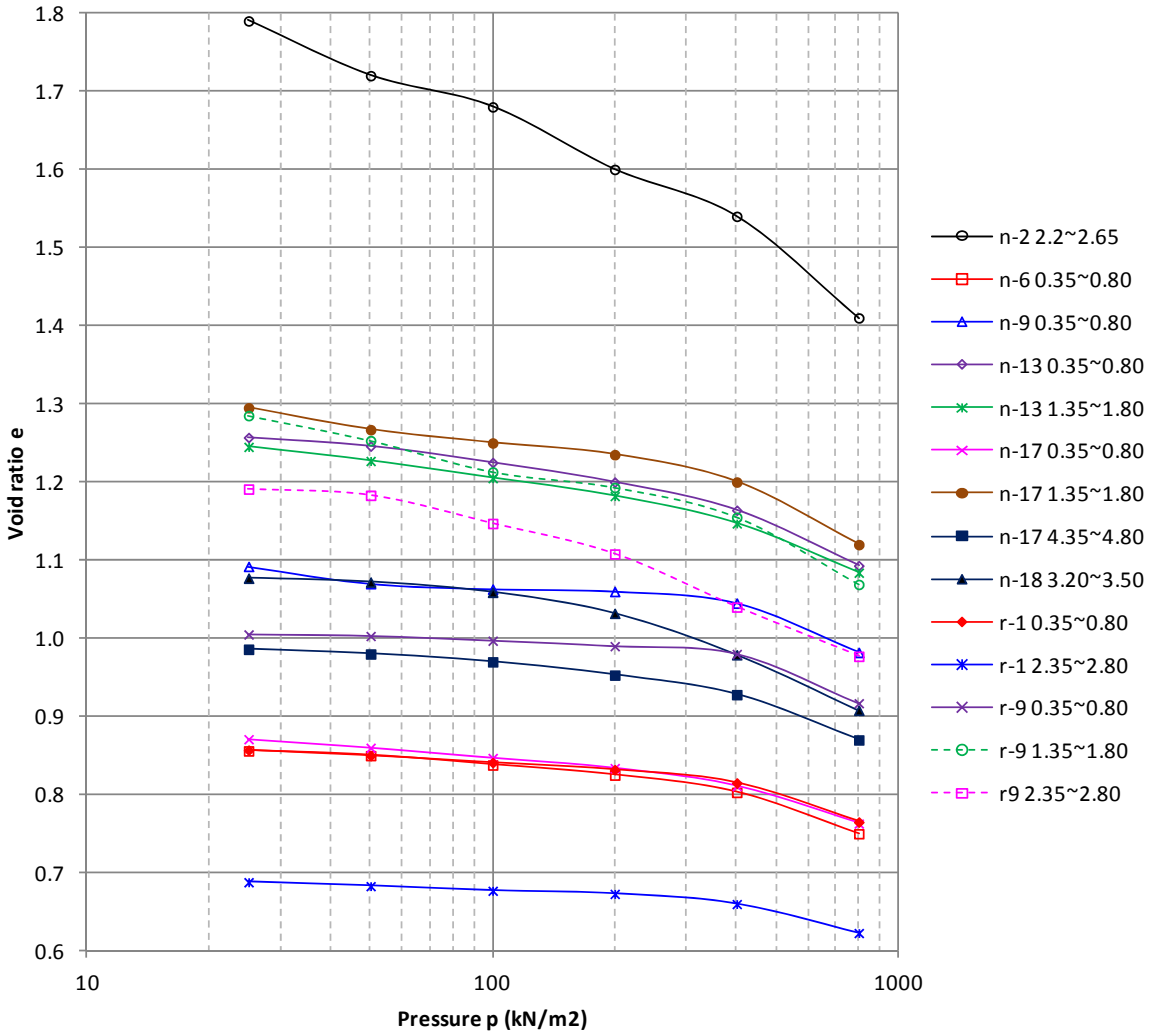
出典：JICA 調査団

3. 圧密沈下量の検討

3.1 圧密試験結果

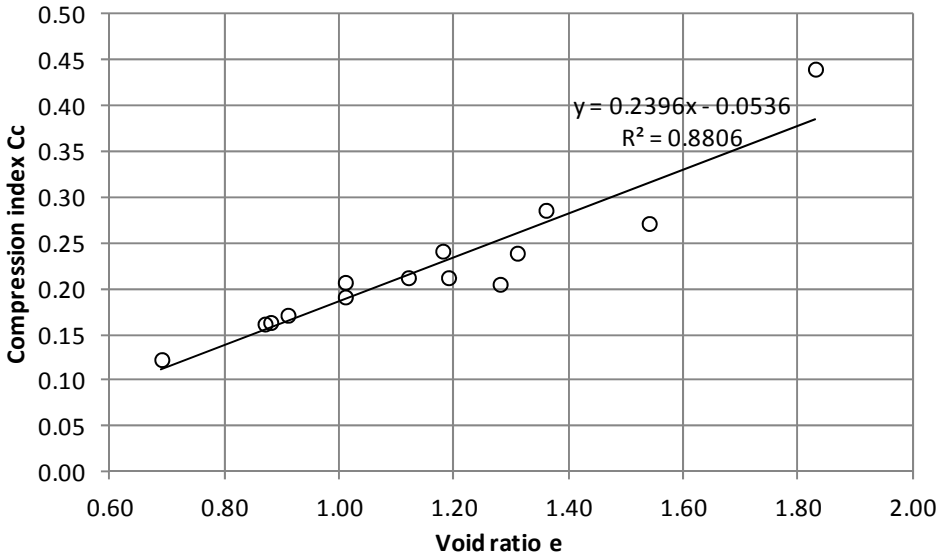
図 3.1 に e-log(p)の関係を示す。200kN/m^2 付近まで直線であり、それから以降、間隙比が下がり始めているため、先行圧密荷重は 200kN/m^2 以上なる。一般的にこれは 20tf/m^2 以上の土被りがあったことを示すが、本地域ではこのような土被りがあったとは考えづらく、乾季の乾燥収縮による影響が出ているのではないかと考えられる。

図 3.2 に初期間隙比と圧縮指数 Cc の関係図を示すが、極めて良い相関関係が得られている。不撹乱試料による平均間隙比は e=0.94 なので、それに対応する圧縮指数は Cc=0.17 となり、小さな値となる。これはシルト質が卓越した粘性土のためと考えられる。



出典：JICA 調査団

図 3.1　e ~ log(p)曲線



出典：JICA 調査団

図 3.2　初期間隙比 e と圧縮指数 Cc の関係

3.2　圧縮指数の設定

室内土質試験結果では Cc=0.15～0.3 であり、平均は 0.20 位になっているため、圧密沈下は少ないと考えられる。また、Cc の推定式は以下のものがある。

Cc = 0.009(W_L – 10)　　Skempton

Cc = 0.017 (Wn -18)　　濃尾平野

上式から、液性限界 30～50％を Skempton の式に適用し Cc=0.18～0.36、自然含水比は 25～35％を濃尾平野の式に適用し Cc=0.12～0.29 と、いずれも圧密試験結果と同レベルの値となっている。以上より、調査地域の代表的な圧縮指数は 0.20 と想定する。

3.3　概略沈下量の推定

(1)圧密検討条件

圧密対象層は N 値が 4 以下、コーン貫入抵抗値が 0.8Mpa の軟弱層とする。軟弱層厚は N 値からは 6 m以下、コーン貫入抵抗値からは 12m 以下となる。盛土高さは 4 m以下、斜面勾配は 1:3.0、天場幅 4.3m とする。盛土速度は軟弱地盤による一般的な盛土速度 3cm/day とする。

(2)軟弱地盤の土質定数

初期間隙比はばらつきがあるが、e_0=0.85 と設定する。湿潤(飽和)密度は 19.0kN/m^3 とする。

圧縮指数 Cc は 0.2 とする。圧密係数は沖積粘土で 10^{-3}~$10^{-2}$$m^2$/day が一般値なので、シルトが卓越する粘性土と考え、c_v=1.0x$10^{-2}$$m^2$/day とする。

(3)盛土の土質定数

締固め試験の最大乾燥密度は、16.7～17.2kN/m^3 が多いので、代表値を 17.0kN/m^3 とする。盛土の締固め度は 95%と仮定すると、乾燥密度は 16.2kN/m^3 となる。最適含水比は代表値の 18％とすると、湿潤密度は 19.1kN/m^3、飽和密度は 20.2kN/m^3 となる。

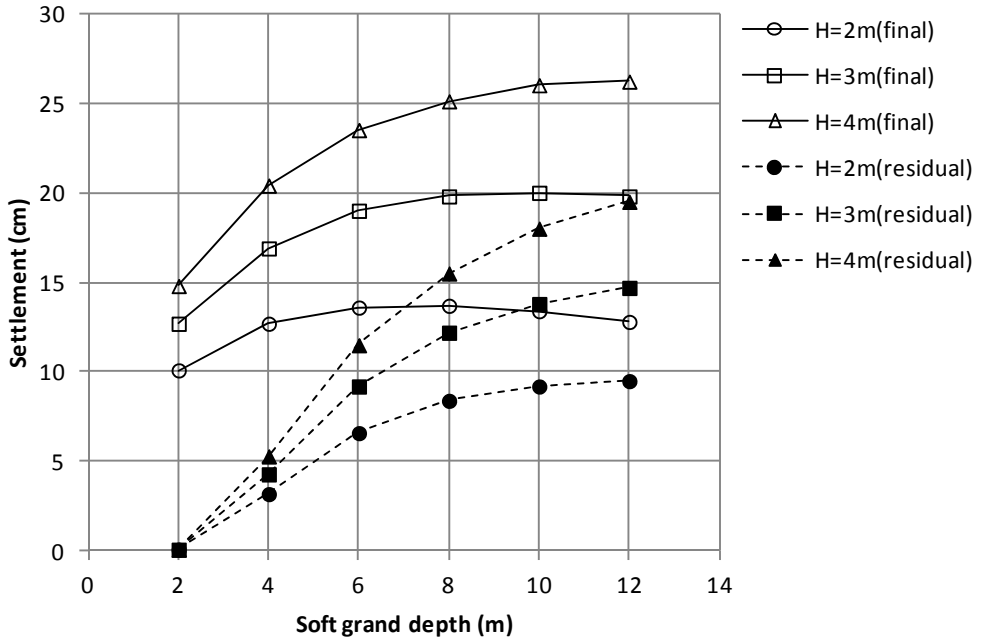
表 3.1　設定定数

	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		

出典：JICA 調査団

(4)圧密沈下量

圧密沈下計算結果を図 3.3 に示す。軟弱地盤の層厚が 12m、盛土高さが 4m の時でも全沈下量は 26cm と小さく、盛土後の残留沈下量は 20cm なので、問題となる圧密沈下は生じない。軟弱層が５ｍ以下では残留沈下量が 10cm 以下となる。



出典：JICA 調査団

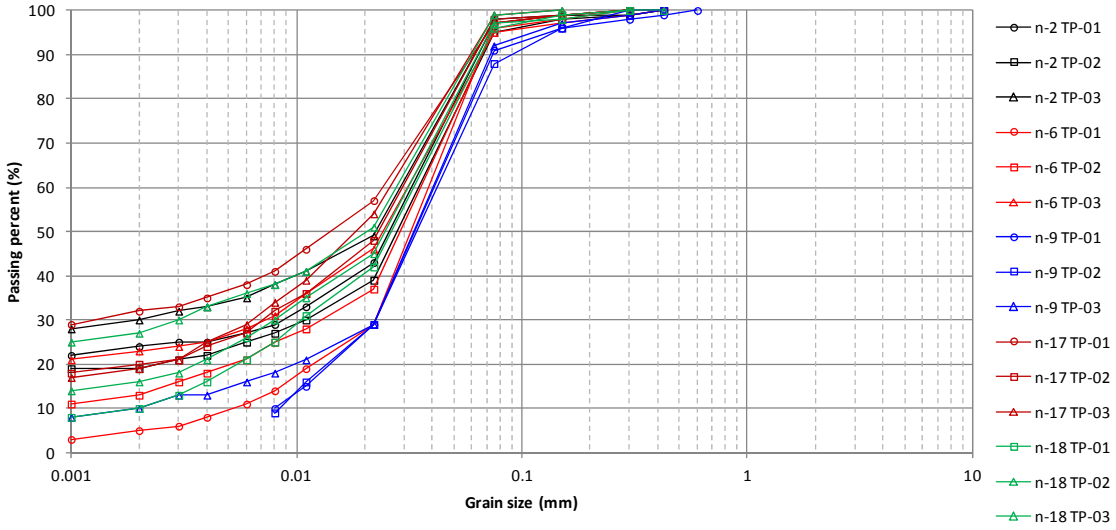
図 3.3　圧密検討結果

4. 盛土材料

4.1 材料試験結果

(1) 物理特性

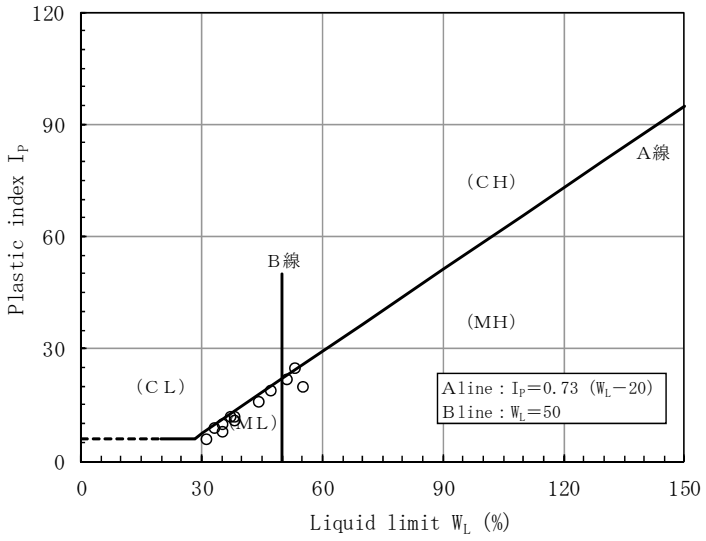
図 4.1 に盛土材料の粒度曲線を示すが、砂分が 12%以下で、シルト分が卓越した粘性土である。シルト分は 70~90%(Ave.80%)を占めている。



出典：JICA 調査団

図 4.1　盛土材料の粒度曲線

図 4.2 に塑性図を示す。土質分類ではほとんどが ML(低液性のシルト)で、一部 MH(高液性のシルト)と CH(高液性の粘土)が含まれている。



出典：JICA 調査団（Plastic Chart は British Standard に基づく）

図 4.2　塑性図（Plasticity chart）

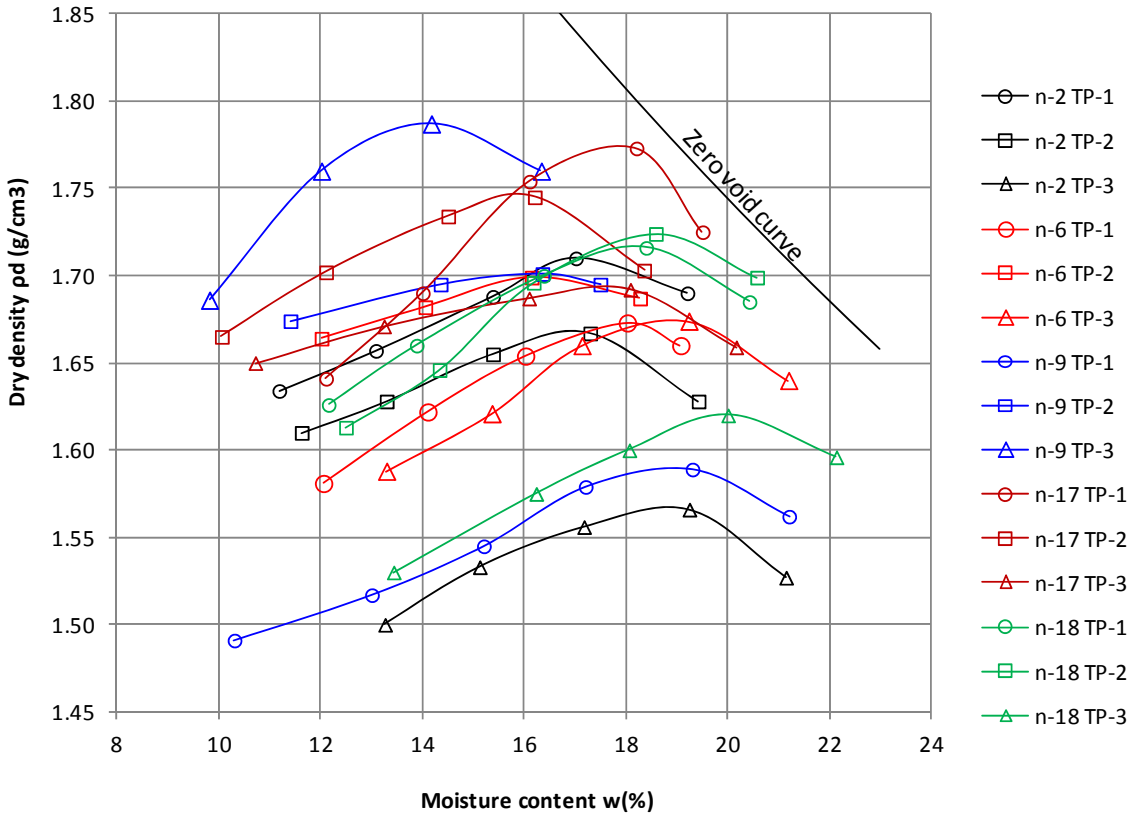
(2) 締固め特性

図 4.3 に締固め曲線を示す。最適含水比と乾燥密度にばらつきはあるが、最適含水比が 18%、最大乾燥密度が 1.7g/cm^3 付近の平均値にデータが多くなっている。

表 4.1　締固め試験結果

	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

出典：JICA 調査団



出典：JICA 調査団

図 4.3　締固め曲線

(3)　強度特性

1)　一軸圧縮強度試験

一軸圧縮強度試験は締固め度 D=90％と D=95％の条件で実施された。

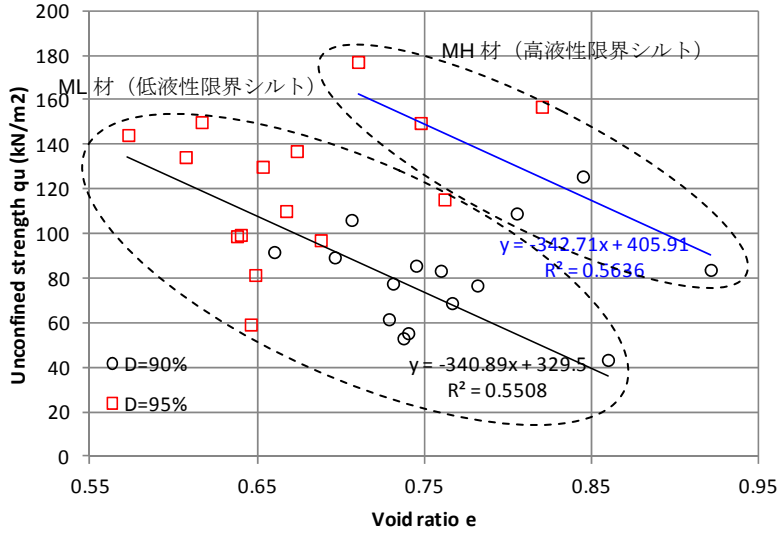
図 4.4 には間隙比 e と一軸圧縮強度 q_u の関係を示す。間隙比が大きくなると一軸圧縮強度が小さくなる傾向がある。また、材料の強度は２つに分類され、強度の大きいものは MH(高液性限界のシルト)に分類されるものが多くなっている。

D=90%では 60kN/m^2 程度以上の一軸圧縮強度が期待され、D=95%では 100kN/m^2 以上の一軸圧縮強度が期待される。

図 4.5 に粘土分と一軸圧縮強度の関係を示すが、粘土分が大きいほど強度が大きくなる傾向となっている。

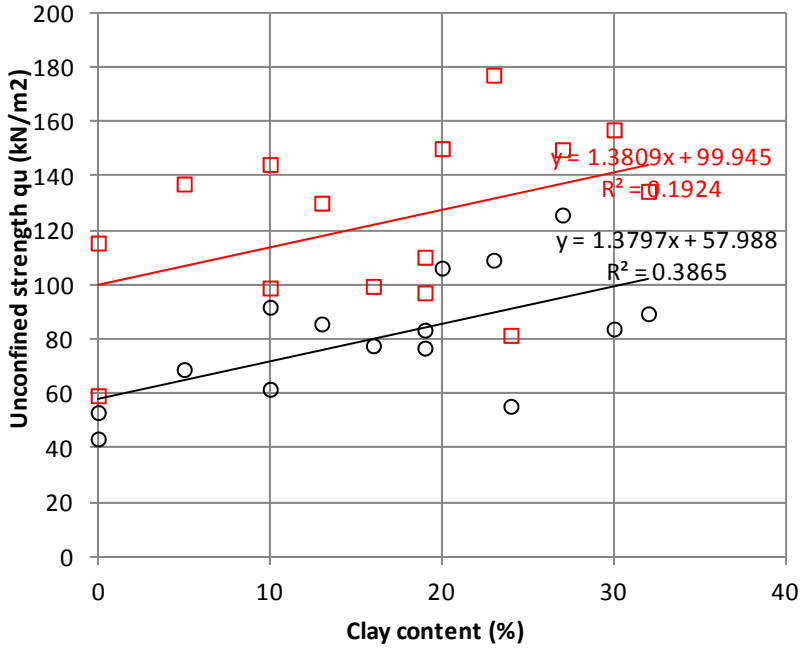
図 4.6 に締固め度 D=90%と D=95%の時の一軸圧縮強度の関係を示すが、D=95%の一軸圧縮強度は D=90%の約 1.5 倍の値となっている。

把握することを提案する。



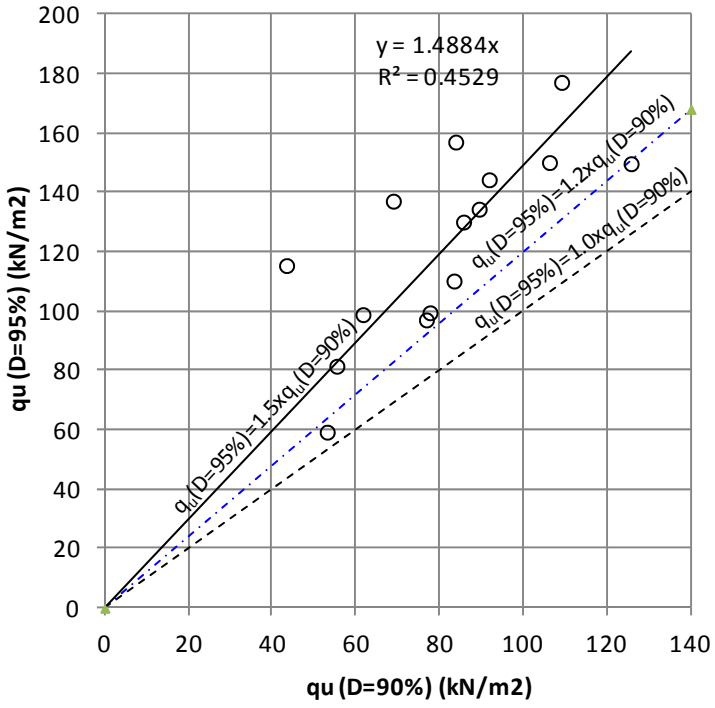
出典:JICA 調査団

図 4.4　一軸圧縮強度と間隙比の関係



出典：JICA 調査団

図 4.5　一軸圧縮強度と粘土分含有量の関係



出典：JICA 調査団

図 4.6　締固度 D=90% and D=95%の一軸圧縮強度の関係

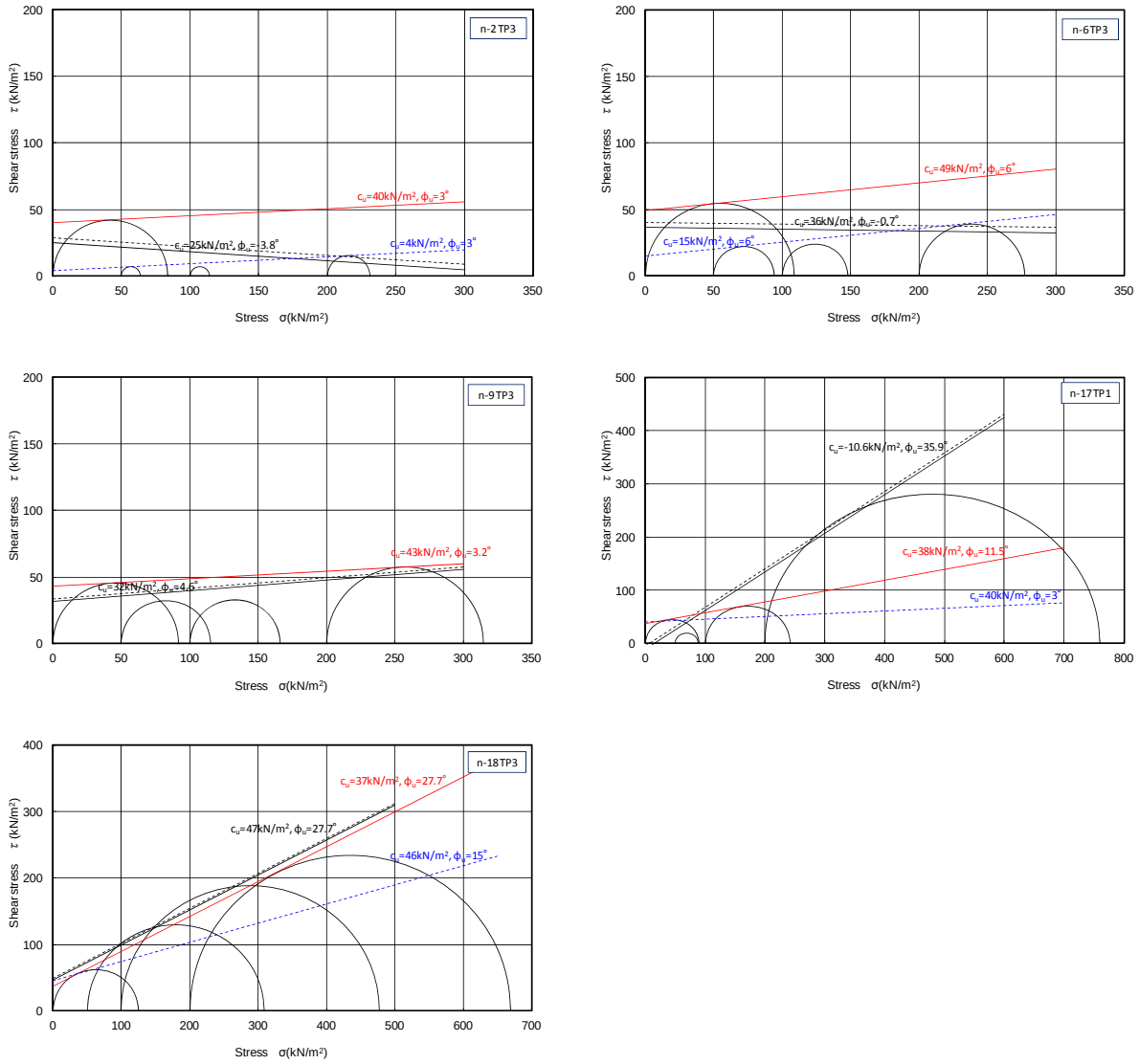
2)　三軸圧縮強度試験

表 4.1 に三軸圧縮試験（UU）の結果から推定される強度定数を示す。なお、強度定数の推定にあたっては一軸圧縮試験を拘束圧ゼロの三軸試験として、合わせて総合的に評価した。

表 4.1　三軸圧縮試験結果による強度定数の推定

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

出典：JICA 調査団
*1：Sat. is saturated and Uns. is unsaturated before triaxial compression test is done,
*2：The values given in parentheses are mean.



出典：JICA 調査団

図 4.7　一軸圧縮試験および三軸圧縮試験結果

(4)　盛土材としての適否

日本の河川土工マニュアルでは築堤材料としては以下の条件を満足するものであり、土質分類からは、試験材料のシルト{M}は含水比が適正であれば使用可能材料となっている。

① 高い密度を与える粒度分布であり、かつせん断強度が大ですべてに対する安定性があること。
② できるだけ不透水性であること。河川水の浸透により浸潤面が裏のり尻まで達しない程度の透水性が望ましい。
③ 堤体の安定に支障を及ぼすような圧縮変形や膨張性がないものであること。
④ 施工性がよく、特に締固めが容易であること。
⑤ 浸水、乾燥などの環境変化に対して、のりすべりやクラックなどが生じにくく安定であること。
⑥ 有害な有機物および水に溶解する成分を含まないこと。

出典：河川土工マニュアル

築堤材料として望ましい材料の評価の中に以下の記載がある。

④ シルト分のあまり多くない土：降雨による浸食、浸透水によるのり面崩壊は水をある程度通しやすく、含水比の増加によりせん断抵抗の低下する土に起こった例が多いが、そのような状態になるのはシルト分の影響が大きいと考えられる。
⑤ 細粒分（0.075mm 以下の粒子）のあまり多くない土：細粒分が50%以上のものは乾燥時にクラックの入る危険性があるので細粒分が 50%以下のものが望ましい。

出典：河川土工マニュアル

粒度特性からは、極めてシルト分が多く、アメリカ開拓局の堤体材料の適正範囲ではクラックの危険性が高い材料となっている。

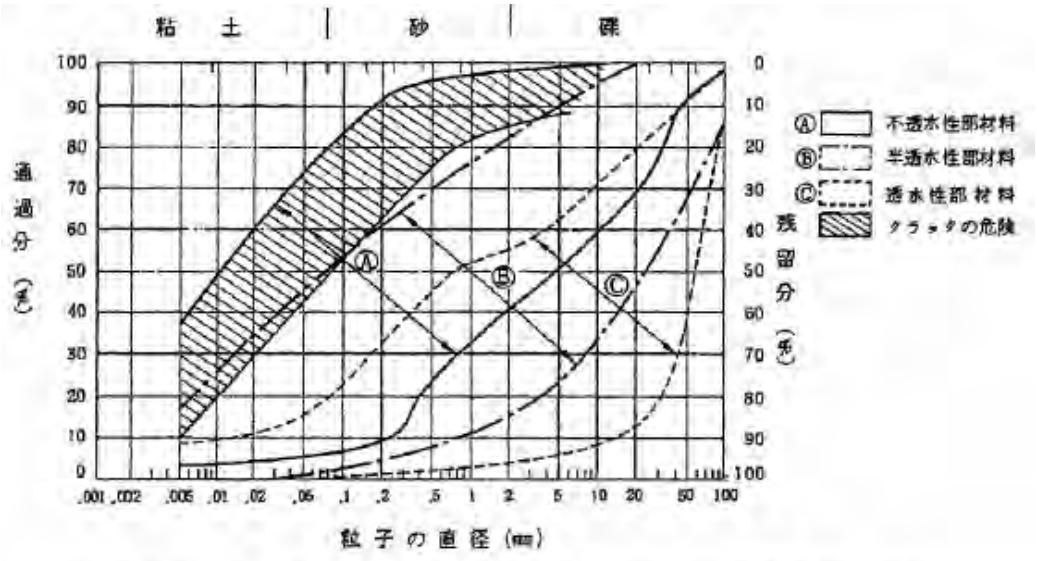


図 3.1.2　堤体材料の適性範囲参考例（アメリカ開拓局 1974）

出典：河川土工マニュアル

以上より、本材料を堤体材料として用いることは可能であるが、以下の配慮をすることが重要となる。

・堤体にクラックを生じさせない対策を行う。
・浸食を受けにくい対策を行う。
・浸透水進入時の斜面の安定性に配慮する。

クラックならびに浸食を発生しにくくする対策として、一般的には植生工が有効である。当地では Dubra Grass といった固有の種を使った植生工による法面保護が多く実施されており、潜水堤防の法面保護としても有効と考えられる。Dubra Grass は水没により枯れるが、根は生き残るため、クラックや浸食をある程度抑制すると考えられる。また、植生工だけではクラック、浸食を防止しきれない場合、良質土（前記の粒度に調整した土）による覆工、あるいは表面をジオテキスタイルで覆い、さらにその上から覆土することが考えられる。

表 3.1.1　堤体材料としての土の評価

土の区分			堤体材料としての評価		対策
名称		記号（日本統一分類）	評価	留意事項	
粗粒土	礫	(GW),(GP)	○	透水性が非常に大きい。	透水性および植生対策が必要になる。
粗粒土	礫質土	(G-M),(G-C),(G-O),(G-V),(GM),(GC),(GO),(GV)	○		
粗粒土	砂	(SW),(SP)	○	透水性が大きく、のりくずれが生じやすい。	遮水性対策が必要である。
粗粒土	砂質土	(S-M),(S-C),(S-O),(S-V),(SM),(SC),(SO),(SV)	○		
細粒土	シルト	(ML),(MH)	○	（場合により対策を必要とする。）水を含んだ場合、機械施工が困難となり、締固めが十分できないことがある。	乾燥による含水比の低下もしくは、土質改良用添加剤による土質改良。
細粒土	粘性土	(CL),(CH)	○		
細粒土	火山灰質粘性土	(OV),(VH_1),(VH_2)	○		
細粒土	有機質土	(OL),(OH)	△	高含水比のものが多く、そのままでは機械施工によって締固めたり整形することが困難である。	乾燥による含水比の低下もしくは、土質改良用添加剤による土質改良、または良質土と粒土調整を行う。
高有機質土		(P_t),(M_k)	×	含水比が高く、締固めが困難である。圧縮変形が大きく、また浸水乾燥などの環境変化に対しても安定性が悪い。	

○　使用可能なもの
△　必要に応じて対策を施せば、堤体材料として使用できるもの
×　堤体材料として不適当なもの

出典：河川土工マニュアル

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)	
							Sand	Silt	Clay			MDD	Void ratio	OMC	D=90%			D=95%				
															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		

出典：JICA 調査団

4.2　盛土材の必要強度

(1) 検討条件

検討断面は一番危険な状態を想定して以下の通りとする。

・最高盛土高さ　4.0m
・最急法面勾配　1:2.0
・浸透水　水位上昇時と水位降下時
・盛土の密度　D=95％相当

(2) 計算結果

斜面安定解析結果によれば、必要安全率 1.2 を満足する粘着力 c_u は 14kN/m^2 である。一軸圧縮、三軸圧縮試験結果から盛土の粘着力は 38～49kN/m^2 程度と推定され、初期強度は十分な値であるが、水没による浸透と乾燥の繰り返しにより、強度が粘着力 c_u=14kn/m^2 まで低下しないように対策しなければならない。初期強度を 38kN/m^2 とすると 14kN/m^2 は 37%（63%の強度低下）に相当する。現在、実施している乾湿繰り返し（9 月 17 日最終結果予定）では、8 サイクルまでの強度低下が締固度 90%で 45%、締固度 98%で 36%、また締固度 80%では 4 サイクル目以降で供試体が自立せずに試験不能の状態である。最終の試験結果が待たれるが、8 サイクル目までの結果から、締固度 90%であれば、強度低下は許容値内に収まる。

表 4.2　盛土の安定検討結果

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

出典：JICA 調査団

4.3　盛土形状の検討

(1)　一般盛土部の安定検討

盛土の安定性で問題となるのは基礎地盤のＮ値で４以下、コーン貫入抵抗値で 0.8MPa 以下の粘性土である。ここでは深度 10m までコーン貫入抵抗値が 0.8Mpa と仮定して検討を行う。

1)解析定数

基礎地盤の粘性土の粘着力 c_u は下記とする。

$$c_u=1/2q_u=1/30q_c=1/30*0.8Mpa=26.7kN/m^2$$

表 4.3　解析定数

解析定数	盛土	軟弱地盤
飽和密度 ρ_{sat} (kN/m^3)	20.2	18.0
湿潤密度 ρ_t (kN/m^3)	19.1	18.0
粘着力　c_u(kN/m^2)	10.0	26.7
内部摩擦角　φ_u(deg)	0.0	0.0

出典：JICA 調査団

2)水位条件

水位降下時で盛土内に水位が残留した状態を設定する。

3)盛土形状

盛土高さ H は H=2.0m, 3.0m, 4.0m の３通りとする。盛土勾配は 1:2.0 と 1:3.0 の２通りとする。また、天場幅は 4.3m とする。

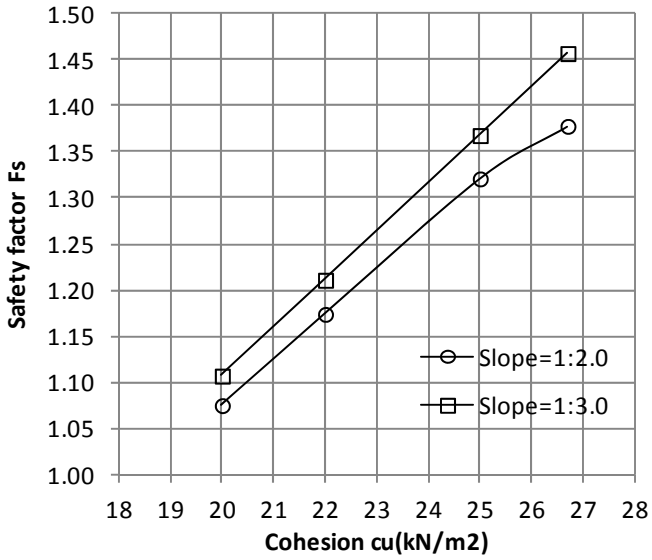
4)計算結果

表 4.4 に安定計算結果を示す。基礎地盤の粘着力が cu=26.7kN/m^2 あれば、必要安全率を満足する。そこで、必要安全率を満足する粘着力を試算した。図 4.8 に基礎地盤の粘着力と安全率の関係を示すが、基礎地盤の粘着力が 23kN/m^2 以上あれば必要安全率 1.2 を満足する。これはコーン貫入抵抗値が 0.7MPa 以上あれば、安定上問題無いと評価される。

表 4.4　基礎地盤の粘着力と安全率の関係

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

出典：JICA 調査団



出典：JICA 調査団

図 4.8　基礎地盤の粘着力と安全率の関係

(2)　軟弱地盤

コーン貫入試験の貫入抵抗値が qc=0.8Mpa 以下が軟弱地盤に相当する。コーン貫入試験結果から、一番軟弱な地層は BH n-6 地域の DCT-1 で qc=0.3Mpa が 3.0m の深度で分布している。この地点での盛土形状を検討する。

1)解析定数

軟弱地盤の強度は一軸圧縮強度 q_u=1/15q_c の関係式より、q_u=20kN/m^2、粘着力 c_u は c_u=1/2q_u から求める。

表 4.5　解析定数

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

出典：JICA 調査団

2)水位条件

水位降下時で盛土内に水位が 100%残留した状態を設定する。

3)盛土形状

盛土高さ H は H=2.0m, 3.0m, 4.0m の３通りとする。盛土勾配は 1:2.0 と 1:3.0 の２通りとする。また、天場幅は 4.3m とする。

4)解析結果

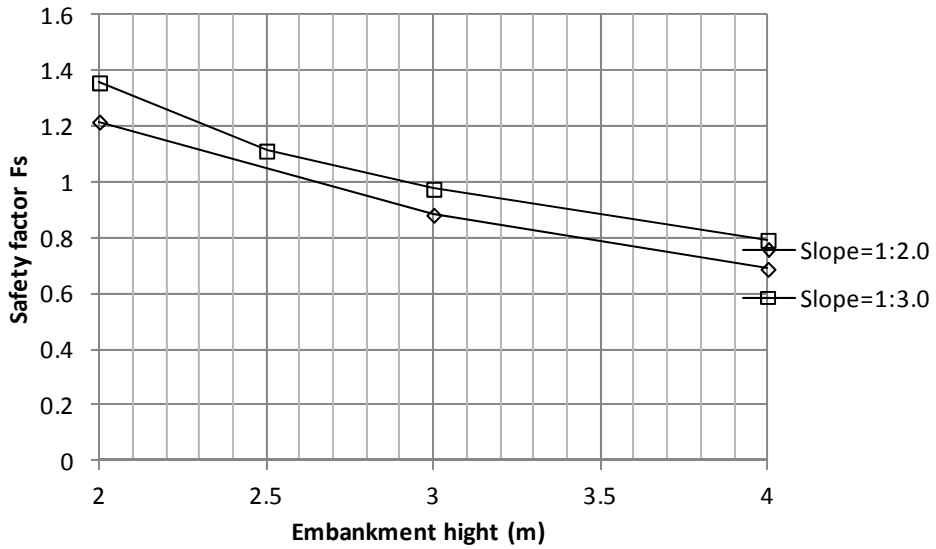
下表に示す解析結果のように、盛土高さが 2m以上になると所用の安全率 1.2 を満足しなくなる。

表 4.6　軟弱地盤上の盛土高と最小安全率

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

出典：JICA 調査団

図 4.9 に 示すように、盛土勾配が 1:2.0 の時の限界盛り土高さは 2.0m、盛土勾配が 1:3.0 の時の限界盛り土高さは 2.3m となる。したがって、これ以上の盛土を行う場合は、盛土の線形を変え、軟弱地盤を避けた配置とする必要がある。



出典：JICA 調査団

図 4.9　軟弱地盤上の盛土高と最小安全率の関係

5. 局所的耐久性の低下状況の把握を目的とした乾湿繰り返し試験の方法

5.1 試験の目的

水浸と乾燥を繰り返すことで、堤防表面の耐久性が低下し、堤防が劣化していくことが想定される。この耐久性の低下は、締め固めの不足により、表層付近が水浸と乾燥の影響を大きく受け、膨潤やひび割れにより密度低下することが原因と推察される。

種々の密度で締め固められた材料が乾湿繰り返しを受けた時、どの程度の耐久性の低下が生じるか確認するため、一軸圧縮強度を指標とした試験を実施した。

5.2 試験条件

締固め試験により、材料の最適含水比 W_{opt} と最大乾燥密度 ρ_{dmax} を求めた。

強度試験は一軸圧縮試験とし、１条件当たり２個の供試体について実施した。

１材料当たりの試験条件と試験数は表 5.1 のとおりとした。

表 5.1　試験数量

Case No.	含水比	締固め度	乾湿条件	一軸圧縮試験 供試体数	
D80-0a	Wopt	80%	無し	2	
D80-0b			湿潤	2	
D80-01			湿潤→（乾燥→湿潤）×１サイクル	2	
D80-02			湿潤→（乾燥→湿潤）×２サイクル	2	14
D80-04			湿潤→（乾燥→湿潤）×４サイクル	2	
D80-08			湿潤→（乾燥→湿潤）×８サイクル	2	
D80-16			湿潤→（乾燥→湿潤）×16 サイクル	2	
D90-0a	Wopt	90%	無し	2	
D90-0b			湿潤	2	
D90-01			湿潤→（乾燥→湿潤）×１サイクル	2	
D90-02			湿潤→（乾燥→湿潤）×２サイクル	2	14
D90-04			湿潤→（乾燥→湿潤）×４サイクル	2	
D90-08			湿潤→（乾燥→湿潤）×８サイクル	2	
D90-16			湿潤→（乾燥→湿潤）×16 サイクル	2	
D95-0a	Wopt	95%	無し	2	
D95-0b			湿潤	2	
D95-01			湿潤→（乾燥→湿潤）×１サイクル	2	
D95-02			湿潤→（乾燥→湿潤）×２サイクル	2	14
D95-04			湿潤→（乾燥→湿潤）×４サイクル	2	
D95-08			湿潤→（乾燥→湿潤）×８サイクル	2	
D95-16			湿潤→（乾燥→湿潤）×16 サイクル	2	
D100-0a	Wopt	100%	無し	2	
D100-0b			湿潤	2	
D100-01			湿潤→（乾燥→湿潤）×１サイクル	2	
D100-02			湿潤→（乾燥→湿潤）×２サイクル	2	14
D100-04			湿潤→（乾燥→湿潤）×４サイクル	2	
D100-08			湿潤→（乾燥→湿潤）×８サイクル	2	
D100-16			湿潤→（乾燥→湿潤）×16 サイクル	2	
			計	56	

出典：JICA 調査団

5.3 供試体作成方法

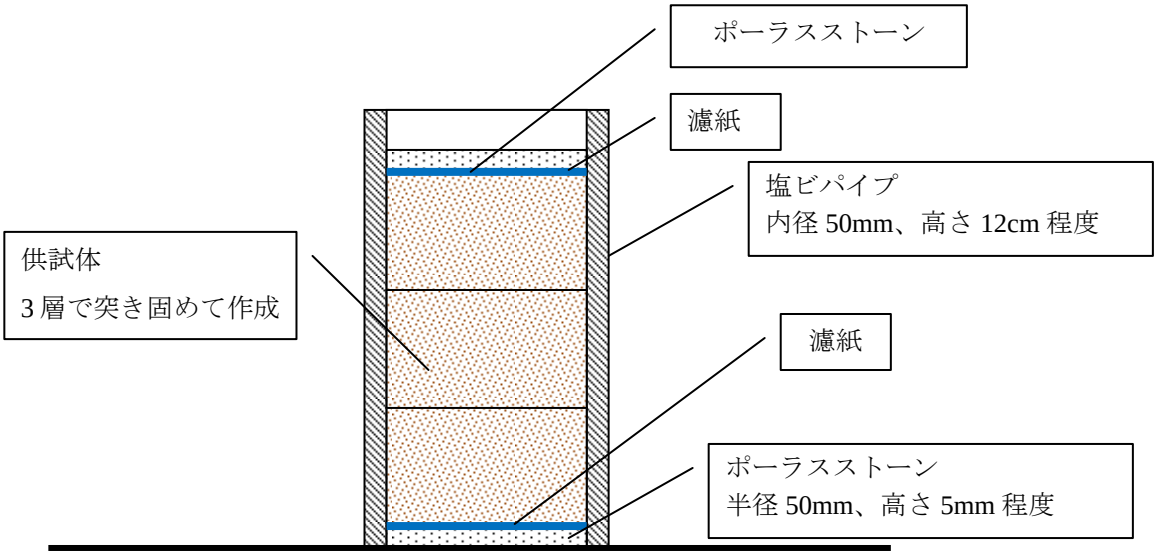
(1) 内径 50mm の塩ビパイプを高さ 12cm 程度でカットし、供試体作成用のモールドとした。

(2) 塩ビパイプ下部にポーラスストーンを入れて、ポーラスストーンの上面に濾紙を敷いた。

(3) 供試体高さ 12cm、半径 5cm に所用の密度になる試料重量を計算し、3 等分した重量を準備し

た。(2)の塩ビパイプ内に 3 層(高さ 4cm 毎)で供試体を突き固めて作成した。突き固めは突き固め棒によった。

(4) 供試体上部に濾紙を引き、その上にポーラスストーンを置いた。



出典：JICA 調査団

図 5.1　供試体の作成

5.4　供試体の乾湿繰り返しと供試体の一軸圧縮試験

(1) 塩ビパイプ、ポーラスストーン、濾紙と一緒に供試体重量を測定した。供試体作成前に塩ビパイプ、ポーラスストーン、濾紙の全重量を測定した。

(2) 供試体を水に入れた水槽に入れ、3 日間水浸させた。その後、直射日光を避けた、気温の高く、風通しの良い所に供試体を 7 日間放置した。この乾燥には、下の写真に示すような穴を開けた容器を利用した。

(3)　(2)を所用サイクル数だけ繰り返した。

(4) 供試体を塩ビパイプより押し抜いて取り出し、供試体の上部と下部を 1cm ずつ切り取って整形し、供試体の半径、高さ、重量を測定した。

(5) ASTM の基準に基づき一軸圧縮試験を実施し、供試体の含水比を測定した。一軸圧縮強度は 2 供試体の平均値とした。

5.5 試験結果の整理

各締固め度毎に乾湿繰り返しサイクル数と一軸圧縮強度の関係図を作成した試験結果は表 5.2 のとおりである。

表 5.2 試験結果一覧

Liquid Limit	Plasticity Index	Proctor Compaction Test		Degree of Compaction	Specimen Number	Wet and Dry Condition	Average Moisture Content	Unconfined Compression Test	
		MDD	OMC					q_u	Average q_u
(%)	(%)	(gm/cm^3)	(%)	(%)			%	(kPa)	(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	**--**

出典：JICA 調査団