Appendices

Appendix-1 Member List of the Study Team

1-1 Study Team of Basic Design Study

Name	Responsibility	Position
1. Mr. Noriaki NAGATOMO	Leader	Team Director, Rural Development Team, Project Management Group III, Grant Aid Management Department, JICA
2. Mr. Nobuo SAMBE	Senior Advisor	Senior Advisor, JICA Cambodia Office
3. Ms Yasuyo KAWAMURA	Project Coordinator	Rural Development Team, Project Management Group III, Grant Aid Management Department, JICA
4. Mr. Toshikazu HIGASHIKAWA	Chief Consultant/ O&M of Project Facilities/ Environmental & Social Considerations	Nippon Koei Co., LTD.
5. Mr. Takashi MISAKI	Facility Design (Civil Works)/ Physical Conditions Survey	Nippon Koei Co., LTD.
6. Mr. Ryuji SHIMODA	Facility Design (Gate Design)	Nippon Koei Co., LTD.
7. Mr. Isamu TSUJINOUE	Facility Design (Construction Plan of Gate)	Nippon Koei Co., LTD.
8. Mr. Hajime ITO	Construction Plan/Cost Estimate	Nippon Koei Co., LTD.

1-2 Study Team for Explanation of Draft Basic Design Report

Name	Responsibility	Position
1. Mr. Hikoyuki UKAI	Leader	Deputy Resident Representative, JICA Cambodia Office
2. Mr. Nobuo SAMBE	Senior Advisor	Senior Advisor, JICA Cambodia Office
3. Ms Yasuyo KAWAMURA	Project Coordinator	Project Management Group III, Grant Aid and Loan Support Department, JICA
4. Mr. Toshikazu HIGASHIKAWA	Chief Consultant/ O&M of Project Facilities/ Environmental & Social Considerations	Nippon Koei Co., LTD.
5. Mr. Ryuji SHIMODA	Facility Design (Gate Design)	Nippon Koei Co., LTD.

Appendix-2 Study Schedule

2.1 Basic Design Study (from November 15, 2007 to December 17, 2007)

No.	Date	Official Member	Consultant Member
1	**Nov.** 15 (Thu)	Departure at Narita →Arrival at Phnom Penh (Project Coordinator: Ms Y. Kawamura)	Departure at Narita →Arrival at Phnom Penh (Mr. T. Higashikawa, Mr. T. Misaki, & Mr. H. Ito)
2	16 (Fri)	Submittal of Inception Report Site Visit to Roleang Chrey Headworks and Kandal Steung Sites	Same with the official members Arrangement of subletting works
3	17 (Sat)	Data Compilation	Arrangement of subletting works
4	18 (Sun)	Departure at Narita →Arrival at Phnom Penh (Team Leader: Mr. N. Nagatomo)	Data Compilation
5	19 (Mon)	Courtesy call to Embassy of Japan, JICA office and MOWRAM. Inception Meeting with MOWRAM	Same with the official members Arrangement of subletting works
6	20 (Tue)	Discussion with MOWRAM Draft Minutes of Meeting	Same with the official members Arrangement of subletting works
7	21 (Wed)	Discussion with MOWRAM Singing of Minutes	Same with the official members Arrangement of subletting works Data collection in Phnom Penh
8	22 (Thu)	Report to EOJ and JICA office Departure at Phnom Penh (Mr. N. Nagatomo & Ms Y. Kawamura)	Data collection in Phnom Penh Arrangement of subletting works Site survey & Data collection
9	23 (Fri)	Arrival at Narita (Mr. N. Nagatomo & Ms Y. Kawamura)	Site survey & Data collection
10	24 (Sat)		Site survey & Data collection
11	25 (Sun)		Data Compilation
12	26 (Mon)		Site survey & Data collection
13	27 (Tue)		Site survey & Data collection
14	28 (Wed)		Site survey & Data collection Departure at Osaka →Arrival at Phnom Penh. (Mr. R. Shimoda)
15	29 (Thu)		Site survey & Data collection
16	30 (Fri)		Site survey & Data collection
17	**Dec.** 01 (Sat)		Site survey & Data collection
18	02 (Sun)		Data Compilation
19	03 (Mon)		Site survey & Data collection
20	04 (Tue)		Site survey & Data collection
21	05 (Wed)		Site survey & Data collection Departure at Osaka →Arrival at Phnom Penh. (Mr. I. Tsujinoue)
22	06 (Thu)		Site survey & Data collection
23	07 (Fri)		Site survey & Data collection
4	08 (Sat)		Site survey & Data collection Departure at Phnom Penh (Mr. H. Ito)
25	09 (Sun)		Data Compilation Arrival at Narita (Mr. H. Ito)

No.	Date	Official Member	Consultant Member
26	10 (Mon)		Site survey & Data collection Departure at Phnom Penh (Mr. R. Shimoda & Mr. I. Tsujinoue)
27	11 (Tue)		Arrival at Osaka (Mr. R. Shimoda & Mr. I. Tsujinoue) Report to EOJ, JICA Office and MOWRAM
28	12 (Wed)		Data compilation Departure at Narita →Arrival at Phnom Penh (Mr. H. Ito)
29	13 (Thu)		Departure at Phnom Penh (Mr. T. Higashikawa & Mr. T. Misaki) Data Collection
30	14 (Fri)		Arrival at Narita (Mr. T. Higashikawa & Mr. T. Misaki) Data Collection (Mr. H. Ito)
31	15 (Sat)		Data Collection (Mr. H. Ito)
32	16 (Sun)		Departure at Phnom Penh (Mr. H. Ito)
33	17 (Mon)		Arrival at Narita (Mr. H. Ito)

Remarks : EOJ : Embassy of Japan
MOWRAM: Ministry of Water Resources and Meteorology

2.2 At Explanation on Draft B/D Report (from June 9, 2008 to June 14, 2008)

No.	Date	Official Member	Consultant Member
1	**June** 9 (Mon)	Departure at Narita →Arrival at Phnom Penh (Project Coordinator: Ms Y. Kawamura)	Departure at Narita →Arrival at Phnom Penh (Mr. T. Higashikawa) Departure at Osaka →Arrival at Phnom Penh (Mr. R. Shimoda)
2	10 (Tue)	Meeting at JICA Office Courtesy call to MOWRAM Submittal of Draft B/D Report and explanation on the report to MOWRAM	Same with the official member
3	11 (Thu)	Discussion with MOWRAM about the minutes of discussions	Same with the official member
4	12 (Thu)	Singing of Minutes	Same with the official member
5	13 (Fri)	Reporting to JICA Office and Embassy of Japan Departure at Phnom Penh (Project Coordinator: Ms Y. Kawamura)	Same with the official member Departure at Phnom Penh (Mr. Higashikawa & Mr. Shimoda)
6	14 (Sat)	Arrival at Narita (Project Coordinator: Ms Y. Kawamura)	Arrival at Narita (Mr. Higashikawa) Arrival at Osaka (Mr. Shimoda)

Appendix-3 List of Parties Concerned in Cambodia

Ministry of Water Resources and Meteorology

H.E. Veng Sakhon	Secretary of State
H.E. Bun Hien	Director General
Mr. Pich Veasna	Director General of Administration Affairs
Mr. Chea Chhun Keat	Director of Administration and Human Resources Department
Mr. Chhea Bunrith	Director of Planning and International Cooperation Department
Mr. Theng Tara	Director of Water Resources Management and Conservation Department
Mr. Sok Muniratana	Director of Water Supply and Sanitation Department
Mr. Long Saravuth	Director of Meteorology Department
Mr. Mao Hak	Director of Hydrology and River Works Department
Mr. Te Auv Kim	Director of Irrigated Agriculture Department
Mr. Choun Bithol	Deputy Director General of Technical Affairs
Mr. Klock Sam Ang	Chief of International Cooperation Office
Mr. Ea Piseth	Director, Provincial Department of Water Resources and Meteorology, Kampong Speu
Mr. Nobuhiro Moriyama	JICA Advisor
Mr. Akihiko Ihara	JICA Advisor
Mr. Shigemitsu Tsukamoto	Chief Advisor/Irrigation (TSC Phase 2)

Embassy of Japan in Cambodia

Mr. Katsuhiro Shinohara	Ambassador
Mt. Tetsumi Murata	Counsellor
Kenichi Kobayashi	Secretary

Japan International Cooperation Cambodia Office

Mr. Kazuhiro Yoneda	Resident Representative
Mr. Hikoyuki Ukai	Deputy Resident Representative
Ms Tomoko Tanaka	Assistant Resident Representative
Ms. Siv Cheang	Programme Officer

Appendix-4 Minutes of Discussions

Appendix 4-1　　At Basic Design Study (November 21, 2007)

MINUTES OF DISCUSSIONS
ON THE BASIC DESIGN STUDY
ON THE PROJECT FOR IMPROVEMENT OF ROLEANG CHREY REGULATOR AND INTAKES
IN THE KINGDOM OF CAMBODIA

In response to a request from the Royal Government of Cambodia (hereinafter referred to as "the Cambodia"), the Government of Japan decided to conduct a Basic Design Study on the project for improvement of Roleang Chrey Regulator and intakes (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to the Cambodia the Basic Design Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Noriaki Nagatomo, Team Director, Rural Development Team, Project Mangement Group III, Grant Aid Department, JICA and is scheduled to stay in the country from 15th November, 2007 to 22nd November, 2007.

The Team held discussions with the officials concerned of the Royal Government of Cambodia and conducted a field survey at the study area.

In the course of discussions and field survey, both parties confirmed the main items described on the attached sheets. The Team will proceed to further works and prepare the Basic Design Study Report.

Phnom Penh, 21st November, 2007

Mr. Noriaki Nagatomo	H.E.Veng Sakhon
Leader	Secretary of State
Basic Design Study Team	Ministry of Water Resources and Meteorology
Japan International Cooperation Agency	The Royal Government of Cambodia

ATTACHMENT

1. Objective of the Project

The objective of the Project is to provide a stable supply of water to the main canals by improving the Roleang Chrey Regulator and intakes.

2. Project site

The site of the Project is Taing Kruoch Commune, Samraong Tong District, Kampong Speu Province, as shown in Annex I.

3. Responsible and Implementing Agency

3-1.The Responsible Agency is Ministry of Water Resources and Meteorology (hereinafter referred to as "MOWRAM").

3-2.The Implementing Agency is National Project Management Office of MOWRAM.

4. Items requested by the Royal Government of Cambodia

Both sides confirmed the requests of the Royal Government of Cambodia on the following items:

(1) Rehabilitation of Roleang Chrey Regulator
- Rehabilitation of all gates and hoist systems of the Regulator
- Improvement of the downstream apron and river side slope protection
- Construction of a river outlet structure at the right side slope protection
- Construction of an operators hut

(2) Reconstruction of the Intake Gates
- Reconstruction of Andong Sla Intake Gate and Vat Kruoch Intake Gate
- Rehabilitation of the approach channels to the Intake Gates
- Construction of a power transmission line from the Regulators to Intake Gates

(3) Engineering Supporting Services
- Survey, design, preparation of tender documents and construction supervision
- to prepare operation rules and an operation manual for the facilities
- to reinforce the organization for the operation and maintenance of the project facility

5. Items confirmed by the both sides

Responding the request from Cambodia, both sides confirmed the urgency of the components are as follows;

(1) Rehabilitation of all gates and hoist systems of Roleang Chrey Regulator
(2) Improvement of river side protection and aprons *of Roleang Chrey Regulator
(3) Construction of a river outlet structure at the right side of Roleang Chrey Regulator
(4) Reconstruction of Andong Sla Intake gates

(5) Soft component for operation of the facilities
* depends on the result of the geological drilling.

6. Japan's Grant Aid Scheme

6-1.Cambodian side understands the Japan's Grant Aid Scheme explained by the Team, as described in ANNEX II .

6-2.Cambodian side will take the necessary measures, as described in Annex-III, for smooth implementation of the Project, as a condition for the Japanese Grant Aid to be implemented.

7. Schedule of the Study

7-1. The consultants will proceed to further studies in Cambodia until 16th December, 2007. Cambodian side promised to open the gates of Roleang Chrey Regulator on 6th and 7th December, 2007 in order to inspect present conditions of rollers, pins and bushings.

7-2. JICA will prepare the draft report in English and dispatch a mission in order to explain its contents around March, 2008.

7-3. In case that the contents of the report is accepted in principle by the Royal Government of Cambodia, JICA will complete the final report and send it to the Royal Government of Cambodia by June, 2008.

8. Other relevant issues

8-1. Water cut-off period

The Team strongly requested Cambodian side to set water cut-off period, approximately from December 2009 to April, 2010, since it is necessary for the smooth and safe implementation of the construction/rehabilitation for the Project. Cambodian side requested the Team to provide alternatives of construction methodologies to minimize the water cut-off period.

8-2. Benefited area of the Project

Both sides confirmed benefited area under the Project is present irrigated area.

8-3. Operation and Maintenance

The Cambodian side shall allocate enough budget and qualified staffs to properly operate and maintain the facilities constructed by the Project.

8-4. Obligation of Cambodian Side for the Project

Both sides confirmed that the items mentioned below are conducted by the Royal Government of Cambodia with its own expenses before and during the implementation of the Project. They are:

(1) Stakeholders' Meeting

The Cambodian side recognizes the importance of holding stakeholder meeting in order to inform the influence which will be caused during the construction of the Project, such as water-cut off period, traffic control on the regulator bridge as so on.

(2) Compensation to farmers (if necessary)

(3) Land Acquisition (if necessary)

8-5. Process of Environmental Impact Assessment

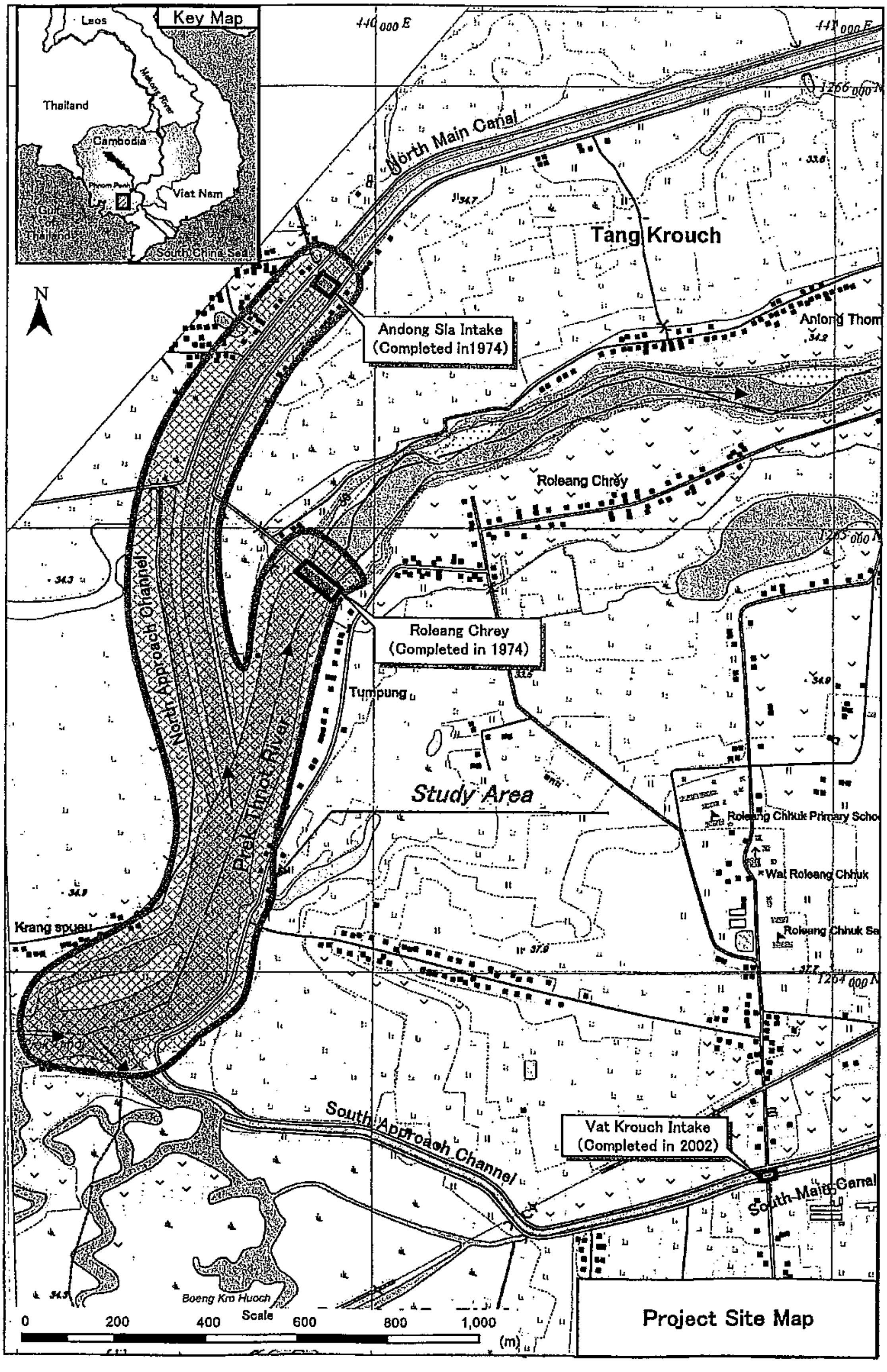
Cambodian side explained the Team that IEE procedure has already completed and approved from the Ministry of Environment and also explained that there is no need for Environment Impact Assessment (EIA) for the Project.

END

Annex I: Project site map

Annex II: Japan's Grant Aid Scheme

Annex III: Undertakings by the Government of the recipient country


Key Map
Laos
Thailand
Cambodia
Viet Nam
South China Sea
North Main Canal
Tang Krouch
Andong Sla Intake
(Completed in1974)
Roleang Chrey
Roleang Chrey
(Completed in 1974)
Tumpung
North Approach Channel
Prek Thnot River
Study Area
Roleang Chhuk Primary School
Wat Roleang Chhuk
Krang spueu
South Approach Channel
Vat Krouch Intake
(Completed in 2002)
South Main Canal
Boeng Kro Huoch
0 200 400 600 800 1,000
Scale
(m)
Project Site Map

ANNEX II: JAPAN'S GRANT AID SCHEME

The Grant Aid Program provides a recipient country with non-reimbursable funds to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedure

1) Japan's Grant Aid Program is executed through the following procedures.

Application	(Request made by a recipient country)
Study	(Basic Design Study conducted by JICA)
Appraisal & Approval	(Appraisal by the Government of Japan and Approval by Cabinet)
Determination of Implementation	(The Notes exchanged between the Governments of Japan and the recipient country)

2) Firstly, the application or request for a Grant Aid project submitted by a recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether or not it is eligible for Grant Aid. If the request is deemed appropriate, the Government of Japan assigns JICA to conduct a study on the request. If necessary, JICA send a Preliminary Study Team to the recipient country to confirm the contents of the request.

Secondly, JICA conducts the study (Basic Design Study), using Japanese consulting firms.

Thirdly, the Government of Japan appraises the project to see whether or not it is suitable for Japan's Grant Aid Programme, based on the Basic Design Study report prepared by JICA, and the results are then submitted to the Cabinet for approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes signed by the Governments of Japan and the recipient country.

Finally, for the implementation of the project, JICA assists the recipient country in such matters as preparing tenders, contracts and so on.

2. Basic Design Study

1) Contents of the Study

The aim of the Basic Design Study (hereinafter referred to as "the Study"), conducted by JICA on a requested project (hereinafter referred to as "the Project"), is to provide a basic document necessary for the appraisal of the Project by the Government of Japan. The contents of the Study are as follows:

a) confirmation of the background, objectives and benefits of the Project and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation;
b) evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from the technical, social and economic points of view;
c) confirmation of items agreed on by both parties concerning the basic concept of the Project;
d) preparation of a basic design of the Project; and
e) estimation of costs of the Project.

The contents of the original request are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed considering the guidelines of Japan's Grant Aid Scheme.

The Government of Japan requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even through they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

2) Selection of Consultants

For the smooth implementation of the Study, JICA uses a consulting firm selected through its own procedure (competitive proposal). The selected firm participates the Study and prepares a report based upon the terms of reference set by JICA.

At the beginning of implementation after the Exchange of Notes, for the services of the Detailed Design and Construction Supervision of the Project, JICA recommends the same consulting firm which participated in the Study to the recipient country, in order to maintain the technical consistency between the Basic Design and Detailed Design as well as to avoid any undue delay caused by the selection of a new consulting firm.

3. Japan's Grant Aid Scheme

1) Exchange of Notes (E/N)

Japan's Grant Aid is extended in accordance with the Notes exchanged by the two Governments concerned, in which the objectives of the project, period of execution, conditions and amount of the Grant Aid, etc., are confirmed.

2) "The period of the Grant" means the one fiscal year which the Cabinet approves the project for. Within the fiscal year, all procedure such as exchanging of the Notes, concluding contracts with consulting firms and contractors and final payment to them must be completed.

However, in case of delays in delivery, installation or construction due to unforeseen factors such as weather, the period of the Grant Aid can be further extended for a maximum of one fiscal year at most by mutual agreement between the two Governments.

3) Under the Grant, in principle, Japanese products and services including transport or those of the recipient country are to be purchased.

When the two Governments deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country.

However, the prime contractors, namely consulting, contracting and procurement firms, are limited to "Japanese nationals". (The term "Japanese nationals" means persons of Japanese nationality or Japanese corporations controlled by persons of Japanese nationality.)

4) Necessity of "Verification"

The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. This "Verification" is deemed necessary to secure accountability of Japanese taxpayers.

5) Undertakings required to the Government of the recipient country

a) to secure a lot of land necessary for the construction of the Project and to clear the site;

b) to provide facilities for distribution of electricity, water supply and drainage and other incidental facilities outside the site;

c) to ensure prompt unloading and customs clearance at ports of disembarkation in the recipient country and internal transportation therein of the products purchased under the Grant Aid;

d) to exempt Japanese nationals from customs duties, internal taxes and fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contracts;

e) to accord Japanese nationals whose services may be required in connection with the supply of the products and services under the verified contracts such as facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work;

f) to ensure that the facilities constructed and products purchased under the Grant Aid be maintained and used properly and effectively for the Project; and

g) to bear all the expenses, other than those covered by the Grant Aid, necessary for the Project.

6) "Proper Use"

The recipient country is required to maintain and use the facilities constructed and equipment purchased under the Grant Aid properly and effectively and to assign the necessary staff for operation and maintenance of them as well as to bear all the expenses other than those covered by the Grant Aid.

7) "Re-export"

The products purchased under the Grant Aid shall not be re-exported from the recipient country.

8) Banking Arrangement (B/A)

a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient country in an authorized foreign exchange bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the verified contracts.

b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an Authorization to Pay (A/P) issued by the Government of recipient country or its designated authority.

9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commission to the Bank.

ANNEX III: UNDERTAKINGS BY THE GOVERNMENT OF THE RECIPIENT COUNTRY

1. To secure a lot of land necessary for the Project;

2. To clear and level the site for the Project prior to the commencement of the construction;

3. To provide a proper access road to the Project site;

4. To provide facilities for distribution of electricity, water supply, telephone trunk line and drainage and other incidental facilities outside the site;

5. To undertake incidental outdoor works, such as gardening, fencing, exterior lighting, and other incidental facilities in and around the Project site, if necessary;

6. To ensure prompt unloading and customs clearance of the products purchased under the Japan's Grant Aid at ports of disembarkation in the Recipient Country;

7. To exempt Japanese nationals from customs duties, internal taxes and fiscal levies which may be imposed in THE RECIPIENT COUNTRY with respect to the supply of the products and services under the verified contracts;

8. To accord Japanese nationals whose services may be required in connection with the supply of the products and services under the verified contracts such facilities as may be necessary for their entry into THE RECIPIENT COUNTRY and stay therein for the performance of their work;

9. To bear commissions, namely advising commissions of an Authorization to Pay (A/P) and payment commissions, to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement (B/A);

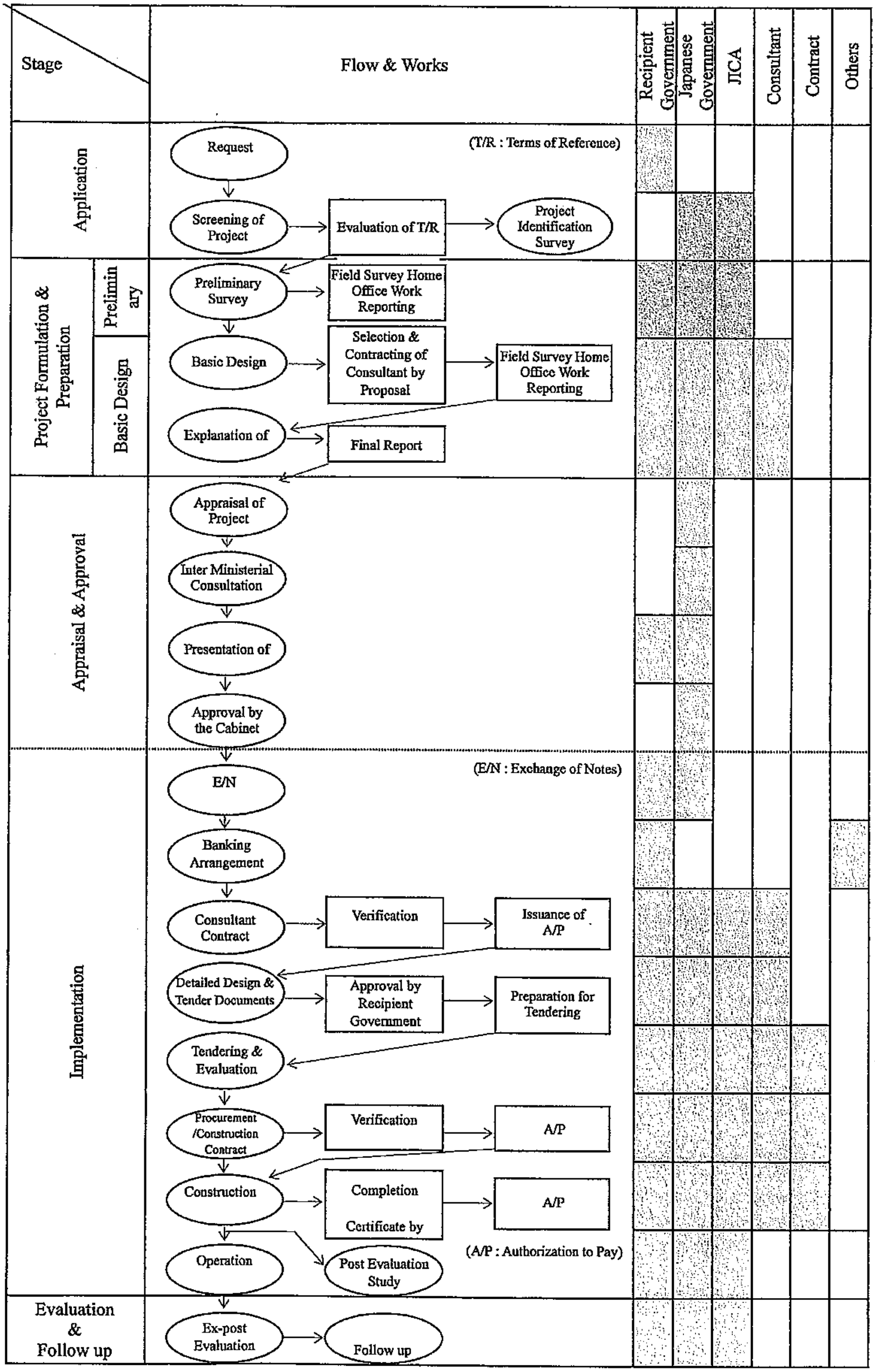
10. To provide necessary permissions, licenses, and other authorization for implementing the Project, if necessary;

11. To ensure that the facilities constructed and equipment purchased under the Japan's Grant Aid be maintained and used properly and effectively for the Project; and

12. To bear all the expenses, other than those covered by the Japan's Grant Aid, necessary for the Project.

Attachment 1

FLOW CHART OF JAPAN's GRANT AID PROCEDURES



Major Undertakings to be taken by Each Government

NO	Items	To be covered by Grant Aid	To be covered by Recipient side
1	To secure land		●
2	To clear, level and reclaim the site when needed		●
3	To construct gates and fences in and around the site		●
4	To construct the parking lot	●	
5	To construct roads		
	1) Within the site	●	
	2) Outside the site		●
6	To construct the building	●	
7	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities		
	1)Electricity		
	a.The distributing line to the site		●
	b.The drop wiring and internal wiring within the site	●	
	c.The main circuit breaker and transformer	●	
	2)Water Supply		
	a.The city water distribution main to the site		●
	b.The supply system within the site (receiving and/or elevated tanks)	●	
	3)Drainage		
	a.The city drainage main (for storm, sewer and others) to the site		●
	b.The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site	●	
	4)Gas Supply		
	a.The city gas main to the site		●
	b.The gas supply system within the site	●	
	5)Telephone System		
	a.The telephone trunk line to the main distribution frame / panel (MDF) of the building		●
	b.The MDF and the extension after the frame / panel	●	
	6)Furniture and Equipment		
	a.General furniture		●
	b.Project equipment	●	
8	To bear the following commissions to a bank of Japan for the banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
9	To ensure prompt unloading and customs clearance at the port of disembarkation in recipient country		
	1) Marine(Air) transportation of the products from Japan to the recipient country	●	
	2) Tax exemption and customs clearance of the products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	(●)	(●)

10	To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		●
11	To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contract		●
12	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid		●
13	To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities as well as for the transportation and installation of the equipment		●

MINUTES OF DISCUSSIONS
ON
THE BASIC DESIGN STUDY
ON
THE PROJECT FOR IMPROVEMENT OF ROLEANG CHREY HEADWORKS
IN
THE KINGDOM OF CAMBODIA
(EXPLANATION ON DRAFT REPORT)

In November, 2007, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a Basic Design Study Team on the Project for Improvement of Roleang Chrey Headworks (hereinafter referred to as "the Project") to Ministry of Water Resources and Meteorology, the Royal Government of Cambodia (hereinafter referred to as "MOWRAM"), and through discussion, field survey and technical examination of the results in Japan, JICA prepared a draft report of the study.

In order to explain and to consult MOWRAM on the components of the draft report, JICA sent to the Kingdom of Cambodia the Draft Report Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Hikoyuki Ukai, Deputy Resident Representative, JICA Cambodia Office, from 9th June, 2008 to 13th June, 2008.

As a result of discussions, both parties confirmed the main items described on the attached sheets.

Phnom Penh, 12th June, 2008

Mr. Hikoyuki Ukai Leader Basic Design Study Team Japan International Cooperation Agency (JICA)	H.E. Veng Sakhon Secretary of State Ministry of Water Resources and Meteorology The Royal Government of Cambodia

ATTACHMENT

1. Components of the Draft Report

MOWRAM agreed and accepted in principle the components of the draft report explained by the Team.

2. Japan's Grant Aid scheme

MOWRAM understood the Japan's Grant Aid Scheme and the necessary measures to be taken by MOWRAM as explained by the Team and described in Annex- II of the Minutes of Discussions signed by both parties on 21st November, 2007.

3. Schedule of the Study

JICA will complete the final report in accordance with the confirmed items and send it to MOWRAM by August, 2008.

4. Confidentiality of the Project

4-1 Detailed specifications of the Facilities

Both sides confirmed that all information related to the Project including detailed specifications of the facilities, equipment and other technical information shall not be released to any outside party before the signing of all the Contract(s) for the Project.

4-2 Confidentiality of the Project Cost Estimation

The Team explained the cost estimation of the Project as described in Annex-I. Both sides agreed that the Project Cost Estimation should never be duplicated or released to any outside parties before signing of all the Contract(s) for the Project. MOWRAM understood that the Project Cost Estimation attached as Annex-I is not final and is subject to change.

5. Other relevant issues

5-1 Project Title

Both sides confirmed that the Project Title should be changed from "The Project for Improvement of Roleang Chrey Regulator and Intakes" to "The Project for Improvement of Roleang Chrey Headworks".

5-2 Water cut-off period

The Team explained the implementation schedule of the Project attached as Annex II, which is planned to minimize the water cut-off period, based on the request from MOWRAM. MOWRAM agreed on the proposed schedule and promised to set a water cut-off period during ten (10) days (tentatively from December 01, 2010 to December 10, 2010) for construction of cofferdams for the Roleang Chrey Headworks, and other ten (10) days (tentatively from April 21, 2011 to April 30, 2011) for removal of the cofferdams. Both sides confirmed that "Water cut-off" means deed of stopping water supply to irrigation canals and/or status of no water in irrigation canals for construction/rehabilitation of the irrigation facilities of the Project, such as Roleang Chrey regulator and Andong Sla intake.

MOWRAM also confirmed that compensation to farmers will be made by the Royal Government of Cambodia side with its own expenses, if necessary.

5-3 Measures to reserve water for domestic use

Before the water cut-off periods, the Team strongly recommended MOWRAM to take necessary measures at their own expense in order to reserve water in canals for residents who depend on canals for domestic use.

5-4 Permission for operating regulator's gates

The Team explained that the following operations of regulator's gates would be necessary by the end of August 2011 in addition to two-time water cut-off periods which were above-mentioned in 5-2.

1) Test of opening and closing of regulator's gates in May 2011 (consecutive 3 days), in order to verify function of the rehabilitated gates.

2) Gate operation training under soft component plan in July and August 2011 (intermittently 3 days) for the purpose that operators will learn how to operate the rehabilitated gates

The Team explained that the proposed gate operations are different from two-time water cut-off necessary for rehabilitation of the regulator's gates, and requested that MOWRAM permit the above gate operations of 1) and 2), which might lower water level in the north and south approach channels and main canals during those periods. MOWRAM understood the necessity and importance, and promised to permit consultant/contractor to carry out the opening and closing of the regulator's gates for smooth implementation of the above 1) and 2).

5-5 Construction Permission

MOWRAM shall make necessary arrangements for the construction/ rehabilitation of Roleang Chrey Headworks prior to the signing of Exchange of Notes.

END

Annex I Project Cost Estimation
Annex II Tentative Schedule of the Project

Appendix-5: Soft Component Plan

MINISTRY OF WATER RESOURCES
AND METEOROLOGY
THE KINGDOM OF CAMBODIA

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR IMPROVEMENT OF ROLEANG CHREY HEADWORKS IN THE KINGDOM OF CAMBODIA

SOFT COMPONENT PLAN

JULY 2007

NIPPON KOEI CO., LTD.

Appendix-5: Soft Component Plan

CONTENTS

1. Background of Soft Component Plan

(1) Present Status of the Existing Irrigation Facilities

Roleang Chrey regulator has five sets of fixed wheel gates (clear span 12.5 m x effective height 6.7 m) and the gates have a total of 40 wheels. However, all 40 wheels do not rotate, since all the bushings and pins of the wheels have firmly rusted due to degradation over the past 33 years and improper maintenance. When the gates are raised, abnormal friction is caused and extra-burden is put on a generator. When the gates are lowered, they are not lowered smoothly. If the gates are not repaired, it is feared that the regulator will lose its function, and a stable water supply to the existing irrigation area and smooth gate-opening operation for flood will become impossible.

Andong Sla intake, constructed in 1974, has supplied water to about 6,500 ha at an end point of the 1.2 km long north approach channel of 1.2 km. The intake has four sets of radial gates (clear span 4 m x effective height 2.7 m), but two sets of gates out of the four have already been useless. The remaining two sets are functioning, but a lot of leakage has been caused due to deteriorated rubber seals provided on the four edges of the gates. The gates of the intake have no discharge regulation function.

Residual water in the north and the south irrigation canals is being used as irrigation water for Kandal Steung irrigation facilities for 1,950 ha (completed in August in 2007 and located about 40 km downstream of the regulator), because the regulator's gate can not control the discharge of 5 m^3/sec due to the large size of the gate (clear span 12.5 m x effective height 6.7 m). For stable irrigation water supply to the downstream area, a river outlet structure is required.

(2) Necessity of Assistance for Operation and Maintenance of the Improved Facilities

All the present problems of the existing facilities, namely Roleang Chrey regulator and Andong Sla intake, will be rehabilitated and improved under Japan's grant aid scheme. In order to achieve the goals and maintain the Project effects as long as possible, operation and maintenance of the improved facilities will be necessary.

The gate operators will have to learn the features of the gates and related facilities to be improved under the Project. In order to i) supply adequate irrigation water to Roleang Chrey irrigation area, ii) release irrigation water to Kandal Steung irrigation area, iii) reduce inundation in the upstream area and iv) mitigate flood damage in the downstream, a coordinated gate operation will be necessary. To accomplish this, a communication network will have to be formed among Roleang Chrey regulator and the downstream gate structures. Furthermore, gate operators will have to learn necessity of regular inspection and maintenance, and carry out it by themselves. At present, the operation and maintenance of the regulator's and intake's gates have been conducted by an experienced gate operator of 69-year old since 1974 under the supervision of Kampong Speu PDOWRAM. MOWRAM will have to train his successor by transferring his technical know-how to a new gate operator soon.

Under these circumstances, assistance for the improvement of MOWRAM's O&M capability has been included as a soft component plan to be carried out under Japan's grant aid scheme.

2. Goal of the Soft Component Plan

MOWRAM will conduct O&M of the improved facilities after the completion of the construction. The soft component plan is designed to attain the following goals:

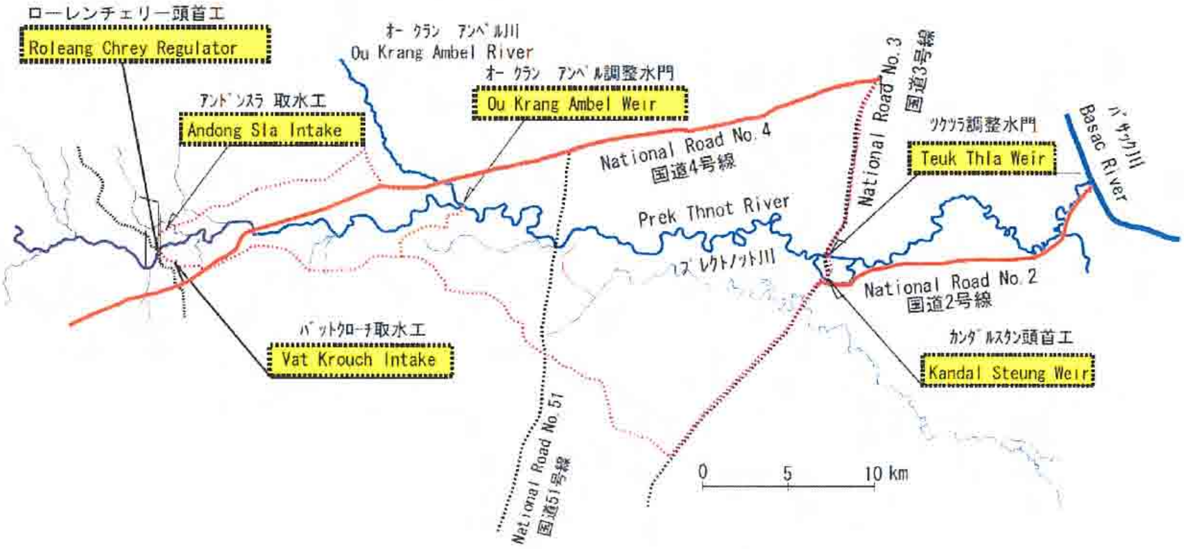
(1) The gate operation of Roleang Chrey regulator and Andong Sla intake will be carried out adequately and efficiently.

(2) The gate operation of the river outlet structure releasing water to Kandal Steung irrigation area will be conducted adequately and efficiently.

(3) The gate operation of the regulator against floods will be conducted quickly and adequately, and a communication network for coordinated gate operation will be formulated among the regulator and the gated structures in the downstream area of Roleang Chrey regulator, such as Kandal Steung weir, Teuk Thla weir and Ou Krang Ambel weir which are shown in the following figure.

(4) Flood entrance to the north main canal will be prevented by the coordinated gate operation between Roleang Chrey regulator and Andong Sla intake.

(5) Gate operators will come to understand the importance and necessity of O&M of the improved facilities, in particular, that of regular inspection and maintenance of mechanical and electrical equipment of the gates.



Downstream Area of the Regulator

3. Results of the Soft Component Plan (Direct Effects)

The results of the soft component plan are as follows:

Result 1) The gate operation of Roleang Chrey regulator will be conducted adequately and efficiently based on the irrigation water supply schedule of Roleang Chrey irrigation area.

Result 2) The gate operation of river outlet structure will be conducted adequately and efficiently to Kandal Steung irrigation area based on the irrigation water supply schedule of Kandal Steung irrigation area.

Result 3) Inundation damage in the upstream area will be reduced by quick and adequate gate operation of Roleang Chrey regulator. Flood damage in the downstream area will be mitigated by a coordinated gate operation among Roleang Chrey regulator, Kandal Steung weir, Teuk Thla weir and Ou Krang Ambel weir.

Result 4) Flood entrance to the north main canal will be prevented and breach of main canals will be saved. In addition, the discharge regulation of Andong Sla intake will become possible.

Result 5) Gate operators will carry out a regular inspection and maintenance of mechanical and electrical equipment and products of gates.

4. Validation of the Results

The results of the soft component plan will be validated as follows:

Result 1) Adequacy and efficiency of the gate operation of Roleang Chrey regulator will be validated with gate operation records together with the irrigation water supply schedule.

Result 2) Adequacy and efficiency of the gate operation of the river outlet structure and Kandal Steung weir will be validated with gate operation records of both gates together with the irrigation water supply schedule of Kandal Steung irrigation area.

Result 3) Whether or not coordinated gate operation was done adequately and the degree of flood damage will be validated with gate operation records and communication network records of Roleang Chrey regulator.

Result 4) Whether or not flood entrance to the north main canal was prevented will be validated with gate operation records of Rolaeng Chrey regulator and Andong Sla intake.

Result 5) Whether or not a regular inspection and maintenance of mechanical and electrical equipment and product of gates were conducted will be validated with regular inspection and maintenance records.

5. Activities in the Soft Component Plan (Input Plan)

MOWRAM will conduct O&M of the improved facilities after the completion of the construction. The soft component plan is designed to attain the following goals which will contribute to maintain the Project effects:

(1) Preparation of O&M guideline for the improved facilities

(2) Preparation of irrigation water supply schedule

(3) Preparation of gate operation manual

(4) Seminar on O&M and gate operation guidance

(5) Guidance of coordinated gate operation among the regulator and the gate structures in the downstream area of the regulator

The content of the activities is shown in the following table.

Content of Activities in the Soft Component Plan

Activities		Content
1.	Preparation of O&M guideline for the improved facilities	Necessity of O&M and regular inspection, method of O&M, facilities to be inspected, O&M record sheet, regular inspection record sheet
2.	Preparation of irrigation water supply schedule	Necessity of irrigation water supply schedule, how to prepare it, seasonal irrigation water supply schedule
3.	Preparation of gate operation manual	How to operate gate according to irrigation water supply schedule, operation rule, how to conduct coordinated gate operation against flood among Roleang Chrey regulator and the downstream gate structures, formulation of communication network among the related gate structures, gate operation record sheet, coordinated gate operation record sheet , communication record sheet
4.	Seminar on O&M and gate operation guidance	Lecture on O&M guideline, irrigation water supply schedule and gate operation manual, gate operation training at site, how to use new control panel, O&M training, regular inspection training
5.	Guidance of coordinated gate operation among the regulator and the gate structures in the downstream area of the regulator	Necessity of coordinated gate operation, mitigation of flood damage, formation of communication network, communication training, coordinated gate operation training

6. Procurement of Local Resources

A Japanese consultant of operation and maintenance expert will provide the services stated in the above input plan, together with one local consultant and one counterpart of MOWRAM. The activities of such local resources are as follows:

(1) Local consultant:

- Translation from English into Khmer of O&M guideline, irrigation water supply schedule and manual prepared by Japanese consultant

- Interpreter from English into Khmer

(2) Counterpart : Coordination between MOWRAM and the consultant

7. Implementation Schedule

The implementation schedule of the soft component plan is shown below:

Implementation Schedule of the Soft Component Plan

Stage	Work \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Preparation	Signing of E/N	▼						▼										
Detailed Design	Detailed Design		━	━	━													
Construction	Tender & Construction								━	━	━					━	━	━
Soft Component Plan	Preparation of Guideline, Manual, etc.																	
	Seminar and Gate Operation Guidance																	
	Japanese O&M Expert																	
	Local Consultant																	
	Counterpart Personnel																	

Stage	Work \ Month	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Preparation	Signing of E/N																	
Detailed Design	Detailed Design																	
Construction	Construction	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━
Soft Component Plan	Preparation of Guideline, Manual, etc.														━	━		
	Seminar and Gate Operation Guidance																━	━
	Japanese O&M Expert														━	━	━	━
	Local Consultant														━	━	━	━
	Counterpart Personnel														━	━	━	━

▒ Rainy Season

8. Outputs of the Soft Component Plan

The outputs of the soft component plan are as follows:

(1) O&M guideline for the improved facilities in English

(2) Summary of O&M guideline for the improved facilities in Khmer

(3) Irrigation water supply schedule in English

(4) Summary of irrigation water supply schedule in Khmer

(5) Gate operation manual in English

(6) Summary of gate operation manual in Khmer

9. Cost Estimation

About Yen 10.7 million

10. Obligations of MOWRAM

The obligations of MOWRAM for the soft component plan are as follows:

(1) MOWRAM should assign one (1) counterpart personnel to the consultant

(2) MOWRAM should assign ten (10) trainees for seminar and gate operation guidance to be conducted under the soft component plan from the following offices :

- Roleang Chrey regulator and intakes O&M office
- Kampong Speu PDOWRAM
- Kandal PDOWRAM
- Kandal Steung weir O&M office
- Teuk Thla Weir O&M office

(3) MOWRAM should permit Roleang Chrey gate operation for gate operation guidance to be conducted under the soft component plan.

(4) MOWRAM should continue O&M of all the irrigation facilities in Roleang Chrey irrigation area as well as that of the improved irrigation facilities

Appendix-6 Other Relevant Data

Appendix 6-1 Basic Design Conditions

(1) Design Standard

Since there is no design criteria for irrigation facility in Cambodia, the following design criteria authorized by GOJ are applied to the design for improvement of the facilities.

Irrigation Facility	Design Criteria
Regulator	- Standard for Plan and Design for Land Improvement Project "Headworks", Ministry of Agriculture, Forestry and Fishery in Japan - Standard for Plan and Design for Land Improvement Project "Canal", Ministry of Agriculture, Forestry and Fishery in Japan - Manual for River Works in Japan "Design", Japan River Association - Government Ordinance for Structural Standard River Administration Facilities, Japan River Association - Standard Specifications for Concrete Structures 2002, Japan Society of Civil Engineering
Intake	- Standard for Plan and Design for Land Improvement Project "Headworks", Ministry of Agriculture, Forestry and Fishery in Japan - Standard for Plan and Design for Land Improvement Project "Canal", Ministry of Agriculture, Forestry and Fishery in Japan - Standard Specifications for Concrete Structures 2002, Japan Society of Civil Engineering
Gate	- Technical Standards for Dam and Weir, Japan Association of Dam & Weir Equipment Engineering - Technical Standard for Gates and Penstocks, Hydraulic Gate and Penstock Association in Japan

(2) River Discharge

The Prek Thnot river discharge at Peam Khley are shown in Table 2.2.1 and summarized in the following table according to the results of the Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia (hereinafter referred to as "JICA study"):

Monthly Average Discharge at Roleang Chrey Regulator (Unit:m^3/s)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Average Discharge	11.3	5.0	5.7	11.6	36.1	48.2	116.6	155.7	238.2	408.1	158.6	35.0
Maximum Discharge	63.5	34.1	53.3	54.7	345.6	221.6	354.5	373.9	505.8	851.0	614.7	391.5
Minimum Discharge	2.4	0.4	0.4	1.5	3.7	3.0	5.3	12.7	69.8	45.6	12.0	2.4

Note: 79 years from 1901 to 2005 (data of 1922, 1973 ~ 1996 are not available)

Source: Interim Report (1) Vol.-III, Appendix A, JICA Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, May 2006

(3) Design High Water Level

The design high water level at the upstream of the regulator is determined at WL.36.00m, which is calculated by adding the maximum allowable overflow depth 0.30m to top elevation of gate EL 35.70 m.

(4) Design Flood Discharge

The design flood discharge for the rehabilitation of the regulator is determined at 1,600 m^3/s that has been estimated by JICA study team. This discharge is approximately a 50-year probable flood discharge. In the case of 1,600 m^3/s of flood discharge, the design flood water level is set at WL.36.00 m, referring to water levels WL.35.86 m calculated at the downstream of the regulator by non-uniform flow calculation and WL.36.00 m based on the observation record of water level at the upstream of the regulator, respectively.

(5) Design Intake Discharge

The design intake discharge is obtained using the following formula established in the JICA Study:

$$\text{Design Intake Discharge } (m^3/s) = \text{Irrigation Area (ha)} \times 0.0016\ m^3/s/ha$$

Based on the above formula, the design discharge for North Main Canal and Andong Sla Intake is estimated at 10.4 m^3/s (=6,500 ha x 0.0016) and the one for South Main Canal and Vat Krouch Intake is estimated at 5.5 m^3/s (=3,450 ha x 0.0016). The total discharge for whole irrigation area is estimated at 15.9 m^3/s.

(6) Rainfall and Rainy Days

Rainfall data observed for five years from 2001 to 2005 at Kampong Speu PDOWRAM are used for preparation of a construction plan. The monthly average rainfall and the number of rainy days are summarized in the following table:

Monthly Average Rainfall and the Number of Rainy Days observed at Kampong Speu PDOWRAM

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Rainfall(mm)	4	4	36	66	104	109	144	123	180	162	31	13	976
Number of Rainy Days	2	1	4	5	6	8	10	11	14	12	6	1	80

Source: Kampong Speu PDOWRAM (2001~2005)

(7) Seismic Coefficient

Since seismic coefficient to be used for design of structure is not standardized in Cambodia and strong earthquake has not been occurred around the project site, minimum seismic coefficient of Kh=0.1 is applied to the design in accordance with the Japanese criteria.

(8) Construction Schedule and Water Cut-Off Period

- In order to secure irrigation water supply for paddy cultivation in the rainy season, the construction works for the temporary coffer dam, spillway and channel for the rehabilitation of the regulator and intake will not be carried out during the rainy cropping season (May to November). Those works will be carried out during the dry season (December to April) and water cut-off period should be minimized.
- The river works should not be carried out during flood season (July to October).

Appendix 6-2 Basic Design of Roleang Chrey Regulator

6-2 Basic Design of Roleang Chrey Regulator

6-2.1 Upstream Design High Water Level (Gate Closing)

The top elevation of the gates of the existing regulator is EL.35.70m. These gates are operated by gate operators to control overflow water depth at the top of the gate not exceeding 30cm. Thus the upstream water level is under control between WL.35.70m and WL.36.00m by adjusting gate operating height.

According to the upstream water level records from February 2001 to September 2007, which were observed by gate operators, the majority of recorded water levels were below WL.36.00m. In addition, the highest level was WL.36.04 m at the largest flood in the above recorded period. Therefore, the upstream design high water level is determined at WL.36.00 m.

The related data and information are shown in the following tables and figures:

- The Upstream Water Level Observation Records in Table 6.4.1
- The Upstream Water Level Fluctuation in Figure 6.4.1
- The Gates Operation Records in Table 6.4.2
- The Highest Upstream Water Level and Maximum Gate Opening Height in Table 6.4.3

6-2.2 Design Flood Level

The design flood level is determined based on the non-uniform hydraulic calculation for 1600 m^3/s of design flood discharge with setting the downstream calculation boundary at 2km from the regulator. As a result, the design flood level at the downstream of the existing apron is given at HWL.35.86 m.

If the upstream water level is not affected by backwater from the downstream, flood level at the upstream of the existing apron under full gate opened condition is obtained from overflow water depth at the existing end sill. However, according to the hydraulic calculation results, the upstream flood level is calculated at WL.34.90 m, which is lower than the downstream flood level (HWL.35.86 m). Therefore, the water flow at the regulator during flood is predicted to become submerged water flow condition. As the upstream water level is considered same or slightly higher than the downstream water level under the submerged water flow condition, the upstream flood level is decided at HWL.36.00 m.

The non-uniform calculation results for 1,600 m^3/s of flood discharge is shown in Table 6.5.1 and hydraulic calculation of overflow depth and level at the existing end sill is shown in Table 6.5.2.

6-2.3 Downstream River Bank and Bed Protection

(1) Length of Downstream River Bed Protection

The river bed protection should be provided in order to protect the present river bed in due consideration of the following facts:

1) As mentioned above, when a gate of the regulator is opened, river flow at the downstream is hydraulically submersible and hydraulic force to river bed scouring is not so strong
2) The downstream river bed of tuff layer has been partially caved in.
3) No river bed degradation has been observed for the past 33 years.

In accordance with the Japanese criteria, Standard for Plan and Design for Land Improvement Project "Headworks", it is mentioned that "the length of the downstream of riprap under the submersible condition is obtained from 10 ~ 15 times water depth at the gate point and this length includes the length of the downstream apron". As mentioned above, since the design flood level is HWL.36.00 m and the bed elevation of the upstream apron is EL.29.00m, the water depth is 7.0m and the required length of the riprap is estimated at 70 ~ 105m (7.0m x 10 ~ 15).

In order to satisfy the above required length, the following river protection will be provided:

1) Existing apron (from gate point to end of apron)	18 m
2) An additional apron of reinforced concrete with a cut-off	8 m
3) Grouted riprap	42 m
4) Gabion	10 m
Total length	78 m > 70m OK

(2) Design of Downstream River Bank Protection

1) Low Flow Channel Elevation

Local scouring place is observed at right bank side of the downstream of the existing apron, however, after local scouring place the lowest river bed elevation is stable at EL.28.5 m. On the other hand, at the left bank of the downstream of the existing apron, strong tuff layer appears on the river bed surface and the river bed elevation is stable at EL.27.0 m ~ 28.0 m. Based on this survey results, the design elevation of low flow channel at right bank side of the downstream of the existing apron is given at EL. 27.0 m.

2) High Water Channel Elevation

The top elevation of the existing riprap at the downstream of the existing apron is EL.33.5 m ~ 34.0 m. The flood level for Q=1,000 m^3/s of flood discharge (5-years probable flood) at the downstream of the existing apron is calculated at WL. 34.05 by non-uniform flow calculation. Therefore, the top elevation of new riprap at the both bank is designed at EL. 34.00 m. In accordance with the Japanese criteria, Manual for River Works "Planning", it is mentioned that "the high water channel elevation in a river having a high water channel and a low water channel cross sections, shall be determined to be submerged one to three times per year". If EL.34.00 m is considered as the design high water channel elevation, it is sufficient for the flood level.

3) Length of Downstream River Bank Protection

Taking grouted riprap area and existing riprap length into consideration, ripraps for river bank protection will be provided at 30 m length of both river side along the river flow direction and after ripraps will be opened at 45 degree at the downstream.

6-2.4 River Outlet Structure

(1) Determination of Cross Section

The river outlet structure will be of culvert type. To minimize the work period and maintenance burden, two barrels of ready-made concrete pipes covered with reinforced concrete are applied. The hydraulic calculation for the river outlet structure is described below:

1) Inlet

The following circular orifice formula is used for hydraulic calculation for the inlet.

$$Q = C\,a\sqrt{2gH} \geq Q_0$$

where
- Q : Orifice discharge (m^3/s)
- C : Coefficient C = 0.61 (Irrigation, Drainage and Reclamation Engineering Handbook Revision 6, "Basic" pp.81)
- a : Cross sectional area of orifice (m^2) $a = \pi d^2 / 4$
- d : Diameter of circular orifice (= internal diameter of concrete pipe) (m)
- g : Acceleration of gravity g = 9.8 m/s^2
- H : Water depth between water surface and center of orifice(m) $H = EL_1 - EL_2 + d/2$
- EL_1 : Upstream water level(m) EL_1 = 35.70m (gate top elevation) – 0.10m = 35.60m
- EL_2 : Inlet base elevation (m) EL_2 = 31.00m
- Q_0 : Maximum design inflow discharge Q_0 = 5.00 m^3/s ($Q_0/2$ = 2.50 m^3/s per pipe)

d (m)	0.60	0.80	1.00
a (m)	0.283	0.503	0.785
H (m)	4.30	4.20	4.10
C	0.61	0.61	0.61
g (m/s^2)	9.8	9.8	9.8
Q (m^3/s)	1.58	2.78	4.29
$Q_0/2$ (m^3/s)	2.50	2.50	2.50
Judgment	OUT	OK	OK

As shown in the above table, when the diameter of orifice (= internal diameter of concrete pipe) is more than 0.8 m, the flow capacity of concrete pipe become more than the maximum design inflow discharge. However, in order to reduce water velocity inside the culvert and make easy inspection of culvert, the internal diameter is decided at 1.0 m. Two sets of steel slide gates for discharge regulation (clear span 1.0 m x effective height 1.0 m) will be installed.

In case that maximum inflow discharge per pipe is 2.50 m^3/s, the maximum water velocity is calculated as below:

$$V = (Q_0/2) / a = 2.50 / 0.785 = 3.18 \text{ m/s}$$

The result is close to the maximum allowable velocity (3.0 m/s) of ready-made concrete pipe.

(2) Structural Calculation for Culvert Section (double box culvert)

The structures to be rehabilitated or newly constructed in the regulator are the river bank and bed protection and the right bank river outlet structure. Out of these structures, structural calculation is required for the right bank river outlet structure. It consists of intake, culvert and outlet, and the structural calculation is carried out for the culvert section.

The structural design of culvert is two barrels of ready-made reinforced concrete pipe (diameter 1.0m) covered with cast-in-place reinforced concrete. However, for the structural calculation, only strength of covered cast-in-place reinforced concrete is considered as double box culvert, because the quality of concrete pipe produced in Cambodia is not reliable.

1) Design Condition

1) Standard unit weight			
Water	$\gamma w=$	10.0	kN/m^3
Soil (wet)	$\gamma\tau=$	18.0	kN/m^3
Soil (saturated)	$\gamma sat=$	20.0	kN/m^3
Reinforced concrete	$\gamma c=$	24.5	kN/m^3
2) Coefficient of earth pressure at rest	Ka=	0.5	
3) Live load			
Type of wheel load		T-14	
Rear wheel load	Pr=	55.0	kN
Front wheel load	Pf=	13.5	kN
Width of earth connection	a =	0.20	m
Front and rear wheel width	b =	0.50	m
Impact coefficient(D□4.0m:0, D<4.0m:0.3)	i =	0	
Crowd load	q =	0.0	kN/m^2
4) Safety factor			
Safety factor for uplift	Fa=	1.2	
5) Allowable stress			
28-day compressive strength of concrete	$\sigma ck=$	21.0	N/mm^2
Allowable bending compressive of concrete	$\sigma ca=$	8.0	N/mm^2
Allowable shearing stress of concrete	$\tau a=$	0.42	N/mm^2
Yield stress of reinforcement bar	$\sigma sy=$	294	N/mm^2
Allowable tensile stress of reinforcement bar	$\sigma sa=$	157	N/mm^2
Young's modulus	n =	15	

2) Design Parameter

1. Dimension of Structure

Internal diameter of concrete pipe	ϕ=	1.00	m
Thickness of concrete pipe	T=	0.08	m
Inner height	H=	1.20	m
Inner width	B=	1.20	m
Haunch height	Hf=	0.30	m
Thickness of side wall	t1=	0.30	m
Thickness of top slab	t2=	0.30	m
Thickness of bottom slab	t3=	0.30	m
Thickness of partition wall	t4=	0.40	m
Overall height of culvert	HT=	1.80	m
Overall width of culvert	BT=	3.40	m
Cover of reinforcement bar (side wall, top slab, bottom slab, partition wall)	d=	0.07	m

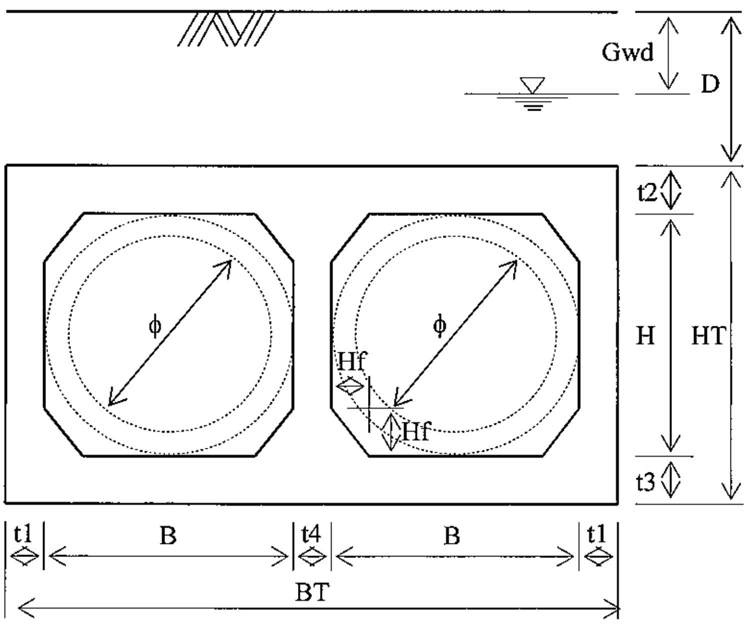
2. Earth cover D= 7.00 m

3. Groundwater

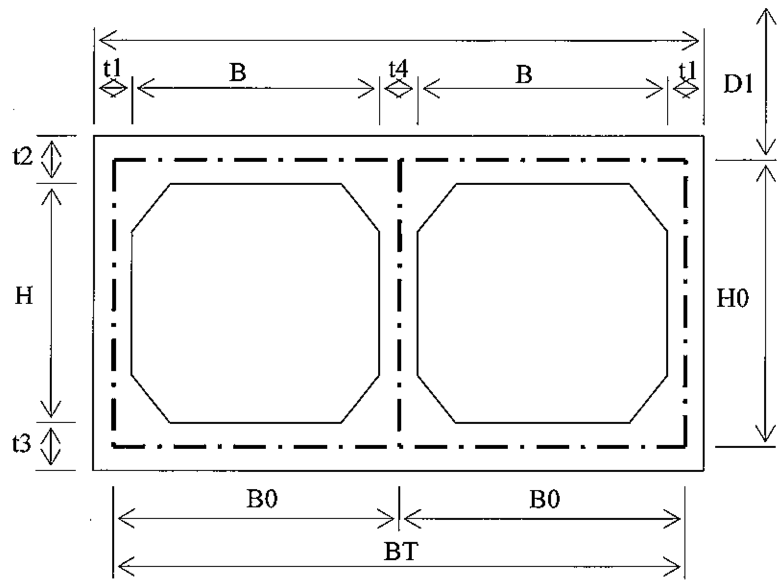
Depth of groundwater level from ground surface	Case 1, 2	Gwd=	3.40	m
	Case 3, 4	Groundwater is not considered.		

4. Inside water

Water depth of inside water	Case 1, 2	Hiw=	0.00	m
	Case 3, 4	Hiw=	1.20	m



Cross Section of Box Culvert



Structural Calculation Frame

Rahmen axis height	H0=	1.50	m
Rahmen axis width (per culvert)	B0=	1.55	m
Rahmen overall axis width	BT0=	3.10	m
Earth cover from axis of top slab	D1=	7.15	m

3) Analysis on uplift

Fs = Vd / U > Fa

where Fs: safety factor against uplift pressure

Vd: Total dead load Vd=418.68 kN/m

U: Total uplift U=61.20 kN/m

Fa: Safety factor Fa=1.2

Fs = 418.68 /61.20 = 6.84 > Fa = 1.2

Thus, the culvert is safe against uplift.

4) Load combination

① Load Combination

The following four cases are considered as load combination:

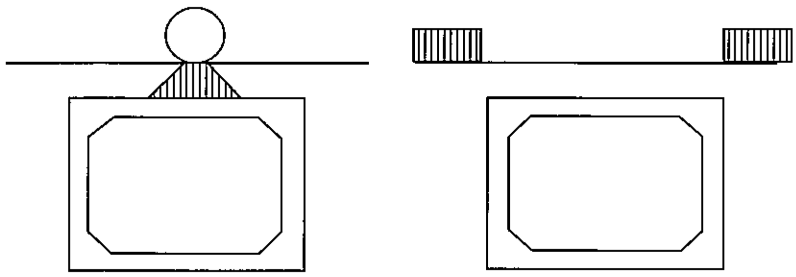
Case 1: No internal water pressure, groundwater level up to top of slab, wheel load case L1

Case 2: No internal water pressure, groundwater level up to top of slab, wheel load case L2

Case 3: Full internal water pressure, no groundwater, wheel load case L1

Case 4: Full internal water pressure, no groundwater, wheel load case L2

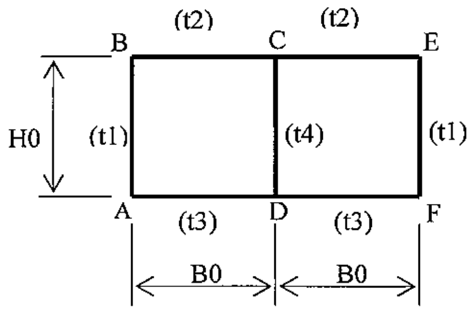
Wheel load case L1 and L2 are shown in the following illustration:

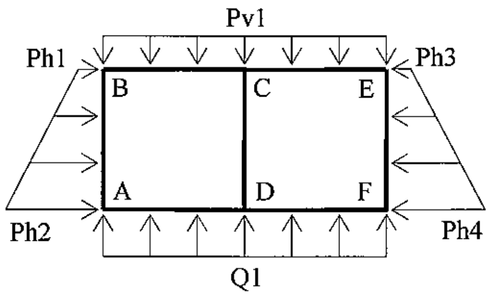


Case L1 Case L2

② Load calculation results

Case	Pv1 (kN/m2)	Pv2 (kN/m2)	Ph1 (kN/m2)	Ph2 (kN/m2)	Pq (kN/m2)	Wsw (kN/m)	Wpw (kN/m)	q1 (kN/m2)
Case 1	142.684	7.000	90.350	112.850	159.168	8.820	11.760	148.910
Case 2	142.684	0.000	90.350	112.850	152.168	8.820	11.760	141.910
Case 3	142.684	7.000	67.850	69.350	159.168	8.820	11.760	176.781
Case 4	135.484	0.000	67.850	69.350	144.968	8.820	11.760	162.581





6-2.5 Design Temporary Coffer Dam

During the construction periods of the regulator a temporary coffer dam is planed to be constructed at the upstream of the regulator. The coffer dam will be constructed in December, which is the beginning of dry season, and will be removed in April, the end of dry season. In order to check stability of the coffer dam, slope stability analysis is carried out. The typical cross section of coffer dam is shown in Figure 6.6.1. The soil constant used for the slope analysis are determined based on the results of the soil laboratory test, boring survey, and site inspection as follows:

Soil type: Clay contain gravel

Unit weight:

Soil (wet) :	18 kN/m^3
Soil (saturated) :	20 kN/m^3
Water:	18 kN/m^3
Internal friction angle:	φ= 15°
Cohesion:	C = 30 kN/m^2

The following two cases of the slope stability analysis were carried out using the software of"COSTANA".

Case 1 (normal condition) : Upstream water depth 7m (full water level) , Downstream water depth 0m

Case 2 (under earthquake) : Upstream water depth 7m (full water level) , Downstream water depth 0m, Seismic coefficient = 0.1

The results of the analysis are shown in Figure 6.6.1 and 6.6.2. According to the results, safety factors are given at 2.4 > 1.2 in normal condition and 1.7 > 1.0 under earthquake condition and they are satisfied with the minimum safety factor respectively. It is judged that additional allowance for safety factor is required because it is difficult to control the quality of embankment strictly due to limitation of work period for embankment (only 10 days) and difficulty of control of moisture contain in the beginning stage of works.

6-2.6 Temporary Spillway and Channel

In order to divert all river water during water cut-off period, a temporary spillway is planed to be constructed along the north approach channel and a temporary channel is planed to be constructed from a temporary spillway to the original river. The hydraulic calculation is carried out for those temporary facilities as follows.

(1) Diversion Discharge

A diversion water discharge is determined at a 10-year probable high river discharge during dry season from December to April based on monthly river discharge shown in Table 2.2.1.

The following table shows the raking of the maximum experienced discharge in December and return periods in 79 years of recorded periods. According to the table, a 10-year probable high river discharge is 50.6 m^3/s and the design diversion discharge is determined at 50.6 m^3/s.

Maximum Experienced Discharge in December and Return Period

Rank	Maximum experienced discharge in December (m^3/s)	Return Period(year)
1	391.5	79
2	182.3	40
3	136.0	26
4	83.6	20
5	82.4	16
6	67.4	13
7	53.0	11
8	**50.6**	**10**
9	48.3	9
10	45.2	8

Record Period: 79 years, 1901～2005 excluding 1922 and 1973 to 1996

(2) Temporary Spillway

As the north approach channel at the upstream of Andong Sla Intake has a flow capacity of around 70 m^3/s of in accordance with JICA study, the channel has enough capacity for 50.6 m^3/s of design diversion water discharge.

As the north main canal after Andong Sla Intake has a flow capacity of 10.4 m^3/s, which is planed to be diverted to the north main canal. Therefore, the design discharge (Qs) to be diverted from the north approach channel to the original river at the temporary spillway is calculated as follows:

$$Qs = 50.6 - 10.4 = 40.2 \text{ m}^3/\text{s}$$

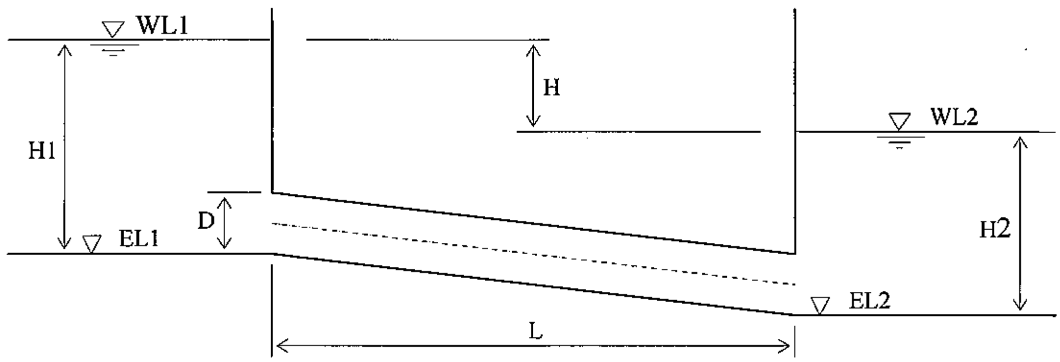
At the inlet of temporary spillway, six barrels of reinforced concrete pipes with a diameter of 1.5 m will be provided and the hydraulic calculation is carried out as follows:

Maximum design discharge	Qo =	40.20	m^3/s	
Barrel of concrete pipe	N =	6	barrels	
Design discharge per pipe	Q1 =	6.70	m^3/s	
Upstream water level	WL1 =	35.40	m	
Downstream water level	WL2 =	34.00	m	
Inlet pipe base elevation	EL1 =	33.20	m	
Outlet pipe base elevation	EL2 =	32.20	m	
Internal diameter of pipe	D =	1.50	m	
Length of pipe	L =	18.10	m	
Upstream water depth	H1 =	2.20	m	= WL1~ EL1
Downstream water depth	H2 =	1.80	m	= WL2~ EL2
Difference of water level	H =	1.40	m	= WL1~ WL2

Inlet loss coefficient	fe =	0.5		(Square edge)

Shape of inlet	Loss coefficient fe
Square edge	0.5
Edge cut	0.25
Round (circle)	0.1
Round (Square)	0.2
Bell-mouth	0.01 - 0.05

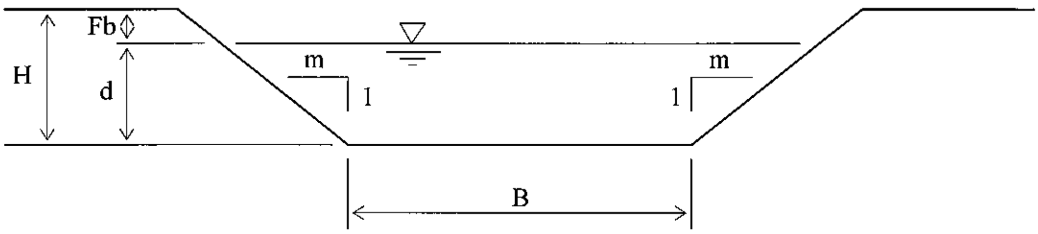
Friction loss coefficient	f =	0.024		$= 124.5\ n^2 / D^{1/3}$
Roughness coefficient	n =	0.015		
,oss coefficient by gate	fg =	0.0		(Full open of gate)
Outlet loss coefficient	fo =	1.0		
Acceleration of gravity	g =	9.8	m/s^2	
Velocity inside pipe	V =	3.910	m/s	$= \{ 2\,g\,H / (fe + fo + fg + f\,L / D) \}^{1/2}$
Velocity head	$V^2/(2g)$ =	0.780	m	
Inlet head loss	he =	0.390	m	$= fe\ V^2/(2g)$
Friction head loss	hf =	0.230	m	$= (f\ L/D)\ V^2/(2g)$
Gate head loss	hg =	0.000	m	$= fg\ V^2/(2g)$
Outlet head loss	ho =	0.780	m	$= fo\ V^2/(2g)$
Total head loss	Σh =	1.400	m	= he + hf + hg+ ho
Flow cross sectional area (per pipe)	A =	1.767	m^2	$= \pi D^2 / 4$
Flow capacity (per pipe)	Q =	6.909	m^3/s	= A V
Judgment				> Q1 =6.70 m^3/s OK



(3) Temporary Channel

The temporary channel is of earthen trapezoid open channel and the cross section is determined by hydraulic calculation using manning formula. As a result of the calculation, the cross section is determined as follows:

Design discharge	Qo =	40.20	m^3/s			
Bottom width	B =	14.00	m			
Water depth	d =	1.90	m			
Free board	Fb =	1.00	m			
Canal height	H =	2.90	m	= d + Fb		
Gradient	I =	0.0008		= 1 / 1250		
Slope(1:m)	m =	1.5				
Roughness coefficient	n =	0.030				
Flow cross sectional area	A =	32.03	m^2	$= (B + m\ d)\ d$		
Wet perimeter	P =	20.85	m	$= B + 2\ d\ (1+m^2)^{1/2}$		
Hydraulic mean depth	R =	1.536	m	$= A / P$		
Velocity	V =	1.26	m/s	$= (1/n)\ R^{2/3}\ I^{1/2}$		
Flow discharge	Q =	40.20	m^3/s	$= A\ V$		
Judgment				= Qo = 40.20	m^3/s	OK



Appendix 6-3 Basic Design of Andong Sla Intake

6-3 Design of Andong Sla Intake

In order to recover the original function and prevent leakage, the intake gate will be replaced with new radial gates (clear span 4.0 m x height 2.7 m x 2 sets). The base elevation of the new gates will be EL 32.00m, which is the same as that of the existing gate.

6-3.1 Creep Length

As the foundation of the intake is a permeable ground, a countermeasure for prevention of piping must be considered. Therefore, the creep length is ensured by using Bligh's method and Lane's method.

(1) Bligh's method

$$S \geqq C \cdot \Delta H$$

where S: Length of creep length measured along the foundation face of the intake (m)
S= Lv+Lh=6.00+27.80=33.80 m (referred to the following figure)
C: Coefficient which varies depending on the type of the foundation ground C=- (Hard clay, no value)
⊿H: Maximum head difference at upstream and downstream side ⊿H=4.00 m (referred to the following figure)

(2) Lane's method

$$L \geqq C' \cdot \Delta H$$

where L: Length of weighted creep length (m)
L=∑Lv+1/3 Σ Lh=6.00+1/3x27.80=15.27 m
Lv: Creep length of vertical direction(inclination of more than 45°) (m)
Lv=1.00+0.40+0.70+0.50+0.25x3+0.45+0.60x2+1.00=6.00 m
Lh: Creep length of horizontal direction(inclination of below 45°) (m)
Lh=5.00 x 2+1.00+16.80=27.80 m
C': Coefficient which varies by the type of ground C=1.6 (hard clay, referred to the following table)
⊿H: Maximum head difference at upstream and downstream side ⊿H=4.00 m (referred to the following figure)

(3) Ensuring of creep length

The elevation of the intake foundation is EL. 31.0 ~ 32.0 m and the type of soil at this elevation is hard clay according to the results of boring survey. As Bligh's method is not applicable for hard clay foundation, Lane's method is applied to ensure the creep length.

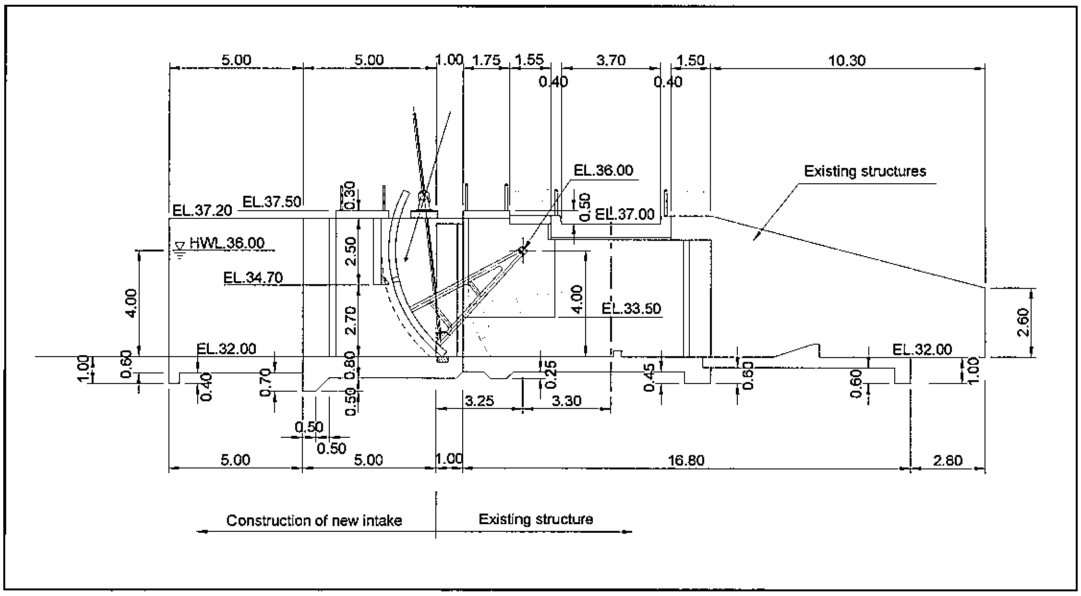
Based on Lane's methods L = 15.27 m

C' ・ ⊿H = 1.6 x 4.00 = 6.40 m

Thus, L > C' ・ ⊿H and it is judged that this structure is safe condition against piping.

Coefficient for Bligh's Method and Lane's Method

Foundation	Bligh's coefficient (c)	Lane's coefficient (C')
Silty sand or clay	18	8.5
Fine sand	15	7.0
Medium sand	—	6.0
Coarse sand	12	5.0
Gravel	—	4.0
Coarse gravel	—	3.5
Sandy gravel	9	—
Cobble stone with gravel	—	3.0
Rocks with cobble stone and gravel	—	2.5
Rocks with gravel and sand	4～6	—
Soft clay	—	3.0
Medium clay	—	2.0
Heavy clay	—	18
Hard clay	—	1.6



Creep Length

6-3.2 Opening Height of Gate

The required opening height of the gates (radial gate) at the intake is determined by hydraulic calculation under submerged flow condition as follows:

$$Q = C_1 \, a \, B \sqrt{2 g h_0} \geq Q_0$$

where Q : Flow discharge (m^3/s)

C_1 : Coefficient(「Hydraulic Calculation Formula, 1999, Volume III "Dam"pp.255」)

$R/D = 5.00/4.00 = 1.25$, $h_0/D = 3.60/4.00 = 0.9$, $h_2/D = 3.30/4.00 = 0.825$

R : Radius of gate leaf $R = 5.00$ (m)

D : Height from bed slab to trunnion pin $D = 4.00$ (m)

a : Opening height of gate (m)

B : Clear span $B = 4.00$ (m)

g : Accelerate of gravity $g = 9.8\ m/s^2$

h_0 : Upstream water depth (m) $H = WL_1 - EL_1 = 3.60$ m

WL_1 : Upstream water level (m) $WL_1 = 35.70$m (top of regulator gate) – 0.10m = 35.60m

EL_1 : Upstream bed slab elevation (m) $EL_1 = 32.00$m

h_2 : Downstream water depth (m) $h_2 = WL_2 - EL_2 = 3.30$ m

WL_2 : Downstream water level (m) $WL_2 = 35.30$m (assumed head difference)

EL_2 : Downstream bed slab elevation(m) $EL_2 = 32.00$m

Q_0 : Design maximum discharge $Q_0 = 10.40\ m^3/s$ ($Q_0/2 = 5.20\ m^3/s$ per gate)

a (m)	0.40	0.80	1.20	1.60	2.00
B (m)	4.00	4.00	4.00	4.00	4.00
D (m)	4.00	4.00	4.00	4.00	4.00
a/D (m)	0.1	0.2	0.3	0.4	0.5
C_1	0.26	0.26	0.28	0.31	0.35
g	9.8	9.8	9.8	9.8	9.8
h_0 (m)	3.60	3.60	3.60	3.60	3.60
Q (m^3/s)	3.49	6.99	11.29	16.67	23.52
$Q_0/2$ (m^3/s)	5.20	5.20	5.20	5.20	5.20
Judgment	OUT	OK	OK	OK	OK

Remarks: $R/D = 5.00/4.00 = 1.25$, $h_0/D = 3.60/4.00 = 0.9$, $h_2/D = 3.20/4.00 = 0.825$

As a result, in case of 0.6m of opening height of two gates, the design maximum discharge flows.

6-3.3 Design of Temporary Diversion Channel

In order to secure irrigation water supply during the construction period for the intake structure, two temporary coffer dams are to be constructed at the upstream and the down stream and a temporary diversion channel is to be constructed at the right bank of the intake. The usage period of the temporary diversion channel is planed for around five months from December, 2010 to April, 2011. The hydraulic calculation of diversion channel is described below:

(1) Design Discharge

The required maximum design discharge for the north main canal is applied for the design discharge for the temporary diversion channel.

(2) Inlet of Temporary Diversion Channel

At the inlet of the temporary diversion channel, five barrels ready-made concrete pipes with 1.0 m diameter will be provided. The hydraulic calculation is shown below:

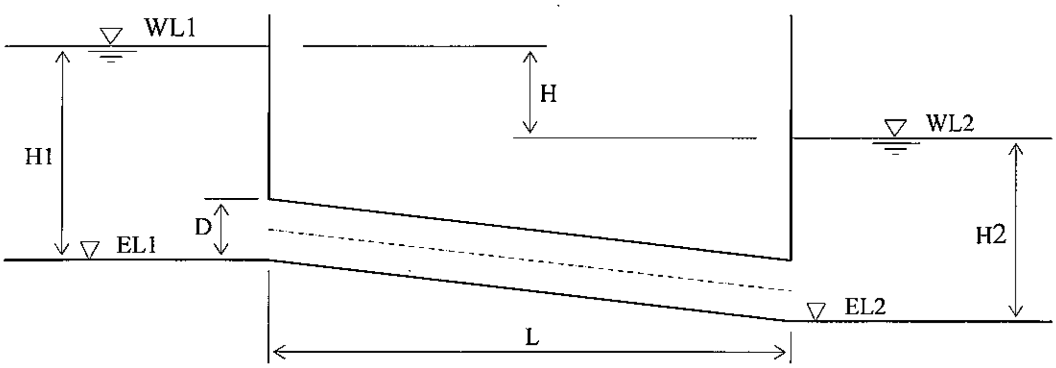
Maximum design discharge	Qo =	10.40	m^3/s	
Barrel of concrete pipe	N =	5	barrels	
Design discharge per pipe	Q1 =	2.08	m^3/s	
Upstream water level	WL1 =	35.40	m	
Downstream water level	WL2 =	34.65	m	
Inlet pipe base elevation	EL1 =	33.80	m	
Outlet pipe base elevation	EL2 =	33.05	m	
Internal diameter of pipe	D =	1.00	m	
Length of pipe	L =	19.50	m	
Upstream water depth	H1 =	1.60	m	= WL1 - EL1
Downstream water depth	H2 =	1.60	m	= WL2 - EL2
Difference of water level	H =	0.75	m	= WL1 - WL2
Inlet loss coefficient	fe =	0.5		(Square edge)

Shape of inlet	Loss coefficient fe
Square edge	0.5
Edge cut	0.25
Round (circle)	0.1
Round (Square)	0.2
Bell-mouth	0.01 - 0.05

Friction loss coefficient	f =	0.028		$= 124.5\, n^2 / D^{1/3}$
Roughness coefficient	n =	0.015		
Outlet loss coefficient	fo =	1.0		
Acceleration of gravity	g =	9.8	m/s^2	
Velocity inside pipe	V =	2.680	m/s	$= \{ 2\,g\,H / (fe + fo + f\,L / D) \}^{1/2}$
Velocity head	$V^2/(2g)$ =	0.367	m	

Inlet head loss	he =	0.183	m	$= fe\ V^2/(2g)$
Friction head loss	hf =	0.200	m	$= (f\ L/D)\ V^2/(2g)$
Outlet head loss	ho =	0.367	m	$= fo\ V^2/(2g)$
Total head loss	$\Sigma h =$	0.750	m	= he + hf + ho

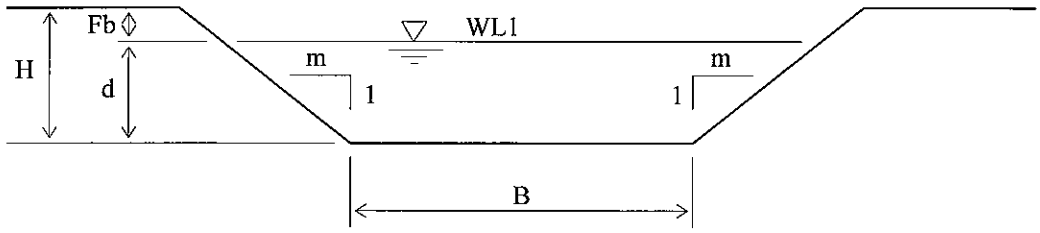
Flow cross sectional area (per pipe)	A =	0.785	m^2	$= \pi\ D^2 / 4$			
Flow capacity (per pipe)	Q =	2.105	m^3/s	= A V			
Judgment				>	Q1 =2.08	m^3/s	OK



(3) Temporary Diversion Channel

The temporary diversion channel is of earthen trapezoid open channel and the cross section is determined by hydraulic calculation using Manning formula. As a result of the calculation, the cross section is determined as follows:

Design discharge	Qo =	10.40	m^3/s			
Bottom width	B =	3.20	m			
Water depth	d =	1.70	m			
Free board	Fb =	0.80	m			
Canal height	H =	2.50	m	= d + Fb		
Gradient	I =	0.001		= 1 / 1000		
Slope(1:m)	m =	1.5				
Roughness coefficient	n =	0.030				
Flow cross sectional area	A =	9.775	m^2	= (B + m d) d		
Wet perimeter	P =	9.329	m	$= B + 2\ d\ (1+m^2)^{1/2}$		
Hydraulic mean depth	R =	1.048	m	= A / P		
Velocity	V =	1.09	m/s	$= (1/n)\ R^{2/3}\ I^{1/2}$		
Flow discharge	Q =	10.63	m^3/s	= A V		
Judgment				> Qo = 10.40	m^3/s	OK



(4) Outlet of Temporary Diversion Channel

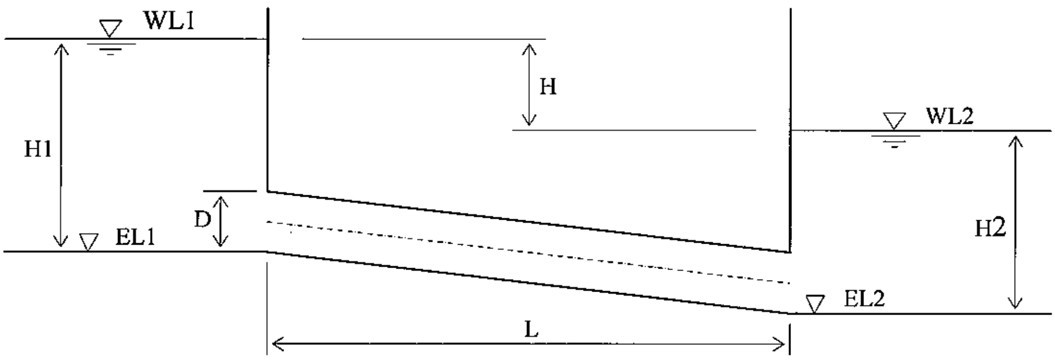
At the outlet of the temporary diversion channel, five barrels ready-made concrete pipes with 1.0 m diameter will be provided. The hydraulic calculation is shown below:

Maximum design discharge	Qo =	10.40	m^3/s	
Barrel of concrete pipe	N =	5	barrels	
Design discharge per pipe	Q1 =	2.08	m^3/s	
Upstream water level	WL1 =	34.25	m	
Downstream water level	WL2 =	33.50	m	
Inlet pipe base elevation	EL1 =	32.65	m	
Outlet pipe base elevation	EL2 =	32.10	m	
Internal diameter of pipe	D =	1.00	m	
Length of pipe	L =	21.20	m	
Upstream water depth	H1 =	1.60	m	= WL1 ~ EL1
Downstream water depth	H2 =	1.40	m	= WL2 ~ EL2
Difference of water level	H =	0.75	m	= WL1 ~ WL2
Inlet loss coefficient	fe =	0.5		(Square edge)

Shape of inlet	Loss coefficient fe
Square edge	0.5
Edge cut	0.25
Round (circle)	0.1
Round (Square)	0.2
Bell-mouth	0.01 - 0.05

Friction loss coefficient	f =	0.028		$= 124.5\ n^2 / D^{1/3}$
Roughness coefficient	n =	0.015		
Outlet loss coefficient	fo =	1.0		
Acceleration of gravity	g =	9.8	m/s^2	
Velocity inside pipe	V =	2.650	m/s	$= \{ 2\, g\, H / (fe + fo + f\, L / D) \}^{1/2}$
Velocity head	$V^2/(2g)$ =	0.358	m	
Inlet head loss	he =	0.179	m	$= fe\ V^2/(2g)$
Friction head loss	hf =	0.213	m	$= (f\ L/D)\ V^2/(2g)$
Outlet head loss	ho =	0.358	m	$= fo\ V^2/(2g)$

Total head loss	$\Sigma h =$	0.750	m	= he + hf + ho	
Flow cross sectional area (per pipe)	A =	0.785	m^2	$= \pi\ D^2 / 4$	
Flow capacity (per pipe)	Q =	2.081	m^3/s	= A V	
Judgment				> Q1 =2.08 m^3/s	OK



6-3.4 Structural Calculation <Gate Base Slab & Pier (One Lane Flume)>

In the reconstruction works for the intake, the rehabilitation of the existing intake and the provision of grouted riprap will be carried out. The rehabilitation of existing intake will consist of gate base slab, wall, cutoff wall, operation deck, and transition and the structural calculation is required for gate base slab and wall. As there are two-type cross sections, one lane flume and two lanes flume, the calculation is done for both types. The design conditions and results are described below:

(1) Design conditions

1) Standard unit weight			
Water	$\gamma w=$	10.0	kN/m^3
Soil (wet)	$\gamma \tau=$	18.0	kN/m^3
Soil (saturated)	$\gamma sat=$	20.0	kN/m^3
Reinforced concrete	$\gamma c=$	24.5	kN/m^3
2) Coefficient of active earth pressure	Ka=	0.279	
Intersectional angle	$\phi=$	30	°
Cohesion	c=	0	kN/m^2
3) Live load			
Type of wheel load		-	
Rear wheel load	Pr=	-	kN
Front wheel load	Pf=	-	kN
Width of earth connection	a =	-	m
Front and rear wheel width	b =	-	m
Impact coefficient(D≧4.0m:0, D<4.0m:0.3)	i =	0	
Crowd load	q =	0	kN/m^2
4) Safety factor			

Safety factor for uplift	Fa=	1.2	

5) Allowable stress

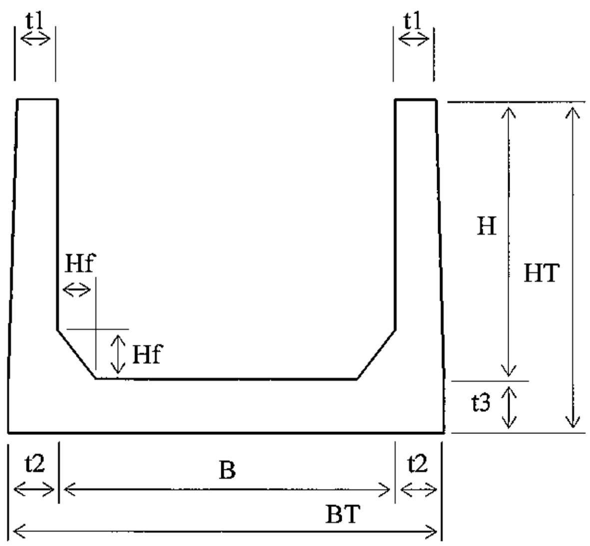
28-day compressive strength of concrete	σck=	21.0	N/mm^2
Allowable bending compressive of concrete	σca=	8.0	N/mm^2
Allowable shearing stress of concrete	τa=	0.42	N/mm^2
Yield stress of reinforcement bar	σsy=	294	N/mm^2
Allowable tensile stress of reinforcement bar	σsa=	157	N/mm^2
Young's modulus	n =	15	

3) Design Parameter

1) Dimension

Internal height	H=	5.20	m
Internal width of one lane	B=	4.00	m
Haunch height	Hf=		m
Thickness of side wall (top)	t1=	0.60	m
Thickness of side wall (bottom)	t2=	0.60	m
Thickness of base slab	t3=	0.80	m
Overall height of flume	HT=	6.00	m
Overall width of flume	BT=	5.20	m
Cover of reinforcement bar (side wall, top slab, bottom slab, partition wall)	d=	0.07	m

2) Groundwater level	Case 1	Half of side wall
	Case 2	Top of side wall
3) Inside water	Case 1	No inside water
	Case 2	Full inside water



Cross Section of Flume

(3) Analysis on uplift

$$Fs = (Vd + Pv) / U > Fa$$

where Fs: Safety factor against uplift pressure

Vd: Total dead load Vd=254.8 kN/m

Pv: 50% of total earth pressure Pv=22.0 kN/m

U: Total uplift U=131.7 kN/m

Fa: Minimum safety factor Fa=1.2

Fs = (254.8+22.0) /131.7 = 2.10 > Fa = 1.2

Thus, the flume is safe against uplift.

(4) Structural calculation

Section force (moment and shearing force) of side wall is calculated by cantilever model and one of base slab is calculated as simple beam model.

The calculation case and results are shown below:

1) Load combination

The following two cases are considered as load combination:

Case 1: No inside water, groundwater level is half of side wall

Case 2: Full inside water, ground water level is top of side wall

2) Section force (bending moment M and shearing force S)

Section	Case	Node	M (kN.m)	S (kN)
Side wall	Case 1	Bottom edge outside	159.483	101.500
		Middle H/2 outside	19.453	20.630
	Case 2	Bottom edge outside	65.473	37.773
		Middle H/2 outside	8.184	9.443
Base slab	Case 1	Edge under surface	159.483	76.440
		Middle under surface	60.111 ~	0 ~
		Middle upper surface		
	Case 2	Edge under surface	65.473 ~	76.440 ~
		Middle under surface		
		Middle upper surface	33.899	0

6-3.5 Structural Calculation <Gate Base Slab & Wall (Two Lanes Flume)>

The design conditions and structural calculation results for gate base slab and wall are described below:

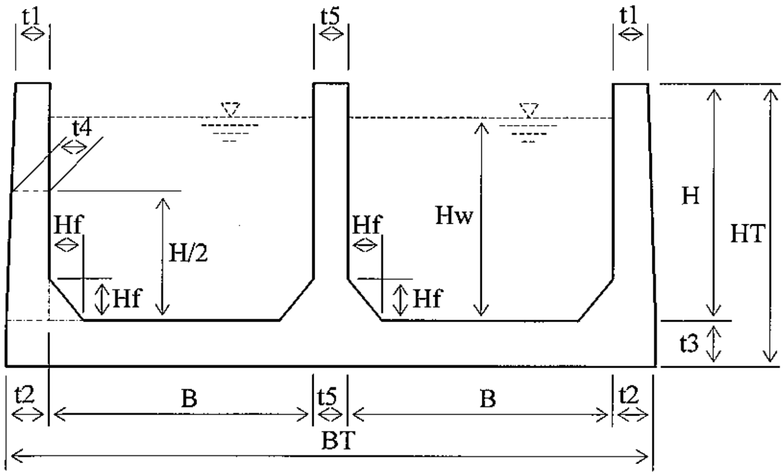
(1) Design conditions

1) Standard unit weight			
Water	γw=	10.0	kN/m^3
Soil (wet)	$\gamma \tau$=	18.0	kN/m^3
Soil (saturated)	γsat=	20.0	kN/m^3
Reinforced concrete	γc=	24.5	kN/m^3
2) Coefficient of active earth pressure	Ka=	0.279	
Intersectional angle	ϕ=	30	°
Cohesion	c=	0	kN/m^2
3) Live load			
Type of wheel load		-	
Rear wheel load	Pr=	-	kN
Front wheel load	Pf=	-	kN
Width of earth connection	a =	-	m
Front and rear wheel width	b =	-	m
Impact coefficient(D>=4.0m:0, D<4.0m:0.3)	i =	0	
Crowd load	q =	5.0	kN/m^2
4) Safety factor			
Safety factor for uplift	Fa=	1.2	
5) Allowable stress			
28-day compressive strength of concrete	σck=	21.0	N/mm^2
Allowable bending compressive of concrete	σca=	8.0	N/mm^2
Allowable shearing stress of concrete	τa=	0.42	N/mm^2
Yield stress of reinforcement bar	σsy=	294	N/mm^2
Allowable tensile stress of reinforcement bar	σsa=	157	N/mm^2
Young's modulus	n =	15	

(2) Dimension parameter

1) Dimension			
Internal height	H=	5.20	m
Internal width of one lane	B=	4.00	m
Haunch height	Hf=	-	m
Thickness of side wall (top)	t1=	0.50	m
Thickness of side wall (bottom)	t2=	0.50	m
Thickness of base slab	t3=	0.80	m
Thickness of partition wall	t4=	0.60	m
Overall height of flume	HT=	6.00	m
Overall width of flume	BT=	9.60	m
Cover of reinforcement bar (side wall, top slab, bottom slab, partition wall)	d=	0.07	m

2) Groundwater level	Case 1	Gwd=	4.00	m
	Case 2	Gwd=	4.00	m
3) Inside water	Case 1	Hw=	0	m
	Case 2	Hw=	4.00	m



Cross Section of Two Barrel Flume

(3) Analysis on uplift

$$Fs = (Vd + Pv) / U > Fa$$

ここに、 Fs: Safety factor against uplift pressure

Vd: Total dead load Vd=392.0 kN/m

Pv: 50%of total earth pressure Pv= 0 kN/m

U: Total uplift U=243.2 kN/m

Fa: Minimum safety factor Fa=1.2

$Fs = (392.0+0) / 243.2 = 1.61 > Fa = 1.2$

Thus, the flume is safe against uplift.

(4) Structural calculation

Section force (moment and shearing force) of side wall is calculated by cantilever model and one of base slab is calculated as simple beam model.

The calculation case and results are shown below:

1) Load combination

The following two cases are considered as load combination:

Case 1: No inside water, groundwater level is 4.0m from top base slab

Case 2: Full inside water, groundwater level is 4.0m from top base slab

2) Structural calculation results

Section	Case	Node	M (kN.m)	S (kN)	Section
Side wall	Case 1	Bottom edge outside Middle H/2 outside	106.667 4.573	80.000 9.800	63.700 31.850
	Case 2	Bottom edge outside Middle H/2 outside	0 0	0 0	63.700 31.850
Partition wall	Case 1	Bottom edge Both sides Middle H/2	0 0	0 0	76.440 38.220
	Case 2	Bottom edge Both sides Middle H/2	106.667 4.573	80.000 9.800	76.440 38.220
Base slab	Case 1	Edge under surface	106.667	63.700	80.000
		Middle under surface	36.623	32.912	80.000
		Middle under surface	11.117	0	80.000
	Case 2	Edge under surface	0	63.700	0
		Middle upper surface	70.043	32.912	0
		Middle upper surface	95.550	0	0