No.

Local Government Engineering Department
Ministry of Local Government,
Rural Development and Cooperatives
The People's Republic of Bangladesh

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR IMPROVING THE LIVING STANDARD OF VULUNERABLE PEOPLE OF THE HAOR AREAS IN THE PEOPLE'S REPUBLIC OF BANGLADESH

DECEMBER 2006

JAPAN INTERNATIONL COOPERATION AGENCY

SANYU CONSULTANTS INC.

GM
JR
06-210

Preface

In response to a request from the Government of the People's Republic of Bangladesh, the Government of Japan decided to conduct a basic design study on "The Project for Improving the Living Standard of Vulnerable People of the Haor Areas in People's Republic of Bangladesh" and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bangladesh a study team from February 20 to March 24, 2006.

The team held discussions with the officials concerned of the Government of Bangladesh, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, as this result, the present report was finalized.

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

I wish to express my sincere appreciation to the officials concerned of the Government of People's Republic of Bangladesh for their close cooperation extended to the teams.

December, 2006

Masafumi KUROKI
Vice President
Japan International Cooperation Agency

December, 2006

Letter of Transmittal

We are pleased to submit to you the basic design study report on “The Project for Improving the Living Standard of Vulnerable People of the Haor Areas in People’s Republic of Bangladesh” in People’s Republic of Bangladesh.

This study was conducted by Sanyu Consultants Inc., under a contract to JICA, during the period from February to December 2006. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Bangladesh and formulated the most appropriate basic design for the project under Japan’s Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Kazumitsu TSUMURA
Project manager,

Basic design study team on
The Project for Improving the Living Standard of
Vulnerable People of the Haor Areas

Sanyu Consultants Inc.

Summary

(1) Overview of the Country

People's Republic of Bangladesh (hereinafter referred to as "Bangladesh") is located in Southwestern Asia, with its territory of 147,570km^2, consists of 64 administrative Districts with 138 million of population (2003). After the period of being British colony and the East Pakistani era, the Country became independent in 1971. Currently, Muslim principally accounts approximately 90% of entire Bengalese population. The land of Bangladesh is as a whole flat except the Chittagong Hill Tracts and the three major rivers, namely Ganges, Jamuna (Brahmaputra) and Meghna which flow from India, forming alluvial plains. In the tropical monsoon climate there, rainfall concentrates during the rainy season (May to October) with 2,000 to 3,000 mm annually. During the rainy season, therefore, one-third of the Country is flooded due to river water and rainfalls running into. At the same time, the southeastern part is constantly damaged by natural disaster, mainly by the cyclones every year.

Since its transition to the democratic entity based on the parliamentary cabinet system in 1991, the Government of Bangladesh has been actively promoting economic deregulation policy. Due to such policy, the Country has maintained an annual economic growth rate of 4.8% since 1992. As well, structuring adjustment of IMF moved into high gear in 1991, having accelerated the reformation of the financial, banking and trade sectors, rationalization of public sectors, activation of private sectors, relaxation of regulations, and foreign investment. As shown in economic indicators, performance of the national economy has been relatively improved and has been sustained especially initiated by the manufacturing industry represented by garments and knits, fishery industry mainly as prawn-fishing, and construction industry (GDP ratio by industries in fiscal year 2003/04: 1st –23%, 2nd–28%, 3rd–49%).

On the other hand, Bangladesh has extremely limited natural resources except for gas. As one of the least developed countries, its GNI per capita is only $445 (2004/05) mainly due to large population and frequent occurrences of natural disasters such as floods and cyclones. Other problems are discontinuous policy due to the bipolar confrontation between Bangladesh Nationalism Party and National Awami League. Furthermore, problems like the general strike are hindering the country's economic development and development potential. All these problems directly affect lives of the people, especially the poor, and have been destabilizing factors on people's living and society in Bangladesh.

(2) Background and Summary of the Requested Japan's Grant Aid Scheme

In Bangladesh, agriculture, forestry and fisheries constitute mainstay of the country with large share, 22% in GDP wherein 60% of the national population is engaged. Major farming activities are concentrated in paddy production which is cropped on over 80% of arable land. The country had favorable climate for paddy production where even triple cropping in a year is practicable, however, the production had not been increased due to low unit yield of paddy. Extension of groundwater irrigation and introduction of high yielding paddy

varieties Boro in dry season has increased paddy production. It reached 11.8 million ton in 2001, equivalent to approximately 6 times as much as the previous level of only 2 million ton in 1970s. As the result, food self-sufficiency of the Country achieved 100% of food self-sufficiency. Rice, however, has been still imported because the level of self-sufficiency is barely exceeded 100%.

Since its independence, Bangladesh has implemented medium-term economic development plan for its economic expansion but failed to attain the targeted rate of economic growth due to natural disasters such as floods and cyclones. Currently Poverty Reduction Strategy Paper (PRSP) based on Millennium Development Goals (MDGs) is employed as a substantial national development plan. PRSP consists of three(3) development strategies relayed with 1)economic growth, 2)promotion of human development and 3)improvement of governance, and recommends that the Government should immediately tackle with poverty reduction.

Four(4) model sites of this Project, wherein Haor area are located, extends through four(4) Districts, namely Habiganj, Kishoreganj, Netrokona and Sunamganj of northeastern Bangladesh. In this area, a vast surface covering 6,500 km^2, is inundated for 6 to 7 months, arable land is also inundated leaving sporadical mounds. Accordingly, around 80% of local population engaged in agriculture, forestry and fishery become job-less during rainy seasons and they are obliged to leave their villages for seasonal migrant worker or to live in mounds. The mounds become densely populated more than 35,000/km^2 during rainy season where the accommodated people are forced to suffer from physical and phycological pain withhin a limited living environment for a long period. The poorest level is placed in the most vulnerable life suffering from malnutrition and degraded sanitation due to depleted food and fuel in late rainy season.

Although Haor area accounts for 4.4% of the area of whole national territory with habitants equivalent to 2.7% of national population, it constitutes the largest production area of Boro where the harvested amount of paddy accounts for 17% of the total national harvest in Boro. Boro paddy harvested in April provides people with precious food during rainy season, if people lose living space in Haor area due to flood wave erosion, Boro production in is staggered and food supply situation in rainy season is most likely aggravated into serious food shortage. Measures taken against waves with bamboo fencing or sandbags end in vain and mounds are annually eroded by about 40 cm, leading to higher population density than ever experienced. Mounds provide base of all activities including agriculture, commerce, livelihood, culture etc. and poverty alleviation in Haor area cannot be achieved without protecting measures thereof. In this context, the fact that disappearance of mounds brings about suspension of farming and economic activities in Haor area, affirm necessity and exigency of improving wave protection.

After experiencing two consecutive heaviest floods in 1987 and 1988, the State switched its policy concept against floods, from trying to control flood by force to adaptation of a flexible “proofing” policy in co-existance with floods, what is called flood-proofing measures. In this measures, construction of large-scale structures typified by river embankment is abolishned, while small-scaled “Structural Measures” including wave protection to protect houses, schools, public markets (bazaars) or submersible roads that function well during dry season are coupled with “Non-structural Measures” including skill training for improvement of living environment, microcredit and medical service support, etc.

Local Government Engineering Department (LGED), the implementing agency of this Project, has taken both "Structural" and "Non-structural Measures" in flood proofing projects. In fact, LGED has addressed to accumulate know-how and to strengthen its technical capacity, organization/systems through its experiences in the past local infrastructure improvement projects. In the field of consolidating "wave protection" as requested for Japan's Grant Aid Scheme, it has developed countermeasures in Haor area but has limited performances in implementing projects with the works on soft ground and it has only recently started its technical enrichment.

Under such situations, the Government of Bangladesh made a request to Japan to implement several structural measures for the purpose of relizing "improvement of living environment" in Char /Haor areas based on JICA Master Plan Study for "Rural Development Focusing on Flood-proofing" in 2002. In response to this request, JICA dispatched a Preliminary Study Mission to Bangladesh (August 2005) to study on the site and to consult with LGED, the implementing agency. Both Bangladesh and Japanese sides agreed to have Basic Design (B/D) Study for "construction of wave protection" as a target project for Japan's Grant Aid Scheme.

The purpose of this Project is "To be taken effective measures for preventing wave erosion at the model sites with sustainability of LGED" in the model sites selected from each one(1) candidate site from 4 districts in Haor area. Precisely, it aims for "Wave erosions in mounds at the model sites are prevented (Direct effect-1)" and "LGED acquires techniques to construct effective wave protection wall (Direct effect-2)". At the same time, it is expected that LGED will, in the future, "To develop wave protection effectively for preventing wave erosion in Haor area other than model sites" (Overall goal of the Project). Furthermore, the Project can contribute to PRSP, the development plan in Bangladesh.

(3) Summary of the Study Results and Contents of the Project

From February 20 to March 24 of 2006, JICA dispatched a Basic Design Study Mission to Bangladesh to discuss with LGED on the maintenance extent of "wave protection" based on the agreement between LGED and the Preliminary Study Mission. As well, they conducted a study on living environment of mounds in the model sites or organization control and Operation and Maintenance (O/M) systems of the implementing agency, and acknowledged that the project would be relevant as a Japan's Grant Aid Scheme.

The requested Japan's Grant Aid Scheme aims to construct "wave protection" for preventing wave erosion of mounds and for improving living environments in Haor Area where is inundated during the rainy season. At the same time, through this Project, LGED will be expectedly able to enforce its designing and surveillance abilities in constructing wave protection on soft ground. In each model site of the four(4) Districts, plans of constructing "wave protection" were made based on the following policies.

As to wave protection types, "Reinforced Concrete (RCC) Inversed T-type wave protection wall" are adopted as requested beforehand. This is reflecting 1) the lessons from Flood Proofing Project (FPP) implemented from 1997 to 2004, assisted by CARE (CARE project) and 2) that Ministry of Environment (MOE) of Bangladesh applies several criteria to those who plan to construct brick factories, with the view of environmental consideration such as depletion of wood resources and detrimental air pollution effects on inhabitants.

The height of wave protection wall is designed following the “CARE design manuals”. It was determined based on the design wave height derived from design flood levels, wind velocity and drifting distance (distance that waves keep heaving up without being negated by any physical impedance) in the water level data during the past 50 years. As to structure of foundation for wave protection, 1) spread foundation, 2) spread foundation with sand replaced foundation or 3) pile foundation are applied.

On the other hand, LGED has already made network, distributing investigation and test equipment, construction machinery and vehicles for extension activities to each district office. It has also made staffing to the district offices required to make use of these inputs and these distributed staffs are engaged in district-level services including investigations, designs, and tenders, implementing supervision and O/M services. From the above situations, it can be expected to secure further extension of wave protection into Haor areas other than the original model sites dominated by the four(4) district offices at the core, the Project is to be implemented in a model site located in each of the four(4) districts.

The total length of “wave protection for preventing wave erosion” at the initial request was 6,400m. However, the length of 5,215m would be more appropriate, based on the following factors: 1) to maximize basically villagers’ desires, 2) to protect existing public facilities, 3) to give implementing priority to the sites subject to damages by higher wave and severer erosion, 4) to effectively utilize existing wave protection, 5) to sustain existing community functions, and 6) to consider current topography and land use. Project components are summarized in the following table;

Summary of the Project components

Wave protection type: Reinforced concrete (RCC) inversed T-type retaining wall								
Model site	Type of standard foundation work	Length of retaining wall (m)	Height of retaining wall(m)		Volume of concrete (m^3)	Stair work (No.)	Openings (No.)	Footing work (m)
			Range	Average				
1. Sazan	Spread foundation	2,305	3.75-6.00	5.3	10,995	0	16	1,235
2. Gurai	Spread foundation by sand replacement	1,525	3.25-4.25	3.5	3,355	5	5	0
3. Lipsha	Spread foundation by sand replacement	635	3.25-6.00	4.8	2,610	5	0	170
	Pile foundation	90						
4. Nazarpur	Spread foundation by sand replacement	660	4.75-6.00	5.3	3,148	-	9	150
Total	-	5,215	-	4.7	20,108	10	30	1,555

(4) Construction Period and Project Cost Estimate

At implementation of the Project, it will take 5.0 months for designing and 20.5 months for construction. It will cost approximately 1,163 million yen (Japan side: 1,060 million yen, Bangladesh sides: 103 million yen).

(5) Evaluation of the Project

The Government of Bangladesh has employed PRSP based on MDGs as a national development plan and reduction of poverty is actually their top priority. Although the country has in recent years maintained an annual growth rate of 4 to 5%, its GNI per capita, $445 is still low (fiscal year 2004/05). As 36% of the population lives on less than one dollar a day, the Country has the largest population of poor in all the least developed countries (LDC). PRSP recognizes that the economic growth is indispensable to overcome the poverty and its special target is the poor in rural areas, wherein 70% of the overall population is concentrated. The target area of the Project is in Haor Area wherein larger number of the poor live, and about 35,000 people living in harsh natural environment are direct beneficiaries of the Project. For this reason, this Project is expected to greatly contributive from the viewpoint of ensuring human security.

Since retaining wall will be constructed by reinforced concrete, O/M after construction will not be necessary. However, regular O/M and repair will be needed for foot protection from corrosion by waves during the rainy season. LGED has District Offices in each of the 64 Districts throughout the Country and take budgetary steps for maintenance works under the responsibility of each District Officer, there will be no particular difficulty in O/M of “RCC retaining wall” after implementing the Project.

Direct effects of this Project are “wave erosions in mounds at the model sites are prevented (Direct effect-1)” and “LGED acquires techniques to construct effective wave protection wall (Direct effect-2) as in the Table below;

Direct effects of the Project

Expected outputs	Current status and problems	Activities under the Project	Objectively verifiable indicators
Wave erosions in mounds at the model sites are prevented (Direct effect-1)	Inhabitants prevent wave erosion by using bamboo or stone materials during the rainy season, annually spending 1,500 Tk./household. However, the edge of their mound is receding by 40cm/year and not only their living environment is deteriorated but also houses washed out and livestock is damaged.	To construct wave protection wall for preventing wave erosion (Total length: 5,215 m).	1) Erosion of the edge of the mounds (40cm/year) will stop. 2) Expenses for wave protection measures (1,500Tk. /household) will be reduced. 3) Damages (houses, livestock) by wave action will be reduced.
LGED acquires techniques to construct effective wave protection wall (Direct effect-2)	LGED has enhanced their technical capabilities, accumulation of know-how, and organizational structure through infrastructure improvement projects and has also constructed “wave protection wall” for preventing wave erosion” in Haor area. However, LGED has limited experience in designing and constructing “RCC inversed T-type retaining wall” on soft ground.	LGED has an experience of constructing “RCC inverse-T type retaining wall” on soft ground through the Project.	Design and O/M manuals for construction of “RCC inverse-T type retaining wall” will be formulated in order to extend to Haor areas other than the model sites.

As an indirect effect, “Base for inhabitants is prepared to improve their living standard at the model sites” is expected. And living environment will be better by that population density is reduced through increasing area of mounds by earth filling along the backside of the wave protection wall (land space between the wall and mounds) by the inhabitants after the construction of wave protection wall. In two(2) of the four(4) model sites, it is expected that a number and duration of migrant workers in Lipsha and Nazarpur villages being reduced by constructing of wave protection wall under the Project, of which indicators are shown in bellow Table;

Indicators for indirect effect of the Project

Indicator for outcomes	Current value: Rate of migrant workers (2006)	Planned value (2009)
Rate of seasonal migrating workers increases in Lipsha and Nazarpur*	1) Lipsha : 67% 2) Nazarpur: 53%	Increase

**) Rate of migrant workers for a long term will not increase in Sazan and Gurai villages because they have employment opportunity in neighboring.*

Furthermore, in the four(4) model sites, the number of villagers who left their villages due to erosion of mound, is expected to return, when the area of mounds is extended and the living environment is improved through earth filling along the backside of the wave protection wall by inhabitants.

LGED is the most reliable organization in government agencies in Bangladesh in partnership with international organizations and donors in the aspects of engineering, staff and budget allocation, project implementation and O/M, etc. And also, LGED steadily executes allocation of the budget for the purposes such as staffing, equipment, O/M and so on to the 64 district offices and the Upazila offices located all over the Country. Therefore, it is assured that O/M will be properly done to the “wave protection wall” in the model sites to be constructed under the Project.

While, the Project is actually a model project and “to develop wave protection effectively for preventing wave erosion in Haor area (other than model sites)” is expected as overall goal of the Project. Through local infrastructure improvement, LGED has experiences in “RCC inversed T-type retaining wall” in Haor area suggested in this B/D study. However, it has limited performances in designing and constructing on soft ground considering subsidence, bearing capacity, wave force and buoyant force etc. Therefore, LGED is required to employ necessary engineers from its Headquarter and District Offices at the stage of project design and implementation so that LGED actively involves in this Project and also required to formulate design policies and O/M manuals for construction of “RCC inverse T-type retaining wall”.

In Bangladesh, Environmental Clearance Certificate (ECC) is required for the implementation of projects. Although this Project is placed in the Category B according to LGED, it can be also placed in the Red Category in reference to the Environment Guidelines published by the Department of Environment (DOE, Bangladesh). LGED is requested to immediately clarify this matter, whether it is placed in the Red Category or not, and necessity of Environmental Impact Assessment (EIA), not only Initial Environmental Evaluation (IEE), must be conducted to gain approval for ECC from the DOE. Immediate acquirement of ECC is a prerequisite to implementation of this Project. Also, there will be no negative effect on the environment generated by the Project implementation.

For construction of retaining wall, a certain width of land has to be acquired. LGED postures that since the inhabitants are expressing significant expectation to this Project and they are the direct beneficiaries, it is necessary to acquire land through a council system among them and there will be no monetary land acquisition. However, if no agreements were reached with landowners and leaseholders, any workshop for inhabitants’ council upon determination of design of retaining wall routes must be hold because it takes four(4) months at a maximum for acquisition procedures.

For implementation of the Project, LGED needs to bear the commission necessary for the procedure of issuing banking arrangement, tax for project implementation, and cost for non-structural measures, etc. Total costs borne by LGED will be 57.8 million Tk. (approx. 103 million Yen). Although this is only 0.2% of their annual budget for development works at the local development sector (25,806 million Tk., fiscal year 2004/05), they are required to certainly contribute funding to the Project.

(6) Conclusion

As mentioned above, the Project is expected to produce considerable effects on the basis of high necessity and relevancy, since the aim of the Project is to protect basic infrastructure, building and people's wealth from wave erosion, highly considerations on safety on soft ground, stability and durability against wave force. In this regard, at the stage of designing this wave protection wall, the height of wall was decided according to Bangladesh regulation, however, to calculate stability of the wall, especially wave force and buoyant force under inundated condition, "Technical standard for stream sediment control" in Japan was adopted because that of Bangladesh regulation does not consider those forces. In case this Project will be implemented under Japan's Grant Aid Scheme, it is impossible to exclude the calculation of wave force and buoyant force to secure durability of the wall. However, as a result, concrete volume of the wall increased, which caused the increase in construction cost, it indicates that unit construction cost would be 2.5 times higher than that of "RCC inversed T-type retaining wall" constructed under assistance from CARE or ADB. Present design policy of the Project is quite appropriate, so it is impossible to modify the design just for the cost reduction. Furthermore, the wall will be only constructed at the model sites under this Project. However, it would be difficult for the Bangladesh side in the future to expand with constructing similar wave protection wall in other Haor areas due to its severe financial circumstance. Also, the effectiveness of Japan's Grant Aid Scheme would be extremely limited because overall goal of the Project that is; "To develop wave protection effectively for preventing wave erosion in Haor area (other than the model sites)", would not be achieved. Furthermore, the high unit cost of construction does not enable to gain understanding of other donors or international organizations in Bangladesh. Thus, Project implementation based on the method proposed in this Basic Design Study should be carefully revisited.

On the other hand, LGED needs to continue constructing "wave protection for preventing wave erosion" to improve the living environment in Haor area, even if the Japan's Grant Aid Scheme will not be implemented. For enhancing technology related to rural infrastructure and accumulating related technological information, Rural Development Engineering Center (RDEC) was established by LGED. Through strengthening capacity of RDEC, it is expected to further carry out the construction of wave protection through their self-reliant efforts. Since there are urgent needs to construct the wave protection, this Report would propose several types of wall under the condition that LGED would construct by themselves, utilizing data and experience collected thorough this Basic Design Study. Considering, current financial circumstance of the Government of Bangladesh and the current

LGED design policies or manuals related to “wave protection for preventing wave erosion”, the following types are suggested to design wave protection by LGED.

(a) RCC inverse T-type retaining wall (spread foundation)

(b) RCC L-type retaining wall (spread foundation)

(c) RCC leaning retaining wall (spread foundation)

(d) Bricklaying gravity type retaining wall (spread foundation)

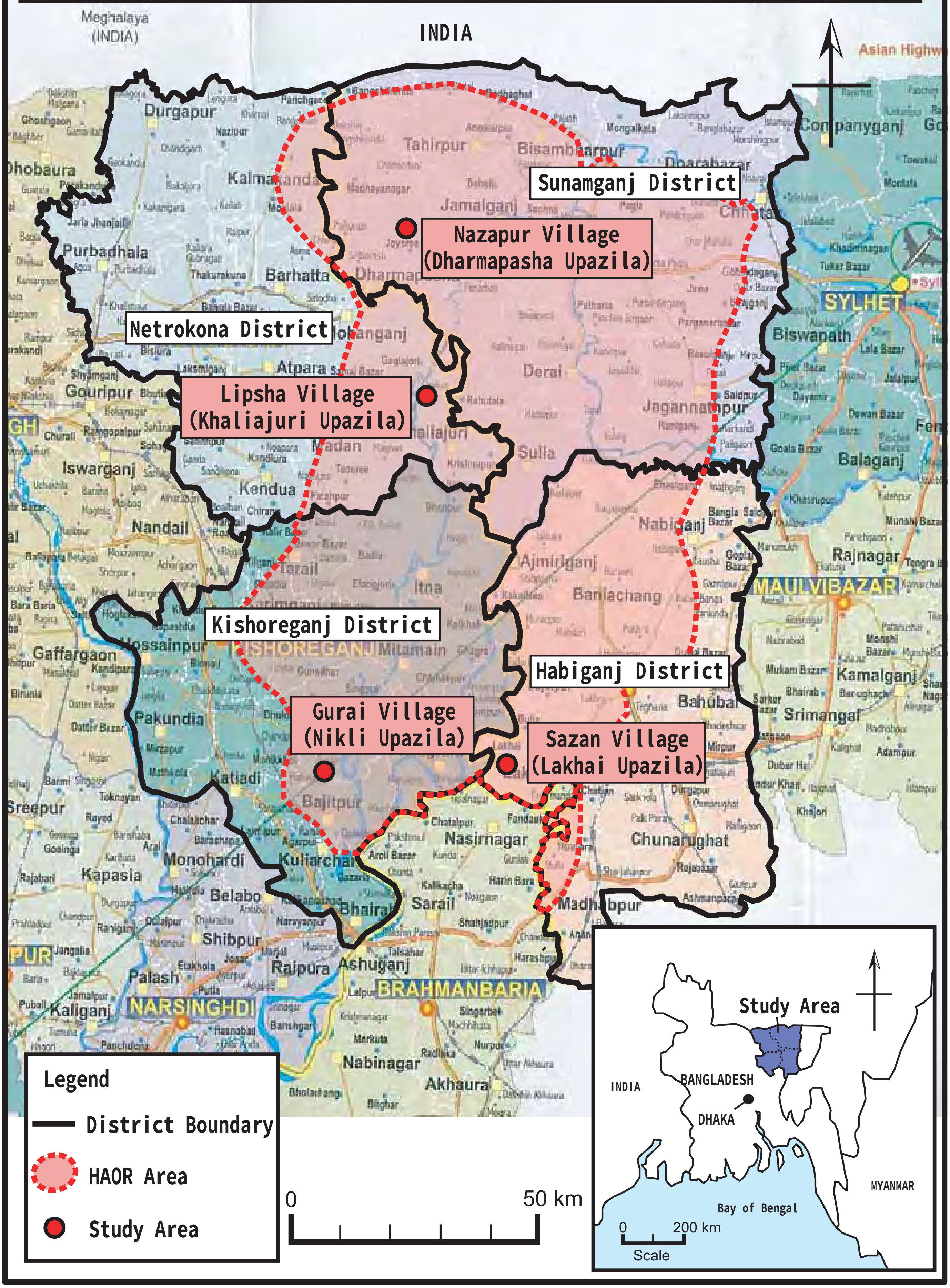
(e) CC block slope protection

It should be reiterated that those suggestions are based on moderate security conditions taking into account of sustainability of Bangladesh side. Therefore, it is advisable for LGED to take further considerations of preconditions of each type. Furthermore, LGED is also requested to take responsibility of warranty.

Contents

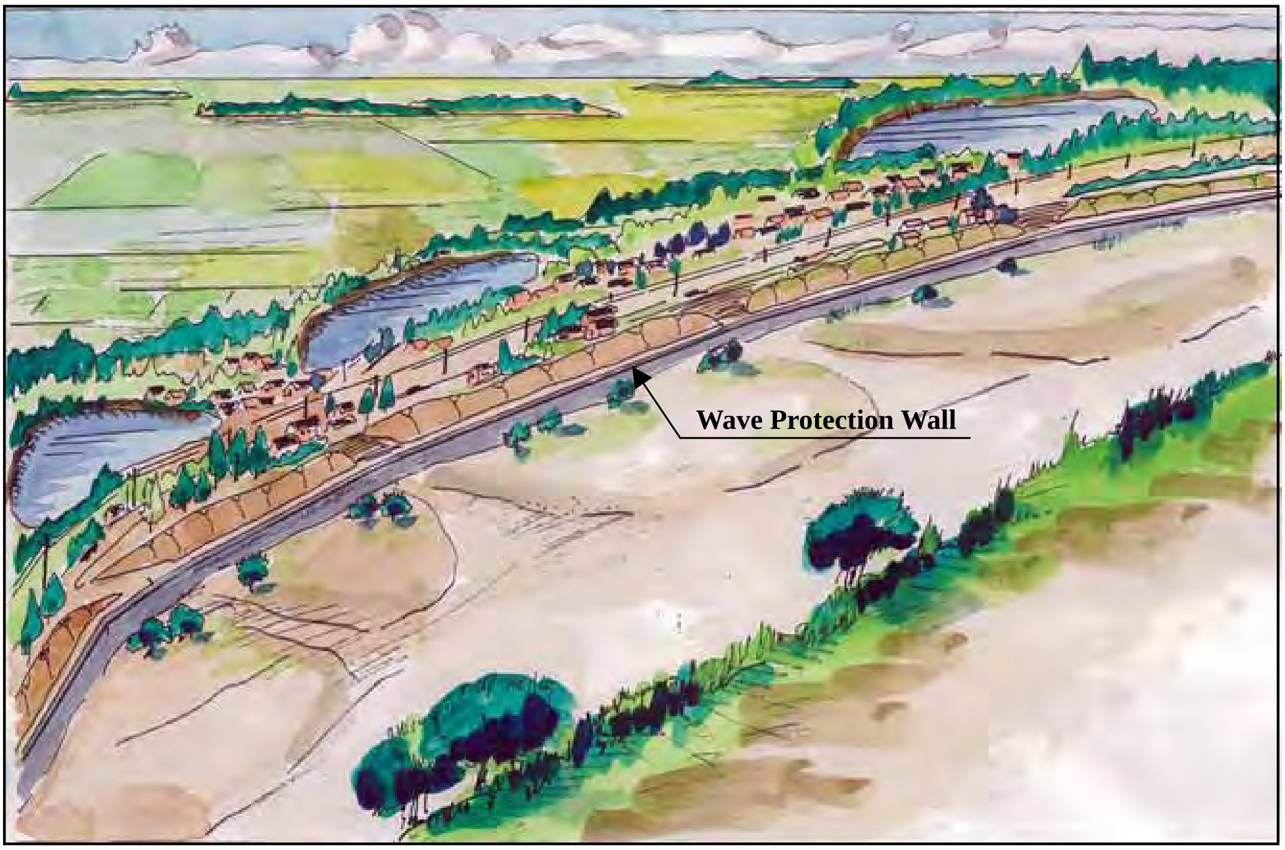
Appendices

Location Map

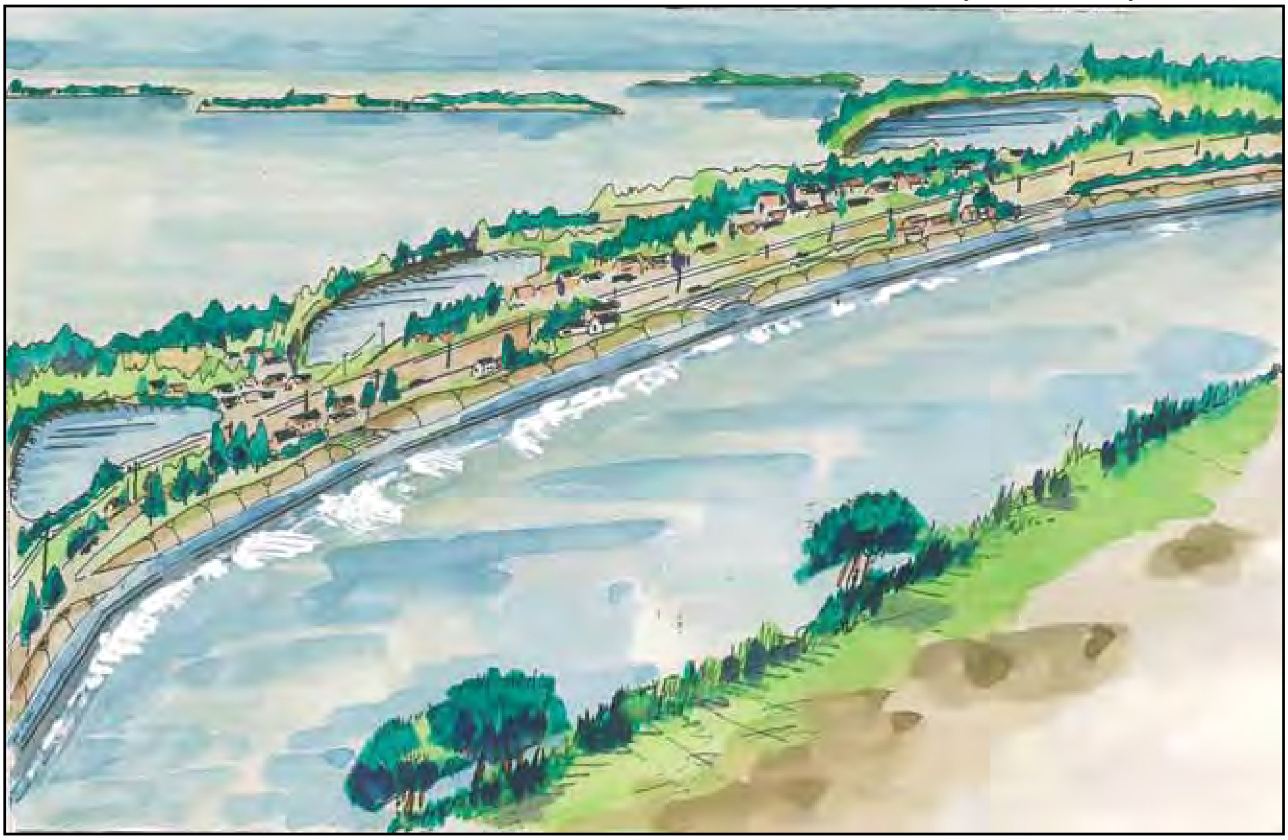


Perspective

Dry Season (November - April)



Rainy Season (May - October)



List of Figures and Tables

List of Figures

List of Table

Abbreviations

Abbreviations

ADB	Asia Development Bank
AE	Assistant Engineer
BRRI	Bangladesh Rice Research Institute
BWDB	Bangradesh Water Development Board
CARE（American NGO）	The Cooperative for Assistance and Relief Everywhere
DOE	Department of Environment
DPP	Development Project Proposal
E/N	Exchange Note
ECA	Ecological Critical Area
ECC	Environment Clearance Certificate
ECR	Environment Conservation Rules
EIA	Environmental Impact Assessment
FPP	Flood Proofing Project
IEE	Initial Environmental Evaluation
IFAD	International Fund for Afrucultural Development
IFSP	Integrated Food Security Program
LCC	Location Clearance Certificate
MDGs	Millennium Development Goals
MLGRD&C	Ministry of Local Government, Rural Development and Co-orperatives
LGED	Local Government Engineering Department
MOE	Ministry of Environment
NDP	National Development Plan
NWMP	National Water Management Plan
PMO	Project Management Office
PRSP	Poverty Reduction Strategy Paper
PWD	Public Works Department
RD&C	Rural Development and Coo-peratives Division
RDEC	Rural Development Engineering Center
RDP	Rural Development Project
SAE	Sub-assistant Engineer
UE	Upazila Engineer
USAID	United States Agency for International Development
WARPO	Water Resources Planning Organization
XEN	Executive Engineer

Unit

cm	centimeter	t	ton (1,000 kg)
m	meter	t/ m^2	ton per square meter
km^2	square kilometer	ha	hectare
m^3	cubic meter	cft	cubic feet
m^2	square meter	ft	feet
m/s	meter per second	N/ m^2	newton per square meter
m^3/s	cubic meter per second	%	percent

Currency

yen	Japanese Yen
US$	US Dollar
Tk.	Taka

Exchange Rate（March, 2006）

US$ = 117.93 yen　　US$ = 66.34 Tk.　　Tk.= 1.78 yen

Chapter1 Background of the Project

Chapter 1 Background of the Project

1-1 Background of the Project

The Government of Bangladesh made a request to Japan to implement several structural measures for the purpose of realizing “improving living standard” in Char / Haor area based on JICA Master Plan study for “Rural Development Focusing on Flood-proofing” in 2002 (hereinafter referred to as M/P). In response to this request, JICA dispatched a Preliminary Study Mission to Bangladesh (August 2005) to study on the site and to consult with LGED, the implementing agent. Both Bangladesh and Japanese sides agreed to study “construction of wave protection wall” for Haor area as a target project under Japan’s Grant Aid Scheme.

Thereafter, Study Team of Basic Design (hereinafter referred to as “B/D”, February 2006～) identified the location of the proposed “wave protection wall” and carried out temporary measurement for the alignemnts of them with LGED based on the above-mentioned consultation. As the result, the total length of 7,050 m was measured and confirmed in the Minutes of Discussions at B/D (refer to Appendix 4-1 Minutes of Discussions).

Then, the total length was modified to 6,600 m later on as shown in Table 1-1 through the topographic survey. Based on this result, the BD Study Team explained to LGED that 6,600 m should be the target length in the Project as a base for further study, and also that length might be shorter than 6,600 m depending on the Study in Japan.

Table 1-1 Proposed length of wave protection wall

Name of model sites	Initially requested length	Temporary measurement (at minutes of B/D)	Actual length measured by topographic survey (at end of B/D field survey)
1. Sazan Village, Lakhai Union, Lakhai Upazila, Habiganj District	2,600 m	2,800 m	2,670 m
2. Gurai Village, Gurai Union, Nikli Upazila, Kishoreganj District	1,700 m	2,100 m	1,770 m
3. Lipsha Village, Chakua Union, Khaliajuri Upazila, Netrokona District	1,000 m	1,050 m	1,060 m
4. Nazarpur Village, Joysree Union, Dharmapasha Upazila, Sunamganj District	1,100 m	1,100 m	1,100 m
Total	6,400 m	7,050 m	6,600 m

1-2 Natural Conditions

(1) Topography, climate /hydrology

Bangladesh is located at the lowest course of the three(3) major rivers, namely Ganges, Brahmaputra (Jamuna) and Meghna, flowing through China, India, Nepal and Bhutan, forming alluvial plains. The total basin area of the rivers is 1,745,000 km^2 and 80% of the annual rainfall (2,000 to 3,000 mm) concentrates during 100 days of the monsoon from June to September. Therefore, the country suffers from flood damages every year in this period. While the land of Bangladesh is a whole flat except the Chittagong Hill Tracts and one-third of the country goes under the water, without public and residential places, roads and so on.

Table 1-2 Basin areas and their ratio of Ganges, Brahmaputra and Meghna rivers by country

River	Ganges		Brahmaputra		Meghna		Total	
Country	'000' km^2	(%)	'000'km^2	(%)	'000' km^2	(%)	'000' km^2	(%)
India	861	(79)	195	(34)	42	(54)	1,098	(63)
China	40	(4)	293	(50)	-	(0)	333	(19)
Nepal	140	(13)	-	(0)	-	(0)	140	(8)
Bhutan	-	(0)	45	(8)	-	(0)	45	(3)
Bangladesh	46	(4)	47	(8)	36	(46)	129	(7)
Total	1,087	(100)	580	(100)	78	(100)	1,745	(100)
Basin Area Ratio (%)	(63%)		(33%)		(4%)		(100%)	

In Haor area, annual rainfall during the rainy season is approximately 2,400mm and in addition Meguna River, flowing southward meandering inside Haor areas, originates in Assam area of India, a heavy rainfall region. Rainwater, therefore, come down into Haor areas during the rainy season, causing floods during 6 - 7 months from May to November keeping as wide as 6,500 km^2 under deeply inundated condition. The water level begins to rise just after Early Flood (occurring around the harvest season of Boro paddy, giving damage to Boro paddy once in 3 years by earlier occurrence of flooding) taking place from late March to April. It reaches the maximum water level from July to August, then, gradually declines to return to the level in the dry season by December with 6 m height difference of water level between the rainy and dry seasons at maximum. And wind generates violent wave during the monsoon period (July to August), which makes erosion on mounds. Table 1-3 shows monthly meteorological data in 2002, which are the average levels in the past years (refer to Appendix 5-1 and 5-2).

Table 1-3 Monthly rainfall, wind velocity and water level in 2002

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (mean)
Rainy/dry season	Dry season			Rainy season						Dry season			-
Rainfall (mm)*[1)]	6	0	041	260	389	578	443	204	255	132	87	0	2,359
Wind velocity (m/s)*[3)]	1.9	1.4	3.2	4.1	4.0	2.8	3.0	3.2	2.1	1.2	3.2	1.0	(2.6)
Water level (m)*[2)]	2.7	2.3	2.5	3.9	5.9	7.2	7.8	7.9	6.7	6.1	5.2	3.9	(5.2)

Source : 1) and 3) Mymensingh Meteorological Observatory, 2) Water level data in Khaliajuri

(2) Geotechnical and ground condition

Table 1-4 shows earth layer profile of the four(4) target model sites resulted from the boring and soil mechanic tests (6 points in total, refer to Appendix 5-3).

Table 1-4 Outline of earth layer profile of the model sites

Model site	Nazarpur			Lipsha (southern side)			Lipsha (northern side)		
Earth layer profile	Thickness	Soil mechanics	Mean N-value	Thickness	Soil mechanics	Mean N-value	Thickness	Soil mechanics	Mean N-value
	3.5m	CH	2.3	2.5m	CH	3.4	3.5m	SM	3.3
	2.0m	CL	4.5	2.0m	SM	6.0	5.0m	SM	4.8
	3.0m	SM	10.3	3.3m	CL	5.0	2.0m	S-M	5.0
	11.8m	SM	50	9.6m	SM	33.0	9.8m	S-M	33.0
Model site	Gurai			Sazan (southern side)			Sazan (northern side)		
Earth layer profile	Thickness	Soil mechanics	Mean N value	Thickness	Soil mechanics	Mean N-value	Thickness	Soil mechanics	Mean N value
	2.8m	CL	1.5	2.5m	CH	2.5	2.50	CH	2.5
	0.7m	CL	5.0	1.0m	SM	7.0	1.00	SM	7.0
	3.0m	SM	5.0	4.0m	CL	2.3	4.00	CL	2.3
	8.0m	SM	23.6	2.0m	CL	8.5	2.00	CL	8.5
	5.8m	SM	45.7	2.0m	CL	3.5	2.00	CL	3.5
	—	—	—	6.0m	CL	13.3	6.00	CL	13.3
	—	—	—	2.8m	SM	23.3	2.80	SM	23.3

Soil mechanical property CH: clay, CL: clayey, SM: silty sand, S-M: silt-mixed sand

1-3 Environmental and Social Considerations

(1) Progress of procedures concerning environment assessment

1) LGED and B/D Study Team confirmed in the Minutes of Discussions (signed on March 2, 2006) "IEE and necessary approval for the Project by Bangladesh side should be completed before dispatching a mission to explain the draft Basic Design report by JICA (initially scheduled at the end of June 2006, refer to Appendix-4 Minutes of Discussions)". Also, LGED expressed that Bangladesh side would provide draft IEE to the Study Team before their departure on the end of March, 2006.

2) Accordingly, LGED submitted draft IEE to the Study Team prior to its repatriation on March 12, 2006.

The B/D Study Team visited Department of Environment (DOE) on March 12, 2006 and confirmed followings;

1) While target model sites are located in Haor area, being outside of ECA (Ecologically Critical Area) is a pre-condition for Project implementation. Without confirmation on this matter, which is responded by Ministry of Environment (MOE), DOE dose not enable to start procedure for environment assessment.

2) The Project of which component involves flood control, would be categorized into Red according to "No.66, construction /reconstruction /expansion of flood control embankment, polder, wall etc." shown in the Environment Conservation Rules (ECR, 1997).

3) Before the Project implementation, LGED has to prepared EIA including Environmental Management Plan (EMP) being approved by DOE after getting Location Clearance Certificate (LCC) in the case of

Red category.

(2) Further procedures

In order to secure the Project implementation, the Study Team requested LGED to confirm the above procedure on environment assessment through JICA Bangladesh office (refer to Appendix 4-2 JICA Letter for confirming procedure of Environment Assessment). Later, followings are confirmed between the Study Team and LGED on March 12, 2006;

1) LGED will immediately take necessary actions with MOE regarding on ECA.

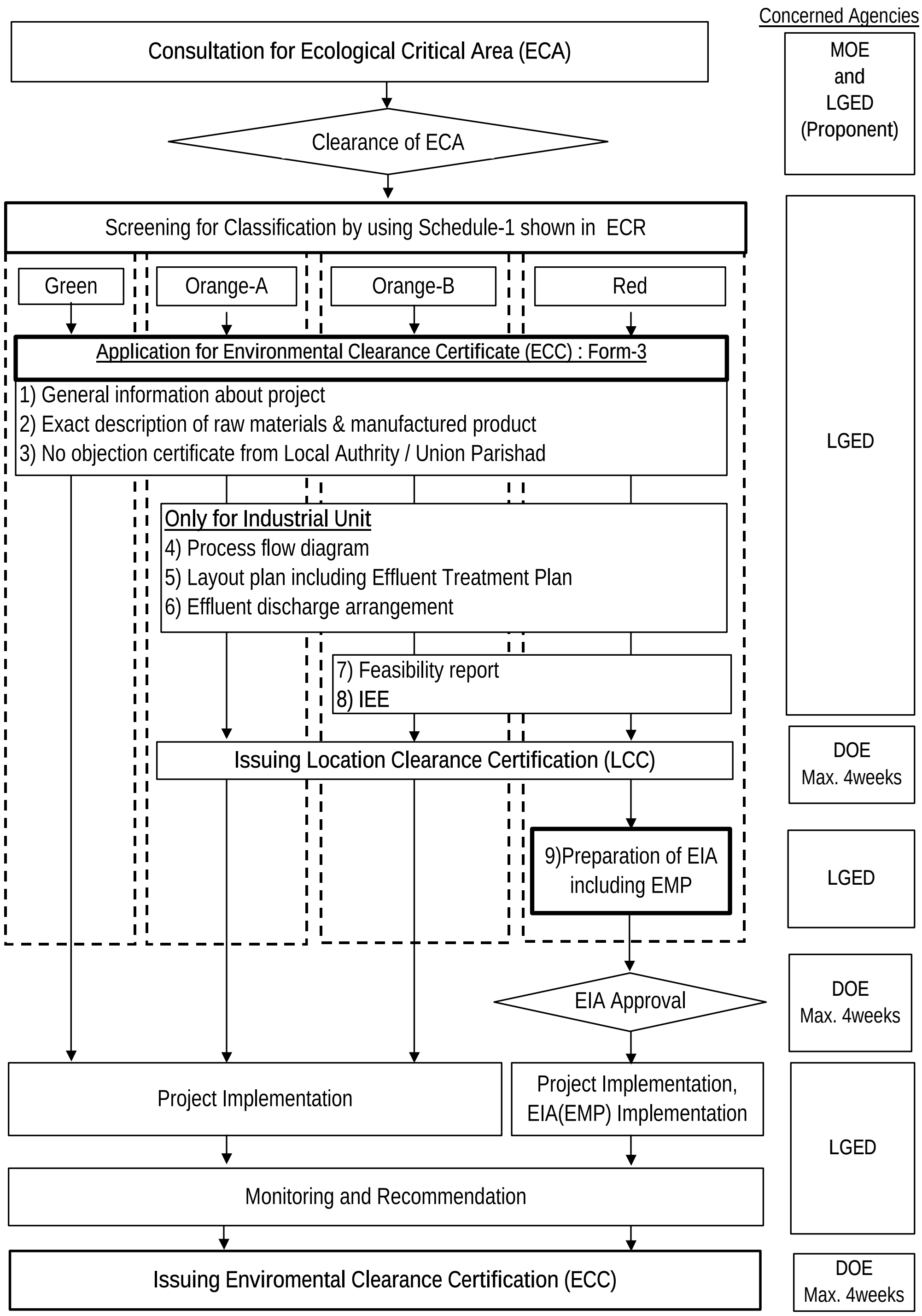
2) This Project should be categorized into Orange-B while main project purpose is “Flood proofing”, not “Flood Control” pointed by DOE.

3) LGED, irrespective of category, has to pay an amount of Tk.100 thousand per each site for applying to obtain Environmental Clearance Certificate (ECC), being Tk.400 thousand in total covering 4 sites.

4) The budgetary allocation for the Project will be made after the approval of the DPP (Development Project Proposal) in general. However, the Chief Engineer of LGED can make beforehand approval.

In this context, flow of the procedure on the ECC by categories is summarized, shown in the Fig. 1-1.

(Remarks: Following Procedure requires for each Project site)



ECR: Environment Conservation Rules, 1997
ECA: Ecological Critical Area
IEE: Initial Environmental Examination
EMP: Environmental Management Plan
ECC: Environmental Clearance Certificate
ETP: Effluent Treatment Plan
MOE: Ministry of Environment

Remarks: This flow is prepared by the consultant of the Basic Design Team of the Project by assessing ECR and hearing from person of DOE concerned

Fig. 1-1 Flow of the procedure on the Environmental Clearance Certificate（ECC）

1-4 Others

(1) Land acquisition

It was confirmed that Bangladesh side would take necessary action to secure both lands for the wave protection wall and temporary yards for construction in the Minutes of Discussions (refer to Appendix 4-1). In this connection, the Japanese side has been explained that the negotiation with beneficiaries cannot be set force until the plan of route for the wave protection is determined. Two(2) alternative solutions for land acquisitions are, one is grant by landowners, the other is governmental compensation to the landowners. According to LGED, the government can acquire lands without any troubles from landowners, while they have a strong desire to realize this Project to bring lots of benefits to their areas. As the result of a consultation with LGED, the flow of the procedure for land acquisition is shown in Fig. 1-2.

(2) Global issues

The Government of Bangladesh has deployed PRSP based on MDGs as a national development plan given top priority to the poverty reduction. Although the Country, in recent years, has sustained an annual growth rate of 4-5%, its GNI per capita is still only $445 (in fiscal year 2004/05). As 36% of the entire population lives under level of one dollar expense a day, the Country has a number of poor people among the least developed countries (LDC). The Government recognizes in PRSP that economic growth is essential for poverty reduction, especially for the poor people of whose 70% stays in rural area. A larger number of 35,000 people that lives in Haor area under the severe natural and environmental conditions, will be benefited by the Project. Therefore, this Project is greatly expected to contribute in the viewpoint of human security.

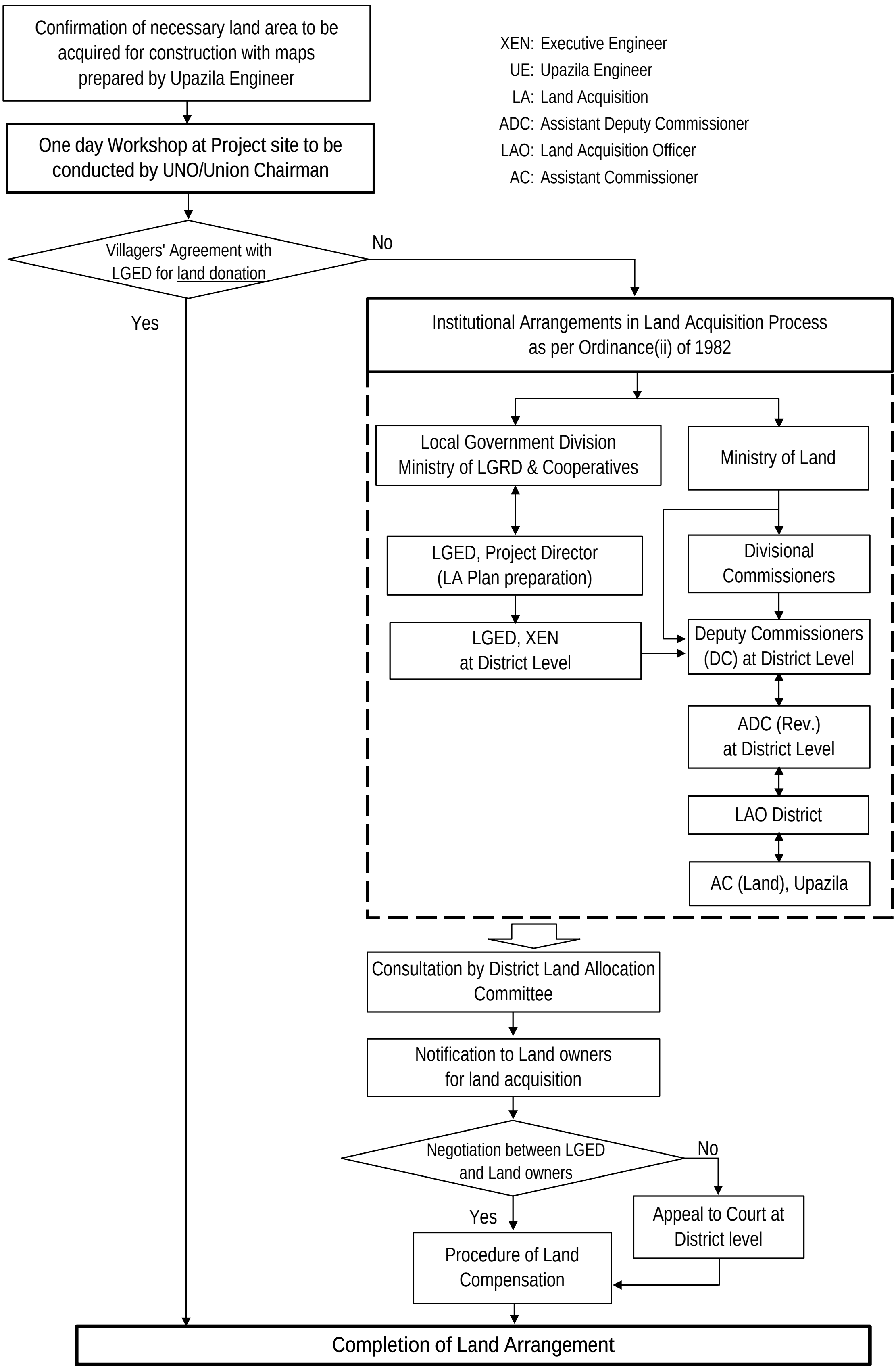


Fig. 1-2 Flow of the procedure for land acquisition

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Purpose

(1) Super goal:

"To protect vulnerable people and their property from flood in Haor area".

(2) Overall goal of the Project:

"To develop wave protection effectively for preventing wave erosion in Haor area other than model sites".

(3) Project purpose:

"To be taken effective measures for preventing wave erosion at the model sites with sustainability of LGED".

Poverty Reduction Strategy Paper (PRSP) based on Millennium Development Goals (MDGs), as a national development plan, recommends that the Government of Bangladesh should immediately tackle with "poverty reduction". Under its harsh natural environment, most of Upazilas located in Haor area indicates higher percentage of poverty (Family budget survey 2000, FAO analysis). This is proved by the ratio of a Hindu population lived in Haor area, of which shows 30% whereas the national average is only about 10%. Thus, the Haor area is prioritized as a target for poverty reduction.

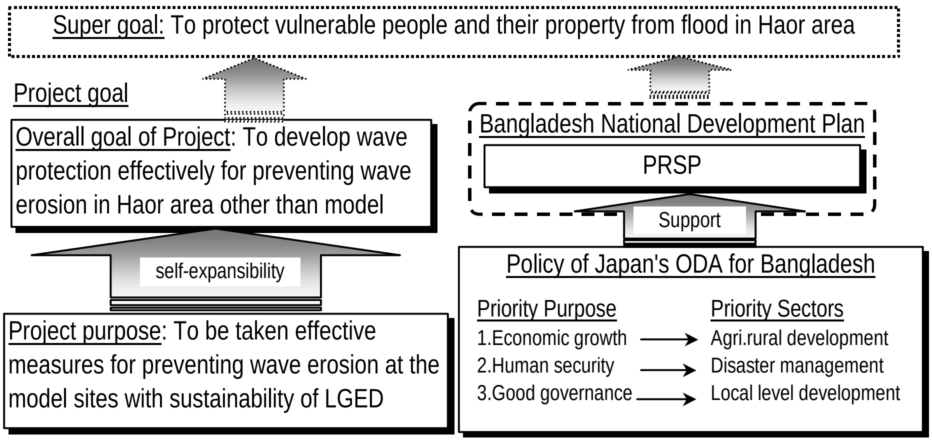


Fig. 2-1 Relationship between Project goal and National Development Plan

Around 80% of local population engaged in agriculture, forestry and fishery become job-less during rainy seasons and they are obliged to leave their villages for seasonal migrant worker or to live in mounds. The mounds become densely populated more than 35,000/km^2 during rainy season where the accommodated people are forced to suffer from physical and phycological pain withhin a limited living environment for a long period. The poorest level is placed in the most vulnerable life suffering from malnutrition and degraded sanitation due to depleted food and fuel in late rainy season.

This Project aims as an overall goal "to develop wave protection effectively for preventing wave erosion in Haor area, so that people living in vulnerable areas will be protected from flood and poverty will be reduced.

2-1-2 Outline of the Project

To achieve overall goal and the Project purpose, total length of effective wave protection wall with 5,215 m will be constructed, "Wave erosions in mounds at the model sites, selected one(1) each candidate from 4 districts of Haor area are prevented (Direct effect-1)". In this process, "LGED acquires techniques to construct effective wave protection wall (Direct effect-2)".

Expected outputs of the Project (direct and indirect effects), activities and objectively verifiable indicators are summarized in Table 2-1.

Table 2-1 Expected outputs of the Project

Expected outputs (Project effect)	Activities (inputs)	Objectively verifiable indicators (after a rainy season)
1. Direct effect		
(1)Wave erosions in mounds at the model sites are prevented (Direct effect-1)	(1) Constructing wave protection wall at the model sites (about 5.2 km in length).	(a) Eroded area in mounds (b) Expenses for wave protection measures by inhabitants (c) Damages (houses, livestock) by wave action
(2)LGED acquires techniques to construct effective wave protection wall (Direct effect-2)	(2) LGED actively participates to the Project in designing / implementing stage under the Grant Aid Scheme.	(d) Preparing manuals of study, design and implementing management on construction of wave protection
2. Indirect effect		
(3)Base for inhabitants is prepared to improve their living standard at the model sites (Indirect effect)	(3) With the assistance of the Government of Bangladesh and NGO, etc., beneficiaries expand their mounds. (4) LGED conducts non-structural measures.	(e) Extended area of mounds (f) Percentage and duration of seasonal migrant workers

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design policy

2-2-1-1 Basic Policy

The relationship between the project targets and expected effects of the Project is summarized in Fig. 2-2.

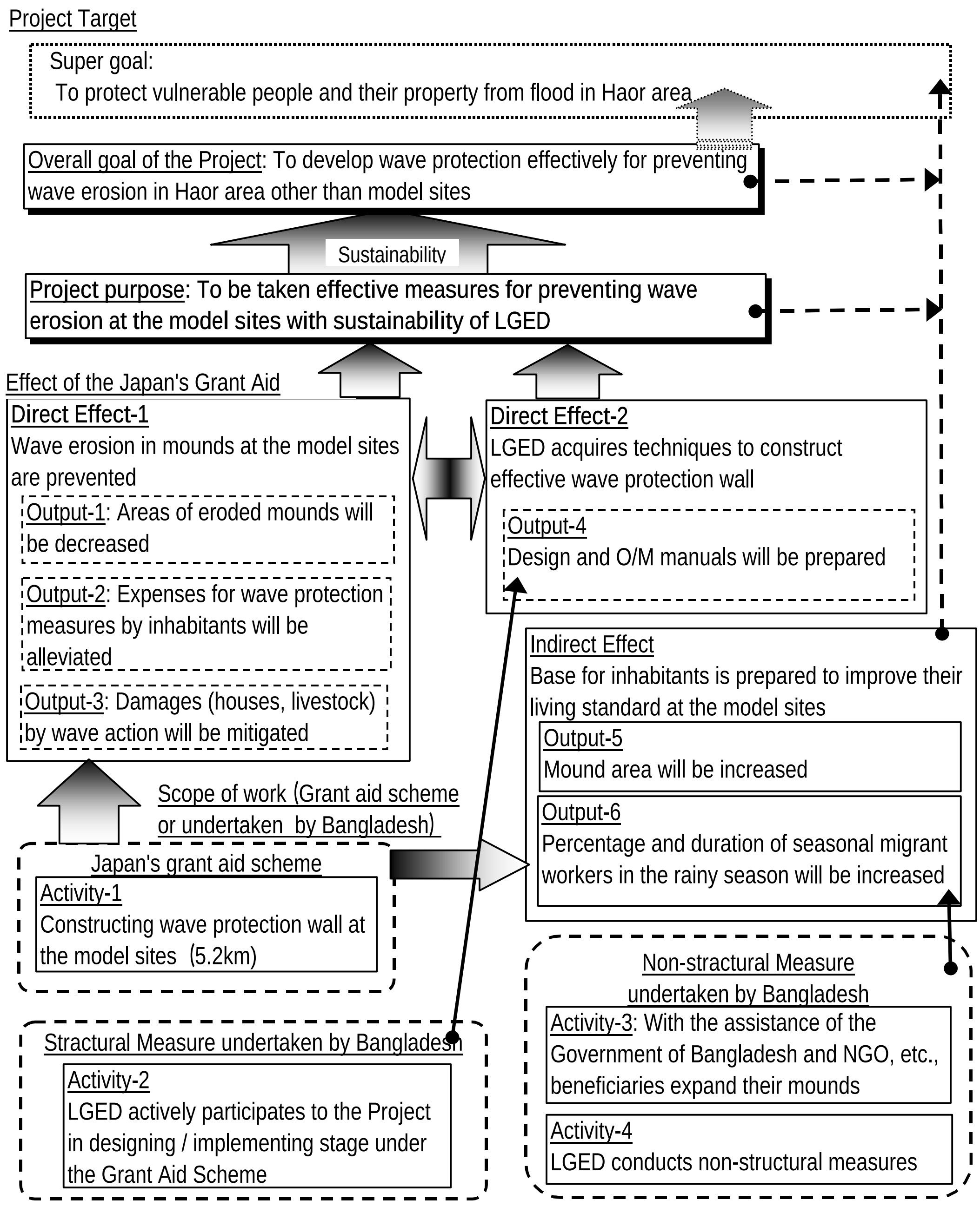


Fig. 2-2 Relationship between the Project targets and expected effects

The following requirements shall be fulfilled to achieve the Project purpose described above that is; "To be taken effective measures for preventing wave erosion at the model sites with sustainability of LGED", and to achieve the overall goal of the Project in the future as shown in Fig. 2-2.

(1) Wave erosions in mounds at the model sites are prevented (Direct effect-1).

(2) LGED acquires techniques to construct effective wave protection wall (Direct effect-2).

To take into account the above requirements (two(2) direct effects), following Basic policies are formulated under the Basic Design study;

Basic Policy-1: Adopting "Reinforced Concrete (RCC) retaining wall" as for type of the wave protection, considering of the line with lessons learned from the CARE projects and the policies of LGED to the recent environmental issues.

Basic Policy-2: To decide the details such as structural type, route, construction plan and so on, for RCC retaining wall, to analyze each natural condition (water level in the rainy season, foundation, topography, land use, etc.) of the four(4) model sites.

Basic Policy-3: To secure sustainability of LGED, using of existing staff availability, equipment and systems of project implementation and O/M owned by the LGED to extend its techniques efficiently to entire Haor area in future.

(1) Basic Policy-1: Adopting RCC retaining wall

(a) Lessons learned from CARE projects

The implementing agency LGED requested to the Government of Japan to adopt RCC protection wall. This is because of the results and lessons from FPP (Flood Proofing Project, "CARE project") implemented from 1997 to 2004, as a component of IFSP (Integrated Food Security Program) assisted by CARE. In this project, CARE has constructed 1)RCC retaining wall, 2)CC (plain concrete) block sloping wall and 3)wave protection by tree planting (Colos, Hijol) and by grass growing (Chaira) in addition to 4)bricklaying gravity type retaining wall, which LGED had been implementing as in the past. Through this process, CARE proposed the following target sites in the viewpoint of participatory approach as shown in Table 2-2.

Table 2-2 Each type of construction sites proposed by CARE project

Type of wave protection	Target construction site	Remarks
1) RCC retaining wall	Public facilities such as market and school where cannot be maintained by beneficiaries.	Construction cost is high but O/M is not much required.
2) CC block slope protection	Residential area where can be maintained by inhabitants.	Heavy burden on O/M shouldered by inhabitants or being impossible by beneficiaries.
3) Tree planting / grass growing wave protection	Same as above	This measure is not affected to wave action, and careful monitoring by inhabitants is essential.

Several issues have been pointed out later at the evaluation stage; beneficiaries have given poor reputation to "2)CC block slope protection" due to easy occurrence of surface cave-in as a result of the scouring of filling material at backside of CC blocks by the wave action. Moreover, repair of the wave protection is difficult for inhabitants and effects of wave protection are poor. For "3)Tree planting / grass growing wave protection, it takes much time before any effect of wave protection is seen, and careful monitoring is required throughout the growth of the planted trees. From these results, CARE has concluded that “RCC retaining wall” is the better measure to prevent erosion in the mounds, in the viewpoint of low O/M cost in the case that initial cost can be allocated for construction. As well, LGED has intention to extend “RCC retaining wall” throughout the Haor areas.

(b) Environmental consideration

Ministry of Environment (MOE) of Bangladesh applies several criteria to those who plan to construct brick factories, reflecting environmental consideration such as depletion of wood resources and detrimental air pollution effects on inhabitants, those are; 1)Not to use firewood or wooden chip as fuel, and 2)to restrict the height of chimneys (over 120 ft). Accordingly, LGED banns brick procurement from the factories failing to satisfy the criteria. Furthermore, LGED recommends to design concrete aggregates using crushed stone but without brick chips for ensuring the strength of major structural objects, in the areas where stone materials are comparatively readily available. Although MOE has not yet ruled out any particular regulation on the use of bricks or brick chips, certain restrictive measures could be issued in the future for economic activities which consume great amount of bricks.

Judging from the above circumstances, the “RCC retaining wall” with crushed stone using for aggregates as the type of wave protection in line with the request from the Bangladesh side, and examine its style and structure based on this type, as illustrated in Fig.2-3 (refer to Table 2-5, “Comparative analysis of type of wave protection wall by structures” in page 2-11).

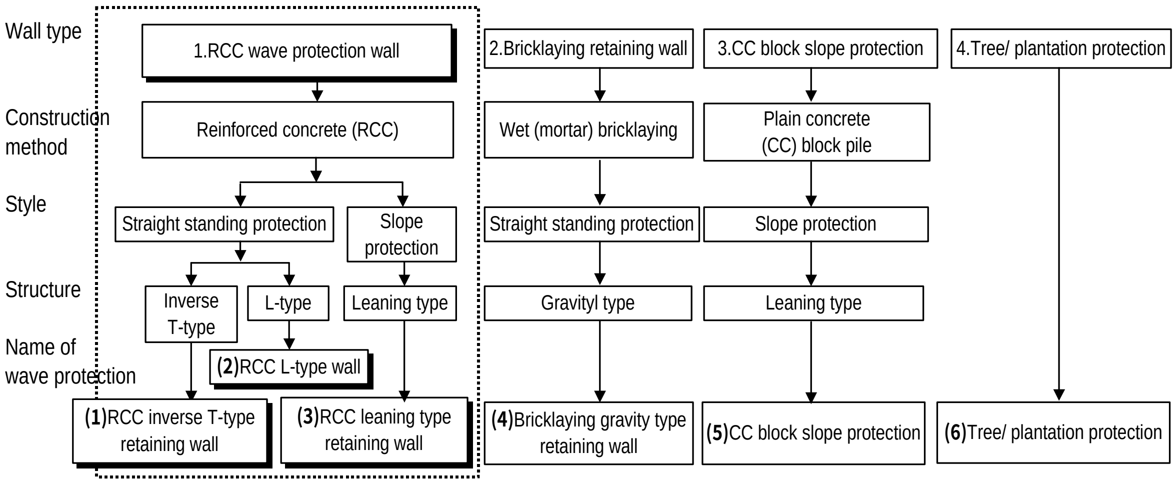


Fig. 2-3 Type of wave protection measures

(c) Basic policy-2: Formulation of style, structure, route and construction plan of protection wall

The range of flooded areas in Haor areas extends to 6,500km^2 with diversified natural conditions. For this reason, it is compared and examined style and structures of wave protection in consideration for natural conditions (water level in the rainy season, foundation, topography, land use) of each model site and also formulate structure of wave protection wall, their route and construction plan applicable to other Haor areas besides the model sites.

The natural conditions to be regarded are as follows;

Table 2-3 Natural conditions to be regarded in the determination of structure of wave protection

Factor	Natural condition
1) Water level, wave height	Water level and wave height as function of drifting distance vary between relatively shallow fringe (Shallow Haor) and central part (Deep Haor), affecting the height of wave protection to be designed.
2) Foundation	Allowable bearing capacity (force of supporting wave protection wall) varies with the state of ground, affecting shape of bottom foundation and measures of foundation treatment, and eventually influencing construction cost and construction plan.
3) Topography and land use	Though beneficiaries desire to create wave protection as far as possible from the edge of their mound with expanding area, style and structure of protection wall, the location of route vary with topographic and land conditions influenced by the river and closer distribution of paddy fields.

(2) Basic Policy-3: Utilization of existing staff, equipment and systems

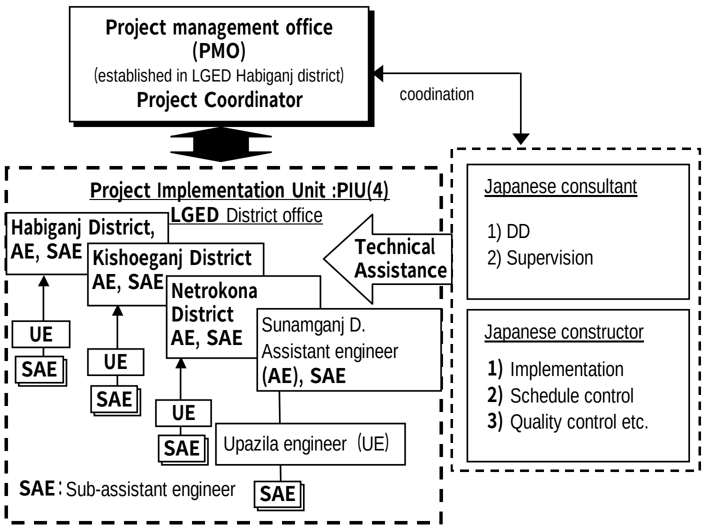


Fig. 2-4 Project implementation system

LGED has an owned network, distributing investigation and test equipment, construction machinery and vehicles for extension activities to 64 district offices located throughout the country. Staffing to the district offices required to make use of these inputs has been made and these distributed staffs are engaged in district-level services including investigations, designs, and tenders, construction supervision and O/M services. From the above situations, it can be expected to secure further extension of protection wall into Haor areas other than the model sites as the district level by making efficient use of existing staff, equipment and already established systems, and also by utilizing "construction supervision manual" provided during the process of the D/D and the implementation as a unit of 4 districts. As described in Fig. 2-4, Project Management Office (PMO) in Habiganj district, which plays a role of liaison among 4 LGED district offices, Japanese consultant or constructor will be established.

2-2-1-2 Natural and Environmental Conditions

Policy-1: The height of wave protection wall shall be determined according to the water level in the rainy season and height of wave attributed to specific meteorological and hydrological conditions in Haor areas.

Policy-2: The basic structure of "RCC wave protection" at each model site shall be determined according to the verification of geologic survey (soft ground).

(1) Policy-1: Consideration on the water level in the rainy season and height of wave attributed to specific meteorological and hydrological conditions in Haor

In Haor areas, there is a clear division between the rainy season from April to September and the dry season from October to March shown in Table 2-4. During 6 to 7 months from May to November, 6,500 km^2 of the land submerged. Not only the difference of water level between the rainy and dry seasons reaches 6 m at maximum, but also monsoon wind generates violent wave with the maximum height of 2 m during the monsoon period (July to August). These climatic and hydrological conditions will be fully considered on design and construction and procurement plan.

(2) Policy-2: Consideration on soft ground at each model site

In the BD study, six(6) boring tests, determined according to the scale of the target area in 4 model sites, were conducted. The summary of the ground analysis shows a trend of soil particle change from the ground surface to substrata in a specrtrum; clay (CH) → clayey soils (CL) → sandy silt (SM), and N values of the ground, an indicator of allowable bearing resistance of foundation are tabulated in Table 2-4 (details are described in Appendix 5-3 “Boring log and results of the soil mechanic tests”). Since the foundation ground around (depth 1 to 3 m) serves as a key factor for determining basic structure of “RCC retaining wall”, the determination of the structure will be made through fully elaborated examination on the results of test boring and soil mechanical testing.

Table 2-4 N-values around the ground surface at each model site

Depth from surface	Sazan (2 sites)		Gurai (1 site)	Lipsha (2 sites)		Nazarpur (1 site)
1 m	2	2	2	2	1	2
2 m	3	2	1	4	2	2
3 m	7	2	5	4	2	3
4 m	1	1	5	3	3	4
5 m	2	2	5	4	4	5
6 m	4	7	5	5	5	6

2-2-1-3 Socio-Economic Conditions

Policy-3: The differences in socio-economic activities between the rainy and dry seasons caused by specific natural conditions in Haor areas shall be considered.

Policy-4: Existing social environment such as religions, education, and poverty shall be considered.

(1) Policy-3: The differences in socio-economic activities between rainy and dry seasons shall be considered

Great seasonal differences exist in socio-economic activities between the rainy and dry season, which are attributed to specific natural conditions in Haor areas. The typical difference is seen in transportation means of people, goods /material and equipment. Major transportation means during the dry season are vehicles using road networks or land transportation such as rikshaws and ox-carts. However in some areas, boat transportation is also available even during the dry season thanks to many tributaries of Megna River running through Haor areas. On the other hand, during the rainy season, boat transportation is more efficient means since the whole Haor areas are submerged. Hence, the characters of socio-economic activities during each season attributed to various site conditions at each the model site should be taken into consideration when formulating construction and procurement plan of the Project.

(2) Policy-4: Existing social environment shall be considered

In Bangladesh, Islamism is the most popular religion and Moslem accounts for 90% of the national population, whereas Hindu represents only 9%. However, in Haor areas Hindu people has higher share reaching 20 to 38% in the model sites. Here, relation between Moslem and Hindu has been favorable. For example, in Nazarpur village /Sunamganj district primary school established in the center of the village is shared by both followers, and teachers of both followers even work together. Problems arise from natural force rather than differences in religion in Lipsha village /Netrokona district where the play ground in the primary school and communicating roads become submerged under flooding. Consequently, education utilizing school grounds and commutation with boats become limited and threatened by flood wave for 3 month during the monsoon period, June to August.

In Gurai village /Kishoreganj district, they have reported that wave erosion is more serious in the mound of Hindu where poorer strata live in higher rate, while in Sazan village /Habiganj district a great many inhabitants are obliged to live in flood shelters after abandoning their erosion-affected homes. Currently, villagers spend 1,500Tk. per year per family for mound protecting works against erosion by means using bamboo and grass but this amount imposes heavier burden on the poorer people, oppressing their livelihood, causing larger poverty gap.

Considering these living environments such as equality among different religious followers, education and, inhabitants’ burden for maintenance, style, structure and routes of wave protection wall shall be selected.

2-2-1-4 RCC Retaining Wall

(1) Policy of selecting route of wave protection

- Policy-5: Basically based on inhabitants’ desires
- Policy-6: To protect existing mound and public facilities such as primary schools and markets
- Policy-7: To give implementing priority to the sites subject to damages by higher wave and severer erosion
- Policy-8: To utilize existing wave protection effectively
- Policy-9: To sustain existing community functions
- Policy-10: To consider current topography and land use

(a) Policy-5: Basically based on inhabitants’ desires

Population density (rate to mound) at the model sites is exceedingly high reaching 35,000 to 154,000 persons/km^2. Especially, villagers are jammed in narrow mound during the rainy season and this seriously aggravates hygiene and sanitary environment. To ease environmental deterioration, villagers highly intend to widen the space in their mound, willing to fill earth by themselves between the wave protection and their mound, thus, longing for the design of the routes as far as possible from the edge of their mound. Therefore, it is to design the routes of RCC protection wall, taking the foundation ground like topography and land use into consideration, and as a rule reflecting their hope as far as possible.

(b) Policy-6: To protect existing mound and public facilities such as primary schools and markets

Part of the route requested from the villagers is for protecting the on-going or scheduled earth filling sites to construct new mound. In this case, filling area and its completion time are uncertain. Therefore, route which earth filling is going on or scheduled is excluded from the target of the Japan’s Grant Aid Scheme, while the target sites for protection are confined to the existing mounds and facilities with high-public priority, those highly requested from villagers or highly dilapidated, such as primary schools and markets.

(c) Policy-7: To give implementing priority to the sites subject to damages by higher wave and severer erosion

Though it is commonly said that wave caused by southeast monsoon mainly contributes mainly to erosion, it has been found that high wave occurs even on the northern side of the mound. Nevertheless, erosion damages are small in the sites where other mounds are located close on the windward because the drifting distance is shorter. The sites with higher flood wave and damages from erosion are severe and have priority for protective works.

(d) Policy-8: To utilize existing wave protection effectively

The existing wave protection facilities will be utilized if they are not yet dilapidated and judged still tolerant against wave from both the result of Schmidt hammer test and appearance examination. In this case, existing wave protection and newly constructed ones are not united because no particular examination on base foundation was made at the stage of designing these existing wave protections. Therefore, there is a fear that sliding and overturning of existing wave protection and an uneven subsidence between old and new wave protection will occur.

(e) Policy-9: To sustain existing community functions

Farming is practiced during the dry season in the lowland, and villagers commute through steps cut at the edge of earth filling from their mound to the farmland. Because the height of wave protection exceeds 5 m in some routes, access to the farmland from their mound would become difficult after the wave protection is constructed connectedly between mounds and the farmland. Besides, boats sail to the mounds during the rainy season. To solve this issue, it is proposed to install stair works or open inlet (described in “2-2 Basic Plan 2-2-2-4 Appurtenant Facilities”) at a fixed interval along the wave protection so that the villagers' free passages can be procured. As well, the route of protection wall is planned to avoid existing trees for preventing wave so that making maximum use of tree’s effect against wave erosion.

(f) Policy-10: To consider current topography and land use

For site selection, rivers, reservoirs and paddy field should be avoided as much as possible because current ground level in these locations are low and unfavorable foundation ground and is not suited for the foundation of

RCC retaining wall. Thus, the route of wave protection is planned nearer to the mound to minimize its height. In the case that the site ground of the route is inclined, taking account of all the above restrictions, foundation consolidation (described in "2-2 Basic Plan 2-2-2-4 Appurtenant Facilities") to prevent erosion at the part of footing and bottom-slab is considered.

(2) Policies on the determination of type and structure of wave protection wall

Policy-11: Out of various types of RCC wave protection, "RCC inverse T-type retaining wall" shall be applied as its structure

Policy-12: Height and structure of retaining wall shall be designed based on "CARE design manuals", also adopting Japanese "technical manual for stream sediment control" for those which are not referred to in the former manuals

Policy-13: Structure of foundation for wave protection wall shall be 1)direct foundation as a standard, according to foundation ground, extent of back-filling and current land use, 2)direct foundation with sand replaced foundation or 3) pile foundation are applied

(a) Policy-11: Out of various types of RCC wave protection wall, RCC inverse T-type retaining wall shall be applied as its structure

As a result of examining "Basic policy-1: selection of wave protection type (page 2-4)" and 10 items shown in Table 2-5, we will adopt "RCC inverse-T type" but its foundation structures will be determined depending on the foundation ground at each model site.

Table 2-5 Comparative analysis for type of wave protection wall by form and structure

Outline							
Outline	1) Wall type	1.RCC reinforced concrete wave protection			2.Bricklaying wave protection	3.CC block inclined protection	4.Tree planting /sodding
	2) Construction method	Reinforced concrete (RCC)			Wet(mortar) bricklaying wave protection	Plain concrete (CC) block piled	Planting water tolerant species or covered with water tolerant vegetation
	3) Style	Straight standing		Inclined type	Straight standing	Inclined type	—
	4) Structure	Inverse T type	L slope type	Leaning type	Gravity type	Leaning type	—
	5) Major material	Reinforcing bar, cement, crushed stone and sand	Reinforcing bar, cement, crushed stone and sand	Reinforcing bar, cement, crushed stone, sand & filling	Brick, cement and sand	Cement, crushed stone or brick chips, sand & filling earth	cut and filling earth

Examination item		Share	(a) RCC inverse T type wall		(b) RCC L-type wall		© RCC leaning type wall		(d) Bricklaying wall		(e) CC block slope protection		(f) Tree plantation	
1. Durability		10	High durability due to RCC structure	10	High durability due to RCC structure	10	High durability due to RCC structure	10	Durable is endured if filling up is properly worked	5	Drawout of back-filled materials makes slope subsidance	5	This takes much time untill effects are manifested	0
2. Wave protectivity		10	High protectivity due to uprigh twall	10	High protectivity due to uprigh twall	10	High protectivity in spite of some inclination	10	High protectivity due to uprigh twall	10	Parapet block is required due to gentle sloping	5	Wave dissipating effect is affected by density of planting	5
3. Applicability to soft ground		10	Measures necessary with broader width of bottom slab, replaced foundation or piling	5	Poor aplicability due to necessity of long bottom slab	5	Poor aplicability due to necessity of long bottom slab	5	Measures necessary with broader width of bottom slab, sand replaced foundation. Low applicability against subsidence	5	Applicable	10	Applicable	10
4. Workability		10	Workable with ordinary concrete work	10	Workable with ordinary concrete work	10	Schedule control is difficult due to stepping work with back-filling	5	Though hithero methoed, enormous bricklaying makes construction period longer	5	Though hithero practiced, enormous earthwork makes construction period longer	5	During growth process of trees, long-term monitoring is needed	0
5. Economic feasibility		10	Expensive because of using RCC	0	Expensive because of using RCC	0	Expensive because of using RCC	0	About 60% of the cost for RCC inverseT type wall	5	About 70%~80% of the cost for RCC inverseT type wall	5	Low cost	10
6. Environment		10	No negative impact thereto	5	No negative impact thereto	5	Necessary to procure large borrowing ground for back-filling	0	Large impact for emviroment in brick making process	0	Necessary to procure large borrowing ground for back-filling	0	Most adaptable to natural emvironment	10
7. Accepta-bility	1) LGED	5	Favorable results obtained from FPP by CARE	5	Unknown	—	Unknown	—	Preferable to avoid large scale application from environmental aspect	0	Poor reputation on the result of FPP by CARE	5	Poor reputation on the result of FPP by CARE	0
	2) Villagers	5	Favorable results obtained from FPP by CARE	5	Unknown	—	Unknown	—	Poor reputation in the long run due to fall of the wall	5	Poor reputation due to larger area occupation caused by gentle slope	5	Poor reputation on the result of FPP by CARE	0
8. Demonstrative / model effect as Grant Aid Project		10	Worth displying as a model by wider application to all types of	10	Suitable for a model though not suitable to soft ground	5	Suitable for a model though not suitable to soft ground	5	Poor suitability for a model of Grant Aid Project due to hitherto	5	Poor suitability for a model of Grant Aid Project due to hitherto practiced method	5	No suitability for a model	0
9. LGED's sustainability		10	Work capacity of LGED on soft ground is not	5	No experience	0	No experience	0	Many experiences	10	Many experiences	10	Many experiences	10
10. O/M		10	Almost no need	10	Almost no need	10	Necessary to regard on back side filling	5	Necessary to regard on joint of bricks	5	Necessary to regard on subsidance caused by drawout of backfill materials	5	Necessary totake care of plant	0
Comprehensive evaluation		100		75		55		40		55		60		45

(b) Policy-12: Height and structure of RCC retaining wall shall be designed based on "CARE design manuals", also adopting Japanese "technical manual for stream sediment control" for those which are not referred to in the former manuals

As for the determination of wave protection structure, LGED has taken "Design Manual for Structural Flood Proofing Measure in Haor Area" ("CARE design manual"), which has been elaborated from the achievement of CARE project as its guideline. However, standard for load and foundation condition, which is based on stability calculation such as drawout, sliding and bearing for determining shape and structure of retaining wall, is not provided in CARE design manual. On this account, the above manual is not sufficient to design standard for "RCC inverse T-type retaining wall". For this reason, the height of wave protection is determined based on "CARE design manual in the Project but as data of water level, the observation data of water level at Khaliajuri is up-dated up to 2006 is provided to the Design data, while shape/structure of wave protection, also Japanese "technical standard for stream sediment control" is adopted for their design. Table 2-6 indicates basic idea of "CARE design manual" and the basis of this B/D.

Table 2-6 CARE design manual and the methods adopted in the B/D

Item	CARE design manual (provided in 2000)	This Basic Design
1.Method of adjustment between water level and site elevation	Site inquiry on the maximum water level in 1998 and collated with ground elevation data	Same as the left column: Site inquiry on flood level in 2004 and collated with ground elevation data
2. Elevation data	Elevation used by former Public Work Dept. (PWD)	Independent elevation of each target site obtained in land survey
3. Water level data	Though water levels data at 10 observatories are listed up to 1994, many annual data are missing	Updated data to 2005 are added to the water level data in Khaliajuri mentioned in the left column
4. Design inundation level	Adopting the maximum water level in 1998 (equivalent to 5-year drought probability)	Due to many missing in water level data in observatory located near each target site, 5-year probability water level derived from the above cited Khaliajuri data
5.Design level of mound (height of back-filling)	Equal to the maximum water level in 1998 + freeboard (in determining the ground height of new mound)	The elevations of existing mound are adopted (no change is made for the elevations of mound in this Project)
6. Wind velocity: V (m/s)	Using wind velocity data in Mymensingh: The maximum value among the mean wind velocity for 3 minutes at every 8 hours, then corrected them at 15 minutes interval and finally varied statistically (5-year probability velocity)	Same as the left column: Using the mean value for past 32 years for the maximum diurnal-mean wind velocity, only confining to the period July to August whence inundation level reaches maximum
7. Fetch distance: F (km)	The distance from the target site to the southern or southeastern edge of Haor area	Same as the left column:
8. Height of wave: H (m)	1) In case of $F < 32$ km： $H = 0.032\sqrt{VF} + 0.763 - 0.2714\sqrt{F}$、 2) In case of $F > 32$ km：$H = 0.032\sqrt{VF}$	Same as the left column:
9. Design freeboard: Fb (m)	Height of wave (H) x 0.67 (m)	Same as the left column:
10.Load/foundation conditions	Not shown	Based on Japanese "technical standard for stream sediment control"

(c) Policy-13: Structure of foundation for wave protection shall be 1)spread foundation as a standard, according to foundation ground, extent of back-filling and current land use, 2)spread foundation with sand replacement or 3)pile foundation applied in parallel with 1)

Foundation structure for protection wall is determined considering the following policies, where the decision is made through the process shown in Fig. 2-5.

1) Spread foundation shall be taken as a standard, extent of back-filling is allowed up to allowable height.

2) In the case of back-fill beyond allowable height, foundation shall be replaced with 1m-thick sand, and

3) In the case subsidence exceeds the allowable extent even with sand replacement and the employed measures fail to cope with subsidence, pile foundation shall be used.

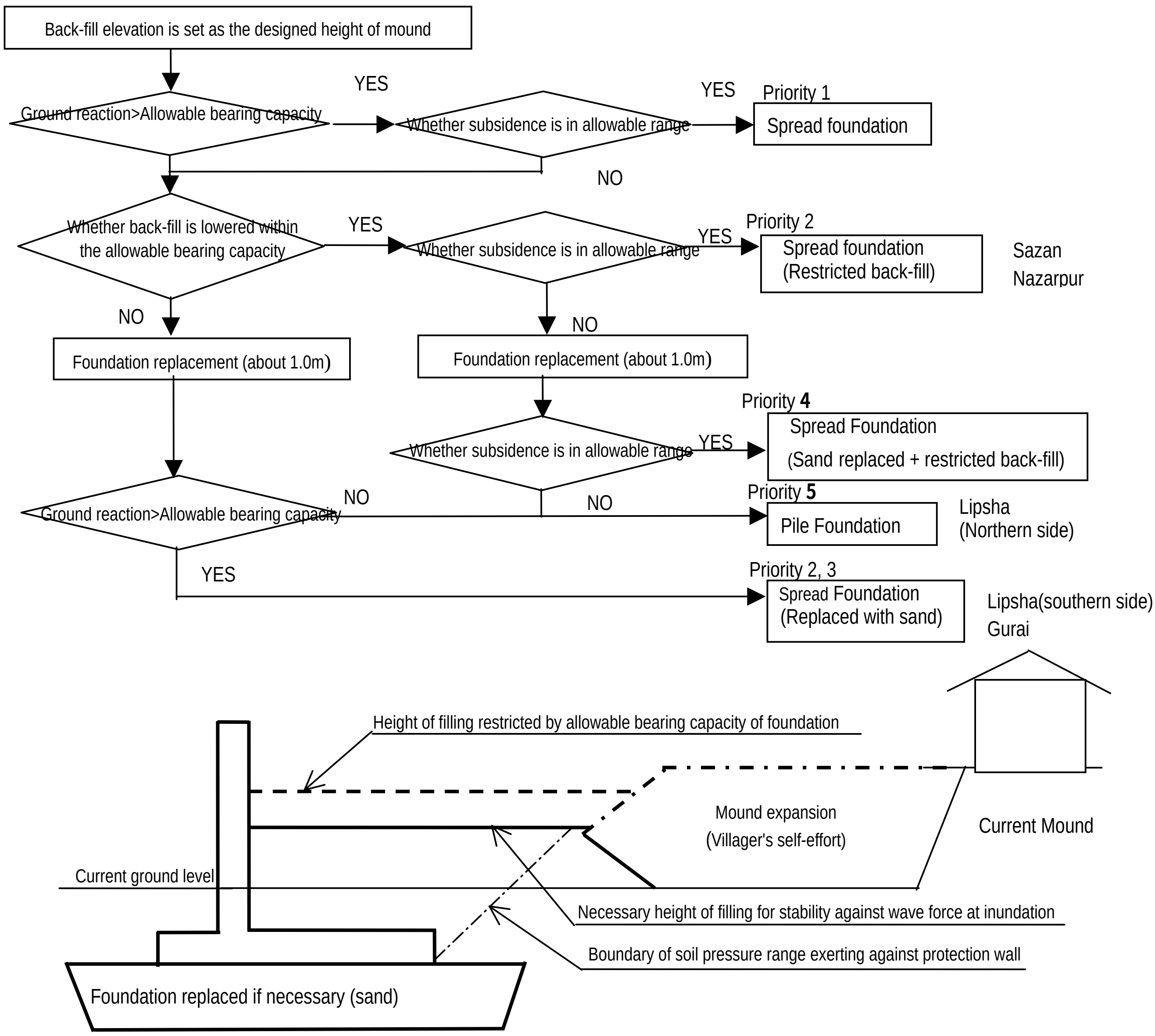


Fig. 2-5 Flow of priority procedure to determine foundation of wave protection

Judging from the results of the test boring survey and soil mechanical tests for 4 model sites carried out by B/D site-study reveal that these sites are soft ground. However, this Project basically tries to employ spread foundation considering expansion to the entire Haor area. On the other hand, in the case that the ground does not allow spread foundation due to high wave protection that increases ground reaction, the height of back filling should be restricted to the allowable range of height sustainable with the direct foundation, although higher filling is allowed in the range that doest not give pressure against the wave protection. On the contrary, under the condition that the sufficient backfill is inevitable to sustain current land use, either replacement foundation or pile foundation will be employed for the last resort. In this context, the thickness of replacement of the foundation is designed to be 1 m from the standpoint of future possibility of self-development, because this thickness can be managed by manual labor in hitherto traditional works in Bangladesh.

2-2-1-5 Construction and Equipment Procurement

Policy-14: The construction schedule management and procurement plans shall be formulated in compliance with the acts and regulations enforced in Bangladesh including legislations related to construction works, labor standards act and regulations and rules on equipment /material procurement.

The Department of Planning in the Ministry of Finance has enacted "The Public Procurement Regulation, 2003"as to the services such as construction works, equipment/material procurement, consultant services etc. ordered/contracted by the Government of Bangladesh. However, in case of projects funded by donors such as international organizations, procurement is made based on the standards provided by the donors in case they exist. Therefore, the procurement standard of Japanese Grant Aid Scheme is prioritized, but procurement standard stipulated by the Government of Bangladesh is also observed as supplemental measures.

Labor acts exist in Bangladesh in which 1)wage and employment, 2)labor unions and labor-management dispute, 3)working environment and 4)management of employees and other related matters have been stipulated. According to these regulations, laborer works are limited to 8.5 hours/day (including 0.5 hour for lunch time) or 48 hours/week, and Fridays should be holiday. Overtime allowance is equivalent to twice the hourly wage. Observing this rule, we will formulate implementation/work schedule management plans to meet these labor conditions.

Large difference is observed on the capacity of engineers and skilled laborers employed by local constructors in the related district and these constructors' capacity is hardly reliable. Hence, in this Project, chief level engineers and other work supervising staff, head of skilled laborers including carpenters, reinforcing rod workers plasterers are employed in the capital, Dhaka, while ordinary skilled laborers are hired in district centers or when need arises employed also in Dhaka.

2-2-1-6 Employment of Local Contractors

Policy-15: Large / medium scale constructors in Dhaka shall be used as sub-contractors of construction works and local constructors who are most acquainted with specific characters of Haor area shall be positively involved.

Policy-16: Local consultants shall be utilized as supervising staff attached to Japanese supervisors when needed during sounding survey at D/D and during general supervision.

(1) Policy-15: Policy to make use of local contractors

In the actual implementation of relatively large-scale construction works in Bangladesh, large/ medium scaled contractors in Dhaka have been engaged therein. These contractors own heavy construction machinery and employ formally hired engineers and skilled laborers, that have experiences of jointly working or undertaking sub-contracted works with foreign constructors and that most of medium scale contractors have experiences of sub-contracted works. As these contractors have been equipped with reliable capacity of construction and quality control, with enough level to fully undertake the requested works from Japanese and local contractors, in Dhaka are sub-contracted in this Project.

On the other hand, local contractors in four district centers where the model sites are located, have the scale as small as a few permanent engineers and skilled laborers and hiring workers only when necessary on a project basis. Furthermore, they own limited construction machinery such as drum type concrete mixers, tractors and pumps, but do not own such heavy machinery as backhoe loader and bulldozers, hiring them on a rental basis from machinery lease companies in Dhaka whenever they need them. Considering capacity of implementation and quality control, they do not have enough capacity to directly undertake the works from Japanese contractors. However, they are fully acquainted with specific profiles of Haor area during the rainy season such as the method of construction works, possible routes of material /equipment procurement etc. Taking all these advantages into account and also counting the future possibility of further development in Haor area, it is proposed to plan to actively mobilize them in this Project.

(2) Policy-16: Policy to utilize local consultants

Due to abundance in the cases of consultancy services through donor funds, Bangladesh is often referred to as a repository of local consultants. They have many experiences of working with Japanese consultants, and sufficiently capable of undertaking not only consultancy services but also various tests and measurements such as land surveys, boring surveys and soil mechanic tests. Their technical levels on analytical capacity of these survey results are also acceptable. In this Project, sounding survey is planned at the D/D stage at each of 4 model sites to complement the results of boring tests and soil mechanical tests carried out at B/D survey where a local consultant will be employed to perform this supplemental study.

In addition, the construction works will be implemented simultaneously in 4 villages, also supervisory staff are necessary at each of 4 sites. Though a Japanese permanent supervisor is dispatched to the Project management office, local engineers will be appointed to other villages. Likewise, during construction supervision, local consultants are going to be mobilized.

2-2-1-7 Ability on Operation and Maintenance of the Implementing Agency

Policy-17: Existing staff and equipment of LGED district offices shall be effectively utilized

Policy-18: The Project shall be coordinated with RDEC strengthened by a Japanese technical cooperation project

(1) Policy-17： Utilization of existing staff and equipment of LGED district offices

LGED has its district office in each of the 64 districts all over the country. Many of the development projects in Bangladesh are deployed at district level where planning, studies, design, tender, implementation of these projects are carried out under the responsible Executive Engineer (XEN) of each district. According to Basic policy-3 (in page 2-6), it is proposed effectively to mobilize these existing staff into D/D and implementation of this Requested Grant Aid Scheme, thereby expecting smooth O/M at the post-project stage, and further expansion of wave protection into the entire Haor area.

(2) Policy-18: Coordination with RDEC strengthened by Japanese technical cooperation

(a) Outline of RDEC

As a test laboratory was established in RDEC through the Japanese technical cooperation program of strengthening its functions, short-term experts were dispatched to instruct various tests and quality control to LGED staff. Furthermore, other short-term experts were dispatched for instructing concrete tests and soil mechanic tests, thus capacity of RDEC was significantly improved. In this Project, so far accumulated information will be effectively input in D/D along with the efficient utilization of testing capacity on soil mechanics, materials and concrete done by each district office of LGED, thus envisaging mutual coordination between related offices/ projects at the implementation stage. More concretely, results of the tests on soil mechanics and concrete required for constructing wave protection will be supplied to RDEC. If testing techniques are accumulated into RDEC at the implementation stage of this Project, the accumulated techniques will enable relevant quality control of concrete and adequate judgment on foundation ground in henceforth diffusing "RCC inverse T-type retaining wall" in the entire Haor area.

From another viewpoint, before starting the RDEC Setting-up project, access to technical information was really difficult because design drawings, implementation plan etc. of each project implemented by LGED were separately kept in related sectors or divisions after the completion thereof. However, after a technical library was established in RDEC, integrated management of technical information became possible. Preservation of technical information in technical library is also essential to secure storage of reports, maps and drawings of this Project to secure their contribution to the future expansion of the model into other parts of Haor area.

(b) Coordination with RDEC

As mentioned above, RDEC has a function of accumulating and disseminating technical information and intelligence into / out of itself, aiming at strengthening technical capability of LGED headquarters and local level (districts, Upazila and Union). With this reason, coordination with RDEC is indispensable for LGED to realize autonomous expansion of wave protection techniques with "RCC inverse T-type retaining wall" by LGED after the completion of this Project. RDEC strengthened its function through the technical cooperation for 3 years. Self-development capacity for the facial expansion into Haor area in the future will be secured through the promotion of active involvement of technical capacity and well-trained staff held by RDEC and LGED at the stage of D/D and implementation supervision.

2-2-1-8 Determination of Grades for Facilities and Equipment

According to the Project purpose, "To be taken effective measures for preventing wave erosion at the model sites with sustainability of LGED" and comprehensively referring to the above policies, the policy of grading the facilities and implemented performances are briefed as follows:

Policy-19: Model projects shall be implemented in each of 4 districts in Haor area

Policy-20: Facilities can be managed and operated by LGED and the villagers concerned

Policy-21: The project shall assist the provision of design manual and supervision manual required for sustaining self-developing of LGED through DD and supervision of implementation

(1) Policy-19：Model projects shall be implemented in each of 4 districts in Haor area

(a) Planned quantity in Master Plan (M/P)

As shown in Table 2-7, Haor area spreading in 4 districts is populated with 3,480 thousand (as of 2001) in 6,502 km^2. It has been proposed to create a total length of 90km of "wave protection" including wall of RCC inverse T-type retaining wall for the period of coming 20 years (2002 to 2021) at M/P of this Grant Aid Project. In the light of a great number of mound and public facilities required for protecting against erosion in the target area, the related 4 districts have urgent consolidation promoting equitable and exigent construction of the required facilities according to the planned quantity of consolidation.

Table 2-7 Surface area, population and required quantity of wave protection wall in 4 districts of Haor area (proposed at M/P)

4 districts in Haor area (number of Upazila within Haor part)	Area (km^2)	Population (1,000)	M/P planned Quantity (20years)		Name of Upazilas
			Retaining wall	Planted protection banks	
1. Habiganj District (7 Upazilas)	1,394	749	24.5 km	2,570 sites	Ajmiriganj, Bahbal, Baniachang, Habiganj, Lakhai, Madhabpur, Nabiganj
2. Kishoreganj District (8 Upazilas)	1,694	1,255	19.8 km	1,760 sites	Osutogram, Bajitpur, Itna, Karimganj, Kishoreganj, Mitamain, Nikli, Tarail
3. Netkorona District (4 Upazilas)	701	272	16.3 km	880 sites	Khaliajuri, Kalmakanda, Madan, Mohanganj
4. Sunamganj District (10 Upazilas)	2,713	1,201	27.3 km	1,330 sites	Bisanbaharpur, Chhatak, Derai, Dharmapasha, Doarabazar, Jagannathpur, Jamalganj, Sulla, Sunamganj, Tahirpur
Total (29 Upazilas)	6,502	3,477	87.9 km	6,540 sites	underlined name above：Priority Upazila

(b) Mobilization of the existing organizations system and O/M system of LGED

As shown in Policy-17 (page 2-15), the system of carrying out projects from planning stage to construction stage by each district has been already established. It is, therefore, evident that construction of "RCC inverse T-type retaining wall" in Haor area other than those in the model sites is deployed through district system, in other words a model site per each of the 4 districts is required. In this regard, the organizational system of LGED and outline of staffing in 4 districts are indicated in Fig. 2-6. In this Grant Aid Scheme, LGED is requested to actively participate in D/D and implementation supervision. In the course of this involvement, mobilizing technical capacity and present personnel held by LGED, sustenance of self-development will be secured through the duties/services offered by the district staff, namely Assistant Engineers (AE), Sub-assistant engineers (SAE) and Upazila Engineers (UEs) in collaboration with Japanese consultant and contractor.

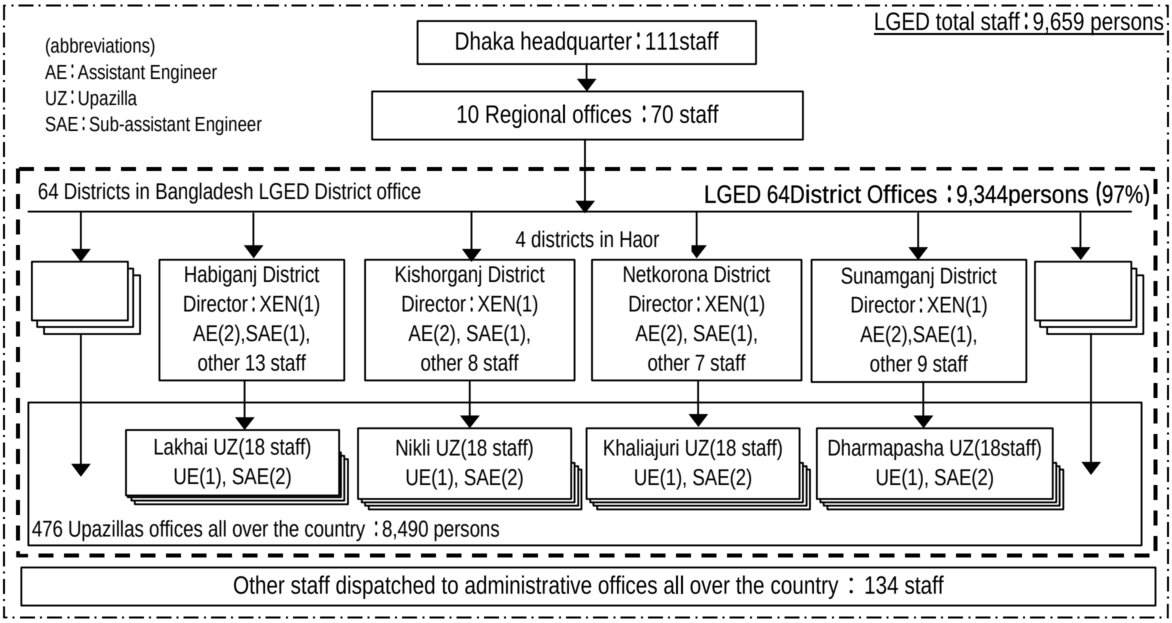


Fig. 2-6 Organization system of LGED and its personnel disposition

(c) Extensibility into Haor area

Along with “structural measures” brought about by this Grant Aid Project, “non-structural measures” are deployed for livelihood improvement at the model sites borne by the side of Bangladesh. Even if the model project (“measures with structures”) was implemented, it will not bring substantial improvement of the villagers’ livelihood unless the latter project is accompanied with the former project. When the mounds are protected by the structural measures, and in addition livelihood improvement is manifested by “non-structural measures”, the demonstrative effect of model “RCC inverse T-type retaining wall” will be enhanced, securing sustainable self-developing momentum towards two-dimensional expansion of the protection measures over the entire Haor area.

Since traffic network have not been developed inside the Haor area yet, traveling out of the district is rather difficult though movement within the district by boat transportation during the rainy season is relatively easy. In view of the reality that there are many people who have not stepped out of their native Upazilas, the demonstrative models created by the Project will increase villagers' chances and willingness of visiting and observing models since they are established within their districts. This is the reason why at least one model site per district is proposed for 4 districts, to secure displaying effect of both “structural measures” and “non-structural measures”.

(2) Policy-20: Sustainable and manageable wave protection and their appurtenant facilities

For the O/M of the constructed RCC retaining wall, an operation manual is provided with the contents shown in Table 2-8. Though traditional brick wave protection and CC blocks constructed by LGED have imposed heavy burden on beneficiaries to protect from washing/scouring loss of back-filled materials, RCC retaining wall can dispense their burden because it is made of reinforced concrete.

On the contrary, risky or detrimental actions to the security of constructed structures such as earth excavation and excessive earth filling, a management manual to ask for villagers' understanding thereon including necessary restrictive control such as restriction of either earth filling at the back side of wave protection or of excavation in front of the wave protection to secure footing depth will be provided.

Table 2-8 Contents of O/M manual

Item	Contents of O/M and reasons of their necessity
1. Restricted earth filling in the back side of wave protection	RCC wave protections for prevention wave to be constructed at Sazan village (Habiganj District) and Nazarpur village (Sunamganj District) are designed with a wave protection type of reducing ground reaction. Necessity therefore arises to restrict filling at the backside of wave protection. This prohibition condition of earth filling is summarized in the manual
2. Restricted excavation at both front and back side of wave protection (securing footing depth)	Wave protection to be constructed keeps required depth of footing. Most wave protection route are facing to paddy field and reservoirs in all of the 4 villages, with high potential of being excavated in the future for the purpose of expansion of paddy field and of use for fish-ponds. A manual is provided to limit such detrimental land use.
3. Foot protection	In three(3) villages except Gurai village (Khishorganj District), some routes run along the inclined ground topographically toward riverbeds or reservoirs. In such sections, foot protection works are installed with brick paving and mortar fixing for the purpose of protecting the wall body against scouring. A manual is provided for repair and O/M of these works.
4. Water level observations with staff gauge and management of records	A manual is provided to manage records of water level data and to maintain staff gauges required for facial expansion of protective techniques in Haor area.

(3) Policy-21: Contents of design manual and supervision manual

Providing 1)design manual and 2)supervision manual in collaboration with LGED through D/D and implementation supervision of the Project contributes to self-developing capacity of LGED.

(a) Complementary work for design manual of CARE flood proofing project

CARE has implemented pilot projects of flood proofing project and developed their achievements in the villages as many as 900, which are highly evaluated by LGED. The contents of these projects include a diversified range of structural measures such as multi-purpose flood shelter, wells, provision of latrines, improvement of local markets and rising ground level of mound by earth filling and those with non-structures. However as far as "RCC inverse T-type retaining wall" as requested in this Project is concerned, their performances have been quite limited.

Moreover, a standard manual (CARE design manual) for designing "wave protections for preventing wave erosion" was provided in the CARE project and LGED has utilized as a guideline of extending this wave protection in Haor area. However, the contents are confined to meteorological and hydrological analyze for determining design height for elevating ground level in mound by earth filling and design height of wave protections, such as water level data, drifting distance, wave height, wind velocity etc., while no information and analysis guideline is included for foundation of wave protection. Hence, this Project plans to supply information and analytical methodology obtained through B/D and D/D to LGED, complementing "CARE design manual".

(b) Supervision manual

Based on "construction supervision plan" and "check-sheet" provided by Japanese consultant in this Grant Aid Scheme, as well on "construction plan" arranged by Japanese constructor, supervision (construction management) in cooperation with regular staff in district offices of LGED will be contributed to promoting supervising capacity of LGED and eventually contributing to facial development of constructing "RCC inverse T-type retaining wall" in Haor area. Items to be collated for putting implementation supervision into a manual are listed up in Table 2-9.

Table 2-9 Items to be checked up for putting implementation supervision into a manual

Item	Major item to be identified
1. Schedule management	Identification of work schedule, period of critical path, acquisition of various certificates for the works, adjustment with the works borne by Bangladesh
2. System of implementation	Assignment of Japanese consultant, constructor and subcontractor, duty sharing of site-management organizations, assignment of spot management, identification of site management office, provision of emergency communication system
3. Implementation method	1) Earth work: survey plan, embankment slope, excavation method, excavation line, carriage machines 2) Foundation work: positions of piling, pile head treatment, crushed stone, sand and bricks 3) Concrete work: support work, forms, reinforcing rods, concrete casting
4. Temporary works	Material yard temporary roads, electricity/ water supply facilities, site office, capacity / volume of facility
5. Quality control	1) Materials: quality certificate, confirmation of control standard, material tests 2) Earth work: soil mechanic and compaction tests, earth work control standard 3) Foundation work: pile driving management, pile bearing resistance, identifying bearing resistance of spread foundation 4) Concrete work: identification of mixing proportion by test mixing, strength test, slump test, casting / expansion joint, placing of reinforcement, covering, curing
6. Control of finished work quality	Norm of finished work quality, confirmation of plan, photographs of works, collation of design values and finished work values
7. Procurement plan	Means of procuring equipment/material, transport plan, outline of subcontractor, adjustment with schedule
8. Safety management	Prior confirmation of work contents, safety tools, emergency contact network, hospital/reporting, staffing of guards, order-keeping, hygiene and cleaning, safety collation, boarding danger area, confirming strength of temporary materials / equipment
9. Environmental measures	Plan of villagers' complaints, measures for noise and vibration, drain water / waste material treatment, e borrow-pit and spoil-bank

Reference: standard construction supervision guideline, JICA

2-2-1-9 Construction/Procurement Methods and Construction Periods

(1) Construction method

Policy-22: Concrete work, major work of the Project, shall be concentrated during the dry season (December to May) in the light of specific conditions of Haor area.

Policy-23: Temporary roads shall be laid along the route of the planned wave protection and work roads shall be introduced inside the village as need arises.

Policy-24: Primary temporal stockyards for storing concrete aggregates shall be placed at ghat in the vicinity of the model sites.

Policy-25: Prevention measures from flown loss shall be taken for stocked concrete aggregates at lowland during inundation period.

Policy-26: Temporary scaffold shall be installed because the height of wave protection exceeds 2m.

Policy-27: Dewatering work shall be planned due to high possibility of water springing out from aquifers at the excavation of foundation ground.

Policy-28: Diesel generators shall be used for electricity source because power failure is frequent at the model sites. As to water supply for construction works, groundwater shall be utilized.

Policy-29: Regarding short workable period for construction, small-sized back hoes shall be used for earth work excavation in main (not temporary) works.

Policy-30: Concrete shall be manufactured through in-site mixing with concrete mixers.

Policy-31: As for foundation pile used at the section of 90m at the northern side of Lipsha, concrete pile (RC pile) shall be manufactured in place and be driven with backhoe loaders.

(a) Policy-22: Dry season work for concrete works

The construction sites where the model sitesare located in are completely flooded during the rainy season ranging May to November. Since concrete works consist of major work of this Requested Japan's Grant Aid Scheme, it shall be concentrated during the dry season (December to May) for limited 4 to 6 months in a year to secure quality of the work.

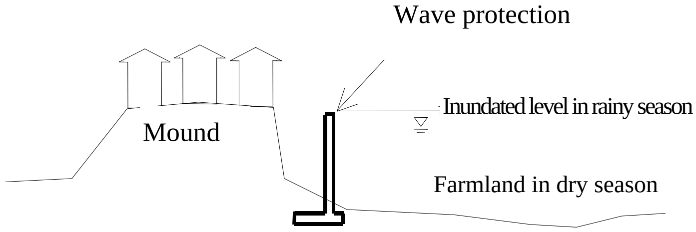


Fig. 2-7 Image figure of inundation

(b) Policy-23: Temporary roads

Existing roads (within the villages) are utilized for transporting materials and equipment from ghat), the points of access to each model site, to construction sites. In this regard, on the side of the route of wave protection, there currently stretches out upland crop field, paddy field or wasteland. Hence, it is necessary to construct temporary roads along the planned routes for the transportation of materials and equipment as shown in Table 2-10. The width of temporary roads is designed as 4.0 m paved with 20-cm-thick crushed brick. In this connection, used village roads will be repaired after the completion of construction works.

Table 2-10 Length of roads for construction works

Model site	Temporary road in village	Temporary road (along planned route)
Sazan	not needed	2,305 m
Gurai	3,000 m	1,525 m
Lipsha	2,500 m	725 m
Nazarpur	not needed	660 m
Total	5,500 m	5,215 m
Grand total	10,715 m	

(c) Policy-24: Primary temporal stockyards for concrete aggregates

Because concrete aggregates are going to be transported by cargo ferries, materials will be stocked temporarily at ghat adjacent to each model site. In this case, backhoe loaders (loading volume: 0.6 m^3) are to be distributed as loading machines to carry unloaded concrete aggregates smoothly to concrete manufacturing sites. These backhoe loaders will be also used in the excavation and the maintenance for temporary roads.

(d) Policy-25: Preventive measures from flown loss for stocked material as concrete aggregates

Aggregates (sand and crushed stone) transported in the rainy season in the 1st year at inundated lowland during the rainy season since sufficient space will not be available in the elevated mound. To prevent flowing loss of the materials, temporary fenced spaces will be procured around the stockyard.

(e) Policy-26: Temporary scaffold

As the designed height of wave protection is over 2 m, temporary foothold will be installed. In this case, steel frame is going to be used for it.

(f) Policy-27: De-watering

The target sites are inundated for 6 months in a year. Besides, there is higher possibility of water springing according to the excavation of the foundation ground, which is attributed to paddy field and streambed distributed around the sites. Therefore dewatering work（by shallow sump drainage）is planned. In this occasion, dewatering is planned from foundation excavation to concrete casting for the deck slab and 1st step of upright wall.

(g) Policy-28: Electricity and water for construction works

While commercial electricity supply is not available in Nazarpur, other model sites have commercial grid but preferentially supplied for irrigation pumps, and frequent power cut takes place during daytime. Use of commercial electricity for construction works accompanies with another inconvenience, that is; construction site is located along a very long route with gradual shift of working spot along the long line. With these reasons, a diesel generator with the capacity of 50 KVA will be installed as power source for the site management office, while another one used as that of construction works with the third one for stand-by purpose (procuring in total 3 generators/site). Then, water source for construction works will be taken from shallow wells because groundwater level stays high.

(h) Policy-29: Earth work

Although generally excavation works have been manually done in Bangladesh, backhoe loaders are used for main works, taking full account of short workable period. Excavated soil is temporarily deposited at side of temporary roads and again used for refilling. Sufficient compaction is applied with vibration rollers and rammers for refilling and foundation replacement works. Since villagers used to utilize soil for filling their own mound, surplus soil will be handed over to villagers after excavation.

(i) Policy-30: Concrete work

Since no concrete plant firm is available around any of the model sites, there remains no other choice than 1) installing concrete batcher plant or 2) in-place mixing by concrete mixer. As to 1) plant installation, utilization of a plant is confined to very limited large constructors in Bangladesh, requiring procurement thereof in the third countries and foreign skilled labor dispatched from overseas. Besides, it takes time for installing and it encounters difficulty in material supply (cement silo etc.), in no account economically feasible considering consumption quantities at each construction site. This is why it has to be manufactured by field mix with concrete mixer as commonly practiced in and around the Project site. In this case, engine-driven concrete mixers with the drum capacity of 5cft（0.14 m^3）and 10cft（0.28 m^3）have been commonly used. In this Project, that with the capacity of 10 cft will be used calculating from the required drum volume to mix up to produce 1 batch (the mixing proportion is assumed at 1:2:4 for cement: coarse aggregates: fine aggregates) to consume 1 bagful (50 kg) of cement, the most conventional measuring method from the aspect of secure quality control.

As concern the relation between concrete strength and mixing proportion, the comparison between LGED standard and that planned in this Project is shown in Table 2-11.

Table 2-11 LGED standard of concrete strength and mixing proportion and concrete mixing plan

	LGED standard		Concrete mixing plan		Planned mixing quantity/m^3		
	Designed strength	Mix. proportion	Designed strength	Mix. proportion	Cement	Coarse aggregate	Fine aggregate
RC concrete	210kg/cm^2	1：2：4	21 N/mm^2	1：2：4	373kg	0.237m^3	0.474m^3
Concrete sub-slab	105kg/cm^2	1：3：6	10.5 N/mm^2	1：3：6	261kg	0.249m^3	0.497m^3

Note) Mixing proportion (volumetric ratio) cement: fine aggregate: coarse aggregate, Water/ cement ratio: reinforced concrete 45%, concrete sub-slab 65%

(j) Policy-31: Foundation pile work

Piles must be driven for the foundation supporting 90m-section at northern side of Lipsha, concrete piles (RC pile) will be cast at the site and drive it with backhoe loader (loading volume:0.6 m^3). Depth of piling will be 8m and section of square RC pile is 20cm×20cm. Since this work requires field manufacturing of RC piles prior to piling, it should start from the 1st year in view of the required days in the work schedule. Considering capacity of piling assumed at 7.7 piles/day, the work schedule for driving RC piles is planned at 2.7 months; 450 piles÷7.7 piles/day÷22days/month = 2.7 months.

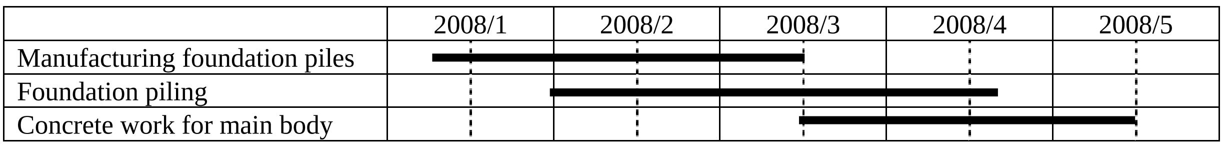


Fig. 2-8 Work schedule for foundation piling

(2) Procurement method

Policy-32: Aggregates and sand for concrete shall be directly procured from Sylhet located near Haor area or collection point of sand / stone materials in Sunamganj district.

Policy-33: Cement shall be procured from Dhaka.

Policy-34: Reinforcing rods shall be procured from Dhaka.

Policy-35: Brick and equipment for temporary works shall be procured from Dhaka.

Policy-36: Equipment shall not be procured from Japan and third countries.

(a) Policy-32: Aggregates, stone and sand

Stone (boulder) and sand for the material of concrete aggregates are conveyed from India during the rainy season and deposited around Indian border of Sylhet and Sunamganj district. These are collected and carried to collection points such as Jamiganj and Jaganatpur by small cargo ferries during the rainy season. Carried sand and stone are thus reloaded on larger ferryboats during the dry season and transported to Dhaka via Bhairab located at the southern edge of Haor area. According to information by local constructors in Haor area, they purchase materials from suppliers whose business is based in these collection points and transport by boats and once unload them on river land or levee. Then, they carry them from the unloaded points to the destination, inland sites by tractors or damp trucks. In this case, different transporters from supplier stake charge of reloading of these materials on ferryboats at collection points where they are manually reloaded and coat transport firms procure labor force for loading.

Taking these into consideration, aggregates and sand for concrete are procured directly from Sylhet located near Haor area or collection point of sand/stone materials in Sunamganj district. As procurement of aggregates is a matter of importance in the operation control, local constructors who are best acquainted with specificity of Haor area are planned to procure for the procurement control.

(b) Policy-33：Cement

Material of cement is ordinarily imported from India etc., and manufactured into cement in the Capital Dahka, Chittagong and Sylhet etc. Because Dacca has the largest number of cement plants, cement will be procured from Dhaka.

(c) Policy-34: Reinforcing rods

Since many large and small ironworks are situated in the Capital Dhaka and Chittagong, it is proposed to procure reinforcing rods from the former.

(d) Policy-35: Brick and equipment for temporary works

Brickyards are found everywhere in Haor area, but MOE of Bangladesh has imposed a legal standard on brickyards coping with environmental issues and many of them fail to meet the standard. Because brick made in such un-standardized yards cannot be used in the projects requested by the Government, brick is procured from Dhaka. Besides, equipment for temporary works such as scaffold and form metal also procured from Dhaka. Limited part of materials like separator to be used for form comes from Japan.

(e) Policy-36: Equipment shall not be procured from Japan and third countries

Equipment used for construction works can be fully equipped with that available in Bangladesh. Also as regards to the equipment used for temporary works, it is available in Bangladesh, but a limited part of temporary work equipment has to be probably imported from Japan. As to equipment/apparatus to be used for the quality control such as concrete compaction tester, we will carry in equipment for bearing resistance testing of piles etc.

from Japan, procuring on rental basis.

(3) Construction schedule

Policy-37: Appropriate construction schedule shall be determined taking account of 1)workable period for construction works (except submerged period), 2)quantity/speed of concrete manufacturing and 3)ability of transporting concrete materials at each model site.

In determining the construction schedule, balance among 3 factors including 1)workable period for construction works (except flood period), 2)quantity/speed of concrete manufacturing and 3)ability of transporting concrete materials is important. Relevant period is scheduled through the procedure as shown in Fig. 2-9.

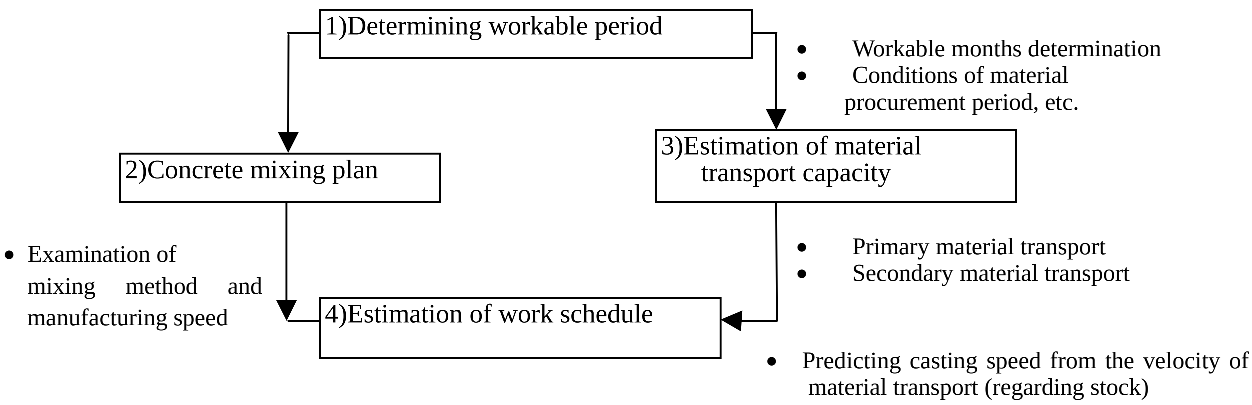


Fig. 2-9 Procedure for determining appropriate construction schedule

(a) Workable period for the construction works (except flood period)

Though water level in Haor area vary slightly according to ground elevation, commonly fluvial water level starts to rise from around April and inundated state takes place during May to June. Later, water level further rises to reach its maximum during the period of mid July to early August, then it recedes to reappearance of ground in October to November. Using data on stream water level at each model site obtained during site study, flood period for the past 27 years was estimated. This result is as a whole accorded with that of the questionnaire survey to the villagers, as indicated in Table 2-12.

On the other hand, in the temporary work plan for river construction works, the height of temporary diversion etc. are designed with "the 2nd highest water level for a decade" in Japan. Following this principle, the workable period for the construction works will be determined based on "the 2nd highest water level for a decade" also in this Grant Aid Scheme. In other words, the maximum water levels in every 10 days during the period 1st October to 31st May for the past decade are extracted, and inundated period during which the 2nd maximum water level exceeds the ground elevation for every ten days in a decade is calculated (also refer to Table 2-12). Considering drying of the ground during non-flood period, the substantial construction period comes to about 3.5 to 5.5 months /year. Further considering the works other than concrete casting including foundation excavation - reinforcing rods placing - preparation of form, back-filling and post-construction restoration etc., the workable period for concrete work at each model site is determined as shown in Table 2-12.

Table 2-12 Flood period estimated based on questionnaire towards villagers and records on water level and workable months for construction works

Model site	Flood period according to villager respondents	Flood period based on 27 years mean water level	Flood period based on 2nd highest water level for past decade	Substantially workable period	Workable period for concrete work
Sazan	Early Jun - end Nov	10th Jun - 20th Oct	1st Jun - 30th Nov	5.0 months	4.0 months
Gurai	Early Jun - end Nov.	10th Jun - 20th Oct	1st Jun - 30th Nov	5.0 months	4.0 months
Lipsha	End Jun - end Oct	11th Jun - 31st Oct	11th May - 20th Nov	5.0 months	4.2 months
Nazarpur	Mid May - end Nov	11th May - 30th Nov	11th Apr - 10th Dec	3.0 months	2.0 months

(b) Manufacturing quantity and manufacturing speed of concrete

As shown in Policy-31 (page 2-23), concrete will be supplied using means of field mix with concrete mixers (volume: 10 cft), commonly used at local sites, and the relevant work schedule will be determined for each model site.

(c) Transport capacity for concrete materials

Although inland transport by tracks is possible in two model sites, Sazan and Gurai, these two sites are subject to specific inland traffic issues of Bangladesh, namely insufficient road width along transport routes or passing place, lack of load bearing resistance of bridges, extreme congestion of rikshaws and pedestrians. On the contrary, both sites are located near the stream (within 3 km from the construction sites) navigable by large transport ships. From the viewpoint of work schedule and procurement control, it is advantageous to utilize large ships that can transport in bulk from the procurement points of materials to each construction site. Hence, the primary transport will be done by large shipments.

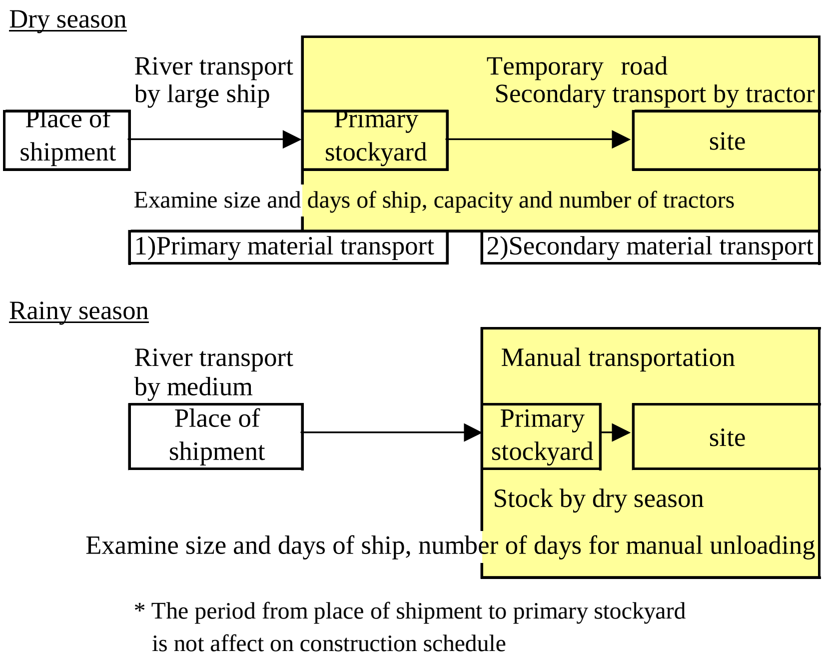


Fig. 2-10 Days for carriage from market site to primary stockyard do not affect work schedule

In this context, it is also possible to transport directly to the construction sites by boats, but transportation is done during the dry season in this Project. Moreover, since large damp truck cannot drive in sites, materials temporarily deposited in boat harbors (primary stockyard) are transported to (secondary transport) the work yard for concrete mixers with means of agricultural tractor (2 t) for stock (secondary stockyard).

2-2-2 Basic Plan

2-2-2-1 Overall Plan

(1) Scope of work, beneficiaries

The range of targets in this Grant Aid Scheme includes 4 model sites in 4 districts located in Haor area. The surface areas and targeted beneficiary population of mound, primary schools, market place to be protected by "wave protection for preventing wave erosion" are summarized in Table 2-13.

Table 2-13 Range of Project target and beneficial population

Name of target model sites	Protected facility	Targeted area	Targeted households	Beneficiary
1. Habiganj District, Lakhai Upazila, Lakhai Union, Sazan Village	Mound	27.0 ha	1,800	11,000 persons
2. Kishoreganj District, Nikli Upazila, Gurai Union, Gurai Village	Mound, primary school	40.0 ha	2,200	14,000 persons
3. Netrokona District, Khaliajuri Upazila, Chakwa Union, Lipsha Village	Mound, primary school and markets	13.0 ha	1,050	8,000 persons
4. Sunamganj District Dharmapasha Upazila Joysree Union Nazarpur Village	Mound	1.3 ha	200	2,000 persons
Total	—	81.3 ha	5,250	35,000 persons

(2) Outline of facility plan

(a) Length of wave protection

The total length of "wave protection for preventing wave erosion" at the initial request had been 6,400m. As the result of route survey based on the request of inhabitants at the stage of B/D study, the total length of the protection wall at 4 model sites was measured at 6,600m. Meanwhile, the relevance of the route was examined in the light of "2-2-1-4 (1) Policy of selecting route of wave protection (page 2-8)" at the B/D analysis. As the result of this analysis, the total length in the Project element will be 5,215m, as shown in Table 2-14.

Policy of selecting routes of wave protection (page2-6)

Policy-5: Basically based on villagers' desires
Policy-6: To protect existing mound and existing public facilities such as primary schools and markets
Policy-7: To give implementing priority to the sites subject to damages by higher wave and severer erosion
Policy-8: To effectively utilize existing wave protection
Policy-9: To sustain existing community functions
Policy 10:To consider current topography and land use

Table 2-14 Length of "wave protection for preventing wave erosion" at initial request and actual measurement

Model site	Length at the initial request	Measured length (at BD site study)	Examined result of BD analysis	Reason of the change in length of wave protection route by the policy of selection (page 2-9)
1. Sazan	2,600 m	2,670 m	2,305 m	Policy-6, policy-9 and policy-10
2. Gurai	1,700 m	1,770 m	1,525 m	Policy-6, policy-8 and policy-9
3. Lipsha	1,000 m	1,060 m	725 m	Policy-6, policy-7 and policy-10
4. Nazarpur	1,100 m	1,100 m	660 m	Policy-6, policy-9 and policy-10
Total	6,400 m	6,600 m	5,215 m	—

(b) Height of wave protection and volume of concrete

Average height of the wave protection and planned volume of concrete to be cast at each model site are shown in Table 2-15.

Table 2-15 Average height of the wave protection and planned volume of concrete to be cast

Model site	Length (m)	Average length of wave protection (m)	Volume of concrete (m^3)	
			volume/m	Total volume
1. Sazan	2,305	5.3	4.77	10,995
2. Gurai	1,525	3.5	2.20	3,355
3. Lipsha	725	4.8	3.60	2,610
4. Nazarpur	660	5.3	4.77	3,148
Model site Total	5,215	−	−	20,108

2-2-2-2 Plan of Facilities

2-2-2-2-1 Height of RCC Retaining Wall

In compliance with Policy-12 (page 2-12), the height of RCC Inverse T-type retaining wall is determined as follows;

(1) Composition of the height of wave protection

As shown in Fig. 2-11, the wall height of "RCC inverse T-type retaining wall" consists of 1)Parapet, 2)earth retaining part and 3)footing. Though each part plays below-mentioned function, these parts are integrated as a concrete structure, where heights are determined based on each part.

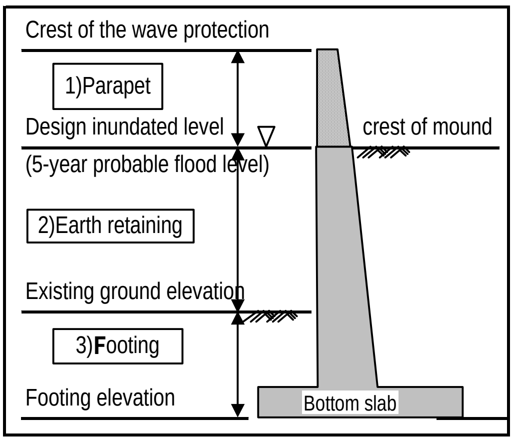


Fig. 2-11 Composition of RCC inverse T-type retaining wall

(a) Parapet: This part has a purpose of protecting public facilities from the threatening of flood wave arising during the monsoon period ranging July to August. Its height is determined based on wave height during this period.

(b) Earth retaining part: This part has an objective of preventing collapse of filled earth in the mound from washing loss due to water submersion and flood wave. Calculating design inundated level from water level at 5-year probable flood in Haor area, the height between this water level and the current ground elevation will be determined as height of earth retaining.

(c) Footing: This part consists of two parts: the bottom slab that sustains upper structure and disperse load of the structure and rising part beneath the ground level. According to Japanese "technical manual for stream sediment control", the minimum footing depth (0.5 to 1.5m) is determined taking account of depression of riverbed or volume of excavation in the case of "spread foundation in riverbed, but 1.0m is taken as its standard". In this B/D, footing depth has to be deeper than 1.0 m, considering the location and state of scouring of the existing structures.

(2) Determinants of the standard height of wave protection

(a) Water level data

There are about 10 gauging stations under Bangladesh Water Development Board (BWDB) in Haor area, and water level records were collected in this B/D study from Khaliajuri, Itna, Manda, Mohanganj and Ostogram, which are located relatively close to the target model sites. Although there are many missing periods of observation, design flood level is determined based on the records at Khaliajuri station that is located around the center of Haor area with relatively fewer measurement blanks. As indicated in Table 2-16 and Fig.2-12, high water levels have been recorded in 1988, 1999 and 2004 in recent 20 years according to the record of this station, showing the highest water level in the past 50 years, 9.55 m (elevation) in 2004.

Table 2-16 Highest submersion levels by year in the record at Khaliajuri observatory station (1945-2005)

Year	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
month	8	7	8	blank	blank	blank	7	7	9	8	8	6	8
F.level	**9.00**	**7.75**	**8.21**	**-**	**-**	**-**	**8.59**	**8.32**	**7.96**	**8.56**	**8.67**	**8.53**	**7.17**
Order	2/47	28/47	15/47	-	-	-	6/47	11/47	23/47	7/47	5/47	9/47	42/47
Year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
month	blank	7	9	blank	8	blank	8	blank	blank	blank	blank	8	8
F.level	**-**	**7.57**	**7.97**	**-**	**7.77**	**-**	**6.77**	**-**	**-**	**-**	**-**	**7.85**	**8.25**
Order	-	32/47	22/47	-	27/47	-	47/47	-	-	-	-	26/47	14/47
Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
month	blank	8	7	8	blank	blank	8	7	7	8	8	8	9
F.level	**-**	**7.39**	**7.73**	**8.99**	**-**	-	**7.53**	**7.19**	**7.73**	**7.35**	**7.57**	**7.65**	**8.05**
Order	**-**	38/47	29/47	3/47	-	-	34/47	41/47	29/47	39/47	32/47	31/47	20/47
Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
month	7	7	10	8	7	8	8	6	7	7	8	blank	7
F.level	**8.13**	**7.52**	**6.92**	**8.03**	**8.74**	**7.94**	**7.13**	**7.94**	**7.05**	**8.15**	**6.94**	**-**	**8.34**
Order	19/47	35/47	46/47	21/47	4/47	24/47	43/47	24/47	44/47	18/47	45/47	-	10/47
Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	Remarks): Sampling number: 47/61(14blanks), bold frames present 5-year probable level, maximum level occurred in 2004			
month	7	9	7	8	8	7	7	7	7				
F.level	**7.51**	**8.18**	**8.54**	**7.52**	**7.26**	**8.17**	**8.32**	**9.55**	**8.26**				
Order	37/47	16/47	8/47	35/47	40/47	17/47	11/47	1/47	13/47				

Fluvial water level at Khaliajuri

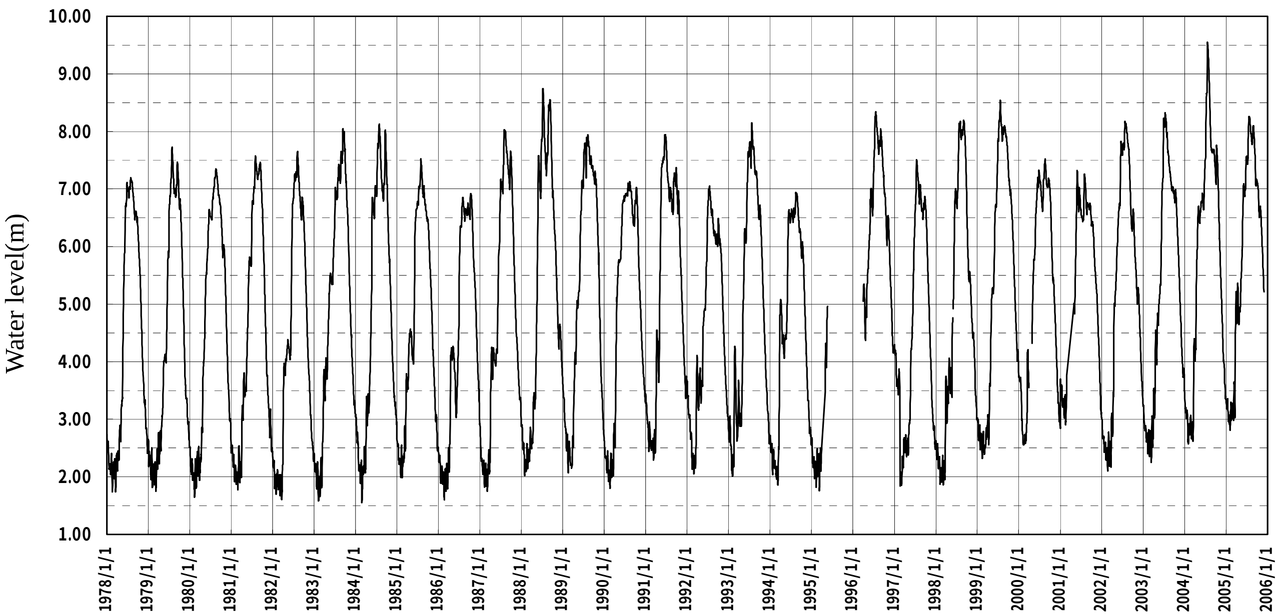


Fig. 2-12 Water level fluctuations at Khaliajuri station（1978-2005）

(b) Design flood water level

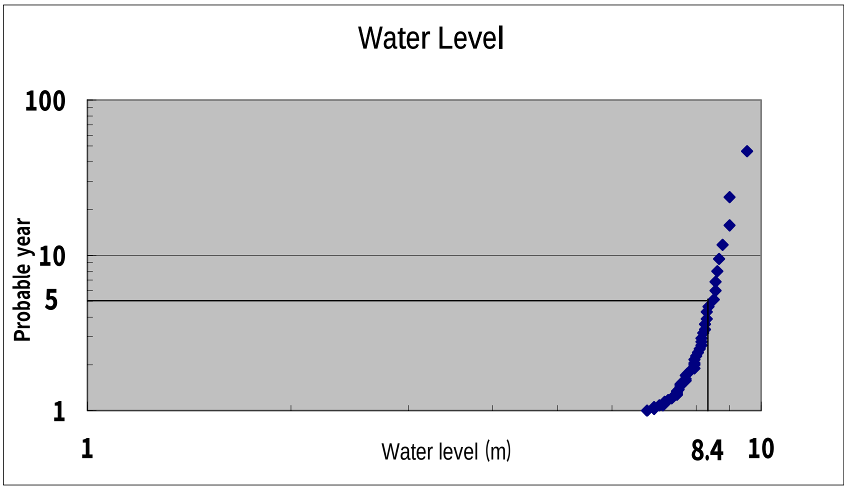


Fig. 2-13 Calculation of flood water level with 5-year probability

With regard to data of water level observation at Khaliajuri gauging station, data observed from 1945 to 1994 have been contained in CARE design manual (provided in 2000). In this manual, 5-yearprobable flood level has been adopted for design flood level and that for each CARE project site is determined from the result of site inquiry on the flood level in 1998, taken place around the project period assuming that this flood was approximately equivalent to the one with 5-year probability. In this Project, CARE design manual record is updated by adding the newest data of water level up to 2005, thereby 5-year probable flood level was calculated. As the result of this calculation, as illustrated in Fig. 2-13, 5-year probability flood level is 8.4m, and this level was equivalent to the one recorded in 1996 or 1956. Whereas, water level data recorded in 2004 gives the highest water level during the past 50 years, and this flood is still kept in mind of the villagers of the model sites of this Project as a vivid memory. As well as CARE design manual (Policy-12), 5-year probable flood level which obtained from the maximum flood level in 2004 through the inquiry to villagers is adopted as the design flood level. In other words, the design flood level at each model site is calculated by subtracting the difference in water level 1.15 m, or difference between 9.55m: highest water level in 2004 and 8.4m: flood level with 5-year probability from the maximum water level in 2004 at each model site.

(c) Wave height: H(m)

Flood wave in Haor area is caused by southerly or southeasterly monsoon wind blowing during July to August with the highest water flooding, escalating erosion in mound. Referring to CARE design manual, wave height is calculated based on the drifting distance measured on records of wind velocity in July to August at Mymensingh meteorological observatory station and the map of inundated area. As shown in Table 2-17, the mean wind velocity in July to August (monthly maximum for 32 years of the mean diurnal velocity) is calculated at 15.3 km/hr.

Design wind velocity: V(km/hr) ＝ (3.9 + 4.6 m/s)÷2 ＝ 4.25 m/s × 3,600 sec/1,000m ＝15.3km/hr

Table 2-17 Monthly maximum wind velocity as daily mean by month and daily mean in 1970-2002
(Mymensingh meteorological observatory station)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1)Daily mean wind velocity 32 years (m/s)	0.6	0.9	1.3	2.0	2.0	2.0	1.9	1.6	1.3	0.8	0.5	0.5
2)Monthly maximum of daily mean 32 years	1.8	2.3	3.3	4.4	4.6	4.1	3.9	4.6	3.8	2.9	1.9	1.5
3)Monthly maximum wind velocity (m/s)32years	5.0	4.7	5.7	9.9	10.6	7.5	11.0	27.6	12.9	7.9	7.3	3.1

Fetch length at each model site F (km) have been calibrated at 20 km for Sazan, 10 km for Gurai, 60 km for Lipsha and 60 km for Nazarpur, respectively, from the from the southern or southeastern edge of Haor area. Likewise, along with the above wind velocity, wave heights are calculated from the formula adopted in CARE design manual as follows;

1) in the case of F < 32 km: $H(m) = 0.032 \sqrt{VxF} + 0.763 – 0.271^4 \sqrt{F}$ (for Sazan and Gurai)
2) in the case of F > 32 km: $H(m) = 0.032 \sqrt{VxF}$ (for Lipsha and Nazarpur)

(d) Design Freeboard: Fb(m)

According to CARE design manual, free board at the side of mound coping with wave height (Fb) is calculated using the following equation based on the wave height (H).

Fb (m) = Wave height (H) × 0.67

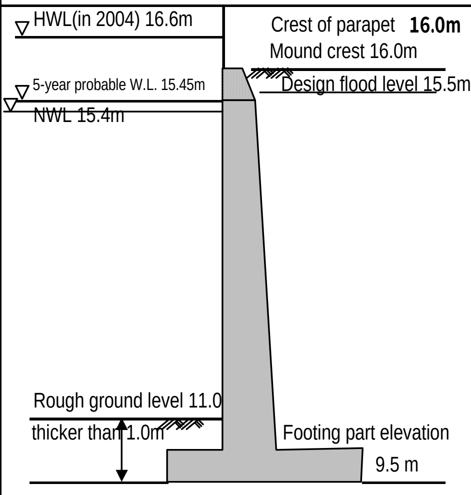
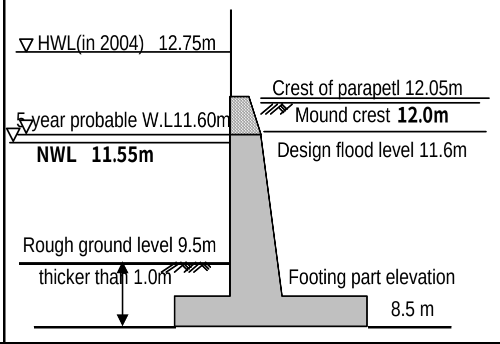
(3) Standard height of wave protection at each model site

Elements determining the above-cited height of wave protection and the heights and standard section of wave protection at each model site obtained by the calculation with these elements are given in Table 2-18 and Fig. 2-14.

Table 2-18 Dimensions of standard height of wave protection at each model site

Model site		Sazan	Gurai	Lipsha	Nazarpur
Elevation of mound (m) *1)		Mound : EL.16.0 m	Mound:EL.12.0 m Highest point: EL.12.5 m	Current market ground EL.20.25 m	Mound : EL.23.2 m
Waterlevel*2) and wave information (m)	2004	EL.16.6 m	EL.12.75 m	EL21.6 m	EL.24.4 m
	Ordinary year	EL.15.4 m	EL.11.55 m	EL19.5 m	EL.22.45 m
	Max.wave height	0.6～0.9 m	0.6～0.9m	2 m	2 m
	Ord.wave height	0.3 m	0.3～0.4 m	1.25 m	0.9～1.2 m
Information at gauging station	Location (observation period)	Ostogram (1984～1994)	Ostogram （1984～1994）	Khaliajuri (1945～2000)	Mohanganj (1995～2005)
	Existing max. water level (a)	Khaliajuri observatory station:9.55 m (2004) was adopted			
	5-year probable water level (b)	Probability analysis of Khaliajuri observatory station: 8.40 m was adopted			
	Difference in water level (c)：(a–b)	1.15 m			
5-year probability water level (EL)		16.6–1.15=15.45m	12.75–1.15=11.60m	21.6–1.15=20.45m	24.4–1.15=23.25m
Design flood level (d)		15.5 m	11.6 m	20.5 m	23.3 m
Wind velocity	Wind direction (inquired)	South -Southeast	South - Southeast	South	Southeast
	Fetch length F (km)	20 km	10 km	60 km	60 km
	Wind velocity: V (km/hr)	Average of July and August on monthly maximum of diurnal mean wind velocity for 32 years: 4.25 m/s = 15.3 km/hr			
Wave height (e)		0.75 m	0.68 m	0.97 m	0.97 m
Design free board (Fb): (f)		0.50 m	0.45 m	0.65 m	0.65 m
Crest height of parapet (g): (d＋f)		15.5＋0.50=16.0m	11.6＋0.45=12.05m	20.5＋0.65=21.15m	23.3＋0.65=23.95m
Current ground elevation (h)		11 m	9.5 m	17.5 m	19.5 m
Earth retaining height (i): (d–h)		15.5–11.0=4.5m	11.6–9.5=2.1m	20.5–17.5=3.0m	23.3–19.5=3.8m
Footing depth (j)：(f＋I＋j)		1.0 m (or thicker)	1.0 m (or thicker)	1.0 m (or thicker)	1.0 m (or thicker)
Height of standard wave protection		6.00 m	3.55 m	4.65 m	5.45 m

Note: *1) Elevation of mound*= Derived from land survey, *2) Information on water level and wave = by reply in the inquiry

Model site	Sazan Village	Gurai Village
Illustrated section		
Design free board (parapet height)	0.50 m	0.45 m
Protection wall height	6.0 m	3.1 m

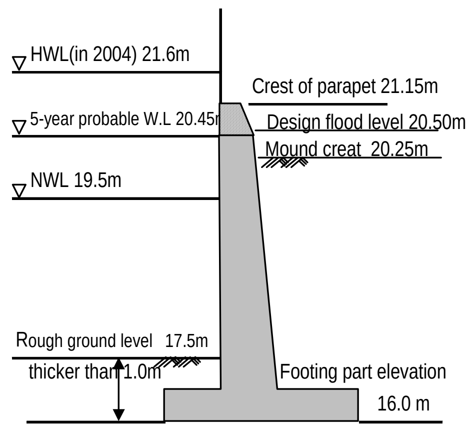
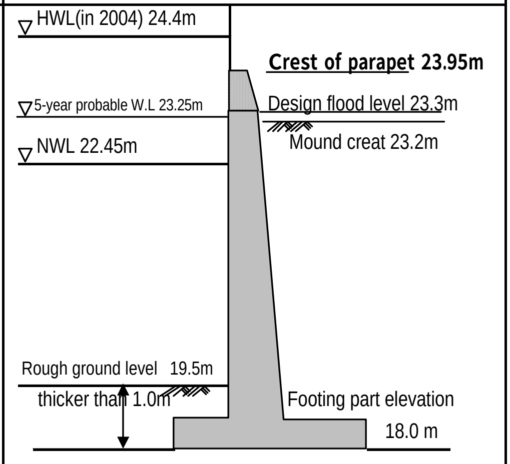
Model site	Lipsha Village	Nazarpur Village
Illustrated section		
Design free board (parapet height)	0.65 m	0.65 m
Protection wall height	4.5 m	5.3 m

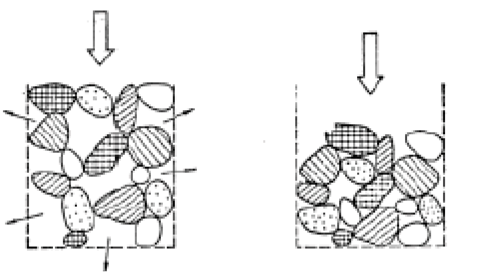
Fig. 2-14 Standard composition of height of wave protection wall at each model site

2-2-2-2-2 Foundation of RCC Retaining Wall

In compliance with "Policy-13 (page 2-12)", the foundation structure of protection bank with RCC inverse T-type retaining wall is determined as follows;

(1) Measures coping with subsidence

Soil has a character of large compression amount and soil's deformation by load is subject to time sequential element complicatedly. Consolidation settlement is mainly caused by the evacuation of air and water that compose soil phase. Since the rate of pores in soil is larger in weak ground, load compacts soil



(a) Evacuation of water and gas phase of soil matrix (b) Deformation of soil aggregate structure making its pores smaller and subsidence amount is larger. By this reason, structures constructed on weak ground cause subsidence by their weight.

If the subsidence occurs homogenously, all the part of structures also horizontally subside, bringing only a negligible influence to the structures. However, in the case of differential settlement, inhomogeneous force would exert on the structures due to positional difference of subsidence and causes crack on these structures. And if the extent of differential settlement becomes greater, it gives the possibility of destructive collapse of the structures. Similarly, there are possibilities of overturning and sliding of the constructed structures caused by subsidence, threatening sustainable structural stability or rigidity thereof.

According to Japanese “Design manual of building foundation structures”, allowable subsidence to maintain functional soundness of the structures have been fixed as in Table 2-19, where up to the extent of subsidence equivalent to 10 to 20cm is considered allowable in the case of continuous foundation to be applied to retaining wall etc. In the light of this standard, the subsidence depth is confined to 20cm (the maximum allowable subsidence), or the foundation of the retaining wall is replaced with sand in this Project for minimizing subsidence depth at the section where the subsidence has to be smaller, or at the location where differential settlement is liable to take place.

In this regard, consolidation subsidence occurs during considerably long period after villagers do backfilling the rear side of the wave protection, free board for settlement is not considered in this plan. This is because that height of retaining wall is designed considering freeboard for wave height, and that additional rising of the retaining wall by concrete can cope with subsidence in the future when necessary.

Table 2-19 Allowable maximum subsidence amount

Structure		Concrete block	Reinforced concrete		
Type of foundation		Continuous (sheet) foundation	Independent foundation	Continuous (sheet) foundation	Mat foundation
Consolidation Settlement	Standard. value	2	5	10	10-(15)
	Maximum value	4	10	20	20-(30)
Consolidation Settlement	Standard. value	1.5	2.0	2.5	3.0-(4.0)
	Maximum value	2.0	3.0	4.0	6.0-(8.0)

(2) Summary of boring survey and soil mechanic tests

Ground at the model sites is judged as weak from the results of boring survey and soil mechanic tests. Even though it was weak ground, it is desirable to apply spread foundation from the standpoint of sustainability of LGED. Therefore, a rough examination has been made on allowable bearing resistance and plausible depth of subsidence. The result of the examination is summarized in Table 2-20 “Outline of the result of boring / soil mechanic tests and estimation of subsidence depth”.

Allowable bearing resistance of the existing ground is around 5 t/m^2, and that at the depth of 1m from the existing ground is about $6t/m^2$, which is assumed as the foundation level of the retaining wall. Suppose a retaining wall with a height of 4m from the existing ground, reaction of the bottom slab comes to around $7t/m^2$, which exceed allowed. On the other hand, in the case that a load of $10t/m^2$ is placed against the ground, corresponding depth of subsidence is estimated at 38 cm in Sazan and 20 cm at other model sites. When 5 t/m^2 is loaded on the ground, the corresponding subsidence is 21 cm in Sazan, but around 10 cm in other sites.

To conclude, the reaction of the bottom is designed at 5 t/m^2 or so.

Table 2-20 Summary of the result of boring / soil mechanic tests and estimation of subsidence depth

Model site	Nazarpur			Lipsha (southern side)			Lipsha (northern side)		
N value > 5	5 m			6 m			6 m		
N value > 10	8 m			9 m			9 m		
N value > 15	8 m			10 m			10 m		
N value > 20	9 m			11 m			11 m		
Allowable B.R. 1)	4.7 t/ m^2			5.8 t/ m^2			1.3 t/ m^2		
Allowable B.R. 2)	5.5 t/ m^2			7.3 t/ m^2			2.4 t/ m^2		
Allowable B.R. 3)	6.5 t/ m^2			8.3 t/ m^2			4.2 t/ m^2		
Soil profile	Thickness	Soil	Mean N-value	Thickness	Soil	Mean N-value	Thickness	Soil	Mean N-value
	3.5m	CH	2.3	2.5m	CH	3.4	3.5m	SM	3.3
	2.0m	CL	4.5	2.0m	SM	6.0	5.0m	SM	4.8
	3.0m	SM	10.3	3.3m	CL	5.0	2.0m	S-M	5.0
	11.8m	SM	50	9.6m	SM	33.0	9.8m	S-M	33.0
	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—
Instant subsidence	5cm / 3cm			3cm / 2cm			20cm / 10cm		
Consolidation settlement	15cm / 10cm			10cm / 7cm			0cm / 0cm		
Total subsidence depth	20cm / 10cm			13cm / 9cm			20cm / 10cm		

Note: B.R.; bearing resistance

Model site	Gurai			Sazan (southern side)			Sazan (northern side)		
N value > 5	3 m			12 m			9 m		
N value > 10	7 m			12 m			14 m		
N value > 15	8 m			16 m			17 m		
N value > 20	8 m			20 m			Over 20 m		
Allowable B.R. 1)	3.2 t/m^2			5.2 t/m^2			4.1 t/m^2		
Allowable B.R. 2)	4.1 t/m^2			6.4 t/m^2			5.0 t/m^2		
Allowable B.R. 3)	5.1 t/m^2			8.2 t/m^2			6.0 t/m^2		
Soil profile	Thickness	Soil	Mean N-value	Thickness	Soil	Mean N-value	Thickness	Soil	Mean N-value
	2.8 m	CL	1.5	2.5 m	CH	2.5	2.5 m	CH	2.5
	0.7 m	CL	5.0	1.0 m	SM	7.0	1.0 m	SM	7.0
	3.0 m	SM	5.0	4.0 m	CL	2.3	4.0 m	CL	2.3
	8.0 m	SM	23.6	2.0 m	CL	8.5	2.0 m	CL	8.5
	5.8 m	SM	45.7	2.0 m	CL	3.5	2.0 m	CL	3.5
	—	—	—	6.0 m	CL	13.3	6.0 m	CL	13.3
	—	—	—	2.8 m	SM	23.3	2.8 m	SM	23.3
Instant subsidence	7cm / 4cm			0cm / 0cm			0cm / 0cm		
Consolidation settlement	12cm / 5cm			38cm / 21cm			41cm / 22cm		
Total subsidence depth	19cm / 9cm			38cm / 21cm			41cm / 22cm		

- Soil mechanical property CH: clay, CL: clayey, SM: silty sand, S-M: silt-mixed sand
- Consolidation settlement is regarded for clayey soils: CH and CL, while instant subsidence is regarded for sandy soils: SM and S-M
- Depth of compaction indicates under the load of (10 t/m^2 / 5 t/m^2).
- Allowable bearing resistance 1)indicates bearing resistance on existing ground surface, allowable bearing resistance 2)is applied to 1m below from footing at inundated condition and allowable bearing resistance 3)indicates that of 1m below from footing at ordinary condition.

(3) Items to be examined in calculation of stability

Conditions of stability calculation greatly differ between that for the dry season and rainy season for determining scale and foundation work of wave protection. During the inundated period, buoyant force, and wave force (compression, tension and uplift pressure) exert in addition to ordinary load acting to wave protection. In calculating stability, therefore, the condition that buoyant and wave force exerting on the wave protection in the rainy season are examined in addition to under ordinary condition in the dry season (Table 2-21).

As to wave force, in addition to the case of assuming design water level and design wave height, the case assuming the recorded maximum water level and the maximum wave height exerting the wave protection is identified (anyway to confirm whether the designed structure can remain stable under the ever-recorded maximum and extreme state).

Table 2-21 Conditions of examining calculation of structure stability

Examined case / Examined condition	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Backside filling (mound elevation)	○	○	○	○				
Ditto (within the height of allowable bearing resistance)					○	○	○	○
Design inundated level		○	○		○	○		
Maximum inundated level				○			○	○
Design wave height (compacting-direction)					○			
Design wave height (stressing-direction)			○			○		
Maximum wave height (compacting-direction)							○	
Maximum wave height (stressing-direction)				○				○
Safety condition for overturning	e＜B/6		e≦B/2		e＜B/6		e≦B/2	
Safety condition for sliding	1.5		1.0		1.5		1.0	
Range of allowable B.R. of ground (dry season)	○							
Range of allowable B.R. of ground (rainy season)		○	○	○	○	○	○	○

○ indicates examination condition to be regarded in stability calculation

"e" stands for eccentric distance from the center of bottom slab; "B", the width of bottom slab

The wave force exerting towards wave protection is calculated using "formula of wave pressure of superposed wave and breaking wave (Gouda's formula)" as stated below, based on Japanese "technical manual for stream sediment control" Design edition, design of coastal conservation facilities.

(a) Wave pressure in the case that the wave crest is positioned at the upright wall of the wave protection

$$\eta^{※} = 1.5H_D$$

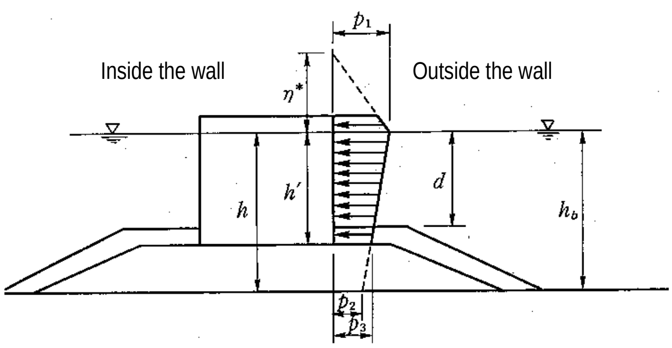
$$p_1 = (\alpha_1 + \alpha_2) \times w_0 \times H_D$$

$$p_2 = \frac{p_1}{\cosh(2\pi h / L)}$$

$$p_3 = \alpha_3 \times p_1$$

$$\alpha_1 = 0.6 + \frac{1}{2}\left[\frac{4\pi h / L}{\sinh(4\pi h / L)}\right]^2$$

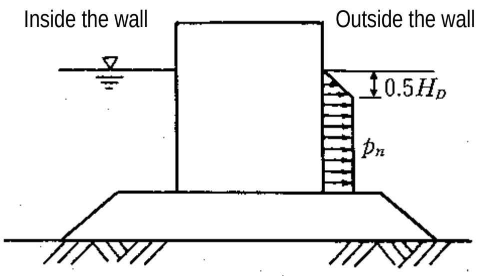
$$\alpha_2 = \min\left\{\frac{h_b - d}{3h_b}\left[\frac{H_D}{d}\right]^2, \frac{2d}{H_D}\right\}$$



$$\alpha_3 = 1 - \frac{h'}{h}\left[1 - \frac{1}{\cosh(2\pi h / L)}\right]$$

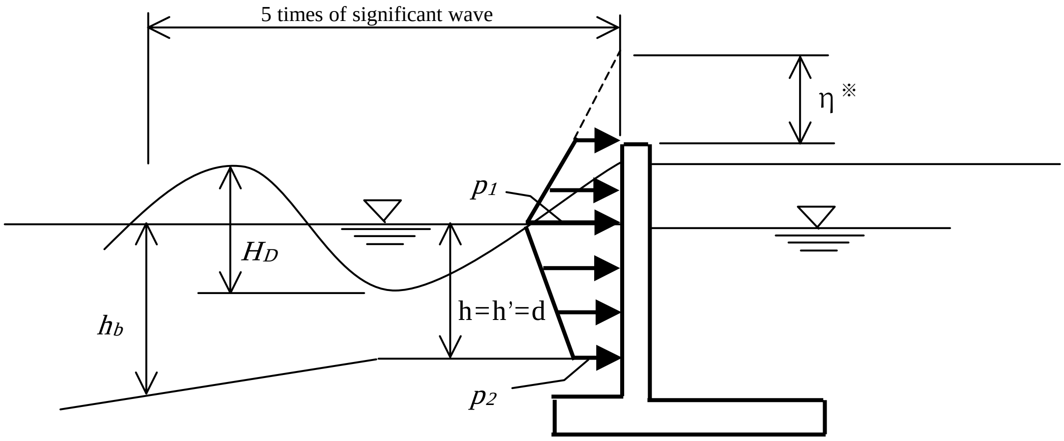
(b) Wave pressure in the case of the wave valley is positioned at the upright wall of the wave protection

$$p_n = 0.5 \times w_0 \times H_D$$

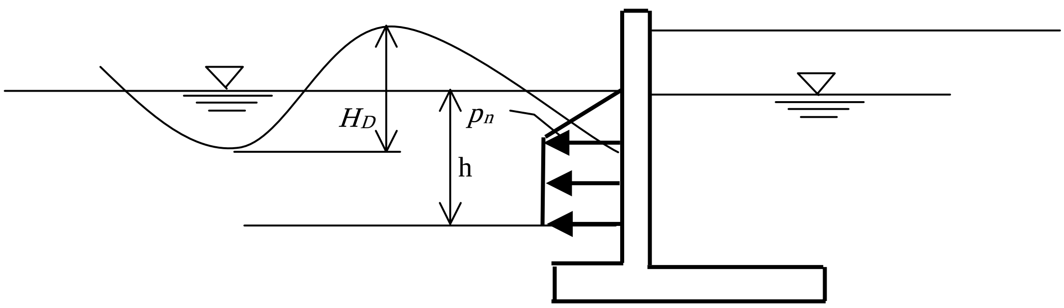


η＊ : Height (m) where wave pressure intensity at static water level becomes 0.
p_1 : Wave pressure intensity at static water level (kN/m2)
p_2 : Wave pressure intensity at water bottom (kN/m2)
p_3 : Wave pressure intensity at the bottom of upright wall (kN/m2)
p_n : Wave pressure intensity at the homogenous part (kN/m2)
h : Water depth (m) at the front of upright wall
h_b : Water depth (m) at the point 5 times as distant as the significant height of wave towards off-shore from upright wall
h' : Water depth (m) at the bottom of upright wall
d : Shallower water depth (m) either at footing work or the crest of the mound cover
w_0 : Unit volumetric weight of water (kN/m3)
HD : Wave height (m) to be adopted in the calculation for design
L : Wave length (m) to be adopted in the calculation for design at the water depth h
Min(a, b): Smaller value (either a or b)

Since the wave protection for preventing wave erosion (inverse T-type) will not be installed on the mound but constructed with foot excavation as deep as 1m from the existing ground level, uplift pressure induced by wave will not be included in the calculation. Hence, the action of wave pressure is considered as shown in the figure below;



(wave crest: pushing force)



(wave valley：stress or pulling)

Fig. 2-15 Design wave pressure to retaining wall

(4) Result of examination for foundation

As the result of the mentioned examination, methods of foundation works are shown as in Table 2-22.

Table 2-22 Standard foundation work at each model site

Model site		Type of standard foundation work
1.	Sazan	Spread foundation: backside filling restricted type
2.	Gurai	Sand replaced spread foundation
3.	Lipsha（southern side）	Sand replaced spread foundation
	Lipsha（northern side）	Pile foundation
4.	Nazarpur	Sand replaced spread foundation: stabilizing fill type

2-2-2-2-3 Route of RCC Retaining Wall

The length of retaining wall at each model site is summarized as shown in Table 2-23. In view of "2-2-1-4 RCC Retaining Wall (1) Policy of selecting route of wave protection (page 2-8) Policy-5 to Policy-10 and as the result of examining height of the wave protection and foundation of wave protection.

Table 2-23 Length of the retaining wall at each model site

Model site		Requested length (m)	Length after examined (m)	Reduction (m)
Sazan: sand replaced spread foundation		2,670	2,305	365
Gurai: spread foundation		1,770	1,525	245
Lipsha	: Sand replaced spread foundation	960	635	325
	: Pile foundation	100	90	10
Nazarpur: sand replaced spread foundation		1,100	660	440
Total		6,600	5,215	1,385

Moreover, Length of the height of each wave protection is shown in Table 2-24.

Table 2-24 Total length of the bank of "RCC inverse T-type retaining wall" by wave protection height

Height of retaining wall (m)		Length of retaining wall (m)				
Height from current ground level (m)	Height from bottom slab (m)	Sazan	Gurai	Lipsha	Nazaarpur	Total length
2.25	3.25	0	590	55	0	645
2.50	3.50	0	585	0	0	585
2.75	3.75	50	205	0	0	255
3.00	4.00	0	70	0	0	70
3.25	4.25	0	75	225	0	300
3.50	4.50	255	0	0	0	255
3.75	4.75	105	0	50	90	245
4.00	5.00	275	0	155	180	610
4.25	5.25	470	0	50	75	565
4.50	5.50	485	0	0	175	660
4.75	5.75	510	0	150	55	715
5.00	6.00	75	0	40	85	200
5.25	6.25	80	0	0	0	80
Total		2,305	1,525	725	660	5,215
Average height (m)	Height from ground level	4.3	2.5	3.8	4.3	3.7
	Height from bottom slab	5.3	3.5	4.8	5.3	4.7

2-2-2-2-4 Appurtenant works

(1) Terrace-step work and openings

The wave protection is going to have a 2-5m height from the current ground elevation. To maintain the existing village functions as indicated in “2-1-4 Design policy of RCC wave protection (1) Policy of selecting route of wave protection (Policy-8: page 2-9)”, stair work for villagers coming from their mound to traverse the wall during the dry season, and openings for utilizing boat transport during the rainy season are planned.

(a) Basic factors to be considered selection of location

To select locations of appurtenant facilities, the following shall be considered.

1) Terrace shall be basically installed in Gurai and Lipsha, where backside filling in the rear of wave protection is allowed up to the crest of mounds after construction.
2) Openings shall be constructed in Sazan and Nazarpur, where backside filling in the rear of wave protection is restricted.
3) Openings shall be installed at the existing entrance to the residential area.
4) Access to public facilities such as primary schools, market places and mosques shall be maintained.
5) Terraces or openings shall be installed where existing mounds are located consequently and no stair or opening is planned.
6) Secondary wall shall be installed for attenuating wave at openings where a mound approaches.

(b) Number of installation sites

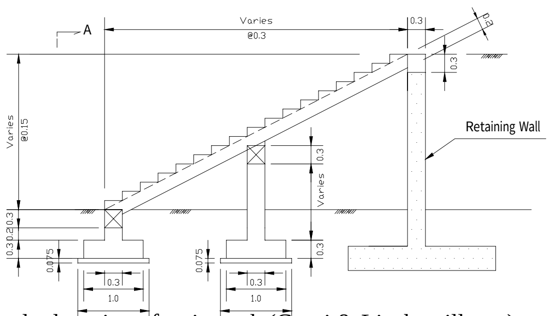
Number of installation points of stair work and openings at each of model site based on the above listed basic factors are given in Table 2-25.

Table 2-25 Number of installation points of stair work and openings

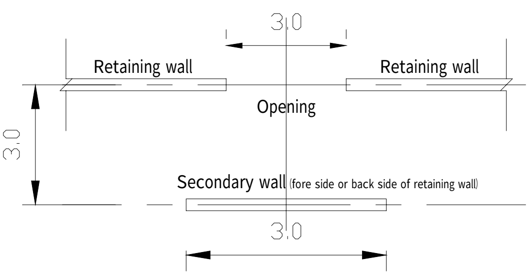
Model site	Appurtenant work		
	Stair work	Openings and secondary wall	Single opening
Sazan	—	11	5
Gurai	5	—	5
Lipsha	5	—	—
Nazarpur	—	—	9
Total	10	11	19

(c) Standard section of stair work and openings

Standard section of stair work and openings are shown in Fig. 2-16.



Standard section of stair work (Gurai & Lipsha villages)



Plan shape of opening

Fig. 2-16 Standard section of stair work and opening

(2) Foot protection

As shown in “2-2-1-4 Design policy of RCC wave protection (1)Policy of selecting route of wave protection (Policy-10: page 2-9)”, when the front site of wave protection is inclined due to topography and land use condition, foot protection to prevent erosion at the basal part is applied.

(a) Installation length

Installation length of foot protection at each model site is shown in Table 2-26.

Table 2-26 Length of installing foot protection

Model site	Length (m)
Sazan	1,235
Gurai	—
Lipsha	170
Nazarpur	150
Total	1,555

(b) Standard cross section of foot protection

Standard cross section of foot protection is shown in Fig. 2-17.

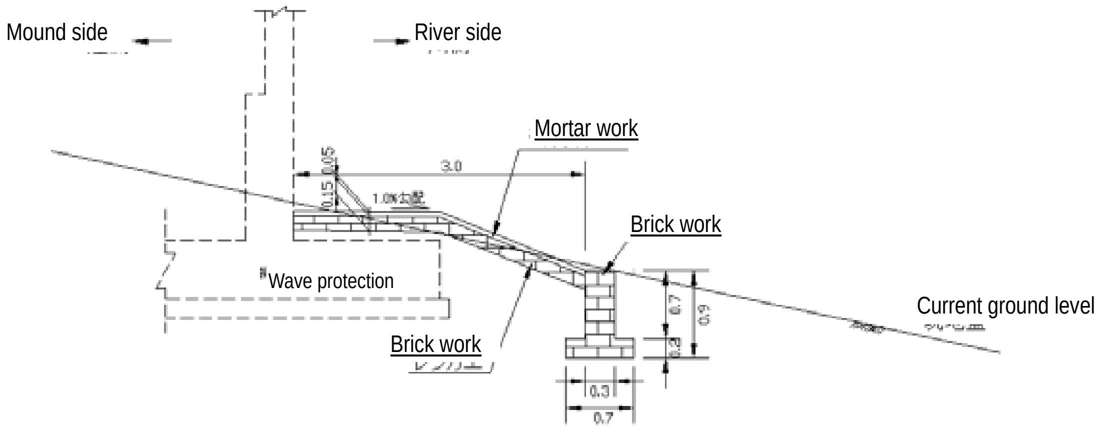


Fig. 2-17 Standard cross-sectional drawing of configuration of foot protection

(3) Staff gauge

A staff gauge consists of two parts, the part equivalent to the wave protection and the other higher than it. For the part of the wave protection, an indent will be directly marked with paint on concrete surface. For the other part higher than the wave protection, a concrete pillar will be installed that can measure even higher level than the largest recorded inundated level. This pillar will also have a directly painted scale. Furthermore, because villagers will directly manage and maintain the staff gauge, it is established nearby villagers' houses or school, so that O/M can be readily and safely done.