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

Guidelines for Small Scale Water Resources Development Project

G6 Detailed Design of Subproject Structure

November 2017

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Document Architecture of the New Sets of Guidelines for SSWRD Project

[Small Scale Water Resources Development (SSWRD) means, from physical points of view, implementing appropriate water management subprojects of small sizes, not exceeding 1000 hectare benefit area by the current definition, to resolve existing water management constraints to agriculture that in turn enhance rural employment leading to reduction of rural poverty. Implementation of SSWR subprojects involve long process from proposal of a subproject from Local Government institutions (Union Parishad and Upazila Parishad) to its final selection, study of feasibility from different considerations (social, environmental, technical, economical), preparing Detailed design and costing, constructing required physical works to standard quality and finally its operation and maintenance by its beneficiaries. The process has multiple facets too. It needs to be comprehensively beneficiaries' and other stakeholders' participatory, acceptable to people of widely varying social and socio-economic conditions, friendly to the environment, etc. Thus, Guidelines for SSWR Development is, of necessity, complex.

The long and complex process has been divided into major distinguishable steps and separate Guidelines for works and activities involved in those major steps have been developed. Environmental study applies to the subproject as whole and is of different nature. So, Guidelines for Environmental Assessment is made a separate document. Following this principle, the Ten (10) Guidelines with Alpha-numeric ID Numbers and Names as below constitute the Documentation of Guidelines for SSWR Development.

This list will appear in all the individual Guideline Documents with highlight of the current Document name for the user to refer when necessary]

The List of New Sets of Guidelines for SSWRD Project

G1	Policy and Development Process
G2	Identification of Subprojects
G3	Participatory Rural Appraisal of Subprojects
G4	Feasibility Study of Subprojects
G5	Environmental Assessment of Subprojects
G6	Detailed Design of Subproject Structures
G7	Construction of Subproject Structures
G8	Operation and Maintenance
G9	Monitoring and Evaluation
G10	Integrated Rural Development Plan between SSWR and Rural Road/Market

Amendment and Upgradation Records

This document "**Guidelines for SSWR Development: G6 Detailed Design of Subproject Structures**" has been issued following amendments and upgrading as outlined below:

Revision	Description	Date
	Guidelines for Participatory Process in Small-scale Water Resources Development, initially developed for ADB-supported SSWRDSP (1995-2002) guided feasibility study and design of SSWR subprojects of the two ADB-supported Projects - SSWRDSP (1995-2002) and SSWRDSP-2 (2002-20010). Detailed design and drawings of hydraulic structures used in these Projects were guided by Standard Design Catalog that provided Design Tables for several ranges and combinations of design conditions for different types of structures. The Catalogs were developed by drawing upon Spreadsheet Design Programs and Standard A3-size Drawings that were developed under WR Section of the Institutional Support Project (ISP) (1991-2000) supported by Swedish International Development Agency (SIDA) Grant Fund. The Design Tables of the Catalog were however not popular in SSWRDSP-2 as design engineers preferred to work with the Spreadsheet Design Programs, both for hydraulic and structural designs, which provided for easy checking alternate possibilities and scenarios.	April 1999 March 2006
A	The above Guidelines document of ADB Projects was updated and adapted, dropping the Design Catalog part, as "Planning and Design Guidelines: Methodology and Common Subproject Components (updated 2009)" for feasibility study and design of the JICA-supported SSWRDP (2009-20015). The ADB-supported PSSWRDSP (2010-2017) also used a similar Guidelines document. Both the Projects continued using Spreadsheet Design Programs for Detailed hydraulic and structural designs of structures.	May 2009
B	LGED adopted advanced method in structural design of hydraulic structures - using STAADPro software for stress analysis and Ultimate Strength Design (USD) for reinforced concrete design in 2014. Design Engineers were given necessary training on STAADPro and the ongoing Projects (JICA-supported SSWRDP and ADB-supported PSSWRDSP) adopted the improved method of design.	2014
D	In this documentation of the suite of Guidelines for SSWR Development, the Detailed design part of the "Planning and Design Guidelines (2009) is made separate from feasibility study part and developed as Document "**Guidelines for SSWR Development: G6 Detailed Design of Subproject Structures**" - the ***Sixth*** Document of the Series of Guidelines for SSWR Development finalized and approved by a Working Group of LGED Professionals with proven experience in SSWR development with assistance from Specialist WRD Consultants under a JICA-LGED Technical Co-operation Project. The Document builds on the guidelines for hydraulic design contained in the "Subproject Planning and Design Guidelines (May 2009)" and incorporates the advanced methods (stress analysis using STAADPro and reinforced concrete design by USD method) together with other lessons learned over the time.	August 2017

GLOSSARY

Aman	Rice grown during the wet season (Kharif), and harvested late (Nov-December). Yields: (i) Broadcast, deep water 1.5t/ha; (ii) Transplanted, local variety 2.2t/ha; (iii) Transplanted, high yielding variety, 3.25t/ha
Aus	Rice grown during the wet season (Kharif), and harvested early (July-August). Yields: (i) Broadcast 1.25t/ha; (ii) Transplanted, high yielding variety, 2.5t/ha
Beel	Saucer shaped low-lying area with pond of static water as opposed to moving water in rivers and canals.
Boro	Irrigated rice grown in the early dry season (Rabi). Transplanted in December-January and harvested in April-May. Yield: Transplanted, high yielding variety, 4.25t/ha
District	Second administrative unit of the government comprising 6-9 Upazilas. There are 64 districts in Bangladesh.
Haor	Haor is a wetland ecosystem in the north eastern part of Bangladesh. Physically a bowl or saucer shaped shallow depression, also known as a back-swamp
Integrated Water Resources Management Unit	Unit comprising two sections: (i) planning & design, and (ii) operation & maintenance, with a mandate to guide LGED's activities in the water sector with specific responsibility to assist in enunciation of policies, formulation of strategies and plans, preparation of new projects, inter-agency coordination and with external agencies, undertake studies and to provide long term support to the completed projects
Khal	Natural or man-made water channel (canal)
Kharif	Wet (monsoon) season
Local Stakeholder	Local Stakeholders are inhabitants of an area directly or indirectly affected by water management, be it as beneficiaries or as "project affected people".
Project Affected People	People negatively impacted by investment in water management projects and / or subprojects or by the manner in which water regulating infrastructure is managed.
Project Consultants	Project implementation consultants working with the PMO
Project Management Office	A unit comprising LGED staff appointed to manage implementation of a Project
Rabi	Dry / winter cropping season (November to March)
Stakeholder Groups	Stakeholder groups are collections of individuals who have similar interests concerning water. Among others, such stakeholder groups are men and women, farmers (low, medium low, medium high and high land farmers), fishers, boatmen, landless, elected representatives, LGED employees, BWDB employees, employees of other government departments, contractors, consultants, and development partners.
Union	Subdivision of Upazila and the lowest governance institution in the country.
Union Parishad	Local government institution at Union level. The Union Parishad consists of an elected council & chairman, and is the oldest government institution in Bangladesh
Upazila	Administrative unit, sub-division of District and lowest administrative tier of the government.
Upazila Parishad	2nd tier of local government institution at Upazila. According to the Upazila Parishad Act 2009, Upazila Parishad consists one elected Chairman and two Vice-chairmen, Chairmen of UPs and Mayor of Municipality within each Upazila including representatives from line agencies with an Upazila Nirbhai Officer as the Secretary. The election of the Upazila Parishad was held on 22 January 2009. Upazila Parishad runs the local administration.

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AE	Assistant Engineer
BWDB	Bangladesh Water Development Board
CA	Community Assistant (Project Based – Subproject Level)
CO	Community Organizer
CPO	Community Participation Officer (Project based, District level)
CS	Construction Supervisor (Project Based – Upazila Level)
DAE	Department of Agricultural Extension
DDM	Detaileded Design Meeting
DLIAPEC	District Level Inter-Agency Project Evaluation Committee
DOC	Department of Cooperatives
DOF	Department of Fisheries
DWRA	District Water Resources Assessment
EIA	Environmental Impact Assessment
EMP	Environmental Mitigation Plan
FMC	First Management Committee (of WMCA)
FSDD	Feasibility Study and Detaileded Design
GoB	Government of Bangladesh
IEE	Initial Environmental Examination
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
ICM	Integrated Crop Management
IWRMU	Integrated Water Resources Management Unit (of LGED)
LCS	Labour Contracting Society
LGED	Local Government Engineering Department
MC	Management Committee (of WMCA)
MEP	Member Education Program
MIS	Management Information System
MLGRDC	Ministry of Local Government, Rural Development and Cooperatives
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
PAP	Project Affected Person
PE	Performance Enhancement
PEA	Performance Enhancement Appraisal
PM	Planning Meeting
PMO	Project Management Office
PRA	Participatory Rural Appraisal
QC	Quality Control
SAE	Sub-Assistant Engineer
SAPROF	Special Assistance for Project Formulation
SP	Subproject
SSWR	Small Scale Water Resources
SSW-1	SSWR Development Project Phase I (ADB), 1996-2002
SSW-2	SSWR Development Project Phase II (ADB), 2002-2009
SSW-3	SSWR Development Project (JBIC), 2009-2016
SSW-4	Participatory SSWR Project (ADB) 2010-2017
TA	Technical Assistance
UDCC	Union Development Coordination Committee
UE	Upazila Engineer
UP	Union Parishad (local council)
UzP	Upazila Parishad
WMCA	Water Management Cooperative Association
XEN	Executive Engineer (usually used in LGED)

FARM AND LAND CATEGORIES

FARM CATEGORIES

Land Holding (ac)	Land Holding (ha)	Farm Category
<0.51	< 0.21	Landless
0.51 – 1.00	0.21 - 0.40	Marginal Farmer
1.01 – 2.49	0.41 – 1.00	Small Farmer
2.50 – 7.49	1.01 – 3.03	Medium Farmer
>7.50	>3.03	Large Farmer

LAND CATEGORIES

Depth of Average Monsoon Flooding (m)	Depth of Average Monsoon Flooding (ft)	Land Category
<0.3	<1.0	Highland
0.3-0.9	1.0-3.0	Medium Highland
0.9-1.8	3.0-5.9	Medium Lowland
>1.8	>5.9	Lowland

SUBPROJECT CATEGORIES AND TYPES

Category		Type		Typical Works
I	**Simple** (without Regulation of Water Flow)	DR	Drainage	Re-excavate drainage *khals* to increase capacity of drainage systems to benefit agriculture as well as fisheries and local navigation
		TI	Tidal Irrigation	Re-excavate existing *khals* to enhance tidal flux (volume and propagation) in the *khals* in dry season to benefit irrigated agriculture in fresh water tidal areas as well as fisheries and local navigation (also increases capacity of drainage system)
II	**Complex** (with Regulation of Water Flow using gated or other kind of structures)	FM	Flood Management	Rehabilitate and construct embankments and / or sluices/ regulators to reduce extent and duration of flooding of farmland inside the subproject
		FMD	Flood Management and Drainage	Rehabilitate and construct embankments, sluices/ regulators and re-excavate *khals* to reduce extent and duration of flooding of farmland and increase drainage capacity of khal system of the subproject
		FMDTI	Flood Management, Drainage and Tidal Irrigation	Rehabilitate and construct embankments, sluices/ regulators and re-excavate *khals* to reduce extent and duration of flooding of

Category		Type		Typical Works
				farmland, increase drainage capacity and tidal flow capacity of khal system of the subproject. Sluices/regulators of these subprojects will have arrangements of automatic flow of drainage and tidal inflow at the gates.
		WC	Water Conservation	Develop water retention capacity of existing *haors*, *beels* and *khals* to increase availability of surface water for irrigation in dry season by installing gated water retention structures (also *Rubber Dams* at appropriate sites) and by re-excavating *khals* and suitable water bodies
		FMDWC	Flood Management, Drainage and Water Conservation	Combination of works involved in FMD and WC type of subprojects outlined above
		CAD	Command Area Development	Development of existing irrigation schemes by providing better water distribution systems over the command area and, as may be agreed, pumping facilities. Works may include: improved canal network, lining of canals, installation of buried pipelines, installation of control structures, construction of pump house, headwater tanks, etc.
		DRCAD	Drainage and Command Area Development	Development of existing irrigation schemes by providing better water distribution systems including drainage improvement measures for the command area and, as may be agreed, pumping facilities. Works may include: improved canal network, lining of canals, installation of buried pipelines, installation of control structures, construction of pump house, headwater tanks, regulators/sluices in drainage khals, etc..
		FMDCAD	Flood Management, Drainage and Command Area Development	Development of existing irrigation schemes by providing better water distribution systems together with flood management and drainage improvement facilities forr the command area and, as may be agreed, pumping facilities. Works

Category		Type		Typical Works
				may include: improved canal network, lining of canals, installation of buried pipelines, installation of control structures, construction of pump house, headwater tanks, etc and construction / rehabilitation of embankments, sluices /regulators in drainage khals, etc..
III	Performance Enhancement	Any Type of Existing Subproject s		Any of the above described works for existing (developed and handed over) subprojects for which additional works are desirable to consolidate planed benefits / result in additional benefits

I. INTRODUCTION

1.1 Preamble

1. As feasibility study of a SSWR subproject recommends implementation of the subproject and the concerned authority, usually the Superintending Engineer (P&D) of IWRM Unit, accords approval to the feasibility study, engineering design of the planned works of the subproject is undertaken that lead to construction of the works. This activity includes preparation of Detailed design of all works of the subproject, preparation of construction drawings of the designed works, preparation of estimate of costs and BOQ for tender documents. Accordingly, this Document ***G6: Detailed Design of Subproject Structures*** is presented in *four* Sections:

Introduction
Detailed Design of Works
Standard Drawings
Estimate of Costs and BOQ.

2. Physical works required for subprojects are planned based on technical analyses and hydraulic design during feasibility studies. In Detailed design of khals for re-excavation and embankments for reconstruction/upgrading, only hydraulic design is sufficient. Construction drawings can be prepared after final hydraulic design is done. For structures, however, hydraulic design confirms configuration and dimensions of the structures from hydraulic flow considerations only. These structures must be analyzed and designed for strength and stability under the various loads that they will experience over their lifetimes. LGED has adopted structural analysis of hydraulic structures – Regulators, Sluices, WRS, etc by using STAADPro software. Accordingly, Detailed design of hydraulic structures involves the following three activities:

a. **Hydraulic Design:** All feasibility level hydraulic designs will be reviewed and final hydraulic designs of all works (khals, embankments, regulators, sluices, WRS, Rubber Dams, and other hydraulic structures if any) of the subproject will be done, incorporating improvements/revisions if necessary, using project specified Excel Spreadsheet Design Programs. Hard copy prints of input data, intermediate calculations/control data input if any and output results of all these designs are to be presented in the Detailed Design Documents of the Subproject.

b. **Structural Analysis using STAADPro:** The STAADPro (**ST**ructural **A**nalysis **A**nd **D**esign **Pro**gram) software allows for both (i) analysis of stresses (moments) in different members of the structure by generating a stress pattern all over the structure under the given load condition and (ii) design of reinforced concrete (or steel) sections of the members. However, practice in LGED is to use STAADPro only to conduct analyses for stresses (moments) in the structure. The design moments of different members (or segments of members) are judged and decided manually by visual inspection of the stress pattern throughout the structure generated by the software.

c. **Reinforced Concrete Design:** Designs for concrete and reinforcement of different members (or segments of members) for the judged out design moments are done using USD (ultimate strength design) method and specifications of USBR (United States Bureau of Reclamation).

3. Some additional site specific survey and data which could not be collected during survey and data collection in the feasibility study stage will now be collected before starting Detailed design. These usually are:

a. **Survey of Structure Site**: As the location of the structure will be exactly known, Plane Table survey of the site of the structure showing location of all objects and features including configuration in plan of the khal (bends, narrow/wide places) and/or river within the survey area together with spot GL values at 5m grid points of the whole PT survey area will be done. Detailed guidelines for the site survey are given in Document G4: Feasibility Study of Subprojects, Exhibit G4-D: Guidelines for Conducting Engineering Survey for SSWRD Subprojects.

b. **Subsoil Data**: For Box Type Sluice/Regulator/WRS of up to 5-6 vents, 3 Bore Holes of each 20m deep are to be investigated. Locations of the 3 Bore Holes will be: BH-1 at the Centre Point (crossing of the transverse and longitudinal centre lines), BH-2 near the end of the upstream right side Return Wall and BH-3 near the end of the left side downstream Return Wall of the structure. For wide structures, say 8-10 vents or more, 5 BH will be investigated: one at the Centre Point and one each near the ends of four Return Walls. SPT counts will be recorded at every 1.5m throughout full depths of all Bore Holes and Unconfined Compressive Strength (q_u) of cohesive/clayey soils will be determined whenever encountered in the Bore Holes (undisturbed soil samples must be collected from each layer of cohesive/clayey soils encountered and tested in laboratory for q_u)

II. DETAILED DESIGN OF WORKS

2.1 Hydraulic Design

2.1.1 Data and Analyses Applied to Both Feasibility Study and Detailed Design

4. Hydro-climatic data and hydrological analyses of subprojects apply both for feasibility study (FS) and Detailed design (DD). However, some data or analysis may be necessary in FS but not in DD or vice versa. As DD is done in a later stage, it may be necessary at times that a certain data or analysis be revised and/or updated. The following sections discuss some of such data and analyses that are done and included in FS study and now will be reproduced here as these would be necessary in DD.

2.1.2 Climatic Data

5. Data on temperature, rainfall and evaporation appropriate for subprojects are provided in Engineering Annexes of the respective Feasibility Study Reports.

6. For DR, TI, FMD, WC (including Rubber Dams) type of subprojects, monthly data for temperature, rainfall, evaporation and evapo-transpiration as required will be given in FS Report of the subproject in *G4-IA: Engineering Annex, Appendix G4-IA.A, Table A2: Climatic Design Data of Subprojec*t. As these data will be required in DD, either for use in calculation or understanding and reference, the above referred Table has been reproduced here in ***Exhibit G6-A: Climatic Design Data of Subproject.*** Print out of the Data Table of the subproject will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project.

7. For CAD subprojects including subprojects with buried pipe irrigation systems, monthly data for temperature, rainfall, humidity, wind velocity and sunshine hours and data on crop water and irrigation water requirements are provided for 13 districts spread over the country. For a particular subproject, data of the nearest or otherwise considered applicable district will be provided in FS Report of the subproject in *G4-IB: Engineering Annex, Appendix G4-IB.A, Table A2* and *Table A3.* These data will be used in design of the system and so the referred Table has been reproduced in ***Exhibit G6-B: Climate & Rainfall Data of Reference Districts (for CAD subprojects)*** and ***Exhibit G6-C: Crop Water & Irrigation Water Requirements and Design Irrigation Duties (for CAD subprojects).*** Print out of the Data Tables of the subproject will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.3 Rainfall and Design Storm Data

8. These data are usually required for DR, TI, FMD and WC subprojects. CAD subprojects usually do not need these data. However, if a CAD subproject includes drainage and/or FMD components, design storm data will be required to design these components.

9. Monthly rainfall (maximum, mean, minimum) data applicable for the subproject and the synthesized 5-day design storm rainfall for pre-monsoon and monsoon seasons as has been developed for the subproject is given in FS Report in *G4-IA: Engineering Annex, Appendix G4-IA.A, Table A3.1*. These data will be used in the final hydraulic design of relevant works - re-excavation of khals and hydraulic structures and so the Data Table has been reproduced here in ***Exhibit G6-D: Rainfall Data of Subproject***. If, however, the design storm data is to be revised for justified reasons or design storm data are to be additionally developed for a subproject (say, CAD subproject with drainage or FMD component), the procedure for developing design storm as outlined in ***G4-IA: Engineering***

Annex, Appendix G4-IA.B, Table B1-B: Rainfall Data would be followed and ***Exhibit G6-D*** will contain the revised data. Print out of the Data Table of the subproject will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.4 Water Level Data

10. Data on monthly (maximum, mean and minimum) WL for either tidal or non-tidal area subprojects and annual HFL of different return periods at the subproject sites analyzed by appropriate method and from data of appropriate WL Guage stations will be analyzed during Feasibility Study of the subproject and given in the FS Report in Engineering Annex *G4-IA, Appendix G4-IA.A, Table A3.2: River WL Data.* These data will be used in final hydraulic design of subproject structures and therefore the Data Table has been reproduced here in ***Exhibit G6-E: River Water Level Data***. Print out of Data Table of the subproject will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.5 Area-Elevation-Storage Data

11. The relationship between land elevation and corresponding area of land under it and the volume of water that can be held in storage on this land area provides a valuable hydro-topographical tool for analysis of various impacts of the subproject. The relationship is established by using the 4 inch to 1 mile scale (1:15840) topographical maps with land elevation contour lines at 1-foot (0.3 m) intervals. These maps, though old – prepared during late-1950s to mid-1960s, are available for all areas of the country except for Hill Tract areas. Areas between successive contour lines, within the subproject boundary (*refer also to Section 3.2.1, Index Map*) are measured and a cumulative Area vs Elevation data from lowest land elevation to higher is prepared in a tabular form. To this table, a column for volume of water that would be held in storage at the consecutive elevation steps can be added. Thus a tabular data of Area-Elevation-Storage characteristics of the subproject area is established which is used by the Spreadsheet Design Programs. Also graphs can be plotted using the data for visual analysis and study.

12. Area-Elevation-Storage relationship of a subproject will be analysed during feasibility study of the subproject and tabular data with plotted curves will be given in FS Report in *Engineering Annex, Appendix G4-IA.B, Section B2.A1*. As the data will be used in Spreadsheet Design Programs, the tabular data along with the plotted curves have been reproduced in ***Exhibit G6-G*** of this document for reference. Print out of the data and plotted curves of the subproject will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.6 Crop Damage Criteria

13. Drainage from a subproject area is dependent on water level in the outfall river or khal in one hand and on capacity of internal system – khals and regulators/sluices on the other. If external water level condition prevents drainage, design of internal system will not help in any way to prevent inundation to crops of low lands. But, when outside water level does not impede drainage, subproject design should be such that damage to crops due to submergence remains up to acceptable limit as runoff from the subproject is drained out. For rice crops, inundation deeper than 0.30 m lasting longer than 3 days is considered to cause 100% crop damage. On the other hand, the acceptable level of crop damage has been adopted at 5% of the subproject net benefitted area. These two criteria together, therefore, define the crop damage criteria.

2.1.7 Design Drainage Rate and Basin Water Level

14. ***Drainage Rate*** is the rate expressed in millimetres per day at which the runoff generated from design storm rainfall over the entire subproject catchment area (may be more than subproject area) has to be drained out so that inundation damage to crops grown in the net benefited area remains within the acceptable limit - up to 5% of the net benefited area. That is to say, as the design storm runoff is drained at a certain drainage rate, the maximum water level in the subproject area should be such that no more than 5% of the benefited area remains submerged for more than three days with depth of water more than 0.3 meter. This water level in the subproject area is termed as the ***Design Basin Water Level.***

15. The design Drainage Rate is determined, to meet the above acceptable crop damage conditions, by applying the design 5-day 10-year storm onto the subproject catchment area (basin) and carrying out an iterative water balance (or flood routing) calculation with a time step of one day. The calculation is carried out using the MS Excel Spreadsheet Program ***DRate&BasinWL*** using the design storm rainfall and the basin area-elevation-storage data. The program calculation is run using a "trial drainage rate value" and observing the "number of days in the column for full damage day". If the number of days is more than 3, the trial drainage rate is increased until the number of days is just 3. This trial drainage rate is the Design Drainage Rate and the maximum value in the WL_{Basin} column is the Design Basin Water Level.

16. An example *run-output* of the *AnalysPro-1,* ***DRate&BasinWL*****,** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. The DD Consultant will conduct analysis of the subproject and print out of the run-output will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Program will be available along with other design programs in CD from PMO.

2.1.8 Land Type Analysis and Land Type Change Calculation

17. Land type or Land class as is related to agriculture and, for that matter, to agricultural water management is defined based on flood phase (depth of flood water on land) of lands as below:

Highland	F0	0-0.3m depth of water on land
Medium highland	F1	0.3-0.9m depth of water on land
Medium lowland	F2	0.9-1.8m depth of water on land
Lowland	F3	>1.8m depth of water on land

18. Full Flood Management subprojects impact agriculture by lowering water depth in the subproject area such that lands from deeper flood phase changes to shallower flood phase whereby area and cropping of shallow flood phase lands increase. Therefore, assessing amount of land changing flood phase i.e. land type change occurring due to the subproject is an essential analysis in impact assessment of Full Flood Management subprojects. Partial Flood Management subprojects and Drainage Improvement subprojects protect crops from pre-monsoon floods and improve cropping by reducing subproject WL but do not change land types as the impacts do not persist over the whole monsoon season and also on long terms. Water Conservation and CAD subprojects are dry season subprojects having no interference with monsoon waters and so do not make any land type change impact.

19. Spreadsheet Program in MS Excel, ***LandType&Change*****,** has been developed that works with the tabulated Area vs Elevation data of a subproject and gives areas of different

land types under a given WL in the subproject according to the above flood phase definition. Accordingly, by using pre-subproject and post subproject WLs, two sets of land types are calculated and the difference between post-subproject and pre-subproject land type figures indicate the land type change due to the subproject.

20. Example *run-output* of the *AnalysPro-2,* ***LandType&Change*****,** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. The Consultant will conduct analysis of the subproject and print out of the run-output will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Program will be available along with other design programs in CD from PMO.

2.1.9 Design of Drainage Khals

21. Drainage khals are designed to pass design discharge safely. The design discharge (Qmax) is calculated based on the computed Drainage Rate and the Drainage Area at a given point of the khal as shown below. This is a day average maximum discharge expected to occur once in a 10-year period in average.

$$\text{Qmax } (m^3/s) = [\text{Drainage rate (mm/day) x Drainage Area (ha)}]/8640$$

22. If the khal is long and/or branch khals from sides join it, the khal should be divided into reaches and each reach will be designed for the discharge calculated at its downstream end. If the drainage system comprises of many khals, some of them may be interconnected, it will be convenient if a table of design discharge of the khals is prepared first and the khals are designed using the tabulated data in the design Program.

23. Discharge capacity of an individual drainage khal is a function of the channel characteristics like cross-sectional area for water flow, roughness and hydraulic gradient. In non-tidal khals, it is assumed that *normal* flow exists i.e depth of flow along the khal is uniform and accordingly, the hydraulic gradient of the khal is taken as the longitudinal slope of the bed profile of the khal. .

24. In tidal khals, hydraulic gradient is controlled by water level in the outfall channel i.e by the tidal variation. When tide level in the outfall channel is higher than the subproject water level drainage remains blocked at the regulator and there is no flow in the khal. Flow resumes when the tide falls below the basin level. As the calculated design discharge is a day-average value, design discharge in tidal conditions is to be increased to take into account the flow blockage period during high tides.

25. Based on tide records, a simplified triangular shape of tide curve is adopted for calculation of drainage time per day, and the design discharge is increased proportionally to the drainage period per day. Accordingly, the equivalent design discharge of tidal khal is:

$$\begin{aligned} Qmax_{\textbf{Equivalent}} &= Qmax_{\text{Day Average}} \times 24/(\text{drainage time in 24 hours}) \\ &= Qmax_{\text{Day Average}} \times 12/(\text{drainage time(hr) per tide cycle}) \end{aligned}$$

26. Drainage khals in subprojects designed for pre-monsoon drainage are sized for passing safely the pre-monsoon design discharge within khal banks to avoid land inundation (submergence of low banks in local depressions to a depth of about 0.30 m may be allowed).

27. In subprojects designed for monsoon drainage, banks for most part of the khal will be submerged causing part of water to flow overland beyond the khal. However, velocity of overland flow is usually small. On the other hand, the khal flows with higher velocity carrying

the major part of discharge. Accordingly, the khals are designed for 2/3rd Qmax with banks of the khal assumed to be at the Basin Water Level.

28. If the khal passes through higher land where the design basin water level is below the khal banks, the khal section should be designed for full design discharge, Qmax.

29. In designing khal sections to carry design discharge, threshold design velocities of flow should be as below:

Minimum flow velocity (to prevent sediment deposition) 0.3 m/s
Maximum flow velocity (to prevent erosion) 1.0 m/s.

30. Side slopes of design section of drainage khals may vary from 1:1 to 1:2 depending on soil type. The recommended channel side slopes are as below:

Soil Material	**Side Slope (V:H)**
Clay (hard, stiff)	1:1
Mixed soil (sandy clay to clayey silt)	1:1.5
Silt to Sandy silt	1:2

31. As a matter of eligibility criteria of SSWRD subprojects, re-excavation will involve only existing khals and accordingly will follow existing alignment. Also, top width of re-excavated khals may not be significantly wider than the existing overall top width (if not encroached upon). There may be places of sharp bends in the existing alignment or existing top width may be inadequate for providing recommended side slopes. If adequate land is not available, under unavoidable circumstances, alternative options like steeper slope with protection measures may have to be adopted.

32. The hydraulic design calculations are carried out by MS Excel Spreadsheet Programs ***KhalDesign(NTidal)*** for non-tidal khals and ***KhalDesign(Tidal)*** for tidal khals using design drainage rate and drainage area or calculated design discharge, existing levels and dimensions of khal obtained from engineering survey and trial combinations of design parameters - bed width, depth, long slope, side slope, etc until a suitable design compatible to existing and/or acceptable condition is obtained.

33. Flow in non-tidal khal is *normal* i.e. depth of flow is constant with distance along the khal. Normal flow in open channel is described best by Manning's equation. Accordingly, the Spreadsheet Design Program ***KhalDesign(NTidal)*** is based on Manning's equation given below:

$Q = A \times (R^{2/3} \times s^{1/2}) / n$

Where A = Cross-sectional area of water flow (m^2)

R = A/P = Hydraulic Radius of Khal Section (m)

P = Wetted Perimeter of Khal Section (m)

S = longitudinal water surface slope = longitudinal bed slope of khal

n = Manning's Roughness Factor (taken as 0.035 for natural khals)

Q = Discharge (m^3/s)

34. In tidal khals, water surface slope, and as a consequence depth of flow also, changes with rise and fall of tidal water level in the outfall river i.e. flow (discharge) in tidal khal *varies* with time and this makes design of tidal khal complex. However, as a technique to simplify the design, the range of WL change from lowest to highest (same as the highest to lowest) during drainage is divided into small steps, number of steps being more if the

range of variation is more to keep the steps small, and assuming that flow in the khal during the period of this short step can be approximated as *normal* and Manning's equation can be applied. Thus, discharge through the khal during each step is calculated using Manning's equation and the step discharges are aggregated to get the overall discharge during the period of rising (or falling) water. Using this approximating technique, the Spreadsheet Design Program ***KhalDesign(Tidal)*** has been developed.

35. Example *run-output* of both the Programs – *DesignPro-3* ***KhalDesign-NT*** and *DesignPro-4* ***KhalDesign-T*** are given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of all khals planned for re-excavation under the subproject will be done and print out of *run-outputs* for all khals will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other programs in CD from PMO.

2.1.10 Design of Tidal Khals for Irrigation Water Supply

36. Tidal khals meant for providing irrigation water in the dry season should be deep enough such that tidal water can flow up to the end of the khal as pumps run to lift water along its length. Such khals involve complex conditions of water flow – discharges and depths varying with both time and distance along khals and therefore design calculations are also complex.

37. The tidal khal for irrigation water supply shall also be designed to be adequate for drainage flow. Discharge requirement for irrigation water supply will usually be much smaller compared to drainage discharge. But irrigation water flow will be with a much low water level and so will require low design bed level in the khal. On the other hand, drainage discharge will occur with higher water level in khal and so design bed level of khal would probably be higher. It may therefore be inferred that if the khal is designed for drainage discharge with the design BL of khal at the upper end point of irrigation water supply fixed at 0.30m (minimum water depth required to operate small pumps) below LTL of the outfall khal (parent khal for irrigation water supply), it is likely that the design would be adequate for irrigation flow because the khal will carry water all the time including at LTL.

38. The tidal khals for irrigation water supply will be designed for drainage by using the Design Program ***KhalDesign-T*** as discussed in **Section 2.1.9**. If design of the khal for drainage require bed level higher than that required by irrigation water supply (0.30m lower than LTL at the uppermost end of khal), the khal bed may be given only a nominal mild longitudinal slope towards downstream.

39. Detailed design of all tidal khals planned for re-excavation under the subproject will be done and print out of *run-outputs* for all khals will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.11 Design of Khal / Chhara for Water Conservation

40. Water Conservation (WC) subprojects are usually built based on Chharas (channels coming down from hilly areas) and rivers (small to medium) that carry small perennial flow in the dry season which could not otherwise be utilized due to difficulty of accessing and/or lifting against high pumping heads. Water Retention Structures (including Rubber Dams for small to medium rivers) constructed on such Chharas/rivers conserve water in the channel storage of the Chhara/river that extends over a reach and is raised in level so that people can draw water from the channel storage at less cost. These are WC subprojects for dry season irrigation. The Chharas, for being in hilly areas, usually have steeper slopes and are

of adequate section to carry rain water from upland catchments without significant flooding problem. However, Chharas usually carry high sediment which may at times cause them to silt up. Such Chharas are to be re-excavated / re-sectioned to their full flood passage capacity. This requires that the Chhara be designed properly for re-excavation and the WRS be built at the design bed level of the Chhara at the desired site, not on the existing bed of the Chhara.

41. WC subprojects are also built in plain land areas based on khals and abandoned channels of rivers to hold water from later part of monsoon in channel storage for providing supplementary irrigation to Aman rice in draught times and to Rabi and Boro rice crops in support to groundwater irrigation. Sometimes, WC subprojects are demanded in areas having less monsoon rain associated with longer rainless days to store monsoon water in khals to bankfull levels for Aman rice crops. All these water retention khals should be designed appropriately for drainage flow and WRS built at design bed level of the khals.

42. All such water conservation khals/Chharas will be designed for full drainage discharge by using the Spreadsheet Design Program ***KhalDesign-NT***. However, if any additional widening or deepening of such water conservation khals/Chharas/river sections, beyond the design requirements, is required by the purpose of the subproject, those dimensions, levels, etc will be used in the design program with necessary explanatory notes therein.

43. Print out of *run-outputs* of the Design Program ***KhalDesign-NT*** for re-excavation of Chhara / khal (even if the work is not being planned) will be submitted, in support of the sill level of WRS, in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.12 Design of Submersible Flood Embankments

44. Submersible flood embankments are designed mainly to protect Boro rice from pre-monsoon flash floods. Considering usual harvest time of Boro rice in Haor areas, May-HFL is to be considered as the design water level. For other areas of the country, pre-monsoon season will include the month of June. During monsoon season these embankments remain submerged and so these are not used for communication. The recommended design section for submersible embankments is:

Design Water Level	: 1:10-year May-HFL (for Haor areas)
	: 1:10-year Pre-monsoon HFL (for other areas)
Freeboard	: 0.30 m
Crest Width	: 2.50 m
Side Slopes	: 1:2 (V:H)

45. To reduce potential of erosion and to facilitate maintenance, when constructed along rivers, khals and borrow pits, embankments should be constructed at a safe set back distance from their banks. Approximate embankment set back distance can be determined from the relation given below.

SB = Ze x Dch

Where: *SB* = Set Back distance (m): min 6 m for small rivers, 3 m for khals

Ze = Side Slope of embankment

Dch = Depth (m) of channel (river, khal, borrow pit)

46. In case the submersible embankment will be used as a submersible road, its crest width should conform to specification for road widths as given under full flood embankment.

47. Design calculations for submersible and full embankments are similar and are done using the same design program as has been described below under full embankments. However, Detailed design of all reaches of submersible embankments that are planned for re-sectioning under the subproject will be done and print out of *run-outputs* of the design Program will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.13 Design of Full Flood Embankments

48. Full flood embankments (sometimes termed as high embankments) are designed to protect the subproject area from inundation by excluding both pre-monsoon and monsoon high floods. Full flood embankments are not recommended for the Haor basins of greater Sylhet and Mymensingh areas for environmental reasons.

49. Design parameters for full flood embankments are discussed in the following paragraphs. However, the recommended minimum design parameters of full flood embankments are as below:

Design Water Level	: 1:20-yr Annual HFL and 1:50-yr Annual HFL
Freeboard	: 0.60 m for inland, 0.90 m for facing big rivers
Crest Width	: Minimum 2.50 m
Side Slopes	: Maximum 1:1.5 (V:H)

50. To reduce potential of erosion and to facilitate maintenance, when constructed along rivers, khals and borrow pits, embankments should be constructed at a safe set back distance from their banks. The minimum design set back distance, including for re-sectioning of existing embankments, shall be 3.0 m. Approximate embankment set back distance can be determined from the following relation.

$$SB = Ze \times Dch$$

Where: SB = Set Back distance (m): min 6 m for small rivers, 3 m for khals

Ze = Side Slope of embankment

Dch = Depth (m) of channel (river, khal, borrow pit)

51. Set back distances of full flood embankments along bigger rivers when constructed or rehabilitated / retired are determined by:

- Erosion rate of shifting channel (provide space for minimum 10-years projected erosion of river bank)
- Sufficient space for borrow pits on river side

52. For embankments not exceeding 5m in height, minimum crest width shall be 2.50m. If the embankment is likely to be used as road, the crest width is selected according to the approved geometric design standards of LGED in below.

Road Class		Crest Width (m)
Village Road A	(VRA)	4.87
Village Road B	(VRB)	4.87
Union Road	(UNR)	5.5
Upazila Road	(UZR)	7.30

53. Crest elevation of full flood embankments will be designed for 1: 20-year annual HFL. However, with the freeboard as used, the embankment should not be overtopped by 1:50-year floods. When high embankments are provided on both sides of river, the embankment crest elevation should be designed for 1:20-year future-with-project HFL i.e. for the design flood level (1:20-year annual HFL) increased by the confinement effect. Calculations for confinement effect are not provided in these Guidelines. When necessary, appropriate reference documents need to be consulted.

54. Freeboard for inland full flood protection embankments shall be 0.60m and for embankments facing big rivers shall be 0.90 m on the 1:20-yr annual HFL. However, if "*1:20-yr annual HFL plus usual FB*" is less than 1:50-yr annual HFL, the FB should be increased as required to meet the requirement of the embankment not overtopping at 1:50-yr annual HFL. Freeboards for all submersible embankments shall be 0.30m (neither less nor more) over the design pre-monsoon HFL - 1:10-yr pre-monsoon HFL or May-HFL as the case may be.

55. Side slopes of full flood embankments will be designed considering slope stability (seepage and slope sliding) and future use of the embankment. As a general guideline, for inland embankments under average fill soil conditions (mixture of silt, clay and sand in moderate proportions), the recommended side slopes are given below. In case the soil used for embankment fill comprise mainly of sand, clay or organic material the side slopes should be flattened accordingly.

Embankment Height (m)	**Side Slope (V:H)**
0 – 1.99	1:1.5
2.00 – 3.99	1 : 2
4.00 – 4.99	1 : 2.5
5 and above	Determine from Detailed slope stability analysis

56. Full flood protection embankments often are required to withstand large difference of water levels between riverside (outside) and countryside (inside of subproject). Such difference causes seepage flow through the body of the embankment.

57. The safe gradient of seepage flow through the embankment body depends on the soil with which the embankment is built. Embankments of SSWRD subprojects are constructed with available local soils which are usually mixed clayey-silt to clayey-silt-fine sand type. For these usual type of soils, safe seepage gradient may be taken as 1 on 6 to 1 on 7. Gradient steeper than this may develop piping failure (dislodging and carrying away of soil particles) at the exit end of seepage line which, if continues for long, may lead to failure of the embankment.

58. Under a given set of riverside and countryside water levels, the gradient of seepage line established in the embankment section is given by:

S_{grad} = (riverside WL- countryside WL) / (horizontal distance between points of intersections of the two WLs with embankment slopes)

59. The embankment section should be so designed (crest width and side slopes) that the "S_{grad}" developed under the critical maximum differential head across the embankment may not be steeper than the safe seepage gradient value of the embankment soil i.e. 1:6 to 1:7 (V:H) which can also be said as 0.167 to 0.142. If other types of soils are used in

construction of the embankment, say predominantly sandy or clay soils, Detailed technical analysis is recommended.

60. Critical maximum head difference across full flood protection embankments are calculated considering 1:20-yr annual HFL on the riverside and Design Basin WL inside for subprojects where monsoon drainage takes place and in tidal areas. For subprojects where monsoon drainage is fully blocked, Basin WL will be obtained from full accumulation of mean monthly rainfalls of monsoon months. Similarly, for submersible embankments, inside WL will be the design pre-monsoon Basin WL for subprojects allowing drainage or the subproject WL caused by accumulation of all pre-monsoon rainfall up to the month of April for non-draining subprojects while the riverside WL will be the design pre-monsoon HFL i.e. 1:10-yr pre-monsoon (including June) HFL for usual areas and 1:10-yr May-HFL for Haor areas.

61. Design of side slopes on sea dikes requires special consideration taking into account tidal range, wind, wave and exposure (fetch distance). Generally sea dikes are designed with side slopes ranging from 1:3 to 1:7. Though subprojects involving sea dykes are not considered under SSWRD projects, inland embankments of SSWRD subprojects are exposed to tidal variation and moderate waves in outside waters. In such cases, depending on embankment height, flatter side slopes of 1: 2 to 1: 3 should be used.

62. In no case, embankments be constructed along existing khals/rivers right on the bank having common slope with the khal/river. If the existing embankment is right along the channel slope, the appropriate reach of the embankment during rehabilitation should be shifted inland to obtain the required minimum set back distance (3 m) or re-aligned along a different existing alignment.

63. Design of embankments, both for full and submersible embankments, are carried out by the MS Excel Spreadsheet Design Program ***EmbankDesign*** using the critical WLs and seepage considerations as discussed above.

64. Example *run-output* of DesignPro-5 ***EmbankDesign*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of all embankment reaches under the subproject will be done and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other programs in CD from PMO.

65. For construction and cost estimate, the embankment height should be increased by 15 cm to account for base stripping. (The 15 cm base stripping is a separate item in the Schedule of Rates but the extra fill volume should be included in the total embankment fill volume)

2.1.14 Borrow Pits and Berms

66. Source areas from which fill material is taken for construction of embankments are called ***borrow pits***. To save agricultural land, borrow pits should be located on riverside only. Free spaces left on both sides of a borrow pit i.e. space between the toe of embankment and the edge of borrow pit on one side, and space left between the edge of borrow pit on the other side and the river bank are called ***berms***.

67. The depth of borrow should not exceed 1.5 m. and a minimum 6.0 m berm should be left between the edge of borrow pit and the riverbank. The width of the embankment side berm i.e. the distance between the river side toe of the embankment and the edge of borrow

pit, should be from 3m to 10m depending on the depth of borrow pit and the side slope of embankment.

68. Borrow pits located on the riverside are expected to get silted, or filled up with soil and sediments carried by water during floods, and consequently reclaimed by agriculture. To prevent development of eroding flow concentration at embankment toe during high stages of river, at least 6 m wide strips between borrow pits every 30 m should be left along the alignment of the embankment.

69. In case of insufficient space for borrow pits on riverside and not enough material can be excavated from the khal or river, embankment fill material can be borrowed from the countryside. As there will be no filling up of borrow pits located behind high flood embankments, to maintain soil fertility, the excavation depth should not exceed 0.60 m.

2.1.15 Design of FMD Regulators/Sluices in Non-Tidal Areas[1] (excluding Haor areas)

Design for Drainage Flow

70. **Design for Size:** All hydraulic structures are to be designed in conjunction with the design of khals and embankments i.e. the same Design Basin Water Level and Drainage Rate that were used in design of khals (bed level, bed width, water depth) and embankments (top width, top level, side slopes, berms) should be used in the design of structures and these dimensions should match. However, to be conservative, design discharge of structures is usually taken a little higher (usually 20%) than the calculated discharge of respective drainage khals.

71. Non-tidal sluices and regulators are designed to pass safely design discharge generated by a 5-day 10-year annual storm rainfall over the subproject catchment (basin) area. The required size of the structure (vent/conduit dimensions and number of them) is determined by matching the structure discharge capacity at 0.30 m hydraulic head with the required basin discharge, calculated from drainage rate and catchment area, increased by 20 percent. In this calculation, the countryside water level should be kept at the Design Basin Water Level obtained from analysis of Drainage Rate and Basin WL corresponding to allowable crop damage criteria.

72. For calculating size (vent dimensions i.e width x height and number of vents) of regulators/sluices/water retention structures in non-tidal areas, the Spreadsheet Program in MS Excel ***SizeCal*** has been developed and used in the implemented SSWRD projects. The same Design Program ***SizeCal*** will be used to design sizes of all hydraulic structures – regulators, sluices, WRS and Rubber Dams.

73. Example *run-output* of DesignPro-6 ***SizeCal*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of all structures planned under the subproject will be done using ***SizeCal*** and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

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[1] The structures are defined as follows: ***Sluice*** – A hydraulic structure usually of conduit type constructed in a drainage khal at the crossing of flood embankment with drainage as the main function and equipped with an automatic flap gate at the downstream as the primary closing device. ***Regulator*** – A hydraulic structure usually with open water surface constructed in khals at embankment crossing or at other required location for various flow regulating functions like drainage, retention, flushing, etc and usually equipped with vertical slide gate as the primary closing device.

74. **Design of Riverside Stilling Basin:** Hydraulic energy of flow through structures is dissipated through formation of hydraulic jumps within concrete stilling basins provided at the downstream of the structures. To reduce lengths of these stilling basins to reduce cost and also to arrest the jump from skidding off from the concrete floor to the earthen channel downstream when extensive scour and damage due to it will happen, various auxiliary elements like baffling blocks on the floor, raised sills of different shapes at end of basin in dimensions and positions have been tested in laboratory models by different agencies and proposed for use under different field conditions.

75. Choice of stilling basin is largely governed by the value of Froude Number generated, at supercritical flow at the point of forming hydraulic jump, as the structure flows with a design head difference between upstream and downstream water levels and an optimum setting of floor level at the downstream. Indian Standard Stilling Basin Type-1 (for Froude Number 2 to 4.5) and USBR Stilling Basin for Low Froude Numbers (for Froude Number up to 4.5) have generally been used in this country with satisfactory performance.

76. For design of stilling basins and cut-off walls, a design hydraulic head of 0.80 m will be used for drainage flow, unless need for using higher hydraulic head is expressly justified by field conditions. Stilling basin floors will generally be depressed below invert level of structures by 0.60 m or 0.80 m. The exit velocity of water after the stilling basin, at the point of the end sill, may not exceed 1.00 m/s to avoid excessive erosion in the earthen section of khal downstream.

77. For erosion at the downstream earthen khal after the structure to be less, it is to be ensured that water level in the downstream khal is a little higher than the water level at the end of the hydraulic jump given by the sequent depth of hydraulic jump above the stilling basin floor. For this, water level in the downstream khal may be taken as the water level that corresponds to the discharge passed by the structure under the condition of forming the hydraulic jump. The desired condition can be met by setting the downstream stilling basin floor at a sufficiently lower level below the sill of the structure. However, too much lowering of the stilling basin floor entails construction problems in terms of dewatering of groundwater level at the construction site.

78. Four Types of Flow can occur through sluices depending on different conditions of upstream and downstream water levels. The four ***Flow Types*** with conditions for their occurring are shown in ***Exhibit G6-G: Conditions of Flow through Sluices*** appended to this document. Hydraulic jump can occur only under conditions of flow Type 3 and Type 5 and so the design engineer will keep the hydraulic head constant at 0.8 m and starting from the Design Basin WL in the subproject keep reducing both upstream and downstream WLs (but maintaining 0.8 m difference) until flow Type 3 or 5 is obtained. Each occurring of Flow Type 3 or 5 will generate a hydraulic jump. Lengths of these hydraulic jumps will be different and the maximum of the lengths will be used as the design length of the stilling basin.

79. Besides making the hydraulic jump to form when flow exits from the structure and holding the jump on the concrete floor, hydraulic design of hydraulic structures needs to address the issue of bed scour in the earthen khal section immediately after the concrete floor. Some bed scour at the place is inevitable as the channel regime changes from concrete to earthen and the flow leaving the concrete floor still carries some residual energy. The bed scour there would undercut foundation soil from beneath the downstream stilling basin that would lead to failure of the structure. This possibility is addressed by providing a vertical cut-off wall at the end of the stilling basin with depth more than the possible depth of scour there. Depth of this cut-off wall is also an important design aspect.

80. The *MS Excel Spreadsheet Design Program* ***EnergyStill*** has been developed and used in hydraulic design of stilling basins at the downstream of sluices/regulators in SSWRD projects with satisfactory performance. This Program for stilling basin and cut-off wall design is recommended for use in all SSWRD projects of LGED.

81. Example *run-output* of DesignPro-7 ***EnergyStill*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of riverside stilling basin of all structures planned under the subproject will be done using ***EnergyStill*** and the *run-output* be marked with ***R/S*** (for riverside) to distinguish it from the run-output of countryside basin. The printout of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

Design for Flushing Flow

82. Flushing, meaning that water enters into the subproject area from outside, is sometimes required in non-tidal environment during later part of monsoon when water level inside the subproject becomes low due to long rainless spell but outside water level remains relatively higher. If such a flow condition at the regulator or sluice is anticipated during planning of the subproject, a stilling basin need to be provided at the country side of the structure too.

83. Also, even when flushing is not expressly needed by the subproject condition, there may be mischievous operation or malfunction of the gates causing a *flushing* flow as the structure is in flood protection mode. Such kinds of situation need to be addressed such that the structure may not undergo severe damage due to scour at the upstream.

84. In non-tidal areas, dry season flushing is usually not possible as outfall rivers/khals also dries up or flows too low.

85. Usually, regulator / sluice structures are sized considering drainage flow as necessary for the subproject and one is to be happy with the amount of water that can be obtained during flushing through the already designed structure. Flushing flow occurs usually at small hydraulic heads. Calculations for available quantity of flushing flow are to be done with a head of 150 -200 mm.

86. Countryside stilling basin is designed for flushing flow with an assumed countryside water level at half-the-depth of the conduit and the structure operating at a constant hydraulic head of 0.60 m (flushing flow is likely to be much less severe than drainage flow). With this condition, river side WL = Invert El. + $D_{barrel}/2$ + 0.6 m and country side WL = Invert El + $D_{barrel}/2$. Usually flow Type 5 occurs; if not, WL on country side should be decreased keeping the riverside WL at same position (hydraulic head increases) until Type 5 flow is obtained.

87. To address the case of possible mischievous gate operation in flushing mode, it is recommended that the same design of countryside stilling basin as for the above flushing condition is adopted. That is to say, irrespective of whether flushing is required of the structure or not, the countryside floor of the structure will be designed for the flushing flow condition described above.

88. The countryside floor of the structures can be designed as stilling basin at the downstream for flushing flow by using the same Design Program ***EnergyStill*** with input data as discussed above. As input data for flushing flow are punched in, the Program indicates '*Flushing'* mode of flow and considers countryside floor as the downstream stilling basin.

89. Example *run-output* of *DesignPro-7* ***EnergyStill*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of countryside floor (stilling basin) of all structures planned under the subproject will be done using ***EnergyStill*** and marked with ***C/S*** (for countryside) to distinguish and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

Design for Exit Gradient and Uplift Pressure

90. Regulators / Sluices of FMD subprojects experience differential water levels across them during their functioning. Regulators/sluices working in flood protection mode (non-flowing) have higher WL on riverside than countryside. During drainage (flowing), these structures have higher WL in the countryside than the riverside. If FMD regulators have water retention functions / arrangements, storage WL (non-flowing) in the countryside will be much higher than WL in the riverside.

91. The difference between the upstream and downstream WLs is called '*head'* or '*pressure head'* across the structure. As these structures rest on porous soil which is also saturated by being submerged under water on both sides, a pressure gradient develops through the foundation soil and water flows under the impervious base of structure (termed as subsurface flow) to release out at the downstream end of it.

92. From the above phenomenon, two issues related to safety of the structure develop – (i) part of the structure downstream (considering hydraulic head) from the gate is subject to upward / floatation pressure which need to be addressed properly, and (ii) the subsurface pressure gradient should not be too steep to float out soil particles from underneath the foundation at the release point at downstream end. The later phenomenon by floating away soil particles from beneath the structure causes formation of pipe like voids under the structure foundation that eventually cause foundation failure.

93. The uplift pressure, being critical at the floor of the stilling basin located downstream considering the pressure head, is addressed by providing adequate thickness of floor concrete such that submerged weight of the floor concrete equals (the maximum if more than one cases exist) such uplift pressure. The possibility of piping failure is addressed by making the path length of subsurface flow longer so that pressure gradient at the exit point, termed as exit gradient Ge, is mild enough not to be able to float away soil particles from the exit point.

94. Analytical equations for exit gradient (Ge) and uplift pressure at key points underneath the structure are given by ***Khoshla*** for hydraulic structures on permeable soil. Khoshla's solution of the problem is considered mathematically complete. This method is commonly used in design of hydraulic structures in the Indian Subcontinent. According to Khoshla, critical exit gradient is 1:1 and safety factors are to be used based on different types of soil. The safety factor used in SSWRD Projects is 6 to 7 which Khoshla recommended for fine sand particles i.e the design exit gradients may not be more than 1:7 to 1:6.

95. A simpler method of calculating exit gradient and uplift pressures at different points underneath structures is given by ***Lane*** in his theory of creep path along the interface of the structure and foundation soil. He considers vertical creep path is fully effective and horizontal creep path is one-third effective and accordingly calculates the weighted creep path from the

upper to lower ends of the structure base. He recommends weighted creep co-efficient to be 8 for soils common in SSWRD projects in Bangladesh. Detaileds of the theories and derivation of equations will be found in reference books.

96. *MS Excel Spreadsheet Design Program* ***ExitG-Uplift*** has been developed and used in hydraulic design of sluices/regulators in SSWRD projects with satisfactory performance. It is recommended that this Program be used in designing hydraulic structures in SSWRD Projects for safe exit gradient and uplift pressure. The Program ***ExitG-Uplift*** addresses uplift pressures and exit gradients for pressure heads from both directions – flood control and water retention modes and gives combined outputs.

97. Example *run-output* of *DesignPro-8* ***ExitG-Uplift*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of all structures planned under the subproject will be done using ***ExitG-Uplift*** and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

2.1.16 Design of Regulators/Sluices in Tidal Areas

Design for Drainage Flow

98. **Design of Size:** Tidal sluices and regulators are designed to safely pass the design discharge generated by 5-day 10-year annual design storm runoff from the subproject catchment (design Drainage Rate x catchment area), taking into account variable downstream water levels over the tide cycle and tidal lockage of drainage, if any. The required size of the structure (vent/conduit dimensions and number of vents) is determined by matching the calculated structure discharge capacity with the required design discharge taking into account possible tidal lockage and increasing the calculated design discharge by 20 percent.

99. If high tide level is higher than the design basin water level, drainage will remain blocked for the time downstream tide water level remains above the basin water level. Therefore, the discharge capacity of structure (Q_{des}) is to be more than the day-average design discharge (Q_{av}) to compensate for the lockage period and is calculated using a multiplying factor as below. The multiplying factor is also given by the ratio of 24 hrs to the actual hrs of drainage occurring during the day (two tide cycles).

$$Q_{des} = K\, Q_{av}$$

Multiplier K = (HTL- LTL)/(Basin WL – LTL), where HTL= high tide level, LTL = low tide Level

100. With the variation of downstream water level with tide, the hydraulic head across the structure changes from “zero” when downstream water level is at Basin water level to maximum “Basin WL- LTL” when downstream water level is at LTL. After this, the hydraulic head again changes to “zero” during the rising tide. Accordingly, discharge through the structure also changes from “zero” to maximum “Q_{LTL}” and then again changes to “zero” during the rising tide. To determine size of the structure (vent/conduit dimensions and number of vents), the average discharge during the tide cycle with an accepted conduit dimension and a trial number of vents will be matched with the Q_{des}. Though a linear variation of tidal water level is assumed at the downstream of structures with constant basin water level at the upstream, discharge through the vents may not be linear over the tide cycle because flow type may change between Type-1 to Type-5 with change of downstream water levels.

101. To take the non-linearity of discharge over the linear variation of water level, discharge calculations are done for short periods by dividing the “drainage time” during a half cycle of tide into several short intervals, usually 5 to 7 steps of time, and then averaging the calculated step discharge values to obtain the overall average discharge during the half tide cycle which is also the $Q_{tidal\ (av)}$. This $Q_{tidal\ (av)}$ will be matched with Q_{des} above to obtain the required number of vents. The step discharges will be calculated by using the Spreadshet Design Program ***SizeCal***. Sample calculation for sizing of a tidal sluice/regulator by using the Program ***SizeCal*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference.

102. **Design of Stilling Basin (Riverside):** Design for stilling basins and cut-off walls for tidal regulators/sluices will be similar to the designs for non-tidal structures except that (i) the design head for tidal stilling basins will be given by Design Basin WL at the upstream side and LTL at the downstream side and (ii) as the water level in downstream khal (termed as Tail WL) is determined by LTL , it may at times be quite low causing the hydraulic jump to skid off from the floor to the earthen khal below and accordingly, the stilling basin floor may have to be depressed more than 0.80m as has been suggested for non-tidal stilling basins. The Spreadsheet Design Program ***EnergyStill*** will be used for design calculations.

103. Example *run-output* of *DesignPro-7* ***EnergyStill*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of riverside stilling basin of all structures planned under the subproject will be done using ***EnergyStill*** and marked with **R/S** for riverside and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

Design for Flushing Flow

104. **Size and Inside WL in Flushing**: Tidal sluices/regulators are provided with flap gates at the riverside that operate automatically in flood protection mode to prevent flushing flow. Therefore, if flushing flow is required, the flap gates are to be hold lifted by installing a special lifting mechanism usually using ropes and tying/locking arrangements. . This makes the sluice / regulator to remain open as long as the gates are hold open i.e subproject inside water level is determined by riverside tidal water level.

105. Flushing is required only in freshwater tidal areas in dry season for HYV Boro rice cultivation. Late monsoon flushing may also be necessary for Aman rice crop in some areas where long rainless days occur towards the end of monsoon season.

106. **Tidal sluices/regulators are not designed in size considering flushing flow**. These are sized for drainage requirements and flushing water available through the structures is used for irrigation. Usually, sizes of such structures are adequate because irrigation water inflow requirement is quite less than drainage outflow requirement.

107. **Design of Stilling Basin (Countryside):** Countryside stilling basins for tidal flushing structures are designed for the condition of flow through the structure with an anticipated low water level inside the subproject and the average HTL over the flushing period on the riverside. The Spreadsheet Design Program ***EnergyStill*** will be used for design of the stilling basin and cut-off wall depths. The maximum velocity at the end of stilling basin (velocity corresponding to discharge and subcritical conjugate depth after the hydraulic jump) should not exceed 1.0 m/s. Width of stilling basin at the end and depressing the floor below invert of the structure may be adjusted to meet the condition.

108. Example *run-output* of *DesignPro-7* ***EnergyStill*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of countryside floor (stilling basin) of all structures planned under the subproject will be done using ***EnergyStill*** but marked with ***C/S*** for countryside and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

109. **Design for Uplift Pressure & Exit Gradient:** Tidal regulators/sluices experience maximum pressure head from the riverside in flood protection mode. The critical condition will be with design HTL (1:20-yr) in the riverside and Design Basin Water Level in the countryside.

110. Maximum pressure head on the tidal structure from the countryside will be with Design Basin Water Level in the basin inside and minimum LTL on the riverside during drainage (pre-monsoon/monsoon) period. Sometimes, water is retained in the countryside for use in irrigation by providing an additional vertical slide gate in the countryside of the structure. In such cases, another pressure head from countryside given by maximum retention WL inside and minimum LTL in the riverside during the retention time (dry period) will exist and the governing one will be used to design uplift and floor thickness in the riverside.

111. The Program ***ExitG-Uplift*** will be used to design the structure for exit gradient and uplift pressures. The Program addresses uplift pressures and exit gradients for pressure heads from both directions – flood control and drainage/water retention modes and gives combined outputs.

112. Example *run-output* of *DesignPro-8* ***ExitG-Uplift*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of all structures planned under the subproject will be done using ***ExitG-Uplift*** and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants

2.1.17 Design of Water Retention Structures

113. **Design for Size:** Water retention structures (WRS) are gated structures meant for conserving water in khals and associated low lands/beels in post-monsoon to dry seasons usually for irrigation use. WRS are constructed in Water Conservation subprojects located in non-tidal areas, in flooded as well as in upland flood free areas.

114. WRS are similar to regulators with vertical gates but with open top without breast wall. In WRS, water flows in only one direction during drainage and so there is no need for a hydraulically designed stilling basin on the upstream (country) side. A nominal floor to make a good transition between the structure vents and the upstream khal will be provided.

115. As the vents in WRS are open at the top, flow passes through the structure unobstructed like an open channel. Accordingly, size of WRS is determined from passing the design monsoon flood discharge (increased by 20%) under Type 4 flow condition with a nominal hydraulic head of maximum 0.3 m.

116. Drainage through the WRS is not restricted like flood management regulators/sluices and so flood routing analysis to find a drainage rate corresponding to a specified crop damage criteria does not apply. Instead, estimate of design monsoon flood discharge is

made based on channel parameters (cross-section and channel bed slope, flood time water surface slope may be a little flatter) and observed HFL (1:10-yr flood) at the site.

117. The main consideration for sizing a WRS is that the structure may not raise monsoon time flood level in the upstream by making a constricted section (at the structure) and therefore design discharge capacity of the structure may not be less than the above estimated maximum monsoon flood flow increased by a safety margin of 20%.The design program ***SizeCal*** will be used to calculate size (vent width and number of vents) of WRS.

118. Example *run-output* of *DesignPro-6* ***SizeCal*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of the WRS planned under the subproject will be done using ***SizeCal*** and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

119. **Design of Downstream Stilling Basin:** The downstream stilling basin length and depth of cut-off wall will be designed considering the 1:10-yr HFL at upstream and a 0.8 m hydraulic head of flow using the design program ***EnergyStill*****.**

120. Example *run-output* of DesignPro-7 ***EnergyStill*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of downstream stilling basin of the WRS planned under the subproject will be done using ***EnergyStill*** and marked with ***D/S*** for downstream/riverside and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants. The Design Program will be available along with other Programs in CD from PMO.

121. **Design of Upstream Floor/Apron:** Usually, WRS never flow from downstream towards upstream and so upstream floor is not required to be designed for hydraulic flow considerations. Length of upstream floor will be governed by what is required for transition of the structure width at the vents to upstream channel section. However, if retention head is big, requirement of total impervious floor length will also be big (refer to design for exit gradient using Program ***ExitG-Uplift*** below). In such situation, upstream floor length may be increased as required on question of economy because thickness of upstream floor is less than the downstream floor.

122. **Design for Uplift Pressure & Exit Gradient:** Downstream stilling basin floor will be designed for pressure head with maximum design water retention level at the upstream and lowest water level in the khal downstream or bed level of khal if it would be dry. The design program ***ExitG-Uplift*** will be used for this design. Usually retention heads are high for WRS and the total impervious length of structure (downstream floor length + central part length + upstream floor length) may fall short in respect of exit gradient. The shortfall may be provided by increasing either of the floor lengths or both as may be considered judicious. It is to be noted that as thickness of upstream floor concrete is less than the downstream floor, increasing length of upstream floor will be economical, if however there is nothing to the contrary.

123. Example *run-output* of *DesignPro-8* ***ExitG-Uplift*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of the WRS planned under the subproject will be done using ***ExitG-Uplift*** and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants

2.1.18 Design of Rubber Dams

124. **Advantages and Considerations**: Rubber Dams, usually built in small to medium rivers and large khals to retain water in the channel of the khals/rivers for use in irrigation in the dry season. Rubber Dams are up to about 30% cheaper than gated regulator structures in channels having widths 30 m or more. For channels smaller than 30m, Rubber Dam is not a recommended option on economic ground.

125. Rubber Dams require much less effort and cost for operation and maintenance compared to gated structures of comparable sizes. Rubber Bags are observed to have 20-yr life period under average care-taking conditions.

126. The principal consideration in designing Rubber Dams is that the structure may not constrict the existing waterway of the channel at the site and cause raised flood level in the upstream. In practice, a maximum of 10% reduction of waterway area is usually allowed. As the damming rubber bag between abutments are deflated to pass monsoon flow of the river/khal, waterway area at the structure calculates to length of Rubber Dam between abutments (L_{dam}) multiplied by the depth of water over the sill of the concrete floor on the river bed (D_w) i.e. $A_{structure} = L_{dam} \times D_w$.

127. A Plane Table survey of the site of the Rubber Dam covering at least 100m distances in the upstream and downstream from the structure location including both banks of the river/khal is obtained and alignments of the mean bank lines over the surveyed 200 m reach on both banks are established by visual inspection of the PT survey map and considering a smooth flow of the river between the bank lines over the surveyed reach. The distance between these two mean bank lines at the proposed centre line of the Rubber Dam is taken as **Length of Rubber Dam (L_{dam})**.

128. Considering longitudinal profile of lowest bed level the river/khal over a reach of about a kilometre, the mean bed profile of the river/khal is established and the mean bed level at the proposed centreline of the Rubber Dam is determined. Usually, **sill of the concrete structure** at the bed of the river/khal is set 300-500 mm above this mean bed level of the river/khal and the rubber bag is fixed on this part of the concrete floor at the river bed. Depth of water for waterway calculation at the Rubber Dam location shall be measured from the 1:20-yr flood flow water level to this sill level and denoted as D_w.

129. Existing waterway at the Rubber Dam location ($A_{existing}$) shall be computed from the surveyed cross-section of the river at the location corresponding to the 1:20-yr flood level. It is to be checked that $\mathbf{A_{structure} > 0.90 x A_{existing}}$.

130. **Afflux at Flood Flow**: Hydraulically, the Rubber Dam structure with the dam bag fully deflated acts as a single vent hydraulic structure in discharging flood flow. The 1:20-yr flood flow (Q_{20}) of the river/khal at the location is estimated from the surveyed cross section of the river/khal using the computed / estimated 1:20-yr HFL and the surveyed mean channel bed slope by Manning's equation considering roughness co-efficient (n) value to be 0.035. The Speadsheet Design Program ***SizeCal*** will be used to calculate afflux (h) at the structure to pass Q_{20}. It is recommended that the afflux may not be more than 500mm. It is expected that with this size of the Rubber Dam structure, afflux at ordinary to low order floods will be insignificant.

131. **Design of Downstream Stilling Basin and Cut-off Walls**: The distance between abutments being quite large (more than 30m) and there being no piers and consequently no possibilities of flow obstruction between the abutments, it is not expected that flow at the structure will ever occur with a significant difference in water level between upstream and

downstream, say more than 500-600 mm, in non-tidal rivers/khals. In floods, flows at the structures will, accordingly, be subcritical. Energy dissipation issue will come at falling floods at smaller depths of water in the river. It is recommended to use Design Program ***EnergyStill*** to generate a set of flow situation (forms hydraulic jump or not, length of jump, scour depth, etc) with different upstream WLs and flow heads of 400mm, 600mm and 800mm with a downstream floor depressed by, say, 1.00m. From the scenario of assumed flow condition and required stilling basins as given by the above calculations, a design stilling basin and cut-off wall depths will be judged out.

132. In tidal rivers/khals, the downstream water level in the river lowers faster under the tidal effect and the differential head between upstream and downstream water levels may be higher depending on the tidal range at the site. That is, the set of calculations using ***EnergyStill*** may be done with a set of a little higher flow heads – say 600 to 1000 mm. The other aspects of the analysis in designing will be similar to the non-tidal Rubber Dams.

133. **Design of Upstream Floor/Apron:** In Rubber Dam structures, upstream floor is not required to be designed for any hydraulic flow considerations. However, water retention head in Rubber Dams are quite big – usually 3 to 5 meters. Such big retention heads require quite long impervious floors, much longer than what are needed at the downstream floor for energy dissipation. Usually, most of this additional length requirement is provided at the upstream floor for reasons of economy as the floor thickness at upstream is only nominal.

134. **Design for Floor Thickness and Exit Gradient:** Rubber Dams retain significant depths (3-5 meters) of water in the upstream and usually this retained pressure head governs requirement of impervious floor length. Thus, additionally safe lengths of downstream stilling basin can be provided. The design program ***ExitG-Uplift*** will be used to design the floor lengths in respect of exit gradient and uplift.

135. Example *run-output* of *DesignPro-8* ***ExitG-Uplift*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of the Rubber Dam structure planned will be done using design program ***ExitG-Uplift*** and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.19 Design of Weirs

136. Weirs are fixed raised sill structures to retain water at its upstream at the level of the raised sill. Flood flow of the khal is to pass over the sill. Length of the weir is usually fixed by the width of the khal and the design discharge (1:10-yr flood increased by 20%) passing over the weir crest attains a depth given by the standard formula for flow over weir as given below. The water level given by this depth on the weir crest is higher than the usual flood level meaning that weirs increase flood level in its upstream. Also, weirs prevent sediments to flow out and the khal at its upstream gets silted up soon. The raised sill weirs are constructed as a RCC or brick wall and a stilling basin for dissipation of energy of over-falling water is provided at the downstream.

$Q_{des} = CLH^{1.5}$, where C= 1.8 (for sharp crested weir)

L= Length of weir

H= Depth on weir crest (neglecting velocity head)

Q_{des}= Estimated design discharge increase by 20%

137. Because of the inherent disadvantages – increasing flood level in the upstream and silting up of the upstream channel as discussed above, use of fixed raised crest weirs are

not usually recommended except in sites where the disadvantages are not considered as significant issues.

138. Detailed design of stilling basin and cut-off walls at the downstream of the weir crest will be done using the design program ***EnergyStill*** with appropriate incorporation of elevation drop between weir crest level and downstream floor level replacing glacis drop (Zc) in the energy equations. Also design program ***ExitG-Uplift*** will be used to design for exit gradient and uplift pressure at the downstream stilling basin of the structure. Print out of *run-outputs* of the design programs will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.20 Design of Regulators in Submersible Embankments in Haor Areas

139. Haors are typical to Sylhet Basin land depressions that remain deeply flooded from May through October. Cropping in monsoon is not possible due to deep flooding. Only Boro rice is grown in dry season throughout the whole Basin area. However, the area suffers from early flash floods that often damage Boro rice, the only crop grown in the area, at harvesting time. Constructing low, submersible embankments with flushing and drainage structures placed at strategic locations can provide protection from early pre-monsoon flooding and permit cultivation of HYV Boro rice that require longer growing season. Since submersible embankments permit flooding during monsoon, this type of development poses only limited restriction on fish habitat, and as such should be considered environment friendly. However, maintenance cost of submersible embankment is relatively more as they undergo erosion at the time of being overtopped.

140. The submersible embankments and regulators are designed to prevent entry of water into protected area in April through 20th May when harvesting of Boro rice is almost done. After 20th May, regulator gates are gradually opened and the Haors filled with incoming flood water nearly to embankment crest level before the riverside water level starts overtopping the embankments. As the subproject area gets flooded, gates of all regulators will be kept fully open vent throughout the monsoon season so that drainage through the structures are not obstructed in post monsoon.

141. It should be noted that the level of annual flood peaks have no bearing on hydraulic design of a structure, except that operating deck should be located above annual flood level. This is mainly for identification of structure location in the sea of water in monsoon season for safety of navigation when water crafts cross cut in the shortest path.

142. These regulators flow twice a year as explained below:

a. **Flushing Flow to Fill Haor**: As harvesting of crops nears completion, water from outside the embankment need to be flushed into the subproject area (Haor) through the regulators to build up inside water level near to top of the submersible embankment quickly so that when water from outside overtops the embankments, difference of water levels remains low, say about 0,30m, and erosion to the embankment remains as low as possible. Only about 10 days time is likely to be available to fill the whole Haor area to level as explained above.

b. **Post-monsoon Drainage:** In post monsoon, the regulators flow in the drainage mode to drain the whole subproject (Haor) area before planting time of Boro rice. Drainage should take place at low heads, say about 0.30m, to prevent possible damage to structures due to excessive scour in the river side. Usually, a time of 30-40 days is available to drain out the subproject Haor, the quantity of water for flushing in and draining out being nearly the same.

143. Haor areas are quite flat and variation in land elevations over the area is likely to be insignificant. Therefore the subproject (Haor) area can be considered as a pond with depth of water (D_w) given by the difference between average GL of the subproject area and the top level of the submersible embankment. Thus, volume of water in the subproject area within submersible embankment top and total drainage and flushing discharges can be estimated as below:

V_{water} = A x D_{av}

$Q_{Flushing}$ = V_{water} /(10days x 24hrs x 60 x 60) = V_{water}/864000 (10-day flushing time)

$Q_{Drainage}$= V_{water} /(30days x 24hrs x 60 x 60) = V_{water}/2592000 (30-day drainage time)

Where, A = area of Haor, D_{av} = av depth, V_{water} = Vol of water, Q = Total Discharge

144. **Number of Regulators Required:** Generally, discharge capacity required for flushing is much higher, 3 to 4 times, than for drainage because time available for drainage is 3 to 4 times more than the time available for flushing, volume of water involved being nearly the same. This can be seen from the derivations above. Thus, number of vents required for a submersible embankment polder is to be designed considering flushing only.

145. Usually, water level outside the regulators will be high, say near to embankment top, when flushing will be started by opening gates. To be noted that gates **must not** be opened too much at a time. This will cause excessive scour below the structure and cause its failure. Initially, the gate shall be opened by 0.30m when hydraulic jump will form but will have tendency to sweep away downwards as tail water level (WL in the basin) will be low. Further opening of gate will be waited until WL inside the basin develops so that the hydraulic jump becomes stable on the stilling basin at the toe of the glacis. At this stage, the gate will be open for a further 0.30m and waited until hydraulic jump is seen to be remaining on the stilling basin area. The gate will be opened this way gradually to the full opening. If there are more than one regulator, all should be operated as simultaneously as possible to get their benefit.

146. As the gates are opened gradually, discharge through the regulator increases to maximum when the gates are fully open. Though variation of discharge is not linear, it can be assumed so for practical purposes and the average discharge may be assumed to pass when the gate is half open. That is to say, discharge of a flushing regulator in a submersible embankment polder can be assumed to be the discharge with outside WL at embankment top, the gate is open by half the vent height and the regulator flowing at Type-3 (inside water level low having no impact on flow). The Spreadsheet Design Program ***SizeCal*** can be used to calculate number of vents required for the total discharge ($Q_{Flushing}$). The vents are distributed in regulators at suitable locations along the embankment.

147. **Design of Stilling Basins:** Regulators in submersible embankments in Haor areas flow in both directions – towards the subproject in flushing mode and outwards in drainage mode. Flow in flushing mode is critical as it occurs under higher head. Inside stilling basin should be designed using outside WL at embankment top and the regulator flowing with Type-3 flow at different gate openings and adopting an optimum stilling basin length. For the drainage flow, it is not expected that flow head may be more than 0.60m head under any special conditions because all regulators will remain open simultaneously. The Spreadsheet Design Program ***EnergyStill*** will be used for design of the insid and outside stilling basins separately.

148. **Design for Exit Gadient and Uplift:** Pressure heads at submersible regulators are not high. From riverside towards inside the subproject, this may be taken as the difference between top level of submersible embankment and average GL of the subproject area and

from countryside towards riverside, this will be even smaller – may be considered nominally as o.80m. Exit gradients and floor thicknesses of both inside and outside stilling basin floors will be designed using the program ***ExitG-Uplift*** using the pressure heads as described.

149. Printout of *run-outputs* of all the design programs will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

150. Generally, Haor area subprojects having less than 1,000 ha area requiring to be completely enclosed by submersible embankments may not be feasible for implementation under SSWRD Projects, because of high cost of structures and maintenance of submersible embankments (annual O&M cost may reach up to 30% of capital cost). However, where the subproject area is already almost enclosed by high roads, or other kind of ridges to about the May 15 WL, it may be feasible to close the remaining gap with either a submersible embankment or a high embankment as may be considered fit and providing regulators. In such cases, even if high embankments are used, the subproject area should be filled up at the end of Boro season using controlled flushing, so the structures are not damaged under high hydraulic head.

2.1.21 Gates of Hydraulic Structures: Types, Sizes and Design

151. Hydraulic structures function up to the purpose for which those are built by use of their gates and hoisting systems. Gate leafs are fabricated using mild steel plates, angles, channels, etc joined, fitted and fixed mainly by welding but also as necessary by using other fitting –fixing methods like nut-bolts, etc. Gates are not required to be designed for individual regulator structures. Standard designs made for standard range of operating conditions prevailing in the country usually are sufficient.

152. Two type of gates - vertical lift gates and flap gates are used in SSWRD subprojects. Standard drawings of a vertical lift gate and a flap gate are given in ***Chapter IV: Standard Drawings*** for reference.

153. Raising and lowering of vertical gates are done mainly by using hoisting gear systems with manual operation. Sometimes, overhead differential pulley - chain systems are also used. In SSWRD subprojects, gate sizes are limited to 1.65m width by 1.875m height (fitting 1.50m x 1.80m vent openings) for mechanical hoisting gear system so that one person can lift the gate by operating the hoisting gear manually by using an operating handle. Standard design of hoisting gears use gears for mechanical advantage for the operator's efforts to be easy. For gates of a little bigger sizes and where lifting and lowering of gates are not frequent in a season, overhead differential pulley - chain systems are generally recommended. Flap gates are fixed at ends of conduits by hanging from end-headwalls using hinges such that it flaps by itself – opens or shuts against the conduit face under pressure of water from either inside or outside respectively. Flap gates do not need any operation when it works in flood protection mode.

154. Gates, both vertical and flap types, meant for flood prevention will be fitted on the riverside face of the conduit / vent so that higher flood level in the riverside presses the gate against the conduit / vent face and no leakage may happen. Gates (only vertical gates) meant for retaining water in the countryside will be fitted on the countryside face of the conduit / vent for the same reason – retained water will keep the gate shut against the vent / conduit face and prevent leakage.

155. Many structures will need to function for both the purposes – flood prevention in monsoon and water retention in the post-monsoon to dry season. Such structures should be

provided with both types of gates because gate for one purpose will not serve for the other purpose as their functions are influenced by pressure of water on them.

156. Flood protection regulators having vertical gates will allow flushing water inside simply when the gate is raised if water level permits. But flushing is ordinarily not possible with flood protection regulator/sluice fitted with flap gates. However, sometimes flap gated sluices are required to flush-in water from outside. In such situation, flap gates are pulled up and hold in its open position for the flushing time by making special arrangements using ropes with some locking or tying mechanism.

157. Gates – both vertical and flap types must be provided with good quality and properly fabricated and fitted sealing rubber strips to make them satisfactorily leak proof.

2.1.22 Selecting Invert Elevation of Hydraulic Structures

158. The invert elevation of hydraulic structures - regulators, sluices, water retention structures, is usually set 0.30 m to 0.50 m above the bed elevation of a channel on the upstream side of the structure. The purpose of raising the invert is to:

- Create a favourable fish habitat by preventing total drainage of the channel during falling water levels (tidal and non-tidal),
- Increase the hydraulic discharge coefficient,
- Improve structure operating conditions by reducing the possibility of sediment deposition in the structure conduit, and
- Secure tail water depth during the initial stage of flushing, particularly for structures in tidal area.

2.1.23 Site Selection for Hydraulic Structures

159. From consideration of construction, quality of works and foundation it is better to locate structure in excavation, in loop-cut or in diversion channel, than in existing channel. This is because, generally, foundation soil in bed of open channel is weaker as the soil is decompressed and also loose or muddy. Also, as in most cases the structure construction is not completed in one year, there is a need for constructing temporary diversion channel or allowing flood water to pass over uncompleted works. However, from consideration of avoiding land loss, most of the SSWRDP structures are located in existing khals.

160. As a general rule, *hydraulic structures should be located downstream from bridge or culvert if existing at the site.* This is to prevent damage of the existing bridge or culvert by concentrated and higher velocity discharge leaving the hydraulic structure for which bridges and culverts may not have been designed. However, *the best would be to incorporate the hydraulic structure with the existing bridge/culvert by necessary modifications/adjustments* so that land loss for construction of new structure is avoided and the cumbersome view of two or more structures at the same place is also avoided.

161. In case the hydraulic structure cannot be combined with the existing bridge/culvert and also there is no suitable location on the downstream side, hydraulic structure can be constructed on the upstream side of the bridge. But in that case, the space between the hydraulic structure and bridge/culvert must be protected. The protection can be by CC blocks or brick blocks, or by concrete/RCC walls attached to the bridge abutments or wing walls.

162. When sluice or regulator is near the outfall river, the governing criterion is a safe set back distance from the outfall channel. Namely, the structure must be beyond the potential riverbank erosion expected within the lifetime of the structure near an active river. If there are no signs of riverbank erosion, a 15 - 20 m distance should be provided from the outfall riverbank to the downstream end of structure block-protective work.

163. If the above set back criteria locate the structures on the downstream side (river side) of flood embankment then the structures may be constructed in a position along the embankment. If however, the location is in the subproject side of the embankment, it should be constructed there and be connected to the embankment by approach embankments.

2.1.24 CAD Subprojects: Design of Irrigation Canals

164. **Alignment:** Irrigation canals should be aligned meticulously for economy and efficiency of the system. The selected alignment should provide:

- Minimum disruption of existing drainage pattern - lines of high grounds to be followed.
- Minimum requirement for cross drainage structures like aqueducts, siphons, culverts.
- Minimum interference with existing roads, navigation and property lines. The alignment may be shifted to boundary line to avoid fragmentation of land properties into cut-off un-accessible small plots
- Maximum command area per unit length of canal to minimize land requirement, construction and maintenance cost.

165. **Design of Canal Section:** General criteria and methods for design of canals (khals) and embankments are applicable in designing cross-section of irrigation canals. Hydraulic design of canals will be done **using Manning's equation** with roughness factor selected appropriately (n=0.035 for earthen and n= 0.03 for concrete sections). Seepage gradient (minimum 6H:1V) through canal embankments should be checked with FSL in the canal and GL at low points along the outside toe of the canal. To reduce land requirement and increase section efficiency, the inside side slopes may be constructed 1:1 and strengthened with concrete, brick lining, etc. if considered appropriate and cost effective.

166. To prevent sediment deposition, minimum flow velocity should be not less than 0.5 m/s, while the maximum velocity should be selected as non-erodible velocity for earthen canals usually not more than 1.0 m/s.

167. Canals with trapezoidal section (earthen section with lined bed and internal slopes) should be provided with 0.3 m freeboard above full supply level (FSL). Square/rectangular section canals made of concrete or brick walls should be provided with 0.15 m freeboard above FSL.

168. To facilitate inspection and communication/transportation, crest width of irrigation canal bank in fill should be provided as per local requirement but not less than the recommended minimum crest width of 0.6 m.

169. **Compaction of fill:** The irrigation canal earthen section can be (i) in excavation (ii) in fill, and (iii) partly in excavation and partly in fill. Ideally, earthen canal on fill should be avoided. However, if unavoidable, much care is to be taken for compaction of the fill soil

properly and a suitable lining on canal bed and side slopes is to be provided to avoid severe seepage and section failure as water flow starts.

170. Construction of raised canals with square/rectangular section of RCC, concrete or brick constructed over earth-filled embankment should be scheduled for 2 years. Earthen portion of the canal should be completed in the first year of construction (with section increased for settlement and erosion) and allowed to settle during monsoon season, and the concrete section constructed in the second construction year, in dry season.

2.1.25 CAD Subprojects (Buried Pipes): Design for Pipe Diameter and Pressure Head

171. **Review of System Layout and Design Parameters:** Layout of pipeline system with irrigation area delineation and design parameters like crop water and irrigation water requirements, irrigation Duty, etc and preliminary design of discharge, pipe diameter will be obtained from Feasibility Report – given in maps, tables and charts in various Appendices in the Engineering Annex. These will be reviewed for revisions, adjustments, if required.

172. **Design of Pipelines:** Deign pressure head at each outlet is taken as 0.50 m above the highest irrigated land level in the command area of the outlet i.e the *irrigator unit*. That means, each outlet will have a minimum pressure head it requires to supply irrigation water throughout the entire *irrigator unit.*

173. Head loss in flowing pipes due to friction can be calculated by two formulas: *Darcy-Wiesbach formula* and *Colebrook White Formula* as shown below. Either one can be used in design of the pipe system of CAD subprojects. In design of LGED's buried pipe irrigation subprojects, the *Darcy-Wiesbach* formula has been used.

> ***Darcy-Wiesbach Formula*: $H_L = f\,(L/D)(v^2/2g)$**
>
> Where
>
> L=pipe length of reach between nodes (m)
>
> D=internal diameter of pipe (m)
>
> V=pipe flow velocity (m/s), for PVC pipes max=1.5m/s, min=0.30m/s, mod=0.80m/s
>
> g= acceleration due to gravity (9.81 m/s^2)
>
> f= Moody friction factor; for PVC pipes 0.0168, for Conc pipes 0.02.
>
> HL= head loss in pipe reach (m)

174. The above formula is written using pipe diameter D. The formula can also be written using hydraulic depth of full flowing pipe which is D/4. In that case, Moody friction factor *f* in this formula is changed to 4f' where value of f' is taken as one-fourth of what is to be taken for f.

> ***Colebrook White Formula*: $V= (-)2(2gDS)^{0.5} \log [(k_s/3.7D) + (2.51v/D(2gDS)^{0.5}]$**
>
> Where
>
> V= pipe flow velocity (m/s), for PVC pipes max=1.5m/s, min=0.30m/s, mod=0.80m/s
>
> D= internal diameter of pipe (m)
>
> S= hydraulic gradient
>
> k_s=effective roughness (m); PVC pipes: spigot-socket=0.06mm, chem. cemented=0.03mm.
>
> g= acceleration due to gravity (9.81 m/s^2)
>
> v= kinematic viscosity of water (0.00111 at 15^{o}C)

175. Buried pipe system includes bends, fittings like tees, valves and entry and exit conditions. This cause loss of head to different extents. These losses are expressed in fractions of the velocity head at the place as $h_l = C\ V^2/2g$, where C is the coefficient defining the fraction and $V^2/2g$ is the velocity head. The coefficient C varies from 0.05 to 1.2 depending on fittings and on smooth or rough conditions faced by flowing water. In practice, a very accurate calculation of head loss for fittings is not necessary. A conservative approach in estimating these head losses is to count all types of fittings and bends together in the reach and use an average value of C as 0.75 to calculate the total head loss of the reach.

176. MS Excel Spreadsheet Design Program ***BuriedPipeDesign*** has been developed and used to facilitate design and choice of pipe diameters, head losses, hydraulic pressure head in each reach of the pipeline. The design is carried out working from the tail towards upstream up to the header tank. All the pipe lines will be designed this way and it is to be checked that the pressure head at the header tank has been the minimum to meet the requirement of all the branch and sub-branch pipelines.

177. Example *run-output* of *DesignPro-9* ***BuriedPipeDesign*** is given in ***Table G6-III.1: List of Spreadsheet Design Programs*** of this Document for reference. Detailed design of all the buried pipelines planned in the subproject will be done using design program ***BuriedPipeDesign*** and print out of *run-outputs* will be submitted in the Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

2.1.26 Height of Header Tank

178. Design of pipe system described above is to be done twice - first with pipe discharges calculated using the *usual* (three-month) duty of irrigation and second using the *peak* (one-month) duty of irrigation. The first one will give design diameter of pipes and the second one will give the design height of the header tank. Maximum pressure head and height of header tank should be limited to 3-5 meters for usual duty condition and 5-8 meters for the peak duty condition.

2.1.27 Surges and Water Hammer

179. **Surge:** Any transient pressure fluctuation in an open pipe line system is termed as *surge.* Surge is caused when air enters into and gets trapped in water in the pipe line and suddenly finds way to exit say through air-vents. Surges particularly occur when pumping re-starts after a closure when air in the pipelines gets trapped easily. If a large volume of air is suddenly released, a shock wave will be developed.

180. **Water Hammer:** When kinetic energy of flowing water is transformed into pressure energy, say by sudden closing of valves, sudden release of large volume of air and sudden stoppage of pumps, a pressure wave is generated that oscillates back and forth in the pipeline. This is called *water hammer*. When the pressure wave finds a open water surface as in a air-vent stand pipe, the wave reflects back on itself resulting a dampening effect and eventually the water hammer dies out. If a free surface of water is not met, the oscillation will continue undampened.

181. The uPVC pipes used in LGED's CAD subprojects are of 3.25 bar (32 m) rated pressure. For such low pressure pipes, standard specification requires that surge/ water hammer pressure may not exceed 30% of rated pressure (10 m) of the pipes. If the maximum operating pressure in the pipe system and the surge pressure exceeds rated pressure of the pipe, the pipe wall or joints may blow up.

182. Providing air valves at the air-vent pipes which prevent sudden air release prevents surge pressures. However, in the flat terrain of Bangladesh, protection against surge and water hammer is provided by the followings:

- Using steel pipe between pumps and the header tank,
- Providing open standpipes upstream of every outlet (these release air and dampen water hammer),
- Using standpipe diameter equal to or not less than 70% of the diameter of the pipeline at the place.

2.1.28 Buried Pipe Irrigation Structures

183. Type of structures and their typical numbers that are usually required in a typical buried irrigation (uPVC) pipe distribution system are described below in ***Table G6-II.1*** below along with summary of their functions. The number of structures shown is typical and will be determined by design of individual subprojects. Some structure, particularly pump house, flow control structure, standpipe outlets, may not be necessary in some subprojects. Outline drawings of the structures are given in ***Exhibit G6-L: Criteria and Design of Command Area Development Subprojects*** for reference. Detailed design and construction drawings of the structures will be prepared and provided in Detailed Design and Drawing Folder of the subproject for review by the PMO-Project Consultants.

Table G6 II-1: Descriptions and Functions of Buried Pipe Irrigation System Structures

Nr	Structures	Typical Nr Required	Description	Function
1	Pump House	0-1	Masonry walls and concrete floor, may be depressed, to house required number of motors and pumps. Steel shutter windows and doors, and corrugated iron sheet or concrete slab roofing.	Protection and security of pumping equipment.
2	Header Tank	1	Rectangular reinforced concrete structure with 3 main separate compartments, and with (steel) ladder and operating platforms to provide access to gates / shutters and flow measurement V-notches. Also hand railing and washouts *(A cheaper alternative would be a circular reinforced concrete tank with electronic flow monitoring devices to outlet pipes).*	To receive discharge from pumps and allow settlement of sediment to removed by flushing / manually. Also to enable flow control and flow measurement to offtaking pipelines. Height to be sufficient to drive design flow through conveyance pipelines.

Nr	Structures	Typical Nr Required	Description	Function
3	Flow Control Structures	0-3	Reinforced concrete structures with gates / shutters / valves and V-notch weirs located at head of rotation units.	To provide flow control and flow measurement facilities at head of rotation units.
4	Outlets for irrigation (risers)	30 (typ.)	Lateral uPVC pipe offtake from pipeline leading to (concrete/PVC) riser pipe capped with an alfalfa valve. Masonry outlet box to be located over riser pipe. The outlet box supplies water to field channels with pucca-nuccas built into the walls of the outlet box controlling flows to the field channels. If lay flat hose connections are proposed then the walls of the outlet box are about 1.2 m high and steel pipes are set into the walls of the outlet box to which hoses may be attached.	To release irrigation flows from pipeline to typically 5-15 ha *irrigator units,* usually every 200-500 m along pipeline.
5	Standpipe Outlets	0-10	Lateral uPVC pipe offtake with control valve and RC access box leading to steel pipe riser to which 1-2 lay flat hoses may be attached.	To release smaller flows for hose conveyance to irrigate small areas of higher land, ponds, homestead gardens, etc
6	Standpipes (air vents)	30 (typ.)	Vertical uPVC pipe leading off from top of uPVC pipeline at high points and usually just upstream of outlets (risers). Standpipes to comprise uPVC pipe placed within concrete pipes for support / protection.	To ensure pressures within pipeline remains within design limits and to allow air to vent. Top of standpipes to be 0.6 (typ) m above design HGL
7	Escapes (standpipe overflows)	3	Vertical uPVC pipe leading off from top of PVC pipeline at key locations and where escape flow can discharge safely through surface ditches. Small clear piezometric tube to be fitted to allow monitoring of water	To allow monitoring of pressures in pipeline, feed back to pump operator to increase / decrease pumping flows, and for excess flow to discharge safely into drainage ditch. Top of standpipes to be 0.3

Nr	Structures	Typical Nr Required	Description	Function
			level (pressure).	(typ) m above design HGL.
8	Washouts	3	uPVC pipe offtake with control valve and RC access box located at low point(s) in pipelines	To allow periodic flushing and emptying of pipeline for repairs and removal of sediment.

2.1.29 Pump House

184. The pump house will typically have brick masonry walls and a concrete floor that may be depressed below ground level so that the suction head for the pumps does not exceed a practical limit of 5-6 m. It should be sufficiently large to house the required number of motors and pumps. Steel suction and delivery pipe work should be arranged to facilitate access to the pumps for operation/ maintenance. For ventilation steel shutter windows and doors are required. The roof may be corrugated-iron sheets or a concrete slab. The pump house provides protection and security for pumping equipment. A typical arrangement of pumps in a pump house is shown in ***Exhibit G6-L: Criteria and Design of Command Area Development Subprojects***. However, arrangements at different sites will be different.

185. For subprojects drawing water from larger rivers, it may not be practical to locate pumps inside the pump house, even with a depressed floor, as the pumping suction head could be too high (more than about 4-6 m) in the lean season. In this case, usual practice is either to provide a concrete platform on the river bank slope where the pumps may be placed in the lean season and removed during the monsoon, or to provide a floating platform anchored to the river bank. Unless the river bank is stable any pumping platform should comprise a reinforced concrete slab supported on top of precast concrete / steel sheet piles. Access steps to the platform would facilitate placement/ removal of pumps.

2.1.30 Header Tank

186. Height of header tank is determined by pipeline design considering peak demand flow based on 1-month irrigation duty to provide necessary head to supply irrigation water to all the outlet risers. A freeboard of 0.2 m may be provided. As pressure head requirement for usual flows is much lower, to avoid pumping excessive heights that incur unnecessary pumping cost, the discharge pipes from the pump house enter the tank in the bottom half of the tank.

187. There would be three main compartments in the Header Tank. The first receives water from the delivery pipes and facilitate settlement of any coarse sediment. Flows into the second compartment are controlled by (200mm or 250mm) alfalfa valves operated from an operating platform on top of the tank. From the second compartment, if flow measurement is not necessary, flows may be through orifices (can be closed by valves operated from the platform) into the third compartment. If flow measurement is required, the orifices will be closed and flow will be passed over 90^0 V-notch weirs and measurements are recorded.

188. The second and third compartments are divided into sub-compartments according to the number of off-taking pipelines. The number and diameter of alfalfa valves is determined from the design flows, adopting a head loss of 100 mm for each valve.

189. Only one V-notch weir will be provided to measure the flows to each off-taking pipeline and their crest levels vary according to the design discharges – the higher the discharge the lower is the crest. Sufficient head loss (likely to be 150 mm) should be allowed so that flow over the notch remains free i.e unaffected by downstream water level

2.1.31 Flow Control/Measurement Structures

190. For many subprojects flow control/measurement for rotation units would be at the header tank when each rotation unit will be supplied by a separate pipeline from the header tank. However, for the larger subprojects, a pipeline offtaking from the header tank may supply water to two or more rotation units, in which case an additional flow control / measurement structure will be needed at junction of the pipelines from those rotation units.

191. A typical secondary flow control/measurement structure will comprise several compartments. The inlet pipe would discharge into the first compartment, from which flows into second compartment would be controlled by alfalfa valves operated from the top of the tank. Flow measurement to each pipeline would be by a 90^0 V-notch weir set into the partition wall between adjacent compartments.

192. The secondary flow control/measurement structure would incorporate the following features: (i) trash racks to prevent trash entering the off-taking pipelines; (ii) an operating platform to access the valve operating handles and V-notch weirs; (iii) access ladders; (iv) small pipe drains set at the floor of the structure to allow cleaning of each compartment; and (v) pipe overflows set at design water level.

193. Height of the structure is given by the pressure head obtained from pipeline design, specifically the hydraulic pressure head in the off-taking pipelines plus head losses at the structure itself.

194. If flow measurement is not needed then a simple and much less expensive alternative would be to provide a gate / sluice valve located within a valve chamber/box at the head of each off-taking pipeline. To protect against surge pressures and allow exit / entry of air a standpipe should be located just upstream of the valve.

2.1.32 Riser Outlets

195. In uPVC pipe line system, outlets typically comprise a laterally off-taking uPVC pipe leading to a riser pipe capped with an alfalfa valve set at an offset position from the main pipe line. The offsetting is to avoid damage to the main pipeline due to construction of heavy masonry works on it and also to allow access to the pipeline in events of repairs being required. For main pipeline with concrete pipes, the riser pipe can offtake directly from top of the main line and the distribution box built there. A masonry distribution box is located over the riser pipe. To prevent tampering of alfalfa valve, a lockable cover may be provided on top the outlet box.

196. Depending on area of the irrigator unit, the offtaking pipe diameter should vary from 160-225 mm, and the alfalfa valve be either 150mm or 200mm in diameter. The distribution box supplies water to field channel, and the pucca-nucca built into the walls of the outlet box control flow to the field channel.

197. For outlets supplying water for lay-flat hose conveyance to farmers' fields an alternative design of the distribution box will be with high walls - assuming water is to be conveyed less than 100-150 m then, a 1.2 m high walls are likely to required. In the walls, outlet pipes are fixed to which farmers are to connect their irrigation hoses.

2.1.33 Standpipe outlets

198. For smaller areas, less than about 10 ha, or to provide water to fish ponds, standpipe outlets are suggested. These structures comprise a uPVC pipe lateral offtake, with control valve housed in a small masonry chamber, leading to a steel pipe riser to which arrangements for connecting 1-2 lay flat hoses may be made.

2.1.34 Air Vent Standpipes

199. Air-vent standpipes comprise vertical (uPVC / concrete) standpipes leading from the top of the main pipeline. Air-vents are located at high points along the pipeline and just upstream of every outlet. They allow entrapped air from the pipeline to vent and ensure that surge/ water hammer pressures in the pipeline remain within limits. Top of air-vent standpipes is usually 0.6 m above the design hydraulic grade line (pressure head) at the standpipe point.

200. The air-vent standpipes may comprise just concrete pipes placed one above the other from small base concrete on top of a short uPVC riser pipe. If this simple design is adopted then the concrete joints must be sealed carefully and may require periodic re-sealing. Alternatively, the uPVC riser pipe may be taken to the required height, in which case a concrete pipe surround will be used in the lower part of the PVC pipe for protection.

201. Diameter of the standpipes should not be less than about 70% of the parent buried pipe diameter while their heights will depend on the design pressure in the pipeline. For an upstream control system, as in ours, the pressure in the pipeline declines from the header tank to the tail. For most subprojects, heights of standpipes will probably vary from about 6.0 m at the head to a minimum of 1.6 m at the tail end.

2.1.35 Escape Standpipes

202. Escape standpipes also, like air-vent standpipes, comprise vertical uPVC / concrete pipes leading from the top of the parent pipeline. Escape standpipes are located at a few key locations and allow excess flow to discharge safely into a drainage ditch. The top of escape standpipes is usually set just 0.3 m above the design hydraulic grade line at the position. Escapes always are provided with a small clear piezometric tube fixed to the standpipe to allow monitoring of pressures in the pipeline and "*feed back*" to the pump operator to increase supply if pressure is low, and to decrease supply if pressure is too high.

203. Construction of escape standpipe will be like the alternative construction of air-vent standpipe explained above – continuing the uPVC riser pipe up to the full height and using a protective concrete pipe surround in the lower part. The piezometer pipe will be fixed above the concrete pipe surround. The escape pipes will be provided with a bend pipe at the top so that excess water falls a distance away from the standpipe, where the ditch starts.

2.1.36 Washouts

204. Washouts comprise a side pipe off-take from the parent pipeline fitted with a control (gate) valve and leading to a concrete / masonry protective box. Washouts should be located at particularly low points along the pipelines, usually one for each line, to allow periodic flushing of sediments from inside the pipelines and emptying for repairs, when needed.

2.1.37 Pumps and Power Requirements

205. A pump set comprises the followings and is about 1-2 percent of the subproject cost:

- *Pump* - cast iron centrifugal pumps up to 8 inch (200mm) size manufactured locally.
- *Power unit* – either an electric motor or a diesel engine
- *Steel base frame*- on which the motor and pump are fixed – usually skid type
- *Main switch and starter* – for electric motors only
- *Electric connection to mains* – for electric motors only
- *Battery and starter* – for diesel engines only (manufactured locally)
- *Other associated items* - steel pipes (suction and delivery), pipe bends, gate valves, foot-valve (to prevent back flow) and screen, etc.

206. Electric motors (average power efficiency 75%) are much more efficient than diesel engines (average fuel efficiency 25%). Also electric power attracts a significant subsidy in Bangladesh. For these reasons adoption of electric motors will reduce operation costs. However, complete reliance on electric motors makes farmers vulnerable to load shedding, frequent in Bangladesh, and crop losses.

207. Roto-dynamic pumps fall into the following categories: (i) axial flow pumps – low head and high discharge; (ii) centrifugal pumps – high head and low discharge; and (ii) mixed flow pumps. They are all designed to run at constant speed and their performance is dependent on pumping head and discharge, power requirement, efficiency of operation.

208. Axial flow pumps, very popular in China, Thailand, Vietnam but not much in use in South Asian countries including Bangladseh, are 10-50% energy saving for static lifts of 1-2 m but not energy saving for heads 3m and above. Axial flow pumps are therefore not suitable for CAD subprojects that usually involve pumping heads of 5-6 meters.

209. Centrifugal pumps covering wide range of discharges and heads are manufactured in Bangladesh by Milners Pumps Ltd. Most of the CAD subprojects under SSWR development have used these local pumps. Information of the pumps on model and sizes, operating range of heads and discharges are given in ***Table G6-II.2*** below. For subprojects with pumping heads ranging between 6-13 m, Pump Type C is likely to be most suitable, while for higher heads, 11-20 m, Pump Type F is suitable. The Yanshan pump is suitable where even larger heads, from 12-29 m, and higher discharges are required.

Table G6 II-2: Particulars of Centrifugal Pumps for Use in CAD Subprojects

(Pumps A to F are from Milners and Yanshan is from China)

Pump ID	Pump Model	Suggested Pipe Size		Range of Flow (m³/hr)	Range of Total Dynamic Head (m)	Most Efficient Operating Point				
		mm	inch			m	m3/hr	l/s	cusecs	Eff %
A	ETA 80-20	100	4	43 - 111	13.8 - 9	**12**	**84**	23	0.8	80%
B	ETA 100-20	125	5	66-158	12.8 - 8.1	**11**	**120**	33	1.2	80%
C	ETA 125-20	150	6	108 - 288	12.5 - 6.6	**11**	**178**	49	1.7	80%
D	ETA 100-26	125	5	70 - 182	21.5 - 13.7	**19**	**132**	37	1.3	80%
E	ETA 125-26	150	6	117 - 285	22.8 - 15	**20**	**218**	61	2.1	80%
F	ETA 150-26 CN	200	8	212 - 458	20 - 11	**16**	**362**	101	3.6	80%
Yanshan	250 S 24	250	10	250 - 650	29 - 12	**24**	**470**	131	4.6	84%

210. Significant friction loss occurs at the pump set and accessories which should be considered with due care. For a reasonable typical pumping installation comprising 4 bends / fittings and 40 m of pipe, the total friction head loss would be about 3-4 m for *peak* flows which may drop to about half this for *usual* flows.

211. Observations indicate that amount spent on energy in a single year is more than the cost of the pump sets. Thus, taking care to select pumps that will be operating efficiently will reduce irrigation cost significantly.

212. To allow for varying irrigation demand, at least three pump sets are recommended for CAD subprojects, and in general 3-6 pumps will be provided depending on scheme size, location and crops grown.

213. For a given discharge and head the energy required is given by:

$$Energy\ (kWh) = \frac{9.81\ Q\ H\ T}{(e_1\ e_2)}$$

where:

Q is the pumped discharge (m^3/s)

H is the average pumping head (m)

e_1 the pump efficiency (in the order 0.7–0.85)

e_2 the motor driving efficiency (0.7–0.9 for electric motors and 0.1–0.35 for diesel engines).

214. Using the above formula and considering pump efficiency 75% and electric motor efficiency 75%, a spreadsheet calculation of power requirement for a scheme of net irrigation area of 313 ha, a gross water requirements of 826 mm and an average pumping head of about 9 m, gives energy requirement using electricity as 360 kWh/ha which with a rate of BDT 4.50 per kWh costs BDT 1620 per ha per season.

2.2 Structural Design

2.2.1 Stress Analysis of Structure Using STAADPro

215. Analysis of stresses (moments and shears) in hydraulic structures are done in LGED using STAADPro V8i. The software is based on Finite Element Method of structural analysis using a matrix approach.

216. **Model of structure geometry:** As hydraulic design of the structure is completed, most of the necessary dimensions (lengths, widths, thickness) and levels including configuration Detaileds of a structure are known. Some dimensions, levels (thickness and, at times, length of piers between vents, elevation of wing wall top, etc will be provided as usually used nominal / minimum values and site specific values. The geometry of an individual structure under analysis will be modelled using these data. The model consists of large number of small finite elements connected by nodes (connections between the elements). An output model geometry of typical regulator is shown in ***Exhibit G6-J*** as an example at the end of this document.

217. **Definition of material:** Material for construction of hydraulic structures will be defined as isotropic concrete with $E_c = 4700\sqrt{f'c}$ where $f'c$ = compressive strength of concrete in N/mm^2.

218. **Defining foundation condition:** Hydraulic structures are considered to be on mat foundation. Accordingly, supports of hydraulic structures are to be defined as plate mat and modulus of foundation soil will be specified as determined by subsoil investigation tests.

219. **Unit weight of materials:** Standard unit weight of materials as given below will be used in the analysis:

Unit weight of soil (moist)	17.40 kN/m^3
Unit weight of soil (saturated)	18.90 kN/m^3
Unit weight of concrete	23.60 kN/m^3
Unit weight of water	9.81 kN/m^3
Backfill material	Sand
Angle of internal friction, φ	25^0 (backfill sand)

220. **Loadings in hydraulic structures:** In pre-monsoon to monsoon seasons, hydraulic structures remain in conditions with high water levels in and around them e.i. the structures will exert their submerged weight on foundation soil while in dry season full weight of the structures will be borne by the foundation soil. Similarly, as there will be water inside the structure (either flowing or non-flowing) during monsoon, lateral load on the structure from backfill soil will be reduced by the counter hydrostatic pressure of water from inside the structure. Thus loading condition of hydraulic structures is not critical in pre-monsoon to monsoon seasons. Accordingly, hydraulic structures are to be designed for loadings appropriate in dry seasons. – dry unit weight of concrete and unit weight of moist soil.

221. **Lateral soil pressure:** Abutments and wing walls of hydraulic structures are subject to lateral soil pressure. Usually, locally available fine sand is specified as the backfill material and so φ=25^0 may be used to calculate active earth pressure. Though design condition will consider dry season, a minimum of 1.00m depth of water will be assumed to exist in the backfill behind the regulator abutments (the same level of water will be considered for the wing walls – depth may be higher). For this part of the backfill, lateral soil pressure will be

with submerged unit weight of soil together with full lateral pressure of water. The lateral loads on abutment and wing walls of hydraulic structures are elaborated in ***Exhibit G6-K***.

222. For all abutments-wing walls, a 750mm surcharge height of soil will be assumed.

223. **Vehicular load** on bridge deck of hydraulic structures will be used considering location and traffic using the bridge. However, minimum vehicular load considered in rural areas without on any traffic route shall be wheel loads of standard H10 trucks. For structures on regular traffic routes or falling on Upazila roads, standard H20 Truck wheel loading shall be used for the bridge deck.

224. **Primary Loads for hydraulic structures:** For small hydraulic structures, wind and seismic loads are not applicable. Therefore, primary loads in hydraulic structures will, typically, be defined as:

Dead Loads (DL)	: self weight of structural elements/members (gravity load)
	: additional self weight, if any in specific cases (gravity load)
Live Load (LL)	: Wheel Load on Bridge Deck (gravity load)
	: Load on operation deck assumed 5 kN/m^2 (gravity load)
	: Weight of soil on heel of retaining wall (gravity load)
	: Lateral earth pressure on abut-wing walls (trapezoidal lateral)

225. **Load Factors and Combination of Loads:** For Ultimate Strength Design (USD) of hydraulic structures, the USACE Engineer Manual 1110-2-2104 (1992), Change-1 (2003) adopted the load factor combination prescribed by Modified ACI 318 by revising load factor for lateral fluid pressure from 1.4 (ACI value) to 1.7 and applying a hydraulic factor (H_f) of 1.3 to the total factored design load for members not in direct tension (the value for direct tension members being 1.65). Accordingly, for hydraulic structures, total factored design load is given by

$U_h = 1.3\,(1.4\ D + 1.7\ L)$, D = Dead Load and L = Live Load

226. **Performing Analysis:** Usually, a Linear-Elastic-Static analysis would be done for hydraulic structure used in SSWRD projects unless otherwise specifically needed for any particular structure. The output of STAADPro analysis will provide stresses (moments) in each of the elements.

2.2.2 Reinforced Concrete Design

227. Component members of the structure like the box part, operation platform part, wing wall (sloping top part),wing wall (horizontal top part) and return wall parts will be designed in sections as appropriate by judging the STAADPro output element moments and selecting a design moment for the section. This is advised to be done by visual examination of the element moments of the sections so as to be able to apply designer's judgement pragmatically.

228. Once the design moments for the component sections are decided as above, Spreadsheet Design Program ***StructuralDesignUSD*** will be used to design reinforced concrete section of the member – thickness of concrete and reinforcing steel bar

requirement. Example run-output of *DesignPro-10* ***StructuralDesignUSD*** is given in ***Exhibit G6-G.10*** of this document.

229. The equations and parameters used in design of reinforced concrete sections by USD method is given below:

Design Equations:

Mu = Moment from STAADPro Output (selected design Moment)

Mn = Mu/ϕ = Design Moment

ρ_{max} = Maximum Steel Ratio

$$m = \frac{f_y}{0.85 f_c'}$$, m= stress ratio

$$\rho_b = \frac{\beta_1}{m} x \frac{600}{600 + f_y}$$ ρ_b= Reinf. ratio producing balanced strain condition

$$\rho = \frac{1 - \sqrt{1 - \frac{2 * m * M_n}{f_y b d^2}}}{m}$$ ρ = steel ratio

Design Parameters

Yield Strength of Steel (f_y)	415 N/mm^2
Compressive Strength of Concrete (f'_c)	21 N/mm^2
Neutral Axis depth factor (β_1)	0.85
Recommended limit of ρ/ρ_b	0.25
Recommended limit of ρ_{max}/ρ_b	0.75
Modulus of Elasticity of Steel (E_s)	2.0 E+05 N/mm^2
Modulus of Elasticity of Conc (E_c=4700$\sqrt{f'_c}$)	2.15 E+04 N/mm^2
Strength Reduction factor for flexure (ϕ)	0.90
Strength Reduction factor for shear (ϕ)	0.75
Temperature/Shrinkage Reinforcement (A_{st})	0.002 bt

III. SPREADSHEET DESIGN PROGRAMS

3.1 Background

230. Spreadsheet Programs in MS Excel have been developed and used in analyses and design of SSWR subprojects in LGED since 1990s. Spreadsheet Programs have the advantage that the user can follow the calculations visually, apply checks and judgment including checking with alternate conditions. However, it is to be noted as a warning that the programs may turn up to inadequate or unsafe design with users who may not be properly qualified in using input data and conditions.

3.2 Spreadsheet Programs for Design of SSWRD Structures

231. The Programs that have been referred in Documents of this Set of Guidelines in relation with planning, analyses and design of the various structures and component works involved in small scale water resources development projects/subprojects are all presented in one place in this Chapter in example printouts for viewing and reference of users. The Programs in soft copy are available in CD with IWRMU/PMO.

232. The following is a list of the Spreadsheet Design Programs and printouts of example *run-outputs* of the Programs are given in ***Exhibit G6-G***.

Table G6 III-1: List of Spreadsheet Design Programs

Nr	Program Nr	Program Name	Use
	A. Hydrological and Impact Analyses		
1	AnalysPro-1	DRate&BasinWL	Analysis for Design Drainage Rate and Design Basin Water Level corresponding to the standard acceptable crop damage criteria. The Design Basin WL is used to analyze agricultural impact of the subproject and in hydraulic design of subproject structures (see ***Exhibit G6-G.1).***
2	AnalysPro-2	LandType&Change	Assessment of flood-depth based Land Type corresponding to WLs in the subproject basin. Used to assess agricultural impact by calculating Land Type change due to DR and FMD interventions (see ***Exhibit G6-G.2).***
	B. Design of Khals and Embankments		
3	DesignPro-3	KhalDesign-NT	For design of drainage khal / irrigation canal in non-tidal condition with '*uniform flow*'. The Program uses Manning Equation (see ***Exhibit G6-G.3).***
4	DesignPro-4	KhalDesign-T	For design of drainage khal in tidal condition / khal for tidal water supply for irrigation. Though these khals flows under 'varied flow' condition, design is done using Manning Equation for short steps of time / small change in WL when flow is considered nearly uniform and Manning Equation is considered to apply. The step discharges are averaged to get the net total discharge (see ***Exhibit G6-G.4).***
5	DesignPro-5	EmbankDesign	For design of flood protection embankments – both for full flood protection and submersible for Haor areas. Main design criteria used in the design program are seepage gradient through embankment body and nominal side slopes for types soil used in construction. And crest widths from minimum of 2.50m to the top widths of roads for which the embankment is likely to be used – village

			roads, union roads, etc (see **Exhibit G6-G.5).**
	C. Design of Hydraulic Structures (Regulators, Sluices, WRS, Rubber Dams)		
6	DesignPro-6	SizeCal	Size of a hydraulic structure (regulator, sluice, WRS) means internal dimensions of vents/conduits (width x height) and number of the vents used in the structure. Hydraulic structures flow under one of *four specific flow types (Type-1, Type-3, Type-4, Type-5)* .under combinations of water levels at their upstream and downstream sides. The program works with appropriate flow types corresponding to the given WLs and calculates discharge through the structure. Usually vent dimensions are pre-specified and number of vents is changed to compare discharge through the structure with the design discharge (see **Exhibit G6-G.6).**
7	DesignPro-7	EnergyStill	Stilling Basins dissipate energy of flowing out water by creating hydraulic jump. Besides, various baffles are added in the basin to ensure forming jump on the basin and increase its energy dissipation efficiency. Various types, shapes and Detaileds of stilling basins have been designed, tested in physical models and suggested for use in applicable field conditions. In Bangladesh, Indian Standard Stilling Bbasin I, USBR Stilling Basin IV and USBR Stilling Basins for Low Froude Numbers have been used in SSWRD subproject structures with satisfactory performance. The program EnergyStill uses these standard stilling basins as the user thinks appropriate (see **Exhibit G6-G.7).**
8	DesignPro-8	ExitG-Uplift	Hydraulic structures are subject to differential head of water between their upstream and downstream sides as they work in different modes – flood protection, drainage and water retention. The differential head establishes subsurface flow and the structure is subject a floatation phenomenon in the downstream (relative to water head) stilling basin floor and also possible loss of foundation soil due to seepage flow. The design program uses Khoshla's method to design addressing the issues (see **Exhibit G6-G.8).**
	D. Design of Buried Irrigation Pipelines		
9	DesignPro-9	BuriedPipeDesign	As pipeline systems are planned to reach all areas in the subproject to supply irrigation water based on approximate calculations, a Detailed design for flow, velocity and head loss through the pipe system by each pipeline is to be done to see if the whole system operates properly and to ascertain required head at the Header Tank and pumping capacity needed for the operation. The design program uses Darcy-Weisbach Formula for pipeline design (see **Exhibit G6-G.9).**
	E. Design of Reinforced Concrete Structure		
10	DesignPro-10	StructuralDesignUSD	The program provides design of reinforced concrete sections based on specified design parameters using USD method (see **Exhibit G6-G.10).**
	F. Estimate of Quantity of Works and Cost		
11	EstimPro-11	QtyEstimate	The Program is developed to carryout calculations of volume of works (concrete, brickwork, reinforcing steel, certain other works required in construction of hydraulic structures. Dimensions, etc are provided from Drawings as data in input file which are then taken by the program for calculation of quantities by members/ works (see ***Exhibit G6-G.11*).**. The calculated quantities may need to be grouped to fit works in LGED Schedule of Rates.

IV. STANDARD DRAWINGS

4.1 Drawings for Re-excavation of Khals

233. **Standard Construction Drawings for Re-excavation of Khals** will be prepared using autoCAD and provided in A3 Sheets and will include:

a. **Title Sheet:** The sheet will contain name of khal with length and name of subproject with location in Upazila nd District.

b. **Longitudinal Profile** of Khal showing (i) existing surveyed profiles of bed and bank lines (left and right banks) with surveyed levels at each 100m and also at special sections surveyed in scale 1cm =.100m (x-axis) and 1 cm = 1m (y-axis), (ii) locations with chainage of all features along the alignment viz bridges and culverts (with length, roadway width, foundation type, structural condition), branch khals (with name, bed level, top width), other similar features, (iii) separate rows will be used along x-axis below the profile drawing to write values of distance, existing bed, left bank and right bank levels, design bed levels, reach wise sectional parameters (bed width, side slope), others, if required.

c. **Cross-Section Profiles** of khal at every 100m survey points showing existing cross-sections with design section superposed. If there is design embankment at the section, its design section will also be shown.

d. At each cross-section, the **area of earthwork** (cutting in khal section and filling, if any, in embankment section should be measured using autoCAD and be written on the Drawing.

e. Each drawing sheet will have a **Title Box** at the right hand bottom corner giving owner agency and office name, name of project, subproject and subproject ID, name of work, Drawing number with sheet number if applicable, date and identification of persons preparing, recommending approving the Drawing.

234. Example **Drawings of Long and Cross-Section Profiles** of khal are given in ***Exhibit G6-H.1*** for reference. Soft copy of **Standard Drawings in AutoCAD** will be obtained from IWRMU/PMO in CD.

4.2 Drawings for Re-sectioning of Embankments

235. **Standard Construction Drawings for Re-excavation of Khals** will be prepared using autoCAD and provided in A3 Sheets and will include:

a. **Title Sheet:** The sheet will contain name of embankment with length and name of subproject with location in Upazila and District.

b. **Longitudinal Profile** of embankment showing (i) existing surveyed profiles of top centreline and toe lines (left and right sides) with surveyed levels at each 100m and also at special sections surveyed in scale 1cm =.100m (x-axis) and 1 cm=1m(y-axis), (ii) locations with chainage of all features along the alignment viz bridges and culverts (with length, roadway width, foundation type, structural condition and name of khal/river), road crossings with type of road, top level and top width, name of market places by the side, other similar features if any, (iii) separate rows will be used along x-axis below the profile drawing to write values of distance, existing crest level, ground levels at eft side and right side toe lines, design crest levels, reach wise sectional parameters (crest width, side slope), others if required.

c. **Cross-Section Profiles** of embankment at every 100m survey points showing existing cross-sections with design section superposed showing top width and side slopes.

d. At each cross-section, the **area of earthwork** in filling in embankment section should be measured using autoCAD and be written on the Drawing.

e. Each drawing sheet will have a **Title Box** at the right hand bottom corner giving owner agency and office name, name of project, subproject and subproject ID, name of work, Drawing number with sheet number if applicable, date and identification of persons preparing, recommending approving the Drawing.

236. Example **Drawings of Long and Cross-Section Profiles** of embankment are given in ***Exhibit G6-H.*2** as reference. Soft copy of **Standard Drawings in AutoCAD** will be obtained from IWRMU/PMO in CD.

4.3 Drawings for Construction of Regulators/Sluices/WRS/Rubber Dams

237. **Standard Construction Drawings** for the structure will be provided in A3 Sheets in autoCAD. Usually the following Drawings will be required; however, there may be change in the names and number of Drawings for particular structures. For Rubber Dams, number of drawings will generally be more as the structures are generally large and have additional components like bridge, pump houses, pipelines, etc.

(i) Index Map of Subproject

(ii) Title Sheet of the Drawing Set

(iii) Layout Plan

(iv) Site Development Plan

(v) Subsoil Bore-Logs

(vi) Foundation Treatment Detaileds

(vII) General Plan and Section

(viii) Section Limit Detaileds

(ix) Protective Works

(x) Concrete Outline Detaileds

(xi) Reinforcement Detaileds

(xii) Detaileds (Miscellaneous)

(xiii) Bar Bending Shapes

(xiv) Bar Bending Schedule

(xv) Drawings of Gates

238. Example **drawings of a 2-vent regulator** (vent size 1.50m x 1.80m) are given in ***Exhibit G6-H.3*** for reference. The drawing numbers and sheet numbers may be arranged and organized as considered necessary for individual cases. Soft copy of **Standard Drawings in AutoCAD** will be obtained from IWRMU/PMO in CD.

4.4 Drawings of Gates of Hydraulic Structures

239. Two types of gates – vertical lift gates and flap gates are used in hydraulic structures. Sometimes both type of gates are used in the same structure. Example Drawings of both type of gates are given in ***Exhibit G6-H.4.*** Flap gates have only two drawings – of the gate leaf and a frame to be fixed embedded at the face of the vent opening against which the gate shuts as water pressure increases. For vertical lift gates, besides the drawing of the gate leaf and embedded metal fittings, mechanical drawings for fabrication of the hoisting gear and pedestals are given. These drawings are standard and fixed, needs no change between gates, sites, etc. Soft copies of the drawings may be obtained in CD from IWRMU/PMO

V. ESTIMATE OF QUANTITY & COST AND BILL OF QUANTITIES

5.1 Estimate of Quantities

240. Estimate of quantities of works - concrete, brickwork, reinforcement, earthwork in foundation excavation, etc for hydraulic structures (regulators, sluices, WRS, Rubber Dams) in LGED are done using the Spreadsheet Program ***QtyEstimate*** developed in MS Excel for the purpose. Input data from Drawing of the structure are inserted in the ***Input Worksheet*** of the Program and the Program give various quantities by works and members/parts of the structure in the **Calculation Worksheet**. The quantity figures of different members/ type of works are added up as necessary to fit the Items of LGED Rate Schedule. An example *run-output* of *EstimPro-11* **QtyEstimate** is given in ***Exhibit G6-G.11*** for reference.

241. If a structure has any special component not covered by the Spreadsheet Program, its quantity should be estimated manually and added to the quantity outputs of the Program as appropriate.

5.2 Estimate of Cost and BOQ

242. Estimated cost of items of works required for the structure are obtained by providing the estimated quantities and using **LGED's RSEPS** (**R**ate **S**chedule **E**stimate **P**reparation **S**ystem) software that uses LGED's Schedule of Rates for concerned Districts for coded items of work. As all the required work items have been included, the total estimated cost of the structure is summed up. The RSEPS also provides **BOQ** of the structure for use in the Tender Documents.

243. Example *run-outputs* of Cost Estimate and BOQ using RSEPS is given in ***Exhibit G6-I.1*** and ***Exhibit G6-I.2*** for reference.

EXHIBITS

Exhibit G6-A: Climatic Design Data of Subproject (for Dr, TI, FMD, WC Subprojects)

Exhibit G6-B: Climate & Rainfall Data of Reference District (for CAD subprojects)

Exhibit G6-C: Crop Water & Irrigation Water Requirements and Design Irrigation Duties

Exhibit G6-D: Rainfall Data of Subproject

Exhibit G6-E: River (Outside) Water Level Data

Exhibit G6-F: Area-Elevation-Storage Data

Exhibit G6- DesignPro-4G: Spreadsheet Design Programs

Exhibit G6-G.1: AnalysPro-1 **DRate&BasinWL**

Exhibit G6-G.2: AnalysPro-2 **LandType&Change**

Exhibit G6-G.3: DesignPro-3 **KhalDesign-NT**

Exhibit G6-G.4: DesignPro-4 **KhalDesign-T**

Exhibit G6-G.5: DesignPro-5 **EmbankDesign**

Exhibit G6-G.6: DesignPro-6 **SizeCal**

Exhibit G6-G.7: DesignPro-7 **EnergyStill**

Exhibit G6-G.8: DesignPro-8 **ExitG-Uplift**

Exhibit G6-G.9: DesignPro-9 **BuriedPipeDesign**

Exhibit G6-G10: DesignPro-10 **StructuralDesignUSD**

Exhibit G6-G.11: EstimPro-11 **QtyEstimate**

Exhibit G6-H: Standard Drawings

Exhibit G6-H.1: Re-excavation of Khal

Exhibit G6-H.2: Re-excavation of Embankments

Exhibit G6-H.3: Regulator

Exhibit G6-H.4: Vertical Gate

Exhibit G6-H.5: Flap Gate

Exhibit G6-I: Estimate of Cost and BOQ

Exhibit G6-I.1: Estimate of Cost (using RSEPS)

Exhibit G6-I.2: BOQ (using RSEPS)

Exhibit G6-J: Model of a Structure Geometry

Exhibit G6-K: Lateral Loads on Abutments-Wing Walls of Hydraulic Structures

Exhibit G6-L: Criteria And Design of PVC Buried Pipe Irrigation Subprojects *(given separately)*

EXHIBIT G6-A: Climatic Design Data of Subproject (for Dr, TI, FMD, WC Subprojects)

Parameters	Apr	May	Jun		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
	Temperature (^{0} C) Station Number & Name: Period of Data:													
Max														
Mean														
Min														
	Evaporation, E (mm/day) Station Number & Name: Period of Data:													
Average														
	Evapo-transpiration, ETo (mm/day) Station Number & Name: Period of Data:													
Average														
	Rainfall, R (mm/month) Station Number & Name: Period of Data:													
Average														
	Water Balance (mm/month)													
Water Body														
Crop Land														

EXHIBIT G6-B: Climate & Rainfall Data of Reference District (for CAD Subprojects)

(Subproject data same as this reference District)

[This is an example District data. FS Consultants will select applicable reference District and provide that District data here. Refer to G4 Feasibility Study of Subprojects, Subsection-3.2.5]

Barisal									
Month	Rainfall			Average monthly					
	Average	Dry	Wet	Min Temp ^{0}C	Max Temp ^{0}C	Humidity %	Wind km/day	Sunshine hours
Jan.	3.8	3.3	4.3	11.8	25.5	79	74	8.1
Feb.	22.3	19.2	25.1	14.9	28.3	76	81	8.1
Mar.	47.5	40.9	53.4	20.1	31.3	75	103	8.3
Apr.	94.4	81.2	106.0	23.6	32.3	80	158	8.2
May	221.3	190.2	248.5	24.7	33.0	83	173	6.8
Jun.	429.7	369.4	482.5	25.6	31.6	88	163	4.3
Jul.	421.9	362.7	473.8	25.5	30.9	90	148	4.2
Aug.	356.4	306.4	400.2	25.6	31.0	89	133	4.5
Sep.	293.9	252.6	330.0	25.3	30.5	88	111	5.2
Oct.	183.7	158.0	206.3	23.6	31.5	86	70	7.2
Nov.	39.5	34.0	44.4	18.9	29.5	83	68	7.9
Dec.	5.9	5.0	6.6	13.4	26.5	80	76	8.0
Average	2,120	1,823	2,381	21.1	30.2	83	113	6.7

EXHIBIT G6-C: Crop Water & Irrigation Water Requirements and Design Irrigation Duties

District Barisal (Subproject data same as this reference District data)

Description	Units	100% Rice: Early Planting (Dec to Feb)	100% Rice: Late Planting (Jan to Feb)	100% Vegetables	100% Pulses	10% Vegetables; 10% Pulses & 80% Rice	20% Vegetables; 20% Pulses & 60% Rice
Net irrigation requirements incl. land preparation & effective rainfall							
Nov	mm/month	0	0	0	0	0	0
Dec	mm/month	121	18	0	0	14	11
Jan	mm/month	164	162	54	32	138	114
Feb	mm/month	80	128	65	66	116	103
March	mm/month	108	105	88	102	103	101
April	mm/month	78	89	12	25	75	61
May	mm/month	8	18	0	0	14	11
Totals	**mm**	559	520	219	225	460	401
Peak net duty (based on peak month)	mm/d	5.29	5.23	2.84	3.29	4.79	4.36
	l/s/ha	0.61	0.60	0.33	0.38	0.55	0.50
Peak net duty (based on peak 3-month period)	mm/d	4.06	4.39	2.30	2.22	3.96	3.54
	l/s/ha	0.47	0.51	0.27	0.26	0.46	0.41
ratio duties 3-months / 1 month		0.77	0.84	0.81	0.68	0.83	0.81
Efficiencies, Duties & Water Requirements							
At Field boundary							
Field irrigation efficiency (weighted)	%	65%	65%	55%	55%	63%	61%
Peak field irrigation duty (based on 3 month period)	mm/d	6.2	6.8	4.2	4.0	6.3	5.8
	l/s/ha	0.72	0.78	0.48	0.47	0.73	0.67
Total water requirement at field level	**mm**	**860**	**800**	**398**	**409**	**731**	**657**
At Pumping Point at Head of System							
Conveyance efficiency (pipe outlet to field	%	80%	80%	80%	80%	80%	80%
Peak duty for at pipe outlet (based on 3 month period)	mm/d	7.8	8.4	5.2	5.1	7.9	7.2
	l/s/ha	0.90	0.98	0.61	0.58	0.91	0.84
Total water requirement at pipe outlet	mm	1,075	1,000	498	511	913	821
Conveyance efficiency (HT to pipe outlet)	%	100%	100%	100%	100%	100%	100%
Total water requirement at pumping point	mm	**1,075**	**1,000**	**498**	**511**	**913**	**821**

[This is example District. DD Consultants will provide here data of applicable District. Refer G4 Feasibility Study of Subprojects, Subsection-3.2.5]

EXHIBIT G6-D: Rainfall Data of Subproject

Mean Monthly Rainfall (mm)

Station Number and Name:...
Period of Data:......................

Parameters	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
Max													
Mean													
Min													

B. Design Storm Rainfall (Synthesized 5-day 10-year Storm)

Station Number and Name:...
Period of Data:......................

Pre-monsoon (Jan-Jun)						Monsoon (Annual)					
Duration (Days)	1	2	3	4	5	Duration (Days)	1	2	3	4	5
Cumulative Depth (mm)						Cumulative Depth (mm)					

EXHIBIT G6-E: River (Outside) Water Level Data

A. Mean Monthly Water Levels (Tidal Zone)

Subproject	Apr		May		Jun		Jul		Aug		Sep	
WL	HTL	LTL	HTL	LTL	HTL	LTL	HTL	LTL	HTL	LTL	HTL	LTL
Max												
Mean												
Min												
	Oct		Nov		Dec		Jan		Feb		Mar	
	HTL	LTL	HTL	LTL	HTL	LTL	HTL	LTL	HTL	LTL	HTL	LTL
Max												
Mean												
Min												

Computational Basis and Procedures	
U/S Stn. Number & Name: Period of Data:	D/S Stn. Number & Name: Period of Data:
Subproject Data Derived by: Interpolation Extrapolation Correlation	Sketch representation of reference stations and the subproject with distances and other comments, assumptions if any:

B. Mean Monthly Water Levels (Non-Tidal Zone)

Subproj WL	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Max												
Mean												
Min												

Computational Basis and Procedures	
U/S Stn. Number & Name: Period of Data:	D/S Stn. Number & Name: Period of Data:
Subproject Data Derived by: Interpolation Extrapolation Correlation	Sketch representation of reference stations and the subproject with distances and other comments, assumptions if any:

C. High Flood Level (HFL)

Return Period (year)	Pre-monsoon	Monsoon
2.33		
5		
10		
20		
50		

Computational Basis and Procedures	
U/S Stn. Number & Name: Period of Data:	D/S Stn. Number & Name: Period of Data:
Subproject Data Derived by: Interpolation Extrapolation Correlation	Sketch representation of reference stations and the subproject with distances and other comments, assumptions if any:

EXHIBIT G6-F: Area-Elevation-Storage Data

(This is an example data and graph. FSDD Consultants will provide actual data and curves for the subproject)

Subproject ....

Upazila: ....

District: ....

Elevation (mPWD)	Area (ha)	Storage (ha-m)
1.5	0.00	0.00
3.00	30.00	22.50
4.30	180.00	252.00
4.60	270.00	319.50
4.90	400.00	420.00
5.20	550.00	562.50
5.50	690.00	748.50
5.80	780.00	969.00
6.10	880.00	1218.00
6.40	970.00	1495.50
6.70	1030.00	1795.50
7.00	1090.00	2113.50
7.30	1150.00	2449.50
7.60	1210.00	2803.50
7.90	1260.00	3174.00

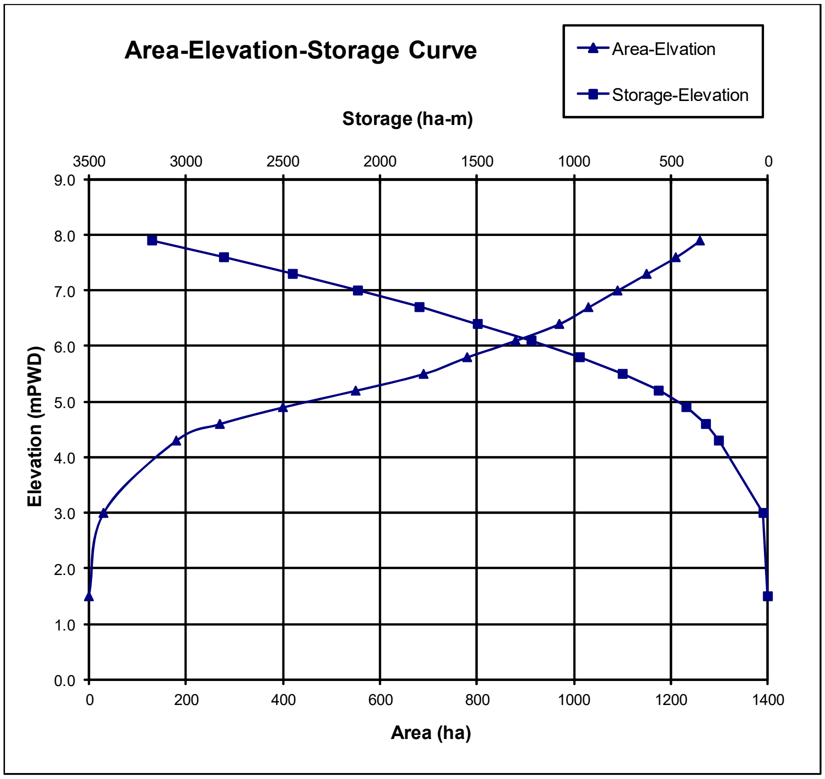


EXHIBIT G6-G: SPREADSHEET DESIGN PROGRAM

Exhibit G6-G1:	**AnalysPro 1**	**- DRate&BasinWL**
Exhibit G6-G2:	**AnalysPro 2**	**- LandType&Change**
Exhibit G6-G3:	**DesignPro 3**	**- KhalDesign-NT**
Exhibit G6-G4:	**DesignPro 4**	**- KhalDesign-T**
Exhibit G6-G5:	**DesignPro 5**	**- EmbankDesign**
Exhibit G6-G6:	**DesignPro 6**	**- SizeCal**
Exhibit G6-G7:	**DesignPro 7**	**- EnergyStill**
Exhibit G6-G8:	**DesignPro 8**	**- ExitG-Uplift**
Exhibit G6-G9:	**DesignPro 9**	**- BuriedPipeDesign**
Exhibit G6-G10:	**DesignPro 10**	**- StructuralDesignUSD**
Exhibit G6-G11:	**DesignPro 11**	**- QtyEstimate**

EXHIBIT G6-G1: AnalysPro 1 - DRate&BasinWL

Drate&BasinWL

Sub-Project	:	**Borang Khal Subproject**	SP No.
Thana	:	Sadar	
District	:	Habiganj	
Union	:		

INPUT DATA:

- Drainage Area (Ha.): Ha.
- Gross Benefited Area (Ha.): 870.00 Ha.
- Lowest Ground Level/**Drainage Level** (mPWD): 5.51 mPWD
- Allaowable Damaged Area (5% of Benefited Area): 43.50 Ha.
- Area-Elevation-Storage Data:

	Elevation (m)	Cum. Area (Ha.)	Cum. Stor. (Ha-m)
LGL=>	5.21	0	0.00
	5.51	30	4.50
	5.81	110	25.50
	6.11	290	85.50
	6.41	440	195.00
	6.71	560	345.00
	7.01	660	528.00
	7.31	720	735.00
	7.61	765	957.75
	7.91	800	1192.50
	8.21	825	1436.25
	8.51	845	1686.75
	8.81	860	1942.50
	9.11	870	2202.00

- Design Storm Rainfall (mm):
  CL110, Habiganj 5 Day 10 Yr. Design Rainstorm

Days	1	2	3	4	5
Premonsoon(Apr-May)Cum RF	178.00	247.00	276.00	317.00	344.00
Monsoon (Apr-Mar) Cum RF	225.00	323.00	357.00	390.00	422.00

- Trial Drainage Rate (mm/day): **70** mm/day (Pre-monsoon)
  88 mm/day (Monsoon)

Pre-monsoon Drainage Rate Calculation

Trial Drainage Rate | **70** **mm/day**

Day	Cum RF (mm)	Cum DR (mm)	Cum RO (mm)	Cum. Stor. (Ha-m)	WL_{basin} (mPWD)	$WL_{dam\%}$ (mPWD)	$WL_{dam\%}$ +0.3 (mPWD)	Day with $WL_{Full\ dam}$	100% Crop Damage (Ha.)	Design Drain. Rate (mm/day)
1	178.00	70.00	108.00	93.96	6.13	5.56	5.86	Day-1	43.50	70.00
2	247.00	140.00	107.00	93.09	6.13	5.56	5.86	Day-2		
3	276.00	210.00	66.00	57.42	5.97	5.56	5.86	Day-3		
4	317.00	280.00	37.00	32.19	5.84	5.56	5.86	-ve		
5	344.00	350.00	0.00	0.00	5.21	5.56	5.86	-ve		

Monsoon Drainage Rate Calculation

Trial Drainage Rate | **88.00 mm/day**

Day	Cum RF (mm)	Cum DR (mm)	Cum RO (mm)	Cum. Stor. (Ha-m)	WL_{basin} (mPWD)	$WL_{dam\%}$ (mPWD)	$WL_{dam\%}$ +0.3 (mPWD)	Day with $WL_{Full\ dam}$	100% Crop Damage (Ha.)	Design Drain. Rate (mm/day)
1	225.00	88.00	137.00	119.19	6.20	5.56	5.86	Day-1	43.50	88.00
2	323.00	176.00	147.00	127.89	6.23	5.56	5.86	Day-2		
3	357.00	264.00	93.00	80.91	6.09	5.56	5.86	Day-3		
4	390.00	352.00	38.00	33.06	5.85	5.56	5.86	-ve		
5	422.00	440.00	0.00	0.00	5.21	5.56	5.86	-ve		

1. A day is counted as "day with WL corresponding to full damage of allowable % of Area" if WL_{basin} > $WL_{dam\%}$ +0.3 for the day.
2. If 3 consecutive days are counted to be crop damage days, crops of land corresponding to allowable % area will be considered fully damaged.
3. If count of crop damage day < 3, rivise trial drainage rate downward.
4. If count of crop damage day > 3, rivise trial drainage rate upward.

EXHIBIT G6-G2: AnalysPro 2 - LandType&Change

LandType&Change

SUBPROJECT NAME = Borobaria-Suakair Subproject Upazila: Sharishabari, District Jamalpur

GROSS AREA=	950	ha
NONCULTIVATED HIGH LAND =	70	ha
NONCULTIVATED LOW LAND =	10	ha

PRE-PROJECT WL =	16.63	m PWD
POST-PROJECT WL =	16.40	m PWD

	Pre-project Condition				Post-project Condition				
	Flood depth	Cu. Area	Area		Flood depth	Cu. Area	Area		
Not flooded-->	16.63	841	109	ha	16.40	814	136	ha	<-- Not flooded
F0, (0.0-0.3)--->	16.33	806	35	ha	16.10	770	44	ha	<-- (0.0-0.3), F0
F1,(0.3-0.9)--->	15.73	668	138	ha	15.50	580	190	ha	<-- (0.3-0.9), F1
F2,(0.9-1.8)--->	14.83	277	391	ha	14.60	190	390	ha	<-- (0.9-1.8),F2
F3,>1.8---->			267	ha			180	ha	>1.8, F3
Non Cultivated Low Land --------->			10	ha			10	ha	
		TOTAL-->	950	ha		TOTAL-->	950	ha	

Elevation (m PWD)	Cumulative Area (ha)
13.80	0
14.10	50
14.40	130
14.70	220
15.00	350
15.30	500
15.60	620
15.90	730
16.20	790
16.50	825
16.80	860
17.10	890
17.40	905
17.70	920
18.00	930
18.30	940
18.60	950

Pre-project Condition		Post-project Condition	Change
Non Cultivated High Land =	70 ha.	70 ha.	0 ha.
F0 =	74 ha.	110 ha.	36 ha.
F1 =	138 ha.	190 ha.	52 ha.
F2 =	391 ha.	390 ha.	-1 ha.
F3 =	267 ha.	180 ha.	-87 ha.
Non Cultivated Low Land =	10 ha.	10 ha.	0 ha.
F2+F3 =	668 ha.	580 ha.	-88 ha.
Net Cult. Area (F0+F1 +F2+F3) =	870 ha.	870 ha.	
Gross Area =	950 ha.	950 ha.	

EXHIBIT G6-G3: DesignPro 3 - KhalDesign-NT

KhalDesign-NT

(Premonsoon)

Subproject:
Upazila: District:

Chainage	Reach	Catch. Area	Existing					Design												Depth of Cutting
(m)		(Ha.)	Bed Level (mPWD)	BW (m)	TW (m)	Bank. GL (mPWD)	Bed Slope	Drainage Rate (mm/day)	Q (m^3/Sec)	Basin WL (mPWD)	Outfall RWL (mPWD)	WS	Side Slope	B (m)	d (m)	Check for V & Q		WL (mPWD)	BL (mPWD)	
Name of Khal : **Betbaria Khal**																				
0			4.64	4.00	16.00		-0.0006	55.00	4.774	5.07		**0.00060**	1.5	**5.00**	**1.15**	V=	**0.626**	5.070	3.920	0.72
1500	1	750	3.7	2.00	15.00											Q=	**4.840**	5.970	4.820	-1.12

Note: Permissible Velocity:- Min^m = 0.5 m/Sec and Max^m = 1.0 m/Sec

EXHIBIT G6-G4: DesignPro 4 - KhalDesign-T

KhalDesign-T
(Premonsoon)

Name of Subproject : Auliar Char Subproject
Thana: Kalkini , Dist.: Madaripur

Data/Assumptions:

1. Permissible Velocity:- Min^{m} = 0.5 m/Sec and Max^{m} = 1.0 m/Sec
2. Mean Monthly HTL = 1.650 mPWD | Refer: calculation of dischage in the previous page
3. During Drainage LTL = 0.850 mPWD | Refer: calculation of dischage in the previous page
4. Max^{m} Basin WL = 2.430 mPWD | From premonsoon drainage routing

Drainage occurs with RWL below Basin WL
Drainage Time/Day = 24.00 Hours | Drainage Time/Day= Total hour per day*(Max^{m} Basin WL-LTL)/(HTL-LTL)
Equivalent Design Q = 1.54 m3/s | From design Q calculations

CALCULATIONS

Chainage (m)	Reach	Cat. Area (Ha.)	Existing: Bed Level (mPWD)	Existing: BW (m)	Existing: TW (m)	Existing: Bank. GL (mPWD)	Existing: Bed Slope	Design: Drainage Rate (mm/day)	Design: Q (m^3/Sec)	Design: Basin WL (mPWD)	Design: Side Slope	Design: B (m)	Design: RWL (mPWD)	Design: WS	Design: d_{flow} (m)	Design: V (m/Sec)	Design: Q (m^3/Sec)	Design: BL (mPWD)	Depth of Cutting
Name of the Khal : Gajaria Khal (3.14 km)																			
0			2.214	3.00	15.00	3.89/3.37	0.00031	38.00	1.54		1.00	3.00	2.43	0.000000	2.10	0.00	0.00	0.33	1.88
													2.20	0.000072	1.87	0.26	2.36		
													1.98	0.000144	1.65	0.34	2.63		
													1.75	0.000216	1.42	0.39	2.45		
													1.53	0.000288	1.20	0.41	2.07		
													1.30	0.000359	0.97	0.42	1.60		
											Tidal range	Step	1.08	0.000431	0.75	0.40	1.11		
											1.580	0.2257	0.85	0.000503	0.52	0.35	0.65		
													1.08	0.000431	0.75	0.40	1.11		
													1.30	0.000359	0.97	0.42	1.60		
													1.53	0.000288	1.20	0.41	2.07		
													1.75	0.000216	1.42	0.39	2.45		
													1.98	0.000144	1.65	0.34	2.63		
													2.20	0.000072	1.87	0.26	2.36		
3140	1	350	1.227	2.00	10.00	3.34/3.19				2.43			2.43	0.000000	2.10	0.00	0.00	0.33	0.90
																$Q_{Ave.}$ =	**1.67**	OK	

EXHIBIT G6-G5: DesignPro 5 - EmbankDesign

EmbankDesign

Subproject: **Roail-Helalpur Subproject**
Upazila: **Jagannathpur** District: **Sunamganj**

Chainage	Reach	Existing					Design												BW$_E$-BW$_D$
		Crest Level	Crest Width	Base Width	Ground Level (mPWD)		HFL (mPWD)		Freeboard on 20-Yr HFL	Crest Level	Crest Width	Side Slope		Berm at EL–	Basin WL (Average)	Seepage Gradient	Soil Type	Base Width	
(m)		(mPW	(m)	(m)	R/S	C/S	1:20-Yr	1:50-Yr.	(m)	(mPWD)	(m)	R/S	C/S	(m)	(mPWD)			(m)	(m)
Name of the Embankment: **Road-cum-Embankment from Roail Bazar to Raniganj Bazar** (resectioning).																			
0		7.143	3.00	7.60	6.390	6.260	6.980	7.170	0.60	7.60	3.70	1.50	1.50	0.00	6.50	0.0768	Silty-Clay	7.525	-0.07
7000	1	7.500	3.00	5.50	5.705	5.630	7.340		0.60	7.90	3.70	1.50	1.50	0.00	6.50	0.1254		10.398	4.90

Note:
Mean HFL = 6.50 m,pwd
1 in 10 Yr. HFL = 6.83 m,pwd
1 in 20 Yr. HFL = 6.98 m,pwd

EXHIBIT G6-G6: DesignPro 6 - SizeCal

SizeCal

(Program to Design Size of Regulators/Sluices/Water Retention Structures)

INPUT DATA SHEET

(Figures in **red colour** are directly input Data)

Name of Subproject: **Borang Khal Subproject**
Name of Regulator : **Borang Khal Regulator (2v-1.5x1.8) at Ch.0+530 km (Khal)**
Upazila: Sadar **District:** Habiganj

Hydrological Data

Drainage Area	819.00	ha
Pemonsoon Drate	70.00	mm/day
Premonsoon Design Basin WL	6.130	m pwd
Monsoon DRate		mm/day
Monsoon Design Basin WL	6.230	m pwd
1:20 Year HFL (HTL)	8.320	m pwd
Mean (Jan-Mar) HTL (for flushing)	5.500	mPwd

Design Data of Khal

Bed Width	3.00	m
Bed Level	4.01	m Pwd
Bed Width	3.00	m
Bank Level (at site)	7.50	m Pwd

Design Data of Embankment

Design Crest EL	8.50	m pwd
Deck EL of Regulator	8.50	mPwd

Regulator Design Data

Invert Level		4.30	m pwd
Vent Size	Width	1.50	m
	Height	1.80	m
Vent Number		2	nr

SizeCal

(Program to Design Size of Regulators/Sluices/Water Retention Structures)

Sub-project : **Borang Khal Subproject**
Upazila : **Sadar** District : **Habiganj**
Regulator/Sluice/WRS : **Borang Khal Regulator (2v-1.5x1.8) at Ch.0+530 km (Khal)**

Flow Types - Conditions and Discharge Formulae

When $H_w > H_v$ and $H_{tw} > H_v$, Flow Type I $Q_I = 0.80 x N x B_w x H_v x (2x9.81xh')^{0.5}$

When $H_w > 1.5H_v$ and $H_{tw} < H_v$, Flow Type III $Q_{III} = 0.60 x N x B_v x H_v x \{2x9.81x(H_w - H_v/2)\}^{0.5}$

When $H_w < 1.5H_v$ and $H_{tw} > 2H_v/3$, Flow Type IV $Q_{IV} = 0.83 x N x B_v x (H_w - h') x (2x9.81xh')^{0.5}$

When $H_w < 1.5H_v$ and $H_{tw} < 2H_v/3$, Htw < Hc, Flow Type V $Q_V = 1.56 x N x B_v x H_w^{3/2}$

Where: H_w = Upstream Water Depth; N = Vent Nos.
H_{tw} = Tail Water Depth; h' = Head Difference
H_v = Vent Hieght; Q = Flow through Regulator
B_v = Vent Width

Input Data:

N =	2	nos.	RWL	5.83	mPWD
Bv =	1.50	m	Basin WL =	6.13	mPWD
Hv =	1.80	m	Design Q =	7.96	m^3/Sec
Sill Level =	4.30	mPWD			

RWL (mPWD)	Hw (m)	HTW (m)	h' (m)	Flow Type	Q m^3/Sec
5.83	1.83	1.53	0.30	IV	9.24

9.24 OK

Discharge Review

Design Basin Discharge	6.64 m^3/Sec	
Additional inflow from outside =	0.00 m^3/Sec	
Total Design Basin Discharge =	6.64 m^3/Sec	
Design Discharge for Structure =	7.96 m^3/Sec	(increased by 20%)

EXHIBIT G6-G7: DesignPro 7 - EnergyStill

EnergyStill

(Program to Design Stilling Basin of Regulators/Sluices/Water Retention Structures)

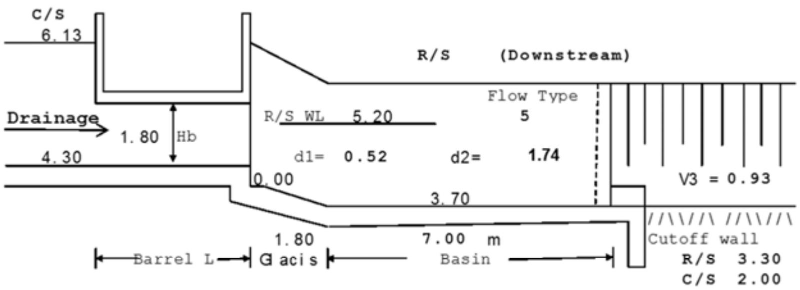
Subproject: **Borang Khal Subproject**
Upazila: **Sadar** **District:** **Habiganj**
Structure: **Borang Khal Regulator (2v-1.5x1.8) at Ch.0+530 km (Khal)**

OUTLET STILLING BASIN DESIGN (Riverside)

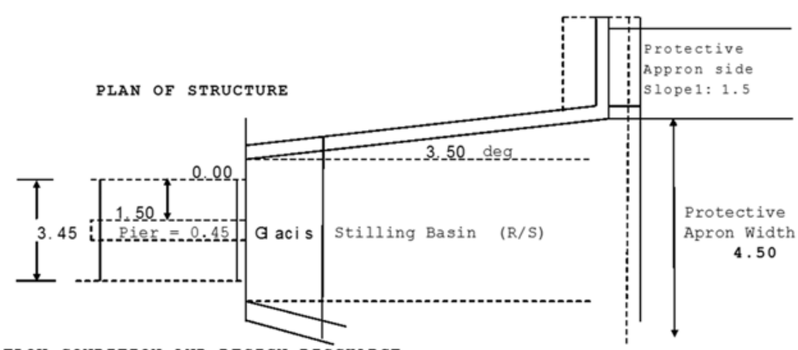
Tidal/NonTidal: **NT**
Mode: **Drainage**

INPUT DATA

Design Basin WL (C/S) -->	6.13	m		FlowType	**5**
Design Water Level (R/S) -->	5.20	m		IL + Hb/2	
No. of Vents -->	2				
Dist.between Abutments(Ba)->	3.45	m			
Inside Barrel Height (Hb)-->	1.80	m			
Inside Barrel Width (Bb) -->	1.50	m			
Barrel Invert Level -->	4.30	m			
R/S Basin Floor Level -->	3.70	m, Drop	0.60	R/S	
C/S Basin Invert Level -->	3.90	m, Drop	0.40	C/S	
Gate Clearance Side (Cs) -->	0.00	m			
Gate Clearance Bottom(Cb) ->	0.00	m			
Glacis Length (Gl) -->	1.80	m	3.00	slope 3H:1V	
Basin Flare Angle (ø) -->	3.50	degree			
Side Slope at Prot Apron -->	1.50			Slope 1.5H:1V	



LONG SECTION THROUGH STRUCTURE



FLOW CONDITION AND DESIGN DISCHARGE

The objective of this section is to determine the design flow condition and design discharge through the structure. The analysis assumes that the only valid flow conditions are Type 3 and Type 5. Only these flow conditions generate hydraulic jumps that necessitate a stilling basin.

Flow Condition Type 1 occurs when H > Hb and Htw > Hb
Flow Condition Type 3 occurs when H > 1.5 Hb and Htw < Hb
Flow Condition Type 4 occurs when H < 1.5 Hb and Htw > 2/3 H, Htw > Hc
Flow Condition Type 5 occurs when H < 1.5 Hb and Htw < 2/3 H, Htw < Hc

H = Height difference between Inlet Water Level and Barrel Invert Level
= U/S Water Level - Barrel Invert Level
= 6.13 - 4.30 = 1.83 m

Htw = Height difference between Tailwater Level and Barrel Invert Level
= D/S Water Level - Barrel Invert Level
= 5.20 - 4.30 = 0.90 m

```
Hb   =  Height of Barrel
     =     1.80  m

H    =     1.02  Hb       ( H < 1.5 Hb   and   Htw < 2/3 H )
Htw  =     0.50  Hb
Htw  =     0.49  H            The Flow Condition is Type   5   <------
```

FLOW CONDITION TYPE 1; (H > Hb and Htw > Hb)

Flow Condition Type 1 has a submerged outlet and does not result in a hydraulic jump that necessitates a stilling basin.

FLOW CONDITION TYPE 3; (H > 1.5 Hb and Htw < Hb)

```
QT3 =  Design Discharge for Flow Condition Type 3
   =  No.Vents  *  Co  *  Ab  *  ( 2g * H-Hb/2 )^0.5
```

The Discharge Coefficient (Co) is determined from a "Co vs Hb/H" curve.

```
For a "Hb/H" value equal to      0.98
Co   =     0.49  (manually picked from Chart)
                WARNING: Co values are unreliable for Hb/H > 0.66

Ab  =  Barrel Full Sectional Area
    =  Inside Barrel Width  *  Inside Barrel Height
    =     1.50     *      1.80     =      2.70  m²

g  =  acceleration of gravity  =  9.81 m/sec²

QT3  =   No.Vents  *  Co  *  Ab  *  ( 2g *( H-Hb/2 )^0.5
   =          2     *      0.49     *      2.70     *  (   18.25  )^0.5
   =      11.37  m³/sec
```

FLOW CONDITION TYPE 4; (H < 1.5 Hb and Htw > dc)

Flow Condition Type 4 has subcritical flow and does not result in a hydraulic jump that necessitates a stilling basin.

FLOW CONDITION TYPE 5; (H < 1.5 Hb and Htw < dc)

```
QT5  =  Design Discharge for Flow Condition Type 5
   =  No.Vents  *  Cw  *  Bb  *  H^1.5
```

Typical values of Discharge Coefficient (Cw) are given below. For Stilling Basin Design a higher value of Cw is more conservative.

Entrance Type	Cw		
Warped Transition	1.62	Use Cw = 1.56	User's 1.56
Cylinder Quadrant	1.58		
Simplified Straight Line	1.56		
Straight Line Transition	1.48		
Square Ended Transition	1.35		

```
Bb  =  Inside Barrel Width =      1.50  m

Q  =  No.Vents  *  Cw  *  Bb  *  H^1.5
   =          2    *     1.56     *      1.50     *      1.83  ^1.5
   =      11.59  m³/sec
```

SUPERCRITICAL CONJUGATE DEPTH

Design Discharge (Q):   11.59 m³/sec

Determine supercritical conjugate depth (d1) by applying Bernoulli's Energy Equation over the Critical Depth Section (c) and Section (1).

$$dc + \frac{Vc^2}{2g} + Zc = d1 + \frac{V1^2}{2g}$$

V1 can be put in terms of d1 by knowing the width (B1) at Section (1) and and applying the equation of continuity.

```
B1   =  Ba  +  2*Cs  +  2*Gl*(tan ø)
     =     3.45     +     0.00     +      3.60    *   (   0.061   )
     =     3.67  m
```

$$V1 = \frac{Q}{A1} = \frac{Q}{B1*d1} = \frac{11.59}{3.67 \;*\; d1} = \frac{3.16}{d1} \quad \text{<------------}$$

At critical depth, in a rectangular section, the following two equations can be applied:

$$dc = \left(\frac{qc^2}{g}\right)^{0.33} \quad \text{and} \quad \frac{Vc^2}{2g} = \frac{dc}{2} \quad \text{<------------}$$

g = acceleration of gravity = 9.81 m/sec²

It is asumed that the critical depth occurs on the Barrel Extension Floor.
qc = unit discharge (discharge per unit width) at Section (c)

$$= \frac{Q}{No.Vents \;*\; Bb} = 3.86 \text{ m}^3\text{/sec per m}$$

$$dc = \left(\frac{3.86^2}{9.81}\right)^{0.33} = 1.15 \text{ m} \quad \text{<------------}$$

Zc = elevation change between Section (c) and (1)
= Barrel Extension Invert Level(Bb-Cb) - Basin Invert Level
= 4.30 - 0.00 - 3.70 = 0.60 m <-------
(Drop for gate recess to be neglected)

When the above results are entered into the Bernoulli's Energy Equation, it becomes:

$$dc + \frac{dc}{2} + 0.60 = d1 + \left(\frac{3.16}{d1}\right)^2 * \frac{1}{2*9.81}$$

$$1.5 * 1.15 + 0.60 = d1 + \frac{0.51}{d1^2}$$

$$2.32 = d1 + \frac{0.51}{d1^2}$$

By trial and error, it is found that

d1 = 0.53 m (d1 should be less than glacis drop)

CHECK SUPERCRITICAL CONJUGATE DEPTH

Check the supercritical conjugate depth (d1) by applying Bernoulli's Energy Equation over Section (0) and (1).

Assuming no energy loss between Section (0) and (1), and that the upstream velocity is essentually zero, the formula becomes:

$$H = d1 + \frac{V1^2}{2g}$$

H = Height difference between Inlet Water Level and Basin Invert Level
= 6.13 - 3.70 = 2.43 m

As formulated above $V1 = \frac{3.16}{d1}$

Entering the values for H and V1, the Energy Equation becomes:

$$2.43 = d1 + \frac{0.51}{d1^2}$$

By trial and error, it is found that

d1 = 0.52 m
user justified d1 = m

The two calculated values for supercritical conjugate depth (d1) are now compared and the smaller value is assumed as the critical design condition.

use d1 = 0.52 m **Chute Blocks:** Height=d1= 0.52 m
Width=Spacing=0.7d1= 0.36 m

FROUDE NO. AND BASIN TYPE

Determine Froude No. at Section (1) $F1 = \frac{V1}{(g*d1)^{0.5}}$

$$V1 = \frac{Q}{B1*d1} = \frac{11.59}{3.67 * 0.52} = 6.13 \text{ m/sec}$$

$$F = \frac{6.13}{(9.81 * 0.52)^{0.5}} = 2.73$$

The default USBR Stilling Basin, for various values of Froude No., is given below:

for	F <= 2.5	use	USBR Stilling Basin Type I
	2.5 < F < 4.5		USBR Stilling Basin Type IV
	F >= 4.5		USBR Stilling Basin Type II

If desired, the user may override the default USBR Stilling Basin, or select the Indian Standard Stilling Basin I (used for 2 < F < 4.5).

Use Indian Standard Stilling Basin I <---------
(The default Stilling Basin has been overridden by the user.)

SUBCRITICAL CONJUGATE DEPTH

Determine the subcritical conjugate depth (d2) use the general formula:

$d2 = d1/2 * ((1 + 8*F1^2)^{0.5} - 1)$
$= 0.52 / 2 * ((1 + 8 * 2.73^2)^{0.5} - 1)$
$= 1.74$ m

Baffle Blocks: Distance = 0.8 *d2 = 1.40 m **End Sill** (Dentated)
Width=Spacing=0.7d1= 0.36 m, Width=Spacg=0.15d2= 0.26 m
m, Height= d1= 0.52 m, Height= 0.2d2= 0.35 m

TAILWATER DEPTH

To ensure that the jump does not get swept out of the stilling basin and cause excessive scouring, the available tailwater depth (TWD) should be greater than the minimum allowable tailwater depth (TWD min).

TWD min = minimum allowable tailwater depth = K1 * d2

The coefficient (K1) depends on the Stilling Basin Type

Basin Type	K1		
USBR I	1.00	For Indian Standard Stilling Basin I	
USBR II	1.05	use K1 = 1.00	<--------
USBR IV	1.10		
Indian I	1.00		

TWD min = 1.00 * 1.74 = 1.74 m

TWD = available tailwater depth
= D/S Water level - Basin Floor Level
= 5.20 - 3.70 = 1.50 m

TWD < TWD min; Design is not O.K., unless Tailwater Velocity <= 1.0 m/s
(refer to the discussion on Tailwater Velocity below)

LENGTH OF OUTLET STILLING BASIN (R/S)

L = Length of Stilling Basin = K2 * d2

The coefficient (K2) is determined from "L/d2 vs Froude No." curves for individual Stilling Basin Types.

For Froude No. equal to 2.73
and using Indian Standard Stilling Basin I

```
K2  =       3.78

d2  =  Subcritical  Conjugate Depth  =              1.74  m

L  =        3.78      *       1.74      =       6.60  m        User Defined value for
                                                               Length   -->      7.00
                                         Use    7.00  m   <--------------

TAILWATER VELOCITY

To ensure that there is no excessive scouring, the maximum permissible
tailwater velocity at the protective apron (V3) must be less than
1.0 m/sec.

        Q
V3  =  --                 A3   =  area of flow at the Protective Apron
       A3                      =  B3 * TWD  +  SS * TWD²

B3  =  Bed Width of Protective Apron
    =  Ba  +  2*Cs  +  2*(Gl + L)*(tan ø)

Ba  = Distance between Abutments  =       3.45  m
Cs  = Gate Clearance Width =      0.00  m
Gl  = Glacis Length         =      1.80  m
ø   = Basin Flare Angle     =      3.50  °

L   =  Length of Stilling Basin  =        7.00  m


B3  =       3.45      +       0.00    +  2 *    8.80     *    (   0.061    )
    =       4.53  m

    Use     4.50  m  <--------            Design BW of Khal =      3.00  m
         Bed width of khal  <  B3;  Need Special Measure

TWD = TWD corresponding to flow depth (d2)= TWDmin=       1.74

Ss    =  Protective Apron Side Slope = (1 :         1.50  ) Vertical:Horizontal


A3  =  B3 * TWD  +  Ss * TWD²
    =       4.50      *       1.74      +       1.50      *       1.74  ²
    =      12.42  m²


        Q         11.59
V3  =  --   =  -------    =           0.93  m/sec
       A3         12.42

V3  <=  1.0 m/sec;  Design is O.K.
```

Measure at D/S Khal Bed Width
Velocity on earthen khal is acceptable. Flaring angle is small (3.5 deg). So recommend to make bed width of khal 4.5 m for 30m and then reduce to 3 m.

```
SCOUR DEPTH & CUT-OFF WALLS

  R = Regime Scour  Depth

  =  1.35 * ( q²/f )^0.33

q =        Q(T5)/B3(r/s)
  =          2.57  m³/sec

f =   Silt Factor
  =          0.42  (for fine sand)

R =   1.35 * (       2.57  ²    /       0.42    )^0.33
  =          3.36  m

Rus = C/S Scour  Depth          =       1.25       *      R
                                =       4.19  m

Rds = R/S Scour  Depth          =       1.50       *      R
                                =       5.03  m

d(u)= C/S Cut-off Wall Depth =       Rus - (Hw + Du)
                                 =   4.19    -    (       1.83       +        0.40   )
                                 =   1.96  m
```

```
             Use  2.00  m       <-------User's value for C/S cutoff ->

d(d)= R/S Cut-off Wall Depth =    R/S Scour depth - R/S Water depth
                              =   Rds      -     d2
                              =   5.03     -       1.74     =      3.29  m

             Use  3.30  m       <------ User's value for R/S cutoff ->

         Accepted d(u) 2.00   m,      C/S of Structure

         Accepted d(d) 3.30   m,      R/S of Structure
```

PROTECTIVE WORKS LENGTH

Length of protective works is determined by multiplying the cut-off wall depths by appropriate co-efficients.

C/S Protective Works

```
Filter & Block Protectn   =  C/S Cut-off Wall Depth * Co-efficient
                          =       2.00     *      1.00
                          =       2.00  m

                          Use    2.00   m       <-----------------

Launching Apron          =  C/S Cut-off Wall Depth * Co-efficient
                          =       2.00     *      1.50
                          =       3.00  m

                          Use    3.00   m       <-----------------
```

R/S Protective Works

```
Filter & Block Protectn     =  R/S Cut-off Wall Depth * Co-efficient
                            =     3.30     *      1.00
                            =     3.30  m
                          Use    3.30   m       <-----------------

Launching Apron         =  R/S Cut-off Wall Depth * Co-efficient
                        =        3.30     *      1.50
                        =        4.95  m

                          Use    5.00   m       <-----------------
```

EXHIBIT G6-G8: DesignPro 8 - ExitG-Uplift

ExitG-Uplift

(Program to Design Regulators/Sluices/Water Retention Structures for Exit Gradient and Uplift Pressure)

Subproject: **Borang Khal Subproject**
Upazila: **Sadar** **District:** **Habiganj**
Structure: Borang Khal Regulator (2v-1.5x1.8) at Ch.0+530 km (Khal)

sign for Exit Gradient and Uplift Pressur | Tidal/Non-Tidal ===: **NT**

REQUIRED INPUT DATA | Water Retn Function (Y/N) **Y**
Water Retention Mode | Retn WL **6.50** mPwd
Design C/S Water Level --> 6.50 mPwd
Design R/S Water Level --> 3.70 mPwd [Min Design Head =1.00 m]

Flushing Mode | Flood Protn Function (Y/N) **N**
Design C/S Water Level --> 4.30 mPwd,Monsoon BWL
Design R/S Water Level --> 4.30 mPWD R/S Flushing WL
[Min Design Head =1.00 m]
C/S Apron Level --> 3.90 m | I L 4.30 mPwd
R/S Apron Level --> 3.70 m | C/S Drop at Glacis 0.40 m
R/S Drop at Glacis 0.60 m

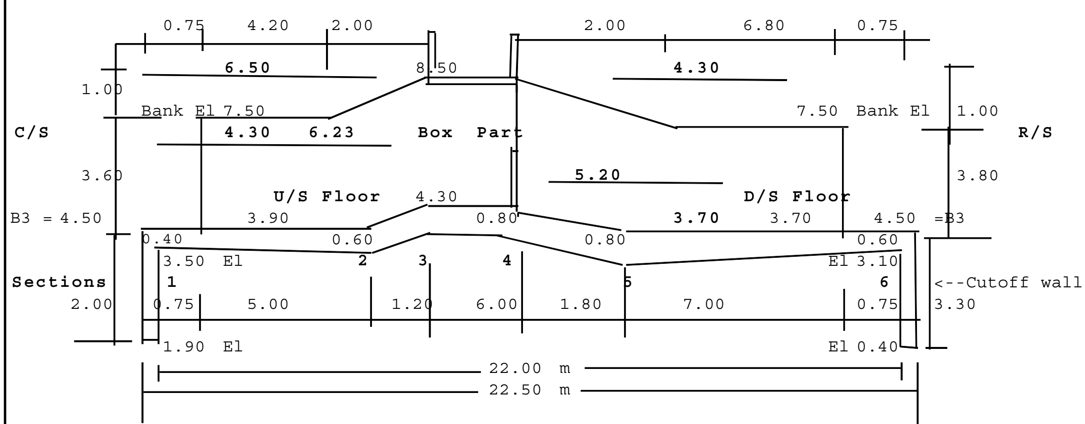
Elevation at bottom of C/S Cutoff Wall --> 1.90 m
Elevation at bottom of R/S Cutoff Wall --> 0.40 m | C/S Cut-off Depth 2.00 m
R/S Cut-off Depth 3.30 m
Elevation under Floor at C/S Cutoff Wall --> 3.50 m | 'lr Thick at End (assumed)
Elevation underneath apron at R/S Cutoff Wall · 3.10 m | C/S End 0.40 m
R/S End 0.60 m
Total Floor Length (b) --> 22.50 m | ıength of Box Part 6.00 m
Distance between U/S and D/S Cutoff Walls (b')· 22.00 m

Intermediate Points where Floor Thickness is Desired:

Section	Length (m) from U/S End (Sec 1)
1 (C/S)	0.00
2	5.50
3	6.70
4	12.70
5	14.50
6 (R/S)	22.00

SCHEMATIC DIAGRAM OF STRUCTURE

Drainage Mode WL **value**
Flood Protn Mode WL **value**
Water Reten Mode WL **value**



I. DESIGN FOR EXIT GRADIENT

Exit gradient is calculated using Khosla's equations.

a. Water Retention Mode

$$Ge = \text{Exit Gradient} = \frac{H}{d} * \frac{1}{pi * r^{0.5}}$$

H = Design Head = C/S Water Retn Level - R/S Stilling Basin Floor L 2.80 m

d = Length of D/S Cutoff Wall
= R/S Channel Level - Elevation at bottom of R/S Cutoff Wall
= 3.70 - 0.40 = 3.30 m

```
b  =  Total Floor Length  =     22.50  m

a  =  b/d  =     6.82

r  =  (1 + (1 + a^2)^0.5)/2  =          3.95

        2.80           1
Ge  =  ------- * ---------------  =     0.136  < Maximum Permitted Gradient 1/6
        3.30    pi *   3.95  ^0.5
```

Floor Length and R/S Cutoff Wall Depth is O.K

b. Flushing Mode

```
                          H         1
Ge  =  Exit Gradient  =  ---  *  ----------
                          d      pi * r^0.5

H  =  Design Head  =     1.00  m

d  =  Length of U/S Cutoff Wall  =      2.00  m

b  =  Total Floor Length  =     22.50  m

a  =  b/d  =    11.25

r  =  (1 + (1 + a^2)^0.5)/2  =          6.15

        1.00           1
Ge  =  ------- * ---------------  =     0.064  < Maximum Permitted Gradient 1/6
        2.00    pi *   6.15  ^0.5
```

Floor and C/S Cutoff Wall Length is O.K

II. DESIGN FOR UPLIFT PRESSURE

The percentage of head acting as uplift at various key points underneath the structure are determined using Khosla's method. Khosla's key points at the U/S and D/S Cut-off Walls are defined in the figure below:

```
                  U/S     (C/S)     |          D/S     (R/S)
                                    |
                                    |
                  ------- ------- ------- ------- ------- --------
              E1 |C1                                         E6 |C6
                 |                                              |
                 |                                              |
                 |D1                                            |D6
```

a. Water Retention Mode

i. At Upstream (c/s) Cutoff Wall Line

```
b  =  Total Floor Length  =     22.50  m
d  =  Length of U/S Cutoff Wall
   =  U/S Khal BL (U/S Floor Level) - Elevation at bottom of U/S Cutoff Wall
   =     3.90    -     1.90    =     2.00  m

a  =  b/d  =    11.25

r  =  (1 + (1 + a^2)^0.5)/2  =          6.15

øE1  =  100%

øC1  =  100%  -  acos((r-2)/r)/pi  =          73.57%

øD1  =  100%  -  acos((r-1)/r)/pi  =          81.59%
```

```
øC1 should be corrected for the following effects:
       c1  =  correction due to effect of D/S Cutoff Wall
       c2  =  correction due to thickness of floor


c1  =  19  *  (d"/b')^0.5  *  (d'+d")/b

b   =  Total Floor Length  =    22.50  m
b'  =  Distance between U/S and D/S Cutoff Walls  =      22.00  m

d'  =  Elevation underneath apron at U/S Cutoff Wall minus
       Elevation at bottom of U/s Cutoff Wall
    =    3.50     -      1.90     =      1.60  m

d"  =  Elevation underneath apron at D/S Cutoff Wall minus
       Elevation at bottom of D/S Cutoff Wall
    =    3.10     -      0.40     =      2.70  m
c1  =  19 *  (    0.12  )^0.5    *   (    0.19  )  =       1.27%   (+ve)


c2  =  (øD1 - øC1)  *  Tc1
        ------- ------- -----
                d1

Tc1  =  Thickness of Concrete at Section 1 (U/S)
     =  U/S Apron Level - Elev. underneath apron at U/S Cutoff Wall  =             0.40  m

d1   =  Depth of U/s Cutoff Wall
        U/S Apron Level - Elevation at bottom of U/S Cutoff Wall  =                2.00  m

c2   =       (    8.02%   ) *     0.40
              - ------- ------- ------- -    =    1.60%   (+ve)
                         2.00

øC1 (corrected)  =  øC1  +  c1  +  c2  =        76.45%
```

ii. At Downstream (r/s) Cutoff Wall Line

```
a  =  b/d  =     22.50     /      3.30     =      6.82

r  =  (1 + (1 + a^2)^0.5)/2  =           3.95

øC6  =  0%

øE6  =  acos((r-2)/r)/pi  =     33.59%

øD6  =  acos((r-1)/r)/pi  =     23.17%


øE6 must be corrected for the effect  of the U/S Cutoff Wall (c1) and the thickness
of the floor (c2).

c1   =  19  *  (d'/b')^0.5  *  (d'+d")/b
     =  19  * (    1.60     /     22.00  )^0.5    *   (      2.70     +        1.20  )  /     22.50
     =    0.89%   (-ve)

c2   =  (øE6 - øD6)  *  Tc6       =   (  10.42% )  *       0.60     =        1.89%   (-ve)
         ------- ------- -----         - ------- ------- ------
                 d6                                3.30

øE6 (corrected)  =  øE6  +  c1  +  c2  =        30.80%
```

iii. Design for Concrete Thickness of Floors

(a) R/S Floor: For Uplift Pressure, **Water Retention Mode** will govern. In this mode:
Retn Design Head (H) = C/S Retn Water Level - R/S Basin Floor Level 2.80 m

```
          submerged unit weight of concrete       23.6  -  9.81
u  =  ---------------------------------    =    ------------    =       1.43
                unit weight of water                  9.81
```

$$\text{Concrete Thickness (m)} = \frac{H * \varnothing}{u}$$

Section	Length from U/S to Section (m)	ø	Uplift Pressure (Kn/M2)	Computed Concrete Thickness (m)	Recommended Thickness (m)
(U/S) 1	0.00	76.45%	21.00	1.50	
2	5.50	65.04%	17.86	1.28	
3	6.70	62.55%	17.18	1.23	
4	12.70	50.10%	13.76	0.98	**0.80**
5	14.50	46.36%	12.74	0.91	**0.80**
(D/S) 6	22.00	30.80%	8.46	0.60	**0.60**

Distance between Wing walls at Glacis end is not big, weigt of Box part and wing walls will add to weight in Sec 4 & 5 area. So, a little less thickness is used.

b. Flood Protection Mode

i. At Upstream (c/s) Cutoff Wall Line

a = b/d = 22.50 / 2.00 = 11.25

r = (1 + (1 + a^2)^0.5)/2 = 6.15

øC1 = 0%

øE1 = acos((r-2)/r)/pi = 26.43%

øD1 = acos((r-1)/r)/pi = 18.41%

øE1 must be corrected for the effect of the D/S Cutoff Wall (c1) and the thickness of the floor (c2).

c1 = 19 * (d"/b')^0.5 * (d'+d")/b
= 19 * (2.70 / 22.00)^0.5 * (1.60 + 2.70) / 22.50
= 1.27% (-ve)

$$c2 = \frac{(øE1 - øD1) * Tc1}{d1} = \frac{(8.02\%) * 0.40}{2.00} = 1.60\% \ (-ve)$$

øE1 (corrected) = øE1 + c1 + c2 = 23.55%

ii. At Downstream (r/s) Cutoff Wall

a = b/d = 22.50 / 3.30 = 6.82

r = (1 + (1 + a^2)^0.5)/2 = 3.95

øE6 = 100%

øC6 = 100% - acos((r-2)/r)/pi = 66.41%

øD6 = 100% - acos((r-1)/r)/pi = 76.83%

øC6 must be corrected for the effect of the U/S Cutoff Wall (c1) and the thickness of the floor (c2).

c1 = 19 * (d'/b')^0.5 * (d'+d")/b
= 19 * (1.60 / 22.00)^0.5 * (2.70 + 1.60) / 22.50
= 0.98% (+ve)

$$c2 = \frac{(øD6 - øC6) * Tc6}{d6} = \frac{(10.42\%) * 0.60}{3.30} = 1.89\% \ (+ve)$$

øC6 (corrected) = øC6 + c1 + c2 = 69.29%

iii. Design for Concrete Thickness of Floors

(a) C/S Floor: For Uplift Pressure, **Flood Protection Mode** will govern. In this mode:

F C Design Head (H) = R/S 1:20-yr Annual HFL - C/S Basin Monsoon WL = 2.09 m

$$u = \frac{\text{submerged unit weight of concrete}}{\text{unit weight of water}} = \frac{23.6 - 9.81}{9.81} = 1.43$$

$$\text{Concrete Thickness (m)} = \frac{H * \varnothing}{u}$$

Section	Length from D/S to Section (m)	⌀	Uplift Pressure (Kn/M2)	Computed Concrete Thickness (m)	Recommended Thickness (m)
(U/S) 1	0.00	23.55%	4.83	0.35	0.40
2	5.50	34.99%	7.17	0.52	0.60
3	6.70	37.48%	7.68	0.56	0.80
4	12.70	49.95%	10.24	0.75	
5	14.50	53.70%	11.01	0.80	
(U/S) 6	22.00	69.29%	14.21	1.03	

EXHIBIT G6-G9: DesignPro 9 - BuriedPipeDesign

Buried Pipe Loss Calculation for Pipeline -1

Name of SP : Mongalpur Subproject
Up : Dowrabazar
Dist : Sunamganj

BuriedPipeDesign

For concrete pipe adopt f = 0.0050
For PVC pipe adopt f = 0.0042

Available PVC pipe sizes outer diameter (mm): 160, 180, 200, 225, 250, 280, 315, 355,400, 450 & 500

Hydraulic Grade Line : HT-A-B-C-D-E-F-G-H-I-J-K-L

L	Chainage	2,990.0					
Length	**KL**	200	m				
Ground EL		6.60	m PWD				
Command		0.80	m	(0.5 plus 0.3 m req'd - min)			
Top of pipeline		5.60	m PWD				
Hydraulic Grade Line El		**7.40**	m PWD				
Freeboard for standpipes		0.60	m				
El of top of standpipes		8.00	m PWD				
Diameter of Pipe (external)		160	mm	hf =	(2*f*l*v^2)/(g*d)		
Diameter of Pipe (internal)		156	mm	f =	0.0042		
Design Discharge		0.012	m3/sec	v =	0.63	m/s	
Pipe Friction Loss		0.43		hf =	**0.433**	m	
Velocity head, v2/sg		0.02	m				
Nr of pipe bends / changes in pipe diameter / values etc		1.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.02	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets		1.43	Nr				
Nr of riser / outlets		2.00	Nr				
Nr of standpipes		1.00	Nr				
Loss per riser / standpipe		0.01	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes		0.04	m				
Total fitting / bend etc losses		**0.05**	m				
Hydraulic Grade Line El at K		**7.88**	m PWD				

K	Chainage	2,790.0					
Length	**JK**	200	m				
Ground EL		7.00	m PWD				
Command		0.88	m	(0.5 plus 0.3 m req'd - min)			
Top of pipeline		6.00	m PWD				
Hydraulic Grade Line El		**7.88**	m PWD				
Freeboard for standpipes		0.60	m				
El of top of standpipes		8.48	m PWD				
Diameter of Pipe (external)		200	mm	hf =	(2*f*l*v^2)/(g*d)		
Diameter of Pipe (internal)		195	mm	f =	0.0042		
Design Discharge		0.024	m3/sec	v =	0.80	m/s	
Pipe Friction Loss		0.57		hf =	**0.567**	m	
Velocity head, v2/sg		0.03	m				
Nr of pipe bends / changes in pipe diameter / values etc		1.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.03	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets		1.43	Nr				
Nr of riser / outlets		2.00	Nr				
Nr of standpipes		1.00	Nr				
Loss per riser / standpipe		0.02	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes		0.06	m				
Total fitting / bend etc losses		**0.09**	m				
Hydraulic Grade Line El at J		**8.54**	m PWD				

J		**Chainage**		2,590.0				
Length	**IJ**		200	m				
Ground EL			7.10	m PWD				
Command			1.44	m	(0.5 plus 0.3 m req'd - min)			
Top of pipeline			6.10	m PWD				
Hydraulic Grade Line El			**8.54**	m PWD				
Freeboard for standpipes			0.60	m				
El of top of standpipes			9.14	m PWD				
Diameter of Pipe (external)			250	mm		hf =	(2*f*l*v^2)/(g*d)	
Diameter of Pipe (internal)			244	mm		f =	0.0042	
Design Discharge			0.037	m3/sec		v =	0.79	m/s
Pipe Friction Loss			0.44			hf =	**0.439**	m
Velocity head, v2/sg			0.03	m				
Nr of pipe bends / changes in pipe diameter / values etc			1.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc			0.03	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets			1.43	Nr				
Nr of riser / outlets			2.00	Nr				
Nr of standpipes			1.00	Nr				
Loss per riser / standpipe			0.02	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes			0.06	m				
Total fitting / bend etc losses			**0.08**	m				
Hydraulic Grade Line El at I			**9.06**	m PWD				

I		**Chainage**		2,390.0				
Length	**HI**		50	m				
Ground EL			8.25	m PWD				
Command			**0.81**	m	(0.5 plus 0.3 m req'd)			
Top of pipeline			7.25	m PWD				
Hydraulic Grade Line El			**9.06**	m PWD				
Freeboard for standpipes			0.60	m				
El of top of standpipes			9.66	m PWD				
Diameter of Pipe (external)			250	mm		hf =	(2*f*l*v^2)/(g*d)	
Diameter of Pipe (internal)			244	mm		f =	0.0042	
Design Discharge			0.037	m3/sec		v =	0.79	m/s
Pipe Friction Loss			0.11			hf =	**0.110**	m
Velocity head, v2/sg			0.03	m				
Nr of pipe bends / changes in pipe diameter / values etc			1.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc			0.03	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets			0.36	Nr				
Nr of riser / outlets			2.00	Nr				
Nr of standpipes			1.00	Nr				
Loss per riser / standpipe			0.02	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes			0.06	m				
Total fitting / bend etc losses			**0.08**	m				
Hydraulic Grade Line El at H			**9.25**	m PWD				

H		**Chainage**	2,340.0	
Length	**GH**	460	m	
Ground EL		8.30	m PWD	
Command		**0.95**	m	(0.5 plus 0.3 m req'd)
Top of pipeline		7.30	m PWD	
Hydraulic Grade Line El		**9.25**	m PWD	
Freeboard for standpipes (min)		0.30	m	
El of top of standpipes (min)		9.55	m PWD	
Diameter of Pipe (external)		280	mm	hf = (2*f*l*v^2)/(g*d)
Diameter of Pipe (internal)		273	mm	f = 0.0042
Design Discharge		0.046	m3/sec	v = 0.79 m/s
Pipe Friction Loss		0.89		hf = **0.891** m
Velocity head, v2/sg		0.03	m	
Nr of pipe bends / changes in pipe diameter / values etc		1.00	Nr	
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.03	m	Adopt loss coefficient, K, of 0.8
Estimated nr of riser outlets		3.29	Nr	
Nr of riser / outlets		3.00	Nr	
Nr of standpipes		1.00	Nr	
Loss per riser / standpipe		0.02	m	Adopt loss coefficient, K, of 0.6
Losses due to risers / standpipes		0.08	m	
Total fitting / bend etc losses		**0.10**	m	
Hydraulic Grade Line El at G		**10.24**	m PWD	

G		**Chainage**	1,880.0	
Length	**FG**	340	m	
Ground EL		8.26	m PWD	
Command		**1.98**	m	(0.5 plus 0.3 m req'd)
Top of pipeline		7.26	m PWD	
Hydraulic Grade Line El		**10.24**	m PWD	
Freeboard for standpipes (min)		0.30	m	
El of top of standpipes (min)		10.54	m PWD	
Diameter of Pipe (external)		315	mm	hf = (2*f*l*v^2)/(g*d)
Diameter of Pipe (internal)		307	mm	f = 0.0042
Design Discharge		0.058	m3/sec	v = 0.78 m/s
Pipe Friction Loss		0.58		hf = **0.582** m
Velocity head, v2/sg		0.03	m	
Nr of pipe bends / changes in pipe diameter / values etc		1.00	Nr	
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.03	m	Adopt loss coefficient, K, of 0.8
Estimated nr of riser outlets		2.43	Nr	
Nr of riser / outlets		2.00	Nr	
Nr of standpipes		0.00	Nr	
Loss per riser / standpipe		0.02	m	Adopt loss coefficient, K, of 0.6
Losses due to risers / standpipes		0.04	m	
Total fitting / bend etc losses		**0.06**	m	
Hydraulic Grade Line El at F		**10.89**	m PWD	

F		**Chainage**	1,540.0				
Length	**EF**	270	m				
Ground EL		8.05	m PWD				
Command		**2.84**	m	(0.5 plus 0.3 m req'd)			
Top of pipeline		7.05	m PWD				
Hydraulic Grade Line El		**10.89**	m PWD				
Freeboard for standpipes (min)		0.30	m				
El of top of standpipes (min)		11.19	m PWD				
Diameter of Pipe (external)		355	mm		hf = (2*f*l*v^2)/(g*d)		
Diameter of Pipe (internal)		346	mm		f =	0.0042	
Design Discharge		0.079	m3/sec		v =	0.84	m/s
Pipe Friction Loss		0.47			hf =	**0.472**	m
Velocity head, v2/sg		0.04	m				
Nr of pipe bends / changes in pipe diameter / values etc		0.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.00	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets		1.93	Nr				
Nr of riser / outlets		2.00	Nr				
Nr of standpipes		1.00	Nr				
Loss per riser / standpipe		0.02	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes		0.06	m				
Total fitting / bend etc losses		**0.06**	m				
Hydraulic Grade Line El at E		**11.43**	m PWD				

E		**Chainage**	1,270.0				
Length	**DE**	240	m				
Ground EL		7.55	m PWD				
Command		**3.88**	m	(0.5 plus 0.3 m req'd)			
Top of pipeline		6.55	m PWD				
Hydraulic Grade Line El		**11.43**	m PWD				
Freeboard for standpipes		0.60	m				
El of top of standpipes		12.03	m PWD				
Diameter of Pipe (external)		355	mm		hf = (2*f*l*v^2)/(g*d)		
Diameter of Pipe (internal)		346	mm		f =	0.0042	
Design Discharge		0.085	m3/sec		v =	0.90	m/s
Pipe Friction Loss		0.49			hf =	**0.485**	m
Velocity head, v2/sg		0.04	m				
Nr of pipe bends / changes in pipe diameter / values etc		1.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.03	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets		1.71	Nr				
Nr of riser / outlets		2.00	Nr				
Nr of standpipes		1.00	Nr				
Loss per riser / standpipe		0.03	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes		0.08	m				
Total fitting / bend etc losses		**0.11**	m				
Hydraulic Grade Line El at D		**12.02**	m PWD				

D		Chainage	1,030.0				
Length	**CD**		310	m			
Ground EL			8.20	m PWD			
Command			**3.82**	m	(0.5 plus 0.3 m req'd)		
Top of pipeline			7.20	m PWD			
Hydraulic Grade Line El			**12.02**	m PWD			
Freeboard for standpipes			0.60	m			
El of top of standpipes			12.62	m PWD			
Diameter of Pipe (external)			400	mm	hf =	(2*f*l*v^2)/(g*d)	
Diameter of Pipe (internal)			390	mm	f =	0.0042	
Design Discharge			0.096	m3/sec	v =	0.80	m/s
Pipe Friction Loss			0.44		hf =	**0.440**	m
Velocity head, v2/sg			0.03 m				
Nr of pipe bends / changes in pipe diameter / values etc			1.00 Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc			0.03 m		Adopt loss coefficient, K, of 0.8		
Estimated nr of riser outlets			2.21 Nr				
Nr of riser / outlets			2.00 Nr				
Nr of standpipes			1.00 Nr				
Loss per riser / standpipe			0.02 m		Adopt loss coefficient, K, of 0.6		
Losses due to risers / standpipes			0.06 m				
Total fitting / bend etc losses			**0.09** m				
Hydraulic Grade Line El at C			**12.55**	m PWD			

C		Chainage	720.0				
Length	**BC**		290	m			
Ground EL			7.30	m PWD			
Command			**5.25**	m	(0.5 plus 0.3 m req'd)		
Top of pipeline			6.30	m PWD			
Hydraulic Grade Line El			**12.55**	m PWD			
Freeboard for standpipes			0.60	m			
El of top of standpipes			13.15	m PWD			
Diameter of Pipe (external)			450	mm	hf =	(2*f*l*v^2)/(g*d)	
Diameter of Pipe (internal)			439	mm	f =	0.0042	
Design Discharge			0.105	m3/sec	v =	0.69	m/s
Pipe Friction Loss			0.27		hf =	**0.272**	m
Velocity head, v2/sg			0.02 m				
Nr of pipe bends / changes in pipe diameter / values etc			1.00 Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc			0.02 m		Adopt loss coefficient, K, of 0.8		
Estimated nr of riser outlets			2.07 Nr				
Nr of riser / outlets			2.00 Nr				
Nr of standpipes			1.00 Nr				
Loss per riser / standpipe			0.01 m		Adopt loss coefficient, K, of 0.6		
Losses due to risers / standpipes			0.04 m				
Total fitting / bend etc losses			**0.06** m				
Hydraulic Grade Line El at B			**12.88**	m PWD			

B		Chainage	430.0				
Length	**AB**	350	m				
Ground EL		7.21	m PWD				
Command		**5.67**	m	(0.5 plus 0.3 m req'd)			
Top of pipeline		6.21	m PWD				
Hydraulic Grade Line El		**12.88**	m PWD				
Freeboard for standpipes		0.60	m				
El of top of standpipes		13.48	m PWD				
Diameter of Pipe (external)	E to F	450	mm		hf = (2*f*l*v^2)/(g*d)		
Diameter of Pipe (internal)		439	mm		f =	0.0042	
Design Discharge		0.113	m3/sec		v =	0.75	m/s
Pipe Friction Loss		0.38			hf =	**0.380**	m
Velocity head, v2/sg		0.03	m				
Nr of pipe bends / changes in pipe diameter / values etc		1.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.02	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets		2.50	Nr				
Nr of riser / outlets		2.00	Nr				
Nr of standpipes		1.00	Nr				
Loss per riser / standpipe		0.02	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes		0.05	m				
Total fitting / bend etc losses		**0.07**	m				
Hydraulic Grade Line El at A		**13.34**	m PWD				

A		Chainage	80.0				
Length	**HT-A**	80	m				
Ground EL		8.50	m PWD				
Command		**4.84**	m	(0.5 plus 0.3 m req'd)			
Top of pipeline		7.50	m PWD				
Hydraulic Grade Line El		13.34	m PWD				
Freeboard for standpipes		0.60	m				
El of top of standpipes		13.94	m PWD				
Diameter of Pipe (external)		450	mm		hf = (2*f*l*v^2)/(g*d)		
Diameter of Pipe (internal)		439	mm		f =	0.0042	
Design Discharge		0.12	m3/sec		v =	0.79	m/s
Pipe Friction Loss		0.10			hf =	**0.098**	m
Velocity head, v2/sg		0.03	m				
Nr of pipe bends / changes in pipe diameter / values etc		1.00	Nr				
Loss due to pipe bends / change in pipe diameter/ control values, etc		0.03	m	Adopt loss coefficient, K, of 0.8			
Estimated nr of riser outlets		0.57	Nr				
Nr of riser / outlets		1.00	Nr				
Nr of standpipes		0.00	Nr				
Loss per riser / standpipe		0.02	m	Adopt loss coefficient, K, of 0.6			
Losses due to risers / standpipes		0.02	m				
Total fitting / bend etc losses		**0.04**	m				
Hydraulic Grade Line El at HT		**13.48**	m PWD				

HT		Chainage	0.0	
Ground EL		8.45	m PWD	
Command		**5.03**	m	
Top of pipeline		7.45	m PWD	
Hydraulic Grade Line El		**13.48**	m PWD	Check also pipeline 2
Freeboard for Header tank		0.60	m	
El of top of header tank		14.08	m PWD	
Height of Tank		5.63		

EXHIBIT G6-G10: DesignPro 10 - StucturalDesignUSD

StructuralDesignUSD

Name of Subproject : Durgapur Khal
Name of Regulator : Durgapur Khal Regulator (2V-1.50mx1.80m)
Upazila: Pangsha
District: Rajbari

Structural Design of Wingwall & Apron of Regulator
(Using STAADPro. Analysis and USD method)

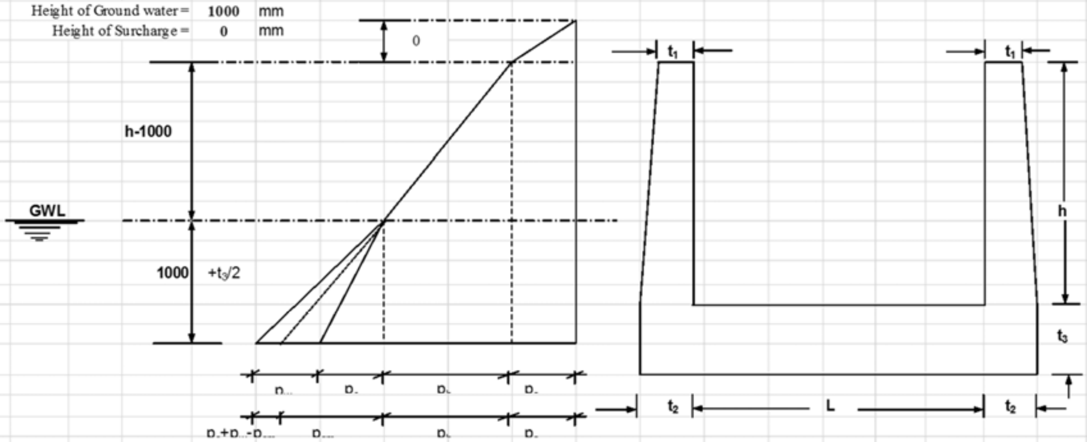
Design Parameters :

fc' =	21.00	N/mm^2	psi = 3000		γ_{conc} =	23.60	Kn/m^3
fy =	415	N/mm^2	psi = 60000		$\gamma_{s(moist)}$	17.40	Kn/m^3
β_1 =	0.85				$\gamma_{s(Sat)}$	18.90	Kn/m^3
ϕ =	0.90				$\gamma_{s(Sub)}$	9.09	Kn/m^3
Ka =	0.41				$\gamma_{w(Water)}$	9.81	Kn/m^3
φ =	25 °						

	R/S =	C-C	G-G	= C/S			R/S =	D-D	H-H	= C/S			R/S =	E-E	I-I	= C/S	
	Section C-C / G-G						Section D-D / H-H						Section E-E / I-I				
	t_1	t_2	t_3	h	L		t_1	t_2	t_3	h	L		t_1	t_2	t_3	h	L
R/S	**250**	**450**	**600**	**4700**	**3450**		**250**	**419**	**600**	**4400**	**4033**		**250**	**378**	**531**	**3200**	**4810**
	250	450	600	4700	3450		250	419	600	4400	4033		250	378	531	3200	4810
1800	250	419	600	4400	4033	2400	250	378	531	3200	4810	4600	250	300	400	3200	6300
C/S	**250**	**450**	**600**	**4700**	**3450**		**250**	**409**	**600**	**4450**	**3927**		**250**	**335**	**465**	**3100**	**4786**
	250	450	600	4700	3450		250	409	600	4450	3927		250	335	465	3100	4786
1500	250	409	600	4450	3927	2700	250	335	465	3100	4786	1300	250	300	400	3100	5200

Pressure Calculation for STAAD input

Height of Ground water = **1000** mm
Height of Surcharge = **0** mm



	Section C-C / G-G						
	p_a	p_b	p_c	p_w	p_{cm}	$p_a+p_b+p_{cm}$	$p_c+p_w-p_{cm}$
R/S	0.00	26.40	4.84	12.75	9.27	35.67	8.32
C/S	0.00	26.40	4.84	12.75	9.27	35.67	8.32

	Section D-D / H-H						
	p_a	p_b	p_c	p_w	p_{cm}	$p_a+p_b+p_{cm}$	$p_c+p_w-p_{cm}$
R/S	0.00	24.26	4.84	12.75	9.27	33.53	8.32
C/S	0.00	24.61	4.84	12.75	9.27	33.89	8.32

	Section E-E / I-I						
	p_a	p_b	p_c	p_w	p_{cm}	$p_a+p_b+p_{cm}$	$p_c+p_w-p_{cm}$
R/S	0.00	15.69	4.72	12.42	9.03	24.72	8.10
C/S	0.00	14.98	4.59	12.09	8.79	23.77	7.89

Design of Wingwall :

	R/S (C-C)				C/S (G-G)			
	Earth face		Exposed face		Earth face		Exposed face	
Result from STAAD :	Hor.(+Mx)	Ver.(+My)	Hor.(-Mx)	Ver.(-My)	Hor.(+Mx)	Ver.(+My)	Hor.(-Mx)	Ver.(-My)
Mu (kN-m/m)=	64.6	159.7	-24.1	-21.3	54.7	100.2	-26.5	-48.4
Cor. Plate No. =	7343	7351	7424	7392	2123	2139	2015	2151
avail. Th., t (mm)=	445	445	329	376	443	443	296	362
Clear Cover, (mm)=	75	75	75	75	75	75	75	75
Assu. Bar Dia, (mm) =	16	16	16	16	16	16	16	16
d (mm)=	362	362	246	293	360	360	213	279
Checking of Depth :								
Design Moment, Mn =	71.79	177.44	26.79	23.62	60.76	111.31	29.46	53.78
d_d (mm)=	184.88	290.65	112.94	106.04	170.08	230.21	118.43	160.01
Provided depth is	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Req. Steel for Flexure :								
k_u =	0.031	0.079	0.025	0.016	0.027	0.049	0.037	0.039
A_s (mm^2/m) =	485	1230	266	196	412	764	340	474
Req. Steel for Temp. and Shrinkage :								
A_s (mm^2/m) =	750	750	750	750	750	750	750	750

EXHIBIT G6-G11: DesignPro 11 - QtyEstimate
(Input Data Sheet)

ESTIMATE OF QUANTITIES OF REGULATOR
Part-B : Box Sluice (1 V - 0.90mX0.90m)
At Ch. 0+5730 Km (East Embkt.)

SP3 : Charkhai-Dakshin Haor Subproject
Upazila: Beanibazar
District: Sylhet

INPUT DATA

	Dimension (mm)	Elevation (m)		Dimension (mm)	Elevation (m)
1. GENERAL:			D/S Wing/Ret. Wall Level:		11.00
Number of Vents:	1		Thickness:	75	
Width of Vents:	900		Protective Works (Block): R/S:		13.2
Height of Vents:	900		Single Layer:	2000	
Pier Thickness:-			Double Layer	0	
Gate Part:	450		Protective Works: C/S:		12.118
Box part:	450		Single Layer:	2000	
Bridge Deck Level:		13.20	Double Layer	0	
Operation Deck Level:	10.9	14.00	Slope:	1.5	
Sill/Invert Level:		9.60	Drop for Flap gate	0	
C/S Floor Level:		9.20	Width for Flap	0	
R/S Floor Level:		9.20	Sand Filling		8.50
U/S Wing/Ret.Wall Level:		11.00	Pile Embedment	0	
2. BOX/BARREL PART:					
Railing: Bridge Deck:			Breast Wall: Numbers	1	
Numbers of Posts:	0		Bottom Elevation:		10.50
Cross-section: Width:	150		Height:	3500	
Length	150		Width:	1700	
Height of Posts:	800		Thickness:	250	
Number of Railings:	0		Thickness:Bottom	250	
Cross-section: Width:	150		Thrust Beam: Numbers	1	
Height:	150		Width:1	0	
Length of Railings:	1700		Width:2	0	
Railing: Operation Deck:			Depth:	0	
Numbers of Posts:	4		Length:	1700	
Cross-section: Width:	150		Piers:		
Length	150		Numbers of Piers:	0	
Height of Posts:	800		Length: Gate Part:	1500	
Number of Railings:	4		Box Part:	5090	
Cross-section: Width:	150		Gate Slots: Numbers:	2	
Height:	150		Width:	150	
Length of Railings:	1400		Depth:	110	
Railing: Operation Deck: Short			Stop log Slots: Numbers:	2	
Number of Railings:	4		Width:	145	
Cross-section: Width:	150		Depth:	65	
Height:	150		Abutments:		
Length of Railings:	1500		Numbers of Abutments:	2	
Curb:			Length: Gate Part:	1500	
Numbers of Curbs:	0		Box Part:	5090	
Curb Width (incl. Posts):	375		Thickness: Gate Part (Top):	250	**250**
Slope Width:	25		Gate Part (Bottom):	400	**400**
Height:	200		Box Part (Top):	400	
Top Slab: Bridge Deck:			Box Part (Bottom):	400	
Width:	4665		Base Slab:		
Length:	1700		Length:	6165	
Thickness:	400		Width:	1700	
Top Slab: Operation Deck:			Thickness:	500	
Length:	1500		Fillets:		
Width: Strip-1	425		Numbers:	4	
Strip-2	495		Depth:	100	
Strip-3	325		Width:	100	
Thickness:	250		Length:	6165	

(Input Data Sheet – Contd)

3. RIVER SIDE PART:			Width (U/S End):	2271	1633
Glacis Slop:	3.00		Width (D/S End):	2400	1800
Glacis Drop:	400		Thickness (U/S End):	424	
Wing Wall: Sloping Part (Glacis):			Thickness (D/S End):	400	
Numbers of Stem:	2		Return Wall Base:		
Flaring Slop:	12.00		Numbers:	2	
Top Slop:	2.00		Length:	2700	
Length:	1200		Width:	1600	
Height: Start:	3600		Thickness:	400	
End:	3400		Cut-off Wall: For Sheet Pile		
Thickness (Top):	250		Length:	7200	
Thickness (Bottom)Start:	400		Depth:	1200	
Thickness (Bottom)End:	378		Thickness of Sheet Pile	8	
Wing Wall: Sloping Part (Flared):			Depth of Sheet Piles:	0	
Numbers:	2		Thickness (Top):1	250	
Flaring Slop:	12.00		Thickness (Top):2	0	
Length (Longitudinal):	3200		Thickness (Bottom):1	250	
Height: Start:	3400		Thickness (Bottom):2	0	
End:	1800		Chute Blocks:		
Thickness (Top):	250		Numbers of Block:	2	
Thickness (Bottom U/S End):	378		Width:	300	
Thickness (Bottom D/S End):	319		Length:	900	
Wing Wall: Level Part (D/S End):			Height:	300	
Numbers:	2		Baffle Blocks:		
Flaring Slop:	12.00		Numbers of Block:	3	
Length (Longitudinal):	1000		Width:	300	
Height:	1800		Length (Top):	150	
Thickness (Top):	250		Length(Bottom):	500	
Thickness (Bottom U/S End):	319		Height:	350	
Thickness (Bottom D/S End):	300		End Sill (Trapezoidal):		
Return Wall (Stem):			Numbers of Block:	1	
Numbers:	2		Width:	1800	
Length:	2700		Length (Top):	150	
Hieght:	1800		Length (Bottom):	750	
Thickness (Top):	250		Height:	300	
Thickness (Bottom):	300		End Sill (Triangular):Numbers	0	
Floor: Glacis Part:			Width:	1800	
Numbers:	1		Height:	150	
Length:	1200		Length (Bottom):	750	
Width :(U/S End)	1700	900	Extension	500	
Width :(D/S End)	1856	1100	Flap Gate Lifting Slab	Flap Gate Lifting Slab is not Prese	
Thickness (U/S End):	500		Length	0	0
Thickness (D/S End):	500		Thickness	0	
Floor: Flaring Part:			Width	0	
Numbers:	1		Railpost (Nos.)	0	
Length:	3200		Railpost Height	0	
Width (U/S End):	1856	1100	Railpost Width	0	
Width (D/S End):	2271	1633	Rialpost Thickness	0	
Thickness (U/S End):	500		Rail (Nos.)	0	0
Thickness (D/S End):	424		Rail Length	0	0
Floor: End Part:			Rail Width	0	
Numbers:	1		Rial Thickness	0	
Length:	1000				

(Input Data Sheet – Contd)

4. COUNTRY SIDE:					
Glacis Slop:	3.00		Width (D/S End):	2400	1800
Glacis Drop:	400		Thickness (U/S End):	449	
Wing Wall: Sloping Part (Straight):			Thickness (D/S End):	400	
Numbers of Stem:	2		Return Wall Base:		
Flaring Slop:	7.19		Numbers:	2	
Top Slop:	2		Length:	2700	
Length:	1200	1200	Width:	1600	
Height: Start:	2518		Thickness:	400	
End:	2318		Cut-off Wall: For Sheet Pile		
Thickness (Top):	250		Length:	7200	
Thickness (Bottom)Start:	400		Depth:	1200	
Thickness (Bottom)End:	363		Thickness of Sheet Pile	8	
Wing Wall: Sloping Part (Flared):			Depth of Sheet Piles:	0	
Numbers:	2		Thickness (Top):1	250	
Flaring Slop:	7.19		Thickness (Top):2	0	
Length (Longitudinal):	1035		Thickness (Bottom):1	250	
Height: Start:	2318		Thickness (Bottom):2	0	
End:	1800		Chute Blocks:		
Thickness (Top):	250		Numbers of Block:	2	
Thickness (Bottom U/S End):	363		Width:	300	
Thickness (Bottom D/S End):	331		Length:	900	
Wing Wall: Level Part (D/S End):			Height:	300	
Numbers:	2		Baffle Blocks:		
Flaring Slop:	7.19		Numbers of Block:	3	
Length (Longitudinal):	1000		Width:	300	
Height:	1800		Length (Top):	150	
Thickness (Top):	250		Length(Bottom):	500	
Thickness (Bottom U/S End):	331		Height:	350	
Thickness (Bottom D/S End):	300		End Sill (Trapezoidal):		
Return Wall (Stem):			Numbers of Block:	1	
Numbers:	2		Width:	1800	
Length:	2700		Length (Top):	150	
Height:	1800		Length (Bottom):	750	
Thickness (Top):	250		Height:	300	
Thickness (Bottom):	400		End Sill (Triangular):Numbers	0	
Floor: Glacis Part:			Width:	1800	
Numbers:	1		Height:	150	
Length:	1200		Length (Bottom):	750	
Width (U/S End):	1700	900	Extension	500	
Width (D/S End):	1960	1234	RCC pre-cast Sheet Pile		
Thickness (U/S End):	500		R/S Depth	0	
Thickness (D/S End):	500		Thickness	0	
Floor: Flaring Part:			C/S Depth	0	
Numbers:	1		Thickness	0	
Length:	1035				
Width (U/S End):	1960	1234			
Width (D/S End):	2184	1522			
Thickness (U/S End):	500				
Thickness (D/S End):	449				
Floor: End Part:					
Numbers:	1				
Length:	1000				
Width (U/S End):	2184	1522			

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(Calculations Sheet)

ESTIMATE OF QUANTITIES OF REGULATOR
Part-B : Box Sluice (1 V - 0.90mX0.90m)
At Ch. 0+5730 Km (East Embkt.)

SP3 : Charkhai-Dakshin Haor Subproject
Upazila: Beanibazar
District: Sylhet

CC (1:3:6) Under Structure:										
Box =		6.165 X	1.70 X	0.075					=	0.786038 m^3
River Side Part:										
Glacis	=	1.265 X(	1.70 +	1.856)X	0.5 X	0.075			=	0.1687 m^3
Floor (Flaring)	=	3.100 X(	1.86 +	2.258)X	0.5 X	0.075			=	0.4782 m^3
Return Wall	=	7.20 X	1.35 X	0.075					=	0.7290 m^3
	=	7.20 X	0.00 X	0.075					=	0.0000 m^3
Under End Wall	=	12.09 X	0.375 X	0.050					=	0.2267 m^3
Country Side Part:										
Glacis	=	1.265 X(	1.70 +	1.960)X	0.5 X	0.075			=	0.1736 m^3
Floor (Flaring)	=	0.935 X(	1.96 +	2.162)X	0.5 X	0.075			=	0.1445 m^3
Return Wall	=	7.20 X	1.35 X	0.075					=	0.7290 m^3
	=	7.20 X	0.00 X	0.075					=	0.0000 m^3
Under End Wall	=	12.09 X	0.375 X	0.050					=	0.2267 m^3
							Total		**=**	**3.6600 m^3**
RCC (1:2:4): Bottom Slab:										
Box Part	=	6.165 X	1.70 X	0.500					=	5.2403 m^3
River Side Part:										
Glacis	=	1.265 X(	0.50 +	0.500)X	0.5 X(	1.70 +	1.856)X	0.5	=	1.1245 m^3
Floor (Flaring)	=	3.100 X(	1.86 +	2.258)X	0.5 X(	0.50 +	0.426)X	0.5	=	2.9527 m^3
	=	1.600 X(	2.26 +	2.400)X	0.5 X(	0.026 +	0.000)X	0.5	=	0.0488 m^3
Return Wall	=	7.20 X	1.60 X	0.400					=	4.6080 m^3
Country Side :										
Glacis	=	1.265 X(	0.50 +	0.50)X	0.5 X(	1.70 +	1.96)X	0.5	=	1.1574 m^3
Floor (Flaring)	=	0.935 X(	1.96 +	2.162)X	0.5 X(	0.50 +	0.45)X	0.5	=	0.9193 m^3
	=	1.600 X(	2.162 +	2.400)X	0.5 X(	0.05 +	0.00)X	0.5	=	0.0986 m^3
Return Wall	=	7.20 X	1.60 X	0.400					=	4.6080 m^3
							Total		**=**	**20.76 m^3**
RCC (1:2:4): Abutment, Pier, Return Wall, Breast Wall, Chute Block, Baffle Block, Cut-off, Caisson etc.:										
Box Part:										
Breast Wall	=	1.700 X	3.25 X	0.250 X	1				=	1.3813 m^3
	=	1.700 X	1.50 X	0.325 X	1				=	0.8288 m^3
Thrust Beam	=	1.700 X	0.000 X	0.00 X	1				=	0.0000 m^3
	=	1.700 X	0.000 X	0.00 X	1				=	0.0000 m^3
Pier (Gate Part)	=	4.150 X	1.500 X	0.45 X	0				=	0.0000 m^3
Pier (Box Part)	=	3.200 X	5.090 X	0.45 X	0				=	0.0000 m^3
Less Gate Slot	=	4.150 X	0.150 X	0.11 X	0 X	4			=	0.0000 m^3
	=	4.150 X	0.145 X	0.065 X	0 X	4			=	0.0000 m^3
Abutment (G.Part)	=	4.150 X(	0.25 +	0.40)X	0.5 X	1.500 X	2		=	4.0463 m^3
Abutment (B.Part)	=	0.900 X(	0.40 +	0.40)X	0.5 X	5.090 X	2		=	3.6648 m^3
Less Gate Slot	=	4.150 X	0.150 X	0.11 X	2				=	-0.0297 m^3
	=	4.150 X	0.145 X	0.065 X	2				=	-0.0782 m^3
Fillet	=	6.165 X	0.10 X	0.10 X	4 X	0.5			=	0.1233 m^3
								Sub-Total	=	9.9364 m^3

(Calculations Sheet - contd)

River Side Part:											
W. Wall (Flar.Slop)	=	1.204 X(	3.60 +	3.40)X	0.5 X(	0.25 +	0.39)X	0.5 X	2	=	2.6931 m^3
W. Wall (Flar.Slop)	=	3.211 X(	3.40 +	1.80)X	0.5 X(	0.25 +	0.349)X	0.5 X	2	=	4.9968 m^3
W. Wall (Flar.Str.)	=	1.003 X(	0.25 +	0.31)X	0.5 X	1.80 X	2			=	1.0106 m^3
Return Wall	=	2.700 X	1.80 X(	0.25 +	0.30)X	0.5 X	2			=	2.6730 m^3
Fillet	=	5.419 X	0.10 X	0.10 X	2 X	0.5				=	0.0542 m^3
Chute Block	=	0.30 X	0.9 X	0.30 X	0.5 X	2				=	0.0810 m^3
Baffle Block	=	0.30 X(	0.15 +	0.5)X	0.5 X	0.35 X	3			=	0.1024 m^3
End Sill (Trap)	=	1.80 X(	0.15 +	0.75)X	0.5 X	0.30 X	1			=	0.2430 m^3
End Sill (Triang)	=	1.80 X	0.150 X	0.75 X	0.5 X	0				=	0.0000 m^3
Toe Block	=	0.50 X	0.600 X	0.250 X	1 X	2				=	0.1500 m^3
								Sub-Total		=	12.0040 m^3
Country Side Part:											
Wing Wall (Flared)	=	1.212 X(	2.52 +	2.32)X	0.5 X(	0.25 +	0.38)X	0.5 X	2	=	1.8500 m^3
Wing Wall (Flared)	=	1.045 X(	2.32 +	1.80)X	0.5 X(	0.25 +	0.347)X	0.5 X	2	=	1.2845 m^3
Wing Wall (Level)	=	1.010 X(	0.25 +	0.316)X	0.5 X	1.80 X	2			=	1.0277 m^3
Return Wall	=	2.700 X(	0.25 +	0.40)X	0.5 X	1.80 X	2			=	3.1590 m^3
Fillet	=	3.266 X	0.10 X	0.10 X	2 X	0.5				=	0.0327 m^3
Chute Block	=	0.30 X	0.90 X	0.30 X	0.5 X	2				=	0.0810 m^3
Baffle Block	=	0.30 X(	0.15 +	0.50)X	0.5 X	0.35 X	3			=	0.1024 m^3
End Sill (Trap)	=	1.80 X(	0.15 +	0.75)X	0.5 X	0.30 X	1			=	0.2430 m^3
End Sill (Triang)	=	1.80 X	0.15 X	0.75 X	0.5 X	0				=	0.0000 m^3
Toe Block	=	0.50 X	0.600 X	0.25 X	1 X	2				=	0.1500 m^3
								Sub-Total		=	7.9302 m^3
Cut-off:											
River Side	=	7.20 X	1.20 X(	0.25 +	0.25)X	0.5				=	2.1600 m^3
	=	7.20 X	1.20 X(	0.00 +	0.00)X	0.5				=	0.0000 m^3
Country Side	=	7.20 X	1.20 X(	0.25 +	0.25)X	0.5				=	2.1600 m^3
	=	7.20 X	1.20 X(	0.00 +	0.00)X	0.5				=	0.0000 m^3
								Sub-Total		=	4.3200 m^3
				34.19 -	0.00			**Total**		**=**	**34.190 m^3**
ABOVE 5.0m											
Box Part:											
Breast Wall	=	1.700 X	0.00 X	0.250 X	1					=	0.0000 m^3
Pier (Gate Part)	=	0.000 X	1.500 X	0.450 X	0					=	0.0000 m^3
Pier (Box Part)	=	0.000 X	5.090 X	0.450 X	0					=	0.0000 m^3
Less Gate Slot	=	0.000 X	0.150 X	0.110 X	0 X	4				=	0.0000 m^3
	=	0.000 X	0.145 X	0.065 X	0 X	4				=	0.0000 m^3
Abutment (G.Part)	=	0.000 X(	0.250 +	0.250)X	0.5 X	1.500 X	2			=	0.0000 m^3
Abutment (B.Part)	=	0.000 X(	0.400 +	0.400)X	0.5 X	5.090 X	2			=	0.0000 m^3
Less Gate Slot	=	0.000 X	0.150 X	0.110 X	2					=	0.0000 m^3
	=	0.000 X	0.145 X	0.065 X	2					=	0.0000 m^3
								Sub-Total		=	0.0000 m^3
River Side Part:											
W. Wall (Flar.Slop)	=	1.204 X(	0.000 +	0.000)X	0.5 X(	0.250 +	0.250)X	0.5 X	2	=	0.0000 m^3
W. Wall (Flar.Slop)	=	0.000 X(	0.000 +	0.000)X	0.5 X(	0.250 +	0.250)X	0.5 X	2	=	0.0000 m^3
W. Wall (Flar.Str.)	=	1.003 X(	0.250 +	0.250)X	0.5 X	0.000 X	2			=	0.0000 m^3
Return Wall	=	2.700 X	0.000 X(	0.250 +	0.25)X	0.5 X	2			=	0.0000 m^3
								Sub-Total		=	0.0000 m^3

(Calculations Sheet - contd)

Country Side Part:											
Wing Wall (Flared)	=	1.212 X(	0.000 +	0.000)X	0.5 X(	0.250 +	0.250)X	0.5 X	2	=	0.00000 m^3
Wing Wall (Flared)	=	0.000 X(	0.000 +	0.000)X	0.5 X(	0.250 +	0.250)X	0.5 X	2	=	0.0000 m^3
Wing Wall (Level)	=	1.010 X(	0.250 +	0.250)X	0.50 X	0.000 X	2			=	0.0000 m^3
Return Wall	=	2.700 X	0.000 X(	0.250 +	0.25)X	0.5 X	2			=	0.0000 m^3
								Sub-Total		=	0.0000 m^3
								Total		**=**	**0.0000 m^3**
RCC (1:2:4): Top Slab, Curb etc.:											
Box:											
Top Slab (B. Deck)	=	4.665 X	1.70 X	0.40						=	3.1722 m^3
Curb	=	0.20 X(	0.350 +	0.375)X	0.5 X	1.70 X	0			=	0.0000 m^3
Top Slab (O. Deck)											
Strip 1	=	0.425 X	1.70 X	0.25						=	0.1806 m^3
Strip 2	=	0.495 X	1.70 X	0.25						=	0.2104 m^3
Strip 3	=	0.325 X	1.70 X	0.25						=	0.1381 m^3
Slab (F.G.Lifting)	=(	0.00 +	0.00)X	0.50 X	0 X	0.00				=	0.0000 m^3
									Total	**=**	**3.7000 m^3**
RCC (1:2:4) Railbar & Railpost:											
Railing (B. Deck)	=	1.70 X	0.150 X	0.15 X	0					=	0.0000 m^3
Railing (O. Deck)	=	1.40 X	0.150 X	0.15 X	4					=	0.1260 m^3
Railing (O. Deck)Sl	=	1.20 X	0.150 X	0.15 X	4					=	0.1080 m^3
Railing (F.G.Lifting)	=	0.00 X	0.000 X	0 X	0					=	0.0000 m^3
	=	0.00 X	0.000 X	0 X	0					=	0.0000 m^3
Railpost (B. Deck)	=	0.150 X	0.150 X	0.500 X	0					=	0.0000 m^3
Railpost (O. Deck)	=	0.150 X	0.150 X	0.500 X	4					=	0.0450 m^3
Railpost (F.G.Liftin	=	0.000 X	0.000 X	0.000 X	0					=	0.0000 m^3
								Total		**=**	**0.2800 m^3**
38mm Wearing Course (1:1.5:3) on Bridge Deck:											
Box	=	4.67 X	1.70 X	0						**=**	**0.0000 m^2**
6mm Thick Plaster in Railing & Railpost:											
Railing (B. Deck)	=	0 X	1.700 X	0.15 X	2					=	0.0000 m^2
	=	0 X	1.700 X	0.15 X	1					=	0.0000 m^2
	=	0 X	1.700 X	0.15 X	1					=	0.0000 m^2
	=	0 X	1.700 X	0.15 X	2					=	0.0000 m^2
Rail Post	=	4 X	0.800 X	0.15 X	4					=	1.9200 m^2
	=	0 X	0.500 X	0.15 X	3					=	0.0000 m^2
	=	0 X	0.500 X	0.15 X	4					=	0.0000 m^2
Railing (F.G.Lifting)	=	0 X	0.000 X	0 X	2					=	0.0000 m^2
	=	0 X	0.000 X	0 X	1					=	0.0000 m^2
	=	0 X	0.000 X	0 X	2					=	0.0000 m^2
	=	2 X	0.000 X	0 X	1					=	0.0000 m^2
	=	0 X	0.000 X	0 X	2					=	0.0000 m^2
	=	2 X	0.000 X	0 X	1					=	0.0000 m^2
	=	-2 X	0.000 X	0 X	2					=	0.0000 m^2
	=	2 X	0.000 X	0 X	1					=	0.0000 m^2
Rail Post(FG Lift)	=	2 X	0.000 X	0 X	1					=	0.0000 m^2
	=	2 X	0.000 X	0 X	3					=	0.0000 m^2
	=	-2 X	0.000 X	0 X	4					=	0.0000 m^2
Railing (O. Deck)sl	=	4 X	1.500 X	0.15 X	2					=	1.8000 m^2
	=	2 X	1.500 X	0.15 X	1					=	0.4500 m^2
	=	2 X	1.200 X	0.15 X	2					=	0.7200 m^2
	=	2 X	1.200 X	0.15 X	1					=	0.3600 m^2

(Calculations Sheet - contd)

Railing (O. Deck)	=	4 X 1.400 X	0.15 X	2			=	1.6800 m^2
	=	2 X 1.400 X	0.15 X	1			=	0.4200 m^2
	=	2 X 1.100 X	0.15 X	2			=	0.6600 m^2
	=	2 X 1.100 X	0.15 X	1			=	0.3300 m^2
						Total	**=**	**8.3400 m^2**
<u>CC Blocks with Stone Chips</u>								
Precast Block (400mmX400mmX300mm):								
River Side: Bed	=	2.00 X 1.30					=	2.6000 m^2
	=	0.00 X 1.30 X	2				=	0.0000 m^2
Slope	=	2.75 X 3.24 X	2				=	17.8475 m^2
Country Side : Bed	=	2.00 X 1.30					=	2.6000 m^2
	=	0.00 X 1.30 X	2				=	0.0000 m^2
Slope	=	2.75 X 3.24 X	2				=	17.8475 m^2
								40.8950 m^2
Number of Blocks in Bed and Slop	=							**256 Nos.**
Number of Blocks in Sides	=							**30 Nos.**
						Total	=	**286 Nos.**
<u>Brick Works in End Wall:</u>								
River Side	=	12.09 X(0.38 X	0.15 + 0.25 X	0.60)			=	2.5026 m^3
Country Side	=	12.09 X(0.38 X	0.15 + 0.25 X	0.60)			=	2.5026 m^3
						Total	**=**	**5.0100** m^3
<u>Embedded Metal:</u>								0.0000
Sheet Piles:River Side	=	1 X(0.00 X	7.20)				=	0.0000 m^2
Country Side	=	1 X(0.00 X	7.20)				=	0.0000 m^2
					0.00	**Total**	**=**	**0.00 m^2**
	=	12 0.00 X	48.00				=	0.0000 Kg
	=	12 0.00 X	48.00				=	0.0000 Kg
						Total	**=**	**0.00 Kg**
GateGuide	=	1 X 2 X	4.40				**=**	**8.8000 m**
Stop Log Guide	=	1 X 2 X(	3.60 +(0.90 +	2 X 0.065))			**=**	**9.2600 m**
Breast Wall Seal Strip	=	1 X 0.90 X	1				**=**	**0.9000 m**
Step Irons	=						**=**	**25 Nos.**
Handholds	=						**=**	**4 Nos.**
Bottom Seal of Gate Guide	=	1 X(0.90 +	2 X 0.12)X				**=**	**1.1400 m**
Breast Wall Plate	=						**=**	**1 Nos.**
Flap Gate Frame	=	0 X(0.900 +	1.80)X	2			**=**	**0.00 m**
Flap Gate Hinge wi	=	0					**=**	**0.00 Nos.**
								598 Kg
<u>Local Sand Under Brick Block:</u>								
River Side	=	2.60 + 2.50 x	0.00 x	2			=	2.6000 m^2
Country Side	=	2.60 + 2.50 x	0.00 x	2			=	2.6000 m^2
							=	5.2000 m^2
Volume of Sand	=	5.2 X 0.15					**=**	**0.7800 m^3**
<u>Khoa Under Brick Block:</u>								
Volume of Khoa	=	5.2 X 0.15					**=**	**0.7800 m^3**
<u>MSGate:</u>								
Vertical Lift Gate:	=	1.070 m X	0.995 m				**=**	**1 Nos**
Flap Gate	=	1.070 m X	1.070 m				**=**	**0 Nos**

(Calculations Sheet - contd)

Fall Boards										
Stop Logs	=								=	**Nos.**
Painting of Gauge:										
River Side	=	3.59 X	0.20						=	0.7182 m^2
Country Side	=	2.52 X	0.20						=	0.5036 m^2
							Total		=	**1.2200 m^2**
Reinforcement:	= For Structure part								=	**4114 Kg**
	= For Piles Only								=	**Kg**
RCC works in Pile	=	0 x	9.86 x	0.3 x	0.3				=	**0.00 m^3**
	=	0 x	8.00 x	0.3 x	0.3				=	**0.00 m^3**
							Total		=	**0.00 m^3**
RCC Shhet Pile :R/S	=	0 X(	0.00 X	7.20)					=	0.0000 m^2
C/S	=	0 X(	0.00 X	7.20)					=	0.0000 m^2
							Total		=	**0.00 m^2**
Sand Filling in Foundation										
Box	=	2.225 X	0.53 X	6.17					=	7.20 m^3
R/S Glacis	=(	2.225 +	2.085)X	0.5 X(	0.53 +	0.125)X	0.5 X	1.20	=	0.84 m^3
R/S Stilling basin	=(	2.085 +	2.63)X	0.5 X(	0.13 +	0.225)X	0.5 X	6.01	=	2.48 m^3
R/S Return Wall	=	1.825 X	0.225 X	2.7 X	2				=	2.22 m^3
C/S Glacis	=(	2.225 +	2.085)X	0.5 X(	0.53 +	0.125)X	0.5 X	1.20	=	0.84 m^3
R/S Stilling basin	=(	2.085 +	2.63)X	0.5 X(	0.13 +	0.225)X	0.5 X	3.85	=	1.59 m^3
R/S Return Wall	=	1.825 X	0.225 X	2.7 X	2				=	2.22 m^3
										17.00 m^3
Leveling & Dressing of Top:										
	=	2 X	15.00 X	4.00					=	120.00 m^2
	=	2 X	0.00 X	4.85					=	0.00 m^2
	=	2 X	0.00 X	3.70					=	0.00 m^2
									=	**120.00 m^2**
Turfing on Slope of Embankment:										
	=	2 X	15.00 X(	2 X	0.60 +	9.84)			=	**331.16 m^2**
	=	0 X	15.05 X(	2 X	0.60 +	9.84)			=	**0.00 m^2**
									Total =	**331.200 m^2**
Earthwork in Excavation	=								=	**425.00 m^3**
Earthwork in Filling	=								=	**1049.00 m^3**
Painting of sheet piles										
R/S	=	2 X	0.30 X	0.60 X	0				=	0.00 m^2
C/S	=	2 X	0.30 X	0.60 X	0				=	0.00 m^2
									Total:	**0.00 m^2**
Supply & Placing of 20 mmhessian cloth of sheet piles										
R/S	=	0.60 X	0.17 X	0					=	0.00 m^2
C/S	=	0.60 X	0.17 X	0					=	0.00 m^2
									Total:	**0.00 m^2**
RCC Bottom:										20.7600
RCC Vertical:										34.1900
RCC Top:										3.9800
									Total:	58.9300 m^3
Reinforcement:		0.88 % of RCC Volume								

(Earthwork Calculation Sheet)

ESTIMATE OF QUANTITIES OF REGULATOR/SLUICE/WCS
Part-B : Box Sluice (1 V - 0.90mX0.90m)
At Ch. 0+5730 Km (East Embkt.)

SP3 : Charkhai-Dakshin Haor Subproject
Upazila: Beanibazar
District: Sylhet

Earthwork in Excavation of Foundation Trenches:

Prework Calculation:

Chainage in m	Elevation in m	Depth in m	Area in m^2
0.00	11.000	0	
			0.000
2.00	11.000	0	
			0.000
4.00	11.000	0	
			0.000
6.00	11.000	0	
			0.000
8.00	11.000	0	
			0.000
10.00	11.000	0	
			0.000
12.00	11.000	0	
			0.000
14.00	11.000	0	
			0.000
16.00	11.000	0	

Total Area = 0.000 m^2

Earth Cutting = 1.98 m
Earth Filling = 2.20 m

Prework Volume = 0.00 m^3

Postwork Calculation:

Box	=	6.17 X(	2.300 +	8.225)X	0.5 X	1.975						=	64.076 m^3
River Side:													
Glacis	=	1.20 X{(	2.30 +	8.225)X	0.5 X	1.975 +(	2.46 +	9.581)X	0.5 X	2.375 }X	0.5	=	14.812 m^3
Basin	=	4.80 X{(	2.456 +	9.581)X	0.5 X	2.375 +(	3 +	9.825)X	0.5 X	2.275 }X	0.5	=	69.318 m^3
R/Wall	=	2.7 X(	2.20 +	9.025)X	0.5 X	2.275 X	2					=	68.950 m^3
Cut (Bed)	=	2.40 X(	0.90 +	4.50)X	0.5 X	1.20						=	7.78 m^3
P. Works	=	2.00 X(	2.40 +	9.23)X	0.5 X	2.275						=	26.45 m^3
Country Side:													
Glacis	=	1.20 X{(	2.3 +	8.225)X	0.5 X	1.975 +(	2.6 +	9.685)X	0.5 X	2.375 }X	0.5	=	14.961 m^3
Basin	=	2.64 X{(	2.56 +	9.685)X	0.5 X	2.375 +(	3 +	9.825)X	0.5 X	2.275 }X	0.5	=	38.378 m^3
R/Wall	=	2.70 X(	2.20 +	9.025)X	0.5 X	2.275 X	2					=	68.950 m^3
Cut (Bed)	=	2.40 X(	0.90 +	4.50)X	0.5 X	1.20						=	7.78 m^3
P. Works	=	2.00 X(	2.40 +	9.23)X	0.5 X	2.275						=	26.447 m^3
										Total		=	407.89 m^3

Total Volume of Excavation:

= 407.889 - 0.00 = **= 408.00 m^3**

Volume for sand filling = **= 17.00 m^3**

Excavation of Khal at D/S of Structure

= 0.00 X(1.80 + 7.20)X 0.5 X 1.8 = 0.000 m^3

Total **= 425.00**

(Earthwork Calculation Sheet – contd)

Earthwork in Filling:												
Backfill to Structure:												
Box	=	6.17 X(	0.6 +	6.8625)X	0.5 X	4.175 X	2				=	192.0764 m^3
River Side:												
Sloped	=	1.20 X{(	0.6 +	6.8625)X	0.5 X	4.175 +(	0.6 +	4.1625)X	0.5 X	2.375 }X	1 =	25.480 m^3
Straight	=	4.20 X{(	0.6 +	4.1625)X	0.5 X	2.375 +(	0.6 +	4.0125)x	0.5 X	2.275 }X	1 =	45.789 m^3
R/Wall	=	2.7 X(	0.6 +	4.0125)X	0.5 X	2.275 X	2 X	2			=	56.665 m^3
Cut-Off	=	7.20 X(	0.6 +	4.2)X	0.5 X	1.20					=	20.736 m^3
Country Side:												
Sloped	=	2.24 X{(	0.6 +	6.8625)X	0.5 X	4.175 +(	0.6 +	4.1625)X	0.5 X	2.375 }X	1 =	47.457 m^3
Straight	=	2.64 X{(	0.6 +	4.1625)X	0.5 X	2.375 +(	0.6 +	4.0125)x	0.5 X	2.275 }X	1 =	28.727 m^3
R/Wall	=	2.70 X(	0.6 +	4.0125)X	0.5 X	2.275 X	2 X	2			=	56.665 m^3
Cut-Off	=	7.20 X(	0.6 +	4.2)X	0.5 X	1.20					=	20.736 m^3
										Sub-Total	=	494.3308 m^3
Approach Road												
	=	15.00 X(	4.00 +	12.800)X	0.5 X	2.20 X	2				=	554.40 m^3
	=	0.00 X(	4.85 +	13.65)X	0.5 X	2.20 X	2				=	0.00 m^3
	=	0.00 X(	3.70 +	12.5)X	0.5 X	2.20 X	2				=	0.00 m^3
		30								Total	=	554.40 m^3
Total Earth Filling											=	1049.00

Exhibit G6-G11

(Bar Bending Schedule Sheet)

BAR BENDING SCHEDULE

MEMBER	BAR MARKS	BAR DIA (mm)	SHAPE CODE	SPACING (mm)	DIMENSIONS (mm) A	B	C	D	E	CUT LENGTH (mm)	BAR PER MEMBER	NOS. OF MEMBER	TOTAL LENGTH (m)	UNIT WT. Kg/m	TOTAL WT Kg
Box Part:	AA	12	8	200	1675	1550	1675			5200	25	1	130.00	0.89	115.82
	AB	12	1	200	8415					8715	8	1	69.72	0.89	62.11
	AC	12	1	200	1550					1850	31	1	57.35	0.89	51.09
	AD	12	20	200	2451	6065	2451			11267	8	1	90.14	0.89	80.30
	BE (C/S)	12	1	200	2182 ~ 0					2482 ~ 0	6	2	14.89	0.89	13.27
	AE	16	8	150	4100	1550	4100			15700	11	1	172.70	1.58	273.52
	BB	12	3	150	1675	300				2125	34	2	144.50	0.89	128.73
	BC	12	3	150	3947	300				4397	68	0	0.00	0.89	0.00
	BD	12	34	200	6165	5344	3191			15000	7	2	210.00	0.89	187.09
	BE (R/S)	12	34	200	1450	4340 ~ 0				6090 ~ 1750	11	2	86.24	0.89	76.83
	QI	12	29	200	275 ~ 173	225	5344			6144 ~ 6042	7	2	85.30	0.89	75.99
	BE (GP)	12	1	200	1400					1700	4	2	13.60	0.89	12.12
	BG	12	8	200	275 ~ 0	225	275 ~ 0			1075 ~ 525	22	2	47.30	0.89	42.14
			9	150	275 ~ 173	3191				3766 ~ 3664	9	2	66.87	0.00	0.00
	BG	12	8	200	173 ~ 125	225	173 ~ 125			871 ~ 775	16	2	26.34	0.89	23.46
	BH	12	14	200	500					500	21	4	42.00	0.89	37.42
	BF	12	8	200	275 ~ 125	5315	275 ~ 125			6165 ~ 5865	6	2	36.99	0.89	32.95
			4	150	350	5315	350	5315		11630	28	0	0.00	0.00	0.00
			4	150	350	225	350	225		1450	28	0	0.00	0.00	0.00
			4	150	350	395	350	395		1790	28	1	50.12	0.00	0.00
			40	150	150	350	230			1260	28	0	0.00	0.00	0.00
			3	150	4497	300				4947	20	0	0.00	0.00	0.00
	BF		1	200	1350					1650	36	1	59.40	0.00	0.00
	BD		1	200	3400					3700	18	1	66.60	0.00	0.00
	BU	12	3	150	4497	300				4947	10	2	98.94	0.89	88.14
Top Slab	**CC**	12	6	200	300	5115	300			6015	9	1	54.14	0.89	48.23
	CB	12	1	200	1550					1850	23	1	42.55	0.89	37.91
	CD	12	1	200	1550					1850	23	1	42.55	0.89	37.91
	CE	12	1	200	5115					5415	9	1	48.74	0.89	43.42
	CF	12	1	200	1350					1650	4	1	6.60	0.89	5.88
	CG	12	1	200	325					625	16	1	10.00	0.89	8.91
	CG	12	1		1400					1700	4	3	20.40	0.89	18.17
	CG	12	1		1350					1650	2	0	0.00	0.89	0.00
			15	200	500	250	504			1554	9	0	0.00	0.00	0.00
	CM	12	1	150	3400					3700	22	1	81.40	0.89	72.52
	CN	12	1	150	2000					2300	46	1	105.80	0.89	94.26
	CS	12	1		1350					1650	6	1	9.90	0.89	8.82
(Thrust Beam)	**CR**	12	4	200	150	325	150	325		1250	8	1	10.00	0.89	8.91
		10	4	200										0.62	
			8	150	150	925	150			1375	22	1	30.25	0.00	0.00
			1	150	2450					2750	11	1	30.25	0.00	0.00
			4	200	225	200	225	200		1150	8	1	9.20	0.00	0.00
Rail Post & Rail Bars	DA	12	2		1125	300				1575	2	0	0.00	0.89	0.00
	DA	12	2		975	300				1425	2	4	11.40	0.89	10.16
	DA1	12	2		-75	300				375	2	0	0.00	0.89	0.00
	DB	12	2		1125	300				1575	2	0	0.00	0.89	0.00

Notes: 1. Deformed bars will be used. Additional length of 150mm has been included in cut length for nominal bend (90º or less) at each end.
2. For variable bar lengths, length of bars should be calculated from the range & numbers of bars.
3. The Contractor shall check the bar bending schedule with the drawings before cutting the bars.

SP3 : Charkhai-Dakshin Haor Subproject
Upazila: Beanibazar District: Sylhet
Part-B : Box Sluice (1 V - 0.90mX0.90m)
At Ch. 0+5730 Km (East Embkt.)

Exhibit G6-G11

(Bar Bending Schedule Sheet - contd)

Rail Post & Rail Bars	DB	12	2		975	300				1425	2	4	11.40	0.89	10.16
	DB1	12	2		-75	300				375	2	0	0.00	0.89	0.00
	DC	12	1		1650					1950	4	0	0.00	0.89	0.00
	DC	12	1		1350					1650	4	4	26.40	0.89	23.52
	DC	12	1		1450					1750	4	4	28.00	0.89	24.94
	DC1	12	1		-50					250	4	0	0.00	0.89	0.00
	DC1	12	1		-50					250	4	0	0.00	0.89	0.00
	DD	9	4	200	100	100	100	100		700	3	0	0.00	0.50	0.00
	DD	9	4	200	100	100	100	100		700	3	4	8.40	0.50	4.21
	DD	9	4	200	100	100	100	100		700	9	0	0.00	0.50	0.00
	DD	9	4	200	100	100	100	100		700	4	4	11.20	0.50	5.61
	DD	9	4	200	100	100	100	100		700	6	4	16.80	0.50	8.42
	DD1	9	4	200	-50	-50	-50	-50		100	0	0	0.00	0.50	0.00
	DD1	9	4	200	-50	-50	-50	-50		100	0	0	0.00	0.50	0.00
	DD1	9	4	200	-50	-50	-50	-50		100	0	0	0.00	0.50	0.00
	CI	12	1	200	-150 ~ -150					150 ~ 150	0	1	0.00	0.89	0.00
	CJ	16	1	150	-150 ~ -150					150 ~ 150	0	1	0.00	1.58	0.00
	CK	12	1	150	-100					200	0	1	0.00	0.89	0.00
River Side	PA	16	7	300	1550 ~ 1706	425 ~ 425	1100			4900 ~ 5056	4	1	19.91	1.58	31.54
	QA	16	7	300	1550 ~ 1706	425 ~ 425	3550 ~ 3350			9800 ~ 9956	4	1	39.51	1.58	62.58
	XB	12	11	200	4650	1660				6610	9	1	59.49	0.89	53.00
	XC	12	1	200	1550 ~ 1706					1850 ~ 2006	6	1	11.57	0.89	10.31
	XD	12	1	200	4950					5250	9	1	47.25	0.89	42.09
	PE	16	7	300	1706 ~ 2121	425 ~ 349	1000			4856 ~ 5119	11	1	54.86	1.58	86.89
	QC	16	7	300	1706 ~ 2121	350 ~ 349	3350 ~ 1750			4706 ~ 3119	11	1	43.04	1.58	68.16
	XF	12	11	200	4650 ~ 1600	1660 ~ 0				6610 ~ 1900	2	1	8.51	0.89	7.58
	XG	12	1	200	1706 ~ 2121					2006 ~ 2421	16	1	35.42	0.89	31.55
	XH	12	1	200	4950 ~ 1450					5250 ~ 1750	2	1	7.00	0.89	6.24
			7	200	2121 ~ 2250	349 ~ 325	1100			5319 ~ 5400	5	1	26.80	0.00	0.00
	PI	12	7	200	2121 ~ 2250	349 ~ 325	1750			6619 ~ 6700	5	1	33.30	0.89	29.66
	XJ	16	1	200	2121 ~ 2250					2421 ~ 2550	5	1	12.43	1.58	19.68
			15	300	1475	100	2086			3961	24	1	95.06	0.00	0.00
	PL	12	8	300	1475	100	1475			3350	24	1	80.40	0.89	71.63
	PM	12	1	200	7050					7350	8	1	58.80	0.89	52.38
	QB	12	3	150	3947 ~ 3747	300				4397 ~ 4197	8	2	68.75	0.89	61.25
	QD	12	3	150	3747 ~ 2071	300				4197 ~ 2521	21	2	141.08	0.89	125.68
	QF	12	3	150	2071 ~ 2047	300				2521 ~ 2497	7	2	35.13	0.89	31.29
	QG	12	15	200	125	5344	500			6269	2	2	25.08	0.89	22.34
	QH	12	3	150	5344	500				5994	3	2	35.96	0.89	32.04
	RA	12	1	200	1450					1750	14	2	49.00	0.89	43.65
	RB	12	1	200	3000					3300	6	2	39.60	0.89	35.28
	BV1	12	1		5638					5938	2	2	23.75	0.89	21.16
	PN	12	1		9009					9309	1	2	18.62	0.89	16.59
	D1	19	1		800					800	2	2	3.20	2.23	7.15
	RK	12	1	300	1200					1500	6	4	36.00	0.89	32.07
	RD	12	1	200	1450					1750	14	2	49.00	0.89	43.65
	RE	12	1	200	3000					3300	6	2	39.60	0.89	35.28
	RF	12	1		7050					7350	4	1	29.40	0.89	26.19
			3	200	1425	300				1875	14	2	52.50	0.00	0.00
	RG	12	3	200	2075	300				2525	14	2	70.70	0.89	62.99

Notes: 1. Deformed bars will be used. Additional length of 150mm has been included in cut length for nominal bend (900 or less) at each end.
2. For variable bar lengths, length of bars should be calculated from the range & numbers of bars.
3. The Contractor shall check the bar bending schedule with the drawings before cutting the bars.

SP3 : Charkhai-Dakshin Haor Subproject
Upazila: Beanibazar District: Sylhet
Part-B : Box Sluice (1 V - 0.90mX0.90m)
At Ch. 0+5730 Km (East Embkt.)

(Bar Bending Schedule Sheet - contd)

River Side	RH	12	3	150	2075	300				2525	18	2	90.90	0.89	80.98
	RI	12	3	200	2575	300				3025	9	2	54.45	0.89	48.51
	RJ	12	3	200	2575	300				3025	9	2	54.45	0.89	48.51
	RC	12	1		7050					7350	4	1	29.40	0.89	26.19
Country Side			7	200	1550 ~ 1810	425 ~ 425	1800			6300 ~ 6560	6	1	38.58	0.00	0.00
	YA	12	7	200	1550 ~ 1810	425 ~ 425	2468 ~ 2268			7636 ~ 7896	6	1	46.60	0.89	41.51
	XB	12	1	200	5435					5735	9	1	51.615	0.89	45.98
	XC	12	1	200	1550 ~ 1810					1850 ~ 2110	6	1	11.88	0.89	10.58
	XD	12	1	200	2760					3060	9	1	27.54	0.89	24.54
			7	200	1810 ~ 2034	425 ~ 374	1700			6360 ~ 6482	5	1	32.11	0.00	0.00
	YC	12	7	200	1810 ~ 2034	425 ~ 374	2268 ~ 1750			7496 ~ 6582	5	1	35.20	0.89	31.35
	PF	12	11	200	2460 ~ 1450	1475 ~ 0				4235 ~ 1750	4	1	11.97	0.89	10.66
	XG	12	1	200	1810 ~ 2034					2110 ~ 2334	5	1	11.11	0.89	9.90
	PH	12	1	200	2760 ~ 1450					3060 ~ 1750	4	1	9.62	0.89	8.57
			7	200	2034 ~ 2250	374 ~ 325	1100			5282 ~ 5400	5	1	26.71	0.00	0.00
	YE	12	7	200	2034 ~ 2250	374 ~ 325	1750			6582 ~ 6700	5	1	33.21	0.89	29.58
	XJ	12	1	150	2034 ~ 2250					2334 ~ 2550	7	1	17.09	0.89	15.23
	ZB	12	1	200	3000					3300	6	2	39.60	0.89	35.28
	XL	12	8	300	1475	300	1475			3550	24	1	85.20	0.89	75.90
			15	300	1475	300	2086			4161	24	1	99.86	0.00	0.00
	ZE	12	1	200	3000					3300	6	2	39.60	0.89	35.28
			1		7050					7350	4	1	29.40	0.00	0.00
	YB	12	3	150	2869 ~ 2693	300				3319 ~ 3143	8	2	51.70	0.89	46.06
	YD	12	3	150	2669 ~ 2112	300				3119 ~ 2562	7	2	39.77	0.89	35.43
	YF	12	3	150	2112 ~ 2063	300				2562 ~ 2513	7	2	35.53	0.89	31.65
	YG	12	15	200	125	3166	500			4091	2	2	16.36	0.89	14.58
	YH	12	3	200	3166	500				3816	2	2	15.26	0.89	13.60
	ZA	12	1	200	1450					1750	14	2	49.00	0.89	43.65
	ZD	12	1	200	1450					1750	14	2	49.00	0.89	43.65
	ZF	12	1		7050					7350	4	1	29.40	0.89	26.19
			3	200	1375	300				1825	14	2	51.10	0.00	0.00
	ZG	12	3	200	2051	300				2501	14	2	70.03	0.89	62.39
	ZC	12	1		7050					7350	4	1	29.40	0.89	26.19
	XN	12	1		7415					7715	1	2	15.43	0.89	13.75
	BV	12	1		3451					3751	2	2	15.00	0.89	13.37
	ZH	12	3	200	2051	300				2501	14	2	70.03	0.89	62.39
	ZI	12	3	200	2575	300				3025	9	2	54.45	0.89	48.51
	ZJ	12	3	200	2575	300				3175	9	2	57.15	0.89	50.91
Baffle Block, Chute Block, End Sill	**SA**	12	9		550	1050				1900	2	2	7.60	0.89	6.77
	SB	12	14		200					200	8	2	3.20	0.89	2.85
	SC	12	12		600	940				1840	3	3	16.56	0.89	14.75
	SC1		12		650	919				1869	0	3	0.00	0.00	0.00
	SD	12	14		200					200	5	3	3.00	0.89	2.67
	SE	12	33		774	635				1709	2	0	0.00	0.89	0.00
	SF	12	12		550	996				1846	2	1	3.692	0.89	3.29
	SH	12	14		1700					1700	1	1	1.70	0.89	1.51
	SG	12	1		2300					2600	1	1	2.60	0.89	2.32

Notes: 1. Deformed bars will be used. Additional length of 150mm has been included in cut length for nominal bend (900 or less) at each end.
2. For variable bar lengths, length of bars should be calculated from the range & numbers of bars.
3. The Contractor shall check the bar bending schedule with the drawings before cutting the bars.

SP3 : Charkhai-Dakshin Haor Subproject
Upazila: Beanibazar District: Sylhet
Part-B : Box Sluice (1 V - 0.90mX0.90m)
At Ch. 0+5730 Km (East Embkt.)

(Bar Bending Schedule Sheet - contd)

Baffle Block, Chute Block, End Sill	**SI**	12	9		550	1050				1900	2	2	7.60	0.89	6.77
	SJ	12	14		200					200	4	2	1.60	0.89	1.43
	SL	12	14		200					200	5	3	3.00	0.89	2.67
	SM	12	33		774	635				1409	2	0	0.00	0.89	0.00
	SP	12	1		2300					2600	1	1	2.60	0.89	2.32
	SK	12	13		600	870				1770	2	3	10.62	0.89	9.46
	SN	12	12		550	996				850	2	1	1.70	0.89	1.51
			14		1700					1700	1	1	1.70	0.00	0.00
	SQ	12	14		1700					1700	1	1	1.70	0.89	1.51
															4114
Pile	P01	19	30												
	P02	16	1												
	S01	10	4												
	S02	10	4												

Notes: 1. Deformed bars will be used. Additional length of 150mm has been included in cut length for nominal bend (900 or less) at each end. **0.00**

2. For variable bar lengths, length of bars should be calculated from the range & numbers of bars.

3. The Contractor shall check the bar bending schedule with the drawings before cutting the bars.

SP3 : Charkhai-Dakshin Haor Subproject
Upazila: Beanibazar District: Sylhet
Part-B : Box Sluice (1 V - 0.90mX0.90m)
At Ch. 0+5730 Km (East Embkt.)

EXHIBIT G6-H STANDARD DRAWINGS

Exhibit G6-H1: Standard Drawings for Re-excavation of Khal

Exhibit G6-H2: Standard Drawings for Re-excavation of Embankment

Exhibit G6-H3: Standard Drawings of Regulator

Exhibit G6-H4: Standard Drawings of Vertical Gate

Exhibit G6-H5: Standard Drawings of Flap Gate

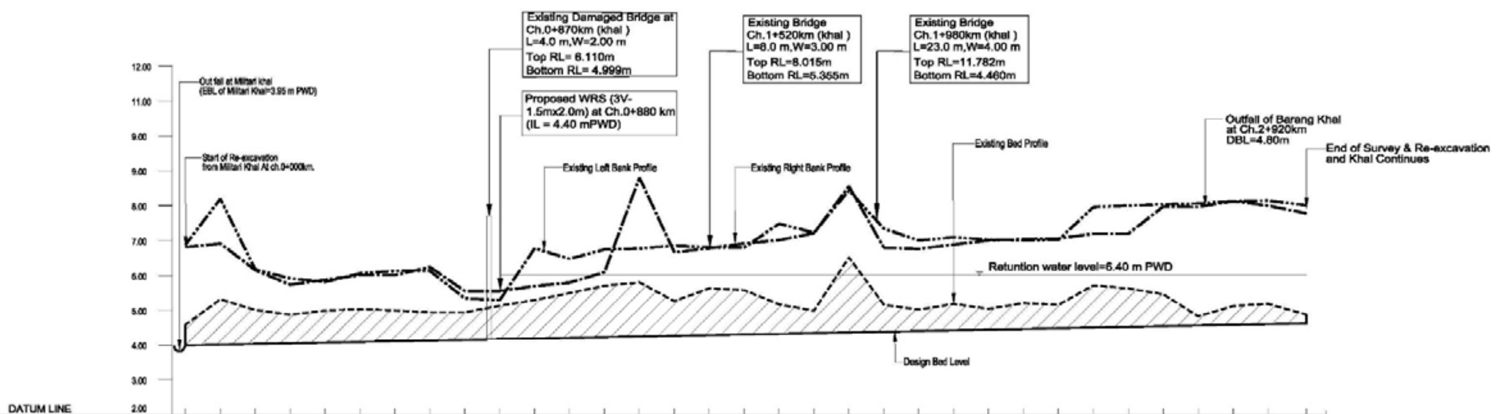
EXHIBIT G6-H1: Standard Drawings for Re-excavation of Khal

DESIGN DRAWINGS
OF
RE-EXCAVATION OF DHAOLONG BARO KHAL
LENGTH = 3.210Km

JULY 2013

CONTENT OF DRAWINGS

TITLE OF DRAWING	DRAWING NO.
KHAL	
A. RE-EXCAVATION OF DHAOLONG BARO KHAL (LENGTH = 3.210Km)	
1. LONG SECTION	/ KHL - DHAOLONG KHAL / 04 - 1/1
2. CROSS SECTION	/ KHL - DHAOLONG KHAL / 05 - 1/1
B. REFERENCE BED BLOCKS	
1. TYPICAL REFERENCE BED BLOCKS	/ RLS - KAMALPUR KHAL / 1/1



PRE-WORK											
EXISTING LEFT BANK LEVEL	6.892	8.205	6.185	5.827	5.827	6.071	6.141	6.145	5.355	5.305	6.785
EXISTING BED LEVEL	4.602	5.326	5.026	4.887	5.007	5.041	5.011	4.955	4.955	5.146	5.306
EXISTING RIGHT BANK LEVEL	6.822	6.926	6.166	5.747	5.887	6.021	6.021	6.255	5.565	5.566	5.706
CHAINAGE (Km)	0+000	0+100	0+200	0+300	0+400	0+500	0+600	0+700	0+800	0+900	1+000
CROSS SECTION NO.	C/S-1	C/S-2	C/S-3	C/S-4	C/S-5	C/S-6	C/S-7	C/S-8	C/S-9	C/S-10	C/S-11
DESIGN											
DESIGN BED LEVEL (m PWD)	4.00	4.02	4.04	4.06	4.08	4.10	4.12	4.14	4.16	4.18	4.20

PRE-WORK											
EXISTING LEFT BANK LEVEL	6.485	6.755	8.785	6.865	6.821	6.811	7.494	7.239	8.448	7.355	7.015
EXISTING BED LEVEL	5.506	5.715	5.815	5.275	5.641	5.591	5.184	5.004	6.528	5.175	5.035
EXISTING RIGHT BANK LEVEL	5.806	6.105	6.815	6.675	6.791	6.931	7.024	7.224	8.568	6.605	6.775
CHAINAGE (Km)	1+100	1+200	1+300	1+400	1+500	1+600	1+700	1+800	1+900	2+000	2+100
CROSS SECTION NO.	C/S-12	C/S-13	C/S-14	C/S-15	C/S-16	C/S-17	C/S-18	C/S-19	C/S-20	C/S-21	C/S-22
DESIGN											
DESIGN BED LEVEL (m PWD)	4.22	4.24	4.26	4.28	4.30	4.32	4.34	4.36	4.38	4.40	4.42

PRE-WORK											
EXISTING LEFT BANK LEVEL	7.107	7.037	7.022	7.032	7.869	8.009	8.053	8.073	8.138	8.158	8.021
EXISTING BED LEVEL	5.197	5.057	5.222	5.172	5.729	5.639	5.473	4.813	5.138	5.198	4.891
EXISTING RIGHT BANK LEVEL	6.897	7.017	7.052	7.072	7.209	7.309	7.983	7.973	8.138	8.008	7.791
CHAINAGE (Km)	2+200	2+300	2+400	2+500	2+600	2+700	2+800	2+900	3+000	3+100	3+210
CROSS SECTION NO.	C/S-23	C/S-24	C/S-25	C/S-26	C/S-27	C/S-28	C/S-29	C/S-30	C/S-31	C/S-32	C/S-33
DESIGN											
DESIGN BED LEVEL (m PWD)	4.44	4.46	4.48	4.50	4.52	4.54	4.56	4.58	4.60	4.62	4.64

DESIGN PARAMETER: From Ch. 0+000 Km. to Ch. 3+210 Km
Bed width = 5.0m, Side slope 1:1.50 (L/B & R/B), L.S = 0.00020m/m

NOTES ON BM/TBM:

1. TBM receive from BM marks on by LGED South-West corner of plinth level of RL=10.580 mPWD Jame Mosque at Eliaspur village.
2. TBM-1, RL=12.067 mPWD kept on North-East corner of bridge at East of Islamic academy at Usman Nagar. Eliaspur village.
3. TBM-2, RL=8.496 mPWD kept at Red Mark at Bat Tree near Abu Bakkar Member House at Kamalpur. Eliaspur village.
4. TBM-7, RL=8.932 mPWD kept at Bat Tree with Red mark near Ch. 0+280 km of Dalar khal.
5. HFL = RL.8.334 m(PWD) in 1988
6. HFL = RL.8.304 m(PWD) in 2004
7. NFL = RL.7.842 m(PWD)

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
in Greater Mymensingh, Sylhet and Faridpur Areas

DHAOLONG HORUA-MERUA HAOR SUBPROJECT | SP ID
UPAZILA : BALAGANJ, DISTRICT : SYLHET

RE-EXCAVATION OF DHAOLONG BARO KHAL (3.210Km)

LONG SECTION

DevCon DevConsultants Limited
House # 4, Road 13, Baridhara, Dhaka-1212

DRAWN BY	DESIGNED BY	CHECKED BY	CHECKED BY	REVIEWED BY	RECOMMENDED BY	APPROVED BY
Abdur Rashed	Abul Hasanat	Wafi.Md.Qamrul Huda	WRP Specialist Project Consultant	DTL WRD Specialist Project Consultant	XEN (P&D) IWRMU, LGED	SE (P&D) IWRMU, LGED
Jr. Engineer	Design Engineer	Team Leader	DRG. No. KHL-DHAOLONG KHAL/04-1/1			JULY 2013

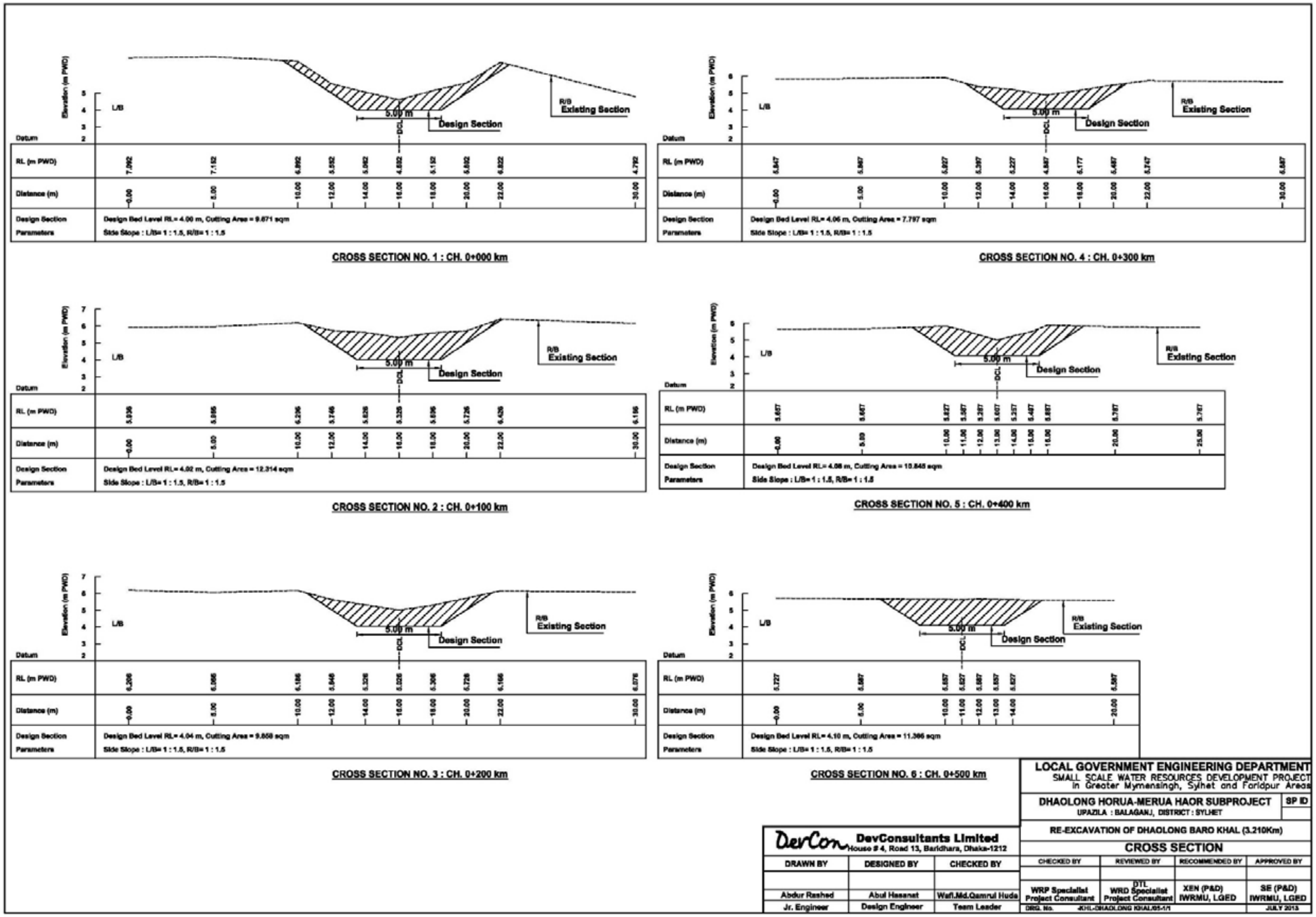
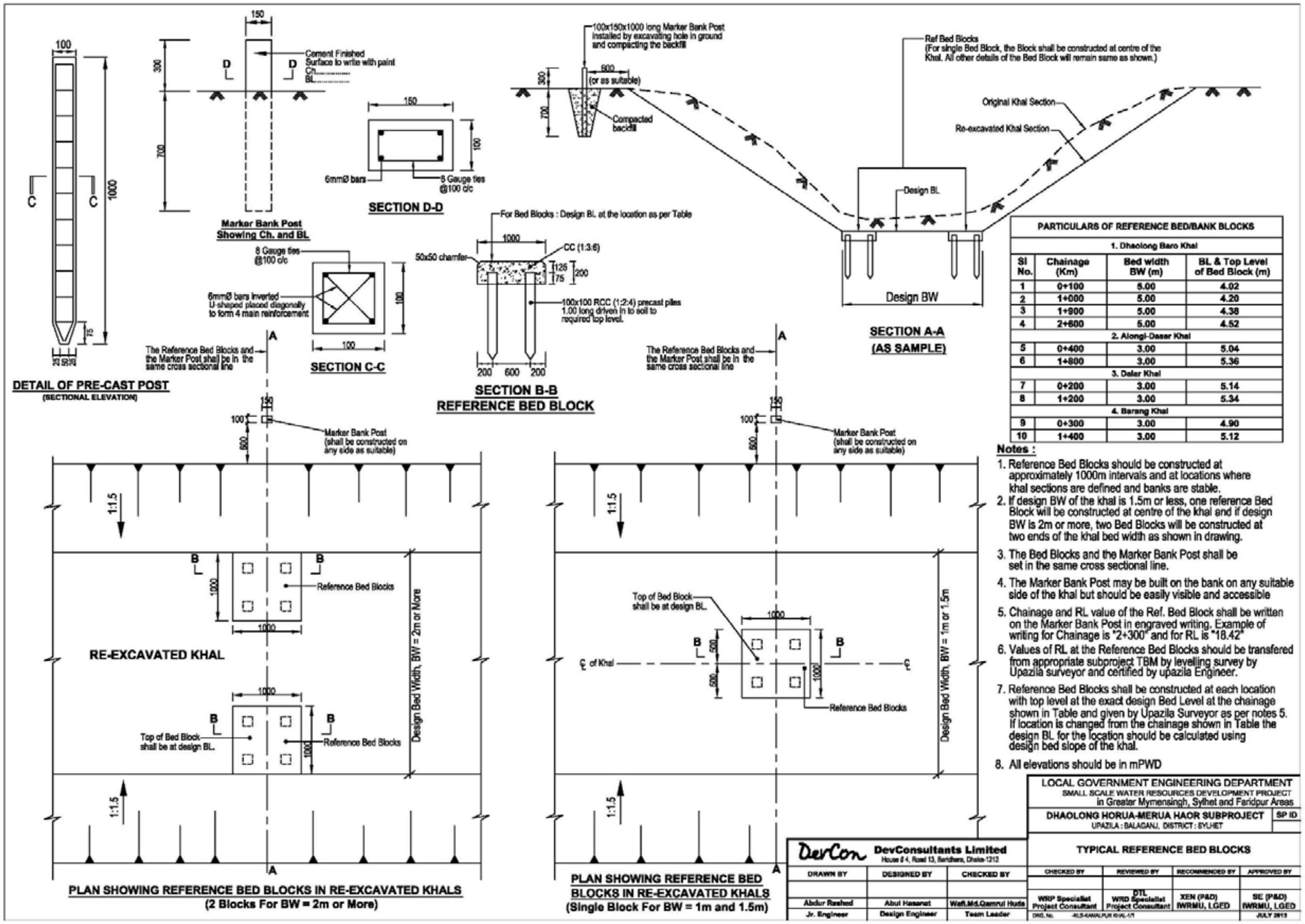

CROSS SECTION NO. 1 : CH. 0+000 km
CROSS SECTION NO. 2 : CH. 0+100 km
CROSS SECTION NO. 3 : CH. 0+200 km
CROSS SECTION NO. 4 : CH. 0+300 km
CROSS SECTION NO. 5 : CH. 0+400 km
CROSS SECTION NO. 6 : CH. 0+500 km
Design Section
Existing Section
5.00 m
L/B
R/B
DCL
Datum
RL (m PWD)
Distance (m)
Design Section Parameters
Elevation (m PWD)
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
DHAOLONG HORUA-MERUA HAOR SUBPROJECT
SP ID
UPAZILA : BALAGANJ, DISTRICT : SYLHET
RE-EXCAVATION OF DHAOLONG BARO KHAL (3.210Km)
CROSS SECTION
DevCon
DevConsultants Limited
House # 4, Road 13, Baridhara, Dhaka-1212
DRAWN BY
DESIGNED BY
CHECKED BY
Abdur Rashed
Jr. Engineer
Abul Hasanat
Design Engineer
Wafi.Md.Qamrul Huda
Team Leader
CHECKED BY
REVIEWED BY
RECOMMENDED BY
APPROVED BY
WRP Specialist
Project Consultant
DTL
WRD Specialist
Project Consultant
XEN (P&D)
IWRMU, LGED
SE (P&D)
IWRMU, LGED
JULY 2013

Exhibit G6-H1



PARTICULARS OF REFERENCE BED/BANK BLOCKS

Sl No.	Chainage (Km)	Bed width BW (m)	BL & Top Level of Bed Block (m)
1. Dhaolong Baro Khal			
1	0+100	5.00	4.02
2	1+000	5.00	4.20
3	1+900	5.00	4.38
4	2+600	5.00	4.52
2. Alongi-Daser Khal			
5	0+400	3.00	5.04
6	1+800	3.00	5.36
3. Dalar Khal			
7	0+200	3.00	5.14
8	1+200	3.00	5.34
4. Barang Khal			
9	0+300	3.00	4.90
10	1+400	3.00	5.12

Notes :

1. Reference Bed Blocks should be constructed at approximately 1000m intervals and at locations where khal sections are defined and banks are stable.
2. If design BW of the khal is 1.5m or less, one reference Bed Block will be constructed at centre of the khal and if design BW is 2m or more, two Bed Blocks will be constructed at two ends of the khal bed width as shown in drawing.
3. The Bed Blocks and the Marker Bank Post shall be set in the same cross sectional line.
4. The Marker Bank Post may be built on the bank on any suitable side of the khal but should be easily visible and accessible
5. Chainage and RL value of the Ref. Bed Block shall be written on the Marker Bank Post in engraved writing. Example of writing for Chainage is "2+300" and for RL is "18.42"
6. Values of RL at the Reference Bed Blocks should be transfered from appropriate subproject TBM by levelling survey by Upazila surveyor and certified by upazila Engineer.
7. Reference Bed Blocks shall be constructed at each location with top level at the exact design Bed Level at the chainage shown in Table and given by Upazila Surveyor as per notes 5. If location is changed from the chainage shown in Table the design BL for the location should be calculated using design bed slope of the khal.
8. All elevations should be in mPWD

EXHIBIT G6-H2: Standard Drawings for Re-Sectioning of Embankment

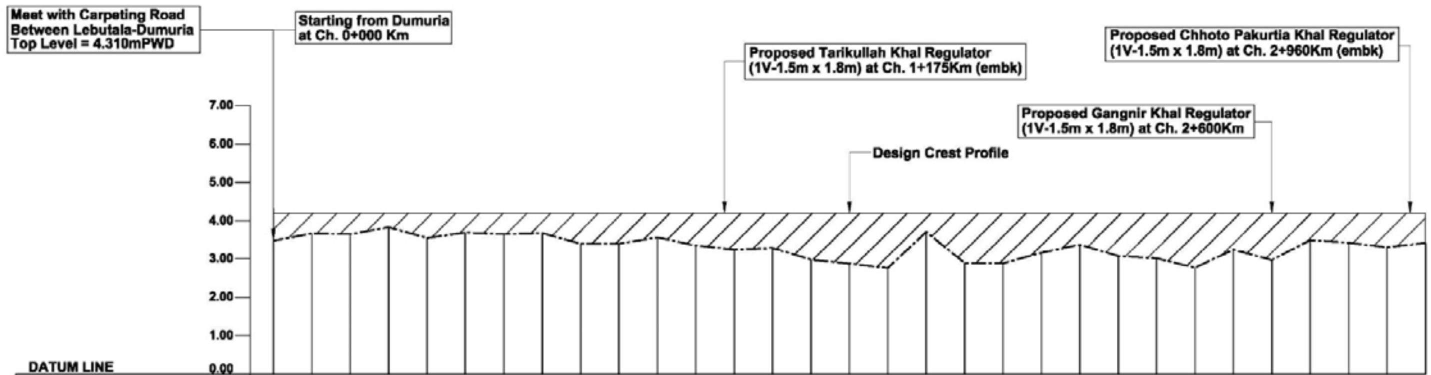
DESIGN DRAWINGS
OF

RE-SECTIONING OF EMBANKMENT
LENGTH = 3.000Km

AUGUST 2011

CONTENT OF DRAWINGS

TITLE OF DRAWING	DRAWING NO.
EMBANKMENT:	
A. RE-SECTIONING OF EMBANKMENT (LENGTH = 3.000km)	
1. LONG SECTION	33060 / EMB-LEBUTALA / 02 -1/1
2. CROSS SECTION	33060 / EMB-LEBUTALA / 03 - 1/1



PRE-WORK

CROSS SECTION NO.	CHAINAGE (km)	EXISTING TOP LEVEL	DESIGN CREST LEVEL (m PWD)
C/S-1	0+000	3.482	4.20
C/S-2	0+100	3.671	4.20
C/S-3	0+200	3.652	4.20
C/S-4	0+300	3.834	4.20
C/S-5	0+400	3.554	4.20
C/S-6	0+500	3.685	4.20
C/S-7	0+600	3.651	4.20
C/S-8	0+700	3.680	4.20
C/S-9	0+800	3.430	4.20
C/S-10	0+900	3.404	4.20
C/S-11	1+000	3.568	4.20
C/S-12	1+100	3.354	4.20
C/S-13	1+200	3.244	4.20
C/S-14	1+300	3.287	4.20
C/S-15	1+400	2.977	4.20
C/S-16	1+500	2.872	4.20
C/S-17	1+600	2.756	4.20
C/S-18	1+700	3.713	4.20
C/S-19	1+800	2.889	4.20
C/S-20	1+900	2.880	4.20
C/S-21	2+000	3.160	4.20
C/S-22	2+100	3.377	4.20
C/S-23	2+200	3.076	4.20
C/S-24	2+300	3.012	4.20
C/S-25	2+400	2.766	4.20
C/S-26	2+500	3.241	4.20
C/S-27	2+600	2.967	4.20
C/S-28	2+700	3.498	4.20
C/S-29	2+800	3.428	4.20
C/S-30	2+900	3.306	4.20
C/S-31	3+000	3.423	4.20

DESIGN

DESIGN PARAMETER: Reach-1 (From Ch. 0+000 Km to 3+000 Km)
Crest Width = 3.70m, Side Slope = 1:1.5 (C/S & R/S)

Notes:
ON BM/TBM

1. BM of value=4.300mPWD has been used which is located at plinth level (varendha) of Tongipara BWDB office building.
2. TBM-1 of value=5.840mPWD has been carried from the above BM and kept at the top of wheel guard of Char Dumuria bridge
3. TBM-2 of value=3.691mPWD has been kept at the top of wheel guard of Tarikullah's culvert
4. TBM-4 of value=5.382mPWD has been kept at the top of wheel guard of Chhoto Pakurtia's culvert

HFL (1988) = 3.520mPWD (Based on local information)
NFL (2010) = 2.920mPWD (Based on local information)

HOUSE OF CONSULTANTS LTD.
44/F/8A, WEST PANTHAPATH 1ST. FLOOR,
DHANMONDI, DHAKA-1205

DRAWN BY	DESIGNED BY	CHECKED BY
Md. A. Ali	Ali Imam	M. A. Mannan
CAD OPERATOR	DESIGN ENGINEER	TEAM LEADER

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
in Greater Mymensingh, Sylhet and Faridpur Areas

LEBUTALA-BASHBARIA SUBPROJECT
UPAZILA : TUNGIPARA, DISTRICT : GOPALGONJ

SP ID 33060

RE-SECTIONING OF EMBANKMENT (3.00km)

LONG SECTION

CHECKED BY	REVIEWED BY	RECOMMENDED BY	APPROVED BY
WRP Specialist Project Consultant	DTL WRD Specialist Project Consultant	XEN (P&D) IWRMU, LGED	SE IWRMU, LGED

DRG. NO.33060-EMB-LEBUTALA/02-1/1

AUGUST 2011

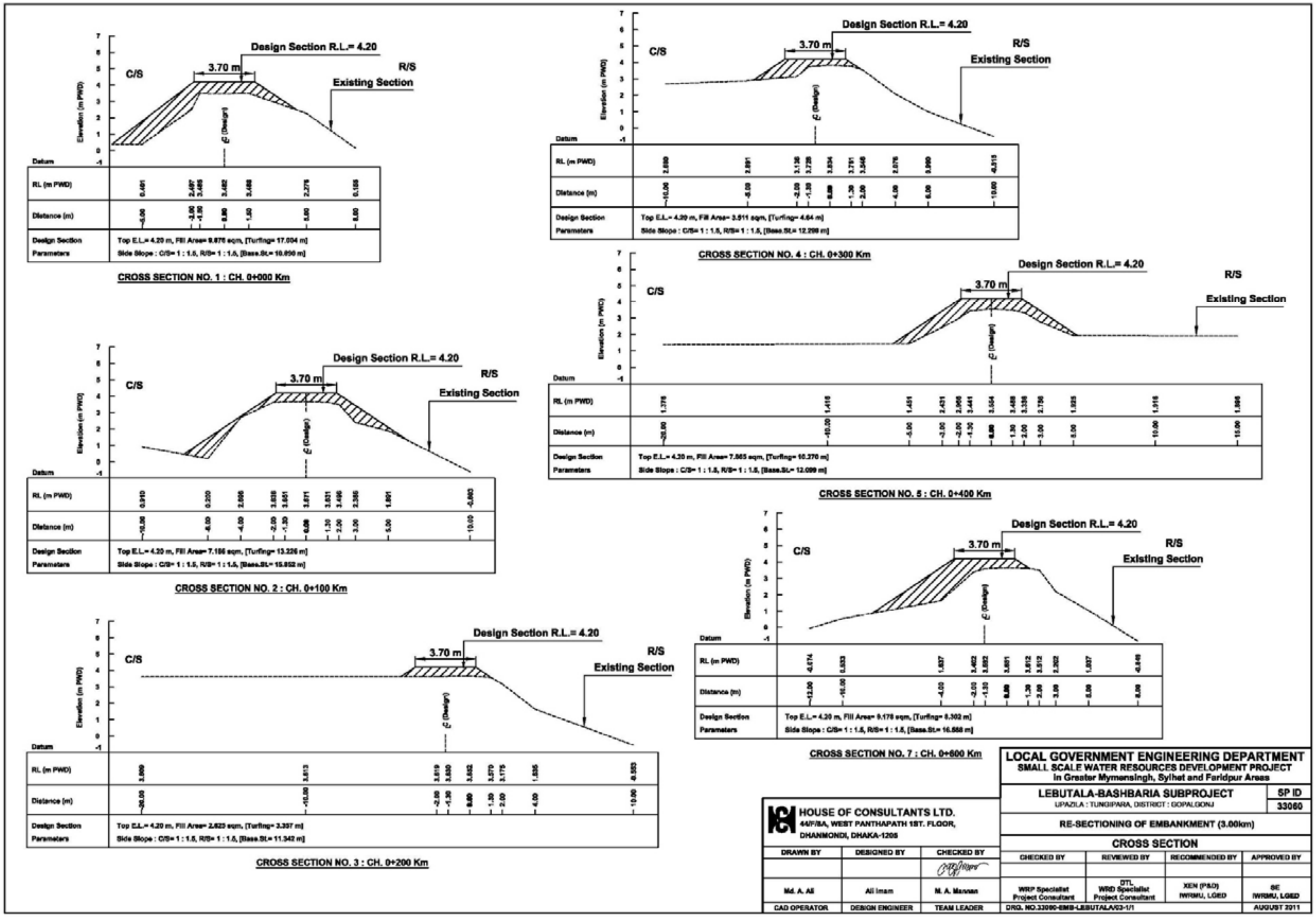

CROSS SECTION NO. 1 : CH. 0+000 Km
CROSS SECTION NO. 2 : CH. 0+100 Km
CROSS SECTION NO. 3 : CH. 0+200 Km
CROSS SECTION NO. 4 : CH. 0+300 Km
CROSS SECTION NO. 5 : CH. 0+400 Km
CROSS SECTION NO. 7 : CH. 0+600 Km
Design Section R.L.= 4.20
3.70 m
C/S
R/S
Existing Section
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
LEBUTALA-BASHBARIA SUBPROJECT
UPAZILA : TUNGIPARA, DISTRICT : GOPALGONJ
SP ID
33060
RE-SECTIONING OF EMBANKMENT (3.00km)
CROSS SECTION
HOUSE OF CONSULTANTS LTD.
44/F/8A, WEST PANTHAPATH 1ST. FLOOR, DHANMONDI, DHAKA-1205
DRAWN BY
DESIGNED BY
CHECKED BY
Md. A. Ali
Ali Imam
M. A. Mannan
CAD OPERATOR
DESIGN ENGINEER
TEAM LEADER
AUGUST 2011

EXHIBIT G6-H.3: Standard Drawings of Regulator

DETAIL DESIGN DRAWINGS
OF
BORANG KHAL REGULATOR (2V-1.50m x 1.80m)
AT CH.0+530 KM (KHAL)

CONTENT OF DRAWINGS

TITLE OF DRAWING	DRAWING NO.
INDEX MAP	/INDEX MAP/01
PART - A : BORANG KHAL REGULATOR (2V-1.50m x 1.80m) AT CH.0+530 KM (KHAL)	
LAYOUT PLAN	/REG–BORANG KHAL/07–1/1
SITE DEVELOPMENT PLAN	/REG–BORANG KHAL/08–1/1
SUB SOIL BORE LOGS	/REG–PROTAPPUR/09–1/1
FOUNDATION TREATMENT (Treatment Details)	/REG–BORANG KHAL/10–1/1
GENERAL PLAN & SECTION	/REG–BORANG KHAL/11–1/1
SECTION LIMITS DETAILS	/REG–BORANG KHAL/12–1/1
PROTECTIVE WORKS	/REG–BORANG KHAL/13–1/1
CONCRETE OUTLINE DETAILS	/REG–BORANG KHAL/14–1/1
REINFORCEMENT DETAILS	/REG–BORANG KHAL/15–1/3~3/3
DETAILS (Include all Miscellaneous)	/REG–BORANG KHAL/16–1/1
BAR BENDING SHAPES	/REG–BORANG KHAL/17–1/1
BAR BENDING SCHEDULE	/REG–BORANG KHAL/18–1/4~4/4
VERTICAL GATE DETAILS	/REG–BORANG KHAL/19–1/5~5/5

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

BORANG KHAL SUBPROJECT
UPAZILA : SADAR, DISTRICT : HABIGANJ

SP ID

BANGLADESH INSTITUTE OF SOCIAL RESEARCH
Hasina De Palace
Appt.# 4/B, House# 6/14, Block#A, Lalmatia, Dhaka-1207

CONTENT OF DRAWINGS

DRAWN BY	DESIGNED BY	CHECKED BY	CHECKED BY	REVIEWED BY	RECOMMENDED BY	APPROVED BY
Arifur Rahman	Salahuddin Khan	Md. Abdus Sabur	WRP Specialist Project Consultant	DTL WRD Specialist Project Consultant	XEN (P&D) (WR&U), LGED	SE (P&D) (WR&U), LGED
CAD Expert	DESIGN ENGINEER	TEAM LEADER	DRG. NO. /CONTENT OF DRAWINGS–1/1			MAY 2014

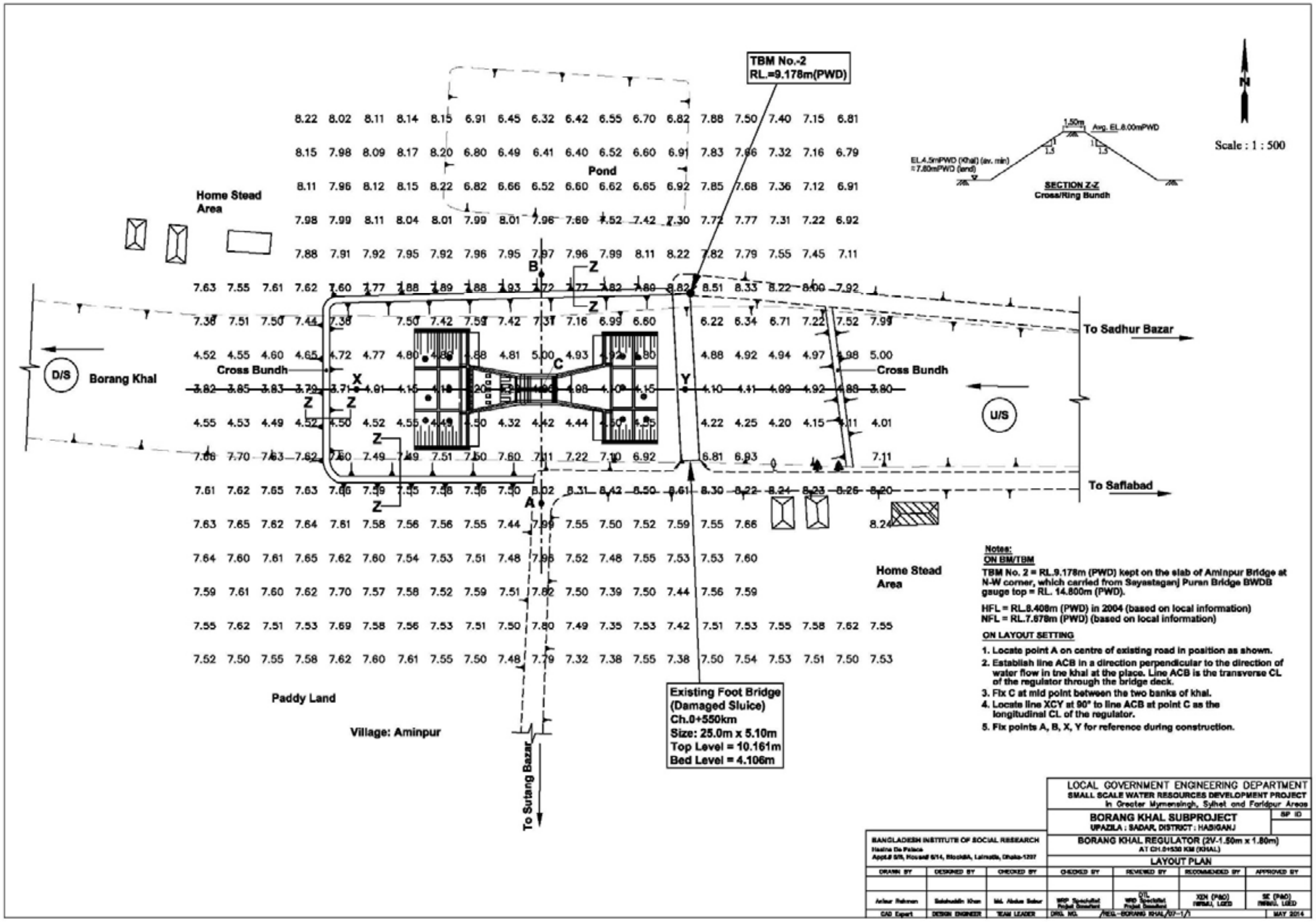

TBM No.-2
RL.=9.178m(PWD)
Scale : 1 : 500
SECTION Z-Z
Cross/Ring Bundh
Avg. EL.8.00mPWD
Pond
Home Stead Area
Borang Khal
D/S
U/S
Cross Bundh
To Sadhur Bazar
To Saflabad
Paddy Land
Village: Aminpur
To Sutang Bazar
Existing Foot Bridge
(Damaged Sluice)
Ch.0+550km
Size: 25.0m x 5.10m
Top Level = 10.161m
Bed Level = 4.106m
Notes:
ON BM/TBM
TBM No. 2 = RL.9.178m (PWD) kept on the slab of Aminpur Bridge at N-W corner, which carried from Sayastaganj Puran Bridge BWDB gauge top = RL. 14.800m (PWD).
HFL = RL.8.408m (PWD) in 2004 (based on local information)
NFL = RL.7.678m (PWD) (based on local information)
ON LAYOUT SETTING
1. Locate point A on centre of existing road in position as shown.
2. Establish line ACB in a direction perpendicular to the direction of water flow in the khal at the place. Line ACB is the transverse CL of the regulator through the bridge deck.
3. Fix C at mid point between the two banks of khal.
4. Locate line XCY at 90° to line ACB at point C as the longitudinal CL of the regulator.
5. Fix points A, B, X, Y for reference during construction.
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
BORANG KHAL SUBPROJECT
UPAZILA : SADAR, DISTRICT : HABIGANJ
SP ID
BANGLADESH INSTITUTE OF SOCIAL RESEARCH
BORANG KHAL REGULATOR (2V-1.50m x 1.80m)
LAYOUT PLAN
DRAWN BY
DESIGNED BY
CHECKED BY
REVIEWED BY
RECOMMENDED BY
APPROVED BY
CAD Expert
DESIGN ENGINEER
TEAM LEADER
MAY 2014

Exhibit G6-H3

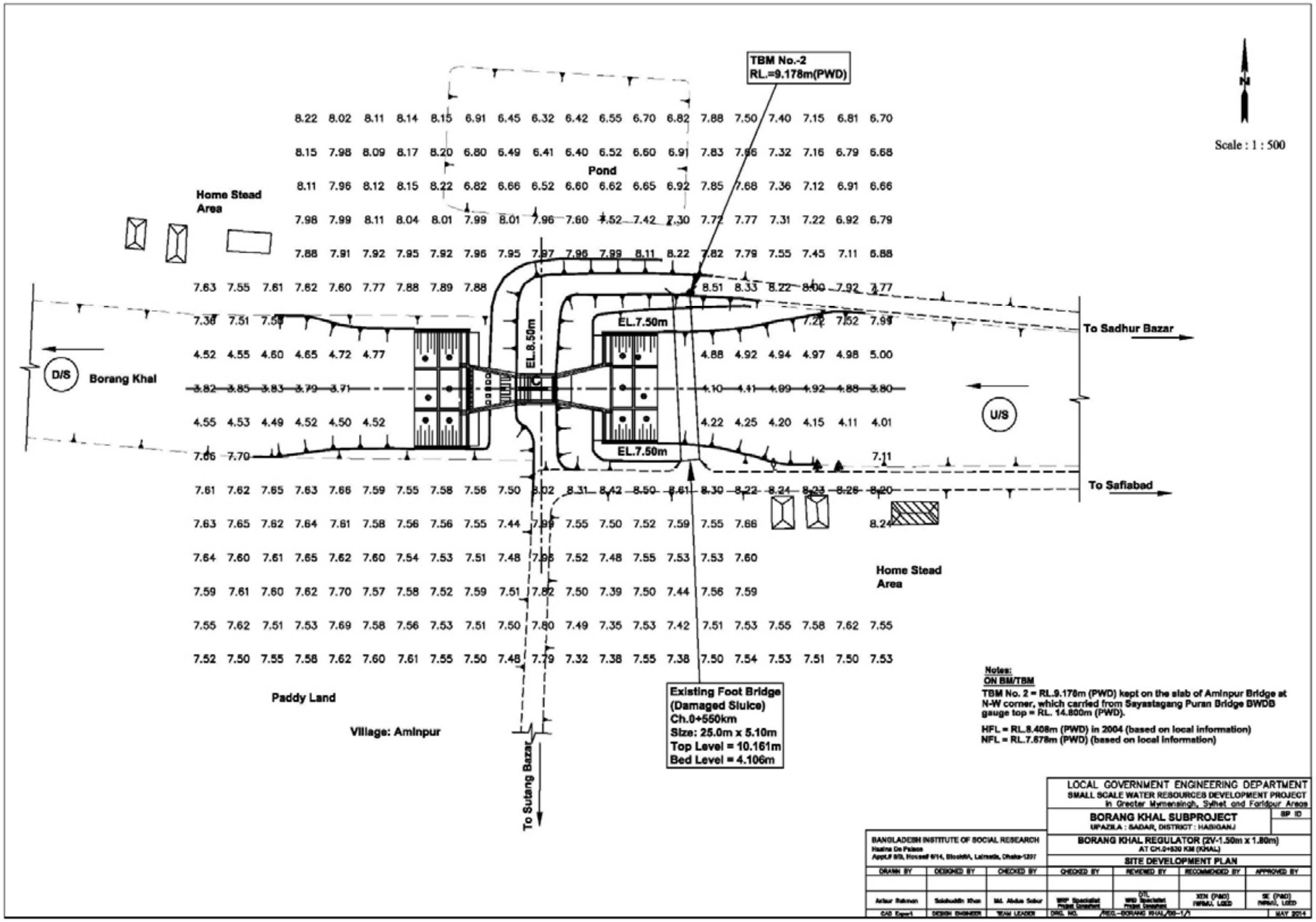


Exhibit G6-H3

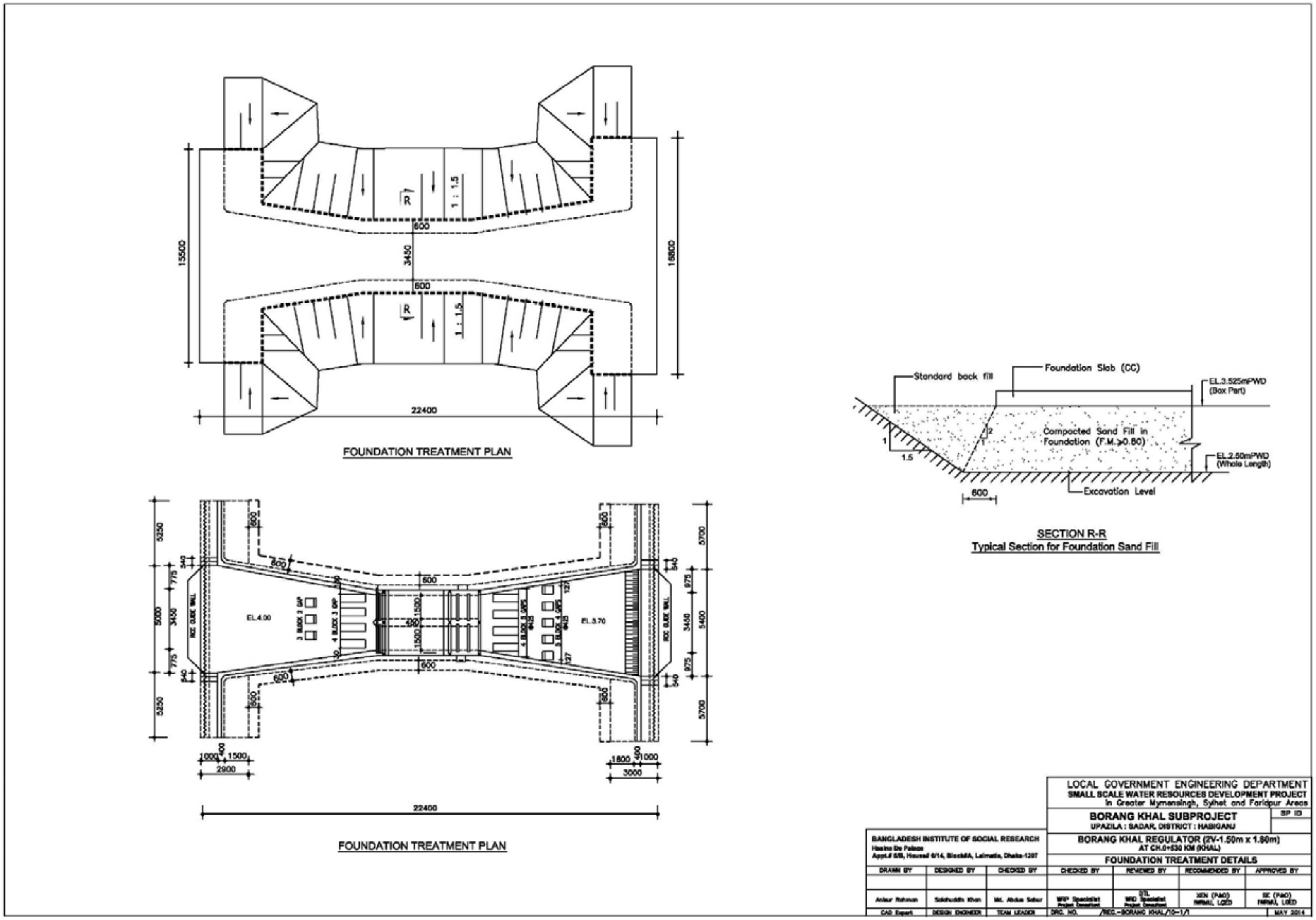
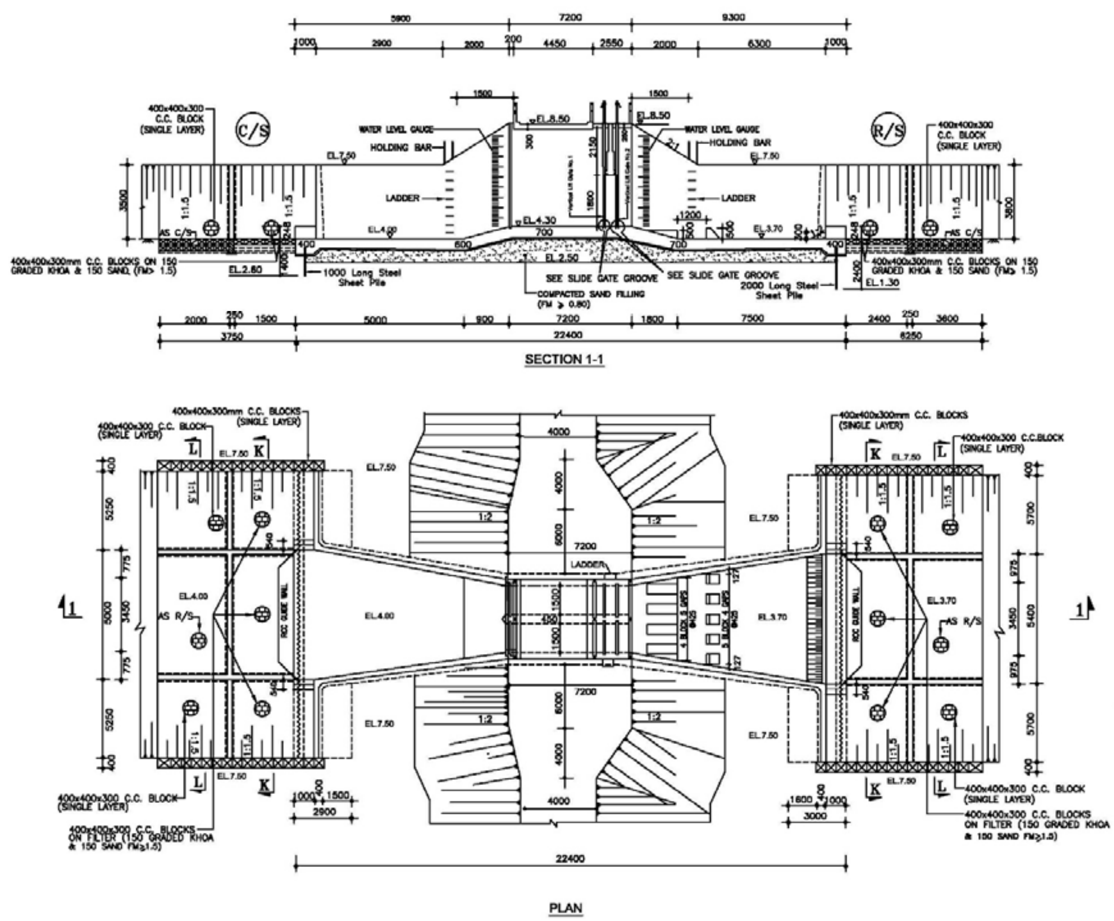


Exhibit G6-H3



SPECIFICATION & NOTES ON MATERIAL & WORK FOR REGULATORS/SLUICES/WRS/RUBBER DAMS/HEADER TANKS			
WORKS	RCC WORKS		CC WORKS (Lean conc., Blocks, etc)
	IN STRUCTURAL MEMBERS	IN MASS CONCRETE	
1. Concrete			
i) Strength	28-days crushing strength (f'c) shall be 21 N/mm²	-	-
ii) Mix Proportion by volume	Shall be determined by Trial Mix to achieve specified strength (f'c) 21 N/mm². However, the minimum mix ratio shall be 1:1.5:3	1:2:4	1:3:6
iii) Cement	Portland Type-1	Portland Type-1	Portland Type-1
iv) Coarse aggregate	20mm down graded crushed stone chips (Well graded between 20mm & 8mm size.)	20mm down graded crushed stone chips (Well graded between 20mm & 8mm size.)	20mm down graded crushed stone chips (Well graded between 20mm & 8mm size.)
v) Sand	FM 1.80	FM 1.80	FM 1.00
vi) Slump (at work)	60-75 mm	60-75 mm	60-75 mm
2. Reinforcement			
i) Grade	60 grade deformed M.S. bar	60 grade deformed M.S. bar	-
ii) Strength	Minimum yield strength (fy) 415 N/mm²	Minimum yield strength (fy) 415 N/mm²	-
iii) Clear cover	Earth faces = 75mm Water faces = 50mm All others = 25mm		-
iv) Others			
3. Brick bolcks	1st class bricks in 1:4 cement mortar with sand (FM 1.00)		
4. Back filling	Back filling in abutments, wing walls and return walls up to FGL shall be done simultaneously on both sides of structure with local sand free from vegetable roots and other organic materials.		
5. Foundation Treatment	Foundation treatment to be done as per design & drawing.		
6. Test Samples	Test samples shall be collected by the contractor from "Flow Line Concrete" during casting in presence of Engineer-in-charge in standard cylinders for testing 7day strengths to check strength achieved. Work not meeting specified strength shall be treated as per provision of the contract.		
7. Protective work	Earthfill in side slopes shall be compacted in horizontal layers to satisfaction of the Engineer in charge before placing filter filter material and blocks.		
8. Embedded Parts of Gates	M.S embedded parts such as angles, channels, anchors plates, wall brackets etc with welded anchor bars (for gates) shall be installed and checked in proper positions and alignments as shown in working drawings before casting of concrete.		
9. Elevations	Eelevations are in meter (PWD) with reference to the TBM kept for the subproject		
10. Dimensions	Dimensions are in millimeters unless otherwise mentioned.		

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

BORANG KHAL SUBPROJECT
UPAZILA : SADAR, DISTRICT : HABIGANJ

SP ID

BANGLADESH INSTITUTE OF SOCIAL RESEARCH
Hasina De Palace
Appt.# 6/B, House# 6/14, Block#A, Lalmatia, Dhaka-1207

BORANG KHAL REGULATOR (2V-1.50m x 1.80m)
AT CH.0+530 KM (KHAL)

GENERAL PLAN AND LONG SECTION

DRAWN BY	DESIGNED BY	CHECKED BY	CHECKED BY	REVIEWED BY	RECOMMENDED BY	APPROVED BY
Anisur Rahman	Salahuddin Khan	Md. Abdus Sabur	WRP Specialist Project Consultant	DTL WRD Specialist Project Consultant	XEN (P&D) IWRMU, LGED	SE (P&D) IWRMU, LGED
CAD Expert	DESIGN ENGINEER	TEAM LEADER	DRG. NO. /REG.-BORANG KHAL/11-1/1			MAY 2014

Exhibit G6-H3

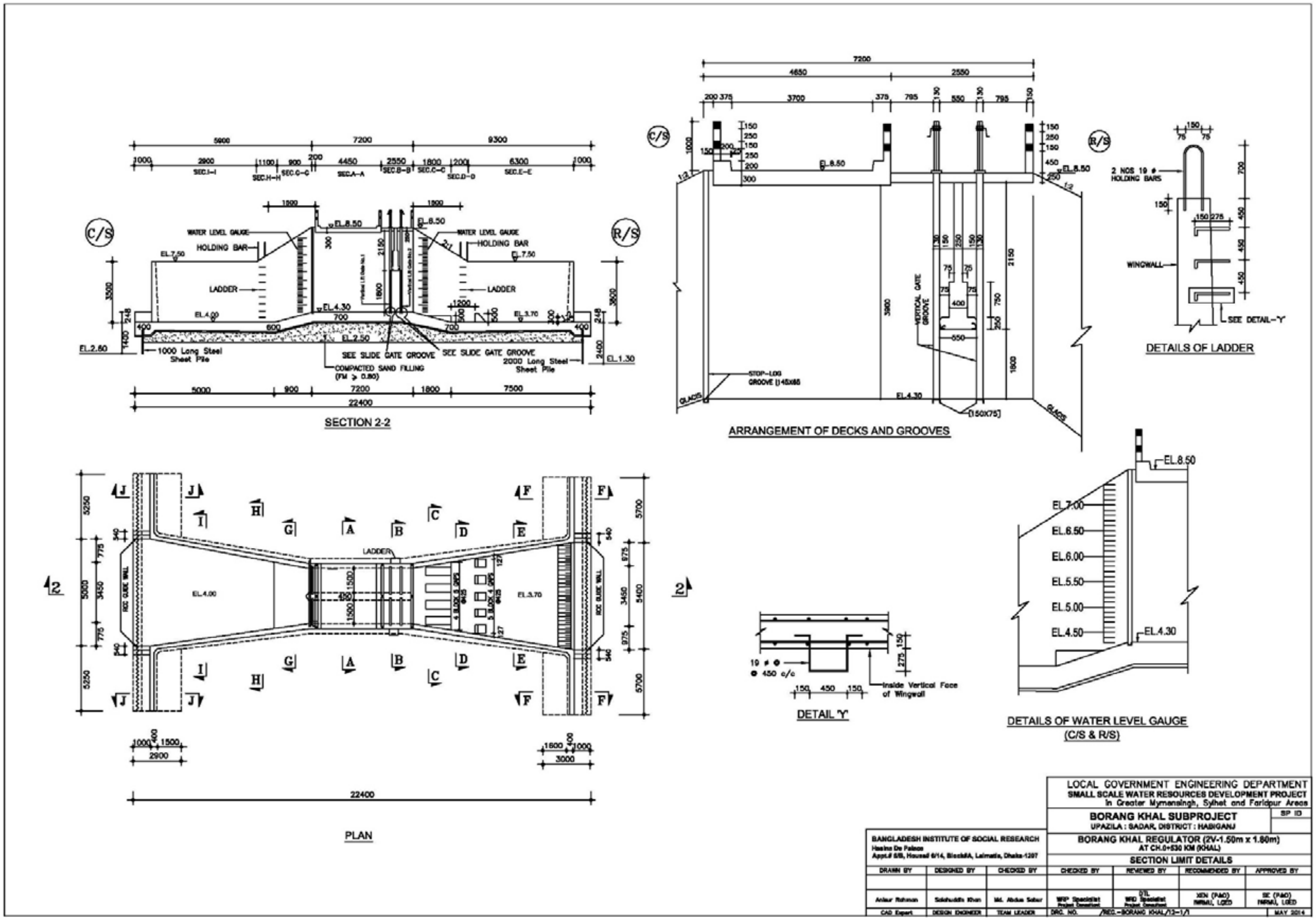
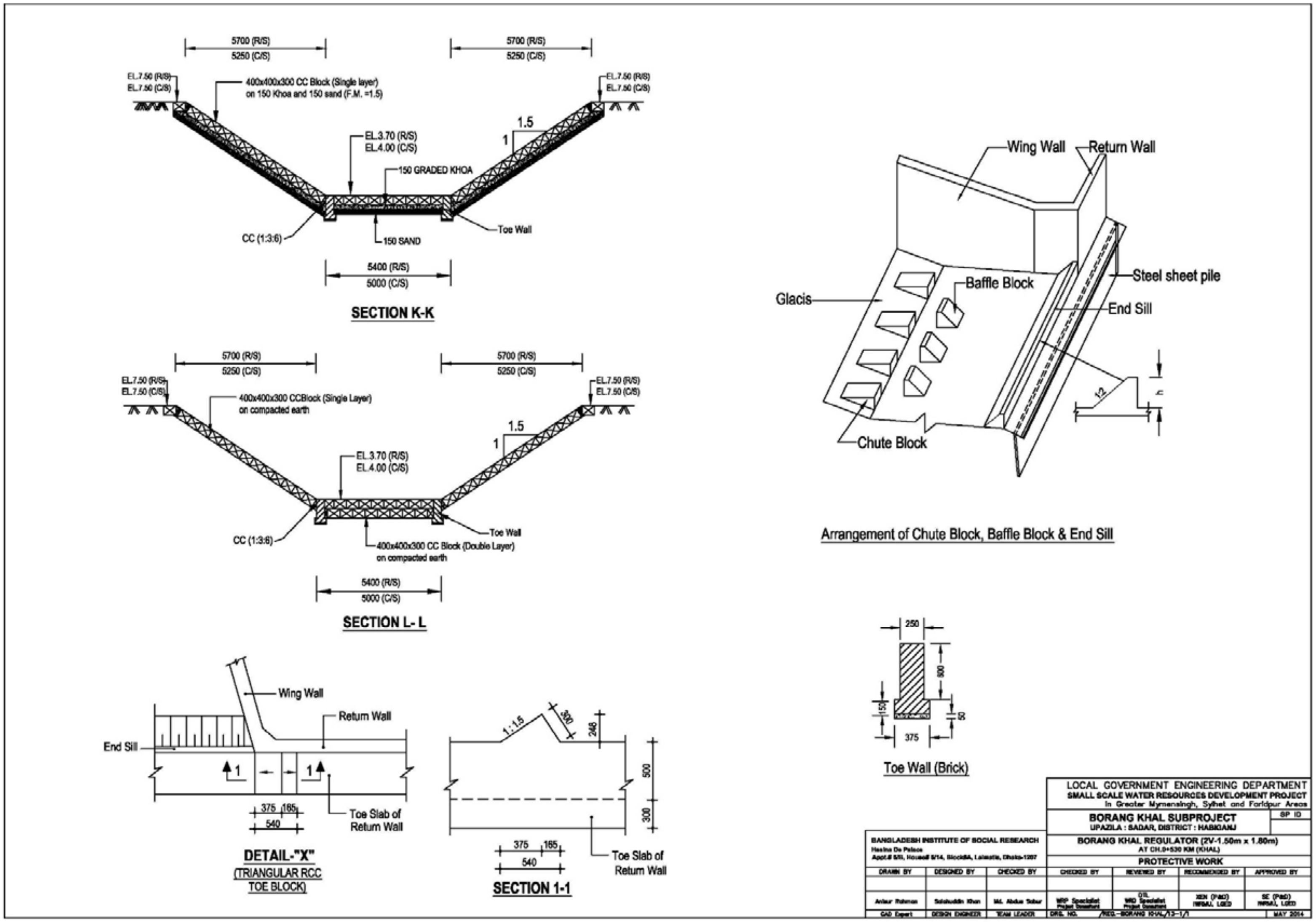


Exhibit G6-H3



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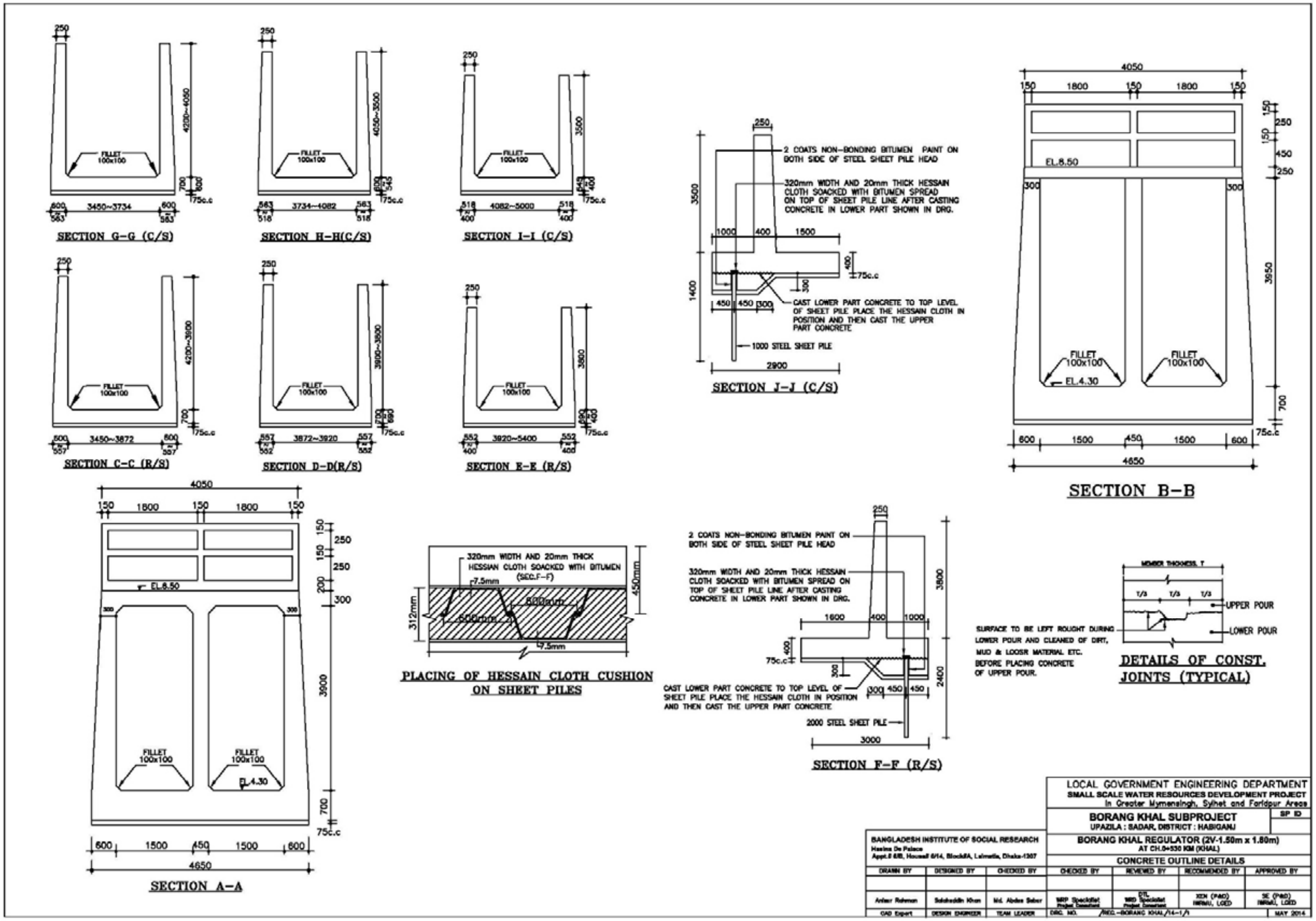
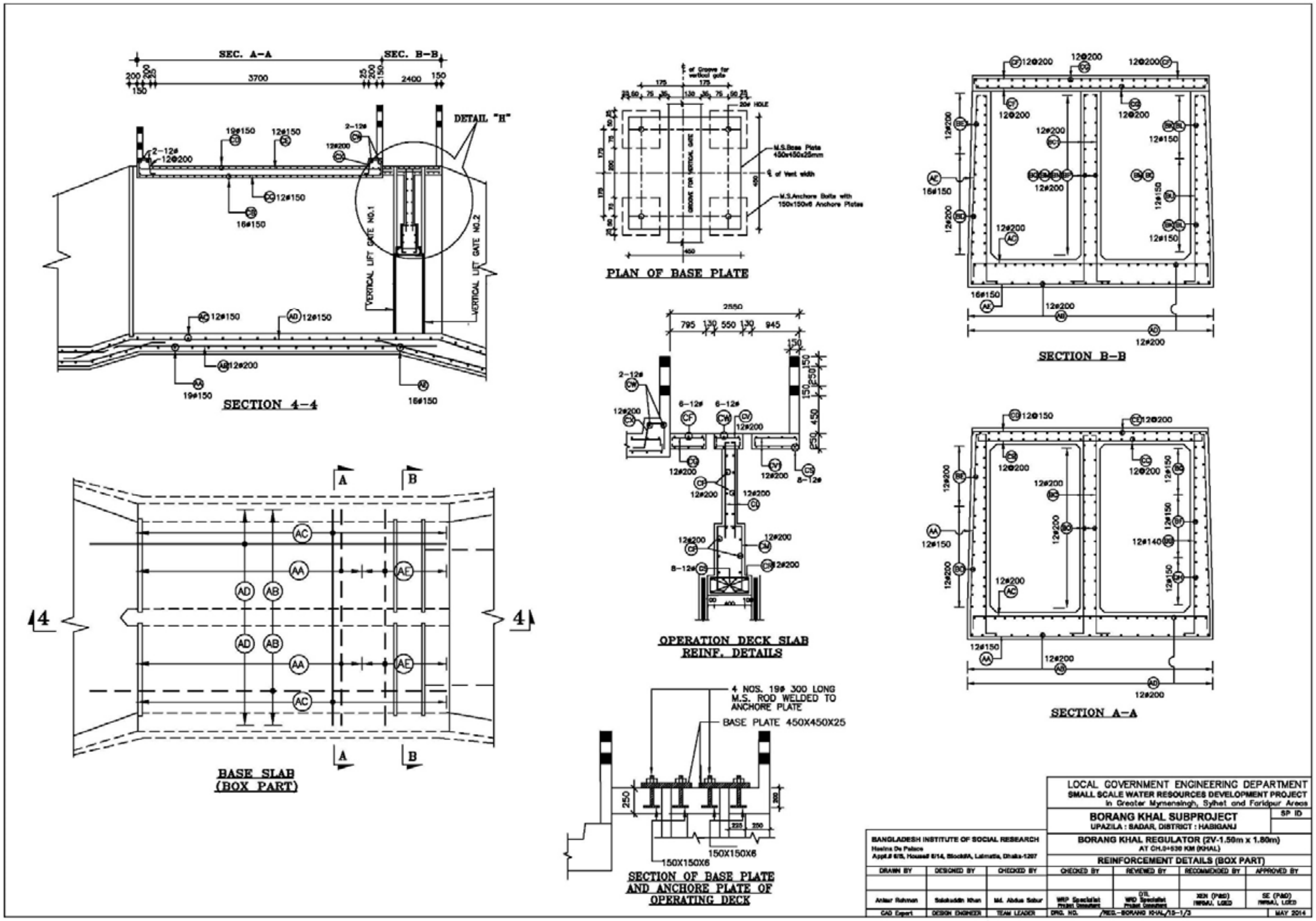


Exhibit G6-H3



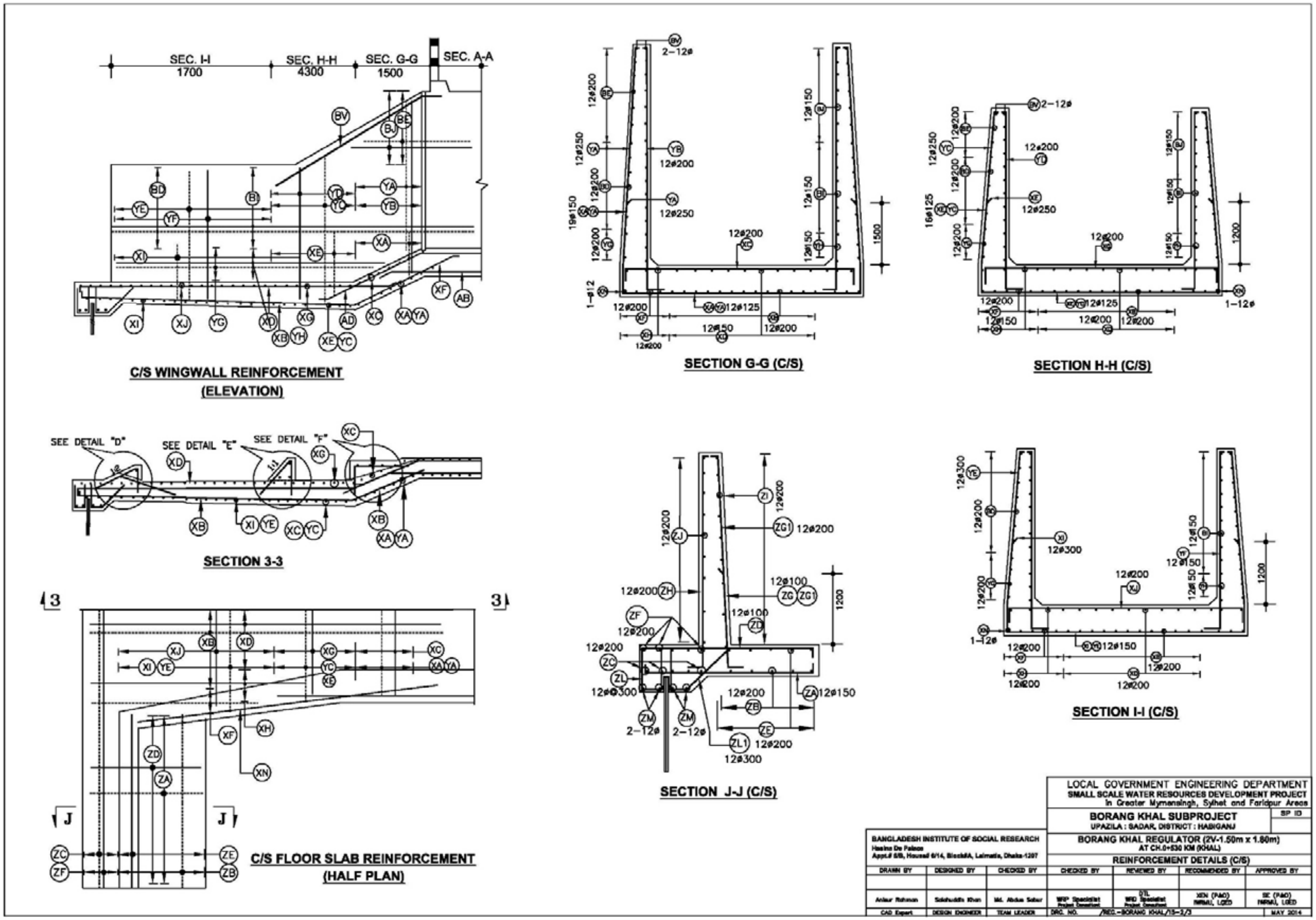

C/S WINGWALL REINFORCEMENT
(ELEVATION)
SECTION G-G (C/S)
SECTION H-H (C/S)
SECTION 3-3
SECTION J-J (C/S)
SECTION I-I (C/S)
C/S FLOOR SLAB REINFORCEMENT
(HALF PLAN)
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
BORANG KHAL SUBPROJECT
UPAZILA : SADAR, DISTRICT : HABIGANJ
BORANG KHAL REGULATOR (2V-1.50m x 1.80m)
REINFORCEMENT DETAILS (C/S)
BANGLADESH INSTITUTE OF SOCIAL RESEARCH
MAY 2014

Exhibit G6-H3

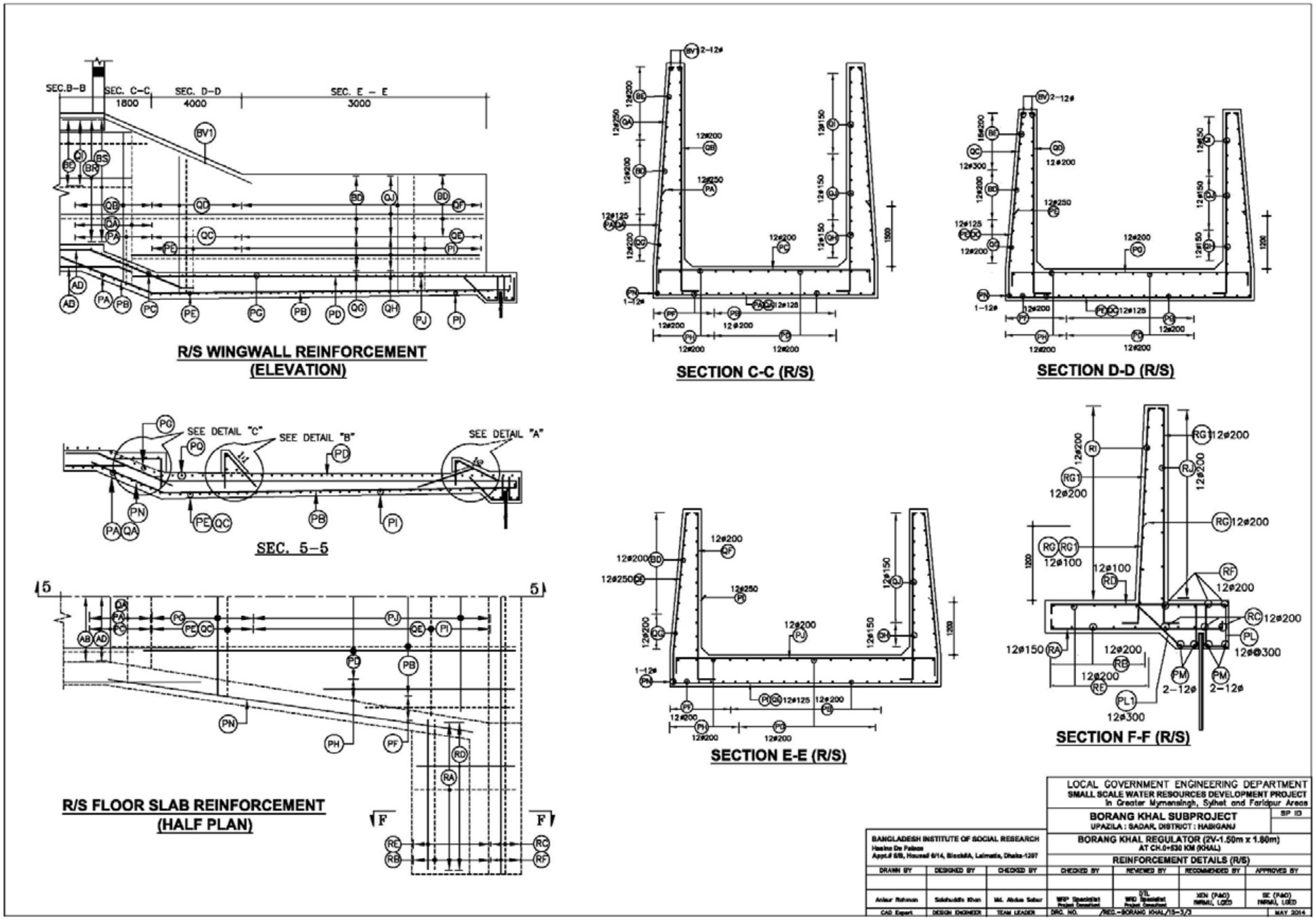


Exhibit G6-H3

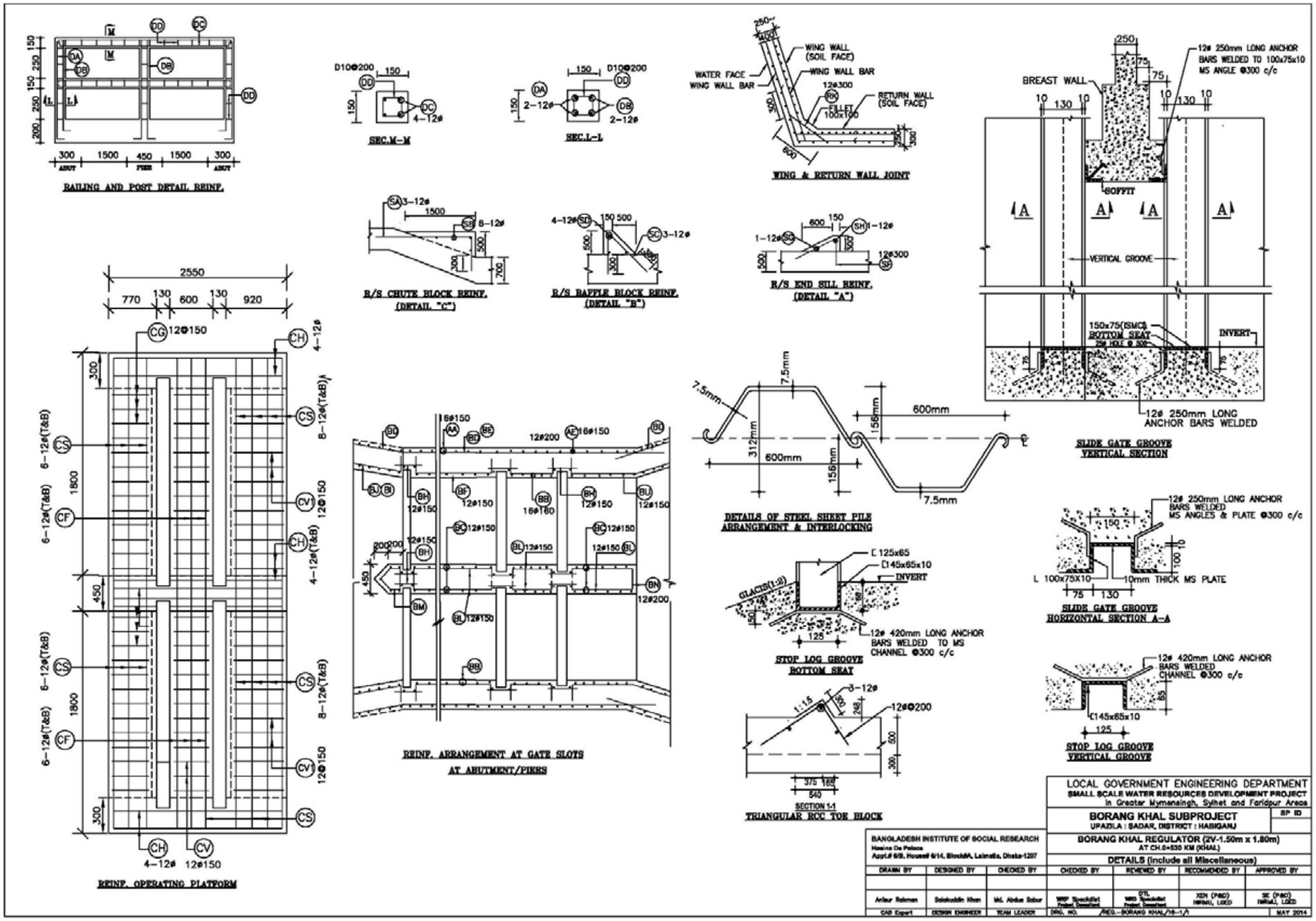


EXHIBIT G6-H4: Standard Drawings of Vertical Gate

DETAIL DESIGN DRAWINGS
OF
VERTICAL GATE (2V-1.50m x 1.80m)

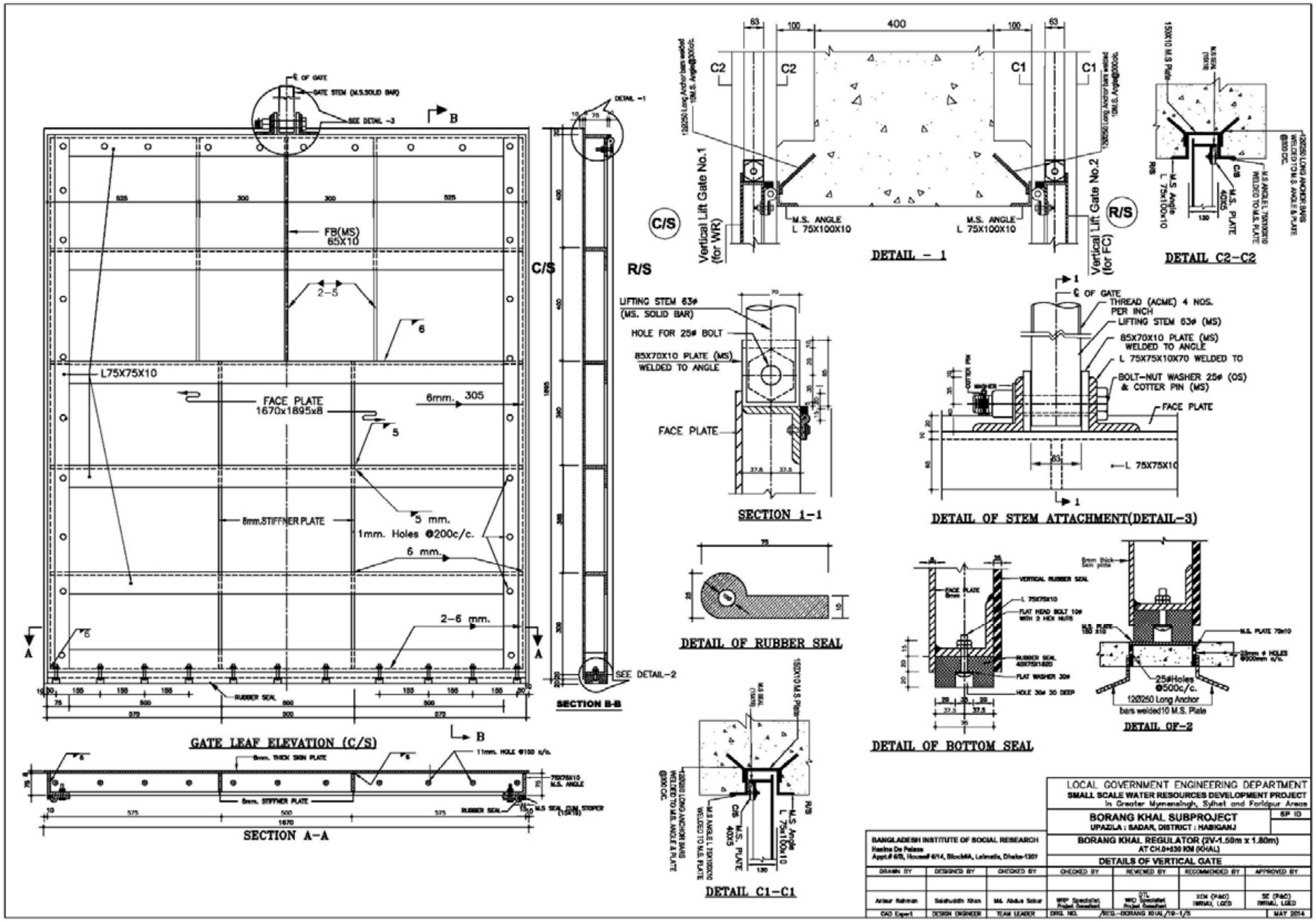

GATE LEAF ELEVATION (C/S)
SECTION A–A
SECTION B-B
DETAIL – 1
DETAIL C2–C2
SECTION 1–1
DETAIL OF STEM ATTACHMENT(DETAIL–3)
DETAIL OF RUBBER SEAL
DETAIL OF BOTTOM SEAL
DETAIL OF–2
DETAIL C1–C1
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
BORANG KHAL SUBPROJECT
UPAZILA : SADAR, DISTRICT : HABIGANJ
DETAILS OF VERTICAL GATE
MAY 2014

Exhibit G6-H4

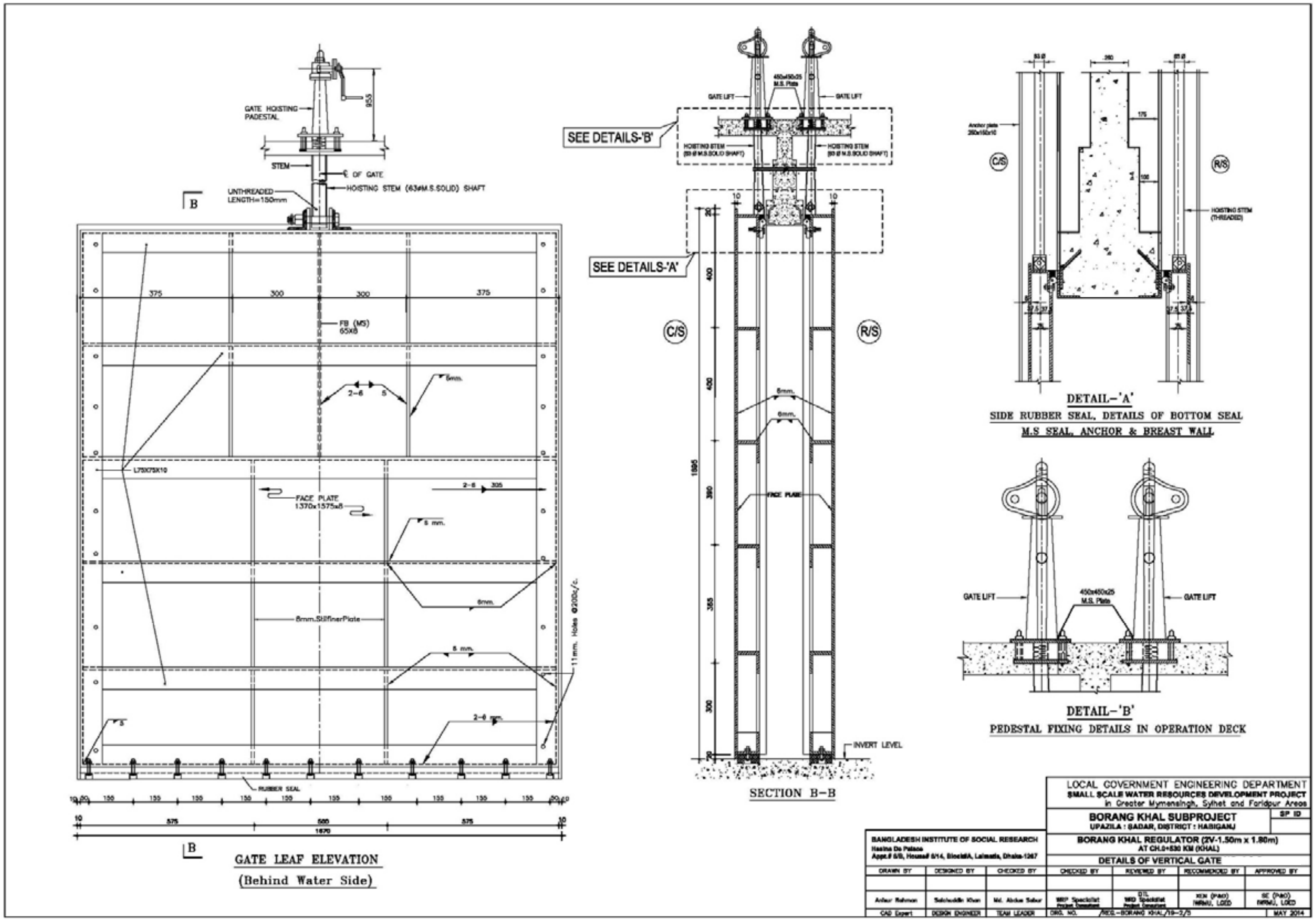
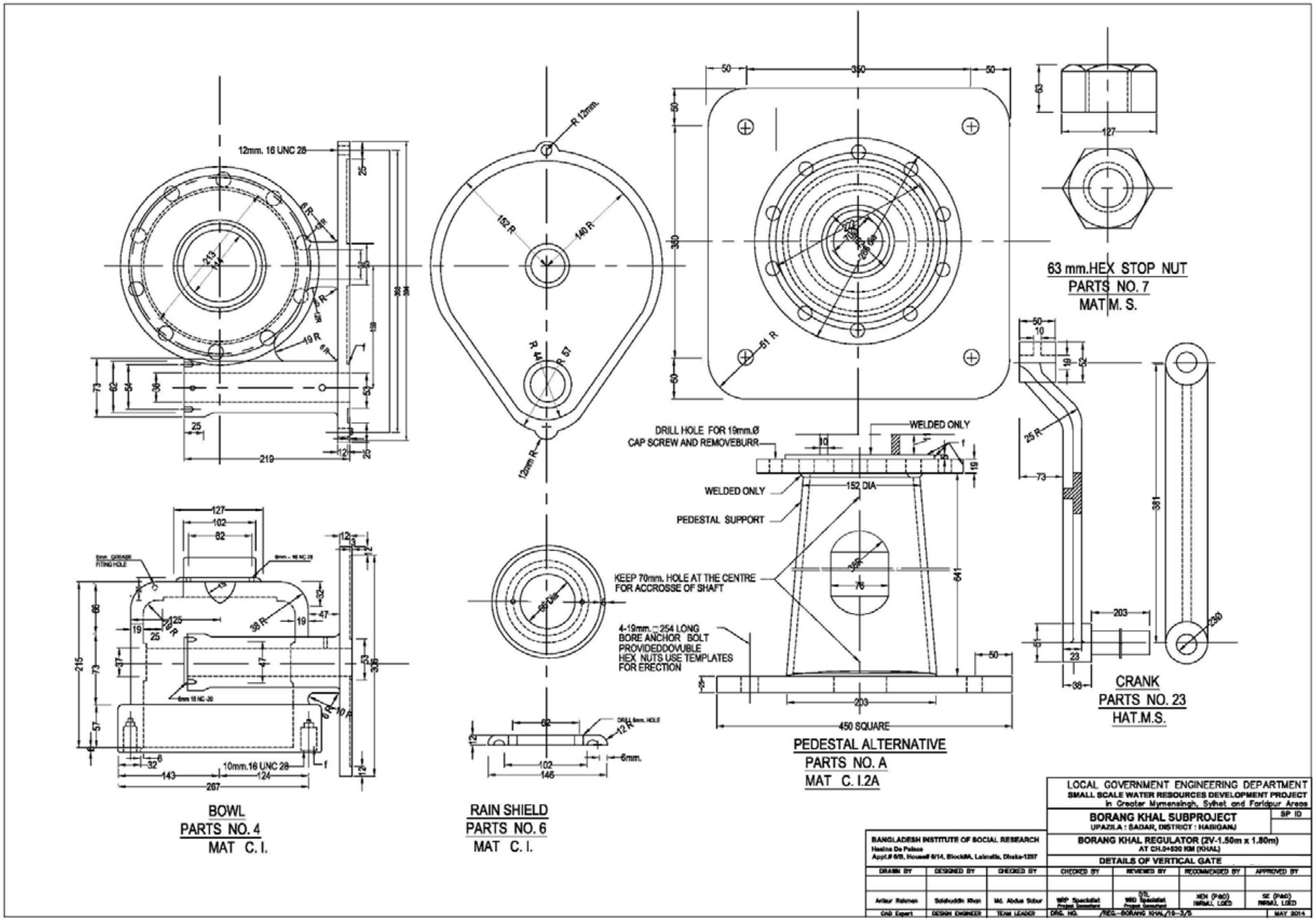
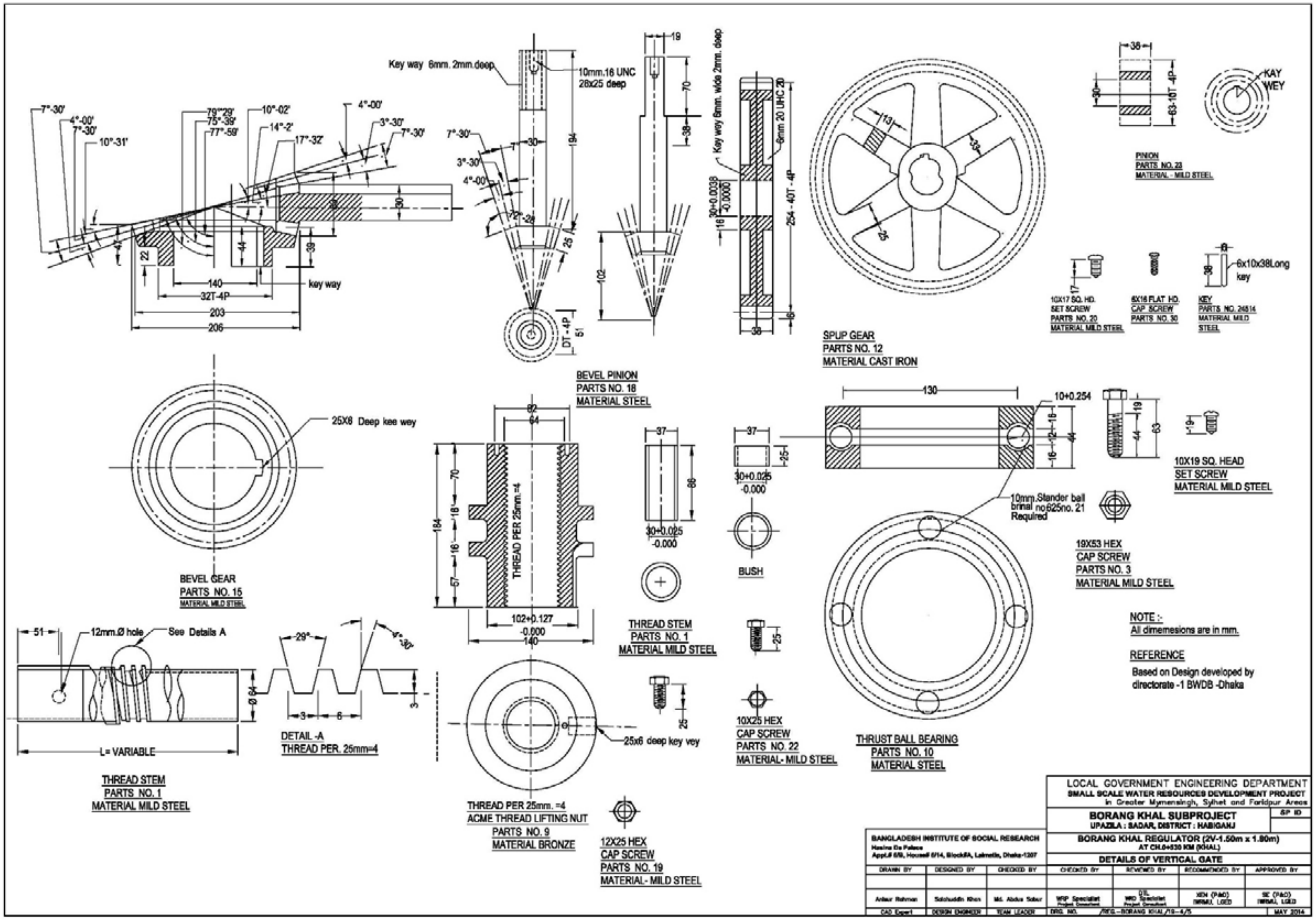
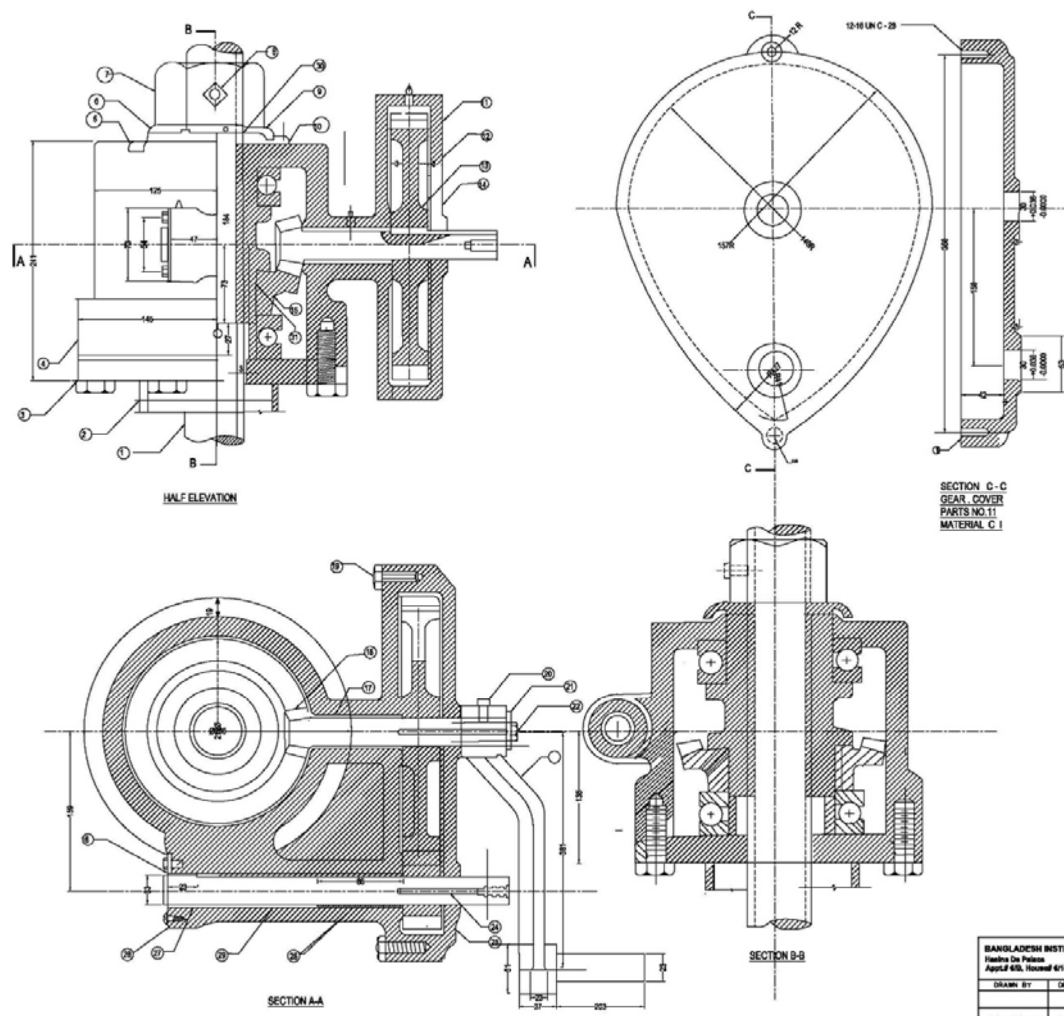


Exhibit G6-H4




BEVEL PINION
PARTS NO. 18
MATERIAL STEEL
SPUP GEAR
PARTS NO. 12
MATERIAL CAST IRON
PINION
PARTS NO. 23
MATERIAL - MILD STEEL
10X17 SQ. HD. SET SCREW PARTS NO. 20 MATERIAL MILD STEEL
6X16 FLAT HD. CAP SCREW PARTS NO. 30
KEY PARTS NO. 24814 MATERIAL MILD STEEL
BEVEL GEAR
PARTS NO. 15
MATERIAL MILD STEEL
THREAD STEM
PARTS NO. 1
MATERIAL MILD STEEL
BUSH
10X19 SQ. HEAD
SET SCREW
MATERIAL MILD STEEL
19X53 HEX
CAP SCREW
PARTS NO. 3
MATERIAL MILD STEEL
NOTE :-
All dimemesions are in mm.
REFERENCE
Based on Design developed by directorate -1 BWDB -Dhaka
DETAIL -A
THREAD PER. 25mm=4
THREAD STEM
PARTS NO. 1
MATERIAL MILD STEEL
THREAD PER 25mm. =4
ACME THREAD LIFTING NUT
PARTS NO. 9
MATERIAL BRONZE
12X25 HEX
CAP SCREW
PARTS NO. 19
MATERIAL- MILD STEEL
10X25 HEX
CAP SCREW
PARTS NO. 22
MATERIAL- MILD STEEL
THRUST BALL BEARING
PARTS NO. 10
MATERIAL STEEL
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
in Greater Mymensingh, Sylhet and Faridpur Areas
BORANG KHAL SUBPROJECT
UPAZILA : SADAR, DISTRICT : HABIGANJ
BANGLADESH INSTITUTE OF SOCIAL RESEARCH
BORANG KHAL REGULATOR (2V-1.50m x 1.80m)
DETAILS OF VERTICAL GATE
MAY 2014



PARTS LIST					
P.C.NO.	NAME	QTY	MAT.	P/M	REMARKS
1	THREADED STEM	1	MS	M	AISI 1020
2	PEDESTAL	1	MS	M	STRUCTURAL
3	HEX HD CAP SCROW	10	MS	P	STRUCTURAL
4	BOWL	1	C. I	M	ASTM 30
5	GREASE FITTING	9	—	P	ASTM 30
6	RAIN SHIELD	1	C.1	M	ASTM 30
7	64mm. HEX STOP UNIT	1	MS	M	STRUCTURAL
8	10mm. SQUARE HEAD SET SCREW	1	MS	M	STRUCTURAL
9	LIFT NUT	1	BRONZ	M	ASTM 30
10	THAUST BALL BEARING	2	—	M	—
11	GEAR COVER	1	C.1	M	ASTM 30
12	SPUR GEAR	1	C.1	M	ASTM 30
13	6mm. ALLEN HEAD SET SCREW	1	MS	M	STRUCTURAL
14	KEY	1	MS	M	STRUCTURAL
15	DEYEL GEAR	1	MS	P	AISI 2317
16	6mm. HEX HD. CAP SCREW	4	MS	M	STRUCTURAL
17	BRONZE DRUSHINGS	1	BRONZ	M	SAE 64
18	PINION AND SHAFT	1	MS	M	STRUCTURAL
19	12mm. HEX HD. CAP SCREW	2	MS	P	STRUCTURAL
20	10mm. SQ. HD. SET SCREW	1	MS	M	STRUCTURAL
21	LOCK WASHER	1	MS	M	STRUCTURAL
22	10mm. CAP SCREW	1	MS	P	—
23	CRANK	1	MS	M	STRUCTURAL
24	KEY	1	MS	M	STRUCTURAL
25	PINION	1	MS	M	STRUCTURAL
26	BRONZE BRUSHINGS	1	BRONZ		SAE 64
27	BRONZE BRUSHINGS	1	BRONZ	M	SAE 64
28	LOCK WASHER	1	BRONZ	M	SAE 64
29	PINION	1	MS	M	AISI 1020
30	6mm.FLAT HEAD CAP SCREW	2	MS	M	STRUCTURAL
31	KEY	1	MS	M	STRUCTURAL

* Std. thrust bearings of nearest dimension may be used necessary alteration of other members for this shall have to be approved before manufacture.

NOTE :

1. For other notes see drg. no.
2. All dimension s are in mm.

REFERENCE :-

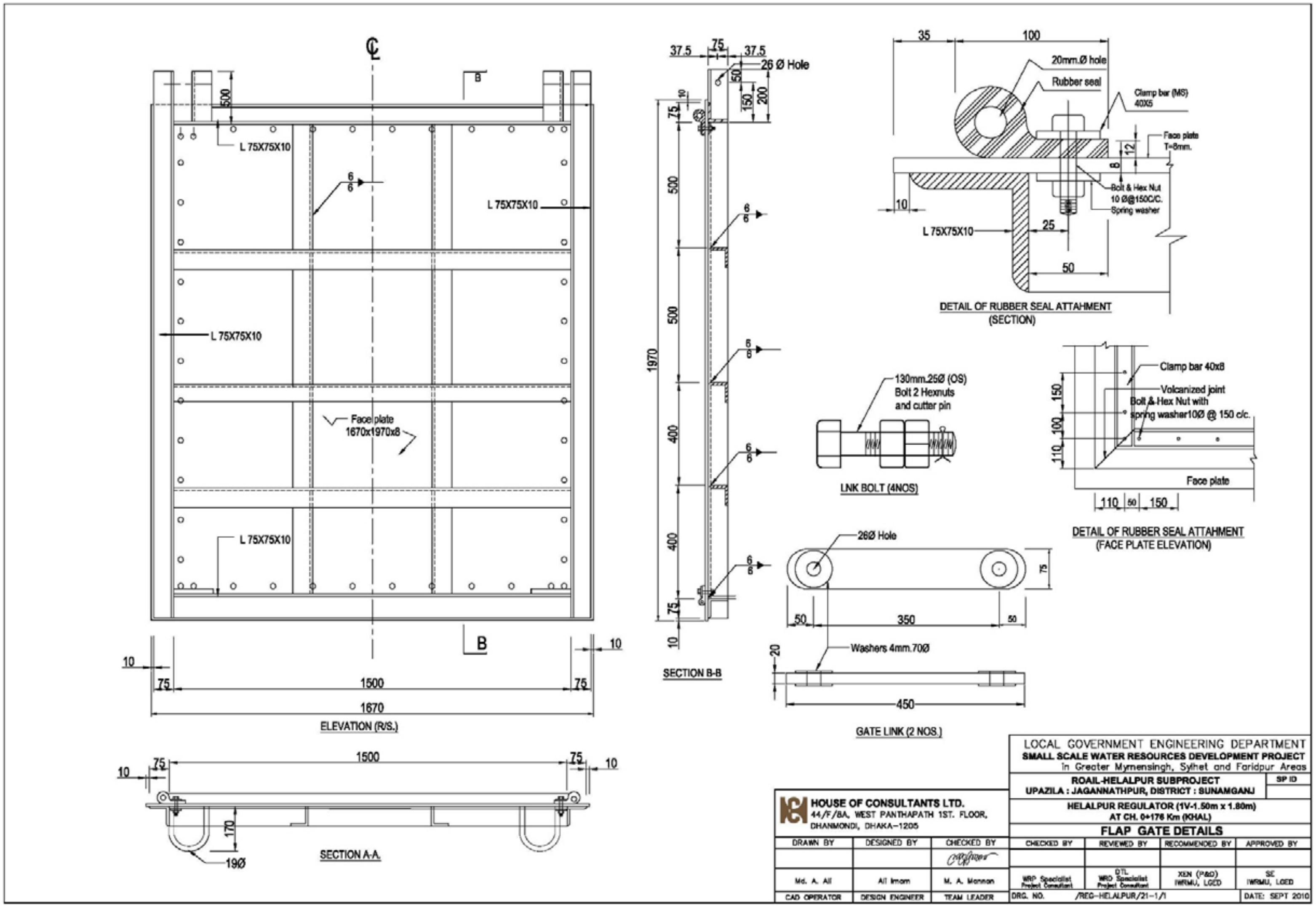
Based on Design developed by Design Directorate -1 . BWDB, Dhaka.

BANGLADESH INSTITUTE OF SOCIAL RESEARCH Hasina De Palace Apptt# 6/D, House# 6/14, Block#A, Lalmatia, Dhaka-1207			LOCAL GOVERNMENT ENGINEERING DEPARTMENT SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT In Greater Mymensingh, Sylhet and Faridpur Areas BORANG KHAL SUBPROJECT UPAZILA : SADAR, DISTRICT : HABIGANJ BORANG KHAL REGULATOR (2V-1.50m x 1.80m) AT CH.0+530 KM (KHAL) DETAILS OF VERTICAL GATE			SP ID
DRAWN BY	DESIGNED BY	CHECKED BY	CHECKED BY	REVIEWED BY	RECOMMENDED BY	APPROVED BY
Arifur Rahman	Salahuddin Khan	Md. Abdus Sobur	WRP Specialist Project Consultant	D.TL. WRD Specialist Project Consultant	XEN (P&D) IWRMU, LGED	SE (P&D) IWRMU, LGED
CAD Expert	DESIGN ENGINEER	TEAM LEADER	DRG. NO. /REG.-BORANG KHAL/19-3/3			MAY 2014

EXHIBIT G6-H5: Standard Drawings of Flap Gate

DETAIL DESIGN DRAWINGS
OF
FLAP GATE DETAILS (1V-1.50m x 1.80m)

Exhibit G6-H5



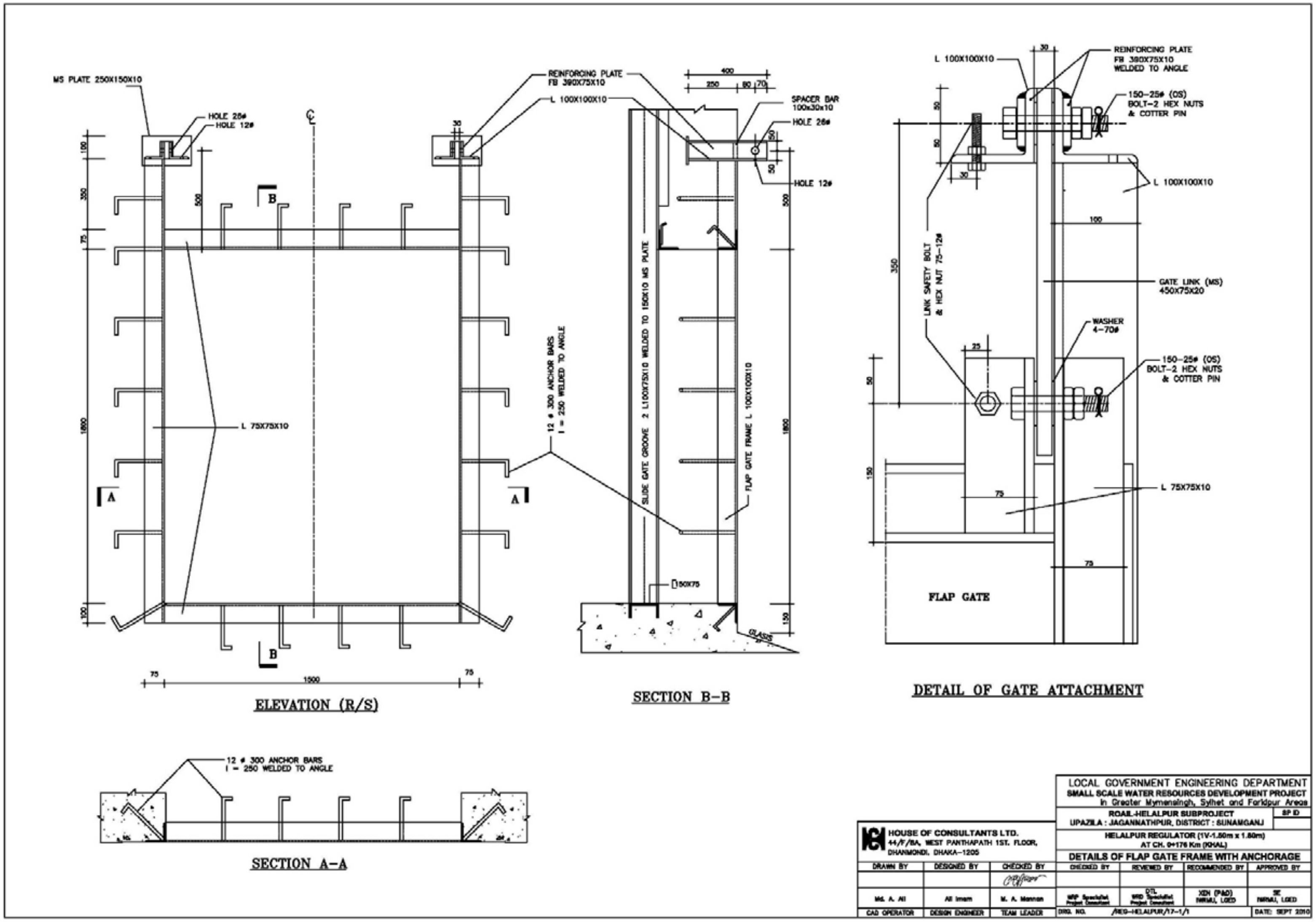

MS PLATE 250X150X10
HOLE 26ø
HOLE 12ø
REINFORCING PLATE FB 390X75X10
L 100X100X10
SPACER BAR 100x30x10
HOLE 26ø
HOLE 12ø
L 75X75X10
12 ø 300 ANCHOR BARS l = 250 WELDED TO ANGLE
SLIDE GATE GROOVE 2 L100X75X10 WELDED TO 150X10 MS PLATE
FLAP GATE FRAME L 100X100X10
ELEVATION (R/S)
SECTION B-B
L 100X100X10
REINFORCING PLATE FB 390X75X10 WELDED TO ANGLE
150-25ø (OS) BOLT-2 HEX NUTS & COTTER PIN
L 100X100X10
LINK SAFETY BOLT & HEX NUT 75-12ø
GATE LINK (MS) 450X75X20
WASHER 4-70ø
150-25ø (OS) BOLT-2 HEX NUTS & COTTER PIN
L 75X75X10
FLAP GATE
DETAIL OF GATE ATTACHMENT
12 ø 300 ANCHOR BARS l = 250 WELDED TO ANGLE
SECTION A-A
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
ROAIL-HELALPUR SUBPROJECT
UPAZILA : JAGANNATHPUR, DISTRICT : SUNAMGANJ
SP ID
HOUSE OF CONSULTANTS LTD.
44/F/8A, WEST PANTHAPATH 1ST. FLOOR,
DHANMONDI, DHAKA-1205
HELALPUR REGULATOR (1V-1.50m x 1.80m)
AT CH. 0+176 Km (KHAL)
DETAILS OF FLAP GATE FRAME WITH ANCHORAGE
DRAWN BY
DESIGNED BY
CHECKED BY
CHECKED BY
REVIEWED BY
RECOMMENDED BY
APPROVED BY
Md. A. Ali
Ali Imam
M. A. Mannan
XEN (P&D) NRMU, LGED
SE NRMU, LGED
CAD OPERATOR
DESIGN ENGINEER
TEAM LEADER
DRG. NO. /REG-HELALPUR/17-1/1
DATE: SEPT 2010

Exhibit G6-H5

EXHIBIT G6-H6: STANDARD DRAWINGS OF WRS

DETAIL DRAWINGS OF

PART A: BOULAR KHAL WRS (2V-1.50m x 2.00m)

AT Ch. 0+550 km (Khal)

MAY 2014

CONTENT OF DRAWINGS

TITLE OF DRAWING	DRAWING NO.
INDEX MAP	/INDEX MAP/ 1/1
STRUCTURE:	
PART A: BOULAR KHAL WRS (2V-1.5m x 2.0m)	
LAYOUT PLAN	/WRS-BOULAR KHAL WRS/07-1/1
SITE DEVELOPMENT & CHANNEL TRANSITION PLAN	/WRS-BOULAR KHAL WRS/08-1/1
GENERAL PLAN & LONG SECTION	/WRS-BOULAR KHAL WRS/10-1/1
FOUNDATION TREATMENT (DETAILS)	/WRS-BOULAR KHAL WRS/11-1/1
SECTION LIMIT DETAILS	/WRS-BOULAR KHAL WRS/12-1/1
PROTECTIVE WORKS	/WRS-BOULAR KHAL WRS/13-1/1
CONCRETE OUTLINE DETAILS	/WRS-BOULAR KHAL WRS/14-1/1
REINFORCEMENT DETAILS	/WRS-BOULAR KHAL WRS/15- 1/3 ~ 3/3
DETAILS (INCLUDE ALL MISCELLANEOUS)	/WRS-BOULAR KHAL WRS/16-1/1
BAR BENDING SHAPES	/WRS-BOULAR KHAL WRS/17-1/1
BAR BENDING SCHEDULE	/WRS-BOULAR KHAL WRS/18-1/4~ 4/4
VERTICAL GATE DETAILS	/WRS-BOULAR KHAL WRS/19-1/4 ~ 4/4

Exhibit G6-H6

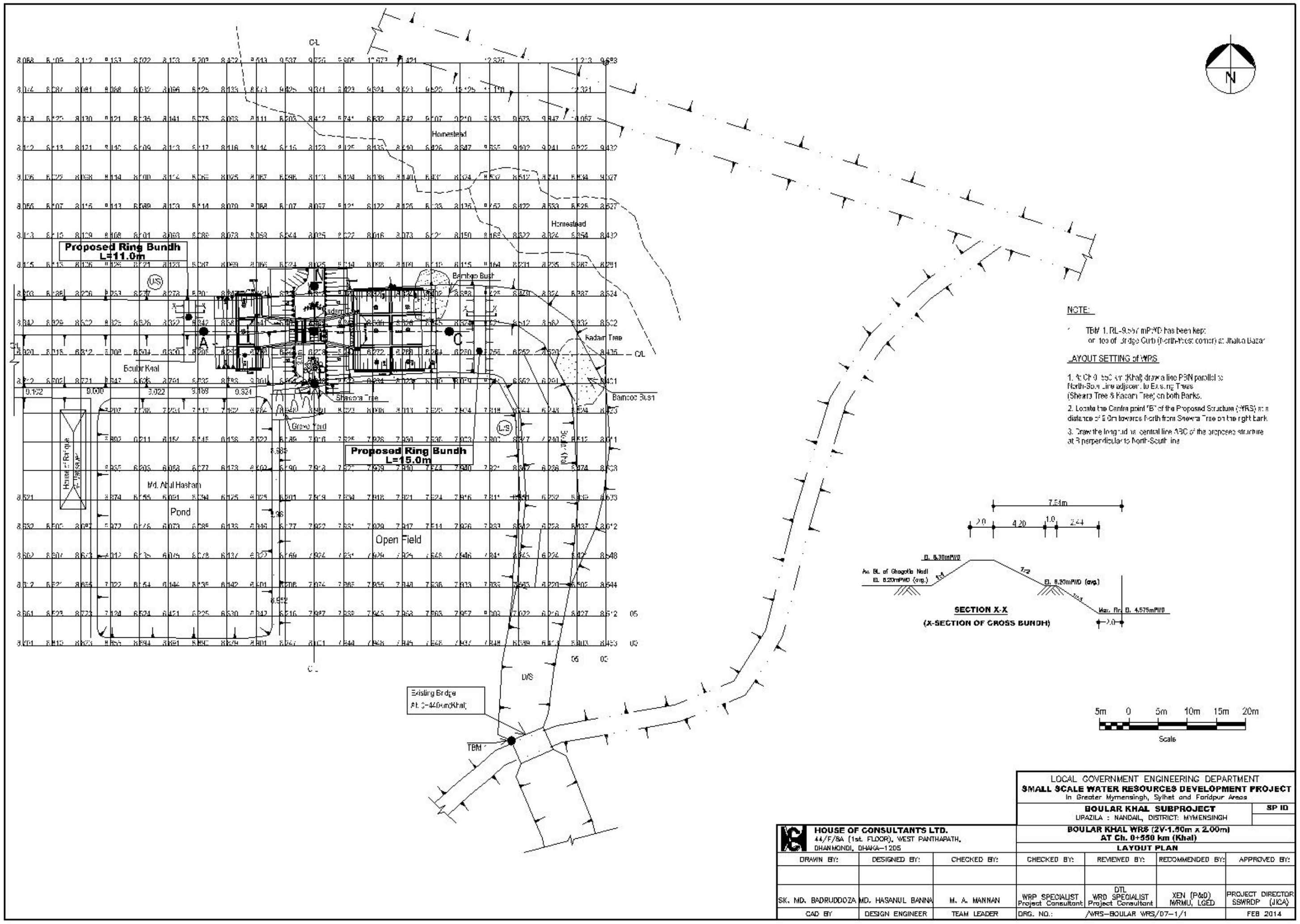


Exhibit G6-H6

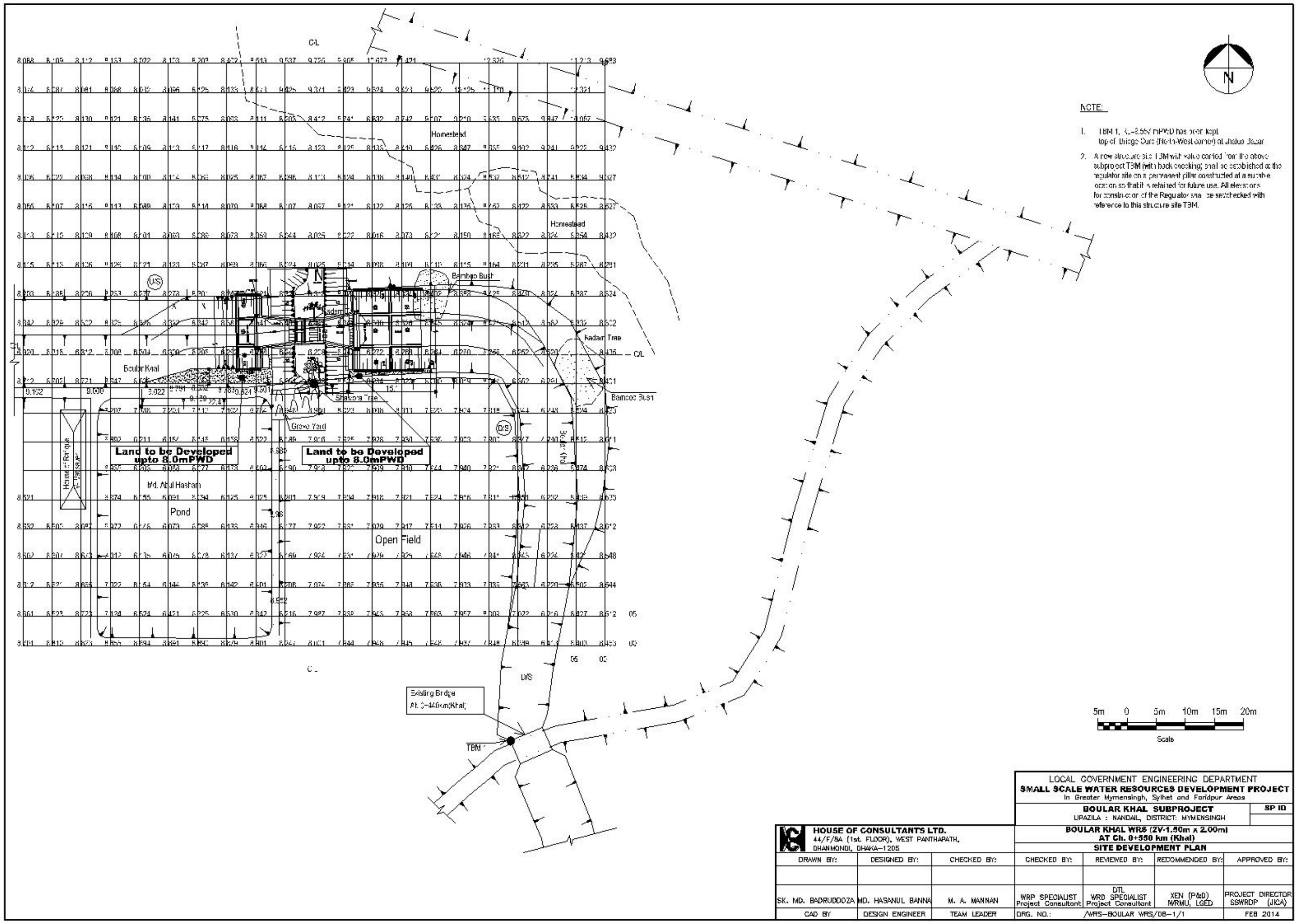
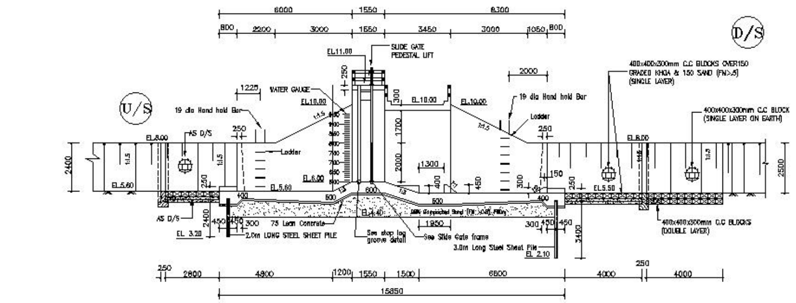
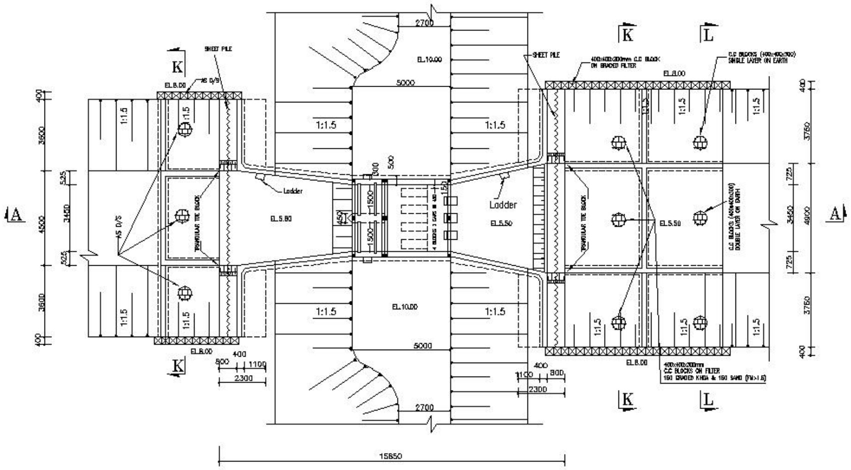


Exhibit G6-H6



SECTION A–A



PLAN

SPECIFICATION & NOTES ON MATERIAL & WORK

1. R.C.C WORKS:	All R.C.C WORKS	R.C.C PILES	LEAN CONCRETE
A. Concrete : i) Strength:	28–days standard cylinder crushing strength shall be 17 N/mm²	28–days standard cylinder crushing strength shall be 20.7 N/mm²	—
ii) Proportion by volume	1:2:4	1:1.5:3	1:3:6
iii) Cement	Portland Type–1	Portland Type–1	Portland Type–1
iv) Coarse aggregate	20mm down graded crushed stone chips (Well graded between 20mm & 8mm size.) (LAA value not more than 40)	20mm down graded crushed stone chips (Well graded between 20mm & 8mm size.)	20mm down graded brick chips (Well graded between 20mm & 8mm size.) (LAA value not more than 40)
v) Sand	FM 1.80	FM 1.80	FM 1.00
vi) Slump: (at work)	60–75 mm	60–75 mm (Precast) 100–125mm (cast-in situ)	60–75 mm
B. Reinforcement	40 grade deformed M.S. bar	40 grade deformed M.S. bar	—
	Minimum yield strength 275 N/mm²	Same as in all R.C.C Works	—
	No hook should be used for M.S deformed bars.		

2. Clear concrete cover over reinforcement bars shall be :
Earth faces = 75mm
Water faces = 50mm
All other faces = 25mm
R.C.C Piles = 40mm

3. C.C bolcks : C.C blocks with cement, sand (FM> 1.50) and shingles (40 mm down graded) with mix proportion 1 : 3 : 6

4. Back filling : Back filling outside abutments, wing walls and return walls up to FGL shall be done simultaneously on both sides with local sandy soil and should be free from vegetable roots and other organic materials, as soon as wall lifts are constructed.

5. Foundation Treatment : Foundation treatment to be done as per design & drawing based on subsoil investigation results.

6. Strength : During pouring samples shall be collected by the contractor in presence of Engineer–in–charge in standard cylinder, one for each wing wall, abutment, return wall, top slab, apron and barrel foundation for testing 7day strengths for quality control.

7. Protective work : Earthfill in side slopes shall be compacted in horizontal layers to satisfaction of the Engineer in charge before placing filter material and block.

8. Filter Materials : i) Brick Chips : 20mm to 40mm Size (LAA Value < 40)
ii) Sand : Coarse Sand (FM=1.5)

9. Elevations : All elevations are in meter (PWD).

10. Dimensions : All dimensions are in millimeters.

11. Embeded Parts of gates : M.S embedded parts such as angles, channels for vertical gates and from & wall brakets for flap gates welded to anchor bars shall be installed in proper alignment during casting of concrete as shown in working drawing.

12. Formwork : Formwork for Concrete for making fully leak proof shall be faced with plain 28/26 gauge steel sheet fitted over 38mm thick wooden plank panels suitably braced or steel framing faced with minimum 12/14 BWG mild steel sheet
Formwork for C.C blocks shall be fabricated from m.s steel of sufficient thickness to prevent any distortion

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

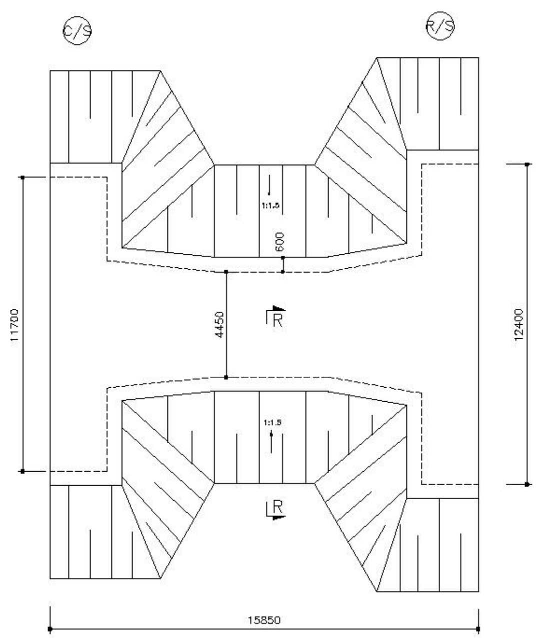
BOULAR KHAL SUBPROJECT — SP ID
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH

HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205

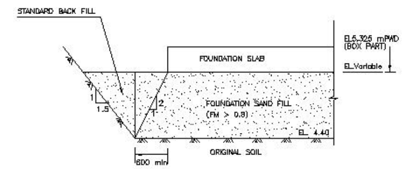
BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
GENERAL PLAN AND LONG SECTION

DRAWN BY:	DESIGNED BY:	CHECKED BY:	CHECKED BY:	REVIEWED BY:	RECOMMENDED BY:	APPROVED BY:
SK. MD. BADRUDDOZA	MD. HASANUL BANNA	M. A. MANNAN	WRP SPECIALIST Project Consultant	DTL WRD SPECIALIST Project Consultant	XEN (P&D) IWRMU, LGED	PROJECT DIRECTOR SSWRDP (JICA)
CAD BY	DESIGN ENGINEER	TEAM LEADER	DRG. NO.:	/WRS–BOULAR WRS/10–1/1		FEB 2014

Exhibit G6-H6



FOUNDATION TREATMENT PLAN

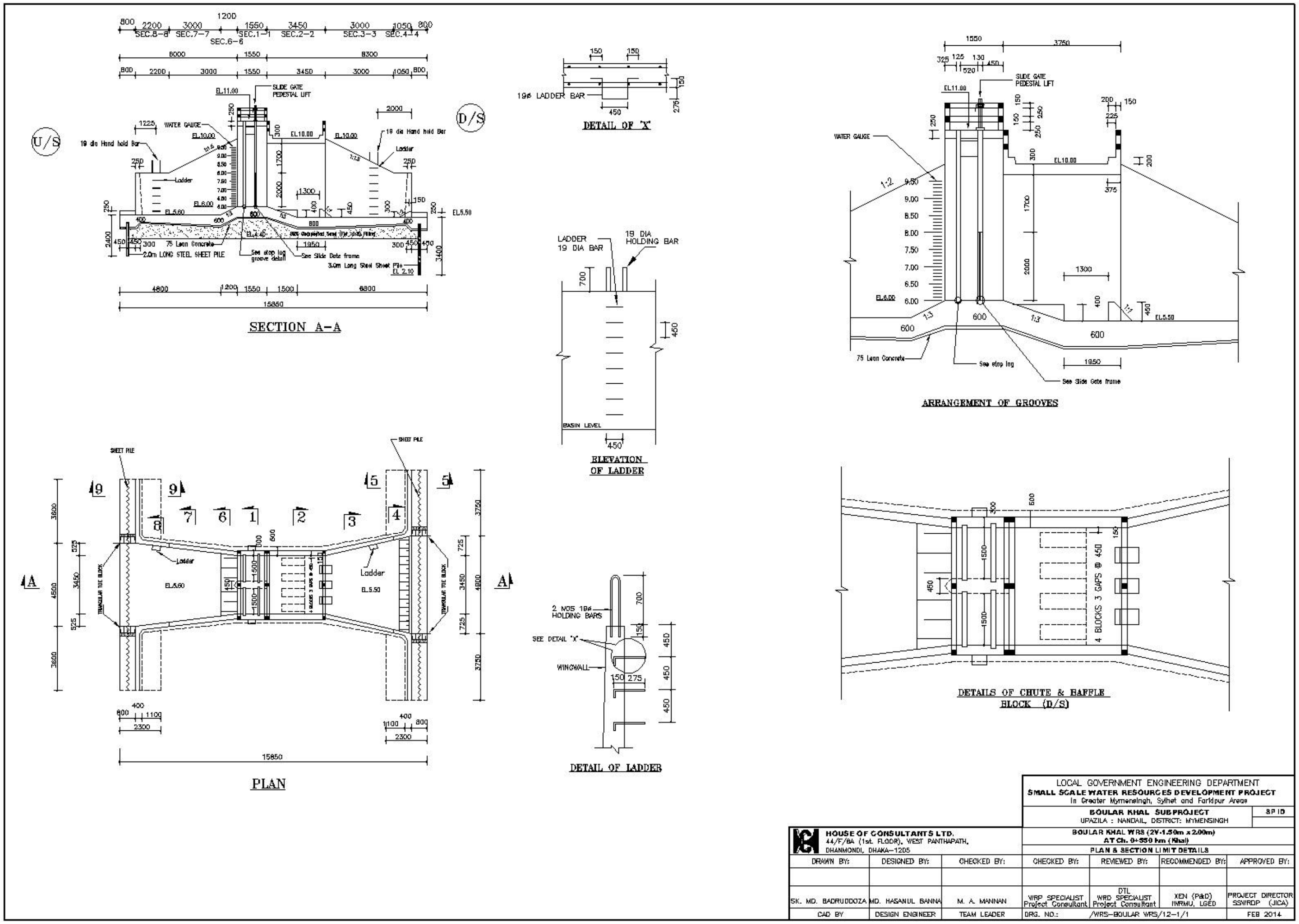


SECTION R-R

TYPICAL SECTION FOR FOUNDATION SAND FILL SECTION

			LOCAL GOVERNMENT ENGINEERING DEPARTMENT **SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT** In Greater Mymensingh, Sylhet and Faridpur Areas			
			BOULAR KHAL SUBPROJECT UPAZILA : NANDAIL, DISTRICT: MYMENSINGH			**SP ID**
HOUSE OF CONSULTANTS LTD. 44/F/BA (1st. FLOOR), WEST PANTHAPATH, DHANMONDI, DHAKA-1205			**BOULAR KHAL WRS (2V-1.50m x 2.00m)** **AT Ch. 0+550 km (Khal)** **FOUNDATION TREATMENT DETAILS**			
DRAWN BY:	DESIGNED BY:	CHECKED BY:	CHECKED BY:	REVIEWED BY:	RECOMMENDED BY:	APPROVED BY:
SK. MD. BADRUDDOZA	MD. RAJEDUL ISLAM	M. A. MANNAN	WRP SPECIALIST Project Consultant	DTL WRD SPECIALIST Project Consultant	XEN (P&D) IWRMU, LGED	PROJECT DIRECTOR SSWRDP (JICA)
CAD BY	DESIGN ENGINEER	TEAM LEADER	DRG. NO.:	/WRS-BOULAR WRS/11-1/1		FEB 2014

Exhibit G6-H6



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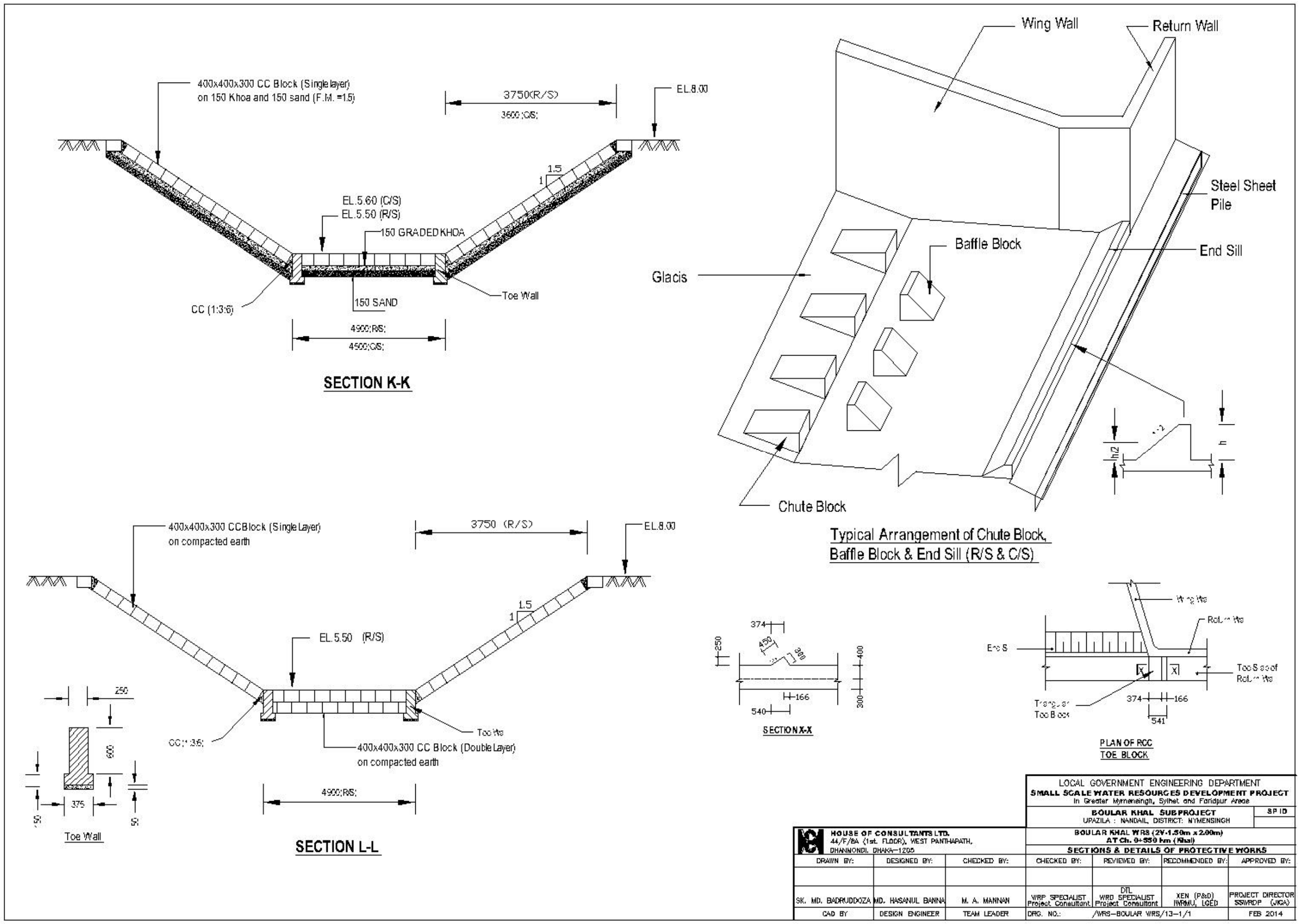
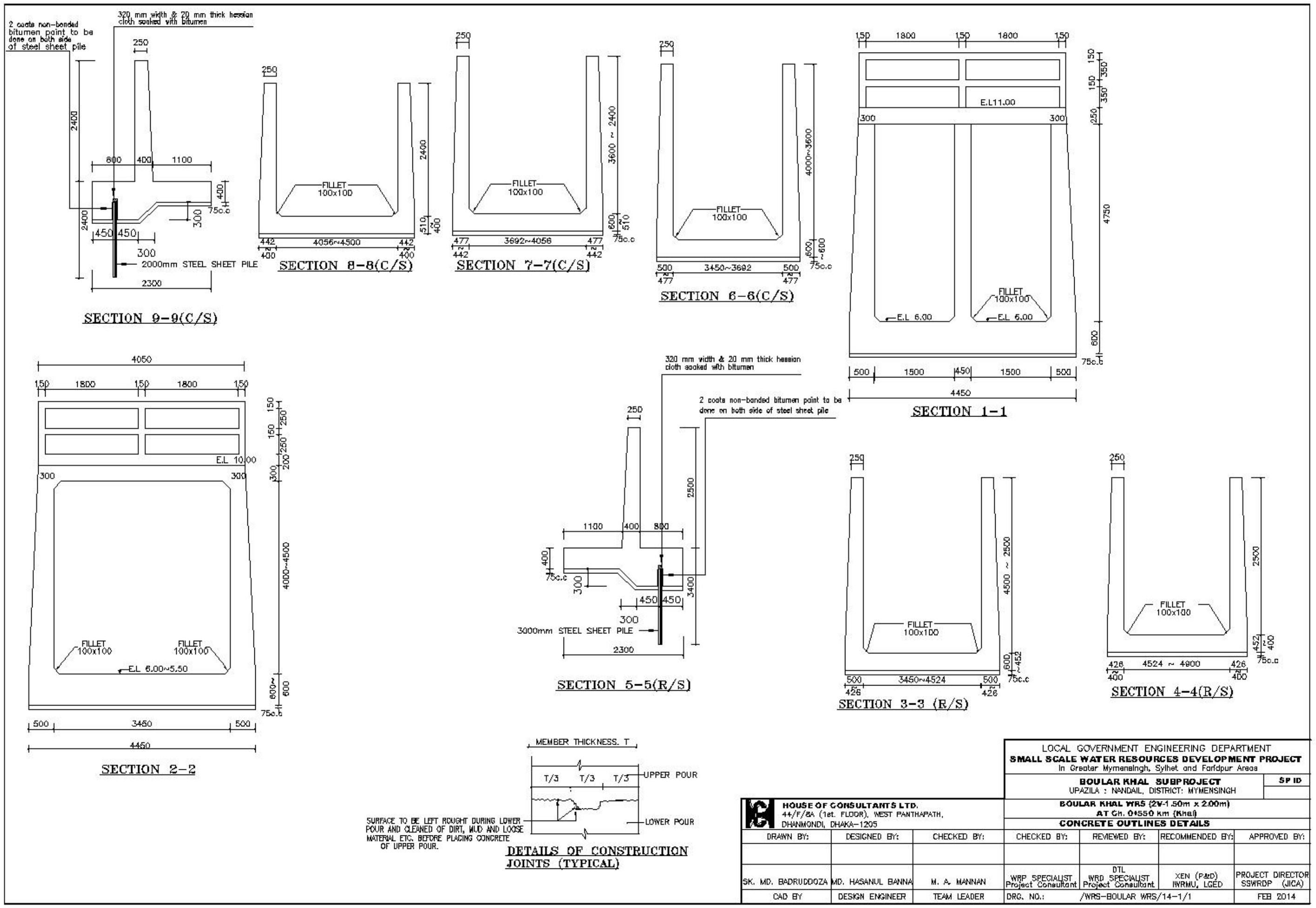


Exhibit G6-H6



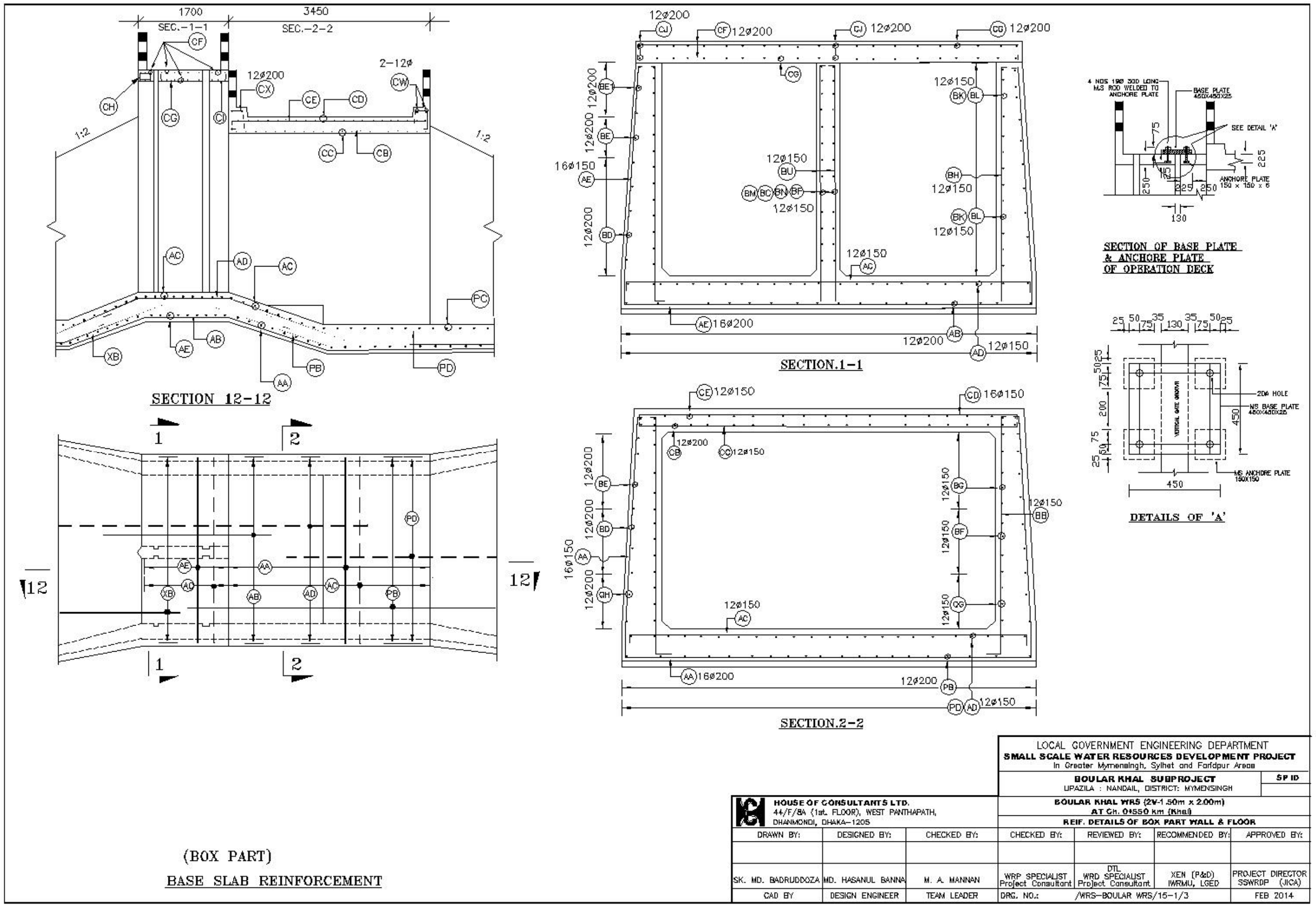
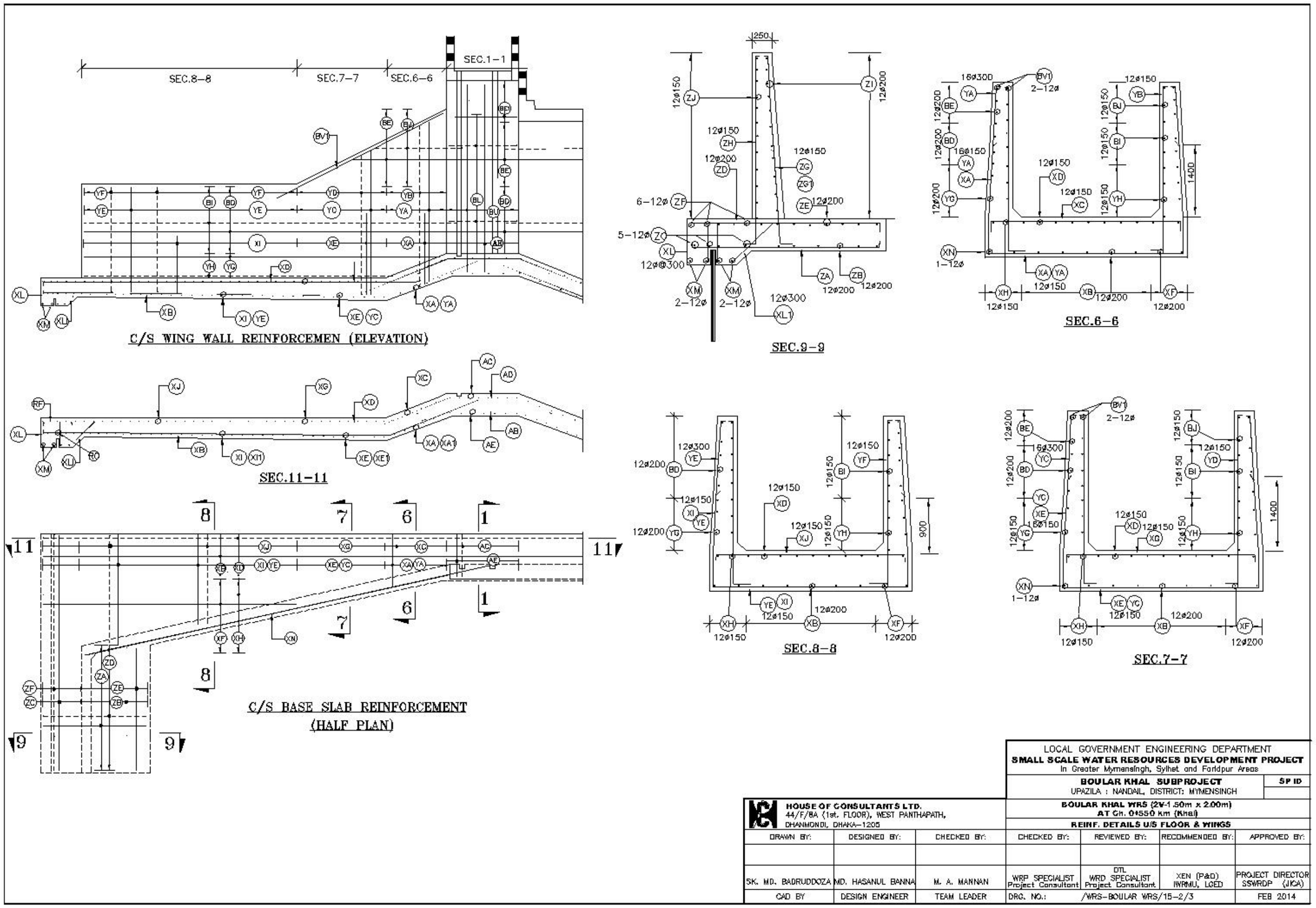
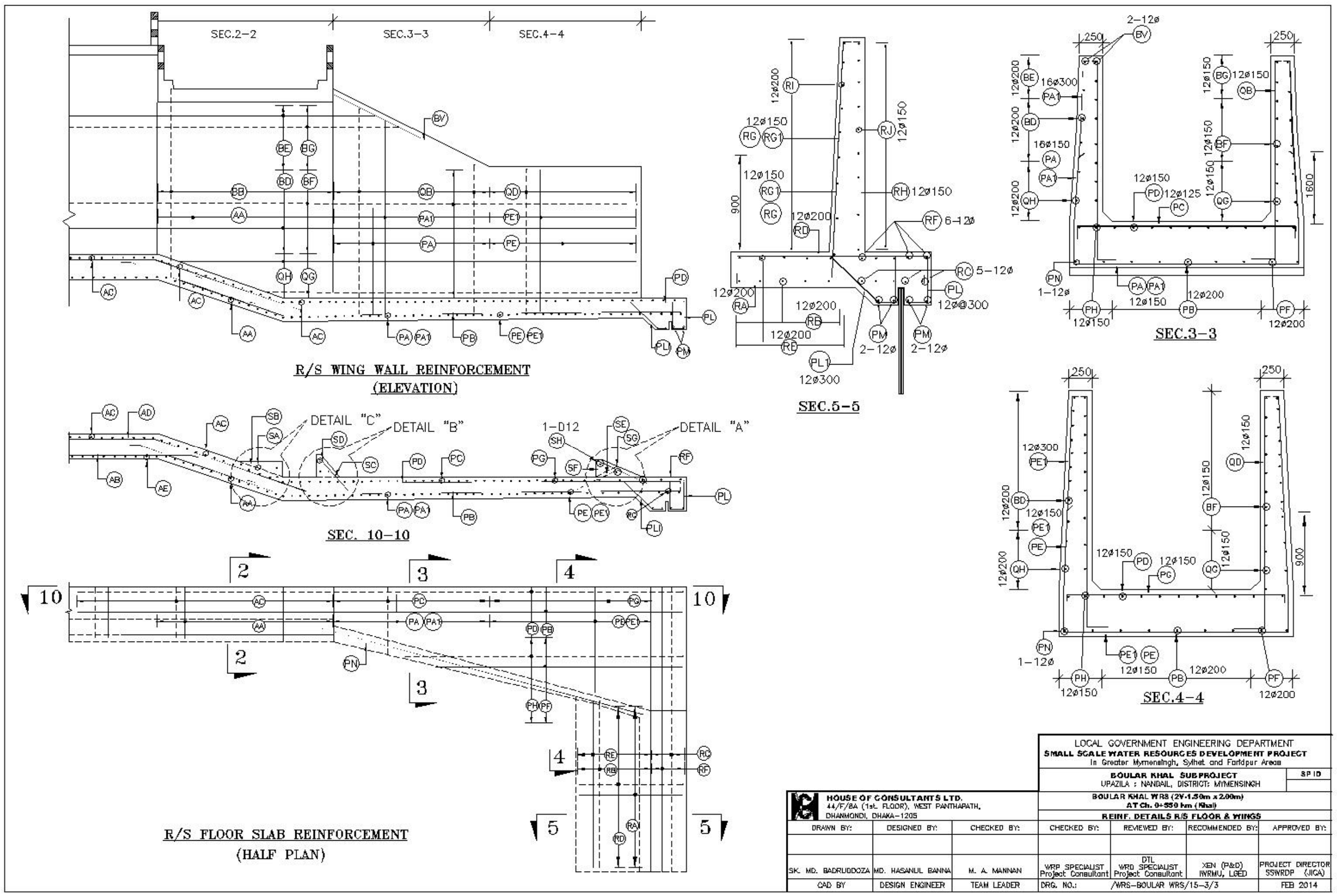
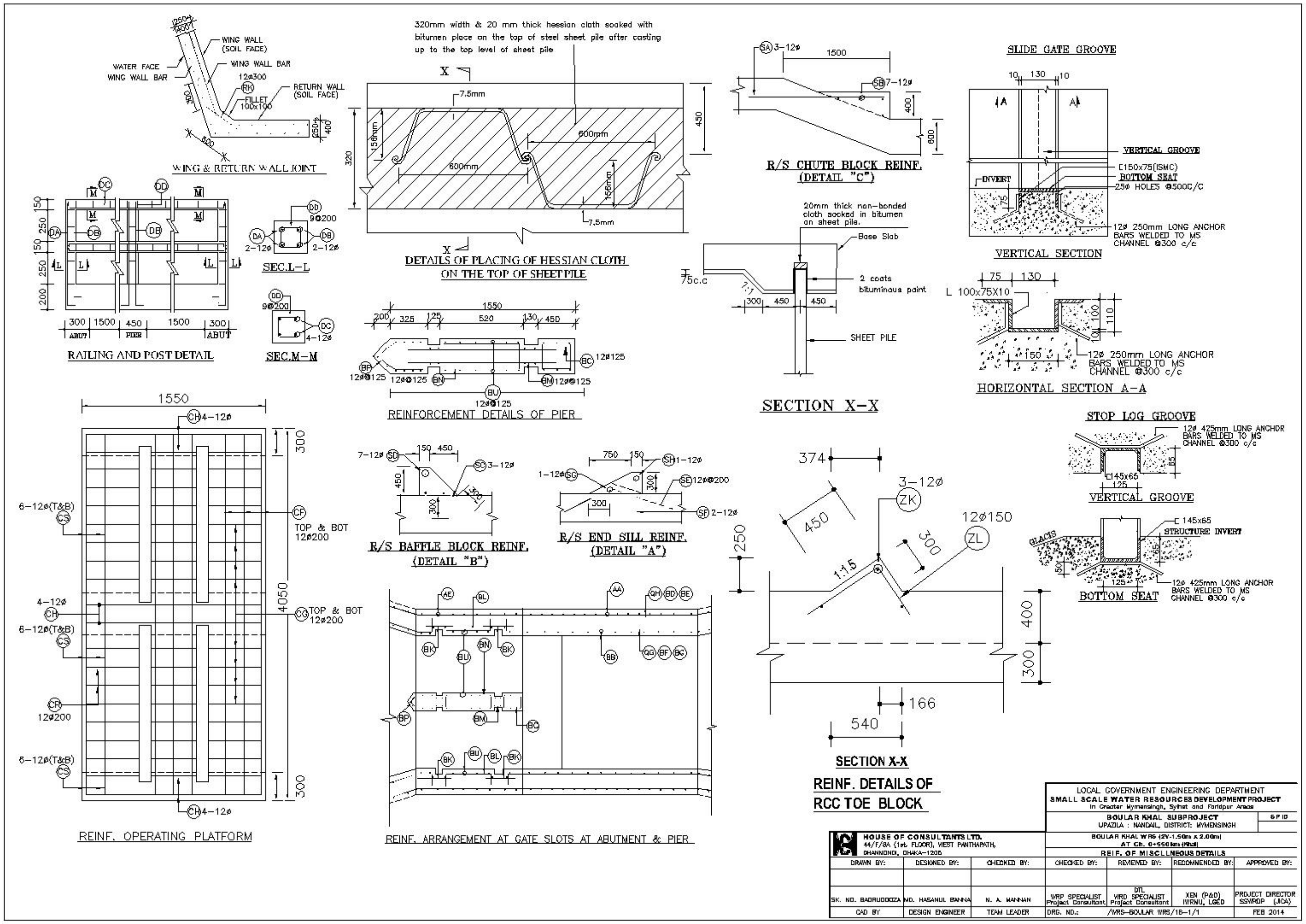
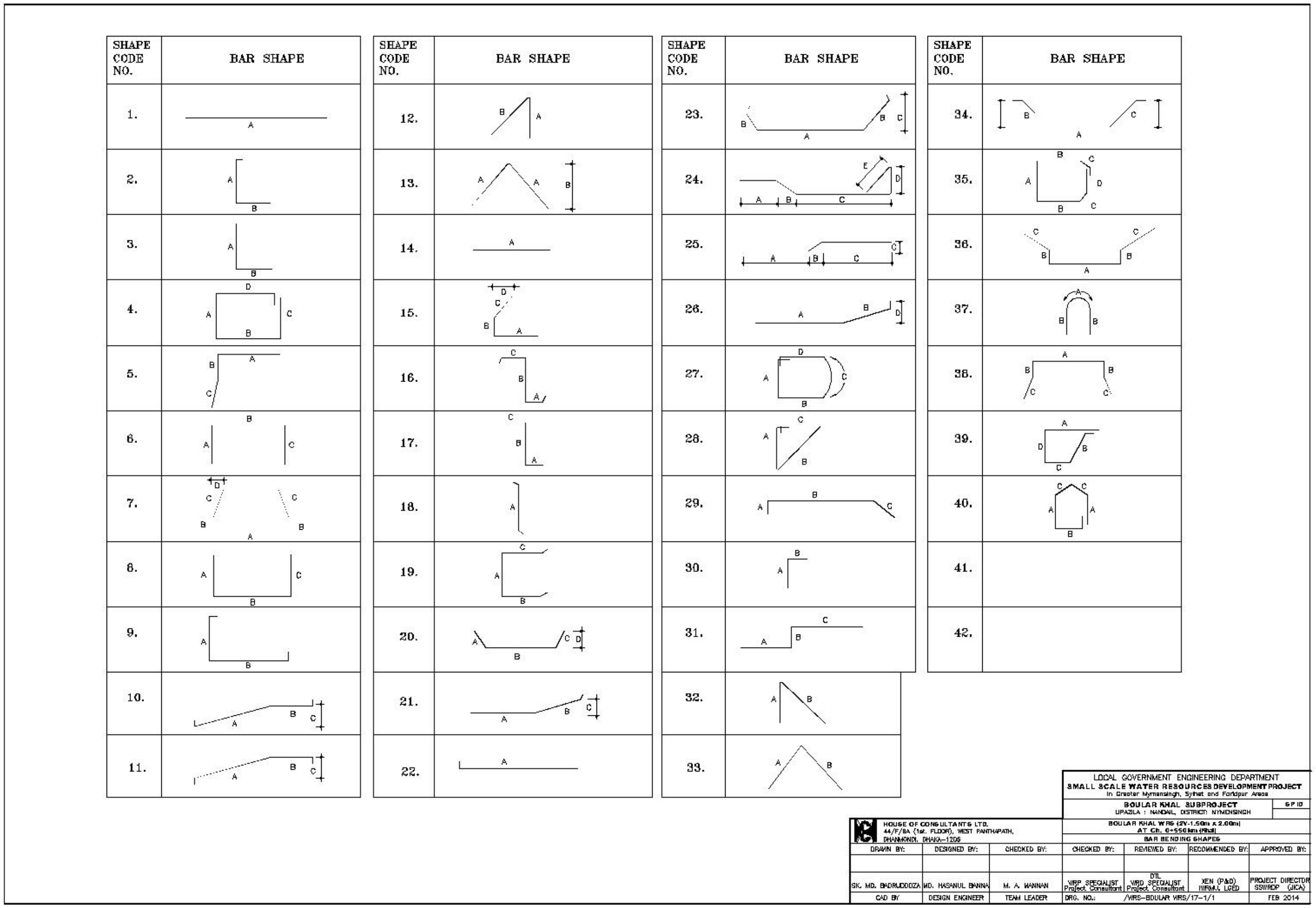

SECTION 12-12
SECTION.1-1
SECTION.2-2
SECTION OF BASE PLATE & ANCHORE PLATE OF OPERATION DECK
DETAILS OF 'A'
(BOX PART)
BASE SLAB REINFORCEMENT
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH
SP ID
HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205
BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
REIF. DETAILS OF BOX PART WALL & FLOOR
DRAWN BY:
DESIGNED BY:
CHECKED BY:
CHECKED BY:
REVIEWED BY:
RECOMMENDED BY:
APPROVED BY:
SK. MD. BADRUDDOZA
MD. HASANUL BANNA
M. A. MANNAN
WRP SPECIALIST Project Consultant
DTL WRD SPECIALIST Project Consultant
XEN (P&D) IWRMU, LGED
PROJECT DIRECTOR SSWRDP (JICA)
CAD BY
DESIGN ENGINEER
TEAM LEADER
DRG. NO.:
/WRS-BOULAR WRS/15-1/3
FEB 2014

Exhibit G6-H6




R/S WING WALL REINFORCEMENT
(ELEVATION)
SEC.5–5
SEC.3–3
SEC. 10–10
SEC.4–4
R/S FLOOR SLAB REINFORCEMENT
(HALF PLAN)
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH
REINF. DETAILS R/S FLOOR & WINGS
HOUSE OF CONSULTANTS LTD.
DHANMONDI, DHAKA–1205
DRAWN BY:
DESIGNED BY:
CHECKED BY:
REVIEWED BY:
RECOMMENDED BY:
APPROVED BY:
SK. MD. BADRUDDOZA
MD. HASANUL BANNA
M. A. MANNAN
CAD BY
DESIGN ENGINEER
TEAM LEADER
FEB 2014


WING & RETURN WALL JOINT
RAILING AND POST DETAIL
SEC.L-L
SEC.M-M
DETAILS OF PLACING OF HESSIAN CLOTH ON THE TOP OF SHEET PILE
320mm width & 20 mm thick hessian cloth soaked with bitumen place on the top of steel sheet pile after casting up to the top level of sheet pile
REINFORCEMENT DETAILS OF PIER
R/S CHUTE BLOCK REINF. (DETAIL "C")
SECTION X-X
20mm thick non-bonded cloth soaked in bitumen on sheet pile.
Base Slab
2 coats bituminous paint
SHEET PILE
SLIDE GATE GROOVE
VERTICAL SECTION
HORIZONTAL SECTION A-A
STOP LOG GROOVE
VERTICAL GROOVE
BOTTOM SEAT
REINF. OPERATING PLATFORM
R/S BAFFLE BLOCK REINF. (DETAIL "B")
R/S END SILL REINF. (DETAIL "A")
REINF. ARRANGEMENT AT GATE SLOTS AT ABUTMENT & PIER
SECTION X-X
REINF. DETAILS OF RCC TOE BLOCK
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH
REIF. OF MISCELLNEOUS DETAILS
HOUSE OF CONSULTANTS LTD.
DHANMONDI, DHAKA-1205
DRAWN BY:
DESIGNED BY:
CHECKED BY:
REVIEWED BY:
RECOMMENDED BY:
APPROVED BY:
CAD BY
DESIGN ENGINEER
TEAM LEADER
N. A. MANNAN
FEB 2014


SHAPE CODE NO.
BAR SHAPE
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11.
12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22.
23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33.
34. 35. 36. 37. 38. 39. 40. 41. 42.
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: NYMENSINGH
SP ID
HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205
BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
BAR BENDING SHAPES
DRAWN BY:
DESIGNED BY:
CHECKED BY:
CHECKED BY:
REVIEWED BY:
RECOMMENDED BY:
APPROVED BY:
SK. MD. BADRUDDOZA
MD. HASANUL BANNA
M. A. MANNAN
WRP SPECIALIST Project Consultant
DTL WRD SPECIALIST Project Consultant
XEN (P&D) IWRMU, LGED
PROJECT DIRECTOR SSWRDP (JICA)
CAD BY
DESIGN ENGINEER
TEAM LEADER
DRG. NO.: /WRS-BOULAR WRS/17-1/1
FEB 2014

BAR BENDING SCHEDULE

MEMBER	BAR MARKS	BAR DIA (mm)	SHAPE CODE	SPACING (mm)	DIMENSIONS (mm) A	B	C	D	E	CUT LENGTH (mm)	BAR PER MEMBER	NOS. OF MEMBER	TOTAL LENGTH (m)	UNIT WT. Kg/m	TOTAL WT Kg
Box Part:	AA	16	7	150	4300	525	3950 ~ 4450			13550 ~ 14550	11	1	154.55	1.58	244.78
	AA	16	7	150	4300	525	4450			14550	9	1	130.95	1.58	207.40
	AB	12	24	200	1550	1581	1250			4681	22	1	102.98	0.89	91.75
	AC	12	6	150	475	4300	475			5550	30	1	166.50	0.89	148.33
	AD	12	42	150	1265	1581	1250			4396	30	1	131.88	0.89	117.49
	AE	16	8	200	4300	475	4750			15050	9	1	135.45	1.58	214.53
	BB	12	3	150	3950 ~ 4450	525				4625 ~ 5125	11	2	107.25	0.89	95.55
		12	3	150	4450	525				5125	9	2	92.25	0.89	82.18
	QH	12	1	200	6800 ~ 6300					6960 ~ 6460	4	2	49.60	0.89	44.19
	BD	12	1	200	13460					13760	10	2	275.00	0.89	244.99
	BE	12	1	200	4300 ~ 10300					7450	11	2	163.90	0.89	146.02
	GO	12	1	160	6800 ~ 6300					6800 ~ 6300	4	2	48.40	0.89	43.12
	BF	12	1	160	6800					6950	14	2	194.60	0.89	173.37
	BG	12	1	150	5750					5900	14	2	165.20	0.89	147.17
	BL	12	6	160	260	400	260			1060	26	2	64.40	0.89	48.64
	BK	12	1	160	730					730	26	4	75.92	0.89	67.64
	BU	12	3	150	300	5225				5525	12	2	132.60	0.89	118.13
Pier	BI	12	2	160	300	6226				6626	6	1	33.16	0.89	29.63
	BG	12	4	160	326	350	326	350		1652	34	1	56.17	0.89	50.04
	BM	12	1	160	1379					1379	68	1	93.50	0.89	83.30
	BN	12	4	160	324	420	326	420		1792	34	1	60.93	0.89	54.28
	BH		2	160	300	5225				5525	6	1	33.15	0.00	0.00
	BY		2		300	5225				5525	8	1	44.20	0.00	0.00
	BJ	12	2	160	300	6226				6626	10	1	66.26	0.89	58.97
	BP	12	39	160	225	350	230			1560	34	1	53.04	0.89	47.25
	BO	12	6	160	300	3200	300			3950	34	6	805.80	0.89	717.88
		12	2	160	300	3200 ~ 4519				3500 ~ 4819	8	6	168.00	0.89	149.67
	BC1	12	8	160	300	800	300			2350	32	4	300.80	0.89	267.98
			8	160	300	800 ~ -700	300			1550 ~ 50	8	4	49.60	0.00	0.00
Deck Slab	CB	12	1	200	3950					4250	14	1	59.50	0.89	53.01
	CC	12	6	160	350	2650	350			3650	26	1	94.90	0.89	84.55
	CD	16	1	150	3950					4250	18	1	76.50	1.58	121.16
	CE	12	1	150	2650					2950	26	1	76.70	0.89	68.33
Opd Slab	CF	12	1	200	3900					4200	8	1	33.60	0.89	29.93
	CG	12	1	200	420					720	36	1	25.92	0.89	23.09
	CQ	12	4	200	400	150	400	150		1400	51	1	71.40	0.89	63.61
	CR	12	4	200	275	150	275	150		1150	51	1	58.65	0.89	52.25
	CS	12	1	150	3950					3950	10	1	39.50	0.89	35.19
	CT	12	1		3550					3950	6	1	23.70	0.89	21.11
	CU	12	1		1550					1550	4	3	18.60	0.89	16.57
Gate Beam	TB	0	1		3950					4250	9	1	38.25	0.00	0.00
	TR	0	4	160	350	-100	350	-100		800	0	1	0.00	0.00	0.00
Curb	CW	12	1		3900					4200	2	2	16.80	0.89	14.97
	CX	12	15	200	400	250	403			1353	20	2	54.12	0.89	48.21
Breast/W	CL	0	1	150	2900					3200	10	0	0.00	0.00	0.00
	CL1	0	1	160	2460					2760	10	0	0.00	0.00	0.00
	CM	0	8	150	200	500	200			1300	10	0	0.00	0.00	0.00
	CS	0	1		3950					3950	6	1	23.70	0.00	0.00
	CP	0	1	160	3900					4200	20	2	168.00	0.00	0.00
	CR	0	4	200	350	200	350	200		1400	8	0	0.00	0.00	0.00
Railing & Post															
Deck Post	DA	12	2		1025	300				1475	2	6	17.70	0.89	15.77
	DB	12	2		1025	300				1475	2	6	17.70	0.89	15.77
	DD	9	4	200	100	100	100	100		700	4	6	16.80	0.50	8.42
Deck Rail	DC	12	1		3550					3850	4	4	61.60	0.89	54.88
	DD	9	4	200	100	100	100	100		700	16	4	44.80	0.50	22.46
OpPostL	DA	12	2		1175	300				1625	2	6	19.50	0.89	17.37
	DB	12	2		1175	300				1625	2	6	19.50	0.89	17.37
	DD	9	4	200	100	100	100	100		700	4	6	16.80	0.50	8.42

Notes:
1. Deformed bars will be used. Additional length of 150mm has been included in cut length for nominal bend (90° or less) at each end.
2. For variable bar lengths, length of bars should be calculated from the range & numbers of bars.
3. The Contractors shall check the bar bending schedule with the drawings before cutting the bars.

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

SP ID

BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH
BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
BAR BENDING SCHEDULE

HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205

DRAWN BY:	DESIGNED BY:	CHECKED BY:	CHECKED BY:	REVIEWED BY:	RECOMMENDED BY:	APPROVED BY:
SK. MD. BADRUDDOZA	MD. HASANUL BANNA	M. A. MANNAN	WRP SPECIALIST Project Consultant	DTL WRD SPECIALIST Project Consultant	XEN (P&D) IWRMU, LGED	Project Director SSWRDP (JICA)
CAD BY	DESIGN ENGINEER	TEAM LEADER	DRG. NO.:	/WRS-BOULAR WRS/16-1/4		FEB 2014

BAR BENDING SCHEDULE

MEMBER	BAR MARKS	BAR DIA (mm)	SHAPE CODE	SPACING (mm)	DIMENSIONS (mm) A		B		C		D	E
Railing & Post												
OpRail (L)	DC	12	1		3560							
	DD	9	4	200	100		100		100		100	
OpRail (S)	DC	12	4		1500							
	DD	9	4	200	100		100		100		100	
FGOpSlab												
Post	DB		2		1025		300					
	DA		2		1025		300					
	DD		4	200	100		100		100		100	
Rail	DC		1		-50							
	DC		1		-50							
	DD		4	200	100		100		100		100	
	DD		4	200	100		100		100		100	
River Side	PE		7	200	4400 ~	5252	525 ~	377	1600			
	QC	0	7	200	4400 ~	5252	525 ~	377	4460 ~	2460		
	PB	12	21	200	4800		504					
	PC	12	6	125	4400 ~	5252	300		300			
	PD	12	1	160	5100							
	PA	16	7	300	4400 ~	5252	525 ~	377	1600			
	PA1	16	7	300	4400 ~	5252	450 ~	377	4460 ~	2460		
	PF	12	1	200	500 ~	4800	0 ~	0				
	PG	12	6	160	300		4400		300			
	PH	12	1	150	500 ~	4800						
	PE	16	7	300	5252 ~	5550	377 ~	325	900			
	PE1	16	7	300	5252 ~	5550	377 ~	325	2460			
	PJ		6	125	5252 ~	5550	300		300			
	QD	12	3	160	4963 ~	2963	300					
	QB	12	3	160	4947 ~	2799	300					
	QF		3	150	2827 ~	2775	300					
	QG	12	1	150			3628					
	QH	12	1	200	3628							
	QI		1	150	1950 ~	4800						
	QJ		1	200	3628							
	PJ1		6	200			300		300			
	PN	12	1		5062.8							
	BV	12	1		500 ~	4105.6						
R/W(R/S)	PL1	12	15	300	575		300		813			
	PL	12	8	300	575		300		575			
	RC	12	1		12250							
	RA	12	6	200	300		2150		300			
	RB	12	1	200	4050							
	RD	12	6	200	300		2150		300			
	RE	12	1	200	4050							
	RF	12	1		12250							
	RG	0	3	150	1158		300					
	RG1	12	3	150	2775		300					

MEMBER	BAR MARKS	CUT LENGTH (mm)		BAR PER MEMBER	NOS. OF MEMBER	TOTAL LENGTH (m)	UNIT WT. Kg/m	TOTAL WT Kg
Railing & Post								
OpRail (L)	DC	3860		4	4	61.60	0.89	54.88
	DD	700		14	4	39.20	0.50	19.64
OpRail (S)	DC	1800		4	4	28.80	0.89	25.66
	DD	700		6	4	16.80	0.50	8.42
FGOpSlab								
Post	DB	1475		2	0	0.00	0.00	0.00
	DA	1475		2	0	0.00	0.00	0.00
	DD	700		3	0	0.00	0.00	0.00
Rail	DC	250		4	2	2.00	0.00	0.00
	DC	250		4	2	2.00	0.00	0.00
	DD	700		0	2	0.00	0.00	0.00
	DD	700		0	2	0.00	0.00	0.00
River Side	PE	8950 ~	9506	15	1	138.42	0.00	0.00
	QC	14650 ~	15206	16	1	238.85	0.00	0.00
	PB	5604		23	1	128.89	0.89	114.83
	PC	6300 ~	6162	24	1	137.42	0.89	122.43
	PD	5400		23	1	124.20	0.89	110.65
	PA	8950 ~	9506	10	1	92.28	1.58	146.15
	PA1	8800 ~	6306	11	1	83.08	1.58	131.59
	PF	800 ~	5100	6	2	35.40	0.89	31.54
	PG	6300		20	1	63.00	0.89	47.22
	PH	800 ~	5100	6	2	35.40	0.89	31.54
	PE	8106 ~	8300	4	1	32.81	1.58	51.97
	PE1	11206 ~	11400	5	1	56.52	1.58	89.51
	PJ	6152 ~	6460	8	1	50.41	0.00	0.00
	QD	5413 ~	3413	20	2	176.52	0.89	157.26
	QB	5397 ~	3249	21	2	181.57	0.89	161.76
	QF	3277 ~	3225	7	2	46.51	0.00	0.00
	QG	3928		3	2	23.57	0.89	21.00
	QH	3778		3	2	22.67	0.89	20.19
	QI	1950 ~	4800	13	2	50.70	0.00	0.00
	QJ	3628		10	2	72.56	0.00	0.00
	PJ1			6	2		0.00	0.00
	PN	5053		1	2	10.11	0.89	9.00
	BV	800 ~	4256	2	2	10.11	0.89	9.01
R/W(R/S)	PL1	1988		41	1	81.51	0.89	72.61
	PL	1750		41	1	71.75	0.89	63.92
	RC	12550		5	1	62.75	0.89	55.90
	RA	3050		19	2	115.90	0.89	103.25
	RB	4350		6	2	52.20	0.89	46.50
	RD	3050		19	2	115.90	0.89	103.25
	RE	4350		7	2	60.90	0.89	54.26
	RF	12550		6	1	75.30	0.89	67.08
	RG	1608		25	2	80.40	0.00	0.00
	RG1	3225		26	2	167.70	0.89	149.40

Notes: 1. Deformed bars will be used. Additional length of 150mm has been included in cut length for nominal bend (900 or less) at each end.
2. For variable bar lengths, length of bars should be calculated from the range & numbers of bars.
3. The Contractor shall check the bar bending schedule with the drawings before cutting the bars.

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

BOULAR KHAL SUBPROJECT | SP ID
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH
BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
BAR BENDING SCHEDULE

HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205

DRAWN BY:	DESIGNED BY:	CHECKED BY:	CHECKED BY:	REVIEWED BY:	RECOMMENDED BY:	APPROVED BY:
SK. MD. BADRUDDOZA	MD. HASANUL BANNA	M. A. MANNAN	WRP SPECIALIST Project Consultant	DTL WRO SPECIALIST Project Consultant	XEN (P&D) IWRMU, LGED	Project Director SSWRDP (JICA)
CAD BY	DESIGN ENGINEER	TEAM LEADER	DRG. NO.:	/WRS-BOULAR WRS/16-2/4		FEB 2014

BAR BENDING SCHEDULE

MEMBER	BAR MARKS	BAR DIA (mm)	SHAPE CODE	SPACING (mm)	DIMENSIONS (mm) A		B		C		D	E	CUT LENGTH (mm)		BAR PER MEMBER	NOS. OF MEMBER	TOTAL LENGTH (m)	UNIT WT. Kg/m	TOTAL WT Kg
R/W(R/S)	RH	12	3	160	2775		300						3225		26	2	167.70	0.89	149.40
	RI	12	3	200	3625		300						4075		13	2	52.98	0.89	47.19
	RJ	12	3	150	3625		300						4075		17	2	138.55	0.89	123.43
	PM	12	1		12250								12550		4	1	50.20	0.89	44.72
	RK	12	20	300	300		900		300				1500		8	2	24.00	0.89	21.38
Country Side	XA	16	7	300	4300 ~	4496	525 ~	525	1400				8450 ~	8646	4	1	34.19	1.58	54.15
	YA	16	7	300	4300 ~	4496	525 ~	525	3950 ~	3550			13550 ~	13748	5	1	68.24	1.58	108.08
	XB	12	21	200	4725		1660						6685		22	1	147.07	0.89	131.02
	XC	12	6	150	300		4300 ~	4496	300				5200 ~	5396	9	1	47.68	0.89	42.48
	XD	12	1	150	5225								5525		30	1	165.75	0.89	147.66
	XE	16	7	300	4496 ~	4790	525 ~	435	1400				8646 ~	8760	6	1	52.22	1.58	82.70
	YC	16	7	300	4496 ~	4790	525 ~	435	3550 ~	2350			12946 ~	10660	7	1	82.82	1.58	130.86
	XF	12	1	200	4725 ~	2150							5025 ~	2450	3	2	22.43	0.89	19.98
	XG	12	6	150	300		4496 ~	4790	300				5396 ~	5660	12	1	66.52	0.89	59.26
	XH	12	1	150	5025 ~	2150							5325 ~	2450	4	2	31.10	0.89	27.71
	XI	12	7	300	4790 ~	5150	435 ~	325	900				7760 ~	7900	7	1	54.81	0.89	48.83
	YE	12	7	300	4790 ~	5150	435 ~	325	2350				10660 ~	10800	8	1	85.84	0.89	76.47
	XJ	12	6	150	150		4790 ~	5150	150				5390 ~	5750	16	1	89.12	0.89	79.40
	YB	12	3	150	4447 ~	4079	300						4897 ~	4529	9	2	84.83	0.89	75.58
	YD	12	3	150	4047 ~	2757	300						4497 ~	3207	12	2	92.45	0.89	82.36
	YF	12	3	150	2761 ~	2651	300						3211 ~	3101	16	2	100.99	0.89	89.97
	YG	12	1	200	5626 ~	4500							5926 ~	4800	3	2	32.18	0.89	28.67
	YH	12	1	150	5626 ~	4500							5926 ~	4800	4	2	42.90	0.89	38.22
	BV	12	1		-401 ~	4105.6							-251 ~	4256	2	2	8.01	0.89	7.14
	BI	12	1	150	5700								6000		14	2	168.00	0.89	149.67
	BJ	12	1	150	500 ~	3500							800 ~	3800	14	2	64.40	0.89	57.37
	XN	12	1		6150								6150		1	2	12.30	0.89	10.96
R/W(C/S)	ZB	12	1	140	3900								4200		8	2	67.20	0.89	59.87
	XL	12	8	300	575		300		575				1750		39	1	68.25	0.89	60.80
	XL1	12	16	300	575		300		813				1988		39	1	77.53	0.89	69.07
	ZE	12	1	200	3900								4200		6	2	50.40	0.89	44.90
	ZF	12	1		11550								11850		6	1	71.10	0.89	63.34
	ZA	12	8	200	150		2150		150				2750		19	2	104.50	0.89	93.10
	ZD	12	1	200	150		2150		150				2750		19	2	104.50	0.89	93.10
	ZC	12	1		11550								11850		5	1	59.25	0.89	52.79
	PM	12	1		11550								11850		4	1	47.40	0.89	42.23
	ZG	0	3	160	1075		300						1525		24	2	73.20	0.00	0.00
	ZG1	12	3	160	2651		300						3101		25	2	155.05	0.89	138.13
	ZH	12	3	160	2651		300						3101		25	2	155.05	0.89	138.13
	ZI	12	3	200	3476		500						4126		13	2	107.25	0.89	95.55
	ZJ	12	3	150	3475		500						4275		17	2	145.35	0.89	129.49
	RK	12	20	300	300		900		300				1500		9	2	27.00	0.89	24.05
Chute (R/S)	SA	12	9		700		2100						3100		3	4	37.20	0.89	33.14
	SB	12	6		700		350		700				1750		7	4	49.00	0.89	43.65
Bafle (R/S)	SC	12	12		750		1061						2111		3	1	6.33	0.89	5.64
	SD	12	14		350								350		7	1	2.45	0.89	2.18
	SC1		12		750		1061						2111		2	0	0.00	0.00	0.00
Endsill (R/S)	SE	12	13		635								1670		2	0	0.00	0.89	0.00
	SF	12	12	200	575		1286						2161		25	1	54.025	0.89	48.13
	SH	12	14		5200								5500		1	1	5.50	0.89	4.90
	SG	12	1		5200								5500		4	1	22.00	0.89	19.60

Notes :
1. Deformed bars will be used. Additional length of 150mm has been included in cut length for nominal bend (900 or less) at each end.
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LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

BOULAR KHAL SUBPROJECT | SP ID
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH

HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205

BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
BAR BENDING SCHEDULE

DRAWN BY:	DESIGNED BY:	CHECKED BY:	CHECKED BY:	REVIEWED BY:	RECOMMENDED BY:	APPROVED BY:
SK. MD. BADRUDDOZA	MD. HASANUL BANNA	M. A. MANNAN	WRP SPECIALIST Project Consultant	DTL WRD SPECIALIST Project Consultant	XEN (P&D) IWRMU, LGED	Project Director SSWRDP (JICA)
CAD BY	DESIGN ENGINEER	TEAM LEADER	DRG. NO.:	/WRS-BOULAR WRS/16-3/4		FEB 2014

BAR BENDING SCHEDULE

MEMBER	BAR MARKS	BAR DIA (mm)	SHAPE CODE	SPACING (mm)	DIMENSIONS (mm) A		B	C	D	E	CUT LENGTH (mm)		BAR PER MEMBER	NOS. OF MEMBER	TOTAL LENGTH (m)	UNIT WT. Kg/m	TOTAL WT Kg
Chute (C/S)	SI	12	9		875		2625				3800		2	0	0.00	0.89	0.00
	SJ	12	6		875		300				1175		5	0	0.00	0.89	0.00
Bafle (C/S)	SK	12	13		635						1570		3	0	0.00	0.89	0.00
	SL	12	1		300						300		5	0	0.00	0.89	0.00
Endsill (C/S)	SP		1		5150						5450		1	1	5.45	0.00	0.00
	SN	12	14		550		100	850			1500		2	0	0.00	0.89	0.00
	SM	12	13	200	635						1570		2	0	0.00	0.89	0.00
	SQ	12	14		300						300		3	0	0.00	0.89	0.00
Gate	CK		1	150	850						850		0	2	0.00	0.00	0.00
operation	CI		1	150	-50 ~	-50					250 ~	250	6	1	1.50	0.00	0.00
slab	CJ		1	125	-50 ~	-50					250 ~	250	7	1	1.75	0.00	0.00
	Dowel		1		500						500		1	4	2.00	0.00	0.00
																	9753.76
Pile	P01	19	30		100		-255	250			85		4	0	0	2.23	0.00
	P02	16	1		3200						3200		4	0	0	1.58	0.00
	S01	10	4		-80		-80	-80	-80		-20		77	0	0	0.62	0.00
	S02	10	4		156		156	156	156		924		55	0	0	0.62	0.00
Cross Beam	CX		8		150		1900	150			2200		3	6	39.60	0.00	0.00
	CY		6		150		1900	150			2200		2	6	26.40	0.00	0.00
	CZ		4	150	224		174	224	174		946		9	6	51.08	0.00	0.00
Peripherial Beam	TA		8		150		3800	150			4100		2	2	16.40	0.00	0.00
	TB		6		150		3800	150			4100		2	2	16.40	0.00	0.00
	TC		1		7900						7900		3	2	47.40	0.00	0.00
	TD		4	150	224		224	224	224		1046		26	1	27.20	0.00	0.00
Tie Beam	TM		8		150		1900	150			2200		2	0	0.00	0.00	0.00
	TN		6		150		1900	150			2200		2	0	0.00	0.00	0.00
	TO		4	150	224		174	224	174		946		9	0	0.00	0.00	0.00
Column	OA		2		4300		300				4750		4	0	0.00	0.00	0.00
			2		4300		300				4750		4	0	0.00	0.00	0.00
	OB		4	230	226		226	226	226		1054		2	0	0.00	0.00	0.00
			4	230	226		226	226	226		1054		2	0	0.00	0.00	0.00
Bottom Tie Beam	BA		8		150		3800	150			4100		3	2	24.60	0.00	0.00
	BB		6		150		3800	150			4100		2	2	16.40	0.00	0.00
	BC		4	150	224		224	224	224		1046		26	1	27.20	0.00	0.00
Notes:	1. Deformed bars will be used. Additional length of 150mm has been included in cut length for normal bend (900 or less) at each end.																0.00
	2. For variable bar lengths, length of bars should be calculated from the range & numbers of bars.														TOTAL=		9754
	3. The Contractor shall check the bar bending schedule with the drawings before cutting the bars.																kg

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH

SP ID

HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205

BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
BAR BENDING SCHEDULE

DRAWN BY:	DESIGNED BY:	CHECKED BY:	CHECKED BY:	REVIEWED BY:	RECOMMENDED BY:	APPROVED BY:
SK. MD. BADRUDDOZA	MD. HASANUL BANNA	M. A. MANNAN	WRP SPECIALIST Project Consultant	DTL WRD SPECIALIST Project Consultant	XEN (P&D) IWRMU, LGED	Project Director SSWRDP (JICA)
CAD BY	DESIGN ENGINEER	TEAM LEADER	DRG. NO.:	/WRS-BOULAR WRS/18-4/4		FEB 2014

EXHIBIT G6-H7: STANDARD DRAWINGS OF VERTICAL GATE

Government of the People's Republic of Bangladesh
Local Government Engineering Department

Small Scale Water Resources Development Project

In Greater Mymensingh, Sylhet and Faridpu r Areas

RDEC Bhaban (Level-6), Agargaon, Shere-Bangla Nagar
Dhaka-1207

SP ID- BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH

DETAIL DRAWINGS FOR

BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)

(SIZE: 1670 mm x 2000 mm)

FEBRUARY 2014

Exhibit G6-H7

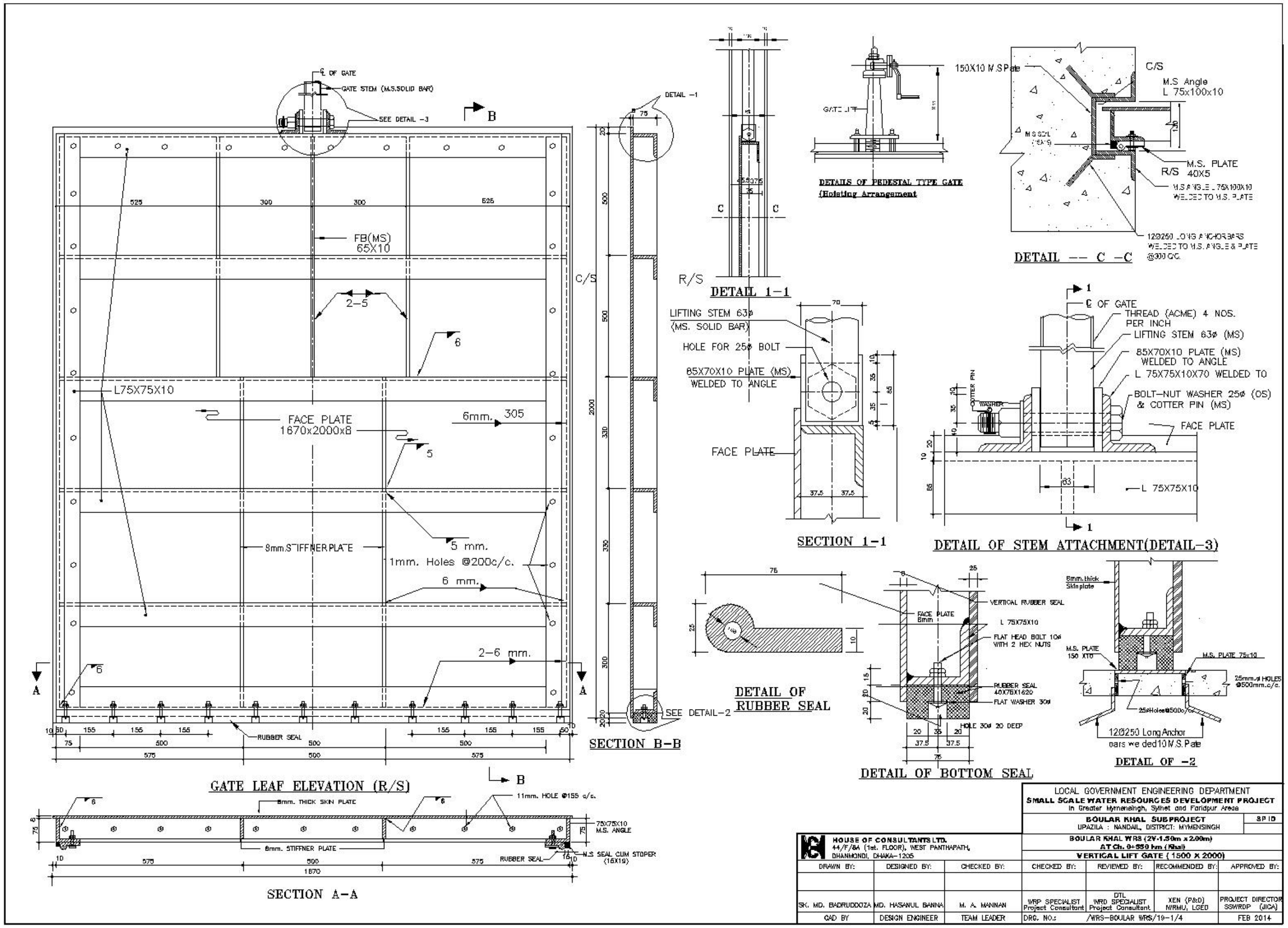
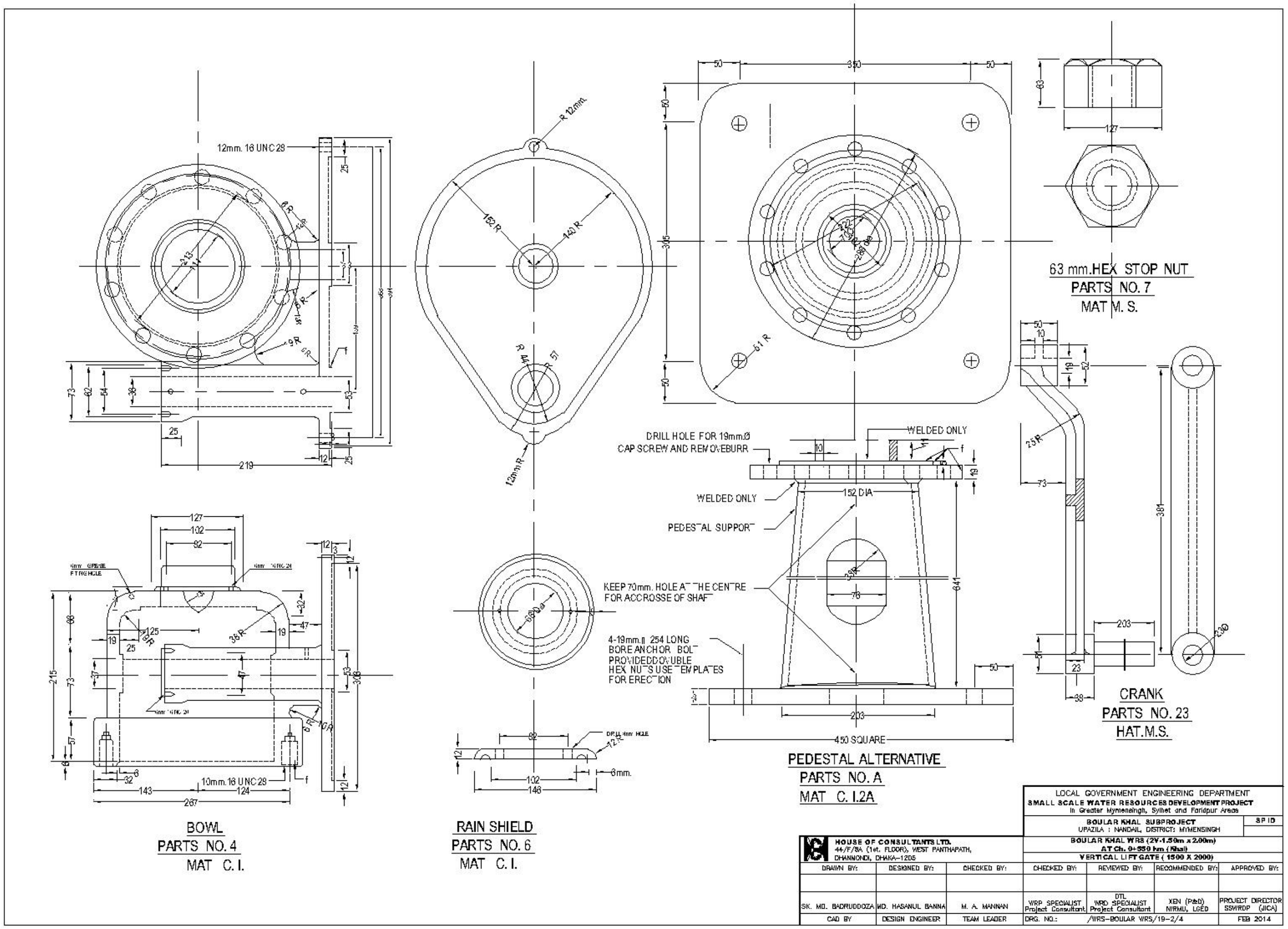
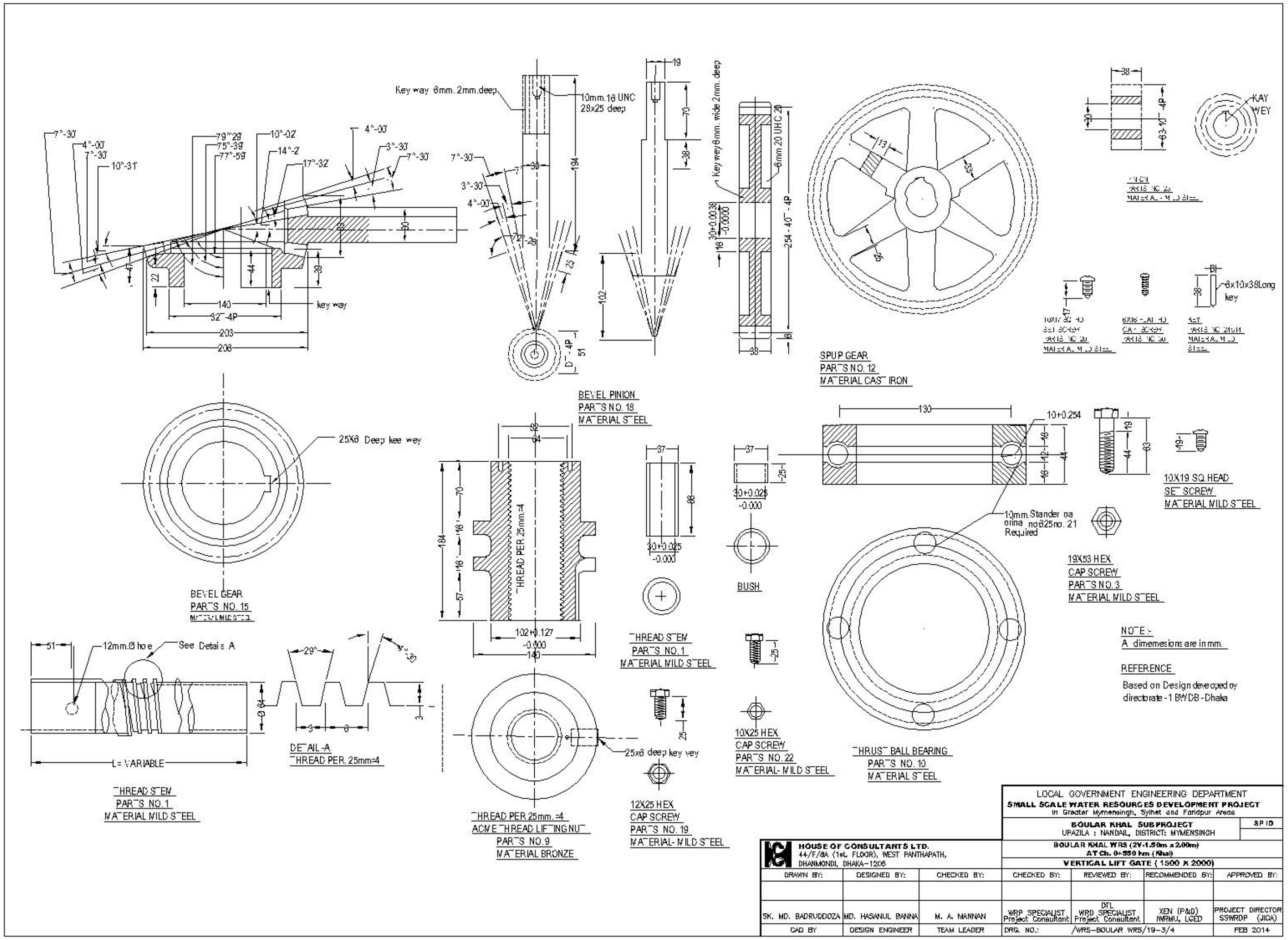
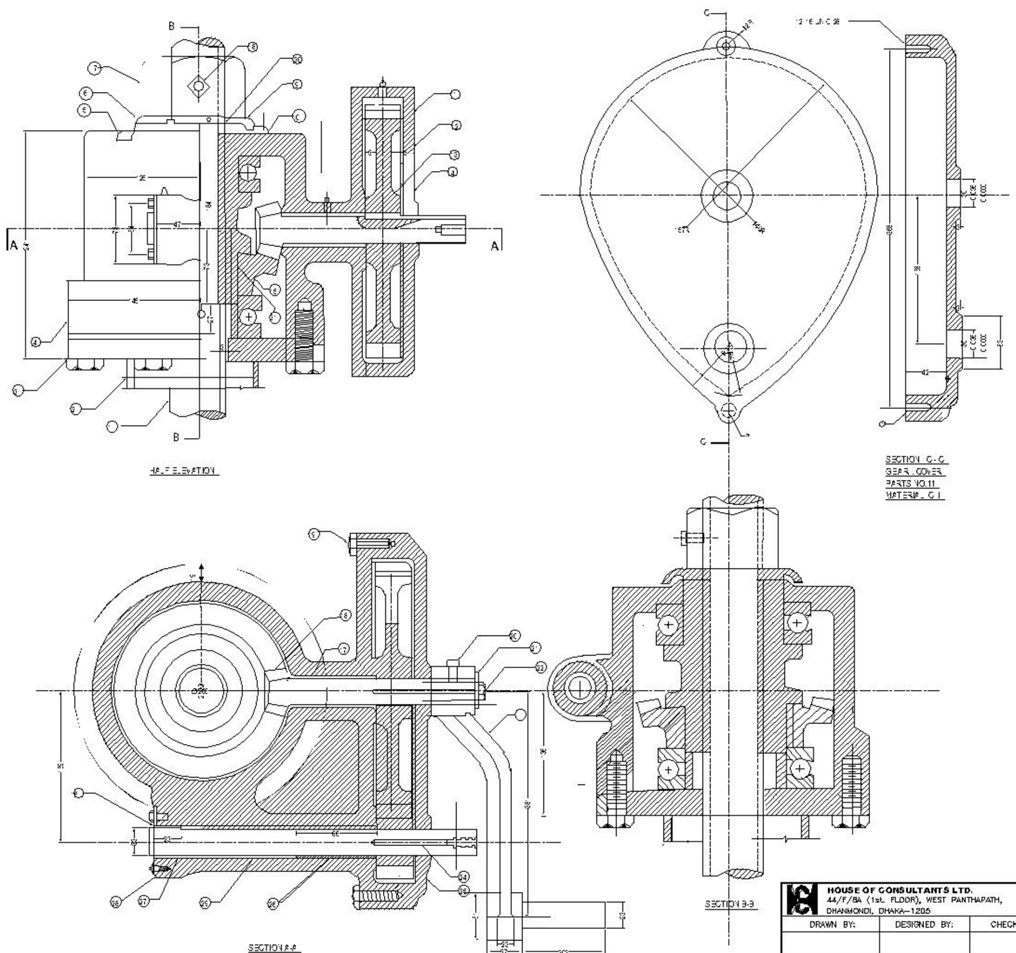


Exhibit G6-H7




Key way 6mm. 2mm.deep
10mm.16 UNC 28x25 deep
Key way 6mm. wide 2mm. deep
6mm 20 UHC 20
key way
BEVEL PINION
PARTS NO. 18
MATERIAL STEEL
SPUR GEAR
PARTS NO. 12
MATERIAL CAST IRON
6x10x38Long key
25X6 Deep kee wey
BEVEL GEAR
PARTS NO. 15
THREAD PER 25mm=4
BUSH
10mm.Stander oa orina no625no. 21 Required
10X19 SQ.HEAD
SET SCREW
MATERIAL MILD STEEL
19X53 HEX
CAP SCREW
PARTS NO.3
MATERIAL MILD STEEL
NOTE:-
All dimemesions are in mm.
REFERENCE
Based on Design developed by directorate -1 BWDB -Dhaka
12mm.Ø hole
See Details A
L= VARIABLE
THREAD STEM
PARTS NO.1
MATERIAL MILD STEEL
DETAIL-A
THREAD PER. 25mm=4
THREAD STEM
PARTS NO.1
MATERIAL MILD STEEL
25x6 deep key wey
THREAD PER 25mm.=4
ACME THREAD LIFTING NUT
PARTS NO.9
MATERIAL BRONZE
12X25 HEX
CAP SCREW
PARTS NO. 19
MATERIAL- MILD STEEL
10X25 HEX
CAP SCREW
PARTS NO. 22
MATERIAL- MILD STEEL
THRUST BALL BEARING
PARTS NO. 10
MATERIAL STEEL
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas
BOULAR KHAL SUBPROJECT
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH
SP ID
HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205
BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
VERTICAL LIFT GATE (1500 X 2000)
DRAWN BY:
DESIGNED BY:
CHECKED BY:
CHECKED BY:
REVIEWED BY:
RECOMMENDED BY:
APPROVED BY:
SK. MD. BADRUDDOZA
MD. HASANUL BANNA
M. A. MANNAN
WRP SPECIALIST Project Consultant
DTL WRD SPECIALIST Project Consultant
XEN (P&D) IWRMU, LGED
PROJECT DIRECTOR SSWRDP (JICA)
CAD BY
DESIGN ENGINEER
TEAM LEADER
DRG. NO.:
/WRS-BOULAR WRS/19-3/4
FEB 2014



PARTS LIST

P.C.NO.	NAME	QTY	MAT	PM	REMARKS
1	THREADED STEM	1	MS	M	AS 1000
2	PEDESTAL	1	MS	M	STRUCTURAL
3	[illegible] CAP SCREW	10	MS	P	STRUCTURAL
4	DOWEL	1	C	M	ASTM 30
5	GREASE FITTING	9		P	ASTM 30
6	[illegible]	1	CI	M	ASTM 30
7	64mm DIA STOP NUT	1	MS	M	STRUCTURAL
8	10mm SQUARE HEAD SET SCREW	1	MS	M	STRUCTURAL
9	LIFT NUT	1	BRONZ	M	ASTM 30
10	THRUST BALL BEARING	2		M	—
11	GEAR COVER	1	CI	M	ASTM 30
12	SPUR GEAR	1	CI	M	ASTM 30
13	6mm ALLEN HEAD SET SCREW	1	MS	M	STRUCTURAL
14	KEY	1	MS	M	STRUCTURAL
15	BEVEL GEAR	1	MS	P	[illegible]
16	6mm DIA HEAD CAP SCREW	4	MS	M	STRUCTURAL
17	BRONZE BUSHINGS	1	BRONZ	M	SAE 64
18	PINION AND SHAFT	1	MS	M	STRUCTURAL
19	12mm DIA HEAD CAP SCREW	2	MS	P	STRUCTURAL
20	10mm SQ HEAD SET SCREW	1	MS	M	STRUCTURAL
21	LOCK WASHER	1	MS	M	STRUCTURAL
22	10mm CAP SCREW	1	MS	P	—
23	CRANK	1	MS	M	STRUCTURAL
24	KEY	1	MS	M	STRUCTURAL
25	PINION	1	MS	M	STRUCTURAL
26	BRONZE BUSHINGS	1	BRONZ		SAE 64
27	BRONZE BUSHINGS	1	BRONZ	M	SAE 64
28	LOCK WASHER	1	BRONZ	M	SAE 64
29	PINION	1	MS	M	AS 1000
30	6mm FLAT HEAD CAP SCREW	2	MS	M	STRUCTURAL
31	KEY	1	MS	M	STRUCTURAL

1. Size [illegible] bearings [illegible]

NOTE

1. [illegible]
2. All dimensions are in mm

REFERENCE

Based on Design developed by Design Directorate BWDB Dhaka

LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
In Greater Mymensingh, Sylhet and Faridpur Areas

BOULAR KHAL SUBPROJECT | **SP ID**
UPAZILA : NANDAIL, DISTRICT: MYMENSINGH

HOUSE OF CONSULTANTS LTD.
44/F/8A (1st. FLOOR), WEST PANTHAPATH,
DHANMONDI, DHAKA-1205

BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)
VERTICAL LIFT GATE (1500 X 2000)

DRAWN BY:	DESIGNED BY:	CHECKED BY:	CHECKED BY:	REVIEWED BY:	RECOMMENDED BY:	APPROVED BY:
SK. MD. BADRUDDOZA	MD. HASANUL BANNA	M. A. MANNAN	WRP SPECIALIST Project Consultant	DTL WRD SPECIALIST Project Consultant	XEN (P&D) IWRMU, LGED	PROJECT DIRECTOR SSWRDP (JICA)
CAD BY	DESIGN ENGINEER	TEAM LEADER	DRG. NO.:	/WRS-BOULAR WRS/19-4/4		FEB 2014

Exhibit G6-H7

EXHIBIT G6-I: ESTIMATE OF COST AND BOQ

Exhibit G6-I.1: Estimate of Cost (using RSEPS)

Exhibit G6-I.2: Bill of Quantities (using RSEPS)

EXHIBIT G6-I.1: Estimate of Cost (Using RSEPS)

Part : 2

Scheme Code : 69117-13-10013

SchemeName : Part-B: Box Sluice (1v- 0.90m x0.90m) at Ch. 0+573 km.(East Embkt.) Under SP : Charkhai Dakshin Haor Subproject, Upazila: Beanibazar, District: Sylhet.

Item No.	Description of Item with measurement	Quantity	Unit	Rate (Tk.)	Amount (Tk.)
1	2	3	4	5	6
36.	(6.001.05) Earth Work in excavation in foundation trenches for hydraulic structures in all sorts of soil except rocky, gravelly, slushy or organic type, up to a depth of 2m to the lines, grades and elevation as shown on the drawings, removing boulders, logs and other objectionable materials, clearing all loose materials, disposing of all excavated materials to a safe distance designated by the Engineer-in-Charge for an initial lead of 20m, and cut to a firm surface etc. all complete as per requirement and direction of the Engineer-in-Charge.	425.000	cum	161.17	68497.25
37.	(6.001.01) Earth filling work with specified soil in any type of dykes/ embankment including cutting, carrying, filling by throwing earth in layers not more than 150mm in each layer in proper alignment, grade, cambering and side slope in all types of soil except rocky, gravelly and slushy including benching not more than 30cm in vertical and 60cm in horizontal steps along the sides while widening any embankment, etc. all complete as per the direction of E-I-C. Earth shall be arranged by the contractor at his own cost and it will include all necessary lead & lift. Payment will be made on compacted volume.	1049.000	cum	121.75	127715.75
38.	(6.049) Leveling & dressing the approach embankment crown, road flanks, building compound etc. in maintenance work by earth cutting and filling as necessary in proper slope and cambering including compaction etc. all complete as per direction of the Engineer-in-Charge.	120.000	sqm	15.81	1897.20
39.	(6.050) Turfing on approach embankment Top & slope, building compound with good quality turf supplied by the contractor of not less than 225 mm x 225 mm in dimension including leveling, dressing, placing, anchoring turf with pegs, and watering till grass is fully grown, etc. all complete as per direction of the Engineer-in-Charge. (Payment to be made only when grass is fully grown)	331.000	sqm	15.50	5130.50
40.	(6.039.1) Cement Concrete (C.C) work in foundation/blinding layer of hydraulic structures with Portland cement, sand (minimum FM 1.80) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, mixing by concrete mixer machine, casting, laying, compacting and curing for the requisite period, breaking of bricks into chips etc. all complete as per direction of the Engineer-in-Charge. Cylinder crushing strength of concrete should not be less than 105 Kg/Cm2 at 28 days of curing (Suggested mix proportion 1:3:6). Additional quantity of cement to be added if required to attain the strength	3.660	cum	6747.53	24695.96
41.	(6.051.2) Supplying and fabrication of M.S High strength deformed bar/ Twisted bar reinforcement of required size and length for all types of RCC work including straightening the rod, removing ruts, cleaning, cutting, hooking, bending, binding with supply of 22 B.W.G. GI wire, placing in position, including lapping, spacing and securing them in position by concrete blocks (1:1), metal chairs, etc. complete including cost of all materials, labour, local handling, laboratory test, incidentals necessary to complete the work as per specifications, drawings and direction of the Engineer. Laboratory test for physical property, strength, elongation% & bend to be performed as per ASTM. (Measurement will be based on standard weight of 490 lbs./ft3 Chairs, laps and separators will not be measures for payment. The cost of these will be included in the unit rate) High strength deformed bar (grade 60, billet)	4114.000	kg	94.50	388773.00
42.	(6.052.01) Reinforced Cement Concrete work including smooth water tight shuttering in bottom and top slab of box culvert, regulator/pipe sluice/Rubber Dam/WRS of any height with stone chips (Preferably Stone Chips from Madhayapara, Dinajpur) 20mm downgraded, sand (minimum FM 1.80) and cement having 28 days ultimate cylinder crushing strength of 210Kg/cm2 (Suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all other materials, watertight shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawing, Specification and direction of the Engineer-in-Charge. Bottom slab and approach slab	20.760	cum	9219.17	191389.97
43.	(6.052.02.1) Reinforced Cement Concrete work including smooth water tight shuttering in bottom and top slab of box culvert, regulator/pipe sluice/Rubber Dam/WRS of any height with stone chips (Preferably Stone Chips from Madhayapara, Dinajpur) 20mm downgraded, sand (minimum FM 1.80) and cement having 28 days ultimate cylinder crushing strength of 210Kg/cm2 (Suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all other materials, watertight shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawing, Specification and direction of the Engineer-in-Charge. Top slab Upto height of 5m	3.700	cum	11277.81	41727.90
44.	(6.053.1) Reinforced Cement Concrete (RCC) including smooth water tight shuttering in diaphragm walls, wing walls, piers columns, abutments and other vertical members of hydraulic structures with 20mm downgraded stone chips (Preferably stone chips from Madhaypara, Dinajpur), (LAA value not exceeding 30), sand (FM minimum 1.80) and cement having minimum 28 days ultimate cylinder crushing strength of 210Kg/cm2 (Suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all other materials, shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawings, specification and direction of the Engineer-in-Charge. Upto 5m height	34.190	cum	10415.03	356089.88
45.	(6.054) Reinforced Cement Concrete (RCC) work including smooth water tight shuttering in railing and rail post with stone chips (preferably stone chips from Madhaypara, Dinajpur), sand (minimum 1.80) and cement having minimum 28 days cylinder crushing strength of 210 Kg/cm2 (suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all materials, shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawings, specification and direction of the Engineer-in-Charge.	0.280	cum	12968.12	3631.07

46.	(6.056) Minimum 6mm thick cement plaster (1:4) to rail bar and rail post with neat cement finishing including washing of sand, finishing the edges and corners and curing for requisite period etc. all complete as per direction of the Engineer-in-Charge. (Sand FM 1.2 be used)	8.340	sqm	161.53	1347.16
47.	(6.015.02) Manufacturing and supplying CC blocks with cement, sand (FM>=1.5) and shingles (40mm down graded) to attain a minimum 28 days cylinder strength of 9.0 N/mm2 (suggested mix proportion 1:3:6), including grading, washings shingles, mixing, laying in forms, consolidating, curing for at least 21 days, including preparation of platform, shuttering and stacking in measurable stacks etc. all complete as per direction of the Engineer in charge (Steel shutter to be used) Size 400mmx400mmx300mm	318.000	each	285.38	90750.84
48.	(6.016) Labour charge for protective works in laying C.C blocks of different sizes including preparation, watering and ramming of base etc. all complete as per drawing & direction of the Engineer in charge	15.260	cum	1114.56	17008.19
49.	(6.058) Making earthen ring/cross bundh of required height and width to prevent water from entering in the working area for any type of foundation with earth arranged and carried by the contractor including bullah/bamboo palisading and double tarja mat/drum sheets walling as and where necessary, maintaining the same throughout the working period, filling by throwing earth in layers, removal of totally on completion of the hydraulic structures etc. all complete as per requirement and instruction of the Engineer-in-Charge.	1.000	LS	75000.00	75000.00
50.	(6.001.12) Manual compaction of earth in 150mm thick compacted layers by breaking clods to a maximum size of 50mm using wooden drag or ladder and compacting using concrete drop hammer (durmus), watering or drying to obtain optimum moisture content if necessary including supplying of wooden drag, ladder, bamboo hammer, steel/concrete hammer & other requisite tools, etc. all complete as per direction of the Engineer-in-Charge. 85% compaction of the maximum dry density is to be obtained by the standard compaction test.	1049.000	cum	30.99	32508.51
51.	(6.036) Manufacturing supplying and installation of M.S embedded parts for flap/vertical lift gate including fabricating, bending, welding, forging, drilling holes, welding anchor bars, fitting, fixing etc. all complete with a prime coat of red oxide where necessary as per design, specification and direction of the Engineer in charge.	598.000	kg	136.74	81770.52
52.	(6.032.01) Manufacturing, supplying of M.S Vertical lift gate shutter of 8mm thick M.S skin plate and stiffener with minimum 75mmx75mmx10mm M.S angle as frame, horizontal & vertical beam, 75mmx25mmx12mm P-type rubber seal, fixed with 10mm diax63.5mm M.S counter shank bolts with nuts and 40mmx10mm M.S strip as clamp drilled space @150mm c/c, stem attachment with proper thread, nut cotter pin and washer as per approved design including the cost of all materials of proper grade and brand new with a prime coat of red oxide where necessary as per specifications including fitting, fixing etc. all complete as per drawing, specification and direction of the Engineer in charge. Size 1.05mx0.975m	1.000	each	31043.03	31043.03
53.	(6.030) Manufacturing, supplying and installation of pedestal type lifting device for slide gate with 63mm dia threaded steel shaft, 146mm outer dia bronze nut, thrust bearing, steel bevel gear etc. as per approved design including supply of all components, labour with a prime coat of red oxide where necessary etc. all complete as per specification and direction of the Engineer in charge.	1.000	each	101307.87	101307.87
54.	(6.034.01) Labour charge for fitting and fixing of M.S vertical lift gate/flap gate shutters of different size including making holes in concrete for hooking arrangements with supply of necessary materials, tools and other accessories required for fitting the same to regulator/sluice and mending the damages with C.C (1:2:4), removing the spoils etc. all complete as per direction of the Engineer in charge. Size 1.05mx0.975m	1.000	each	8932.61	8932.61
55.	(6.011.02) Erection of 200mm wide water level gauge on 6mm thick plastering with Portland cement and sand (minimum FM 1.2) in proportion (1:4) on the body of hydraulic structure on both country side and river side including preparing the surface, curing including cutting the gauge marks including marking the value in English & Bengali upto centimeter in small division BWDB's RL value with respect to PWD datum and painting with synthetic enamel paint etc. all complete as per specification and direction of the E-I-C.	1.220	sqm	226.32	276.11
56.	(6.037) Epoxy paint 2 coats of approved colour and specification over a priming coat to gate, hoisting device and embedded metal parts including scraper, steel wire brush & emery paper etc. complete in all respect as per direction of the Engineer in charge.	4.000	sqm	333.61	1334.44
57.	(6.080) First class brick work in cement mortar (1:4) in toe walls/ guide walls with sand (minimum FM 1.5) and cement, cutting bricks to required sizes, hoisting and watering, etc. complete including cost of all materials all complete as per direction of the Engineer-in-Charge.	5.010	cum	6132.69	30724.78
58.	(6.082) Supplying, fitting and fixing 300mmx300mmx20mm thick marble Name plate at left hand wheel guard on each side, one in English and one in Bengali including cost of materials, labour, form work, engraving neatly the approved Sample given by the engineer etc. complete as per drawings and direction of the Engineer-in-charge.	1.000	each	1359.24	1359.24
59.	(6.059) Bailing out of water from work site including supply, operation and maintenance of requisite numbers of water pumps. It should be carried out in such a manner as to produce possibilities of the movement of water through or alongside any concrete being placed, etc. all complete as per direction of the Engineer-in-Charge.	1.000	LS	20000.00	20000.00
60.	(6.047) Supplying Sign Board at site of 1.5mx1.0m size in plain CI sheet; painting, writing, erecting & fixing with bamboo including all complete as per direction of Engineer-in-Charge.	1.000	LS	500.00	500.00
61.	(6.079) Sand filling on the prepared foundation bed with sand of minimum FM 0.80 in difficult areas with 150mm in thickness each layer including supplying, placing in conformity with the profile and level as per design including watering, compaction etc. all complete as per instruction of the Engineer-in-Charge.	17.000	cum	830.65	14121.05
				Part : 2 Total :	**1,717,532.82**

EXHIBIT G6-I.2: Bill of Quantities (Using RSEPS)

SL No.	(Item Code) Item of Works	Unit	Quantity	Quoted Unit Rates (Tk)		Total Amount In Figure (Tk)
				In Figure	In Words	
1	2	3	4	5	6	7
Part-2 (Scheme Code : 69117-13-10013)						
36.	(6.001.05) Earth Work in excavation in foundation trenches for hydraulic structures in all sorts of soil except rocky, gravelly, slushy or organic type, up to a depth of 2m to the lines, grades and elevation as shown on the drawings, removing boulders, logs and other objectionable materials, clearing all loose materials, disposing of all excavated materials to a safe distance designated by the Engineer-in-Charge for an initial lead of 20m, and cut to a firm surface etc. all complete as per requirement and direction of the Engineer-in-Charge.	cum	425.000			
37.	(6.001.01) Earth filling work with specified soil in any type of dykes/ embankment including cutting, carrying, filling by throwing earth in layers not more than 150mm in each layer in proper alignment, grade, cambering and side slope in all types of soil except rocky, gravelly and slushy including benching not more than 30cm in vertical and 60cm in horizontal steps along the sides while widening any embankment, etc. all complete as per the direction of E-I-C. Earth shall be arranged by the contractor at his own cost and it will include all necessary lead & lift. Payment will be made on compacted volume.	cum	1,049.000			
38.	(6.049) Leveling & dressing the approach embankment crown, road flanks, building compound etc. in maintenance work by earth cutting and filling as necessary in proper slope and cambering including compaction etc. all complete as per direction of the Engineer-in- Charge.	sqm	120.000			
39.	(6.050) Turfing on approach embankment Top & slope, building compound with good quality turf supplied by the contractor of not less than 225 mm x 225 mm in dimension including leveling, dressing, placing, anchoring turf with pegs, and watering till grass is fully grown, etc. all complete as per direction of the Engineer-in-Charge. (Payment to be made only when grass is fully grown)	sqm	331.000			
40.	(6.039.1) Cement Concrete (C.C) work in foundation/blinding layer of hydraulic structures with Portland cement, sand (minimum FM 1.80) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, mixing by concrete mixer machine, casting, laying, compacting and curing for the requisite period, breaking of bricks into chips etc. all complete as per direction of the Engineer-in-Charge. Cylinder crushing strength of concrete should not be less than 105 Kg/Cm2 at 28 days of curing (Suggested mix proportion 1:3:6). Additional quantity of cement to be added if required to attain the strength	cum	3.660			

41.	(6.051.2) Supplying and fabrication of M.S High strength deformed bar/ Twisted bar reinforcement of required size and length for all types of RCC work including straightening the rod, removing ruts, cleaning, cutting, hooking, bending, binding with supply of 22 B.W.G. GI wire, placing in position, including lapping, spacing and securing them in position by concrete blocks (1:1), metal chairs, etc. complete including cost of all materials, labour, local handling, laboratory test, incidentals necessary to complete the work as per specifications, drawings and direction of the Engineer. Laboratory test for physical property, strength, elongation% & bend to be performed as per ASTM. (Measurement will be based on standard weight of 490 lbs./ft3 Chairs, laps and separators will not be measures for payment. The cost of these will be included in the unit rate) High strength deformed bar (grade 60, billet)	kg	4,114.000			
42.	(6.052.01) Reinforced Cement Concrete work including smooth water tight shuttering in bottom and top slab of box culvert, regulator/pipe sluice/Rubber Dam/WRS of any height with stone chips (Preferably Stone Chips from Madhayapara, Dinajpur) 20mm downgraded, sand (minimum FM 1.80) and cement having 28 days ultimate cylinder crushing strength of 210Kg/cm2 (Suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all other materials, watertight shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawing, Specification and direction of the Engineer-in-Charge. Bottom slab and approach slab	cum	20.760			
43.	(6.052.02.1) Reinforced Cement Concrete work including smooth water tight shuttering in bottom and top slab of box culvert, regulator/pipe sluice/Rubber Dam/WRS of any height with stone chips (Preferably Stone Chips from Madhayapara, Dinajpur) 20mm downgraded, sand (minimum FM 1.80) and cement having 28 days ultimate cylinder crushing strength of 210Kg/cm2 (Suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all other materials, watertight shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawing, Specification and direction of the Engineer-in-Charge. Top slab Upto height of 5m	cum	3.700			
44.	(6.053.1) Reinforced Cement Concrete (RCC) including smooth water tight shuttering in diaphragm walls, wing walls, piers columns, abutments and other vertical members of hydraulic structures with 20mm downgraded stone chips (Preferably stone chips from Madhaypara, Dinajpur), (LAA value not exceeding 30), sand (FM minimum 1.80) and cement having minimum 28 days ultimate cylinder crushing strength of 210Kg/cm2 (Suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all other materials, shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawings, specification and direction of the Engineer-in-Charge. Upto 5m height	cum	34.190			
45.	(6.054) Reinforced Cement Concrete (RCC) work including smooth water tight shuttering in railing and rail post with stone chips (preferably stone chips from Madhaypara, Dinajpur), sand (minimum 1.80) and cement having minimum 28 days cylinder crushing strength of 210 Kg/cm2 (suggested mix proportion 1:2:4), excluding cost of reinforcement and its fabrication but including cost of all materials, shuttering, casting, curing for 28 days and all incidental charges, etc. complete in all respect as per design, drawings, specification and direction of the Engineer-in-Charge.	cum	0.280			

46.	(6.056) Minimum 6mm thick cement plaster (1:4) to rail bar and rail post with neat cement finishing including washing of sand, finishing the edges and corners and curing for requisite period etc. all complete as per direction of the Engineer-in-Charge. (Sand FM 1.2 be used)	sqm	8.340			
47.	(6.015.02) Manufacturing and supplying CC blocks with cement, sand (FM>=1.5) and shingles (40mm down graded) to attain a minimum 28 days cylinder strength of 9.0 N/mm2 (suggested mix proportion 1:3:6), including grading, washings shingles, mixing, laying in forms, consolidating, curing for at least 21 days, including preparation of platform, shuttering and stacking in measurable stacks etc. all complete as per direction of the Engineer in charge (Steel shutter to be used) Size 400mmx400mmx300mm	each	318.000			
48.	(6.016) Labour charge for protective works in laying C.C blocks of different sizes including preparation, watering and ramming of base etc. all complete as per drawing & direction of the Engineer in charge	cum	15.260			
49.	(6.058) Making earthen ring/cross bundh of required height and width to prevent water from entering in the working area for any type of foundation with earth arranged and carried by the contractor including bullah/bamboo palisading and double tarja mat/drum sheets walling as and where necessary, maintaining the same throughout the working period, filling by throwing earth in layers, removal of totally on completion of the hydraulic structures etc. all complete as per requirement and instruction of the Engineer-in-Charge.	LS	1.000			
50.	(6.001.12) Manual compaction of earth in 150mm thick compacted layers by breaking clods to a maximum size of 50mm using wooden drag or ladder and compacting using concrete drop hammer (durmus), watering or drying to obtain optimum moisture content if necessary including supplying of wooden drag, ladder, bamboo hammer, steel/concrete hammer & other requisite tools, etc. all complete as per direction of the Engineer-in-Charge. 85% compaction of the maximum dry density is to be obtained by the standard compaction test.	cum	1,049.000			
51.	(6.036) Manufacturing supplying and installation of M.S embedded parts for flap/vertical lift gate including fabricating, bending, welding, forging, drilling holes, welding anchor bars, fitting, fixing etc. all complete with a prime coat of red oxide where necessary as per design, specification and direction of the Engineer in charge.	kg	598.000			
52.	(6.032.01) Manufacturing, supplying of M.S Vertical lift gate shutter of 8mm thick M.S skin plate and stiffener with minimum 75mmx75mmx10mm M.S angle as frame, horizontal & vertical beam, 75mmx25mmx12mm P-type rubber seal, fixed with 10mm diax63.5mm M.S counter shank bolts with nuts and 40mmx10mm M.S strip as clamp drilled space @150mm c/c, stem attachment with proper thread, nut cotter pin and washer as per approved design including the cost of all materials of proper grade and brand new with a prime coat of red oxide where necessary as per specifications including fitting, fixing etc. all complete as per drawing, specification and direction of the Engineer in charge. Size 1.05mx0.975m	each	1.000			
53.	(6.030) Manufacturing, supplying and installation of pedestal type lifting device for slide gate with 63mm dia threaded steel shaft, 146mm outer dia bronze nut, thrust bearing, steel bevel gear etc. as per approved design including supply of all components, labour with a prime coat of red oxide where necessary etc. all complete as per specification and direction of the Engineer in charge.	each	1.000			

54.	(6.034.01) Labour charge for fitting and fixing of M.S vertical lift gate/flap gate shutters of different size including making holes in concrete for hooking arrangements with supply of necessary materials, tools and other accessories required for fitting the same to regulator/sluice and mending the damages with C.C (1:2:4), removing the spoils etc. all complete as per direction of the Engineer in charge. Size 1.05mx0.975m	each	1.000			
55.	(6.011.02) Erection of 200mm wide water level gauge on 6mm thick plastering with Portland cement and sand (minimum FM 1.2) in proportion (1:4) on the body of hydraulic structure on both country side and river side including preparing the surface, curing including cutting the gauge marks including marking the value in English & Bengali upto centimeter in small division BWDB's RL value with respect to PWD datum and painting with synthetic enamel paint etc. all complete as per specification and direction of the E-I-C.	sqm	1.220			
56.	(6.037) Epoxy paint 2 coats of approved colour and specification over a priming coat to gate, hoisting device and embedded metal parts including scraper, steel wire brush & emery paper etc. complete in all respect as per direction of the Engineer in charge.	sqm	4.000			
57.	(6.080) First class brick work in cement mortar (1:4) in toe walls/ guide walls with sand (minimum FM 1.5) and cement, cutting bricks to required sizes, hoisting and watering, etc. complete including cost of all materials all complete as per direction of the Engineer-in-Charge.	cum	5.010			
58.	(6.082) Supplying, fitting and fixing 300mmx300mmx20mm thick marble Name plate at left hand wheel guard on each side, one in English and one in Bengali including cost of materials, labour, form work, engraving neatly the approved Sample given by the engineer etc. complete as per drawings and direction of the Engineer-in-charge.	each	1.000			
59.	(6.059) Bailing out of water from work site including supply, operation and maintenance of requisite numbers of water pumps. It should be carried out in such a manner as to produce possibilities of the movement of water through or alongside any concrete being placed, etc. all complete as per direction of the Engineer-in-Charge.	LS	1.000			
60.	(6.047) Supplying Sign Board at site of 1.5mx1.0m size in plain CI sheet; painting, writing, erecting & fixing with bamboo including all complete as per direction of Engineer-in-Charge.	LS	1.000			
61.	(6.079) Sand filling on the prepared foundation bed with sand of minimum FM 0.80 in difficult areas with 150mm in thickness each layer including supplying, placing in conformity with the profile and level as per design including watering, compaction etc. all complete as per instruction of the Engineer-in-Charge.	cum	17.000			
	Sub-Total (Part-2)					

EXHIBIT G6-J Model of Structure Geometry of a Regulator

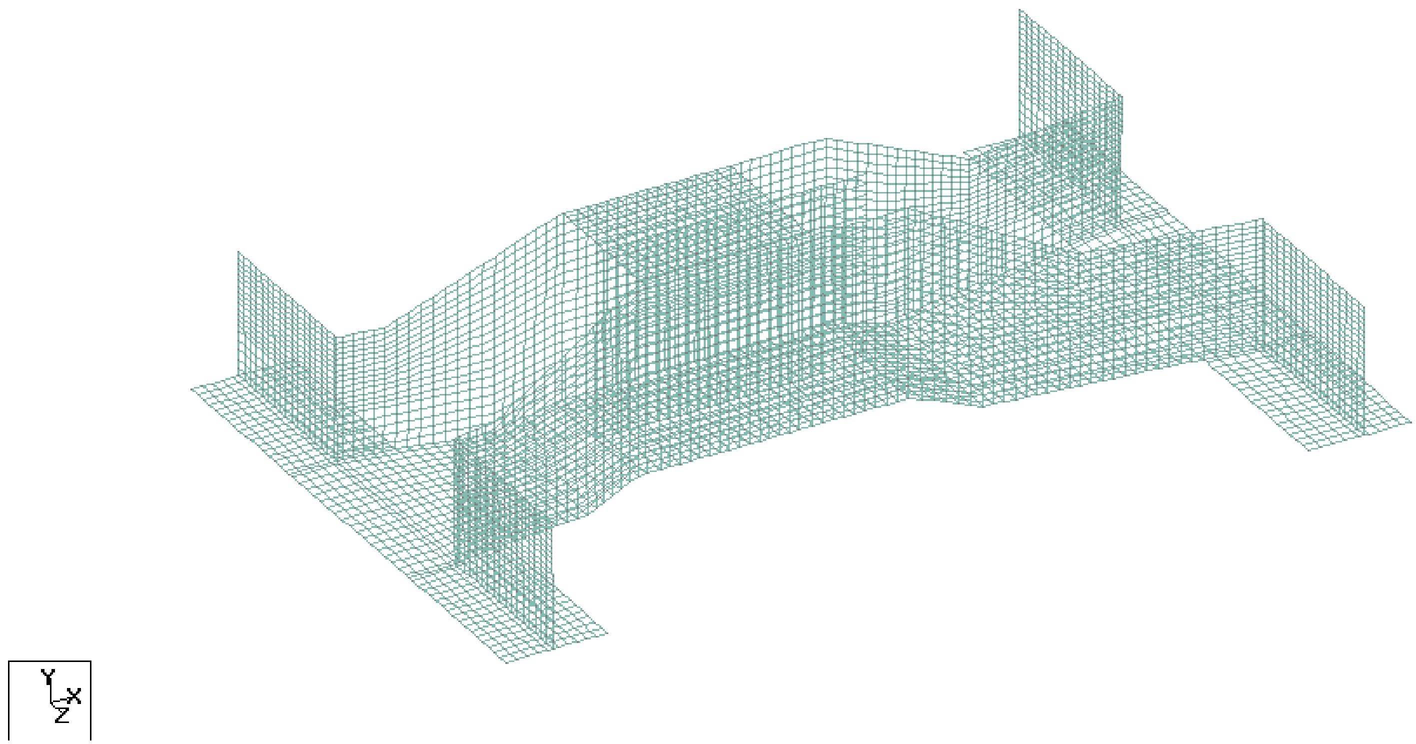


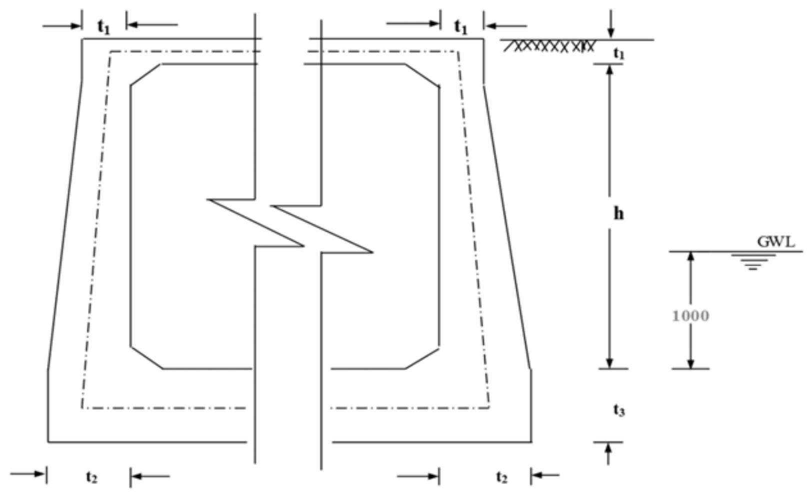
EXHIBIT G6-K Calculation of Lateral Loads on Abutments-Wing Walls of Hydraulic Structures

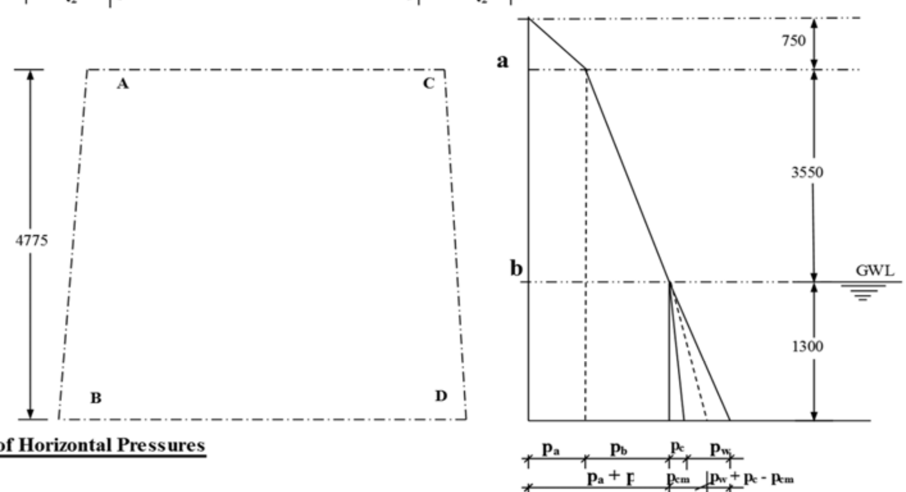
Design Parameters :

fc' = **21.00** N/mm^2 = 3000 psi		γ_{conc} =	23.60 Kn/m^3
fy = **415** N/mm^2 = 60000 psi		$\gamma_{s(moist)}$ =	17.40 Kn/m^3
β_1 = 0.85		$\gamma_{s(Sat)}$ =	18.90 Kn/m^3
ϕ = 0.90		$\gamma_{s(Sub)}$ =	9.09 Kn/m^3
K_0 = 0.58		$\gamma_{s(Water)}$ =	9.81 Kn/m^3
φ = 25 °			

Required Input Data

t_1	t_2	t_3	h		Surcharge	Live Load
300	450	600	4400		600 mm	H 20





Calculation of Horizontal Pressures

p_a =	7.57 Kn/m^2		
p_b =	35.83 Kn/m^2		
p_c =	6.85 Kn/m^2		
p_w =	12.75 Kn/m^2	$p_a + p_b + p_{cm}$ =	56.52 Kn/m^2
p_{cm} =	13.12 Kn/m^2	$p_c + p_w - p_{cm}$ =	6.49 Kn/m^2

EXHIBIT G6-L Criteria and Design of PVC Buried Pipe Irrigation Subprojects

[This Exhibit is presented separately as it is bigger in size]