

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 | 2 nd 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 | Detailed 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 Detailed 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) | (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 | | Land Category |
|-----------------------------------|---------|-----------------|
| (m) | (ft) | |
| <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 |
| | | TI | Tidal Irrigation |
| II | Complex (with Regulation of Water Flow using gated or other kind of structures) | FM | Flood Management |
| | | FMD | Flood Management and Drainage |
| | | FMDTI | Flood Management, Drainage and Tidal Irrigation |

| 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 <i>haors</i> , <i>beels</i> and <i>khals</i> to increase availability of surface water for irrigation in dry season by installing gated water retention structures (also <i>Rubber Dams</i> at appropriate sites) and by re-excavating <i>khals</i> 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/sluches 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 for 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 Subprojects |

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 (**S**Tructural **A**nalysis **A**nd **D**esign **P**rogram) 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 Subproject*. 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/sluches 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 (Q_{max}) 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.

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

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:

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

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.

$$SB = Ze \times Dch$$

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)

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:

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

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 Areas¹ (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/slides/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, slides, 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.

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/slides 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 G_e , is mild enough not to be able to float away soil particles from the exit point.

94. Analytical equations for exit gradient (G_e) 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 $K = (\text{HTL} - \text{LTL}) / (\text{Basin WL} - \text{LTL})$, 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 $Q_{\text{tidal (av)}}$. This $Q_{\text{tidal (av)}}$ will be matched with Q_{des} above to obtain the required number of vents. The step discharges will be calculated by using the Spreadsheet 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/sluches 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 held 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 held 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/slides 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/slides 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. $A_{\text{structure}} = L_{\text{dam}} \times D_w$.

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 $A_{\text{structure}} > 0.90 \times A_{\text{existing}}$.

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 Spreadsheet 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.

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

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 (Z_c) 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:

$$V_{water} = A \times D_{av}$$

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

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

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 Gradient 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 0.80m. 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/sludge 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 held 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:** Design 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.

$$\text{Darcy-Wiesbach Formula: } H_L = f \left(\frac{L}{D} \right) \left(\frac{V^2}{2g} \right)$$

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/s²)

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.

$$\text{Colebrook White Formula: } V = \left(-2 \left(\frac{2gDS}{D} \right)^{0.5} \log \left[\left(\frac{k_s}{3.7D} \right) + \left(\frac{2.51V}{D} \right) \left(\frac{2gDS}{D} \right)^{0.5} \right] \right)^{0.5}$$

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/s²)

v= kinematic viscosity of water (0.00111 at 15°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 restarts 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 <i>(A cheaper alternative would be a circular reinforced concrete tank with electronic flow monitoring devices to outlet pipes).</i> | To receive discharge from pumps and allow settlement of sediment to be 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 puccanuccas 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 <i>irrigator units</i> , 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° 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° 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 (iii) 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 Bangladesh, 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:

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

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/mm².

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° (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 $\phi=25^\circ$ 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

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

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:

M_u = Moment from STAADPro Output (selected design Moment)

M_n = M_u/ϕ = Design Moment

ρ_{max} = Maximum Steel Ratio

$$m = \frac{f_y}{0.85f'_c} , \quad m = \text{stress ratio}$$

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

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

Design Parameters

Yield Strength of Steel (f_y) 415 N/mm²

Compressive Strength of Concrete (f'_c) 21 N/mm²

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/mm²

Modulus of Elasticity of Conc ($E_c=4700\sqrt{f'_c}$) 2.15 E+04 N/mm²

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 <i>four specific flow types</i> (<i>Type-1, Type-3, Type-4, Type-5</i>) 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 Basin 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 and 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** (Rate Schedule Estimate Preparation System) 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 ($^{\circ}$ 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]

| <i>Barisal</i> | | | | | | | | |
|----------------|----------|-------|-------|-----------------|-------------|------------|-------------|----------------|
| Month | Rainfall | | | Average monthly | | | | |
| | Average | Dry | Wet | Min Temp °C | Max Temp °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 WL | Apr | | May | | Jun | | Jul | | Aug | | Sep | |
|--|-----|-----|---|-----|--|-----|-----|-----|-----|-----|-----|-----|
| | HTL | LTL | HTL | LTL | HTL | LTL | HTL | LTL | HTL | LTL | HTL | LTL |
| Max | | | | | | | | | | | | |
| Mean | | | | | | | | | | | | |
| Min | | | | | | | | | | | | |
| <hr/> | | | | | | | | | | | | |
| | Oct | | Nov | | Dec | | Jan | | Feb | | Mar | |
| | HTL | LTL | HTL | LTL | HTL | LTL | HTL | LTL | HTL | LTL | HTL | LTL |
| Max | | | | | | | | | | | | |
| Mean | | | | | | | | | | | | |
| Min | | | | | | | | | | | | |
| <hr/> | | | | | | | | | | | | |
| 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 |

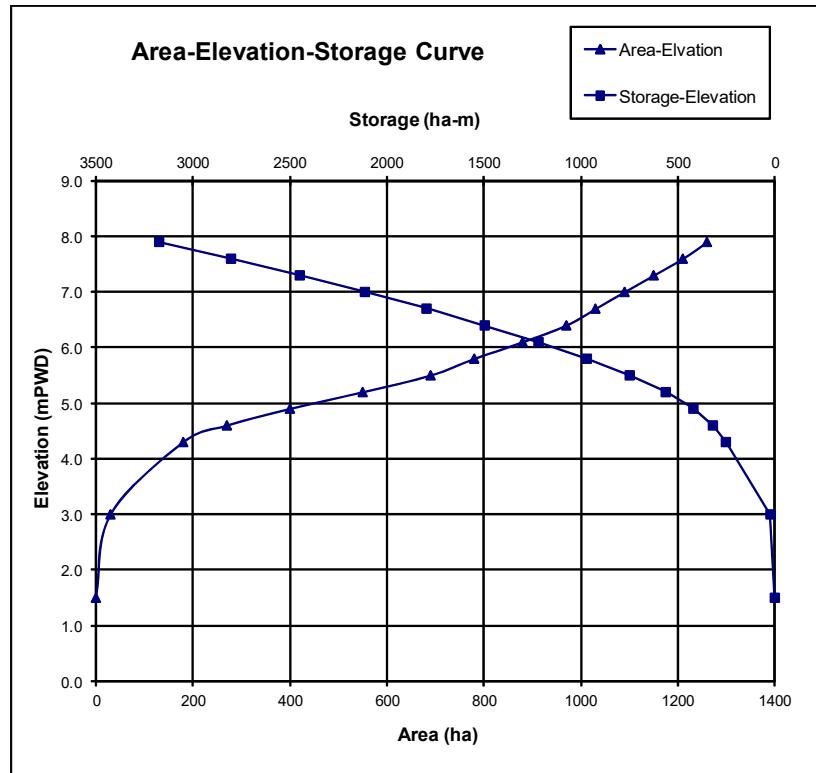


EXHIBIT G6-G: SPREADSHEET DESIGN PROGRAM

- 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 | | |
| 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 | | |
| 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, revise trial drainage rate downward.
 4. If count of crop damage day > 3, revise 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 | | | | PRE-PROJECT WL = 16.63 m PWD | | POST-PROJECT WL = 16.40 m PWD | | |
| NONCULTIVATED HIGH LAND = 70 ha | | | | | | | | |
| NONCULTIVATED LOW LAND = 10 ha | | | | | | | | |
| Cumulative | | Pre-project Condition | | Post-project Condition | | | | |
| Elevation (m PWD) | Area (ha) | Flood depth | Cu. Area | Area | Flood depth | Cu. Area | Area | |
| 13.80 | 0 | Not flooded--> | 16.63 | 841 | 109 ha | 16.40 | 814 | 136 ha <- Not flooded |
| 14.10 | 50 | F0, (0.0-0.3)--> | 16.33 | 806 | 35 ha | 16.10 | 770 | 44 ha <- (0.0-0.3), F0 |
| 14.40 | 130 | F1,(0.3-0.9)--> | 15.73 | 668 | 138 ha | 15.50 | 580 | 190 ha <- (0.3-0.9), F1 |
| 14.70 | 220 | F2,(0.9-1.8)--> | 14.83 | 277 | 391 ha | 14.60 | 190 | 390 ha <- (0.9-1.8),F2 |
| 15.00 | 350 | F3,>1.8--> | | 267 ha | | 180 ha | | >1.8, F3 |
| 15.30 | 500 | | | 10 ha | | 10 ha | | |
| 15.60 | 620 | | | TOTAL--> | 950 ha | | | |
| 15.90 | 730 | | | | | TOTAL--> | 950 ha | |
| Pre-project Condition | | | | | | | | |
| 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: | Reach | Catch. Area (Ha.) | Existing | | | | | Design | | | | | | | | | | | |
| | | | Bed Level (mPWD) | BW (m) (mPWD) | TW (m) | Bank. GL (mPWD) | Bed Slope | Drainage Rate (mm/day) | Q (m³/Sec) | Basin WL (mPWD) | Outfall RWL (mPWD) | WS | Side Slope | B (m) | d (m) | Check for V & Q | WL (mPWD) | BL (mPWD) | Depth of Cutting |
| Name of Khal : Betbaria Khal | | | | | | | | | | | | | | | | | | | |
| 0 1500 | 1 | 750 | 4.64 3.7 | 4.00 2.00 | 16.00 15.00 | | -0.0006 | 55.00 | 4.774 | 5.07 | | 0.00060 | 1.5 | 5.00 | 1.15 | V= 0.626 Q= 4.840 | 5.070 5.970 | 3.920 4.820 | 0.72 -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

EXHIBIT G6-G5: DesignPro 5 - EmbankDesign

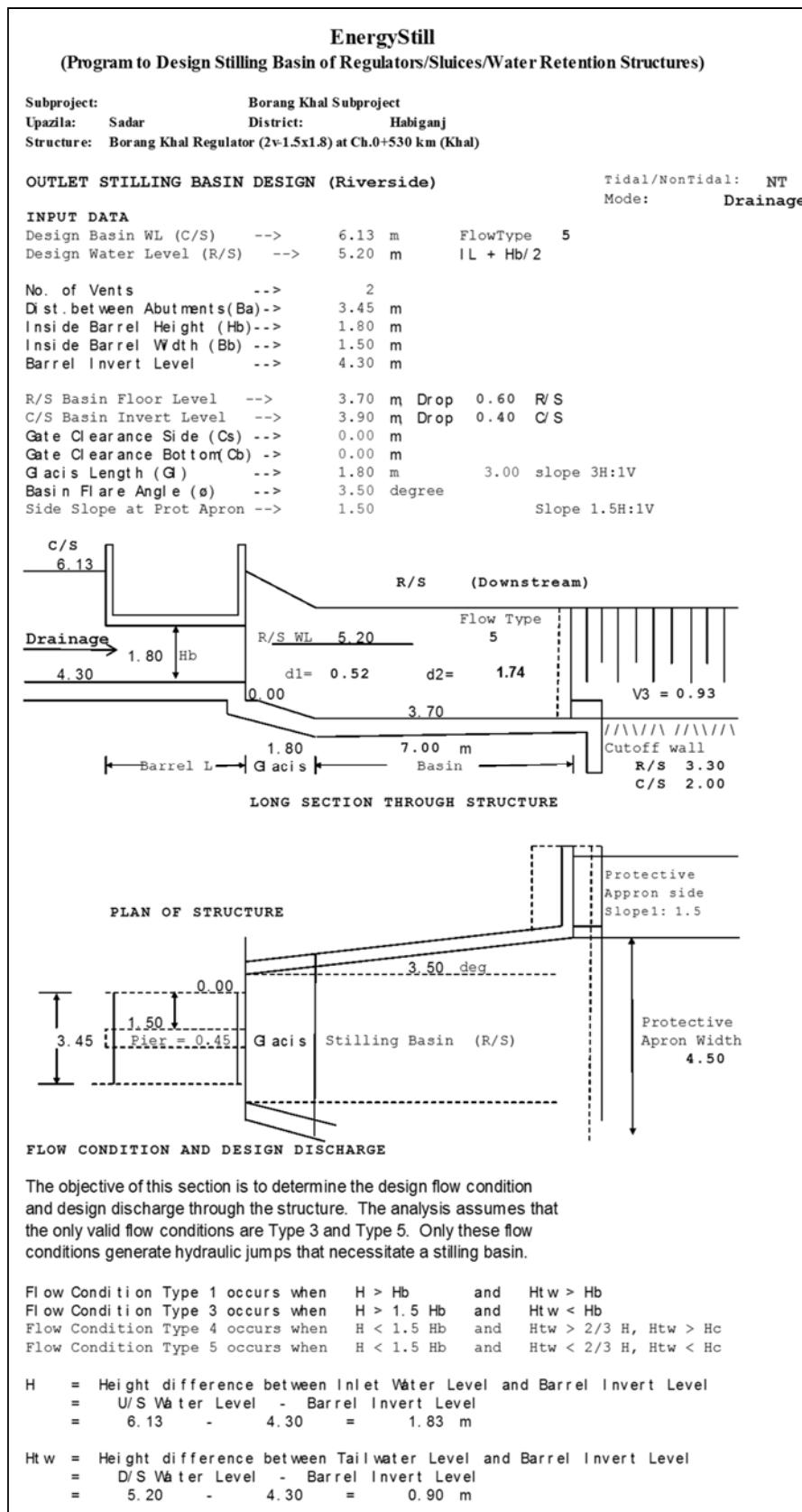
| EmbankDesign | | | | | | | | | | | | | | | | | | |
|---|-------|-------------------------|-----------------------|----------------------|------------------------|----------------|-------------------------------------|--------------------------|-----------------------|-------------------|------------------------------------|--------------------|---------------------|--------------|----------------------|----------------------|-----------------|---------------|
| Chainage (m) | Reach | Existing | | | | | Design | | | | | | | | | | BWE-BWD (m) | |
| | | Crest Level (mPW) | Crest Width (m) | Base Width (m) | Ground Level (mPWD) | HFL (mPWD) | Freeboard on 20-Yr HFL (m) | Crest Level (mPWD) | Crest Width (m) | Side Slope R/S | Berm at EL- (Average) (m) | Basin WL (mPWD) | Seepage Gradient | Soil Type | Base Width (m) | | | |
| | | 1:20-Yr | 1:50-Yr. | R/S | C/S | 1:20-Yr | 1:50-Yr. | | | | | | | | | | | |
| Name of the Embankment: Road-cum-Embankment from Roail Bazar to Raniganj Bazar (resectioning). | | | | | | | | | | | | | | | | | | |
| 0 7000 | 1 | 7.143 7.500 | 3.00 3.00 | 7.60 5.50 | 6.390 5.705 | 6.260 5.630 | 6.980 7.340 | 7.170 7.340 | 0.60 0.60 | 7.60 7.90 | 3.70 3.70 | 1.50 1.50 | 1.50 0.00 | 0.00 6.50 | 6.50 0.1254 | 0.0768 Silty-Clay | 7.525 10.398 | -0.07 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/Slices/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 | Wdt h Height | 1.50 m 1.80 m |
| Vent Number | 2 nr | |

| SizeCal | | | | | | | | | | | | | | | | | | | | | |
|--|--|------------|--------------------------|---------------|--------------------------|------------|-----------|-----------|--------------------------|------|------|------|------|----|------|--|--|--|--|--|---------|
| (Program to Design Size of Regulators/Slices/Water Retention Structures) | | | | | | | | | | | | | | | | | | | | | |
| Sub-project : | Borang Khal Subproject | | | | | | | | | | | | | | | | | | | | |
| Upazila : Sadar | District: Habiganj | | | | | | | | | | | | | | | | | | | | |
| Regulator/Slice/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 | $Q_I = 0.80 \times N \times B_w \times H_v \times (2 \times 9.81 \times h)^{0.5}$ | | | | | | | | | | | | | | | | | | | | |
| When $H_w > 1.5H_v$ and $H_{tw} < H_v$, Flow Type III | $Q_{III} = 0.60 \times N \times B_v \times H_v \times (2 \times 9.81 \times (H_w - H_v/2))^{0.5}$ | | | | | | | | | | | | | | | | | | | | |
| When $H_w < 1.5H_v$ and $H_{tw} > 2H_v/3$, Flow Type IV | $Q_{IV} = 0.83 \times N \times B_v \times (H_w - h') \times (2 \times 9.81 \times h)^{0.5}$ | | | | | | | | | | | | | | | | | | | | |
| When $H_w < 1.5H_v$ and $H_{tw} < 2H_v/3$, $H_{tw} < H_c$, Flow Type V | $Q_V = 1.56 \times N \times B_v \times H_w^{3/2}$ | | | | | | | | | | | | | | | | | | | | |
| Where: | H_w = Upstream Water Depth H_{tw} = Tail Water Depth H_v = Vent Height B_v = Vent Width | | | | | | | | | | | | | | | | | | | | |
| | N = Vent Nos. h' = Head Difference Q = Flow through Regulator | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <thead> <tr> <th>RWL (mPWD)</th> <th>Hw (m)</th> <th>Htw (m)</th> <th>h' (m)</th> <th>Flow Type</th> <th>Q m³/Sec</th> </tr> </thead> <tbody> <tr> <td>5.83</td> <td>1.83</td> <td>1.53</td> <td>0.30</td> <td>IV</td> <td>9.24</td> </tr> <tr> <td colspan="5"></td> <td>9.24 OK</td> </tr> </tbody> </table> | | | | 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 |
| 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



```

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 Wdth * 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*G*(tan φ)
   = 3.45 + 0.00 + 3.60 * ( 0.061 )
   = 3.67 m

```

| |
|---|
| $V_1 = \frac{Q}{A_1} = \frac{Q}{B_1 \cdot d_1} = \frac{11.59}{3.67 \cdot d_1} = \frac{3.16}{d_1} <-----$ <p>At critical depth, in a rectangular section, the following two equations can be applied:</p> $dc = \frac{qc^2}{g} \wedge 0.33 \quad \text{and} \quad \frac{Vc^2}{2g} = \frac{dc}{2} <-----$ <p>$g = \text{acceleration of gravity} = 9.81 \text{ m/sec}^2$</p> <p>It is assumed that the critical depth occurs on the Barrel Extension Floor.</p> <p>$qc = \text{unit discharge (discharge per unit width) at Section (c)}$</p> $Q = \frac{3.86}{\text{No. Vents} \cdot B_b} = 3.86 \text{ m}^2/\text{sec per m}$ $dc = \frac{3.86^2}{9.81} \wedge 0.33 = 1.15 \text{ m} <-----$ <p>$Z_c = \text{elevation change between Section (c) and (1)}$ $= \text{Barrel Extension Invert Level}(B_b - C_b) - \text{Basin Invert Level}$ $= 4.30 - 0.00 - 3.70 = 0.60 \text{ m} <-----$ (Drop for gate recess to be neglected)</p> <p>When the above results are entered into the Bernoulli's Energy Equation, it becomes:</p> $dc + \frac{dc}{2} + 0.60 = d_1 + \left(\frac{3.16}{d_1} \right)^2 \cdot \frac{1}{2 \cdot 9.81}$ $1.5 \cdot 1.15 + 0.60 = d_1 + \frac{0.51}{d_1^2}$ $2.32 = d_1 + \frac{0.51}{d_1^2}$ <p>By trial and error, it is found that</p> $d_1 = 0.53 \text{ m} \quad (\text{d}_1 \text{ should be less than glacis drop})$ <p>CHECK SUPERCRITICAL CONJUGATE DEPTH</p> <p>Check the supercritical conjugate depth (d_1) by applying Bernoulli's Energy Equation over Section (0) and (1).</p> <p>Assuming no energy loss between Section (0) and (1), and that the upstream velocity is essentially zero, the formula becomes:</p> $H = d_1 + \frac{V_1^2}{2g}$ <p>$H = \text{Height difference between Inlet Water Level and Basin Invert Level}$ $= 6.13 - 3.70 = 2.43 \text{ m}$</p> <p>As formulated above $V_1 = \frac{3.16}{d_1}$</p> <p>Entering the values for H and V_1, the Energy Equation becomes:</p> $2.43 = d_1 + \frac{0.51}{d_1^2}$ <p>By trial and error, it is found that</p> $d_1 = 0.52 \text{ m} \quad \text{user justified } d_1 = \text{m}$ <p>The two calculated values for supercritical conjugate depth (d_1) are now compared and the smaller value is assumed as the critical design condition.</p> |
|---|

```

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 = -----
                                         V1
                                         (g*d1)^0.5

V1 = Q = 11.59
     B1*d1   3.67 * 0.52 = 6.13 m/sec

F = 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=Spacing=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

```

| |
|---|
| $K_2 = 3.78$ $d_2 = \text{Subcritical Conjugate Depth} = 1.74 \text{ m}$ $L = 3.78 * 1.74 = 6.60 \text{ m}$ 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. $V_3 = \frac{Q}{A_3}$ A3 = area of flow at the Protective Apron $A_3 = B_3 * TWD + SS * TWD^2$ $B_3 = \text{Bed Width of Protective Apron}$ $= B_a + 2 * C_s + 2 * (G + L) * (\tan \phi)$ $B_a = \text{Distance between Abutments} = 3.45 \text{ m}$ $C_s = \text{Gate Clearance Width} = 0.00 \text{ m}$ $G = \text{Gacis Length} = 1.80 \text{ m}$ $\phi = \text{Basin Flare Angle} = 3.50^\circ$ $L = \text{Length of Stilling Basin} = 7.00 \text{ m}$ $B_3 = 3.45 + 0.00 + 2 * 8.80 * (0.061)$ $= 4.53 \text{ m}$ Use 4.50 m <----- Design BW of Khal = 3.00 m Bed width of khal < B3; Need Special Measure $TWD = \text{TWD corresponding to flow depth (d2)} = TWD_{min} = 1.74$ $Ss = \text{Protective Apron Side Slope} = (1 : 1.50) \text{ Vertical : Horizontal}$ $A_3 = B_3 * TWD + Ss * TWD^2$ $= 4.50 * 1.74 + 1.50 * 1.74^2$ $= 12.42 \text{ m}^2$ $V_3 = \frac{Q}{A_3} = \frac{11.59}{12.42} = 0.93 \text{ m/sec}$ $V_3 \leq 1.0 \text{ m/sec; Design is O.K.}$ |
| 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 $R = \text{Regime Scour Depth}$ $= 1.35 * (q^2/f)^{0.33}$ $q = Q(T5)/B3(r/s)$ $= 2.57 \text{ m}^3/\text{sec}$ $f = \text{Slit Factor}$ $= 0.42 \text{ (for fine sand)}$ $R = 1.35 * (2.57^2 / 0.42)^{0.33}$ $= 3.36 \text{ m}$ $R_{us} = C/S \text{ Scour Depth} = 1.25 * R$ $= 4.19 \text{ m}$ $R_{ds} = R/S \text{ Scour Depth} = 1.50 * R$ $= 5.03 \text{ m}$ $d(u) = C/S \text{ Cut-off Wall Depth} = R_{us} - (H_w + D_u)$ $= 4.19 - (1.83 + 0.40)$ $= 1.96 \text{ m}$ |

Use **2.00** m <----- User's value for C/S cutoff ->
 $d(d) = R/S \text{ Cut-off Wall Depth} = R/S \text{ Scour depth} - R/S \text{ Water depth}$
= 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 Pressure | | | |
| Tidal/Non-Tidal ==> NT | | | |
| REQUIRED INPUT DATA | | | |
| Water Retention Mode | | | |
| Design C/S Water Level | --> 6.50 mPwd | Water Retn Function (Y/N) | Y |
| Design R/S Water Level | --> 3.70 mPwd | Retn WL | 6.50 mPwd |
| <small>[Min Design Head =1.00 m]</small> | | | |
| Flushing Mode | | | |
| Design C/S Water Level --> 4.30 mPwd, Monsoon BWL Design R/S Water Level --> 4.30 mPWD R/S Flushing WL <small>[Min Design Head =1.00 m]</small> | | | |
| C/S Apron Level --> 3.90 m R/S Apron Level --> 3.70 m | | | |
| Elevation at bottom of C/S Cutoff Wall --> 1.90 m Elevation at bottom of R/S Cutoff Wall --> 0.40 m | | | |
| Elevation under Floor at C/S Cutoff Wall --> 3.50 m Elevation underneath apron at R/S Cutoff Wall . 3.10 m | | | |
| Total Floor Length (b) --> 22.50 m Distance between U/S and D/S Cutoff Walls (b') . 22.00 m | | | |
| I L 4.30 mPwd C/S Drop at Glacis 0.40 m R/S Drop at Glacis 0.60 m | | | |
| C/S Cut-off Depth 2.00 m R/S Cut-off Depth 3.30 m | | | |
| 'lr Thick at End (assumed) C/S End 0.40 m R/S End 0.60 m | | | |
| Length of Box Part 6.00 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 | | | |
| | | | |
| C/S R/S Sections | | | |
| B3 = 4.50 2.00 1.90 El | | | |
| I. DESIGN FOR EXIT GRADIENT | | | |
| Exit gradient is calculated using Khosla's equations. | | | |
| a. Water Retention Mode | | | |
| $Ge = \frac{H}{d} * \frac{1}{\pi * r^{0.5}}$ | | | |
| 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
Ge = 2.80 * 1 / (3.30 * pi * 3.95 ^ 0.5) = 0.136 < Maximum Permitted Gradient 1/6
Floor Length and R/S Cutoff Wall Depth is O.K

```

b. Flushing Mode

```

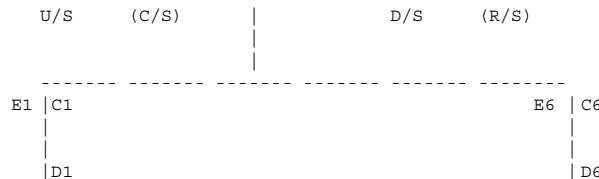
H      1
Ge = Exit Gradient = --- * -----
d      pi * r^0.5

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:



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

```

| Concrete Thickness (m) | $\frac{H * \phi}{u}$ | Section Length from U/S to Section (m) | ϕ | Uplift Pressure (Kn/M2) | Computed Concrete Thickness (m) | Recommended Concrete 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, weight 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

$$a = b/d = 22.50 / 2.00 = 11.25$$

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

$$\phi c_1 = 0\%$$

$$\phi E_1 = \arccos((r-2)/r)/\pi = 26.43\%$$

$$\phi D_1 = \arccos((r-1)/r)/\pi = 18.41\%$$

ϕE_1 must be corrected for the effect of the D/S Cutoff Wall (c_1) and the thickness of the floor (c_2).

$$c_1 = 19 * (d''/b')^{0.5} * (d' + d'')/b \\ = 19 * (2.70 / 22.00)^{0.5} * (1.60 + 2.70) / 22.50 \\ = 1.27\% \text{ (-ve)}$$

$$c_2 = (\phi E_1 - \phi D_1) * T_{c1} = (8.02\% * 0.40) = 1.60\% \text{ (-ve)}$$

$$d_1 = 2.00$$

$$\phi E_1 \text{ (corrected)} = \phi E_1 + c_1 + c_2 = 23.55\%$$

ii. At Downstream (r/s) Cutoff Wall

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

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

$$\phi E_6 = 100\%$$

$$\phi C_6 = 100\% - \arccos((r-2)/r)/\pi = 66.41\%$$

$$\phi D_6 = 100\% - \arccos((r-1)/r)/\pi = 76.83\%$$

ϕC_6 must be corrected for the effect of the U/S Cutoff Wall (c_1) and the thickness of the floor (c_2).

$$c_1 = 19 * (d'/b')^{0.5} * (d' + d'')/b \\ = 19 * (1.60 / 22.00)^{0.5} * (2.70 + 1.60) / 22.50 \\ = 0.98\% \text{ (+ve)}$$

$$c_2 = (\phi D_6 - \phi C_6) * T_{c6} = (10.42\% * 0.60) = 1.89\% \text{ (+ve)}$$

$$d_6 = 3.30$$

$$\phi C_6 \text{ (corrected)} = \phi C_6 + c_1 + c_2 = 69.29\%$$

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

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

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

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

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

| J | IJ | Chainage | 2,590.0 |
|---|----|----------|-------------------------------------|
| Length | | 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 EI | | 8.54 | m PWD |
| Freeboard for standpipes | | 0.60 | m |
| EI of top of standpipes | | 9.14 | m PWD |
| Diameter of Pipe (external) | | 250 | mm $hf = (2*f*I*v^2)/(g*d)$ |
| Diameter of Pipe (internal) | | 244 | mm $f = 0.0042$ |
| Design Discharge | | 0.037 | m ³ /sec $v = 0.79$ m/s |
| Pipe Friction Loss | | 0.44 | $hf = 0.439$ m |
| Velocity head, v ² /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 EI at I | | 9.06 | m PWD |

| I | HI | Chainage | 2,390.0 |
|---|----|----------|-------------------------------------|
| Length | | 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 EI | | 9.06 | m PWD |
| Freeboard for standpipes | | 0.60 | m |
| EI of top of standpipes | | 9.66 | m PWD |
| Diameter of Pipe (external) | | 250 | mm $hf = (2*f*I*v^2)/(g*d)$ |
| Diameter of Pipe (internal) | | 244 | mm $f = 0.0042$ |
| Design Discharge | | 0.037 | m ³ /sec $v = 0.79$ m/s |
| Pipe Friction Loss | | 0.11 | $hf = 0.110$ m |
| Velocity head, v ² /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 EI 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 $hf = (2*fI*v^2)/(g*d)$ |
| Diameter of Pipe (internal) | | 273 | mm $f = 0.0042$ |
| Design Discharge | | 0.046 | m ³ /sec $v = 0.79$ m/s |
| Pipe Friction Loss | | 0.89 | $hf = 0.891$ m |
| Velocity head, v ² /2g | | 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 $hf = (2*fI*v^2)/(g*d)$ |
| Diameter of Pipe (internal) | | 307 | mm $f = 0.0042$ |
| Design Discharge | | 0.058 | m ³ /sec $v = 0.78$ m/s |
| Pipe Friction Loss | | 0.58 | $hf = 0.582$ m |
| Velocity head, v ² /2g | | 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 | EF | Chainage | 1,540.0 |
|---|----|--------------|--|
| Length | | 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 | DE | Chainage | 1,270.0 |
|---|----|--------------|--|
| Length | | 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 | CD | Chainage | 1,030.0 |
|---|----|----------|--|
| Length | | 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 EI | | 12.02 | m PWD |
| Freeboard for standpipes | | 0.60 | m |
| EI of top of standpipes | | 12.62 | m PWD |
| Diameter of Pipe (external) | | 400 | mm $hf = (2*f*I*v^2)/(g*d)$ |
| Diameter of Pipe (internal) | | 390 | mm $f = 0.0042$ |
| Design Discharge | | 0.096 | m³/sec $v = 0.80 \text{ m/s}$ |
| Pipe Friction Loss | | 0.44 | hf = 0.440 m |
| Velocity head, v²/2g | | 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 EI at C | | 12.55 | m PWD |

| C | BC | Chainage | 720.0 |
|---|----|----------|--|
| Length | | 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 EI | | 12.55 | m PWD |
| Freeboard for standpipes | | 0.60 | m |
| EI of top of standpipes | | 13.15 | m PWD |
| Diameter of Pipe (external) | | 450 | mm $hf = (2*f*I*v^2)/(g*d)$ |
| Diameter of Pipe (internal) | | 439 | mm $f = 0.0042$ |
| Design Discharge | | 0.105 | m³/sec $v = 0.69 \text{ m/s}$ |
| Pipe Friction Loss | | 0.27 | hf = 0.272 m |
| Velocity head, v²/2g | | 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 EI 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 |
| EI 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 |
| EI 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 |
| EI of top of header tank | | 14.08 | m PWD |
| Height of Tank | | 5.63 | |

EXHIBIT G6-G10: DesignPro 10 - StructuralDesignUSD

| 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 : | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| $f'_c = 21.00 \text{ N/mm}^2$ | $\psi = 3000$ | $f_y = 415 \text{ N/mm}^2$ | $\psi = 60000$ | $\beta_1 = 0.85$ | $\phi = 0.90$ | $K_a = 0.41$ | $\psi = 25^\circ$ | $\gamma_{\text{conc}} = 23.60 \text{ Kn/m}^3$ | $\gamma_{\text{s(moist)}} = 17.40 \text{ Kn/m}^3$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| $\gamma_{\text{s(SAT)}} = 18.90 \text{ Kn/m}^3$ | $\gamma_{\text{s(Sub)}} = 9.09 \text{ Kn/m}^3$ | $\gamma_{\text{w(Water)}} = 9.81 \text{ Kn/m}^3$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <thead> <tr> <th>R/S =</th><th>C-C</th><th>G-G</th><th>= C/S</th><th></th></tr> <tr> <th colspan="4">Section C-C / G-G</th><th></th></tr> <tr> <th>t₁</th><th>t₂</th><th>t₃</th><th>h</th><th>L</th></tr> </thead> <tbody> <tr> <td>R/S</td><td>250</td><td>450</td><td>600</td><td>4700</td><td>3450</td></tr> <tr> <td></td><td>250</td><td>450</td><td>600</td><td>4700</td><td>3450</td></tr> <tr> <td>1800</td><td>250</td><td>419</td><td>600</td><td>4400</td><td>4033</td></tr> <tr> <td>C/S</td><td>250</td><td>450</td><td>600</td><td>4700</td><td>3450</td></tr> <tr> <td></td><td>250</td><td>450</td><td>600</td><td>4700</td><td>3450</td></tr> <tr> <td>1500</td><td>250</td><td>409</td><td>600</td><td>4450</td><td>3927</td></tr> </tbody> </table> | R/S = | C-C | G-G | = C/S | | Section C-C / G-G | | | | | t ₁ | t ₂ | t ₃ | h | L | R/S | 250 | 450 | 600 | 4700 | 3450 | | 250 | 450 | 600 | 4700 | 3450 | 1800 | 250 | 419 | 600 | 4400 | 4033 | C/S | 250 | 450 | 600 | 4700 | 3450 | | 250 | 450 | 600 | 4700 | 3450 | 1500 | 250 | 409 | 600 | 4450 | 3927 | <table border="1"> <thead> <tr> <th>R/S =</th><th>D-D</th><th>H-H</th><th>= C/S</th><th></th></tr> <tr> <th colspan="4">Section D-D / H-H</th><th></th></tr> <tr> <th>t₁</th><th>t₂</th><th>t₃</th><th>h</th><th>L</th></tr> </thead> <tbody> <tr> <td>R/S</td><td>250</td><td>419</td><td>600</td><td>4400</td><td>4033</td></tr> <tr> <td></td><td>250</td><td>419</td><td>600</td><td>4400</td><td>4033</td></tr> <tr> <td>2400</td><td>250</td><td>378</td><td>531</td><td>3200</td><td>4810</td></tr> <tr> <td>C/S</td><td>250</td><td>409</td><td>600</td><td>4450</td><td>3927</td></tr> <tr> <td></td><td>250</td><td>409</td><td>600</td><td>4450</td><td>3927</td></tr> <tr> <td>2700</td><td>250</td><td>335</td><td>465</td><td>3100</td><td>4786</td></tr> </tbody> </table> | R/S = | D-D | H-H | = C/S | | Section D-D / H-H | | | | | t ₁ | t ₂ | t ₃ | h | L | R/S | 250 | 419 | 600 | 4400 | 4033 | | 250 | 419 | 600 | 4400 | 4033 | 2400 | 250 | 378 | 531 | 3200 | 4810 | C/S | 250 | 409 | 600 | 4450 | 3927 | | 250 | 409 | 600 | 4450 | 3927 | 2700 | 250 | 335 | 465 | 3100 | 4786 | <table border="1"> <thead> <tr> <th>R/S =</th><th>E-E</th><th>I-I</th><th>= C/S</th><th></th></tr> <tr> <th colspan="4">Section E-E / I-I</th><th></th></tr> <tr> <th>t₁</th><th>t₂</th><th>t₃</th><th>h</th><th>L</th></tr> </thead> <tbody> <tr> <td>R/S</td><td>250</td><td>378</td><td>531</td><td>3200</td><td>4810</td></tr> <tr> <td></td><td>250</td><td>378</td><td>531</td><td>3200</td><td>4810</td></tr> <tr> <td>4600</td><td>250</td><td>300</td><td>400</td><td>3200</td><td>6300</td></tr> <tr> <td>C/S</td><td>250</td><td>335</td><td>465</td><td>3100</td><td>4786</td></tr> <tr> <td></td><td>250</td><td>335</td><td>465</td><td>3100</td><td>4786</td></tr> <tr> <td>1300</td><td>250</td><td>300</td><td>400</td><td>3100</td><td>5200</td></tr> </tbody> </table> | R/S = | E-E | I-I | = C/S | | Section E-E / I-I | | | | | t ₁ | t ₂ | t ₃ | h | L | R/S | 250 | 378 | 531 | 3200 | 4810 | | 250 | 378 | 531 | 3200 | 4810 | 4600 | 250 | 300 | 400 | 3200 | 6300 | C/S | 250 | 335 | 465 | 3100 | 4786 | | 250 | 335 | 465 | 3100 | 4786 | 1300 | 250 | 300 | 400 | 3100 | 5200 | | | | | |
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| R/S | 250 | 378 | 531 | 3200 | 4810 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Pressure Calculation for STAAD input | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Height of Ground water = 1000 mm Height of Surcharge = 0 mm</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <thead> <tr> <th colspan="7">Section C-C / G-G</th> </tr> <tr> <th>p_a</th><th>p_b</th><th>p_c</th><th>p_w</th><th>p_{cm}</th><th>p_a+p_b+p_{cm}</th><th>p_c+p_w-p_{cm}</th></tr> </thead> <tbody> <tr> <td>R/S</td><td>0.00</td><td>26.40</td><td>4.84</td><td>12.75</td><td>9.27</td><td>35.67</td><td>8.32</td></tr> <tr> <td>C/S</td><td>0.00</td><td>26.40</td><td>4.84</td><td>12.75</td><td>9.27</td><td>35.67</td><td>8.32</td></tr> </tbody> </table> | | | | | | | | | | 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 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <thead> <tr> <th colspan="7">Section D-D / H-H</th> </tr> <tr> <th>p_a</th><th>p_b</th><th>p_c</th><th>p_w</th><th>p_{cm}</th><th>p_a+p_b+p_{cm}</th><th>p_c+p_w-p_{cm}</th></tr> </thead> <tbody> <tr> <td>R/S</td><td>0.00</td><td>24.26</td><td>4.84</td><td>12.75</td><td>9.27</td><td>33.53</td><td>8.32</td></tr> <tr> <td>C/S</td><td>0.00</td><td>24.61</td><td>4.84</td><td>12.75</td><td>9.27</td><td>33.89</td><td>8.32</td></tr> </tbody> </table> | | | | | | | | | | 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 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 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 (mm²/m) = | 485 | 1230 | 266 | 196 | 412 | 764 | 340 | 474 | |
| Req. Steel for Temp. and Shrinkage : | | | | | | | | | |
| A_s (mm²/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: | | | Breast Wall: Numbers | 1 | |
| Railing: Bridge Deck: | | | Bottom Elevation: | | 10.50 |
| Numbers of Posts: | 0 | | Height: | 3500 | |
| Cross-section: Width: | 150 | | Width: | 1700 | |
| Length | 150 | | Thickness: | 250 | |
| Height of Posts: | 800 | | Thickness:Bottom | 250 | |
| Number of Railings: | 0 | | Thrust Beam: Numbers | 1 | |
| Cross-section: Width: | 150 | | Width:1 | 0 | |
| Height: | 150 | | Width:2 | 0 | |
| Length of Railings: | 1700 | | Depth: | 0 | |
| Railing: Operation Deck: | | | Length: | 1700 | |
| Numbers of Posts: | 4 | | Piers: | | |
| Cross-section: Width: | 150 | | Numbers of Piers: | 0 | |
| Length | 150 | | Length: Gate Part: | 1500 | |
| Height of Posts: | 800 | | Box Part: | 5090 | |
| Number of Railings: | 4 | | Gate Slots: Numbers: | 2 | |
| Cross-section: Width: | 150 | | Width: | 150 | |
| Height: | 150 | | Depth: | 110 | |
| Length of Railings: | 1400 | | Stop log Slots: Numbers: | 2 | |
| Railing: Operation Deck: Short | | | Width: | 145 | |
| Number of Railings: | 4 | | Depth: | 65 | |
| Cross-section: Width: | 150 | | Abutments: | | |
| Height: | 150 | | Numbers of Abutments: | 2 | |
| Length of Railings: | 1500 | | Length: Gate Part: | 1500 | |
| Curb: | | | Box Part: | 5090 | |
| Numbers of Curbs: | 0 | | Thickness: Gate Part (Top): | 250 | 250 |
| Curb Width (incl. Posts): | 375 | | Gate Part (Bottom): | 400 | 400 |
| Slope Width: | 25 | | Box Part (Top): | 400 | |
| Height: | 200 | | Box Part (Bottom): | 400 | |
| Top Slab: Bridge Deck: | | | Base Slab: | | |
| Width: | 4665 | | Length: | 6165 | |
| Length: | 1700 | | Width: | 1700 | |
| Thickness: | 400 | | Thickness: | 500 | |
| Top Slab: Operation Deck: | | | Fillets: | | |
| Length: | 1500 | | Numbers: | 4 | |
| Width: Strip-1 | 425 | | Depth: | 100 | |
| Strip-2 | 495 | | Width: | 100 | |
| Strip-3 | 325 | | Length: | 6165 | |
| Thickness: | 250 | | | | |

(Input Data Sheet – Contd)

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

(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): | 0 | |
| Floor: Glacis Part: | | | Numbers | 1800 | |
| Numbers: | 1 | | Width: | 150 | |
| Length: | 1200 | | Height: | 750 | |
| Width (U/S End): | 1700 | 900 | Length (Bottom): | 500 | |
| Width (D/S End): | 1960 | | Extension | | |
| Thickness (U/S End): | 500 | 1234 | RCC pre-cast Sheet Pile | | |
| Thickness (D/S End): | 500 | | R/S Depth | 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 | | | |

(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 | | | | | | |
| <u>CC (1:3:6) Under Structure:</u> | | | | | | |
| 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 m³ |
| <u>RCC (1:2:4): Bottom Slab:</u> | | | | | | |
| 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 m³ |
| <u>RCC (1:2:4): Abutment, Pier, Return Wall, Breast Wall, Chute Block, Baffle Block, Cut-off, Caisson etc.:</u> | | | | | | |
| 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 m³ |

(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 | |
| | | | | | | | 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 | | | |
| <u>RCC (1:2:4): Top Slab, Curb etc.:</u> | | | | | | | |
| 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 | | | |
| <u>RCC (1:2:4) Railbar & Railpost:</u> | | | | | | | |
| 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)SI = | 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.Lifting) = | 0.000 X 0.000 X 0.000 X 0 | = | 0.0000 m ³ | | | | |
| | | Total | = | 0.2800 m ³ | | | |
| <u>38mm Wearing Course (1:1.5:3) on Bridge Deck:</u> | | | | | | | |
| Box = | 4.67 X 1.70 X 0 | = | 0.0000 m ² | | | | |
| <u>6mm Thick Plaster in Railing & Railpost:</u> | | | | | | | |
| 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)SI = | 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 |
| CC Blocks with Stone Chips | | | |
| 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 Slope = | | | 256 Nos. |
| Number of Blocks in Sides = | | | 30 Nos. |
| | | Total = | 286 Nos. |
| Brick Works in End Wall: | | | |
| 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 |
| Embedded Metal: | | | |
| 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 |
| | | 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 |
| Local Sand Under Brick Block: | | | |
| 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 |
| Khoa Under Brick Block: | | | |
| Volume of Khoa = | 5.2 X 0.15 | = | 0.7800 m ³ |
| MSGate: | | | |
| 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)

| <u>Fall Boards</u> | | | | | <u>Nos.</u> |
|--|----------------------|--|--|---------------|--------------------------------|
| Stop Logs | = | | | | = |
| <u>Painting of Gauge:</u> | | | | | |
| 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 m² |
| <u>Reinforcement:</u> | = For Structure part | | | | = 4114 Kg |
| | = For Piles Only | | | | = Kg |
| <u>RCC works in Pile</u> | = | 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 m³ |
| <u>RCC Shhet Pile :R/S</u> | = | 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 m² |
| <u>Sand Filling in Foundation</u> | | | | | |
| 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 m³ |
| <u>Leveling & Dressing of Top:</u> | | | | | |
| | = | 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 m² |
| <u>Turfing on Slope of Embankment:</u> | | | | | |
| | = | 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 m² |
| <u>Earthwork in Excavation</u> | = | | | | = 425.00 m ³ |
| <u>Earthwork in Filling</u> | = | | | | = 1049.00 m ³ |
| <u>Painting of sheet piles</u> | | | | | |
| 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 m² |
| <u>Supply & Placing of 20 mmhessian cloth of sheet piles</u> | | | | | |
| 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 m² |
| RCC Bottom: | | | | | 20.7600 |
| RCC Vertical: | | | | | 34.1900 |
| RCC Top: | | | | | 3.9800 |
| | | | | Total: | 58.9300 m³ |
| <u>Reinforcement:</u> | 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: | | | |
| <u>Prework Calculation:</u> | | | |
| 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 | 0.000 |
| Total Area = | | | 0.000 m ² |
| Prework Volume = | | | 0.00 m ³ |
| Earth Cutting = | | | 1.98 m |
| Earth Filling = | | | 2.20 m |
| <u>Postwork Calculation:</u> | | | |
| 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 |

(Bar Bending Schedule Sheet)

| MEMBER MARKS | BAR (mm) | BAR DIA (mm) | SHAPE CODE | SPACING (mm) | DIMENSIONS (mm) | | | | | CUT LENGTH (mm) | BAR PER MEMBER | NOS. OF MEMBER | TOTAL LENGTH (m) | UNIT WT Kg/m | TOTAL WT Kg |
|-----------------------------|----------|--------------|------------|--------------|-----------------|----------|-----------|-----|---|-----------------|----------------|----------------|------------------|--------------|-------------|
| | | | | | A | B | C | D | E | | | | | | |
| BAR BENDING SCHEDULE | | | | | | | | | | | | | | | |
| 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 (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 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 Embt.) |

(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 | 700 | 3 | 0 | 0.00 | 0.50 | 0.00 | |
| | DD | 9 | 4 | 200 | 100 | 100 | 100 | 700 | 3 | 4 | 8.40 | 0.50 | 4.21 | |
| | DD | 9 | 4 | 200 | 100 | 100 | 100 | 700 | 9 | 0 | 0.00 | 0.50 | 0.00 | |
| | DD | 9 | 4 | 200 | 100 | 100 | 100 | 700 | 4 | 4 | 11.20 | 0.50 | 5.61 | |
| | DD | 9 | 4 | 200 | 100 | 100 | 100 | 700 | 6 | 4 | 16.80 | 0.50 | 8.42 | |
| | DD1 | 9 | 4 | 200 | -50 | -50 | -50 | 100 | 0 | 0 | 0.00 | 0.50 | 0.00 | |
| | DD1 | 9 | 4 | 200 | -50 | -50 | -50 | 100 | 0 | 0 | 0.00 | 0.50 | 0.00 | |
| | DD1 | 9 | 4 | 200 | -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 | 88.89 |
| | 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 | | | | | 3080 ~ 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 | SA | 12 | 9 | 550 | 1050 | | | | | 1900 | 2 | 2 | 7.60 | 0.89 | 6.77 |
| Block, End Sill | 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 | 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 - 0.90m X 0.90m) |
| At Ch. 0+5730 Km (East Embkt.) |

(Bar Bending Schedule Sheet - contd)

| | | | | | | | | | | | | | | |
|----------|-----|----|----|------|------|--|--|--|------|---|---|-------|------|------|
| Baffle | SI | 12 | 9 | 550 | 1050 | | | | 1900 | 2 | 2 | 7.60 | 0.89 | 6.77 |
| Block, | SJ | 12 | 14 | 200 | | | | | 200 | 4 | 2 | 1.60 | 0.89 | 1.43 |
| Chute | SL | 12 | 14 | 200 | | | | | 200 | 5 | 3 | 3.00 | 0.89 | 2.67 |
| Block, | SM | 12 | 33 | 774 | 635 | | | | 1409 | 2 | 0 | 0.00 | 0.89 | 0.00 |
| End Sill | 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 | | | | | | | | | | | 0.00 |
| | 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.

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 - 0.90m x 0.90m) |
| | At Ch. 0+5730 Km (East Embkt.) |
| | |
| | |
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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
2. CROSS SECTION

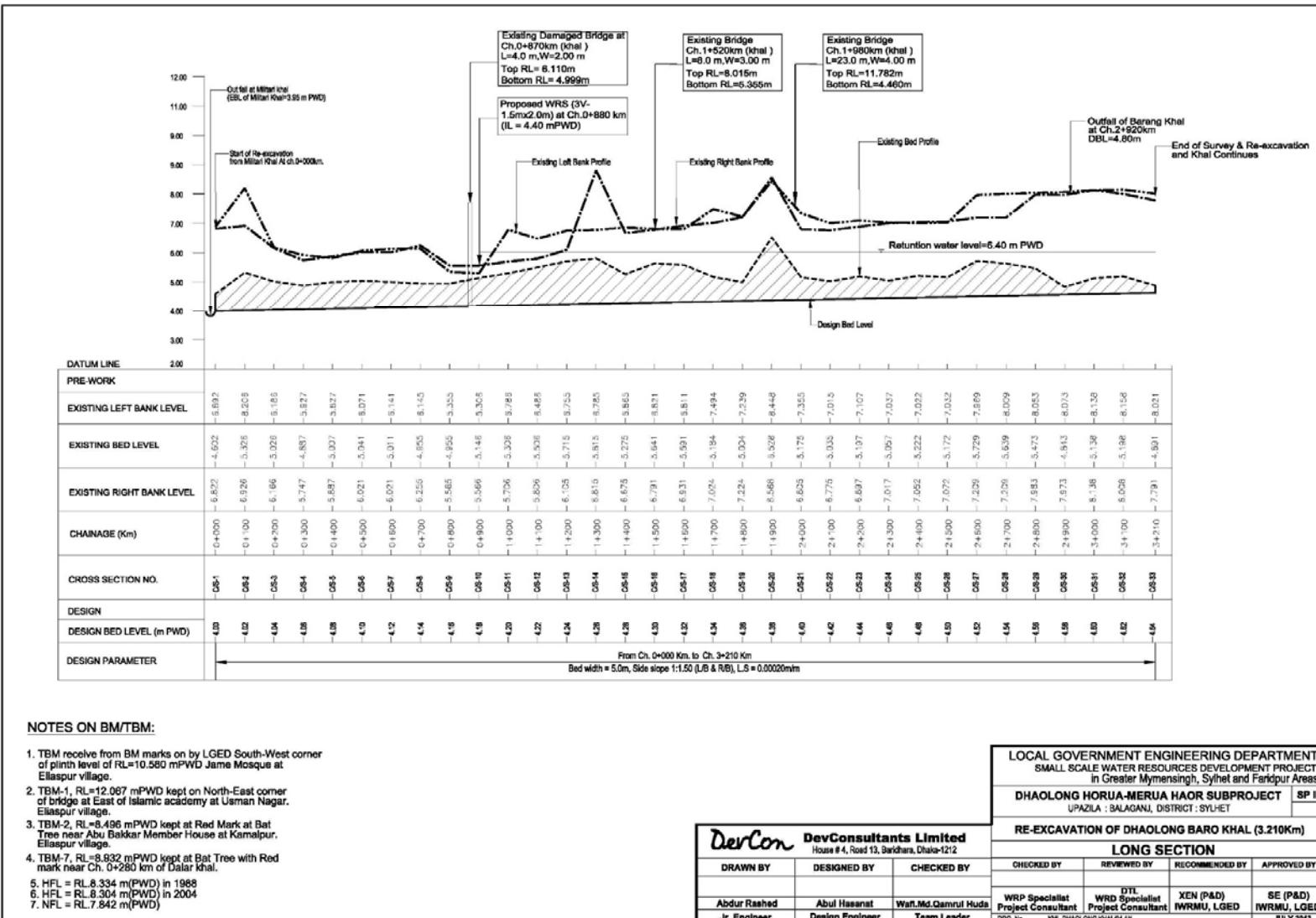
/ KHL - DHAOLONG KHAL / 04 - 1/1

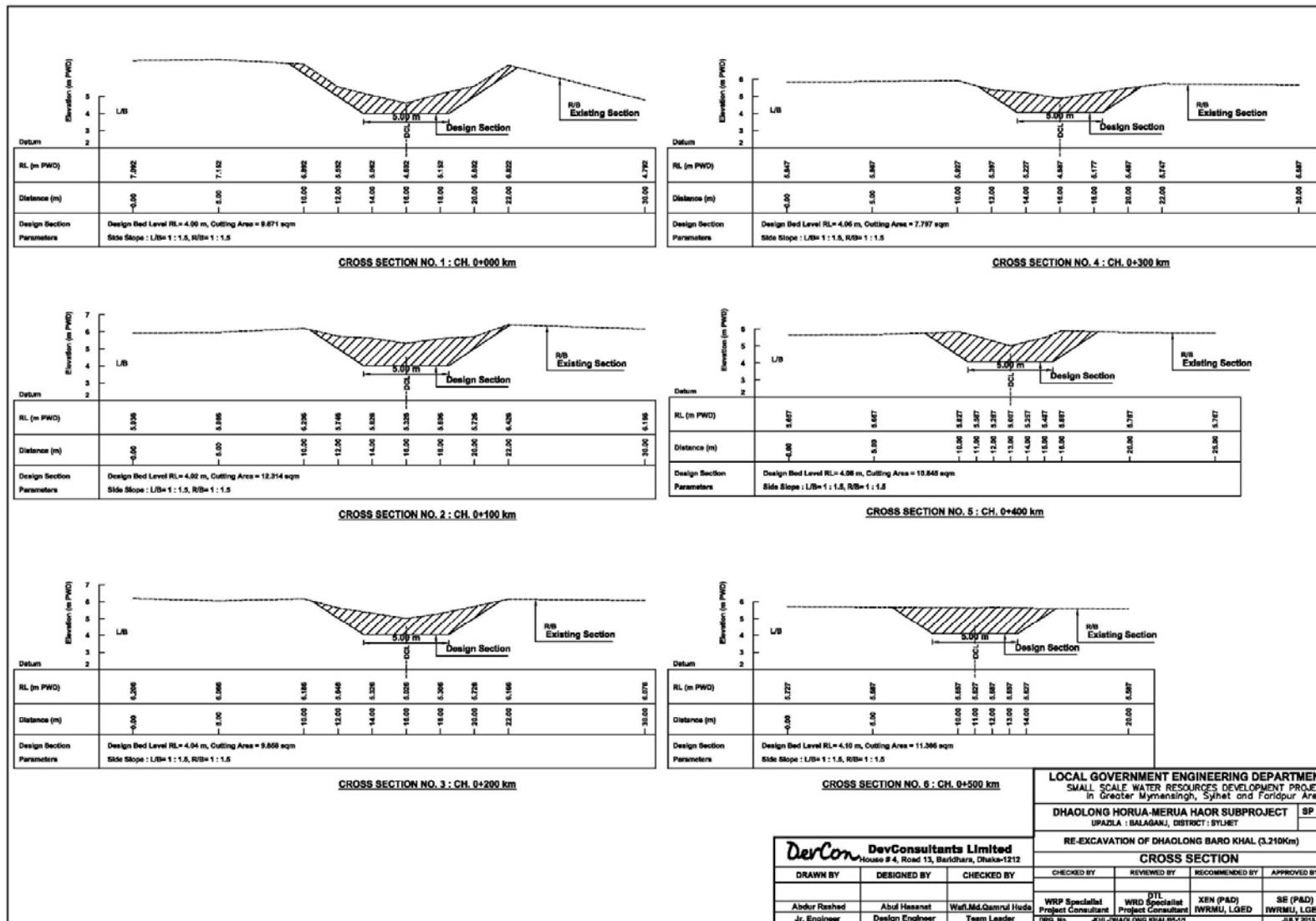
/ KHL - DHAOLONG KHAL / 05 - 1/1

B. REFERENCE BED BLOCKS

1. TYPICAL REFERENCE BED BLOCKS

/ RLS - KAMALPUR KHAL / 1/1





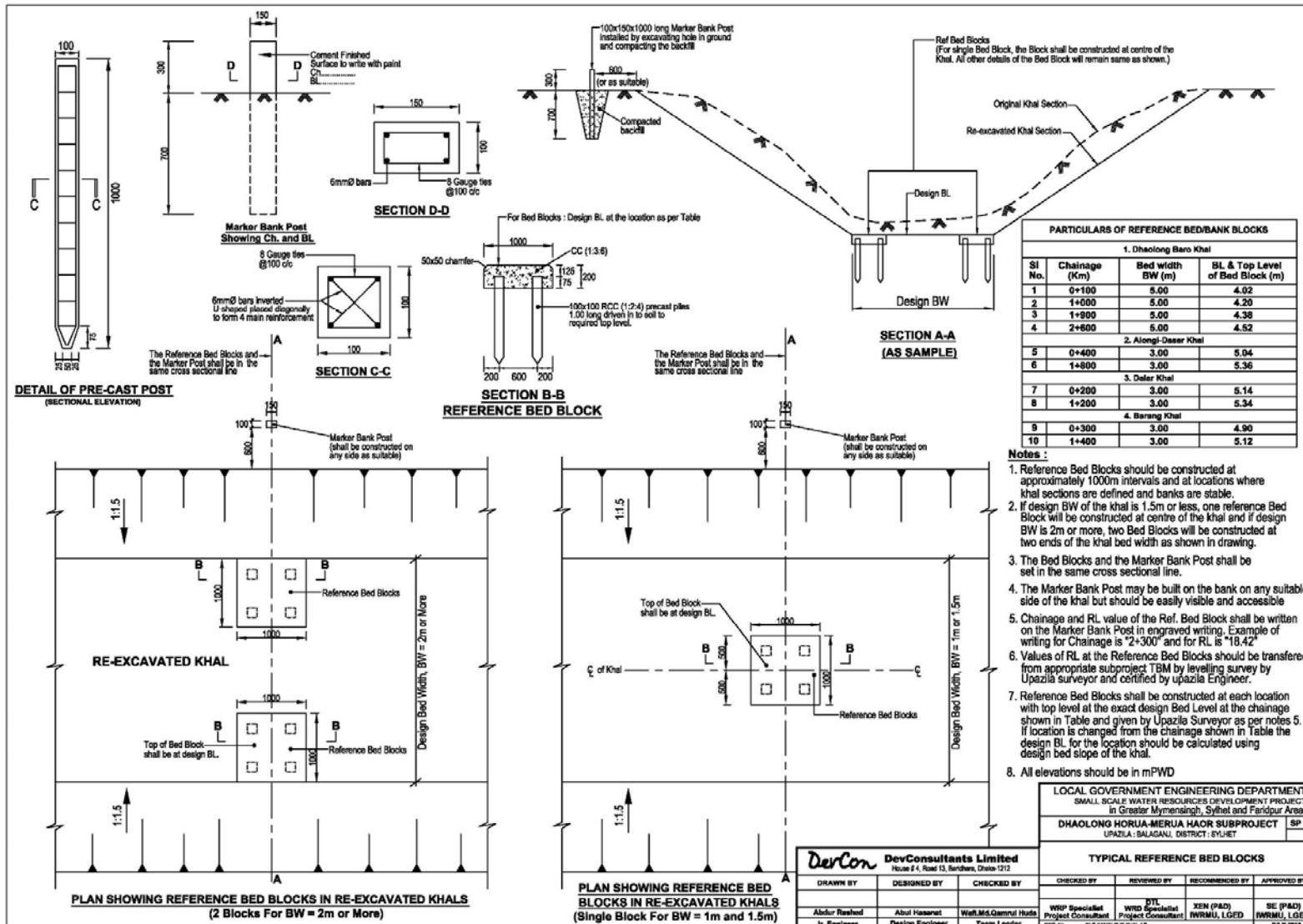


EXHIBIT G6-H2: Standard Drawings for Re-Sectioning of Embankment

DESIGN DRAWINGS
OF
RE-SECTIONING OF EMBANKMENT
LENGTH = 3.000Km

AUGUST 2011

CONTENT OF DRAWINGS

TITLE OF DRAWING

DRAWING NO.

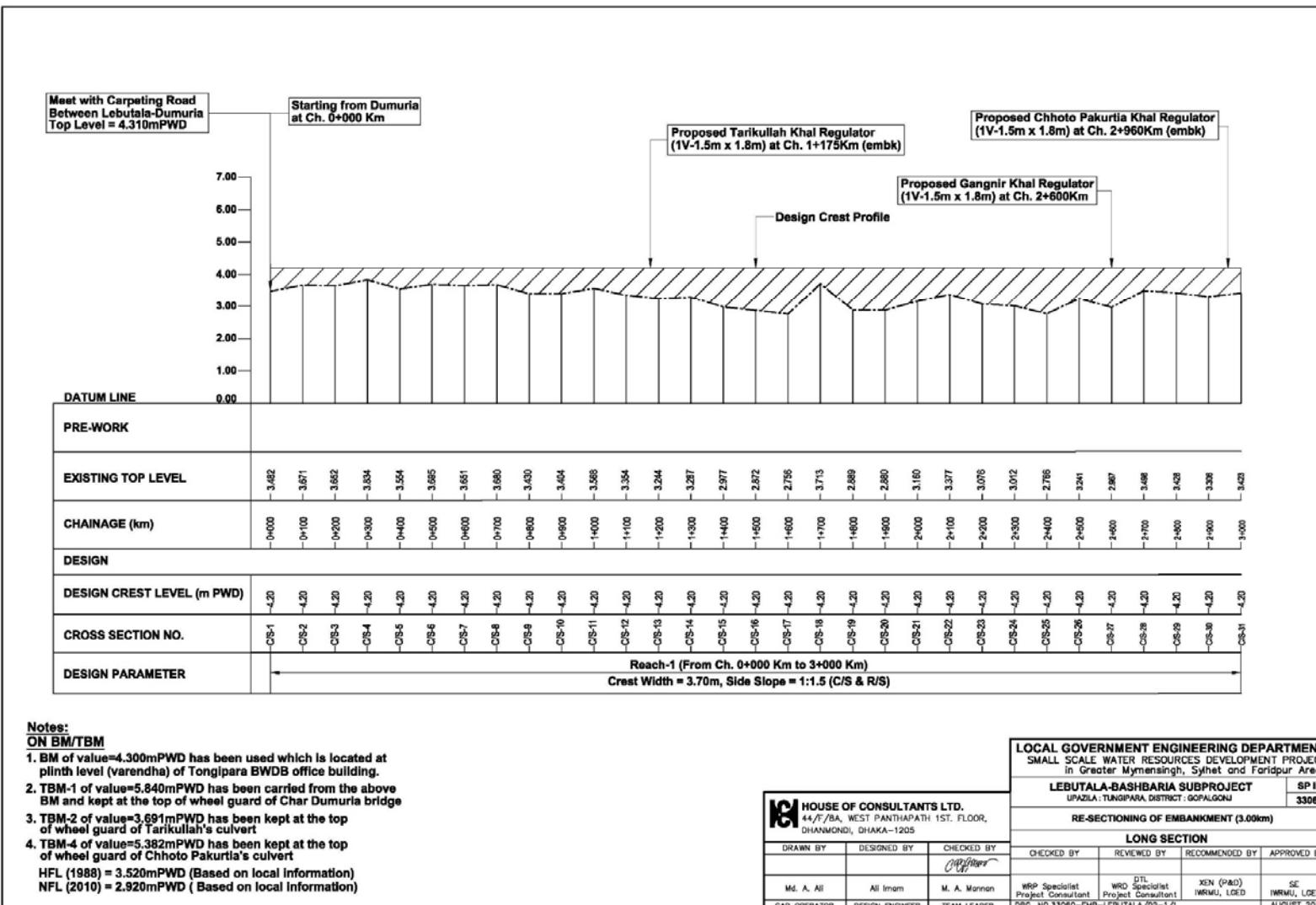
EMBANKMENT:

A. RE-SECTIONING OF EMBANKMENT (LENGTH = 3.000km)

- 1. LONG SECTION
- 2. CROSS SECTION

33060 / EMB-LEBUTALA / 02 -1/1

33060 / EMB-LEBUTALA / 03 - 1/1



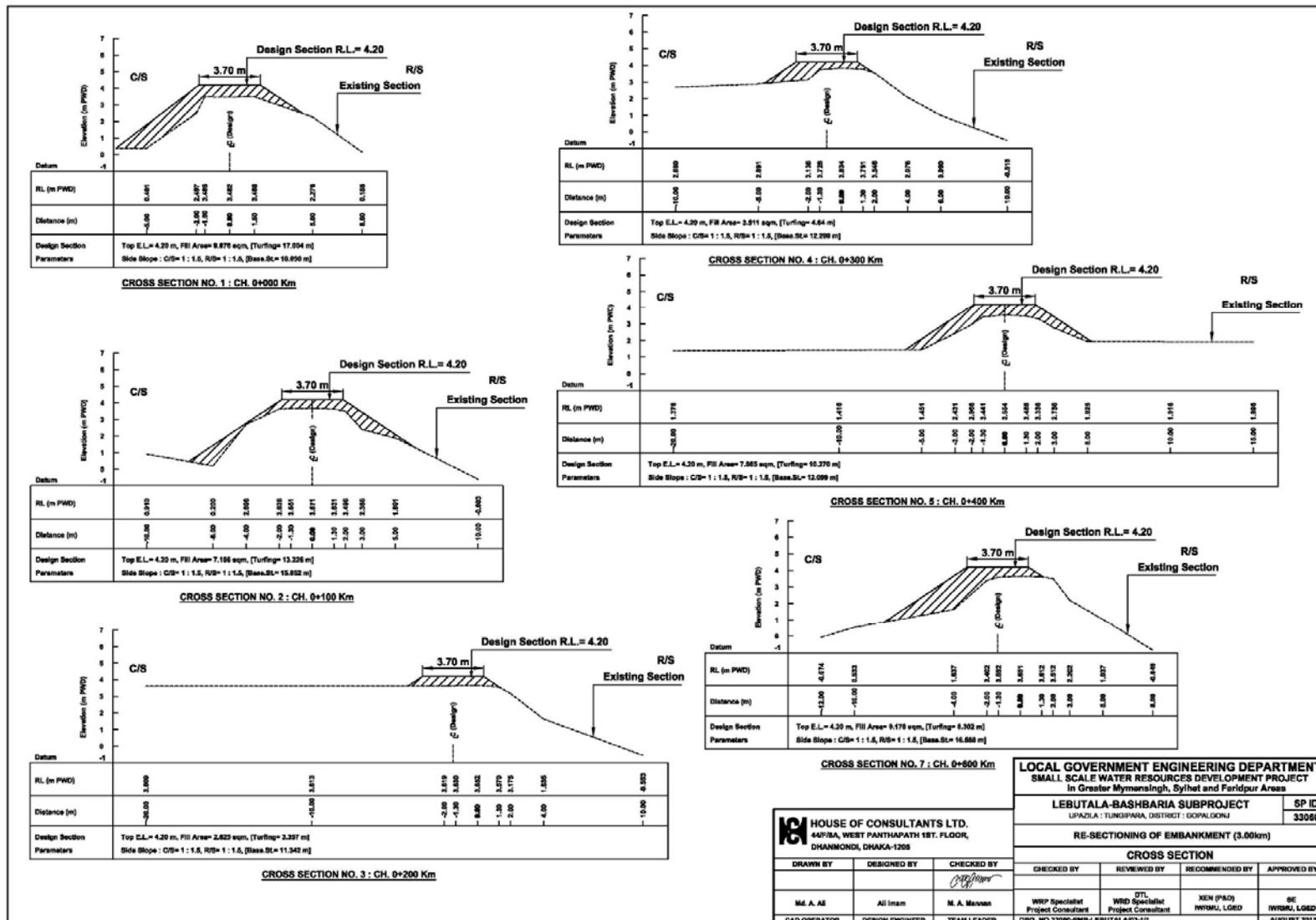


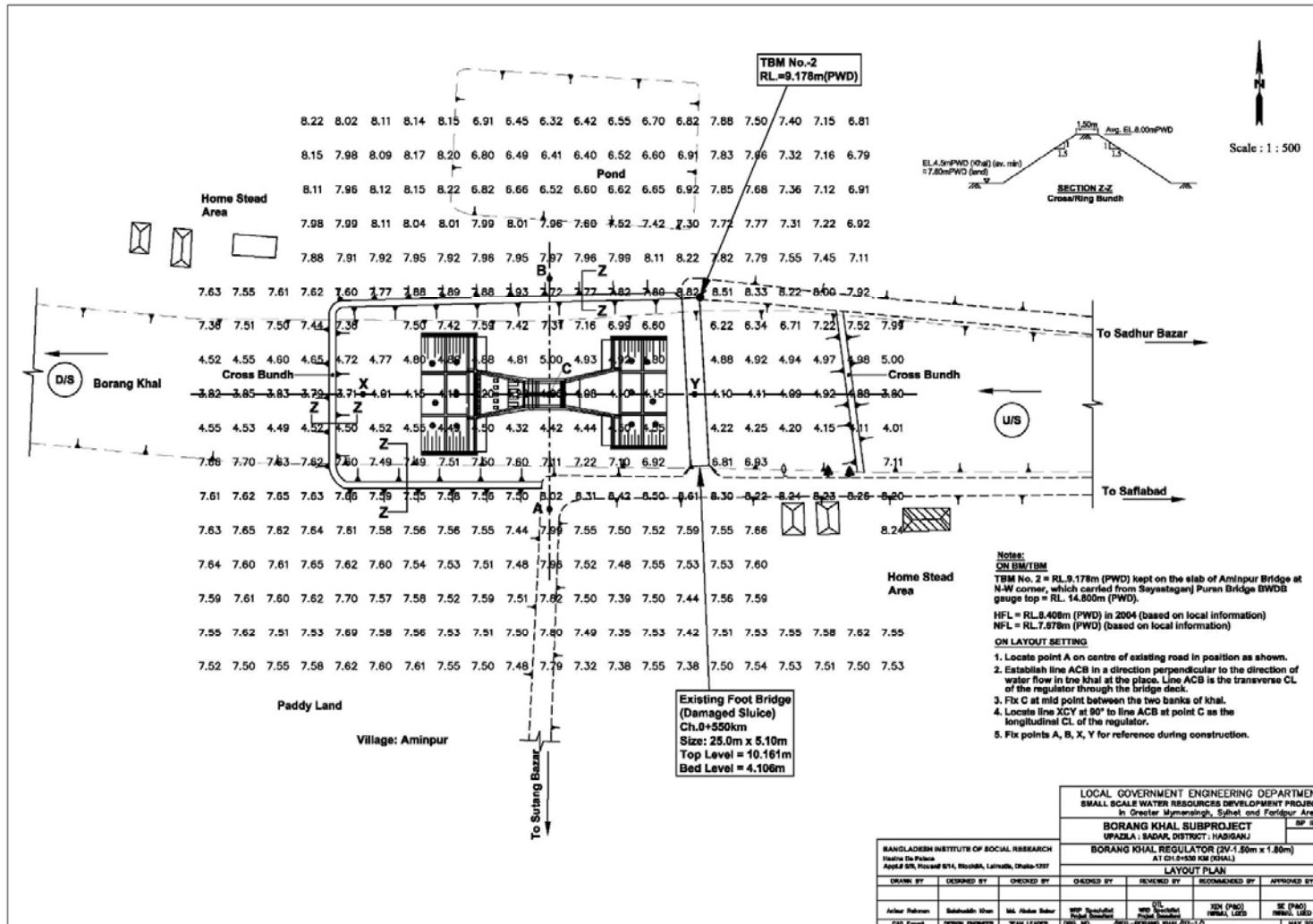
EXHIBIT G6-H.3: Standard Drawings of Regulator

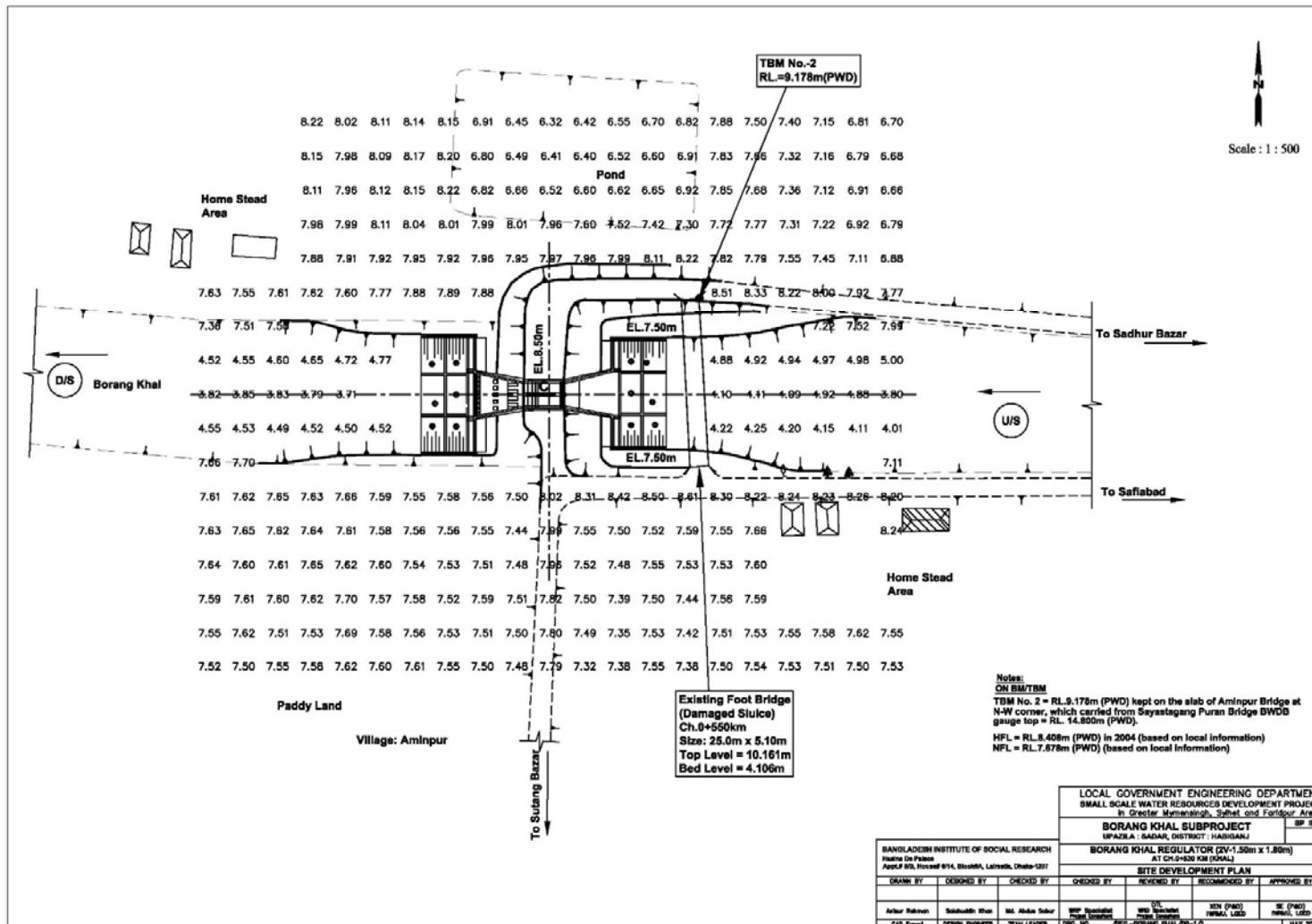
DETAIL DESIGN DRAWINGS
OF
BORANG KHAL REGULATOR (2V-1.50m x 1.80m)
AT CH.0+530 KM (KHAL)

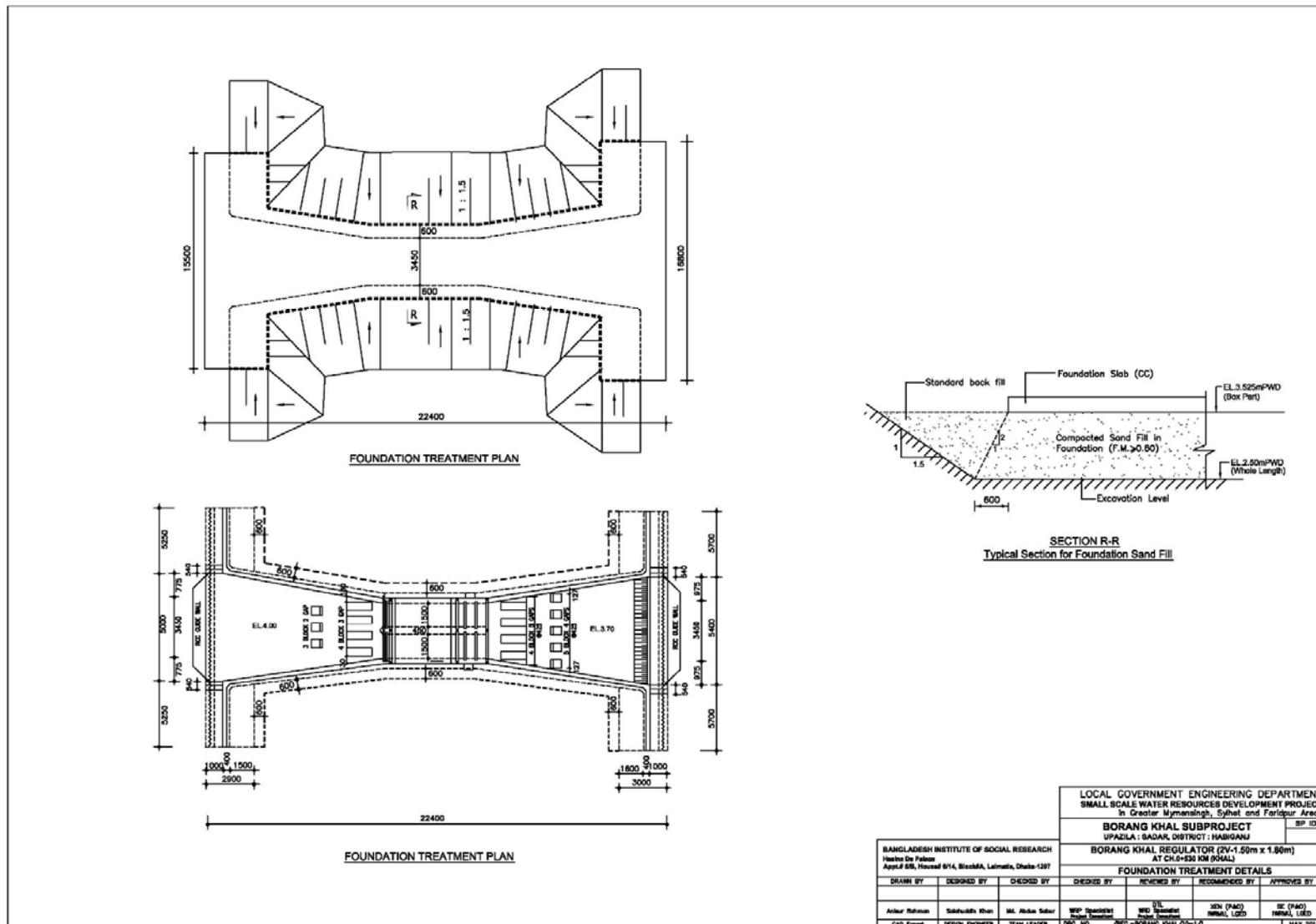
CONTENT OF DRAWINGS

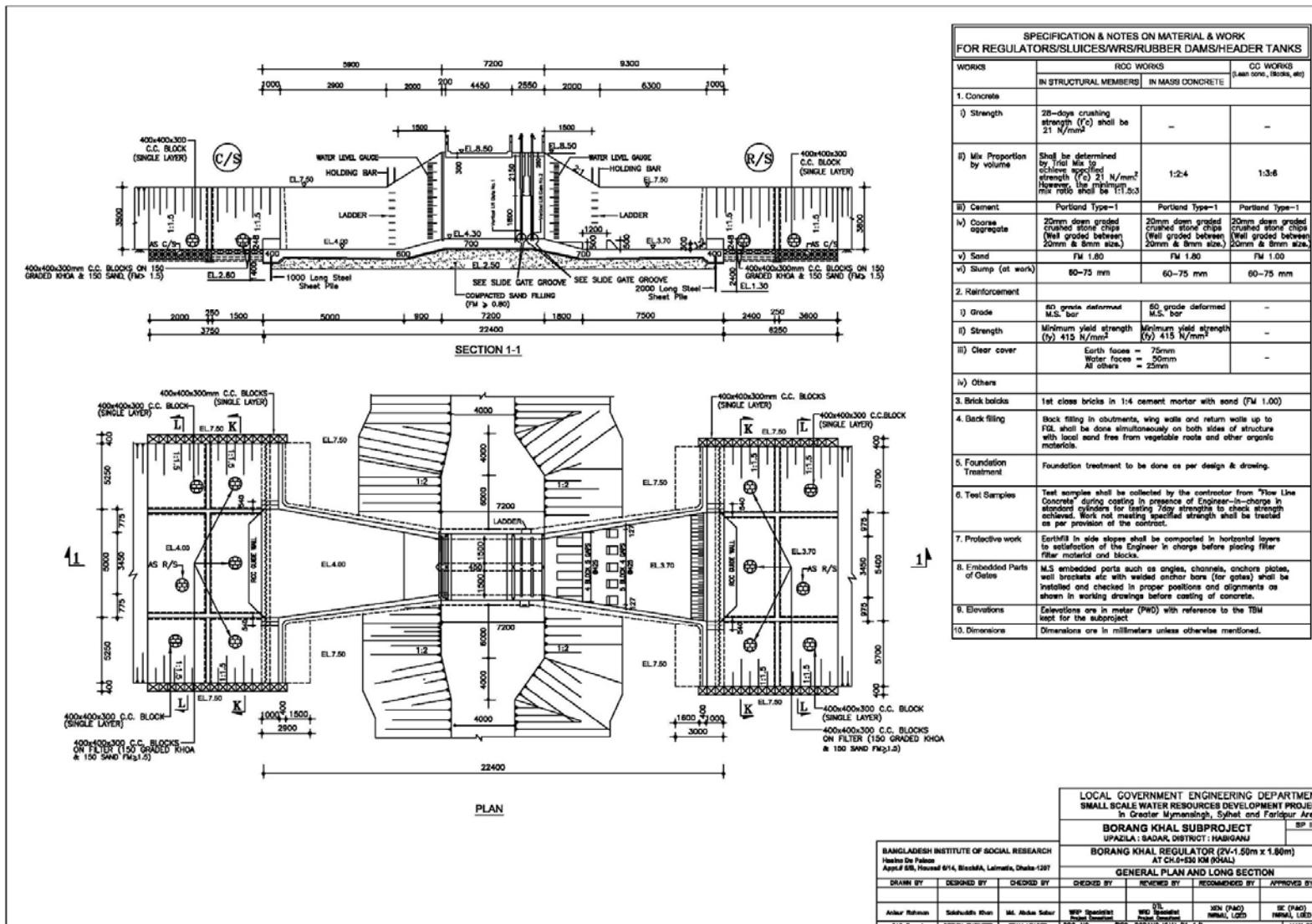
| TITLE OF DRAWING | DRAWING NO. |
|--|-----------------------------|
| INDEX MAP | /INDEX MAP/01 |
| PART - A : BORANG KHAL REGULATOR (2V-1.50m x 1.80m) AT CH.0+530 KM (KHAL) | |
| LAYOUT PLAN | /REG-BORANG KHAL/07-1/1 |
| SITE DEVELOPMENT PLAN | /REG-BORANG KHAL/08-1/1 |
| SUB SOIL BORE LOGS | /REG-PROTAPPUR/09-1/1 |
| 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 |

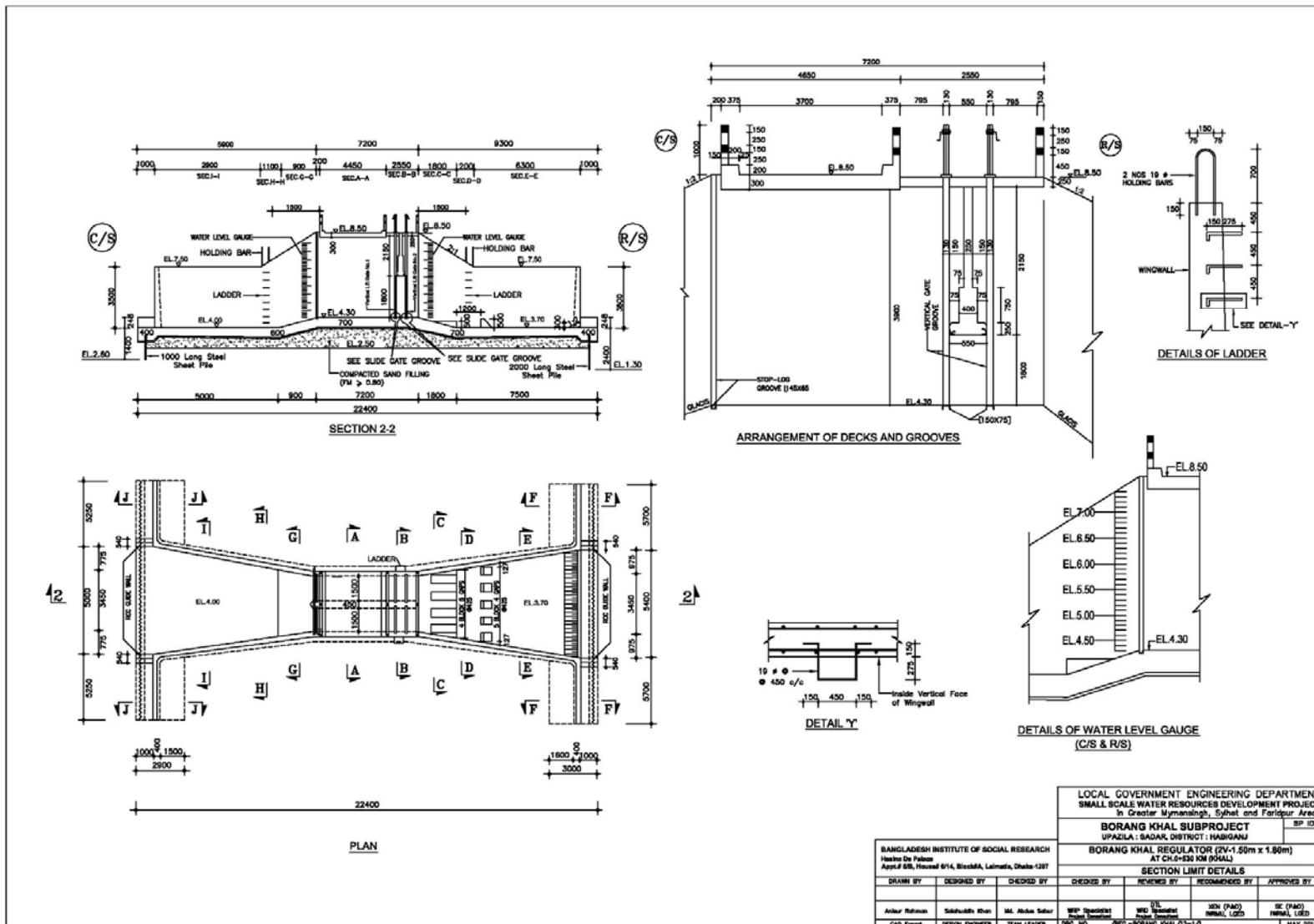
| | | | | | |
|--|-------------------|------------------|-----------------------------------|-----------------------------------|-------------------------|
| LOCAL GOVERNMENT ENGINEERING DEPARTMENT | | | | | |
| SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT | | | | | |
| In Greater Mymensingh, Sylhet and Feniupur Areas | | | | | |
| BORANG KHAL SUBPROJECT | | | | | |
| UPAZILA : SADAR, DISTRICT : HABIGANJ | SP ID | | | | |
| CONTENT OF DRAWINGS | | | | | |
| DRAWN BY | DESIGNED BY | CHECKED BY | REVIEWED BY | RECOMMENDED BY | APPROVED BY |
| Arifur Rahman | Sakibul Islam | M. Ahsanul Islam | WSD Specialist Project Manager | WSD Specialist Project Manager | SE (P&O) Normal Load |
| CAD Expert | EXTERIOR ENGINEER | TEAM LEADER | DRS. NO. /CONTENT OF DRAWINGS-1/ | | I MAY 2016 |

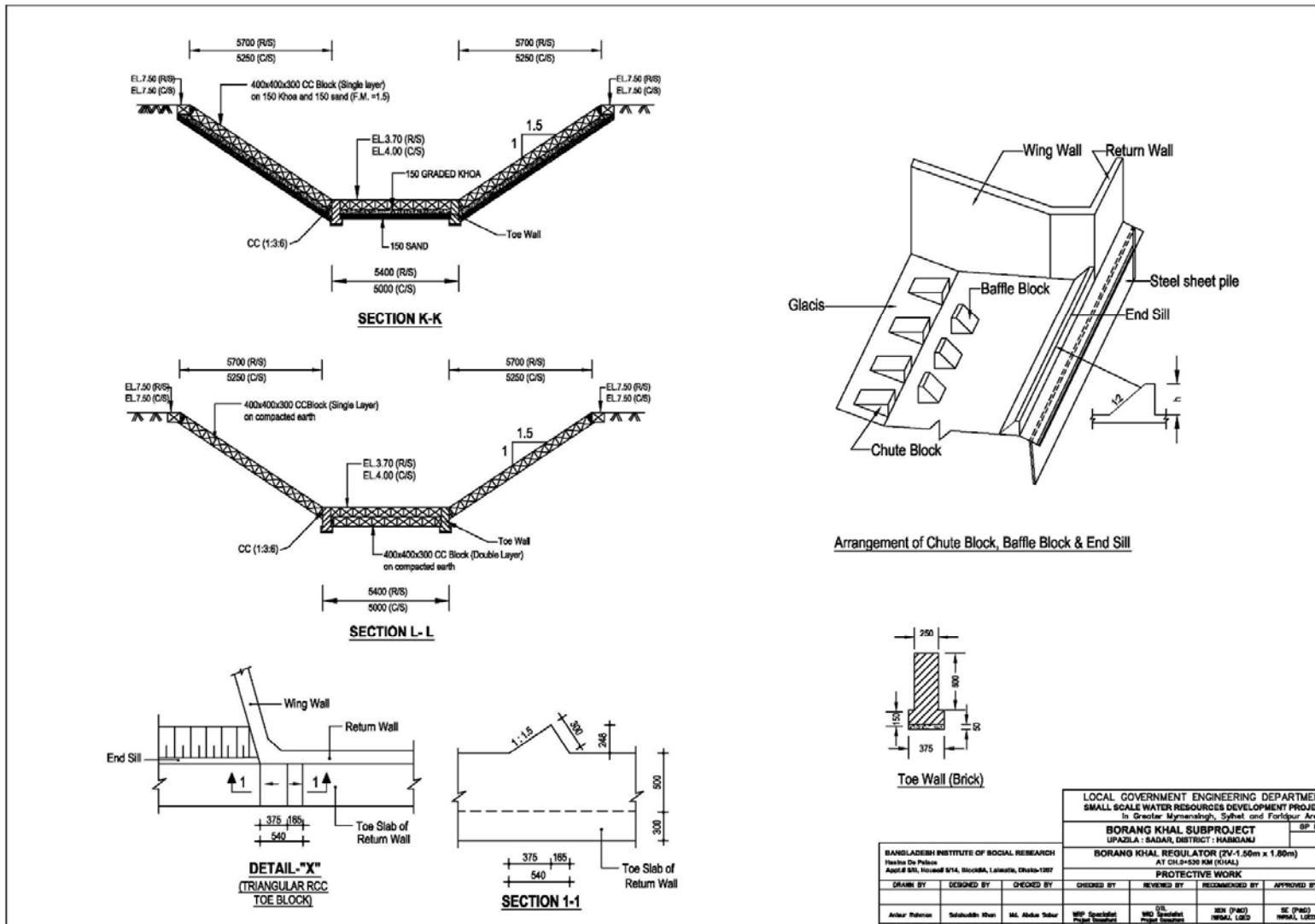


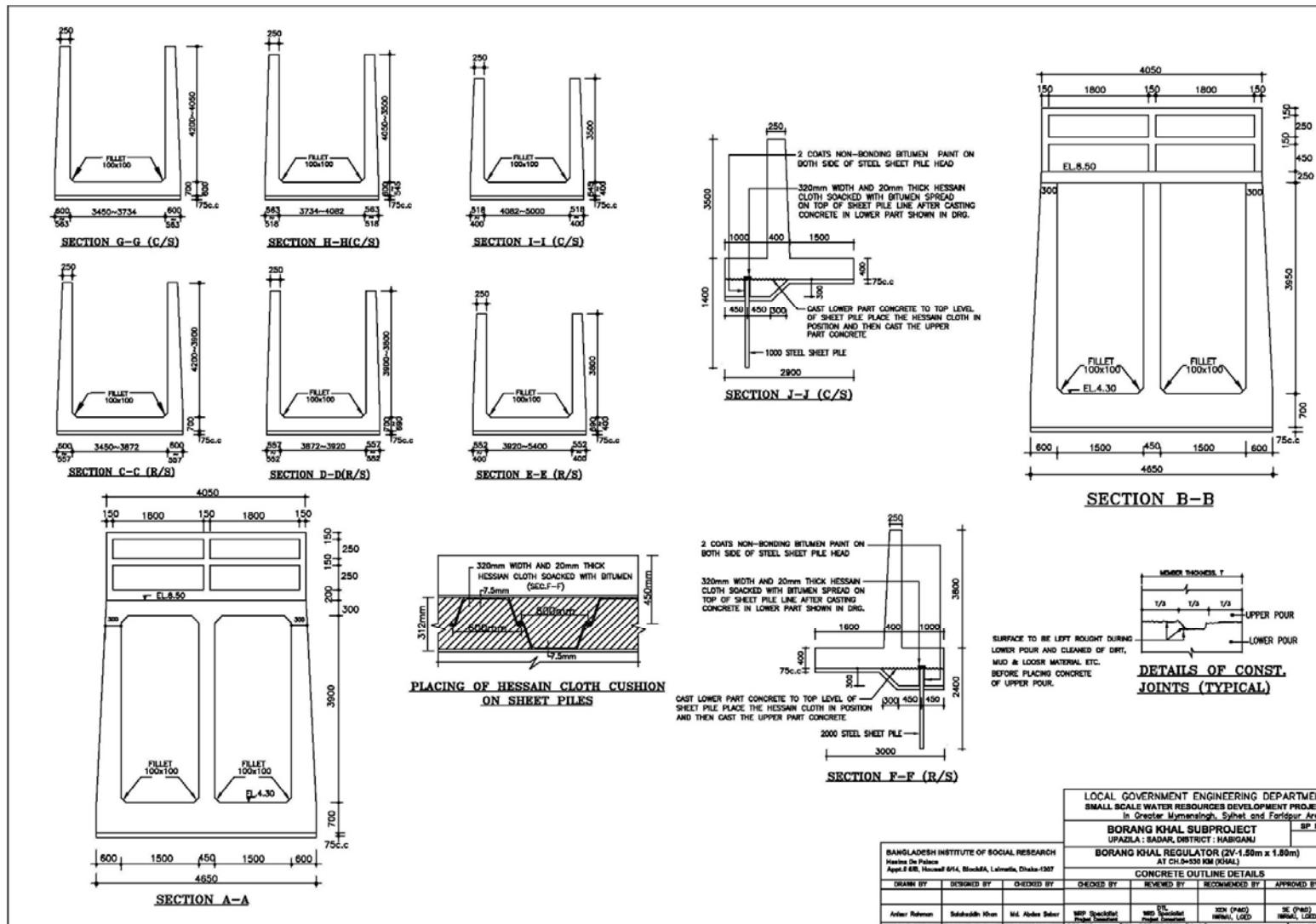


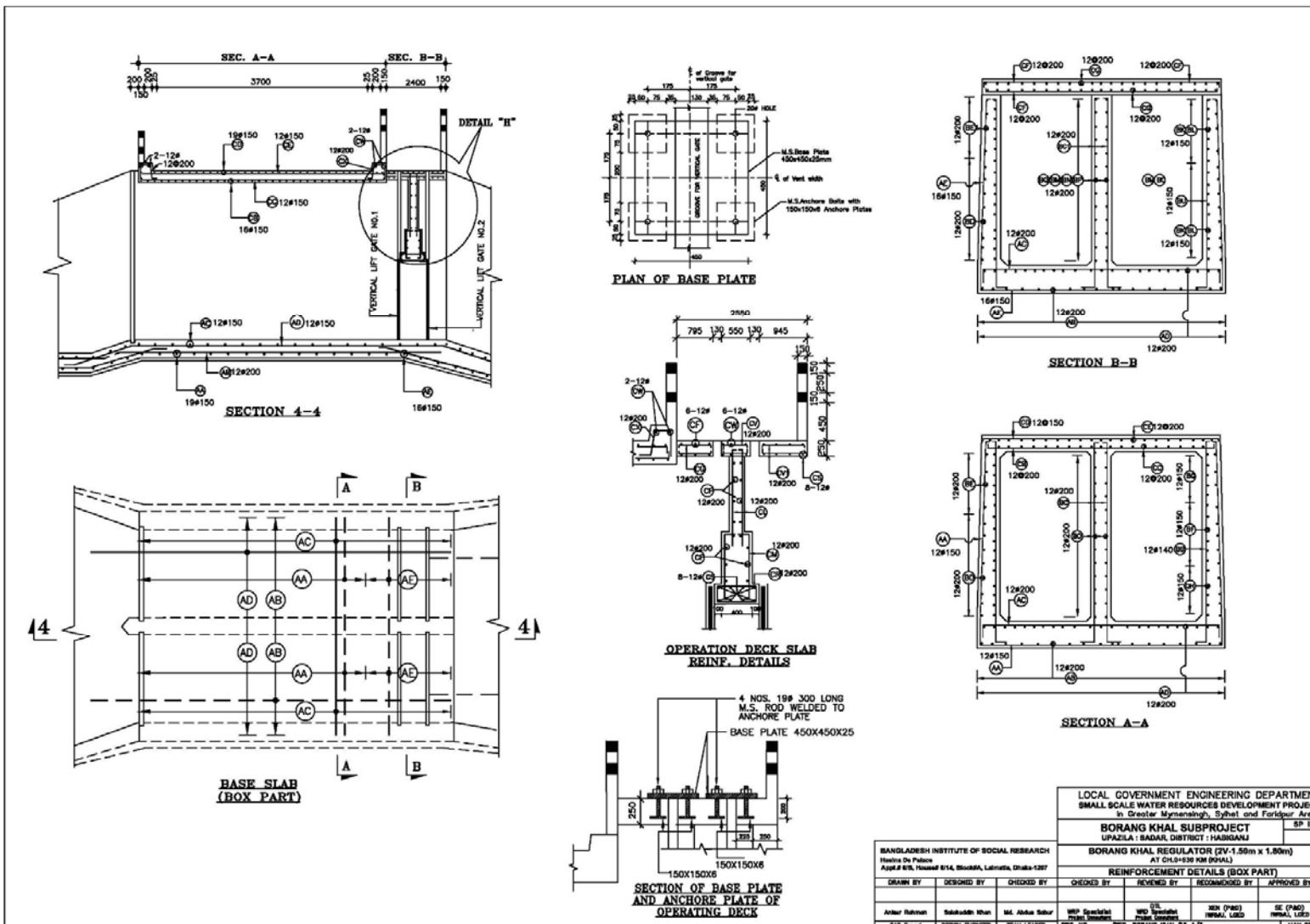


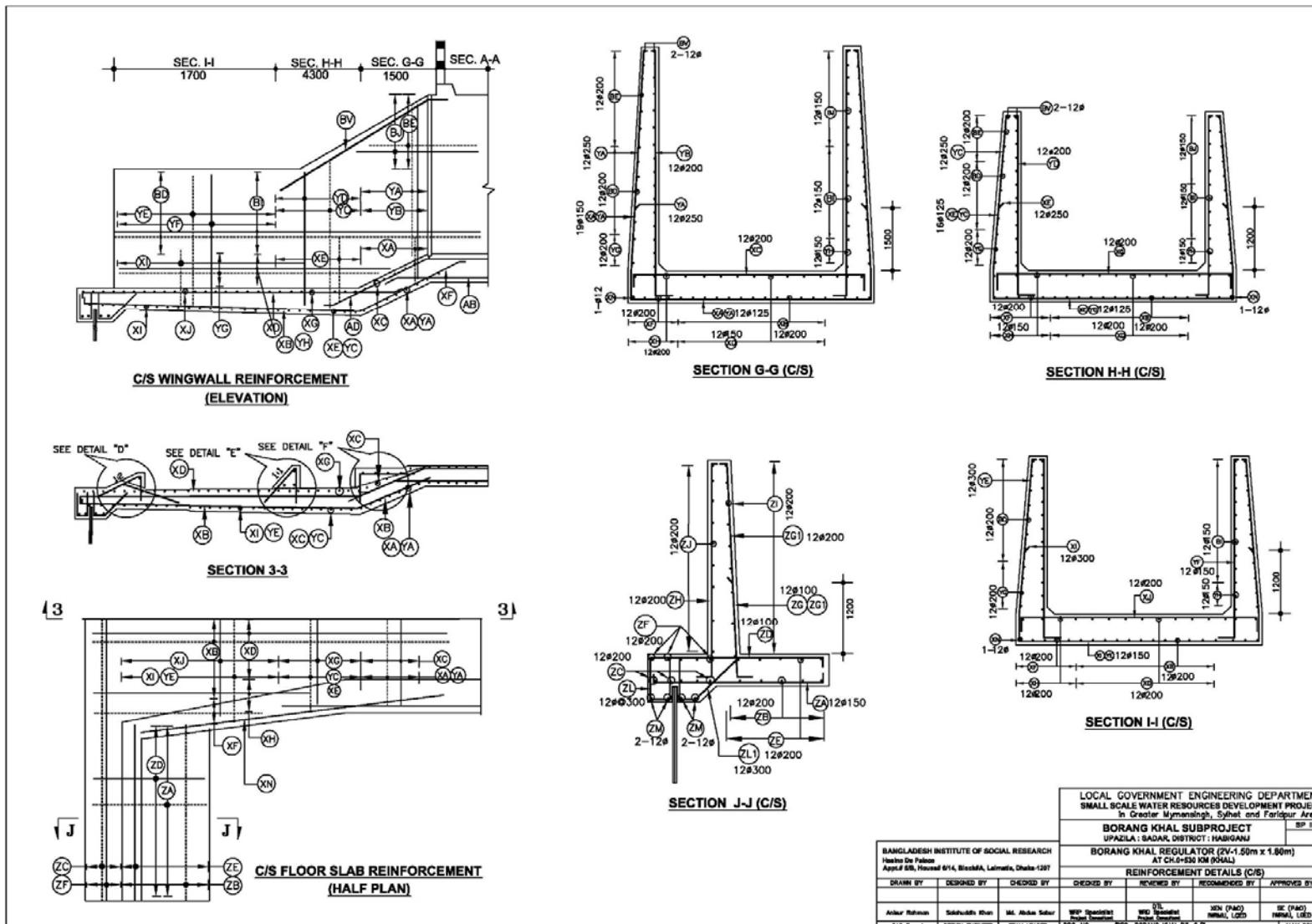


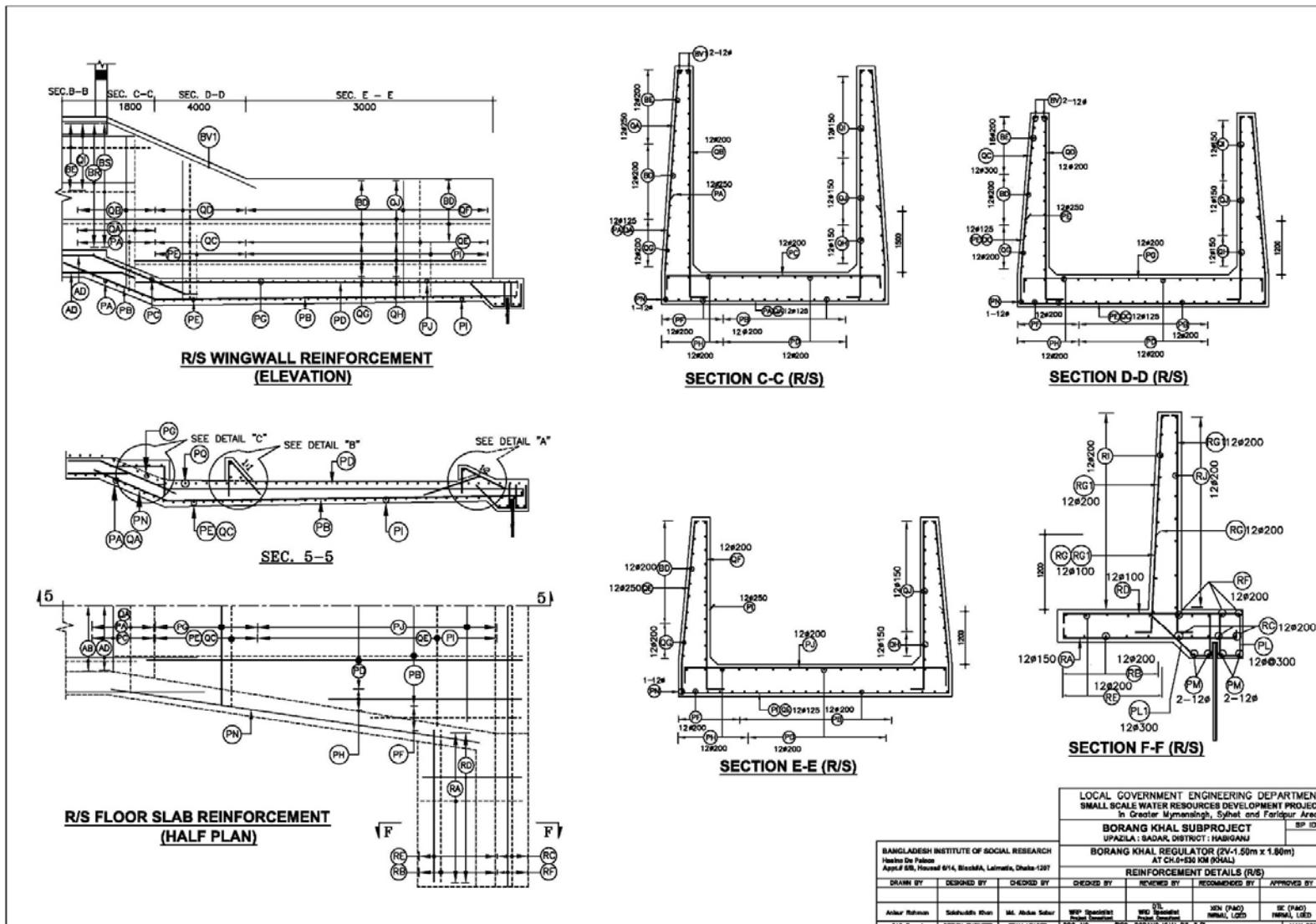












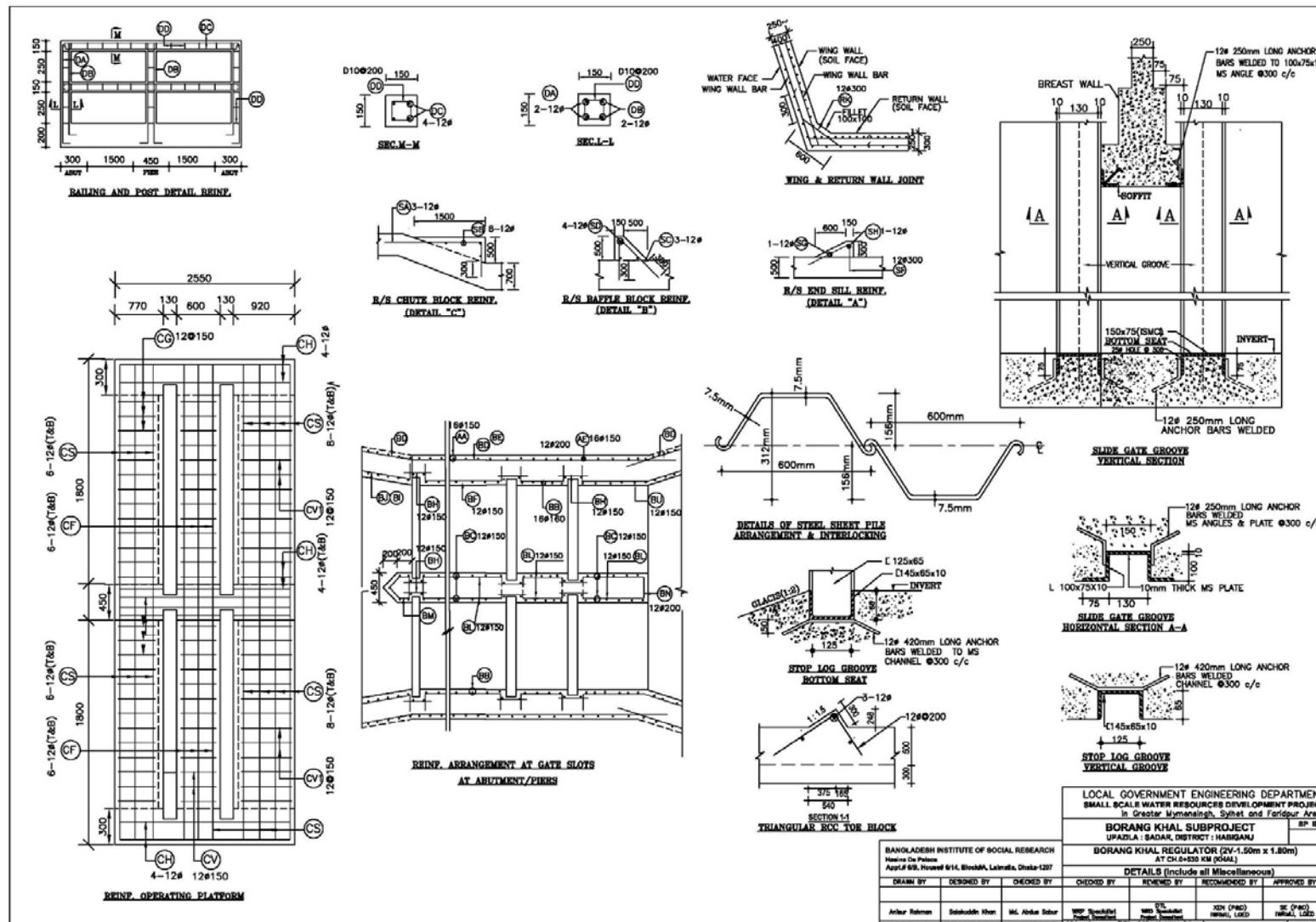
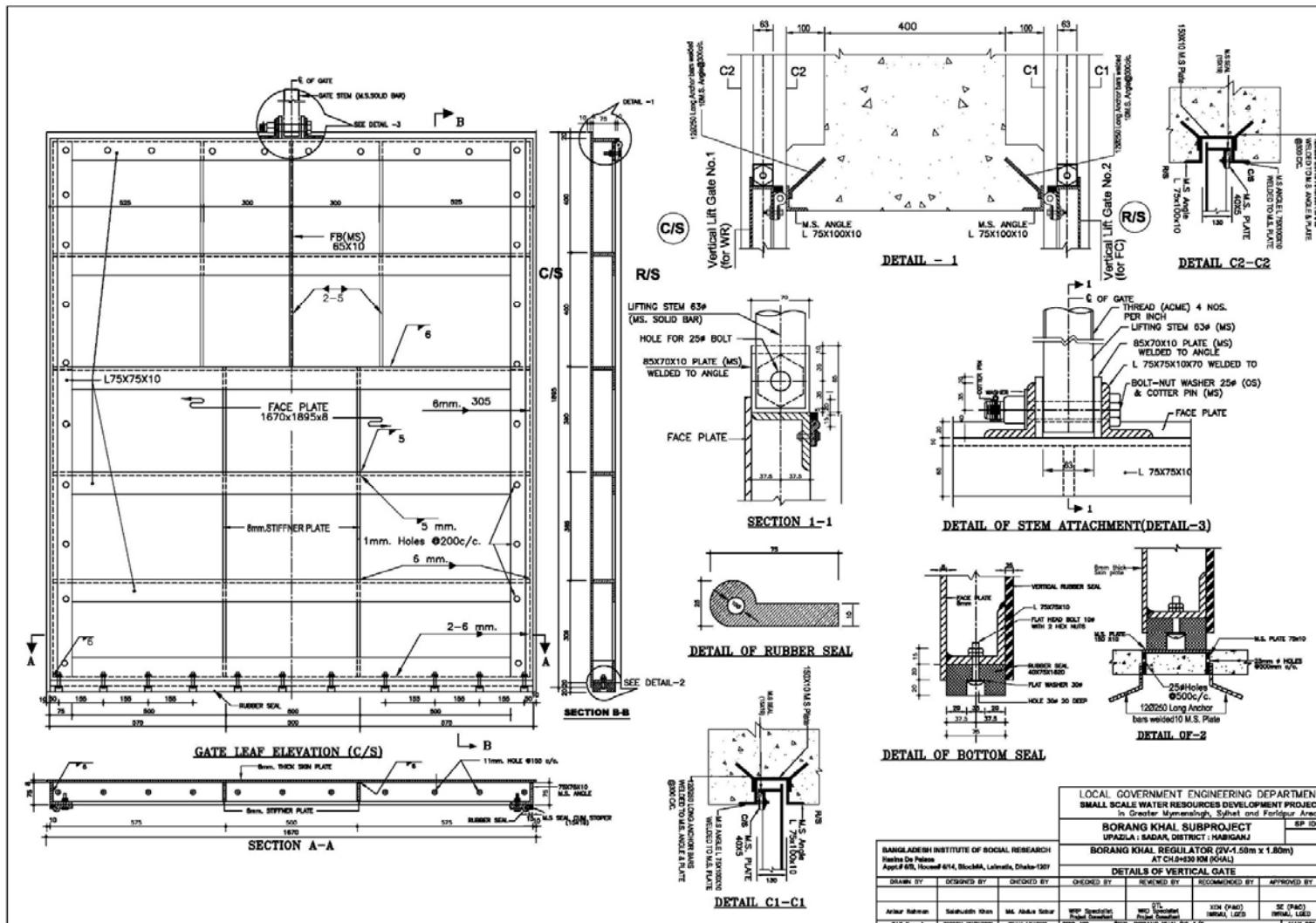
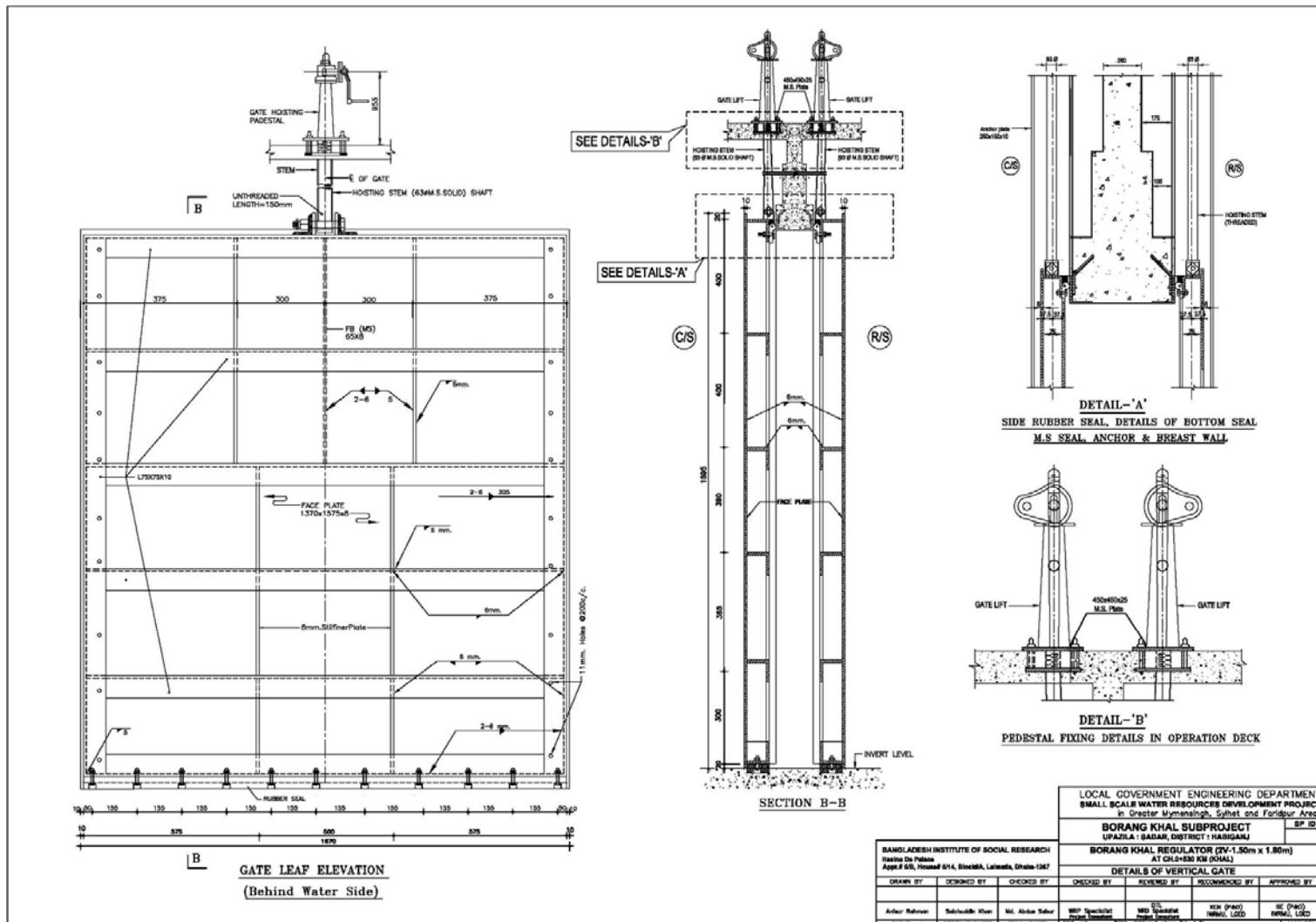
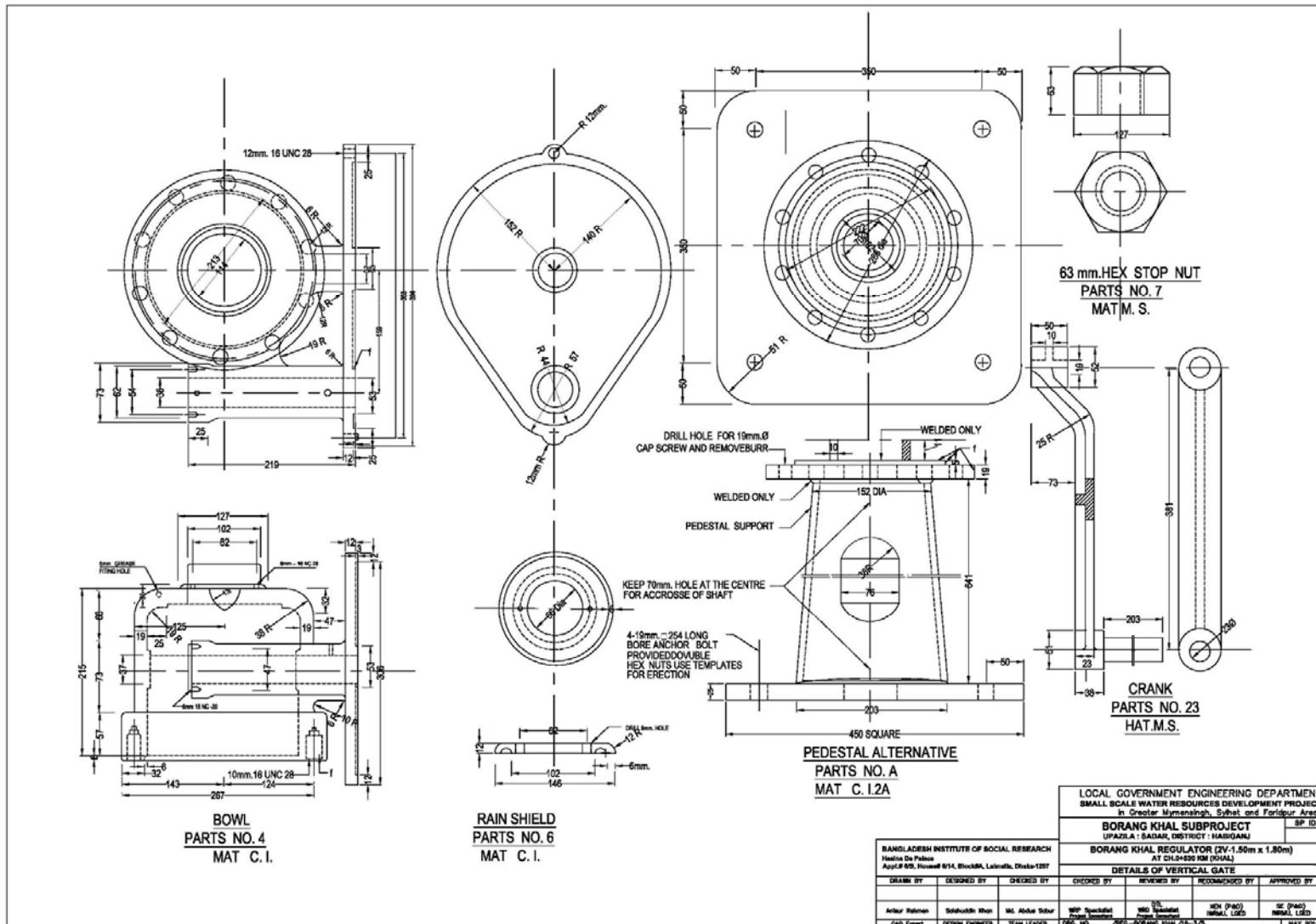


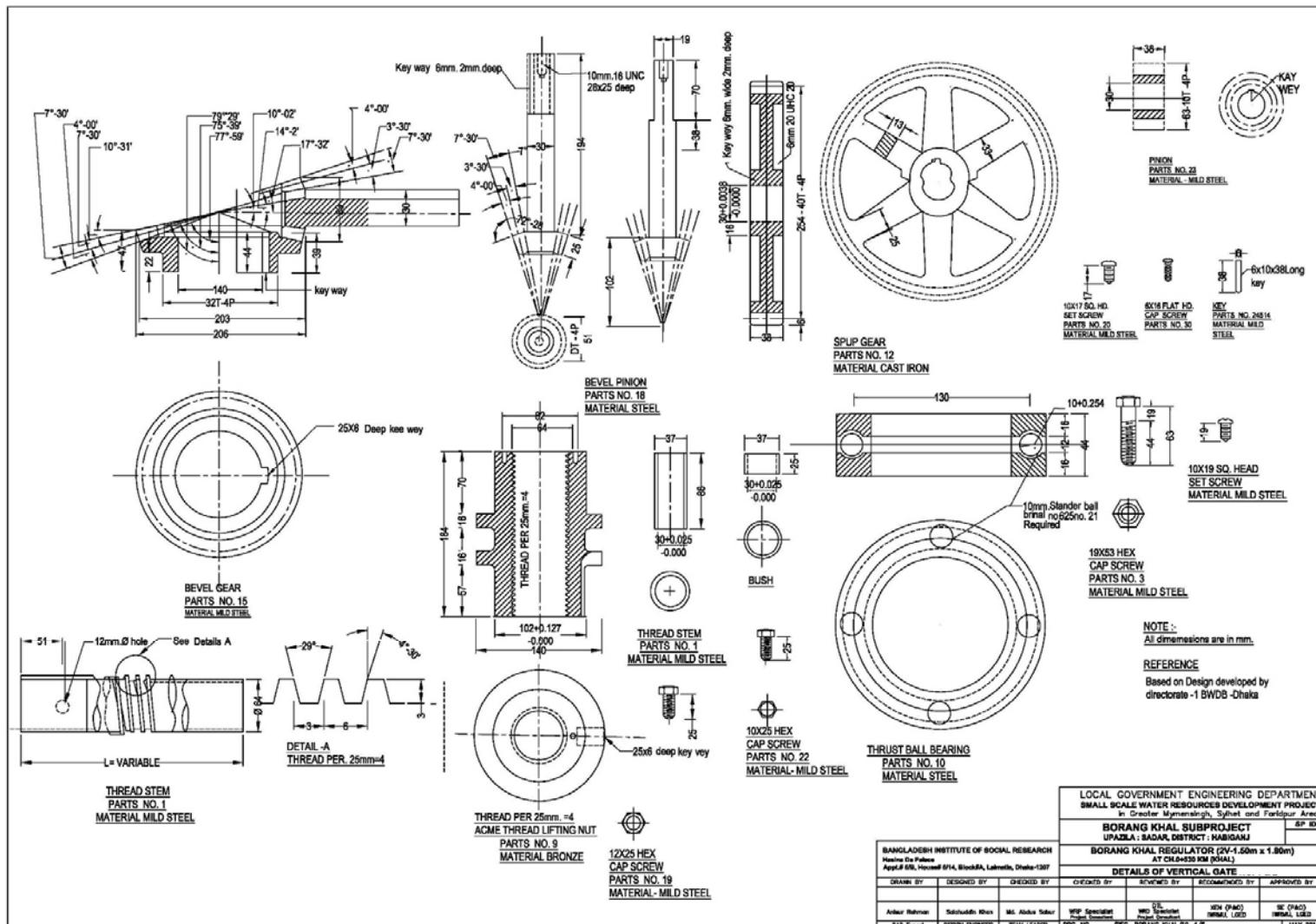
EXHIBIT G6-H4: Standard Drawings of Vertical Gate

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









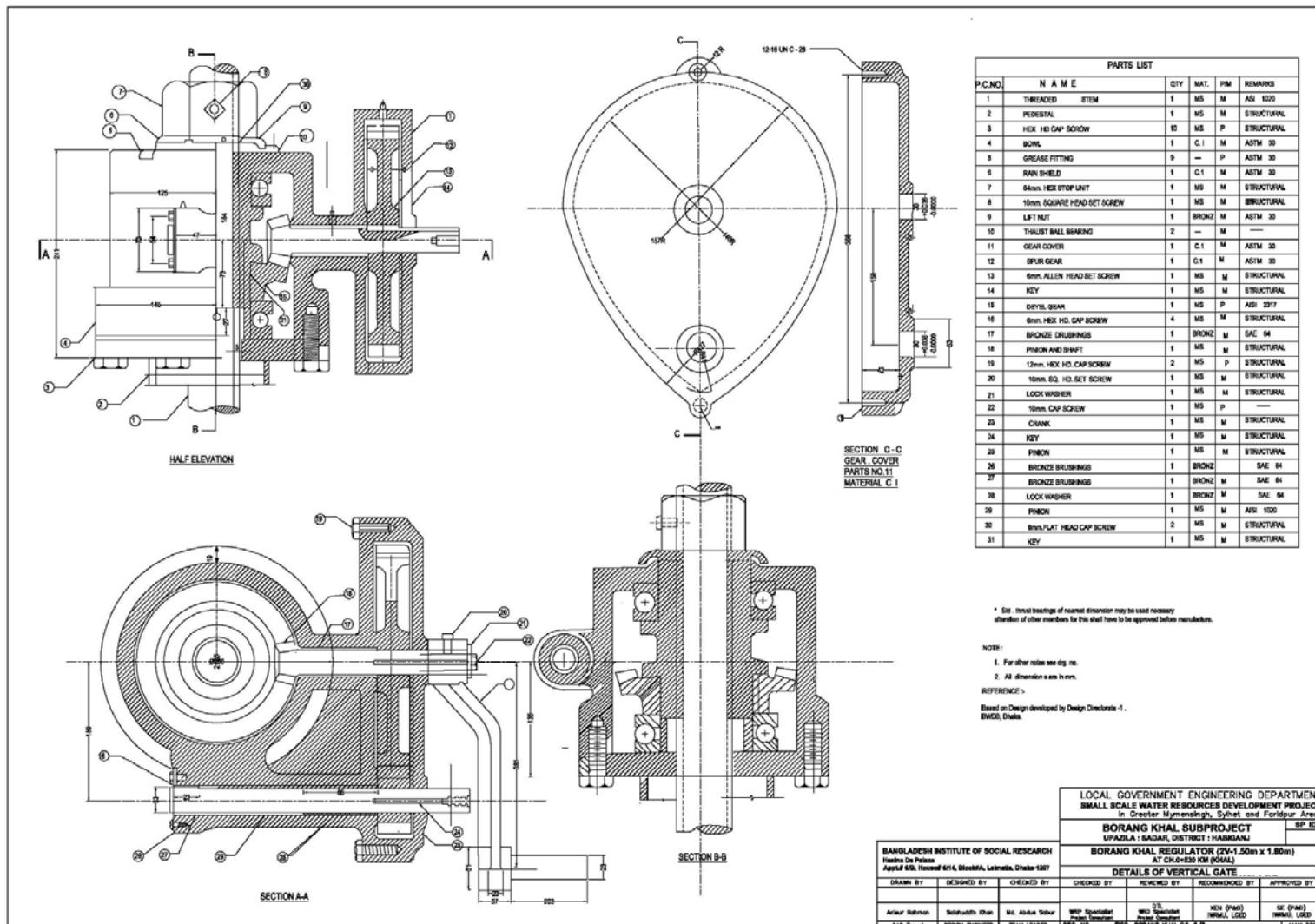
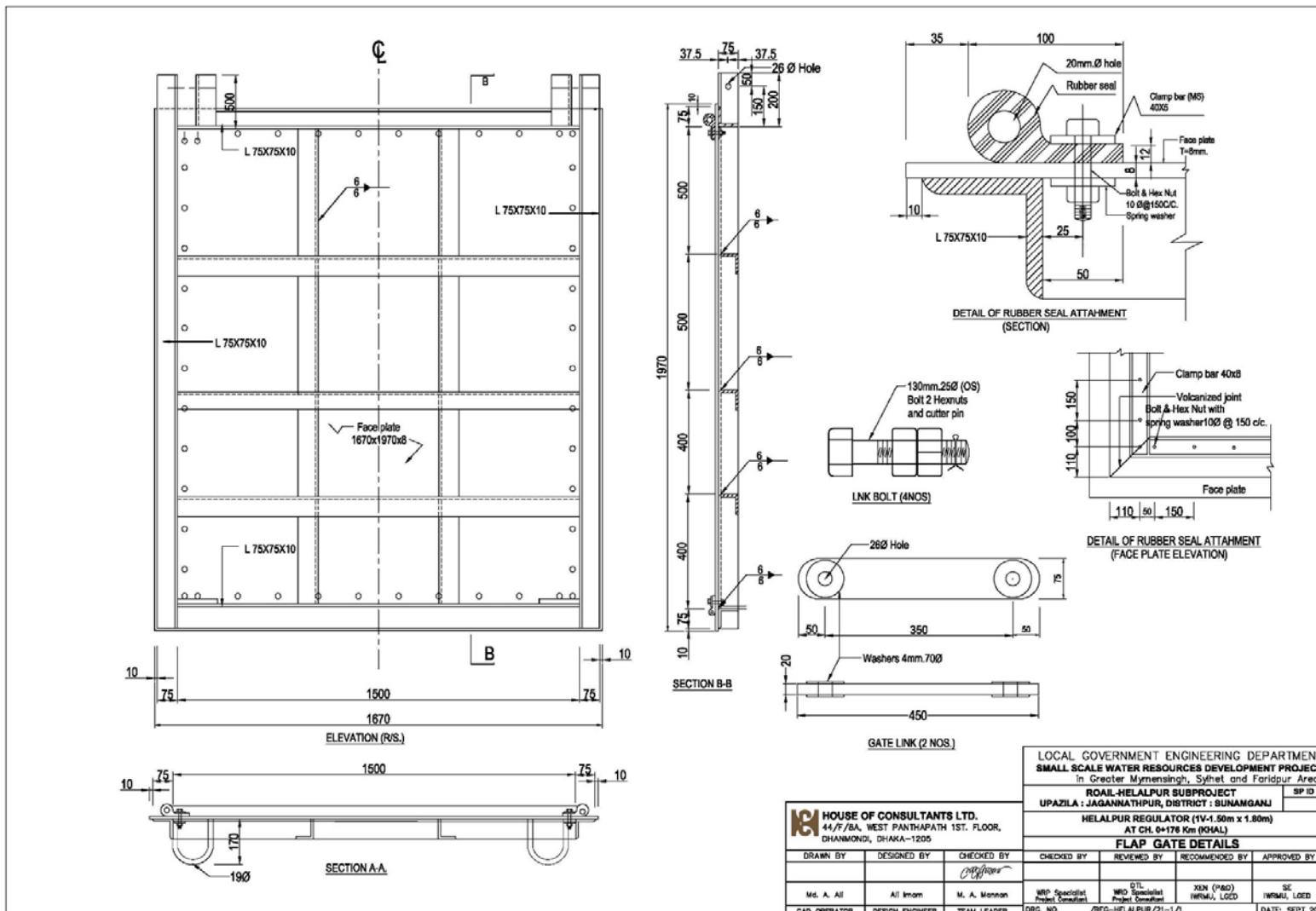


EXHIBIT G6-H5: Standard Drawings of Flap Gate

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



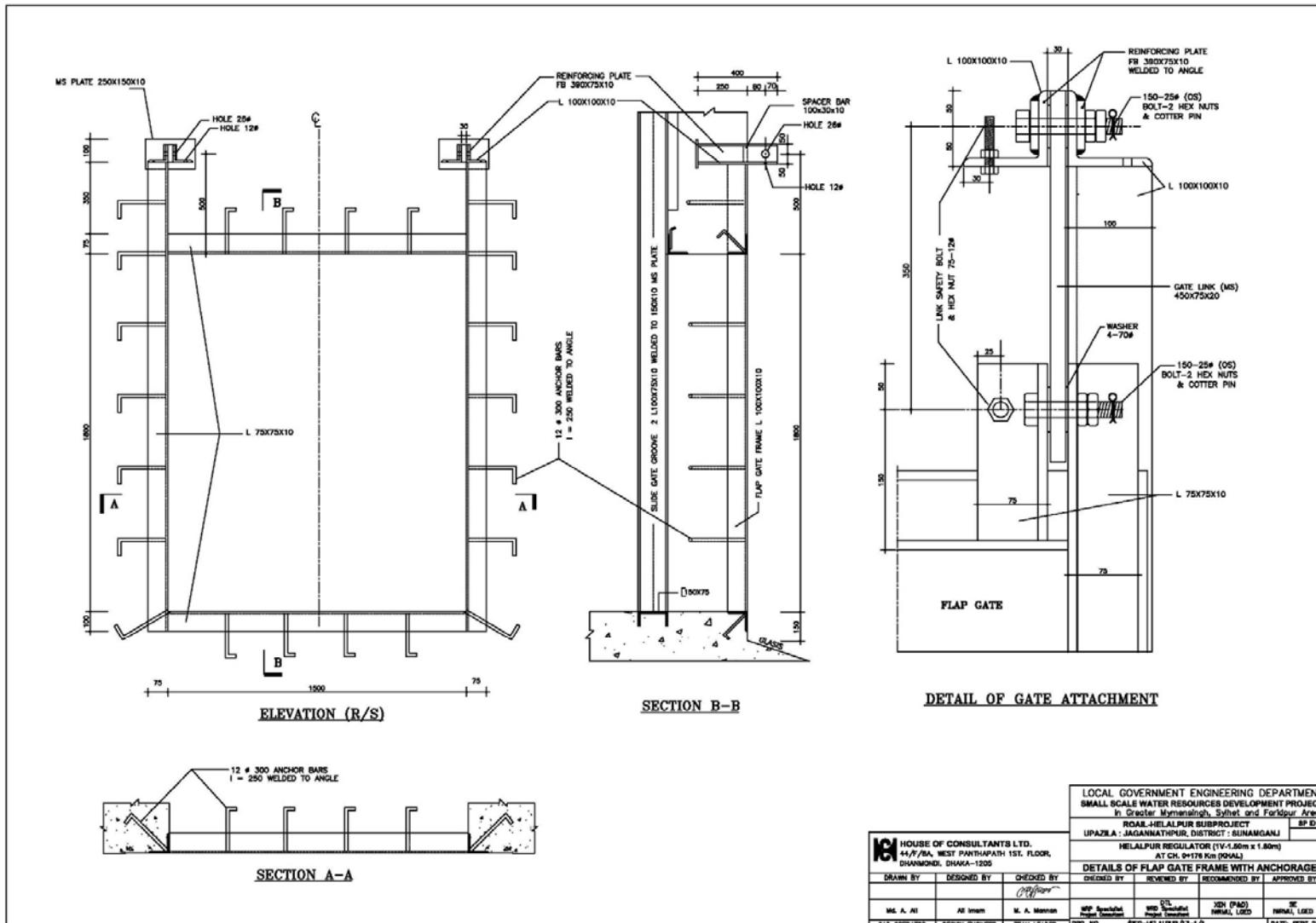


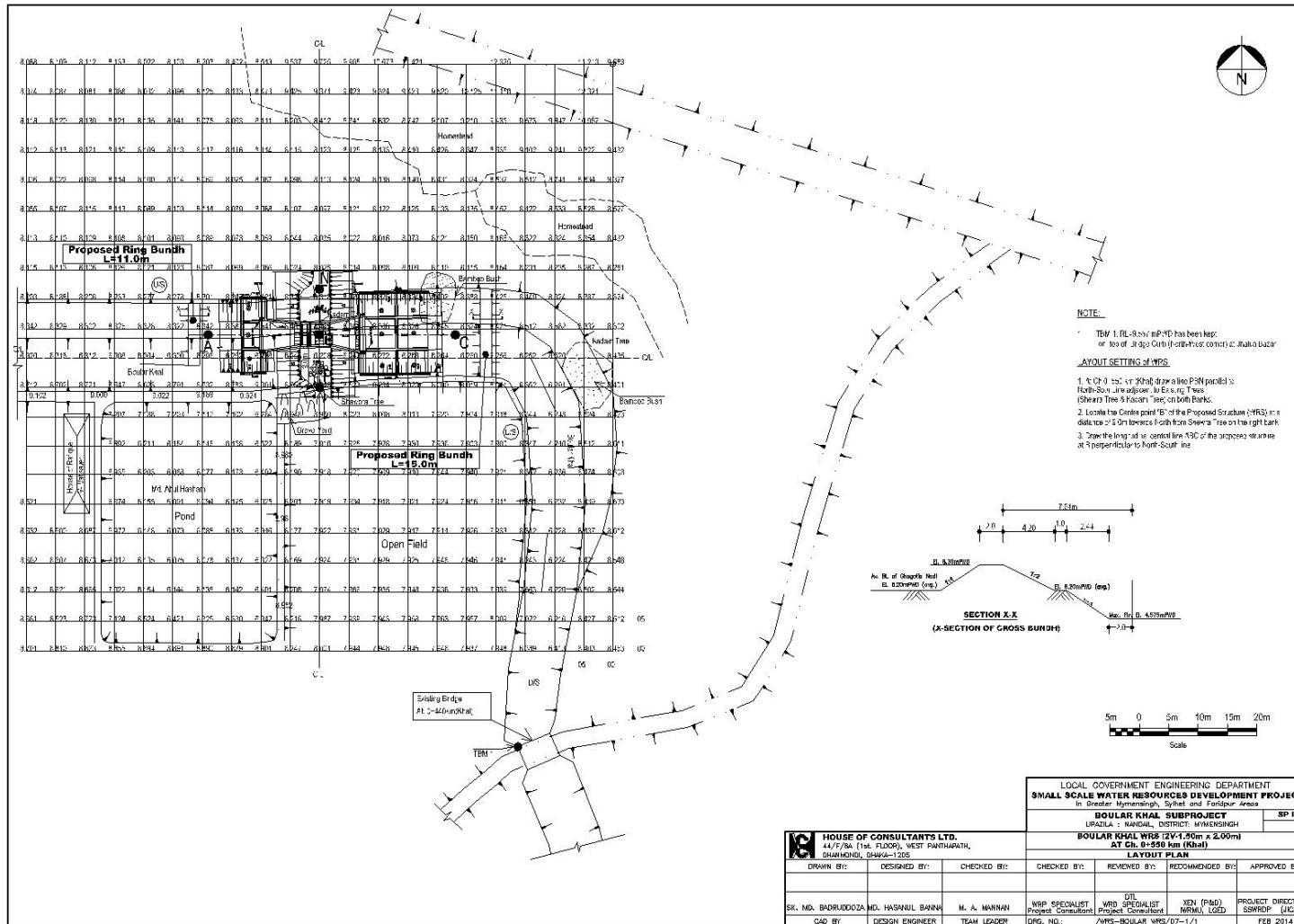
EXHIBIT G6-H6: STANDARD DRAWINGS OF WRS

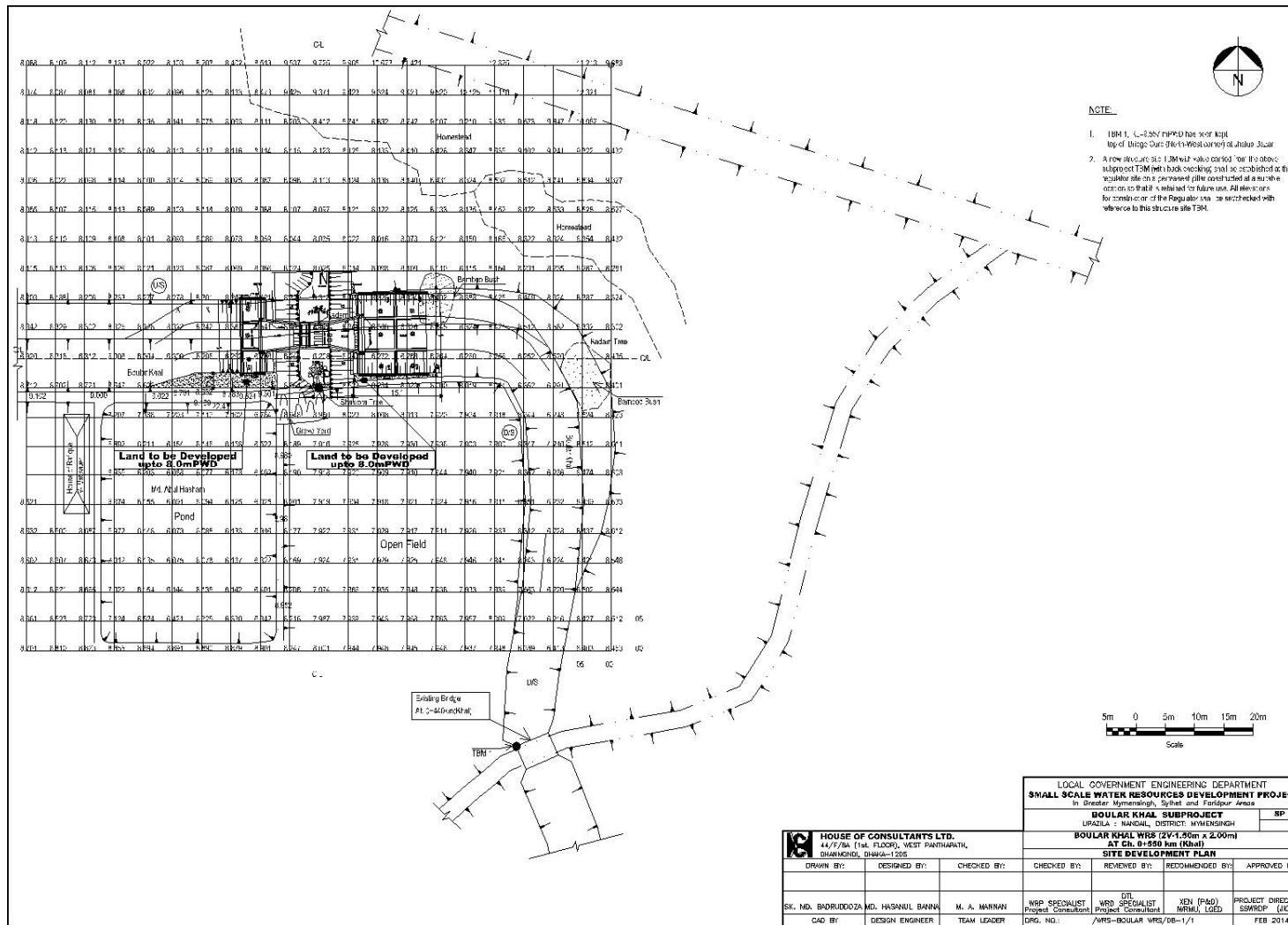
DETAIL DRAWINGS OF
PART A: BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)

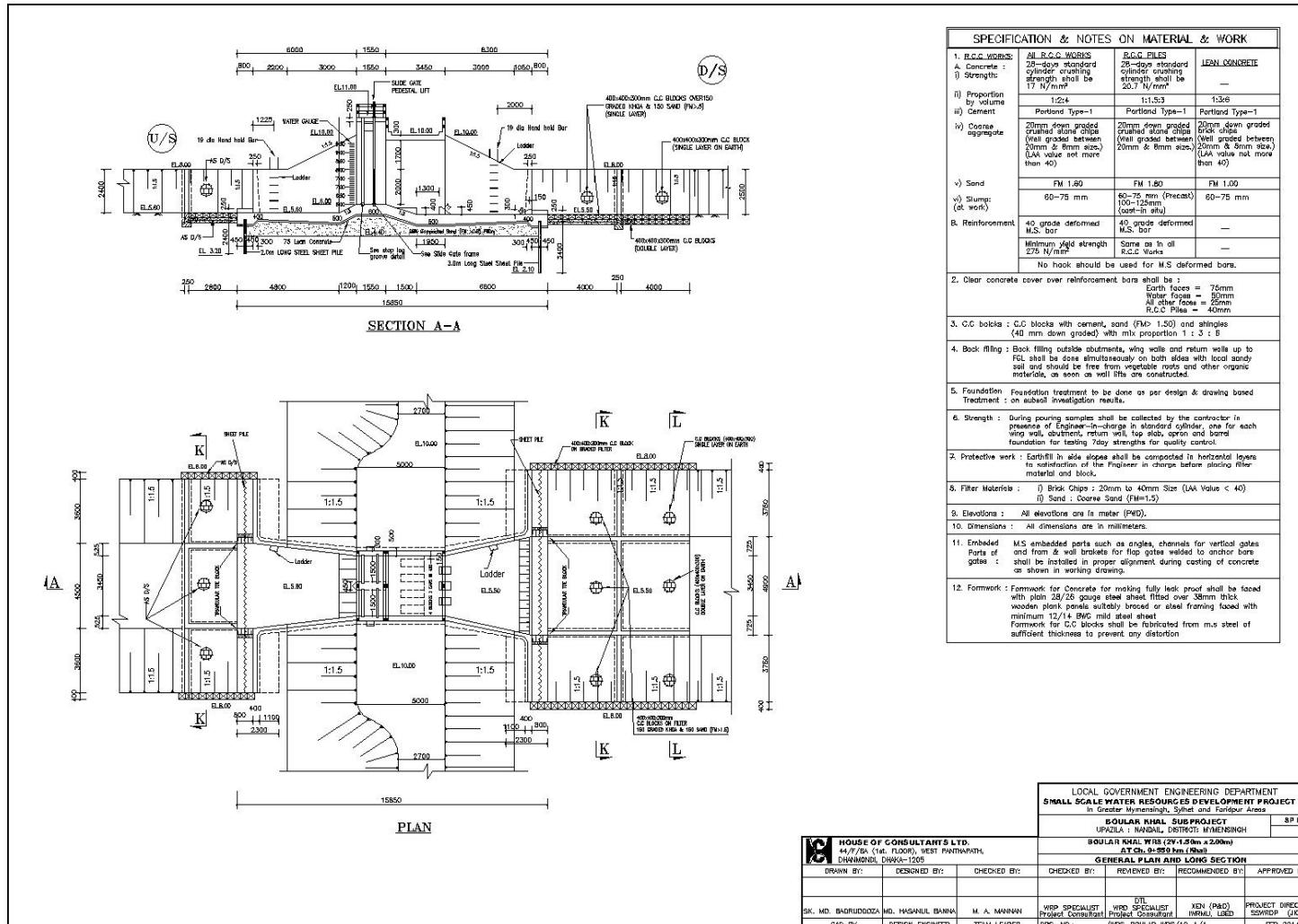
MAY 2014

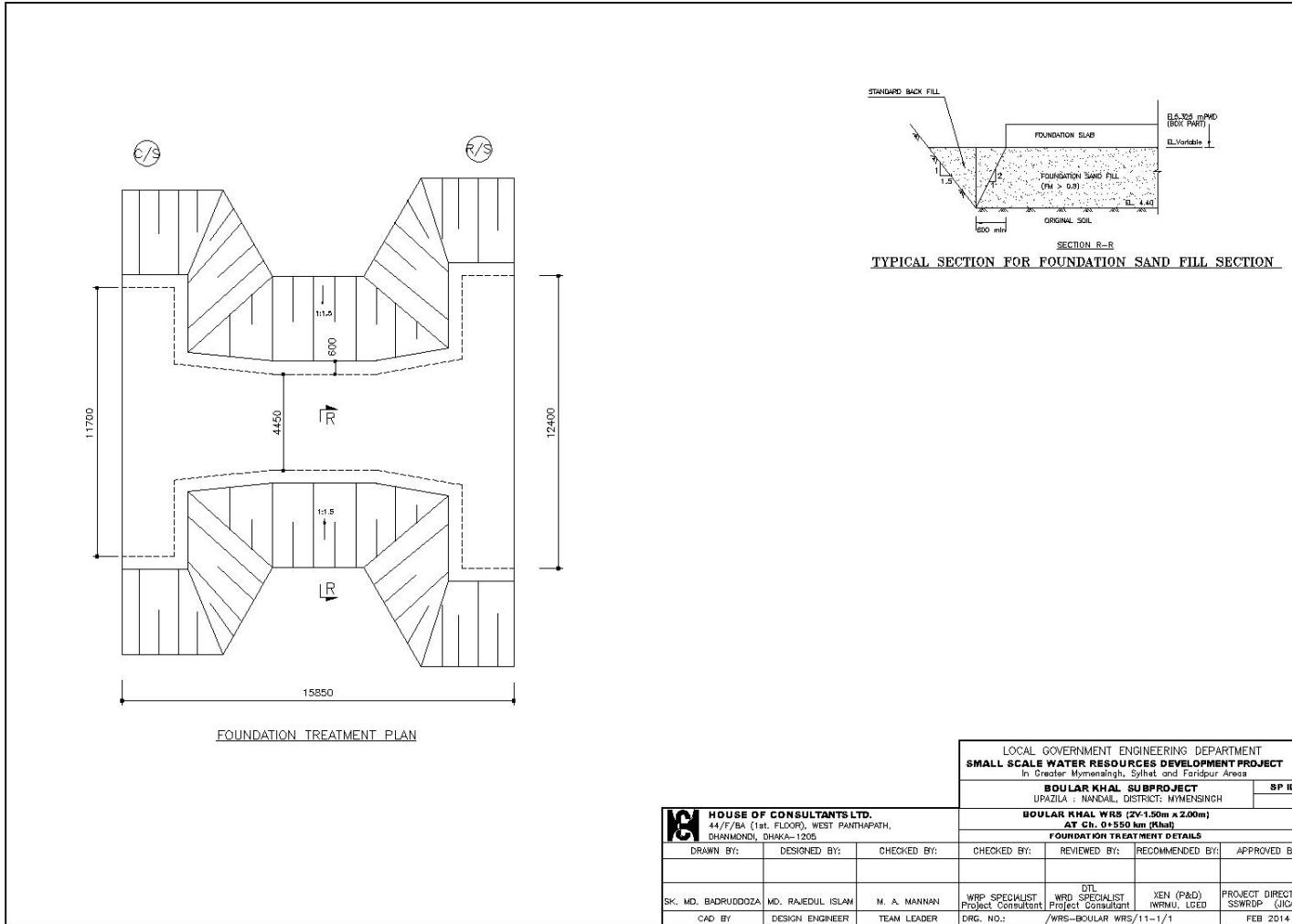
CONTENT OF DRAWINGS

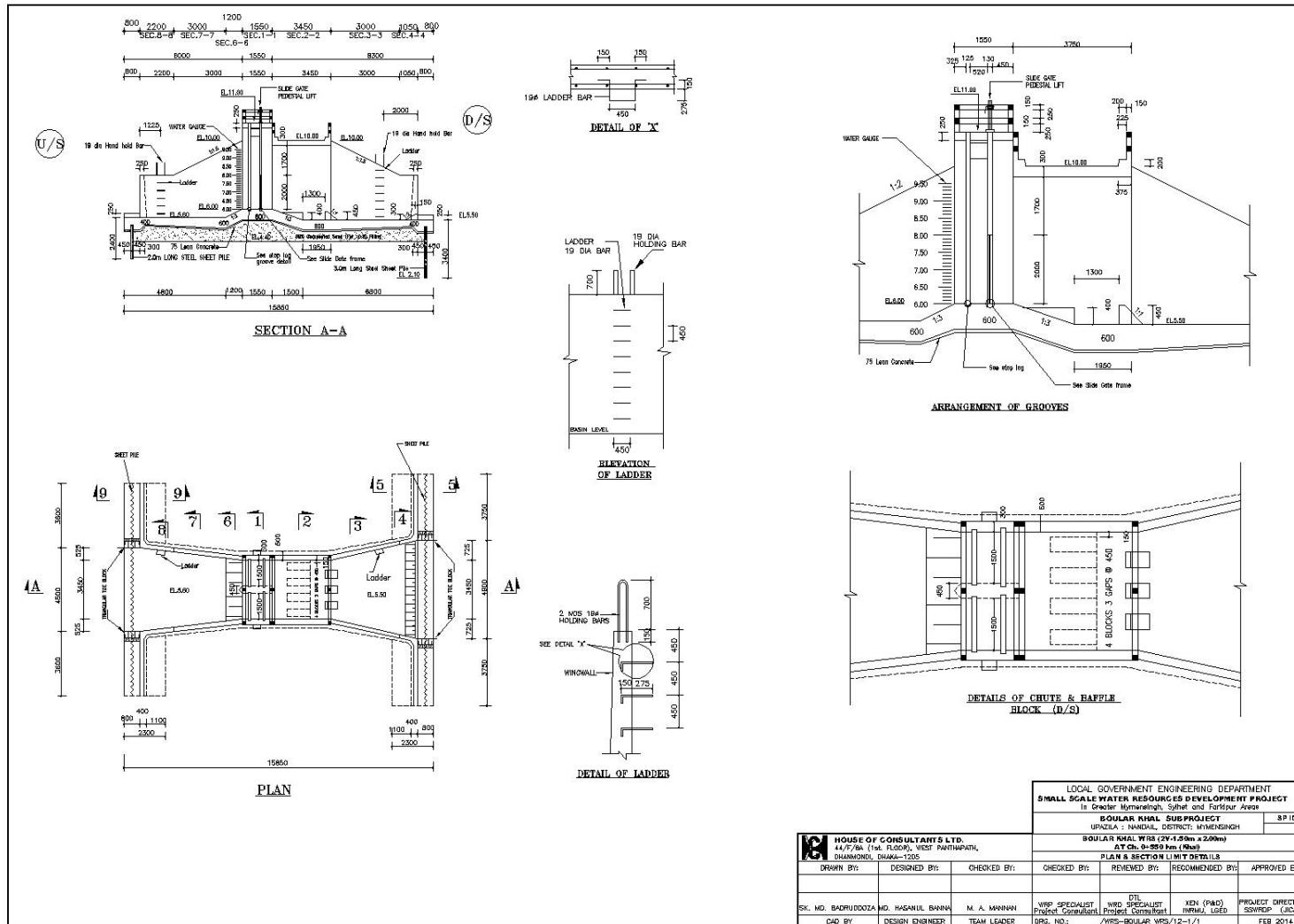
| TITLE OF DRAWING | DRAWING NO. |
|---|------------------------------------|
| INDEX MAP | /INDEX MAP/1/ |
| STRUCTURE: | |
| PART A: BOULAR KHAL WRS (2V-1.5m x 2.0m) | |
| LAYOUT PLAN | /WRS-BOULAR KHAL WRS/07-1/ |
| SITE DEVELOPMENT & CHANNEL TRANSITION PLAN | /WRS-BOULAR KHAL WRS/08-1/ |
| GENERAL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

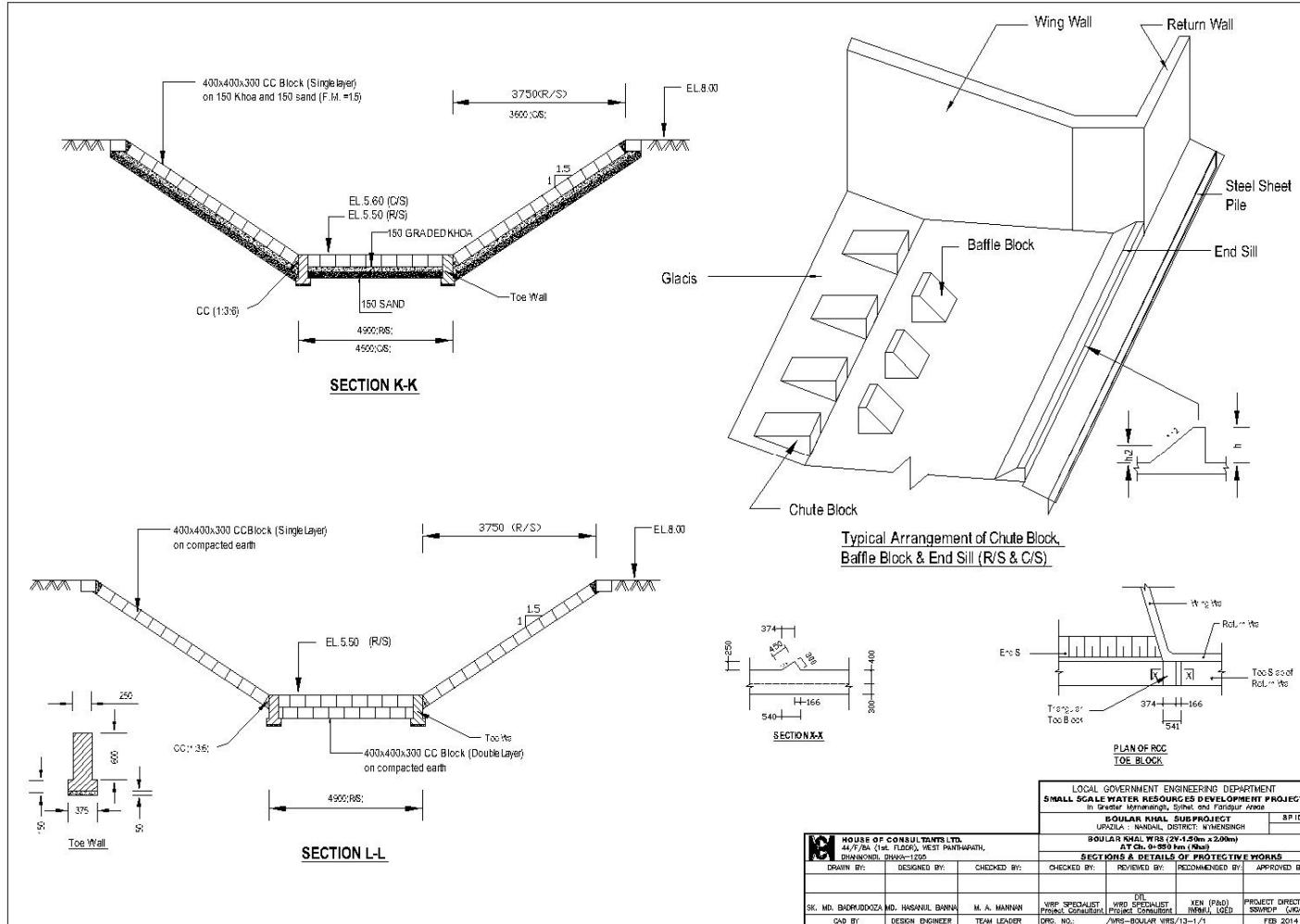


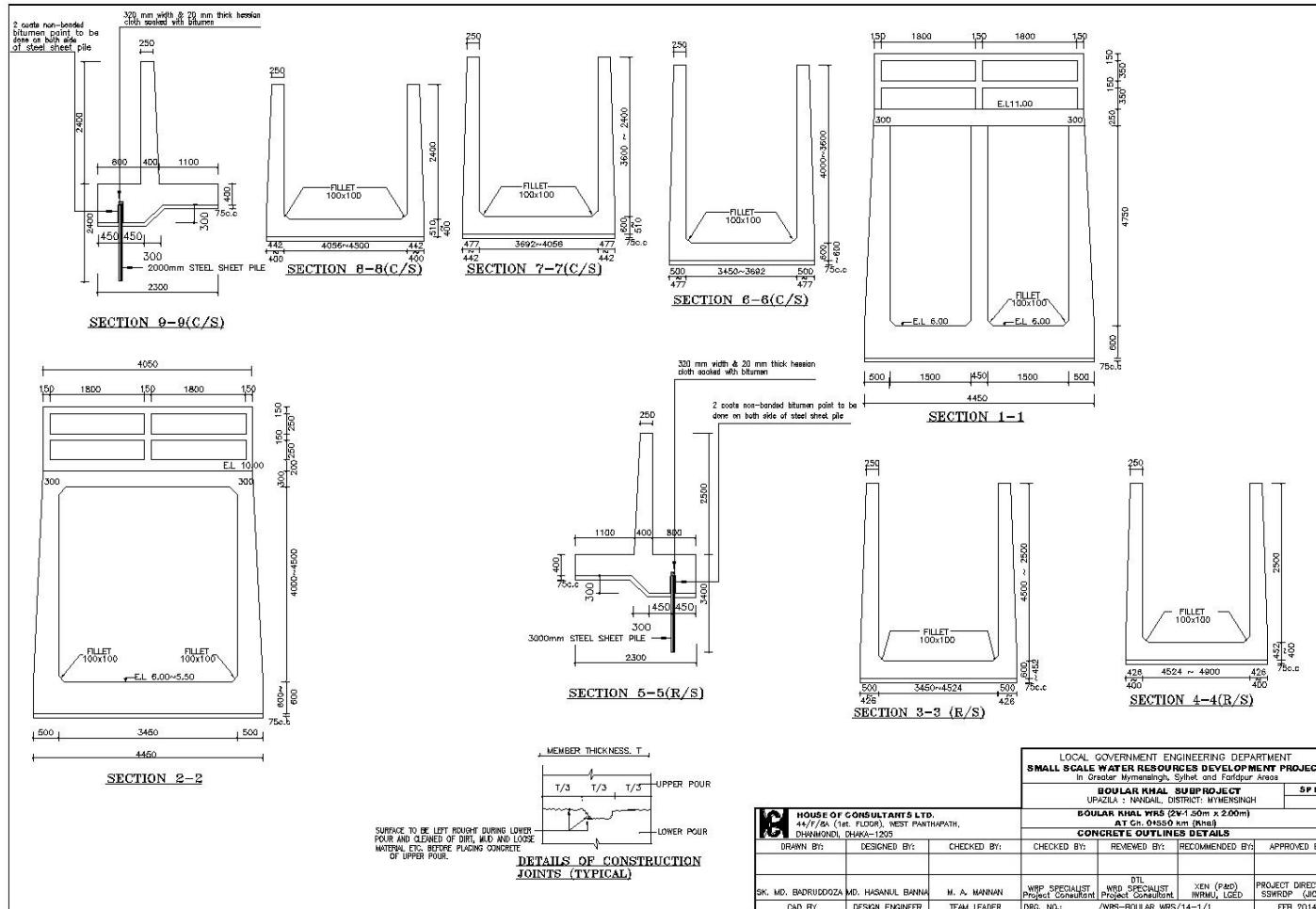


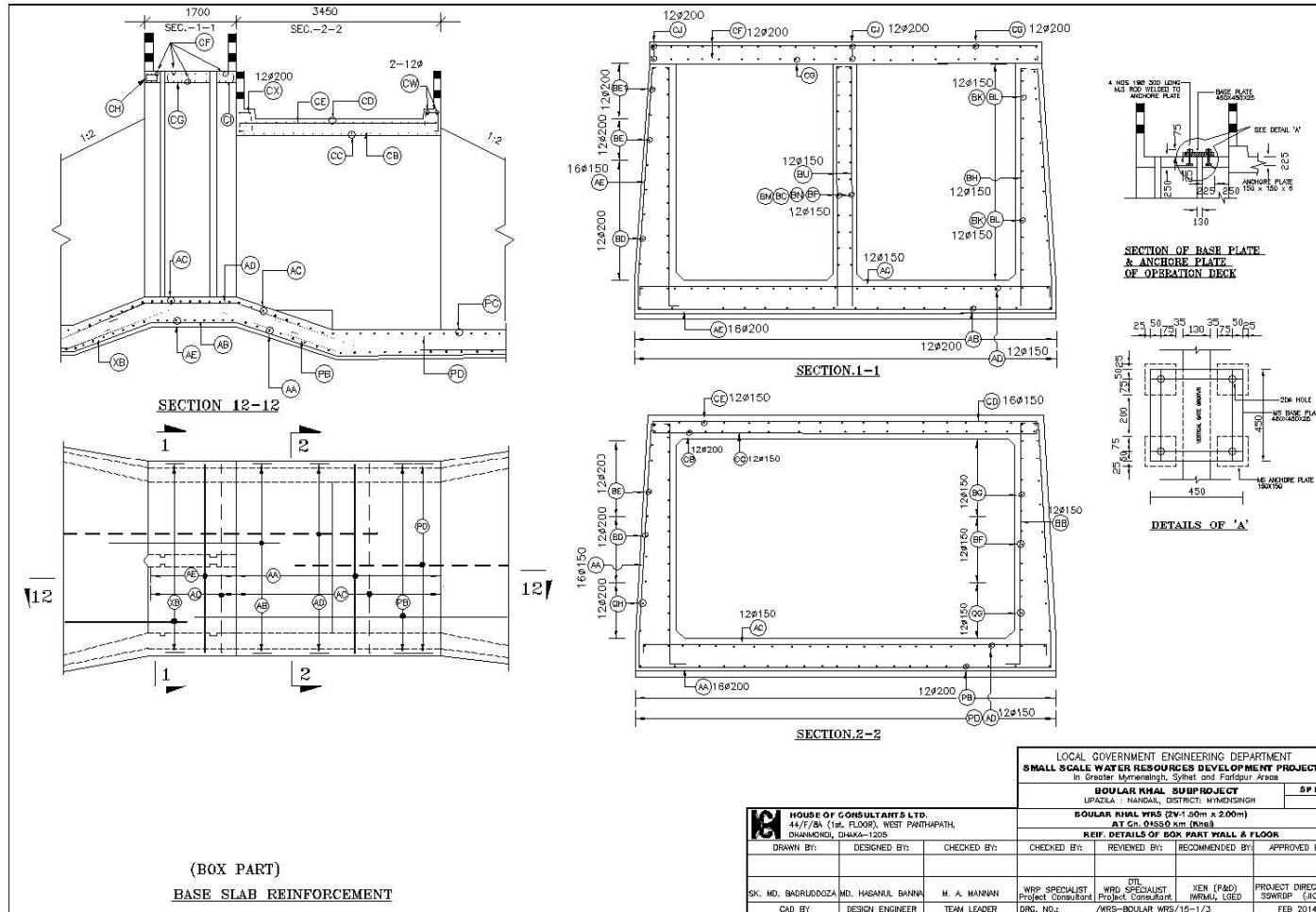


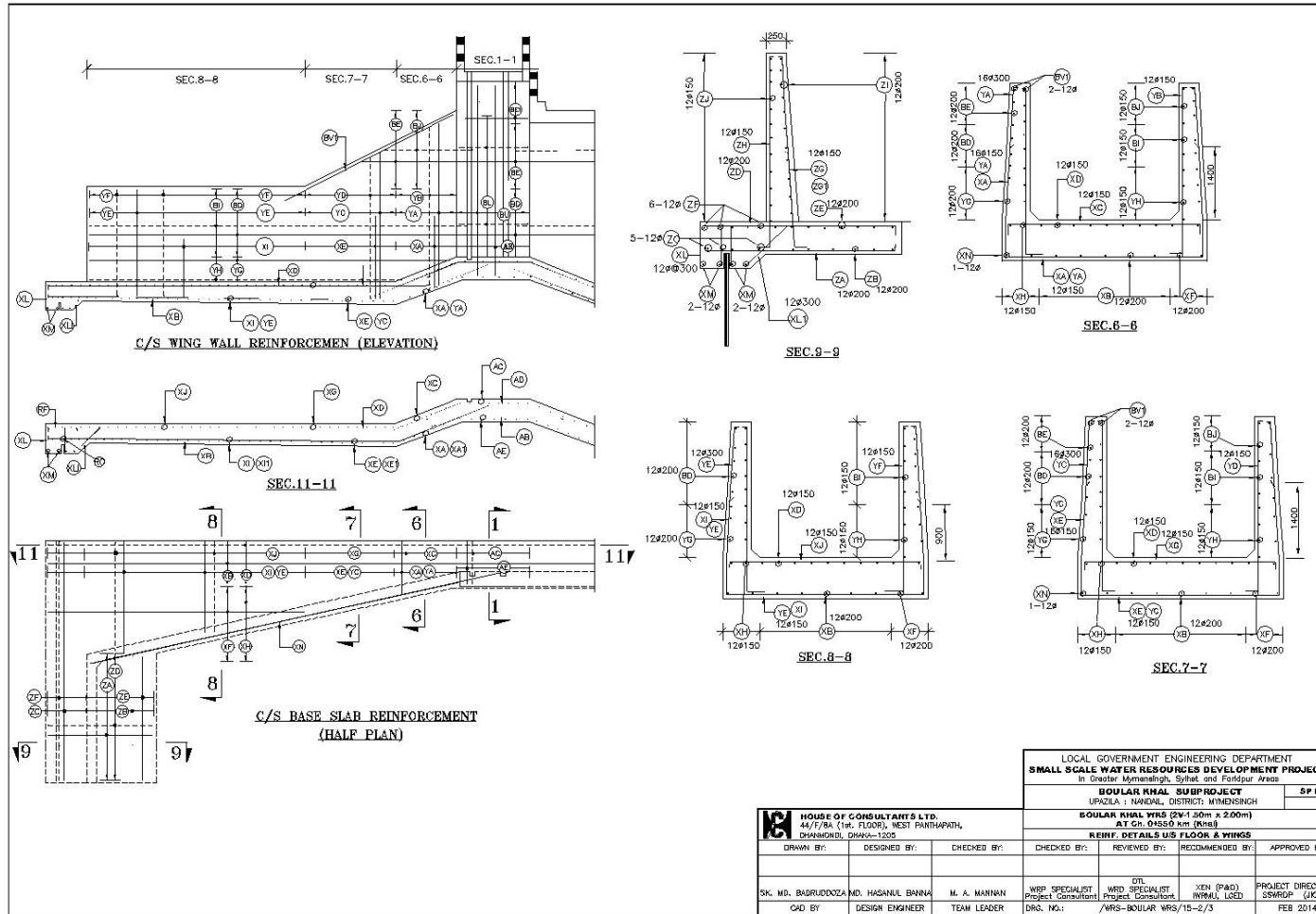


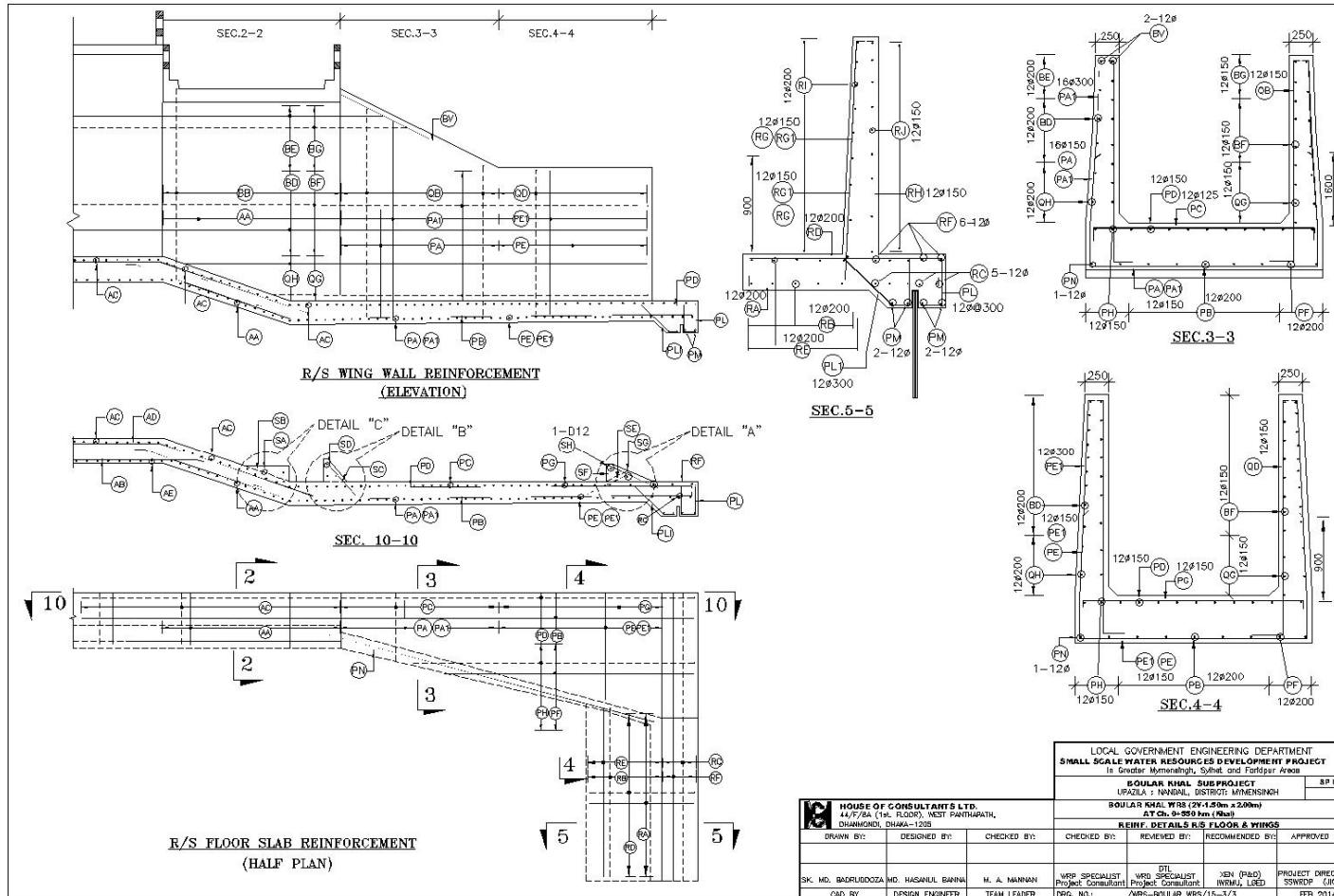


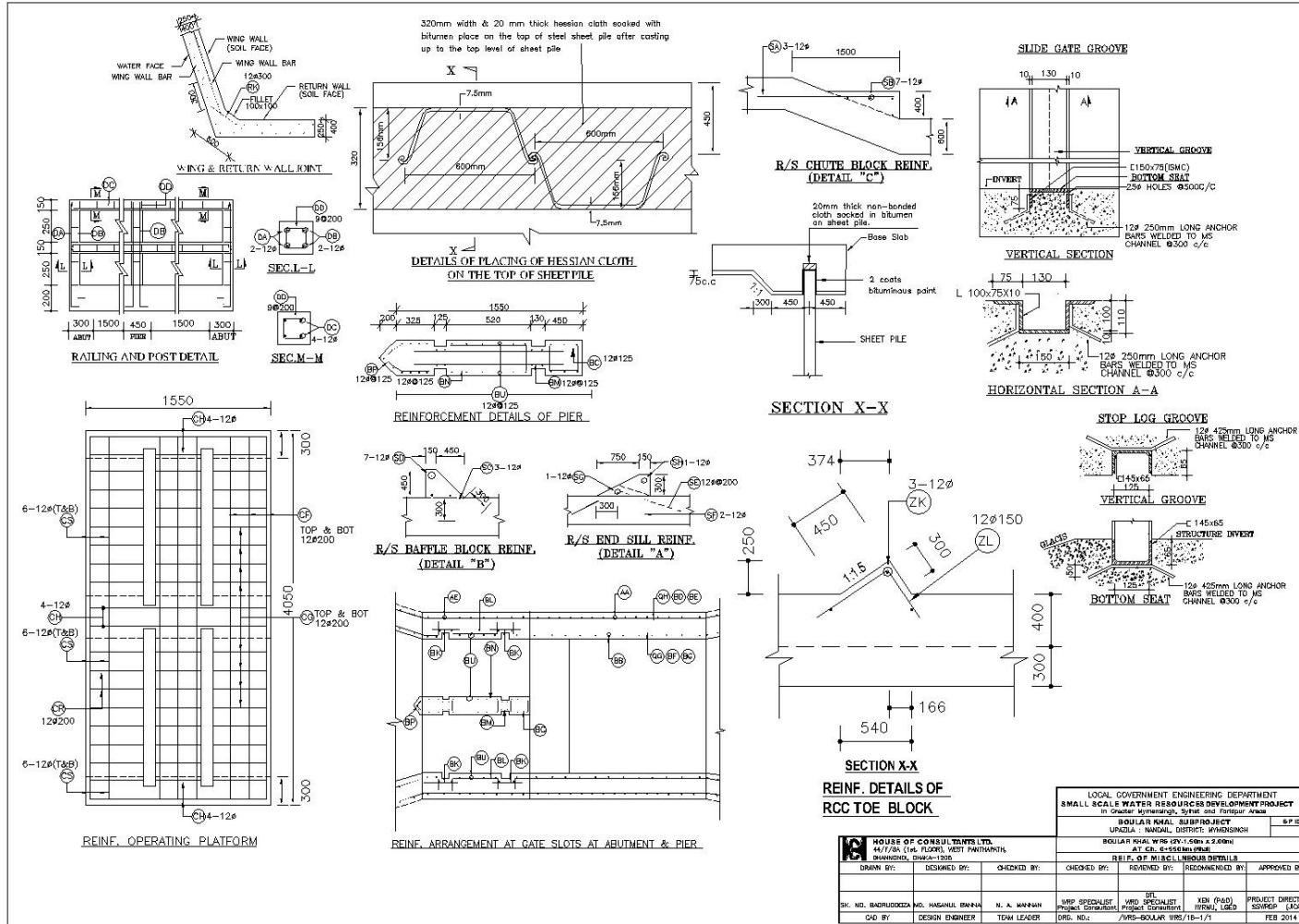












| SHAPE CODE NO. | BAR SHAPE |
|----------------|-----------|----------------|-----------|----------------|-----------|----------------|-------------|
| 1. | A | 12. | B A | 23. | B A B C | 34. | B A C |
| 2. | A B | 13. | A A B | 24. | A B C D E | 35. | A B C D B C |
| 3. | A B | 14. | A | 25. | A B C C | 36. | C B C B A |
| 4. | A B C D | 15. | C D B A | 26. | A B D | 37. | B B |
| 5. | B A C | 16. | C B A | 27. | A D C | 38. | A B C |
| 6. | A C B | 17. | B A | 28. | A C B | 39. | D B C |
| 7. | C C B A B | 18. | A | 29. | A B C | 40. | C C A B |
| 8. | A B C | 19. | A C | 30. | A B | 41. | |
| 9. | A B | 20. | A B C D | 31. | A B C | 42. | |
| 10. | A B C | 21. | A B C | 32. | A B | | |
| 11. | A B C | 22. | A | 33. | A B | | |

| | | | | | | | |
|---|--------------|-------------|--------------|--------------------|--------------|--|--|
| LOCAL GOVERNMENT ENGINEERING DEPARTMENT SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT IN DISTRICT NAMKHANNA, JHARKHAND, INDIA | | | | | | | |
| SUBSIDIARY SUBPROJECT | | | | S.P ID | | | |
| UPAZILA : NAMKHALA, DISTRICT NAMKHANNA | | | | S.P ID | | | |
| BOLAR KHANA : PFB-17/200 x 2.80m C.R. : 1:2.50 | | | | BAR BEARING SHAPES | | | |
| DRAWN BY: | DESIGNED BY: | CHECKED BY: | REVIEWED BY: | RECOMMENDED BY: | APPROVED BY: | | |
| HOME OF COMPUTER ARTS LTD. MAP FLOOR PLATE NO. 101, 1ST FLOOR, DHAKA-1205 | | | | | | | |
| S. K. HMD. BAKHLUDDEZA M. A. KHANNA VWD SPECIALIST VWD SPECIALIST NEW P&D PROJECT DIRECTOR C.R. : 1:2.50 DESIGNER TEAM LEADER DR. No. /WSD-BOLAR PFB/17-1/1 C.R. : 1:2.50 | | | | | | PROJECT DIRECTOR DR. No. /WSD-BOLAR PFB/17-1/1 C.R. : 1:2.50 | |

| MEMBER MARKS | BAR DIAM. (mm) | SHAPE CODE | SPACING (mm) | DIMENSIONS (mm) | | | | CUT LENGTH (mm) | BAR PER MEMBER | NO. OF MEMBER | TOTAL LENGTH (m) | UNIT Wt. Kg/m | TOTAL wT Kg | |
|-----------------|--|---------------|-----------------|-----------------|-------------|-------------|-----|--------------------|-------------------|------------------|---------------------|------------------|----------------|--------|
| | | | | A | B | C | D | | | | | | | |
| 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 | 130.55 | 1.58 | 207.40 |
| AB | 12 | 24 | 200 | 1550 | 1551 | 1250 | | | 4621 | 22 | 1 | 107.55 | 0.89 | 91.75 |
| AD | 12 | 6 | 150 | 475 | 4300 | 475 | | | 5550 | 30 | 1 | 165.50 | 0.89 | 148.33 |
| AO | 12 | 42 | 150 | 1255 | 1581 | 1250 | | | 4396 | 30 | 1 | 131.88 | 0.89 | 117.48 |
| AE | 16 | 8 | 200 | 4300 | 475 | 4750 | | | 15050 | 5 | 1 | 135.45 | 1.58 | 214.53 |
| BB | 12 | 3 | 150 | 3950 ~ 4450 | 525 | | | | 4625 ~ 5125 | 11 | 2 | 107.25 | 0.89 | 95.55 |
| BB | 12 | 3 | 150 | 4450 | 525 | | | | 5125 | 5 | 2 | 92.25 | 0.89 | 82.18 |
| CH | 12 | 6 | 200 | 4300 ~ 4300 | | | | | 4625 ~ 6465 | 2 | 2 | 45.25 | 0.89 | 40.50 |
| BD | 12 | 1 | 200 | 13565 | | | | | 3760 | 10 | | 26.60 | 0.89 | 244.68 |
| BE | 12 | 1 | 200 | 4300 ~ 18300 | | | | | 7450 | 11 | 2 | 165.50 | 0.89 | 146.02 |
| QO | 12 | 1 | 150 | 4300 ~ 4300 | | | | | 4800 ~ 6300 | 4 | 2 | 45.40 | 0.89 | 43.12 |
| BF | 12 | 1 | 150 | 6200 | | | | | 6550 | 14 | 2 | 165.50 | 0.89 | 173.37 |
| BO | 12 | 1 | 150 | 5750 | | | | | 5500 | 14 | | 165.20 | 0.89 | 147.17 |
| BL | 12 | 6 | 150 | 260 | 400 | 260 | | | 1060 | 24 | 2 | 64.40 | 0.89 | 42.64 |
| BK | 12 | 1 | 150 | 730 | | | | | 730 | 26 | 4 | 78.92 | 0.89 | 67.64 |
| BU | 12 | 3 | 150 | 300 | 525 | | | | 5525 | 12 | 2 | 137.60 | 0.89 | 118.13 |
| Pier: | | | | | | | | | | | | | | |
| BI | 12 | 2 | 150 | 300 | 6225 | | | | 6625 | 6 | 1 | 33.16 | 0.89 | 26.63 |
| BJ | 12 | 4 | 150 | 325 | 350 | 325 | 380 | | 1892 | 24 | 1 | 59.17 | 0.89 | 50.04 |
| BM | 12 | 1 | 150 | 325 | | | | | 1375 | 32 | 1 | 52.25 | 0.89 | 50.30 |
| BN | 12 | 5 | 150 | 325 | 420 | 325 | 420 | | 1982 | 34 | 1 | 45.50 | 0.89 | 43.28 |
| BR | 12 | 2 | 150 | 300 | 5225 | | | | 5525 | 6 | 1 | 33.16 | 0.89 | 26.63 |
| BY | 12 | 2 | 150 | 300 | 5225 | | | | 5525 | 6 | 1 | 45.20 | 0.89 | 0.00 |
| BJ | 12 | 3 | 150 | 300 | 6225 | | | | 6625 | 10 | 1 | 64.24 | 0.89 | 36.22 |
| BP | 12 | 29 | 150 | 225 | 350 | 230 | | | 1580 | 24 | 1 | 52.04 | 0.89 | 47.28 |
| BO | 12 | 6 | 150 | 300 | 3200 | 300 | | | 3060 | 24 | 6 | 201.00 | 0.89 | 717.00 |
| BC | 12 | 2 | 150 | 300 | 3200 ~ 4615 | | | | 3850 ~ 4815 | 8 | 6 | 165.00 | 0.89 | 149.47 |
| BC1 | 12 | 5 | 150 | 300 | 300 | 300 | | | 2350 | 32 | 4 | 300.00 | 0.89 | 267.92 |
| BC | 12 | 6 | 150 | 300 | 300 ~ 700 | 300 | | | 1550 ~ 50 | 8 | 4 | 49.00 | 0.89 | 0.00 |
| Deck Slab: | | | | | | | | | | | | | | |
| CB | 12 | 4 | 200 | 3950 | | | | | 4250 | 14 | 1 | 59.50 | 0.89 | 53.01 |
| CO | 12 | 6 | 150 | 360 | 2650 | 350 | | | 3560 | 24 | 1 | 9.500 | 0.89 | 84.56 |
| CO | 16 | 1 | 150 | 3950 | | | | | 4250 | 16 | | 76.50 | 1.58 | 121.16 |
| CE | 12 | 1 | 150 | 2950 | | | | | 2950 | 26 | 1 | 75.70 | 0.89 | 68.33 |
| CF | 12 | 1 | 200 | 3900 | | | | | 4200 | 8 | 1 | 32.50 | 0.89 | 29.92 |
| CG | 12 | 1 | 200 | 420 | | | | | 720 | 36 | 1 | 25.52 | 0.89 | 23.09 |
| CR | 12 | 4 | 200 | 400 | 150 | 400 | 150 | | 1400 | 51 | 1 | 71.40 | 0.89 | 63.61 |
| CS | 12 | 1 | 150 | 3950 | | | | | 1150 | 51 | 1 | 58.65 | 0.89 | 52.25 |
| CT | 12 | 1 | 150 | 3950 | | | | | 3950 | 10 | 1 | 39.50 | 0.89 | 35.19 |
| CU | 12 | 1 | 150 | 3950 | | | | | 3550 | 6 | 1 | 23.70 | 0.89 | 21.11 |
| CV | 12 | 1 | 150 | 3950 | | | | | 1550 | 4 | 3 | 18.60 | 0.89 | 16.57 |
| CR | 12 | 6 | 150 | 360 | | | | | 4250 | 5 | 1 | 38.25 | 0.89 | 0.00 |
| CR | 12 | 6 | 150 | 360 | | | | | 800 | 5 | 1 | 8.00 | 0.89 | 0.00 |
| Curb: | | | | | | | | | 4200 | 2 | 2 | 18.00 | 0.89 | 14.57 |
| CK | 12 | 15 | 200 | 400 | 250 | 403 | | | 1353 | 20 | 2 | 54.12 | 0.89 | 48.21 |
| CL | 0 | 1 | 150 | 2900 | | | | | 3200 | 10 | 0 | 0.00 | 0.00 | 0.00 |
| CL1 | 0 | 1 | 150 | 2460 | | | | | 2760 | 10 | 0 | 0.00 | 0.00 | 0.00 |
| CM | 6 | 8 | 150 | 200 | 500 | 200 | | | 1350 | 10 | 0 | 0.00 | 0.00 | 0.00 |
| CS | 6 | 1 | 150 | 3950 | | | | | 3550 | 6 | 1 | 23.70 | 0.00 | 0.00 |
| CR | 6 | 4 | 200 | 350 | 250 | 350 | 200 | | 4200 | 2 | 2 | 145.00 | 0.00 | 0.00 |
| Railing & Post: | | | | | | | | | 1400 | 5 | 0 | 0.00 | 0.00 | 0.00 |
| Deck Post: | | | | | | | | | 1475 | 2 | 6 | 17.70 | 0.89 | 15.77 |
| DS | 12 | 2 | 150 | 1025 | 300 | | | | 1475 | 2 | 6 | 17.70 | 0.89 | 15.77 |
| DO | 6 | 4 | 200 | 350 | 100 | 100 | 100 | | 700 | 5 | 6 | 14.20 | 0.89 | 5.02 |
| DC | 12 | 1 | 200 | 3950 | | | | | 3550 | 5 | 4 | 61.60 | 0.89 | 64.33 |
| DC | 12 | 9 | 200 | 100 | 100 | 100 | 100 | | 700 | 16 | 6 | 40.20 | 0.89 | 22.08 |
| OpPostL: | | | | | | | | | 1626 | 2 | 6 | 19.50 | 0.89 | 17.37 |
| DA | 12 | 2 | 150 | 1175 | 300 | | | | 1626 | 2 | 6 | 19.50 | 0.89 | 17.37 |
| DB | 12 | 2 | 150 | 1175 | 300 | | | | 1626 | 2 | 6 | 19.50 | 0.89 | 17.37 |
| DO | 9 | 4 | 200 | 100 | 100 | 100 | 100 | | 700 | 4 | 6 | 16.20 | 0.89 | 3.42 |
| Notes: | 1. Determined bars will be used. Additional length of 15mm has been included in cutting length for consideration of DPM or less attachment. 2. For rebar & bar bolts, height of bars should be calculated from the design & numbers of bars. 3. The Contractors shall check the bar bending schedule at the drawing before cutting the bars. | | | | | | | | | | | | | |

| | | | |
|--|-------------------|--------------|---|
| LOCAL GOVERNMENT ENGINEERING DEPARTMENT SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT In Greater Mymensingh, Sylhet and Pernia Areas | | | |
| SOULAR KHAL SUBPROJECT UPZILA NAMOONIKAH, MYMENSINGH | | | |
| BOLALAR KHAN, PMS (CY-1.500, Z-2.00m) AT Ch. 0-355 Km (Neha) | | | |
| BAR BENDING SCHEDULE | | | |
| DRAWN BY: | DESIGNED BY: | CHECKED BY: | REVIEWED BY: |
| S/D. MD. BADRUDDOZA | MD. HAGANUL BANNA | M. A. MANNAN | WFO SPECIALIST Project Consultant Project Manager |
| O/S. No.: | TEAM LEADER | O/S. No.: | XEN (PMS) Project Director Engineering (SIC) |
| O/D. No.: | | O/D. No.: | FEB 2014 |

BAR BENDING SCHEDULE

| MEMBER | BAR MARKS | BAR Dia. (mm) | SHAPE CODE | SPACING (mm) | DIMENSIONS (mm) | | | | CUT LENGTH (mm) | BAR PER NO. OF MEMBER | TOTAL LENGTH (m) | UNIT WT. Kg/m | TOTAL WT. Kg | |
|---------------------------|-----------|---------------|-------------------|-------------------|-----------------|-------------|-----|---|-----------------|-----------------------|------------------|---------------|--------------|--------|
| | | | | | A | B | C | E | | | | | | |
| Railing & Post | | | | | | | | | | | | | | |
| OpRail(L) | DC | 12 | 1 | 3500 | | | | | 3860 | 4 | 4 | 61.00 | 0.89 | 54.88 |
| OpRail(S) | DC | 9 | 4 | 200 - 100 | 100 | 100 | 100 | | 700 | 14 | 4 | 39.20 | 0.50 | 19.64 |
| OpRail(S) | DC | 12 | 4 | 1500 | | | | | 1800 | 4 | 4 | 28.00 | 0.89 | 25.66 |
| FoOpSlab Post | DB | | 2 | 1025 | 300 | | | | 1475 | 2 | 0 | 0.00 | 0.00 | 0.00 |
| | DA | | 2 | 1025 | 300 | | | | 1475 | 2 | 0 | 0.00 | 0.00 | 0.00 |
| FoOpSlab Post | DD | 4 | 200 - 100 | 100 | 100 | 100 | 100 | | 700 | 3 | 0 | 0.00 | 0.00 | 0.00 |
| Rail | DC | 1 | -50 | | | | | | 250 | 4 | 2 | 2.00 | 0.00 | 0.00 |
| | DC | 1 | -50 | | | | | | 250 | 4 | 2 | 2.00 | 0.00 | 0.00 |
| | DC | 4 | 200 - 100 | 100 | 100 | 100 | 100 | | 700 | 0 | 2 | 0.00 | 0.00 | 0.00 |
| | DC | 4 | 200 - 100 | 100 | 100 | 100 | 100 | | 700 | 0 | 2 | 0.00 | 0.00 | 0.00 |
| River Side | PE | 7 | 200 - 4400 ~ 5252 | 525 ~ 377 | 1600 | | | | 8950 ~ 9500 | 15 | 1 | 138.42 | 0.00 | 0.00 |
| | QC | 0 | 7 | 200 - 4400 ~ 5252 | 525 ~ 377 | 4460 ~ 2400 | | | 14600 ~ 16200 | 10 | 1 | 288.85 | 0.00 | 0.00 |
| | PB | 12 | 21 | 200 - 4800 | 504 | | | | 5604 | 23 | 1 | 128.88 | 0.89 | 114.83 |
| | PC | 12 | 8 | 125 - 4400 ~ 6252 | 300 | 300 | | | 6300 ~ 6162 | 23 | 1 | 137.43 | 0.89 | 122.43 |
| | PD | 12 | 1 | 150 - 5100 | | | | | 6400 | 23 | 1 | 124.20 | 0.89 | 110.65 |
| | PA | 16 | 7 | 300 - 4400 ~ 5252 | 525 ~ 377 | 1600 | | | 8950 ~ 9500 | 10 | 1 | 62.26 | 1.59 | 146.15 |
| | PA1 | 16 | 7 | 300 - 4400 ~ 5252 | 450 ~ 377 | 4460 ~ 2400 | | | 8800 ~ 6300 | 11 | 1 | 63.08 | 1.59 | 131.59 |
| | PF | 12 | 1 | 200 - 600 ~ 4800 | 0 ~ 0 | | | | 800 ~ 6100 | 6 | 2 | 35.40 | 0.89 | 31.64 |
| | PG | 12 | 8 | 100 - 300 | 4400 | 300 | | | 6300 | 20 | 1 | 63.00 | 0.89 | 47.22 |
| | PH | 12 | 1 | 150 - 500 ~ 4800 | | | | | 600 ~ 5100 | 6 | 2 | 35.40 | 0.89 | 31.54 |
| | PE | 16 | 7 | 300 - 5252 ~ 6600 | 377 ~ 325 | 900 | | | 8108 ~ 8300 | 4 | 1 | 32.81 | 1.59 | 51.97 |
| | PE1 | 16 | 7 | 300 - 5252 ~ 6600 | 377 ~ 325 | 2460 | | | 11205 ~ 11400 | 5 | 1 | 56.52 | 1.59 | 89.51 |
| | PJ | 8 | 125 - 5252 ~ 5550 | 300 | 300 | | | | 6152 ~ 6460 | 8 | 1 | 50.44 | 0.00 | 0.00 |
| | QD | 12 | 3 | 150 - 4943 ~ 2093 | 300 | | | | 6413 ~ 3413 | 20 | 2 | 176.62 | 0.89 | 157.28 |
| | QB | 12 | 3 | 150 - 4947 ~ 2796 | 300 | | | | 6367 ~ 3248 | 21 | 2 | 161.57 | 0.89 | 151.76 |
| | QE | 3 | 150 - 2927 ~ 2775 | 300 | | | | | 3277 ~ 3225 | 7 | 2 | 46.51 | 0.00 | 0.00 |
| | QG | 12 | 1 | 150 - 3828 | | | | | 3628 | 3 | 2 | 23.57 | 0.89 | 21.00 |
| | QH | 12 | 1 | 200 - 3828 | | | | | 3778 | 3 | 2 | 22.07 | 0.89 | 20.19 |
| | QI | 1 | 150 - 1940 ~ 4800 | | | | | | 1950 ~ 4800 | 13 | 2 | 50.70 | 0.00 | 0.00 |
| | QJ | 1 | 200 - 3828 | | | | | | 3628 | 10 | 2 | 72.66 | 0.00 | 0.00 |
| | PJ1 | 8 | 200 - | 300 | 300 | | | | | 6 | 2 | 0.00 | 0.00 | 0.00 |
| | PN | 12 | 1 | 5052.6 | | | | | 5053 | 1 | 2 | 10.11 | 0.89 | 9.00 |
| | BV | 12 | 1 | 500 ~ 4105.6 | | | | | 900 ~ 4250 | 2 | 2 | 10.11 | 0.89 | 9.01 |
| R/W(R/S) | PL1 | 12 | 15 | 300 - 576 | 300 | 813 | | | 1088 | 41 | 1 | 81.51 | 0.89 | 72.61 |
| | PL | 12 | 8 | 300 - 576 | 300 | 675 | | | 1760 | 41 | 1 | 71.76 | 0.89 | 63.02 |
| | RC | 12 | 1 | 12250 | | | | | 12550 | 5 | 1 | 62.75 | 0.89 | 56.90 |
| | RA | 12 | 6 | 200 - 300 | 2150 | 300 | | | 3050 | 10 | 2 | 116.00 | 0.89 | 103.25 |
| | RB | 12 | 1 | 200 - 4960 | | | | | 4950 | 8 | 2 | 62.20 | 0.89 | 46.60 |
| | RS | 12 | 8 | 200 - 300 | 2150 | 300 | | | 3050 | 19 | 2 | 115.00 | 0.89 | 103.25 |
| | RE | 12 | 1 | 200 - 4940 | | | | | 4950 | 7 | 2 | 60.90 | 0.89 | 54.28 |
| | RF | 12 | 1 | 12260 | | | | | 12650 | 0 | 1 | 76.30 | 0.89 | 67.08 |
| | RG | 0 | 3 | 150 - 1158 | 300 | | | | 1608 | 23 | 2 | 80.40 | 0.00 | 0.00 |
| | RG1 | 12 | 3 | 150 - 2775 | 300 | | | | 3225 | 25 | 2 | 167.70 | 0.89 | 149.40 |

Notes: 1. Deformed bars will be used. Additional length of 150mm has been included in cutting length for hooked bend (600 or less) at each end.

2. For rebars bar lighter, length can be calculated from the gauge & number of bars.

3. The Contractor shall check the bar bending schedule w.r.t. the drawings before cutting the bars.

| LOCAL GOVERNMENT ENGINEERING DEPARTMENT SMALL SCALE WATER RESOURCE DEVELOPMENT PROJECT BULAND KHAN DISTRICT, BULDAGHAR, BULDAGHAR, U.P. | | | | SP ID |
|---|-----------------|--------------------------------------|--------------------------------------|--|
| BULAND KHAN SUB PROJECT UPAZILA : BULDAGHAR, DISTRICT: BULDAGHAR BULAND KHAN WRS (2Y-1.5km x 2.00m) ATC : 1.55 km x 2.00 m BAR BENDING SCHEDULE | | | | |
| DRAWN BY: | DESIGNED BY: | CHECKED BY: | CHECKED BY: | REVIEWED BY: |
| M. NO. BHUROOZA MO. INGANUL BANNA | M. A. MANNAN | VTP SPECIALIST Project Consultant | VTP SPECIALIST Project Consultant | XEN (P&D) INRML, LOKD Project Director CONTRP. JICA |
| GD BY | DESIGN ENGINEER | TEAM LEADER | DR. NO. 1 | /WRS-BULDAGH WRS/16-2/4 FEB 2014 |

| BAR BENDING SCHEDULE | | | | | | | | | | | | | | | | | |
|--|----------|-----|------|-------|---------|--------|-------|------|--------|------|------------|----------------|--------------|----------|-----------|--------|--------|
| MEMBER | MATERIAL | BAR | DIA | SHAPE | SPACING | A | B | C | D | E | CUT LENGTH | BAR PER MEMBER | TOTAL LENGTH | UNIT WT. | TOTAL WT. | | |
| | | | (mm) | | (mm) | | | | | | (mm) | NO. OF | (m) | Kg/m | Kg | | |
| R/W(R/S) | RH | 12 | 3 | 100 | 2775 | 300 | | | | | 3225 | 2 | 167.70 | 0.89 | 149.40 | | |
| | RI | 12 | 3 | 200 | 3925 | 300 | | | | | 4075 | 13 | 2 | 52.99 | 0.89 | 47.19 | |
| | RJ | 12 | 3 | 100 | 3925 | 300 | | | | | 4075 | 17 | 2 | 138.55 | 0.89 | 123.43 | |
| | PM | 12 | 1 | 12250 | | | | | | | 12660 | 4 | 1 | 40.20 | 0.89 | 44.72 | |
| | RK | 12 | 20 | 300 | 300 | 600 | 635 | 1400 | | | 1600 | 8 | 2 | 24.00 | 0.89 | 21.39 | |
| Country Side | XA | 16 | 7 | 300 | 4300 ~ | 4490 | 525 ~ | 635 | 1400 | | 8460 ~ | 8640 | 4 | 1 | 34.19 | 1.68 | 54.15 |
| | YA | 16 | 7 | 300 | 4300 ~ | 4490 | 525 ~ | 635 | 3950 ~ | 3550 | 13550 ~ | 13749 | 5 | 1 | 89.24 | 1.59 | 108.09 |
| | RB | 12 | 21 | 200 | 4725 | 1880 | | | | | 8665 | 22 | 1 | 142.97 | 0.89 | 131.02 | |
| | RC | 12 | 6 | 100 | 300 | 4300 ~ | 4490 | 300 | | | 8200 ~ | 6386 | 9 | 1 | 47.58 | 0.89 | 42.48 |
| | RD | 12 | 1 | 100 | 5225 | | | | | | 6625 | 30 | 1 | 165.75 | 0.89 | 147.65 | |
| | RE | 16 | 7 | 300 | 4490 ~ | 4790 | 525 ~ | 435 | 1400 | | 8846 ~ | 8760 | 6 | 1 | 52.22 | 1.59 | 82.70 |
| | YC | 16 | 7 | 300 | 4490 ~ | 4790 | 525 ~ | 435 | 3550 ~ | 2350 | 12946 ~ | 10660 | 7 | 1 | 82.82 | 1.59 | 100.08 |
| | YF | 12 | 1 | 200 | 4725 ~ | 2150 | | | | | 5025 ~ | 2450 | 3 | 2 | 22.42 | 0.89 | 19.98 |
| | XG | 12 | 6 | 100 | 300 | 4490 ~ | 4790 | 300 | | | 5306 ~ | 5600 | 12 | 1 | 85.52 | 0.89 | 99.26 |
| | XH | 12 | 1 | 100 | 5025 ~ | 2160 | | | | | 5325 ~ | 2450 | 4 | 2 | 31.10 | 0.89 | 27.71 |
| | XI | 12 | 7 | 300 | 4790 ~ | 5150 | 435 ~ | 325 | 900 | | 7760 ~ | 7940 | 7 | 1 | 54.81 | 0.89 | 48.93 |
| | YE | 12 | 7 | 300 | 4790 ~ | 5150 | 435 ~ | 325 | 2350 | | 10660 ~ | 10800 | 8 | 1 | 85.84 | 0.89 | 78.47 |
| | XJ | 12 | 6 | 100 | 150 | 4790 ~ | 5150 | 150 | | | 5306 ~ | 5750 | 15 | 1 | 89.12 | 0.89 | 79.40 |
| | YB | 12 | 3 | 100 | 4447 ~ | 4670 | 206 | | | | 4867 ~ | 4620 | 9 | 2 | 84.83 | 0.89 | 75.68 |
| | YD | 12 | 3 | 100 | 4047 ~ | 2767 | 300 | | | | 4467 ~ | 3207 | 12 | 2 | 92.45 | 0.89 | 82.36 |
| | YF | 12 | 3 | 100 | 2761 ~ | 2651 | 300 | | | | 3211 ~ | 3101 | 16 | 2 | 100.99 | 0.89 | 99.97 |
| | YG | 12 | 1 | 200 | 5826 ~ | 4500 | | | | | 5926 ~ | 4800 | 3 | 2 | 32.18 | 0.89 | 28.67 |
| | YH | 12 | 1 | 100 | 5826 ~ | 4500 | | | | | 6926 ~ | 4800 | 4 | 2 | 42.90 | 0.89 | 38.22 |
| | BV | 12 | 1 | 401 | 4106.6 | | | | | | -251 ~ | 4256 | 2 | 2 | 8.01 | 0.89 | 7.14 |
| | BI | 12 | 1 | 100 | 5700 | | | | | | 6000 ~ | 14 | 2 | 168.00 | 0.89 | 149.67 | |
| | BJ | 12 | 1 | 100 | 500 ~ | 3500 | | | | | 800 ~ | 3800 | 14 | 2 | 84.40 | 0.89 | 57.37 |
| | XN | 12 | 1 | 8150 | | | | | | | 6150 ~ | 1 | 2 | 12.00 | 0.89 | 10.99 | |
| 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 | | | | 1760 ~ | 39 | 1 | 88.24 | 0.89 | 80.80 | |
| | XU | 12 | 16 | 300 | 575 | 300 | 813 | | | | 1998 ~ | 39 | 1 | 77.53 | 0.89 | 69.07 | |
| | ZB | 12 | 1 | 200 | 3900 | | | | | | 4200 ~ | 6 | 2 | 50.40 | 0.89 | 44.90 | |
| | ZF | 12 | 1 | 11550 | | | | | | | 11850 ~ | 6 | 1 | 71.10 | 0.89 | 63.44 | |
| | ZA | 12 | 8 | 200 | 150 | 2150 | 150 | | | | 2760 ~ | 19 | 2 | 104.50 | 0.89 | 93.10 | |
| | ZD | 12 | 1 | 200 | 150 | 2150 | 150 | | | | 2760 ~ | 19 | 2 | 104.50 | 0.89 | 93.10 | |
| | ZC | 12 | 1 | 11550 | | | | | | | 11860 ~ | 5 | 1 | 59.25 | 0.89 | 52.79 | |
| | PM | 12 | 1 | 11550 | | | | | | | 11860 ~ | 4 | 1 | 47.40 | 0.89 | 42.23 | |
| | ZG | 0 | 3 | 100 | 1075 | 300 | | | | | 1628 ~ | 24 | 2 | 73.20 | 0.00 | 0.00 | |
| | ZH | 12 | 3 | 100 | 2651 | 300 | | | | | 3101 ~ | 25 | 2 | 165.05 | 0.89 | 138.13 | |
| | ZH | 12 | 3 | 100 | 2651 | 300 | | | | | 3101 ~ | 25 | 2 | 165.05 | 0.89 | 138.13 | |
| | ZI | 12 | 3 | 200 | 3475 | 500 | | | | | 4126 ~ | 13 | 2 | 107.25 | 0.89 | 95.55 | |
| | ZJ | 12 | 3 | 100 | 3475 | 500 | | | | | 4275 ~ | 17 | 2 | 145.35 | 0.89 | 129.49 | |
| | ZK | 12 | 20 | 300 | 900 | 300 | | | | | 1600 ~ | 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 | | | | | 1760 ~ | 7 | 4 | 49.00 | 0.89 | 43.65 | |
| | SC | 12 | 12 | 750 | 1061 | | | | | | 2111 ~ | 9 | 1 | 6.33 | 0.89 | 5.64 | |
| | SD | 12 | 4 | 350 | | | | | | | 350 ~ | 7 | 1 | 2.45 | 0.89 | 2.18 | |
| | SC1 | 12 | 12 | 750 | 1061 | | | | | | 2111 ~ | 2 | 0 | 0.00 | 0.00 | 0.00 | |
| Endwall (R/S) | SE | 12 | 13 | 636 | | | | | | | 1670 ~ | 2 | 0 | 0.00 | 0.89 | 0.00 | |
| | SF | 12 | 12 | 200 | 575 | 1286 | | | | | 2161 ~ | 25 | 1 | 54.05 | 0.89 | 48.13 | |
| | SH | 12 | 14 | 5200 | | | | | | | 5500 ~ | 1 | 1 | 5.50 | 0.89 | 4.90 | |
| | SG | 12 | 11 | 5200 | | | | | | | 5500 ~ | 4 | 1 | 22.00 | 0.89 | 19.60 | |
| Notes: | | | | | | | | | | | | | | | | | |
| 1. Deformed bars will be used. Additional length of 100mm bar has been added to extend for non-tensioned (300 or less) attack end. | | | | | | | | | | | | | | | | | |
| 2. For useable bar lengths, height of bars should be calculated from the stage & number of bars. | | | | | | | | | | | | | | | | | |
| 3. The contractor shall check the bar bend locations before it is the drawn line before casting on the bases. | | | | | | | | | | | | | | | | | |

| LOCAL GOVERNMENT ENGINEERING DEPARTMENT SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT In Greater Mymensingh, Syntet and Purbapara Areas | | | | | |
|---|-------------------|--------------|----------------|-----------------------|----------------------------------|
| BOULAR KHALI WATER PROJECT BPL-1, 1st Floor, BRTC Building, Mymensingh | | | | | |
| BOULAR KHALI WBS (2x1.5km x 2.00m) | | | | | |
| ATC: 0-555 Km / Km² | | | | | |
| BAR BENDING SCHEDULE | | | | | |
| DRAWN BY: | DESIGNED BY: | CHECKED BY: | CHECKED BY: | REVISED BY: | RECOMMENDED BY: |
| SH. MO. IDRISUDDOZA | MD. HASANUL BANNA | M. A. MANNAN | WRF SPECIALIST | WRF CO-ADVISOR | XEN (Pab) |
| DESIGN ENGINEER | TEAM LEADER | DR. NO: | WRF.001 | WRF.002 | Project Director SSWRD (JICA) |
| OD BY: | DESIGN ENGINEER | TEAM LEADER | DR. NO: | /WRF-BOLAR WBS/18-3/4 | FEB 2014 |

| MEMBER MARKS | BAR (mm) | BAR DIA (mm) | SHAPE CODE | SPACING (mm) | DIMENSIONS (mm) | | | | | CUT LENGTH (mm) | BAR PER MEMBER | NOS. OF MEMBER | TOTAL LENGTH (m) | UNIT WT. Kg/m | TOTAL WT. Kg | |
|--|-------------|-----------------|---------------|-----------------|-----------------|------|-----|-----|---|--------------------|-------------------|-------------------|---------------------|------------------|-----------------|--|
| | | | | | A | B | C | D | E | | | | | | | |
| Chute (C/S) S1 | 12 | 9 | | | 826 | 2626 | | | | 3800 | 2 | 0 | 0.00 | 0.00 | 0.00 | |
| | | | | | 826 | 300 | | | | 3800 | 2 | 0 | 0.00 | 0.00 | 0.00 | |
| Barre (C/S) S2 | 12 | 10 | | | 635 | | | | | 1500 | 3 | 0 | 0.00 | 0.00 | 0.00 | |
| | | | | | 635 | | | | | 300 | 3 | 0 | 0.00 | 0.00 | 0.00 | |
| Ends III (C/S) S3 | 12 | 1 | | | 6180 | | | | | 6180 | 1 | 1 | 5.45 | 0.00 | 0.00 | |
| | | | | | 6180 | | | | | 1500 | 3 | 0 | 0.00 | 0.00 | 0.00 | |
| | | | | | 550 | 100 | 860 | | | 1500 | 3 | 0 | 0.00 | 0.00 | 0.00 | |
| | | | | | 550 | 200 | 635 | | | 1500 | 3 | 0 | 0.00 | 0.00 | 0.00 | |
| | | | | | 550 | 300 | | | | 300 | 3 | 0 | 0.00 | 0.00 | 0.00 | |
| Gate operation stab | CK | | 1 | 150 | 850 | | | | | 850 | 0 | 2 | 0.00 | 0.00 | 0.00 | |
| | CI | | 1 | 150 | -50 | -50 | | | | 250 | 6 | 1 | 1.50 | 0.00 | 0.00 | |
| | CJ | | 1 | 120 | -60 | -60 | | | | 250 | 7 | 1 | 1.75 | 0.00 | 0.00 | |
| | Dowel | | 1 | | 500 | | | | | 500 | 1 | 2 | 2.00 | 0.00 | 0.00 | |
| Piles | P01 | 19 | 30 | | 100 | -255 | 250 | | | 85 | 4 | 0 | 0 | 2.23 | 0.00 | |
| | P02 | 15 | 1 | | 3200 | | | | | 3200 | 4 | 0 | 0 | 1.58 | 0.00 | |
| | S01 | 10 | 4 | | 80 | -80 | -80 | | | -20 | 77 | 0 | 0 | 0.62 | 0.00 | |
| | S02 | 10 | 4 | | 156 | 156 | 156 | 156 | | 524 | 55 | 0 | 0 | 0.62 | 0.00 | |
| Check Beams | CCX | | 8 | 150 | 1900 | | 150 | | | 2000 | 3 | 6 | 39.60 | 0.00 | 0.00 | |
| | CY | | 6 | 150 | 1900 | | 150 | | | 2000 | 2 | 6 | 25.40 | 0.00 | 0.00 | |
| | CZ | | 4 | 130 | 224 | 174 | 224 | 174 | | 946 | 9 | 6 | 51.08 | 0.00 | 0.00 | |
| Peripherial Beams | TA | 8 | | | 3800 | 150 | 150 | | | 4100 | 2 | 2 | 16.40 | 0.00 | 0.00 | |
| | TB | 6 | | | 150 | 300 | 150 | | | 4100 | 2 | 2 | 16.40 | 0.00 | 0.00 | |
| | TC | 1 | | | 1900 | | | | | 7900 | 3 | 2 | 47.50 | 0.00 | 0.00 | |
| | TD | 4 | 130 | 224 | 224 | 224 | 224 | 224 | | 1046 | 26 | 1 | 27.20 | 0.00 | 0.00 | |
| Tie Beams | TM | 8 | | | 150 | 1900 | 150 | | | 2000 | 2 | 0 | 0.00 | 0.00 | 0.00 | |
| | TN | 6 | | | 150 | 1900 | 150 | | | 2200 | 2 | 0 | 0.00 | 0.00 | 0.00 | |
| | TO | 4 | 130 | 224 | 174 | 224 | 174 | 174 | | 946 | 9 | 0 | 0.00 | 0.00 | 0.00 | |
| Column | GA | | 2 | | 4300 | 300 | | | | 4730 | 0 | 0 | 0.00 | 0.00 | 0.00 | |
| | | | 2 | | 4300 | 300 | | | | 4730 | 4 | 0 | 0.00 | 0.00 | 0.00 | |
| | GB | | 4 | 150 | 226 | 226 | 226 | 226 | | 1034 | 2 | 6 | 0.00 | 0.00 | 0.00 | |
| | | | 4 | 150 | 226 | 226 | 226 | 226 | | 1034 | 2 | 0 | 0.00 | 0.00 | 0.00 | |
| Bottom Tie Beams | BA | 8 | | | 3800 | 150 | 150 | | | 4100 | 3 | 2 | 24.60 | 0.00 | 0.00 | |
| | BB | 6 | | | 150 | 300 | 150 | | | 4100 | 2 | 2 | 16.40 | 0.00 | 0.00 | |
| | BC | 4 | 130 | 224 | 224 | 224 | 224 | 224 | | 1046 | 26 | 1 | 27.20 | 0.00 | 0.00 | |
| Notes: 1. Deformed bars will be used. Additional length of 15mm has been included in cut length for nominal bend (900 or less) at each end. | | | | | | | | | | | | | TOTAL = 975.4 Kg | | | |
|  LOCAL GOVERNMENT ENGINEERING DEPARTMENT SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT In Greater Mymensingh, Sylhet and Pabna Areas BOULAR KHAL SUBPROJECT UPGRADATION OF RIVER MYMENSINGH BOULAR KHAL (100-150 Km², 200m) AT Ch. 0+250 Km (Nail) 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. MANIYAN VWP SPECIALIST VWP SPECIALIST INRML (PAB) QD BY: DESIGN ENGINEER TEAM LEADER Proj. Consultant Proj. Manager INRML, LGED NEN (PAB) FEB 2014 Project Director SSWRD (JICA) | | | | | | | | | | | | | | | | |

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 Faridpur Areas

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

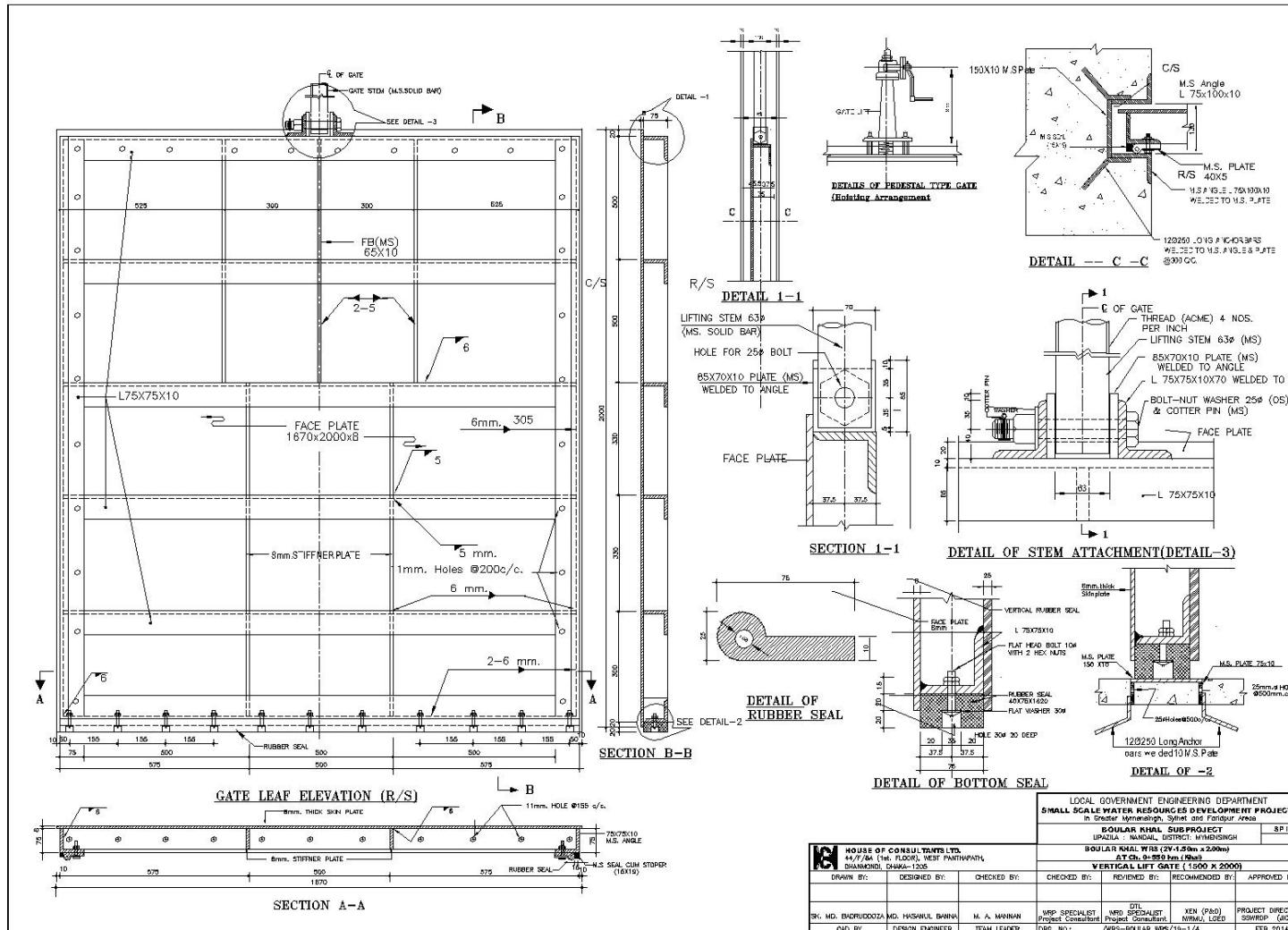
Dhaka-1207

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

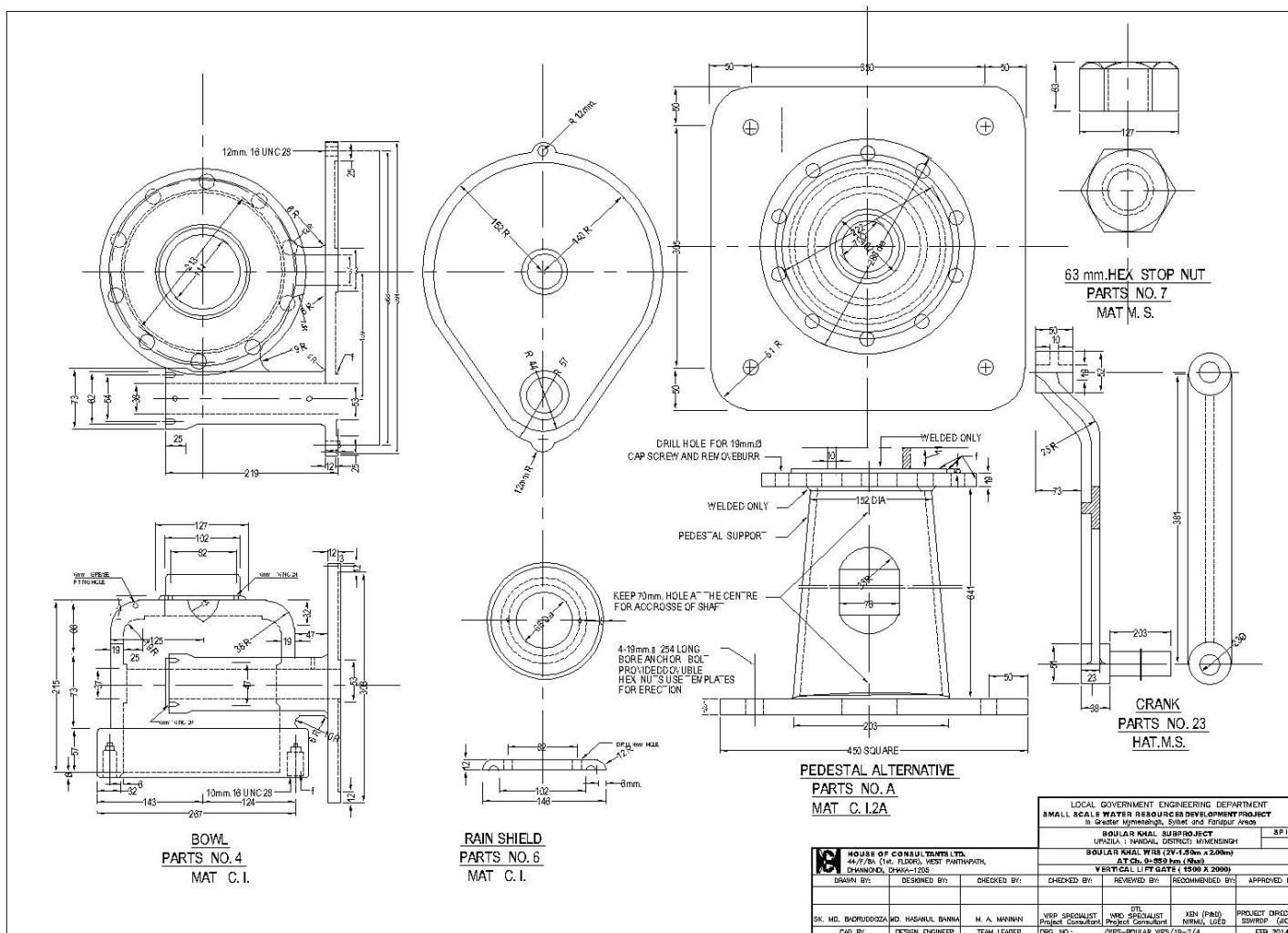
**DETAIL DRAWINGS FOR
BOULAR KHAL WRS (2V-1.50m x 2.00m)
AT Ch. 0+550 km (Khal)**

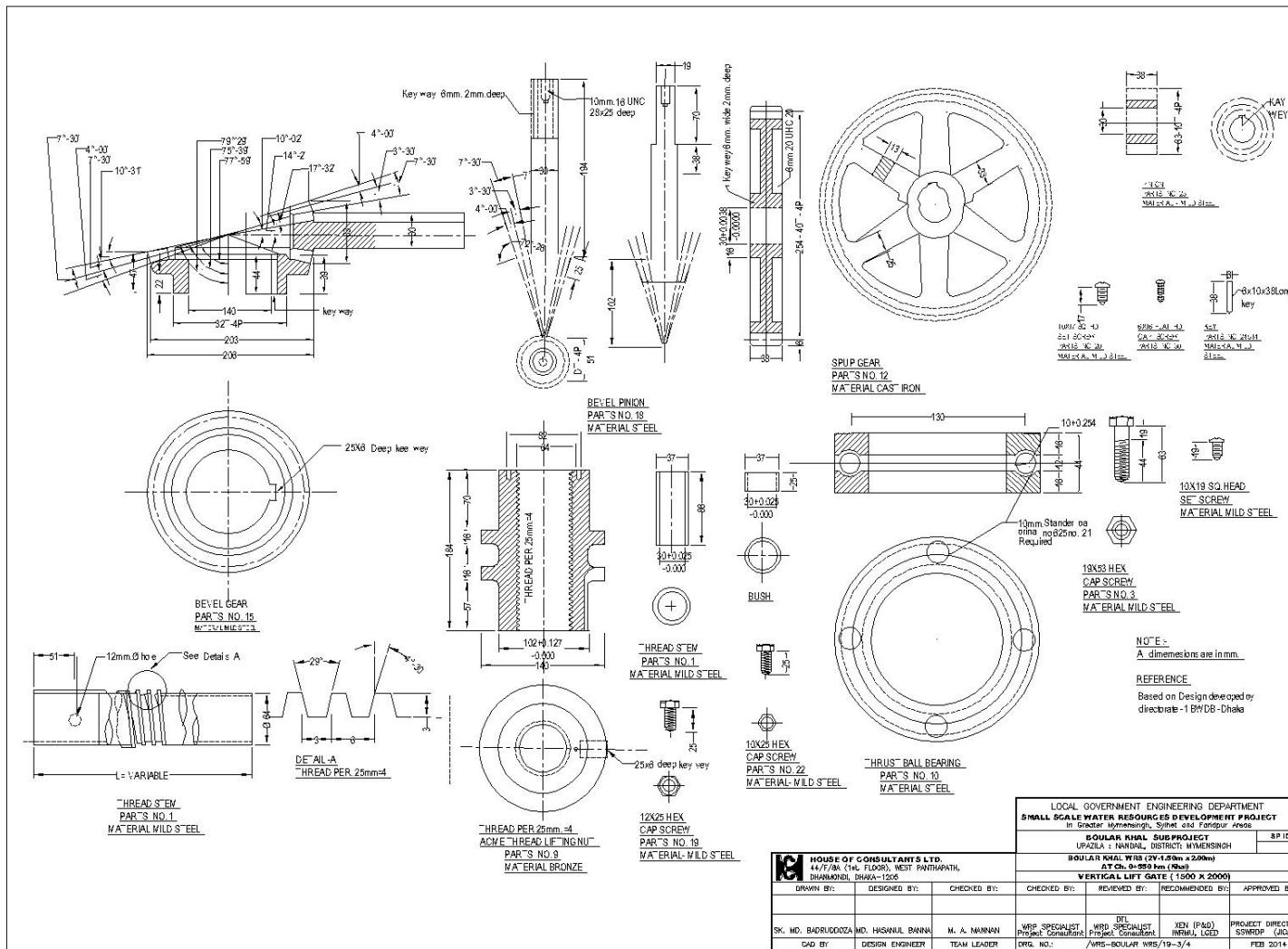
(SIZE: 1670 mm x 2000 mm)

FEBRUARY 2014



LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SMALL SCALE WATER RESOURCES DEVELOPMENT PROJECT
in Greater Mymensingh, Syntet and Faridpur Areas
BOULAR KHAL SUB-PROJECT
UPPER TURAG RIVER, BANGLADESH SPID
BOULAR KHAL WSS (29x1.25m x 2.00m)
ATC 6, 950 Km² (Nanai)
VERTICAL LIFT GATE (1500 x 2000)
DRAWN BY: DESIGNED BY: CHECKED BY: APPROVED BY:
Mr. Md. Bhoruduzzo MD. HISHAMUL BANNA M. A. MANNAN DILIP XEN (P&O) PROJECT DIRECTOR
H.C. HOUSE OF CONSULTANTS LTD. Project Consultant NIRMAL LOED FEB 2014
44/F/7/A (Int. Floor), WEST PANTHAPATH TEAM LEADER
DHAKA-1205
D.G. NO. /WRS-BOULAR WSS/19-1/4





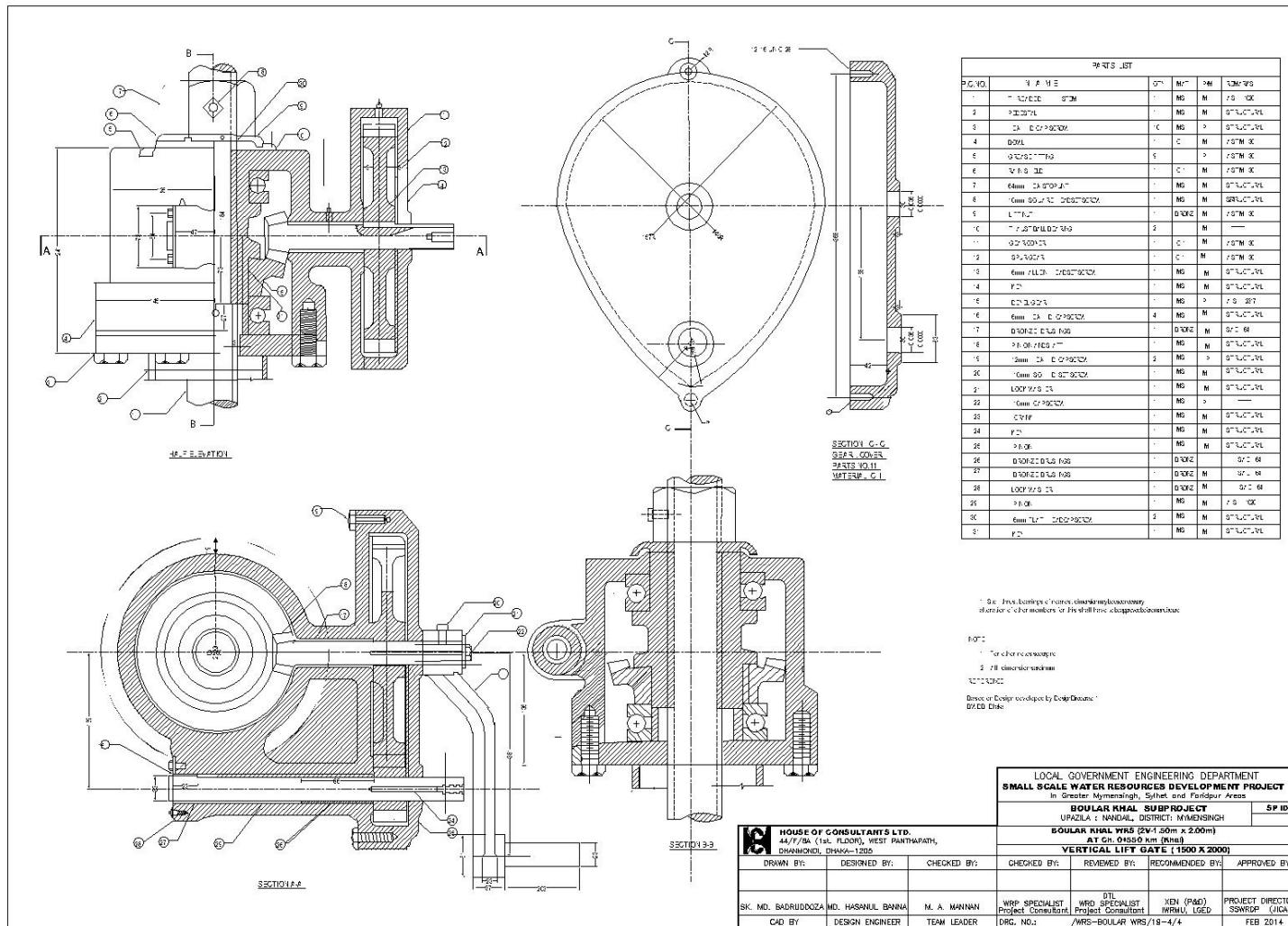


EXHIBIT G6-I: ESTIMATE OF COST AND BOQ

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 x 0.90m) 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.) |
|----------|---|----------|------|------------|--------------|
| | | | | | |
| 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 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/Cm ² 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.5 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./ft ³ 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/cm ² (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 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/cm ² (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 Madhayapara, Dinajpur), (LAA value not exceeding 30), sand (FM minimum 1.80) and cement having minimum 28 days ultimate cylinder crushing strength of 210Kg/cm ² (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 Madhayapara, Dinajpur), sand (minimum 1.80) and cement having minimum 28 days cylinder crushing strength of 210 Kg/cm ² (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/mm ² (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 bullock/bamboo pallsading 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 supply 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 stifferener with minimum 75mmx75mmx1.0mm M.S angle as frame, horizontal & vertical beam, 75mmx25mmx1.2mm 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/sludge 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/Cm ² 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./ft ³ 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 slice/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/cm ² (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 slice/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/cm ² (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 Madhayapara, Dinajpur), (LAA value not exceeding 30), sand (FM minimum 1.80) and cement having minimum 28 days ultimate cylinder crushing strength of 210Kg/cm ² (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 Madhayapara, Dinajpur), sand (minimum 1.80) and cement having minimum 28 days cylinder crushing strength of 210 Kg/cm ² (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/mm ² (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 bullock/bamboo palisading and double tarje 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 diax3.5mm 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/sllice 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

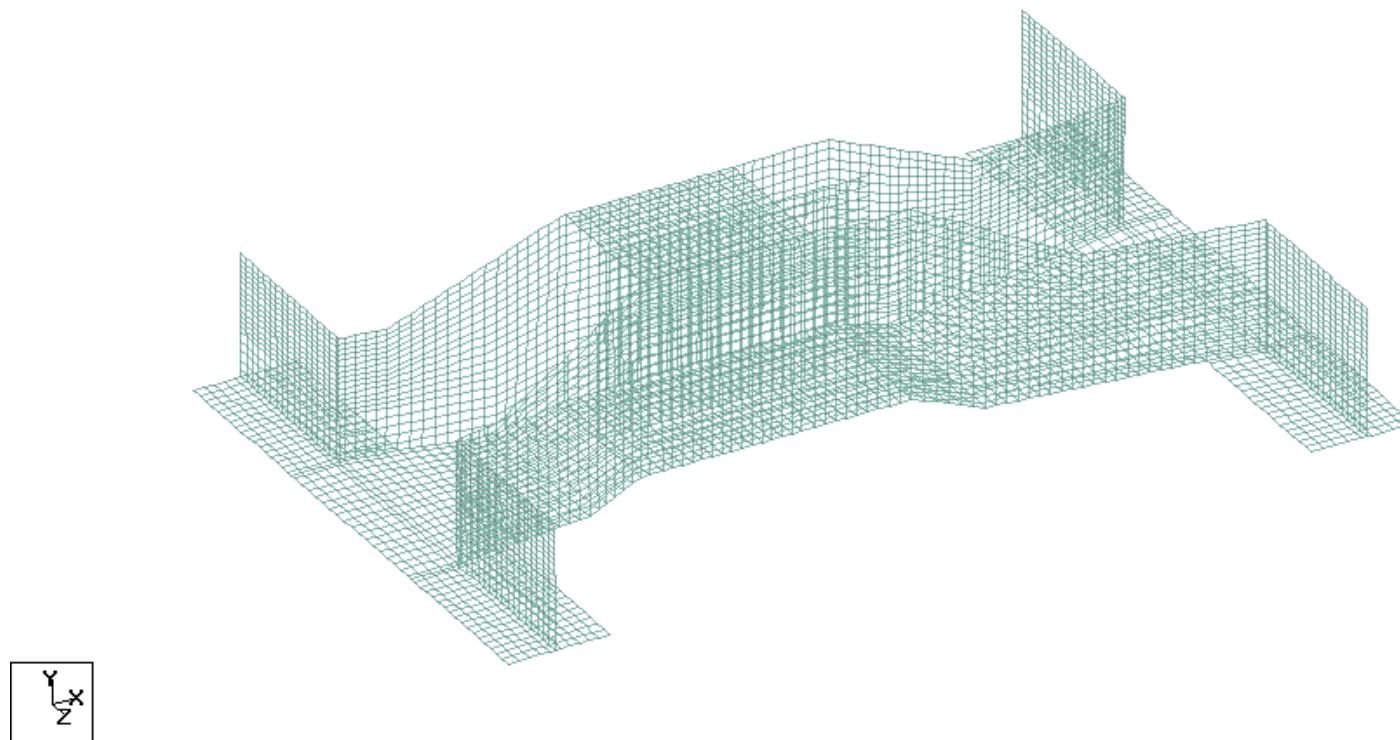


EXHIBIT G6-K Calculation of Lateral Loads on Abutments-Wing Walls of Hydraulic Structures

Design Parameters :

$$f'_c = 21.00 \text{ N/mm}^2 = 3000 \text{ psi}$$

$$f_y = 415 \text{ N/mm}^2 = 60000 \text{ psi}$$

$$\beta_1 = 0.85$$

$$\phi = 0.90$$

$$K_0 = 0.58$$

$$\varphi = 25^\circ$$

$$\gamma_{\text{conc}} = 23.60 \text{ Kn/m}^3$$

$$\gamma_s(\text{moist}) = 17.40 \text{ Kn/m}^3$$

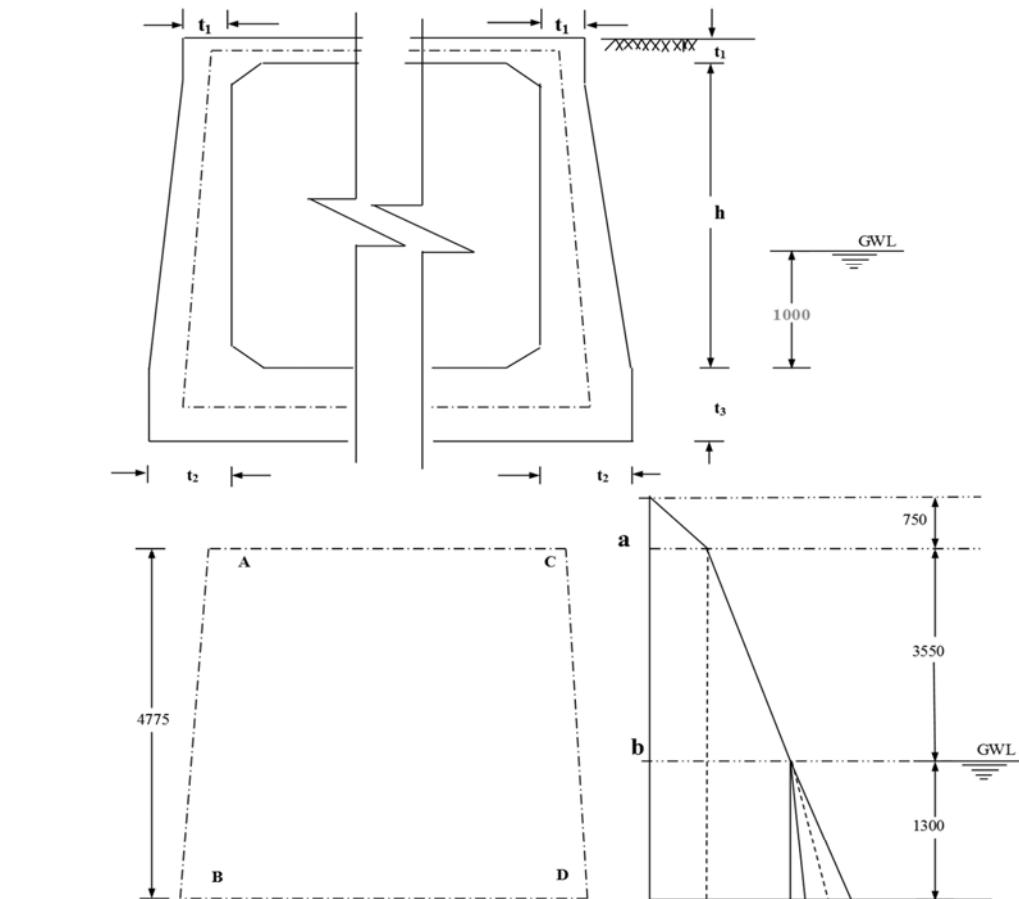
$$\gamma_s(\text{Sat}) = 18.90 \text{ Kn/m}^3$$

$$\gamma_s(\text{Sub}) = 9.09 \text{ Kn/m}^3$$

$$\gamma_s(\text{Water}) = 9.81 \text{ Kn/m}^3$$

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

$$p_a = 7.57 \text{ Kn/m}^2$$

$$p_b = 35.83 \text{ Kn/m}^2$$

$$p_c = 6.85 \text{ Kn/m}^2$$

$$p_w = 12.75 \text{ Kn/m}^2$$

$$p_{cm} = 13.12 \text{ Kn/m}^2$$

$$p_a + p_b + p_{cm} = 56.52 \text{ Kn/m}^2$$

$$p_c + p_w - p_{cm} = 6.49 \text{ Kn/m}^2$$

$$\begin{array}{cccc}
 p_a & p_b & p_c & p_w \\
 \hline
 p_a + F & p_{cm} & p_c + p_w + p_{cm} & p_c - p_{cm}
 \end{array}$$

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

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