Government of Bangladesh World Food Programme Government of the Netherlands

CHAR DEVELOPMENT AND SETTLEMENT PROJECT II

চর উন্নয়ন ও বসতি স্থাপন প্রকল্প ২

BANGLADESH

Functioning of Gates of Regulators/Sluices and Measures for Sustainable Operation & Maintenance Under BWDB

(Special Reference to CDSP-II)

Technical Report No. 15b

Prepared by

Mukhles uz zaman
Consultant

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CDP
Haskoning
Consultants for Development Programmes
Royal Dutch Consulting Engineers and Architects

Sheltech
Sheltech Consultants

TABLE OF CONTENTS

List of Abbreviations

BWDB	:	Bangladesh Water Development Board
CERP	:	Coastal Embankment Rehabilitation Project
CDSP-II	:	Char Development and Settlement Project-II
LRP	:	Land Reclamation Project
ME	:	Mechanical Engineering
O&M	:	Operation and Maintenance
PMU-ESPP	:	Project Monitoring Unit-Estuary Study Pilot Project
SDE	:	Sub-Divisional Engineer
WMC	:	Water Management Committee

1.0 Introduction

The report reflects the findings of the individual consultant for the CDSP-II to evaluate the performance and maintenance of the gates in sluices and suggestion for the sustainable operation and maintenance of the gates. The shortfalls and discrepancies as pointed out by different mission members and TA team are also mentioned in brief to establish the background history of preparing such report and suggesting solutions to overcome those difficulties or shortfalls.

The salient question and there probable answers to be dealt with have been formulated in the TOR of the consultant are: (Detail in Appendix-1)

- Inspect the work done on the 'pilot sluice' undertaking of CDSP-II and also some undertaking of LRP and CERP in the vicinity of CDSP area.

- Report on the strengths and weaknesses of the pilot sluices undertaking of CDSP in respect of functioning and O&M.

- Consider and briefly report on the potential of the sluice used in the pilot project to sluices in Bangladesh.

- Finally to draft a proposal which would in two stages resolve the sluice problems of Bangladesh by: -

    - Renovating the existing sluices.
    - Ensuring the adaptation of the most suitable quality of fabrication of standard sluice designs.

2.0 Background

The Technical Report No.15a of Char Development and Settlement Project-II, Prepared by Mr. Stuart P. Pearson, Team Leader CDSP-II in April 2004, highlights the Mechanical Aspects of Sluice Design and Fabrication. The observations made by the Team Leader and his associates mainly on mechanical aspects of sluice design and operational difficulties are summarized in this report. Sr. Civil Engineer, Mr. Jelle Fekkes in Technical Report no.12 of CDSP, also made similar observations in September 1998. Final Report; Mid Term Review Mission; Char Development and Settlement Project II; 2000-2004; July 2002 also made some specific observations about the defects and shortfalls of mechanical aspects of sluice design and production.

The observations of the Team Leader in Technical Report No.15a are, "the Char Development and Settlement Programme encompasses the activities of six Implementing Agencies (IAs) for the benefit of the peoples of the Coastal Chars of Bangladesh. Each of the activities of the six IA's is cross-linked to the activities of the others in both active and passive means. There is no better example of this symbolic reliance than that of the sluices being constructed to control the water levels and flows within the area enclosed by embankments".

In the report the background and problems are noted in a sequential manner, summary of relevant portions of which are stated here for easy reference for moving towards a sustainable solution.
In order to appreciate the crucial role of the sluice, it is important to understand the functions of the sluice in coastal area. The sluice enables:

- The exclusion of saline water during the period when the saline water intrudes into the lower reaches of the main rivers.

- The inflow of fresh water from the rivers into polders when the river discharge is sufficient to push the saline water.
- The retention of fresh water within the polder, which has flowed within the polder by either overland flow, inflow from the river or rainfall.

The overriding fault found in the sluice gates, as observed in the technical report:

- Gates neither exclude nor retain water when required to do so.

This brief statement is justified by the inspection of 11 sluices made by TA Team both under CDSP-II area and outside the CDSP-II area. (Technical Report No.15a)

It is obvious that, the success of the work, which the BWDB and CDSP are undertaking on the development of water management systems run by the peoples of the coastal chars, requires the efficient operation of the sluices.

The critical weakness, as identified in the technical report, is mechanical aspects of sluices. In particular, the design, construction and installation of two types of gates fitted to the sluices, flap gates and vertical lift Gates.

The report also mentions that it should be well noted that the cost of sluice gates (mechanical parts) is a mere fraction of the total cost of the civil work of a sluice, perhaps 12%, and an increase of 50% in gate manufacturing cost would be a relatively small price to pay to resolve the problems which are widely recognized.

The purpose of the technical report, as stated in the report, was to firstly highlight the problem and its effects and secondly to propose and demonstrate a solution to the problem. The intention of the report, was not to find fault but to give due regard to successful work on sluice gates carried out in the past (>10 years ago) and also to draw attention to the works done by others to address the problem

In general the mechanical faults of the sluices as mentioned in the report are:

- Poor design which does not adhere to BWDB standard designs, which themselves need reviewing,
- There is not a standard design to be used for a vent size,
- Tolerances are omitted.
- The safety factor used, does not take any regard of the extremely poor maintenance record of the sluice gates.
- Non-adherence to the drawings produced,
- Use of sub-standard and cheap materials,
- Poor manufacturing procedures,
- Poor installation,
- Extremely low level of maintenance.

Suggestions, made in the report, to overcome the problems/faults are:

- Use of gearboxes which are not of suitable quality where simple turn wheels are more suitable being simple, effective, require little maintenance and not prone to failure.

- Water seal material of a type and design (rubber seal material sandwiched between the gate leaf and guide channel) which adds to the resistance in sliding movement of the gate against full horizontal load, replaced with a sealing device which reduces sealing resistance to lift the gate.

- Hinge pin and bush of very large size and suitable materials machined to recommended engineering tolerances being used to extend the replacement time.

- Hinge pin securing devices that will guarantee that the pin will not slip out causing the gate damage.

- A move upwards of the gate lift point (vertical lift gate) to facilitate more even lift across the width of the gate.

- New sluice exit (where a flap gate is needed) should have a 5-7 degree slope in the vent exit face ensuring a positive close against the sluice wall.

- "Standard" unit may be produced for both vertical lift and flap gates, which will only vary for different vent size. The standard unit will have replaceable parts, (e.g. hinge pin, bush, sealing materials) which are completely standard and interchangeable. The standard unit would be fabricated and fully assembled in the workshop; the unit would then be delivered on site.

- The additional costs of standardization and over design of the smaller units are considered to be outweighed by the advantages of standardization.

3.0 Designers Observation

The inspection report of Mr. Mozaffar Ahmed, Executive Engineer, Design Circle-3 (Mech), BWDB and Mr. Md. Masudur Rahman, SDE, Design Circle-3 (Mech), BWDB for Gangchil Regulator (enclosed with Technical Report 15a) also supported the TA Team's view to some extent.

The design Engineers opined that the main beams, skin plate and hoists used in design and manufacturing of the gates was suitable for the type of installation. The discrepancies as they pointed out were mainly due to some manufacturing and installation faults, unskilled operation, lack of proper periodic maintenance etc.

In the inspection report they also mentioned that the flap gates are under designed, they are not suitable to withstand the water pressure, hinge system is very poor and already some of the gate are dislocated from the hinge, anchor bolts are damaged or broken etc.

Other observations of the design team were, one vertical lift gate is smaller than the opening size, in two cases the clearance between the gate groove and gate thickness for vertical lift gate is same and there is no clearance for operating the gate. In many cases the sealing between the gate groove or gate seat in idle condition is not proper, there are gaps in between.

In a nutshell the opinion of Design Engineers about flap gates of Gangchil Regulator is that they are inoperable and lift gates are operable with great difficulty.

4.0 The Project

The main objective and the long-term goal of the Char Development and Settlement Project II are to uplift economic condition and living standard of the population of the southeastern coastal area of Bangladesh. The project commenced in 1999-2000 and is proposed to be completed in 2004-2005.

The Project consists of three geographical areas close to Noakhali main land. These areas are: Muhuri Accreted Area (3315 ha), Noakhali Char Area (5149 ha), and South Hatiya (2495 ha). Moreover, full-scale feasibility study concerning removal of drainage congestion of Baggardona and Noakhali Khal Basins has been considered.

The Project design combines land development by empolderment with measures to increase productivity and production of agriculture, livestock, aquaculture, forestry and other activities to formulate a feasible development.

The project area is the morphologically dynamic coast and its hinterland, east of the Meghna River that is growing into the Bay of Bengal at a rate of about 2000 ha per year. Drainage congestion is one of the major (growing) problems in this area, caused by the formation of new chars, the increasing distance to the Bay and the construction of regulators, which often results in siltation of existing drainage channels. The saline conditions of surface and groundwater and the subsoil hamper agricultural development and adversely affect public health conditions. Proper drainage in combination with bringing freshwater from the Meghna River would be one possibility to overcome these problems.

The priority activities and studies recommended in the project are considered important for a sustainable development of the central part of Bangladesh' central zone. They either create conditions for a more effective and efficient CDSP type project or they would draw on CDSP's experience and opportunities to learn lessons for more general purposes. The proposed activities below would incorporate CDSP experience and support and enhance future CDSP type project implementation.

- An overall water management strategy for the Noakhali mainland and new char areas, to find a long-term solution for the ever-increasing drainage and fresh water problems of this area, among other things, due to the formation and empoldering of new lands.

- A vision on future char development and settlement, including the development of different land accretion scenarios, the identification of possible drainage and empoldering units, and defining administrative boundaries to facilitate further development of these areas.

- A coastal groundwater management plan, establishing extraction rates and corresponding management arrangements for controlling the utilization of the fresh water aquifers.

The Project incorporates physical programme such as flood embankment, drainage sluice, and irrigation inlet to enhance agricultural output in addition to distribution of khas land to landless farmers, construction of cluster village for the poor and all the ancillary facilities for making the newly accreted land habitable to the inhabitants.

The long-term objective of the project is to bring about an improvement in the economic situation and in the living condition of the population in the coastal areas of southern Bangladesh. To achieve the long-term objectives the short-term project purposes need to be realized are: (a) direct improvement of the economic and social situation of the people in the char areas, (b) stimulation of accretion of land, (c) accumulation of data and knowledge on the coastal

areas, and (d) promotion of an institutional environment that would sustain similar interventions as in the proposed project.

The stated objective and purposes can only be achieved through a number of interventions and results are expected when a number of activities of different nature are undertaken simultaneously. The proposed activities are grouped in four components. The four components are: (a) concrete interventions at the field level in the project areas, (b) stimulating land accretion, (c) study and monitoring, and (d) institutional strengthening of government and non-government organizations.

The four components as explained above for the project area implies a temporary deviation in the present mandate of CDSP. Currently the project focuses primarily on the first component (concrete interventions at field level) and to some extent on component three and four (study and monitoring, and institutional strengthening). The proposed activities are very much land and water related.

The first priority of interventions in the Noakhali main land will be the completion of the infrastructure works in the present polders. Necessary slide/flap gate fixation, modification, repairing etc. in different sluices to check the leakage through the sluices.

Second priority will be the rehabilitation or completion of a number of sluices located in the southern part of the Noakhali District in the coastal embankment around polder 59/3B.

By the end of the project period the expected output of the drainage study and O&M component should be an optimal O&M friendly design of drainage infrastructure.

5.0 Present Study

The findings and recommendations of the Team Leader, CDSP-II and the TA team as depicted above, findings and recommendations in Final Report of Mid-Term Evaluation Mission, CDSP-II and the report of Sr.Civil Engineer, Mr.Jelle Fekkes, lead the TA team of the project to prepare a proposal and search out some ways and means to solve these problems and find out a sustainable solution in consultation with the client.

With that aim, a Terms of Reference (ToR) for the study was formulated and a consultant was engaged. The ToR framed for the study is enclosed as Appendix-1.

6.0 Activities of the Consultant

The consultant went through the relevant records of the project and also records for other area throughout the coastal zone of Bangladesh. A good number of reports and publications by the project TA Team and different missions has repeatedly indicated the non-performance of both the vertical lift gates and flap gates of different sizes installed for control of saline water intrusion and retention of fresh water.

A visit to the project area in main Noakhali and Muhuri Accreted Area was made with the Project Director, PMU-ESPP and the Co-team leader of the TA Team from 20-03-05 to 23-03-05. The Superintending Engineer, Feni O&M Circle, BWDB, The Executive Engineer, Noakhali O&M Division, Feni O&M Division, the Executive Engineer, CERP Division and other officers and staff took keen interest in collecting the relevant information and took part in the inspection in their respective area.

During the visit of Gangchil regulator some local people were pointing out about the facility for retention of fresh water within the polder. Under the present scenario water can be retained up to the top level of the vertical lift gate. This amount of storage is not of any benefit to the local people. They suggested making a provision of increasing the retention level to at least 60cm above the present retention level.

Mr. Nural Amin Talukder, Chief Engineer, South Eastern Zone, BWDB, Chittagong and the Executive Engineer, ME, Chittagong joined a discussion on defects of sluices and gates and the problems of operation of the gates in Feni BWDB Inspection Bunglow on 21-03-05**.**

Second visit in the project area was made by the consultant along with Co-Team Leader of TA Team from May 9 to May 12, 2005. The information collected on different features of the project was exchanged with the Zonal Chief Engineer, BWDB, Superintending Engineer, Feni O&M Circle, Executive Engineer, Noakhali O&M Division, Executive Engineer, CERP Division, Concerned Sub-divisional Engineers, Sectional officers of ME and Civil Engineering discipline and the TA team members.

All the staff of local TA team also took keen interest in supplying the data and sharing the views for a sustainable solution.

As per request of the consultant Mr. Qazi Ghulam Mostafa, Additional Director General, O&M-1, BWDB (and also in Charge of Planning) and Mr. Zulfiqure Haider, Chief Engineer, Design, BWDB organized an informal meeting with some of the Design Engineers of Civil and Mechanical Engineering in the Library Room of Chief Engineer, Design, BWDB on 17-04-05. Mr.Md. Habibur Rahman, Project Director, PMU-ESPP was also present in the discussion.

A preliminary and very lively discussion was held with the design engineers about the design and construction defects of sluices and sluice gates. Observations made by different missions, TA team of the project, BWDB inspection team from ME Design and other high officials were discussed in the meeting. A brief note mentioning various types of defects in gates, sluice structure itself, operational difficulties and some suggested remedial measures was handed over to the members present in the meeting for their comments and suggestions.

Third visit of the consultant was made to the Char Majid Sluice on June 18, 2005. During the visit Mr. Stuart P Pearson, Team Leader of the consultant's TA team, Mr. A.C. Sarkar, SQE and Mr. Mahfuzur Rahman, DME from TA team , Mr. A.K.Azad, Executive Engineer and Mr.Kalyan das SDE from BWDB were present. Functioning of eight flap and eight lift gates installed this year, as per revised design, was observed during the inspection. Water level outside the polder was about 0.90m higher than the countryside during inspection. It was observed that there was virtually no leakage through the flap gates. The flap gate no-7 that is not equipped with any rubber seal also apparently showed no leakage.

The revised design of flap gates, proposed by the TA team, included a steel frame to fix the flap gate at an angle of about 7 °. The gate leaf, frame, hinge and link arms are also fabricated as per revised design with rubber water stop in seven gates and one without any rubber water stop. The vertical lift gates are also fabricated and erected as per revised design proposed by the TA team. The hoisting system of the gates are provided with wheel in place of gear box and the traditional rubber water stop has been replaced with a rubber flap along two vertical edges and traditional rubber water stop at top and bottom edges of the lift gates.

A trial was given to lift one of the lift gate with the new hoisting system (wheel in place of gear box and rubber flap in place of traditional rubber water stop), the arrangement did not appear to be much improved as it took about twenty five minutes to lift about 4 ft of the gate. Finally, it was suggested that the rubber water stop at the top edge of the gate that was extended within the guide channel (about 75mm) should be removed to facilitate easy operation of the lift gate.

The Bamni Regulator was visited on June 19, 2005 along with the same team members During the inspection R/S water level was 4.30 m (PWD) and C/S water level was 2.40 m (PWD), head difference between C/S and R/S was 1.90m. Only three flap gates have been installed this year as per revised design. It was observed that out of three one showed virtually no leakage, other two were showing a reasonable amount of leakage. The Executive Engineer was requested to verify the cause of this type of leakage during low tide when the gates can be inspected clearly.

On June 22, 2005 a seminar for dissemination and feedback on the report was held in the Conference Room of the Chief Engineer, Design, BWDB. Mr. Md. Nurul Amin Talukder, Chief Engineer, South Eastern Zone, BWDB, Chittagong, Mr.Md. Habibur Rahman, Project Director, ESPP, BWDB, Mr. Stuart P. Pearson, the Team Leader, Mr. M. A. Sekendar, the Co-Team Leader, Mr. A. C. Sarkar, SQE and Mr. Mahfuzur Rahman, DME of TA Team, CDSP-II and Superintending Engineers, Executive Engineers, Sub-divisional Engineers and Assistant Engineers of design office attended the discussion seminar. On request Mr. Matiur Rahman, Chief Engineer, Dredger and Mr. Md. Shahjahan Ahmed, Executive Engineer, Chittagong, ME also attended the seminar.

The Seminar was presided over by Mr. Zulfiqure Haider, the Chief Engineer, Design, BWDB. After a brief introduction the Chairperson of the session requested the consultant to present the salient features of the report. After a brief presentation by the consultant the floor was opened for discussion. The participants from design offices and also other participants took active part in discussion. Some questions were raised about the requirement of additional head for opening of a inclined flap gate, increased cost of gates and hoisting system as per suggestions given in the report, operational facilities etc. All those problems and probable solutions were also discussed in the seminar. The distinguished participants were concerned about the huge percentage of inoperable gates and they were also in the opinion of attaining a sustainable O&M of the gates and other infrastructures of the project. Finally, the Chief Engineer, Design and the Chairperson of the seminar summarized the discussion and declared closure of the seminar.
The records of discussion and list of participants from design office is enclosed in Appendix-I(a).

7.*0* *Gates Under CDSP*

The secondary and primary data collected and observations made on gates, hoists and functioning of regulators from the area under CDSP is annexed in Appendix-II. CDSP-II having its one of the prime objective on Water Management by the beneficiaries facing main obstruction by the condition of the regulator gates as, it is obvious that, the success of the work, which the BWDB and CDSP are undertaking on the development of water management systems run by the peoples of the coastal chars, requires the efficient operation of the sluices. The conditions of the gates are stated in the appendix and a brief statement and observations are noted in Para 8.1.

It is astonishing to observe that CDSP area being at the southern most end of Noakhali and Feni and the offshore islands like Hatiya many of the sluices are not equipped with vertical lift gates. In Hatiya islands none of the sluices in polder 73/1A&B, and 73/2 are equipped with vertical lift gates.

8.0 Gates in Coastal Area in Bangladesh

8.1 CDSP Area

In an investigation within the CDSP area (Appendix- II & III) it has been observed that in CDSP project area in Polders 59/1A, 59/3B, 59/3C, Baggardona Polder-1, Baggardona Poldwer-2, Muhuri Accreted Area, Polder 73/1A&B, Polder 72/2 and Polder 73/2 (Extension) there are a total of 70 regulator/sluices; equipped with 188 flap gates and 91 lift gates of different sizes.

Inventory shows that out of 188 flap gates 50 (48.94%) are operable, 42 needs major repair and 83 (44.15%) need replacement and others also need repair in link arm, hinge pin, rubber seal etc. Out of 91 lift gates, 58 (63.74%) are operable with difficulty, 24 need major repair in hoisting system including change from pedestal to wheel; 9 need replacement including the embedded parts. From the above observations it is apparent that almost 45% of the flap gate and 10% of lift gates need replacement.

Other flap gate and lift gates need repair with revised design like change of hinge pin, link arm, guide channel and lifting mechanism of lift gates etc.

8.2 Khulna O&M Circle

The preliminary investigation in Khulna O&M Circle, BWDB under South Western Zone, BWDB, Faridpur show that out of 1365 flap and lift gates, 762 (55.82%) flap and lift are operable, 419 (30.70%) flap and lift gates need replacement; again 183 flap and lift gates need major repair. Even the gates those are shown as operable need frequent maintenance. Base plate of some of the vertical lift gates are twisted and one or two anchor bolts in many gates are broken due to misalignment of the gate guide and excessive friction with rubber stop and gate guide during lifting of the gate.

But in Khulna Division-II, out of 224 flap gates and 48 lift gates only 81 (36.16%) flap and 31 (64.58%) lift gates are operable. In Satkhira Division-II, out of 223 flap and 75 lift gates 113 (50.67%) flap gates and 35 (46.67%) lift gates are operable. The condition of gates in other Divisions under Khulna O&M Circle is also enclosed. (Appendix-III)

The estimated cost for repair and replacement of the gates as per existing design is about Tk.40.073 million.

The causes for all theses defects as per their opinion are bad or no maintenance, use of inferior quality of materials in link arm, hinge pin, bush, base plate, anchor bolt etc as a whole and specifically gear box greasing is not done properly and regularly. Bad workmanship in concrete work and guide channel. Misalignment in gate guide channel, gate and hoisting system including other embedded parts are also causes of such types of failure and frequent repair.

8.3 Jessore O&M Circle

Preliminary investigation under Jessore O&M Circle show that out of 837 flap and lift gates 728 (86.98%) are operable, 109 flap and lift gates are inoperable, again of that 77 need replacement.

Estimated cost for repair and replacement of inoperable gates as per existing design is Tk.1.576 million.

8.4 Southern Zone, Barisal

The investigation in Southern Zone, BWDB, Barisal shows that 514 sluices/ regulators are equipped with 1148 flap gates and 780 lift gates making a total of 1928. A preliminary inventory shows that a total of 953 (49.43%) gates are operable and 669 (34.70%) gates are inoperable and need to be replaced. But the data does not specifically mention about the type of defects in flap and lift gates as done in case of CDSP gates.

The preliminary estimate for repair of the inoperable gates as per existing design is about Tk. 41.072 million. An inventory as done in case of CDSP regulators may provide a clear picture and accurate estimate for repair of all these gates.

In Patuakhali O&M Division under the Southern Zone it is observed that only 151 (24.35%) of flap and lift gates out of 620 flap and lift gates are operable. Inoperable flap and lift gates are 469 (75.65%) and out of that 326 (52.58%) need replacement.

In Barguna O&M Division the condition is a bit better, out of 890 flap and lift gates 606 (68.09%) are operable, 284 (31.91%) needs repair and out of that 204 (22.92%) gates may need replacement.

The type of defects as described by the field officers of Southern Zone, BWDB are, Gear box of vertical lift gate is less durable because of bad maintenance, threads of shaft are broken, base plate and anchor bolts for both type of gates break or deformed frequently, hinge pin, link arm, bush of flap gates are broken frequently, water seal breaks or does not work properly, flap gate bends in irregular shape.

8.5 Chittagong O&M Circle

The inventory of gates under Chittagong O&M Circle, BWDB show that out of 1666 flap and lift gates 944 (56.66%) are operable, 722 (43.34%) are inoperable and of that 688 (41.30%) may need replacement.

In Coxs Bazar O&M Division preliminary survey show that out of 678 flap and lift gates only 250 (36.87%) are operable, 428 (63.13%) are inoperable and of that 424 (62.54%) need replacement.

The estimated cost for repair and replacement of gates under Chittagong O&M Circle as per existing design is Tk. 32.722 million.

8.6 Feni O&M Division

In Feni O&M Division out of 176 flaps and lift gates 127 (72.16%) are operable, 49 (27.84%) inoperable and only 3 (1.70%) need replacement. Under the Feni O&M Circles conditions of some of the gates are shown under CDSP.

8.7 Gate position in Coastal Zone

In this report the jurisdiction of Chittagong O&M Circle, Feni O&M Circle, Southern Zone, Barisal, Khulna O&M Circle and Jessore O&M Circle is considered as coastal zone. Number of flap and lift gates under coastal zone is 3958 and 2293 respectively making a total of 6251. Out of that 3622 (57.94%) of flap and lift gates are operable, 2629 (42.06%) are inoperable and 1948 (31.16%) are replaceable. Even within the operable gates a lot many need repair in hoisting mechanism, link arm, hinge pin, base anchor plate, rubber water stop etc for easy operation.

The overall picture of coastal zone about the gates reveals that Water Management or in true sense Integrated Water Management in coastal zone is hardly possible with 42.06% of gates being inoperable.

Total estimated cost for repair and replacement of the gates in coastal area as per existing design is Tk.123.248 million. The revised and improved design of gates implemented in case of

replacement of gates of Char Majid regulator and Bamni regulator may change the estimated repair amount to a considerable margin. Still the improvement done in case of replacement of those gates should also be implemented in other cases after proper monitoring.

The information on gates of other O&M Divisions in coastal area under BWDB is also enclosed as Appendix-III.

8.8 Water management aspects in Coastal Zone

The investigation conducted under coastal area show that the number of flap gates (3958) are much higher than lift gates (2293) installed in the coastal regulators. It is apparent from the installation that the planners' emphasis is mainly to exclude saline water and high tide from the polder, and a less priority to preserve fresh water within the polder.

As per recent approach of Integrated Water Resources Management the regulator should exclude saline water and retain fresh water as needed for the water management. To accommodate the recent approach the regulators/ sluices should be equipped with vertical lift gate after proper consultation with the beneficiary.

Both vertical lift and flap gates being the only means for control of water level inside the polder for efficient water management by the WMCs, easily operable, durable, proper functional and low maintenance cost type gates should be furnished with the regulators.

The project area is the morphologically dynamic coast that is growing into the Bay of Bengal. Drainage congestion is one of the major and most important factors caused by formation of new chars and increasing distance from the Bay of Bengal.

The foreland between Gangchil regulator and Zillar Khal regulator facing the sea has already attained width of about 5km and increasing steadily. This part of the hinterland behind the embankment is suffering badly because of siltation in the long outfall drainage channel. This type of area between the sea and the existing embankment major portion of which is already above the normal high tide should be studied to include them in CDSP type of projects.

Low retention level of fresh water of Gangchil Regulator is not of any use to the beneficiaries. Fresh water can be retained within the polder only upto top of lift gate. People desire that the retention level should be raised by at least another 60cm. This type of measure may be required in some other regulator where the vertical opening is upto the crest level of the embankment.

8.9 Condition of gates under non-coast area.

In this report jurisdiction of North-Eastern Zone, Comilla, Central Zone, Dhaka, Northern Zone, Rangpur, South-Western Zone, Rajshahi, Faridpur O&M Circle and Kustia O&M Circle is considered as non-coast area. In non-coast area due to existence of irrigation projects like Chandpur Irrigation Projects, Meghna Dhonagoda Irrigation Project, Manu Barrage Project, Teesta Barrage Project, Buri Teesta Irrigation Project, Pabna Irrigation and Rural Development Project, Ganges-Kobodak Irrigation Project etc. gates of different type and different sizes have been used in Pump House, Barrages and in Irrigation distribution networks. Types of gate are radial, lift, roller and flap and the size varies from 0.30mx0.30m to 12.20mx5.50m. To accommodate the sizes especially in irrigation projects different size and different type of gates with hoisting mechanism suitable for the operation have been selected. But normally in Flood Control Drainage and Irrigation Projects gate of sizes vary from 0.30mx0.30m to 1.5mx1.8m, and major percentage of size is 1.50mx1.80m.

In a preliminary inventory it is observed that in non-coast area number of flap and radial gates are 715 and number of lift/ roller gates are 3876 making a total of 4591, out of that 3515 (76.56%) are operable. Again about 398 (8.67%) of the gates may need replacement and others need repair to make it operable.

The percentage of inoperable gates (23.44%) even in the non-coast area is very high posing a major threat against attaining an integrated water resources management.

The causes for all theses defects are bad or no maintenance, use of inferior quality of materials in gear box, shaft, link arm, hinge pin, bush, base plate, anchor bolt etc as a whole and specifically gear box greasing is not done properly and regularly. Bad workmanship in guide channel of vertical lift gate, misalignment in gate guide channel, gate and hoisting system including other embedded parts are also causes of such types of failure and frequent repair.

The estimated cost for repair and replacement of gates in non-coast area is about is Tk. 66.481 million. Statement showing condition of gates and approximate cost for repair of the gates as per present design is shown in Appendix-IV.

8.10 Experts opinion on type of defects and causes

One Executive Engineer of ME workshop was requested to express his opinion about the type of defects he encounters in gates during repair and replacement. His observations on defects in gates are: twisted/bent gates, detachment of link arm from the wall bracket, detachment of wall bracket assembly, broken anchor bolt, broken/twisted link arm, lost/broken hinge pin and damage of embedded angle/ guide channel.

The causes for all these defects as per his observation are: due to improper skin plate thickness, weak section in angle and stiffener in gate frame, short arm/link arm, hinge bracket fitted on top of gate frame, improper fixing of anchor bolt etc.

Suggestions for improvement of the condition are increase of maintenance budget, use of anti corrosive stainless materials in different parts of the gate to ensure high durability and use of proper water seal.

Absence of link between the construction division and the mechanical design office has also a lot of contribution in the construction and erection defects. It is reported that sometimes the request for gate design or fabrication is received by the ME design or ME Workshop after completion of the civil engineering part of the regulator/sluice.

The repetition of design for same size of vent opening and similar or almost same water head unnecessarily consumes the time available for construction of a regulator. The standardization of the gates in certain area therefore could save lot of time. The fabrication and erection of similar things and observing their performances could contribute a lot in increasing the expertise in this field.

The drainage capacity of a structures arrived by the existing rules also need to be reviewed. People now a days do not like to tolerate or accept a submergence of paddy field for a period of 72 hrs. The criteria need to be reviewed even if it is not harmful for paddy field. Social acceptance is a major concern for the sustainability of the project operation and maintenance.

To achieve that any drainage structure need to be designed with higher capacity than required. In case of a multi-vent regulator standard vent size of 1.5mx1.8m should therefore be selected, the smaller size of vent shall only be selected when a single vent regulator for a very small catchments area is required.

In Muhuri Accreted Area (MAA), Regulator SS-1 is a 5 vent (1.2mx1.2m) and Regulator SS-2 is a 3 vent (0.9mx1.2m) structure. This type of variation in one polder with different size of opening is neither economic nor efficient. Similar or larger opening area could be provided with a little increase in cost in case of maintaining a standard vent size, preferably 1.5mx1.8m.

Standardization of vent opening and gate size as already exists in Standard BWDB Design Manual should be followed strictly and if possible the alternative of opening sizes may be more narrowed down.

The sizes of gates frequently used in the coastal belt should have standard design assuming the highest load the gate can encounter during operation.

8.11 Cost of gate in comparison to the structure

An attempt was made to compare the cost of gates and embedded structure to that of the civil engineering component. To conduct that comparison some data from Khulna O&M Circle, some from Chittagong O&M Division, some from CERP and some from CDSP were consulted. The study does not lead to a conclusion that could guide our further steps. The statement (Appendix-V) show that the cost of gate and embedded parts vary from 1% to even more than 16%. This indicates inconsistency of the data and acceptability of such data stands questionable.

The recent estimate obtained from the Executive Engineer, Chittagong ME shows that the cost of a flap gate (size 1.95mx1.65m) as per revised design is about 55% higher and that of a lift gate is about 82% higher than this years (2004-2005) schedule of rates on fabrication of gates. The cost of embedded parts shows higher percentage of rise.

In spite of all these apparently abnormal high cost of gates with revised design in comparison to the existing gates the options with revised design may be more attractive and desired due to easy operation, sustainable O&M and less maintenance cost.

Use of more durable and improved quality of materials like stainless steel, bronze bush, heavy section of plates, angles etc are major contributor to the increase in production and erection of regulator gates as per improved design. Such increase in percentage of unit price of gates indicates not only use of higher quality of material and this year's abnormal price hike of steel materials but also some discrepancy in the analysis already incorporated in the schedule of rates and the present one prepared by the Executive Engineer, ME, Chittagong. To solve these anomalies a thorough review of the analysis as per revised design should be conducted.

8.12 Defects in Civil Engineering aspects to accommodate the Gates

The observations on Regulator SS-1 in Muhuri Accreted Area (MAA) showed that the clearance between vent opening and pier and abutment extension at vertical sides vary from 140mm to 120mm and that at the bottom end with base is about 105mm. Concrete surface finish in wing wall, pier and railing is poor. Use of proper steel shuttering as specified in the standard specification could overcome all these defects. These aspects must be looked into in all the works.

The clearance between vent opening and wing wall/ pier extension in SS-II in MAA in vertical sides varied from 100mm to 135mm and 70mm at bottom. Concrete surface finish in wing walls, piers and barrel surfaces are very poor. The flaps are equipped with double hinge and link arms also have hinge connection at both the ends. The link arms within the guide in anchor plate are free to move laterally by about 40mm, having a high possibility of damaging the gates during drainage at moderate (60cm and above) head difference.

In Char Majid Regulator the offset between vent opening and pier/abutment extension is about 70-80mm. With this space the accommodation and smooth operation of a flap gate is hardly possible as the clearance between fabricated gate and the pier/abutment extension is hardly 5-10mm**.**

Similar observation and measurements were taken in Bamni Sluice, Gopal Sluice, Karim Sluice, Mamtaj sluice, Baggardona Sluice-I and Baggardona Sluice-II. The clearance between wing/pier extension and vent opening in all the sluices are not uniform, in some sluices like Bamni, Baggardona-I & II the available spaces satisfy the requirement but in all other cases the space available for accommodating and playing of flap gates are inadequate.

In many of the vertical lift gates the gate, the shaft and the hoisting system are not in same alignment. Even some of the guide channel are not properly finished and not fixed in a vertical plane.

8.13 Monitoring the Performance of Pilot Sluices

In order to achieve a better water management and a sustainable O&M, the activities undertaken in pilot sluices need to be monitored in a regular basis. The performance or efficiency in lifting a vertical lift gate need observation and monitoring, at different stages of loading, with the stainless steel lining in the gate edge and the guide channel and also rubber flap instead of traditional rubber water stop. The amount of leakage through the gate also need to be monitored at different water head.

Same type of observations regarding functions of inclined flap gates, sealing of flap gates against different water pressure need observation to decide further course of action or further improvement. In Char Majid Regulator where flap gates have been installed this year on an inclined exit. The original concrete face at exit end was vertical, to make it an inclined exit an additional steel frame has been installed to monitor the behavior of the inclined flap gates.

The type of hinge used in Bamni Regulator and that used in Char Majid Regulator are not same or identical. The behavior of both of these types of hinges during drainage under different head difference and also performance and behavior at closed condition need to be monitored.

All the flap gates of Bamni Regulator are being changed as per revised design given by the Mechanical Design Circle of BWDB. The gates with some adjustments needed as per site condition are being installed by the ME, Chittagong. The performance of these new gates need to be monitored very closely to use all the new knowledge base for further improvement of the mechanical aspects of gate design and production.

The modified and revised design implemented in pilot polders need monitoring and review before this concept is replicated in other areas of the coastal zone. But some of the concepts like inclination of flap gates with the exit end of the barrel, use of at least 250mm to 300mm long link arm in flap hinges, use of minimum two hinges, improved metal quality and heavy size/section of hinge pin, bush, lock etc can be used without any further time lapse.

In case of fixing an inclined flap gate in a old structure where exit face of the barrel concrete is vertical, the provision of extension of inclined exit face by steel framing need to be observed more carefully in saline zone. This modification may be replicated only after an observation for at least three years.

The hoisting mechanism of the lift gates and the rubber water stop used for vertical lift gates in pilot sluices desires constant attention and monitoring before they are replicated in any of the new structure.

Some observations made on June 18 and 19, 2005 on the fabricated and erected gates as per revised design this year is noted under Para-6.0

8.14 Facilities for Fabrication and Erection of Gates

Most of the workshops other than ME workshops at Dhaka and Chittagong are not well equipped or knowledgeable for production and erection of gates as per standard specification. So first preference shall be given to ME workshops for production and erection of all such types of gates. In case the load is too big for ME, outside private workshop may be entrusted with the job. In that case the capability, knowledge base and availability of proper manpower of the workshop need to be assessed before selecting them for the assignment.

In selecting such mechanical workshops a short-term study may be conducted by a local expert in this field. There can be a zoning in selection of such types of workshop like Dhaka, Narayanganj, Chittagong, Khulna, Barisal, Bogra and Rajshahi or any other place where mechanical workshops of this nature and category are available.

The facility should be such that the executing personnel and the ME personnel can inspect the fabrication and erection of gates from the very beginning of the fabrication works. A certification from the ME personnel on quality of the gates including erection may be made mandatory in case the production and erection of gate is not undertaken by the ME.

9.0 Observations Made by Missions

The mid-term review mission (July 2002) reports as:

The effectiveness of infrastructure provided by the project to prevent drainage congestion depends on a combination of items.

- The design (capacity, invert level), execution and operation of regulators.
- The design, execution and operation of the internal network of the canals.
- The hydraulic capacity of the culverts and bridges, which should be sufficient.

The most important reason for the reduced drainage capacity of regulators is their operation. The combination of deficient regulator operation, absence of internal canal operation and obstruction of culverts and bridges, will result in drainage congestion. O&M arrangements, including drainage infrastructure, are therefore expected to be little effective to control water logging. Measures required to overcome these problems are rather simple but vital for system functioning.

Influencing water levels within the polder is done only by operating regulator. The WMC will decide about the canal water level that has to be maintained at sluice site. The WMC has no other instrument to control water levels.

Due to lack of proper operation and maintenance and because in several cases gates are missing or inoperable, the sluices are not properly used in the dry and monsoon seasons.

It is obvious that through an open sluice gate a part of the sediments entering with water during every incoming tide will settle in the drainage system and reduce its capacity. A proper operation of the sluice gates will considerably reduce the rate of sedimentation. The total operation and repair cost of a sluice (in general the gates) will only be a fraction of the re-excavation cost of the drainage system.

Deficiencies of mechanical parts, as found in a number of regulators, make operation difficult. Such problems often have the effect of reducing the capacity of the regulator for drainage.

Sediment clogging of the flap gates represents additional problems in beginning of monsoon season, which could be avoided where it is possible to place the stop logs or put temporary barrier in the riverside in beginning of the dry season.

The main issue is therefore sustainable O&M. Siltation is a serious problem and BWDB maintenance performance is at present insufficient to guarantee long life of the provided infrastructure. Operation of the sluices is part of the total water management of a polder. It should further be improved, taking into account the interests of farmers, fisherman and others.

Regulator maintenance must be made easier and cheaper. A modified design is required of the mechanical parts, which takes into account the limitations and possibilities of the WMCs.

The Mission further observed that, "The design and study capacity of BWDB was found to be insufficient in CDSP with regard to the sluice location, sluice design and canal design". Part A, page 20, Position Paper, CDSP, 13 March 1997.

"The design process has been rather inadequate. Some drains in Char Bhatirtek and Char Majid were dropped, as the total of priority drains cost estimates was far higher than provided for in the Project Proforma. Consultant's surveys pointed out that the design data were incorrect and that estimate should be much cheaper, so that more canals can be taken up with the same money".

"The first year the consultants did not receive design data, detailed contour maps or layout were made or provided. In view of time pressure and the estimate that the output would not be much different, the consultants have not made a pre-condition in the first year, while lenience was again the strategy in the second year after seeing a tight time schedule, progress problems with sluices. In the third year, the consultants were finally involved in the design process, by first receiving the design data and later being allowed to comment and improve on the design. The design was found lacking indication of water levels, existing canal dimensions and bed levels and proper details. Later on, while checking design data in detail these were found faulty as well, resulting in overestimating." Page 16, part B, position Paper, CDSP, 13 March 1997.

" The sluice design as practiced by BWDB does not much depend on the location. The delay depends more on the problematic design process within BWDB. Mission Report No.12." Page 16, Part B, Position Paper.

Designs of structures are not fully documented and therefore it is difficult to evaluate the existing construction of sluices and outfall channels.

"A second issue is the replicability of the design process. Revamping design offices and processes is outside the scope for a regional project like CDSP. If another CDSP is considered before improvements are made at national level, making the consultants co-responsible for making the design seems unavoidable." Page 17, part B.

The stilling basins of sluice are constructed with floor elevation equal to bottom level of the existing outfall. If all gates are open when the water level in the polder side is maximal, and there is low tide level outside the sluice, the tail water level downstream of the stilling basin is not sufficient to submerge the water jump. In such circumstances the energy is not sufficiently dissipated within the stilling basin, resulting in scouring in the sections of the outfall channel downstream of the stilling basin. Consequently the sluice may be undermined and its stability endangered. A better design of the stilling basin in order to enclose the water jump within the stilling basin is required to avoid occurrence of such problems.

Existing designs of drainage sluices can be considerably improved by taking into consideration the encountered problems and experience in the coastal zone during the last 30 years.

To avoid blocking of the flap gates by sediment deposition in a long outfall channel it is recommended to construct an earth cross-dam or an artificial barrier away from the gates so that the gates are not clogged.

9.1 Specific Examples:

Some regulators were found to have other design faults, (partly) impeding their function. An example is Nabagram Regulator in Char Bhatirtek Polder. Some of the flaps fit rather tight between wing and guide walls, to the point that these flaps are jammed between walls. As the flaps are jammed, salt water with silt, enters into the polder causing siltation and other problems, while drainage is severely impeded.

Thirteen out of fifteen flap gates of Bamni Regulator broke off and the gates are already lost. The type of failure was breaking of any one part e.g. link arm, hinge pins, anchor bolts and base plates or combination of all of them. In most of the cases the failure of anchor bolt in Bamni regulator was common. The remaining two also is almost to break off.

The Gangchil regulator illustrates a few of the consequence for operation of the described problems. It is the major drainage structure, 12 vents, in 59/3B polder. It is rather new and has the (design) problems described above. Eight out of twelve sliding gates were inoperable. This means that the draining capacity of this polder was reduced to a point where drainage congestion can be expected on a yearly basis. Besides, one flap gate broke off, while the hinges of some other flaps were almost to break off also. The free flow of water through the gates caused scour holes.

9.2 Sustainable O&M

Sustainable operation and maintenance (O&M) is crucial if the positive impacts of CDSP on the lives of the char dwellers are to continue. Overall the CDSP approach has to make the WMCs responsible for operation and the line agencies for maintenance. As far as operation is concerned this strategy is sound, but maintenance should not only be the responsibility of the line agencies. GPWM also recommends that the WMCs take responsibility for all maintenance within their area.

Local organizations need to be able to maintain and even replace hoisting mechanism, including the gearboxes (if such boxes are required). It may be that another simpler mechanism should be designed, which may use a wheel, a wheel with reducing gear, or a wheel with chain and gear, rope or cable and which can be made and maintained locally.

Design and production of mechanical parts of all regulators must be drastically improved (rubber seal, hoisting mechanism etc). This issue should be looked into and various such mechanisms should be tested.

Water management often involves conflict of interest, and can be fairly complicated. The WMCs are not well equipped to handle this core business. CDSP must therefore do more to train and assist WMCs in this task. Among others this includes maintaining transparent records of issues raised, decision taken, operation orders given and actual gate operation.

It will probably take WMCs a number of years before they are fully aware of the ins-and-outs of their particular water management system. CDSP should assist the WMCs in analyzing what the

actual impact was of gate operation on agriculture in its area. Based on that, and on the planned cropping patterns and related water level wishes of the farmers, the operational parameters of the next season need to be set.

Note: BWDB O&M divisions have no responsibility nor accountability over water management (water levels for example). There is responsibility and accountability in maintenance, even of redundant structures, but not for maintaining water levels.

10.0 Defects/Shortfalls in Civil Engineering Parts of Regulators/Sluices;

1. Opening size (i) 1500mmx1800mm; (ii) 1200mmx1500mm; (iii) 900mmx1200mm or (iv) 1200mmx1200mm; which ever is specified in design, is not maintained strictly in construction.

2. The deviation in dimension of opening may be accepted upto a maximum of ± 15mm; with this deviation a gate and embedded parts manufactured as per standard design can fit well in the regulator, in practice some times deviation is more than ± 50mm.

3. Low retention level of Gangchil Regulator is not of any use to the beneficiaries. People desire that the retention level should be raised by at least another 60cm.

4. To accommodate a flap gate in the regulator an allowance of 150mm is specified all around the opening, a flap gate with an overlap of 75mm (maximum) all around the opening can easily operate in moderate flow condition. In a number of cases this allowance of 150mm is not maintained, somewhere it is even less than 75mm.

5. The lower end of head wall where the upper end of vertical lift gate rests in closed position, shall be at least 25mm extended than the other part of the head wall as per detail of the standard design manual; that is not strictly maintained.

6. The Channels guiding the vertical lift gate is not always in proper alignment, the embedded frame for vertical lift gate and also for flap gate is not in same plane.

7. Standard Design of vent size and relevant groove size, channel dimension is not followed.

8. The flap gate in a vertical position can hardly create a situation that can obstruct entry of silt laden flood/saline water, because of irregular contact surface and not strictly following the specifications.

9. The stilling basins of sluice is constructed with floor elevation equal to bottom level of the existing outfall or lower considering the average high water during critical drainage period. If all gates are open when the water level in the polder side is maximal, and there is low tide level outside the sluice, the tail water level downstream of the stilling basin is not sufficient to submerge the water jump. In such circumstances the energy is not sufficiently dissipated within the stilling basin, resulting in scouring in the sections of the outfall channel downstream of the stilling basin.

11.0 Defects in Vertical Lift Gates:

1. Vertical sliding gates have rubber seals that are fitted on the gates. The rubber seals are located between the gate guides and the gate itself. The pressure of water forces the rubber seal against the metal gate guides. When the gate is opened, the gate has to slide

over the gate guide. A considerable resistance is faced during opening of the gate as the frictional resistance between the gate and gate guide is excessive due to rubber sealing. To lift these gates still force is applied. The seal either tears or the hoisting mechanism breaks or bends by this operation. It may not be possible to open the gate. Such situations have occurred in project area several times. Under this situation, the people still try to open the gate by other means and thereby either the gates or some parts are bend.

2. A number of gates that were seen already had torn rubber seals. These gates have therefore excessive leakage. Leakage of regulators in tidal areas will mean that silt-laden water will enter the canal system with each tide. The silt will be deposited in the canals. Leaking regulators therefore greatly increases the frequency with which re-excavation must be done

3. The hoisting mechanism of vertical lift gates consists of a spindle, gearbox and a detachable handle. The gearbox contains a number of moving parts. The gearbox should be filled with grease to reduce friction and excessive wear. Gearboxes have grease nipples enabling to maintain the required amount of grease in the boxes.

4. None of the gearboxes, observed were found to be filled with grease. The issue is considered to be serious as wear of its parts will be excessive; lifetime of gearbox is therefore short and maintenance expensive.

5. Lack of grease makes that the gearboxes operates with difficulty. People therefore try to grease their gearboxes by removing the grease nipples, dripping engine oil in it. As a result, quite a number of grease nipples are missing, leaving only a hole. These holes allow the entry of water, sand and other abrasives/ corrosive materials inside the box.

6. Gearboxes need seals to avoid that grease leaks out. None of the gearboxes seen on regulators have seals. The quality of workmanship of the boxes is such that the surfaces to be sealed are too irregular to be sealed at all.

7. Design and quality of the gearboxes must improve and they should all be filled with grease before installation. That implies that the ones already fitted must be replaced by new and properly designed and manufactured ones.

8. The Channel for vertical lift gates is not in proper shape and finishes, in embedded position the vertical and horizontal alignment with gate and hoisting arrangement is not in order. Inside surfaces of channels for gate grooves are not smooth and properly finished. (This type of defects mainly occur when the gates are not fabricated and erected by ME)

9. Deficiencies of mechanical parts, as found in a number of regulators, make operation difficult. Such problems often have the effect of reducing the capacity of the regulator for drainage.

10. Mechanical parts of regulators have design and production flaws that impede water flow or hamper operation and make maintenance cost high. Design faults were found in all sliding gates used throughout the project area. Quality of material and workmanship was found with all hoisting mechanisms.

12.0 Defects in Flap Gates:

1. Fixing of hinges of some flaps was found to be so poor that flaps can be expected to break loose.

2. Some of the flaps fit rather tight between wing and guide walls, to the point that these flaps are jammed between walls. As the flaps are jammed, salt water with silt, enters into the polder causing siltation and other problems, while drainage is severely impeded.

3. One flap gate of Gangchill Regulator broke off, while the hinges of some other flaps were almost to break off also. The free flow of water through the gates caused scour holes.

4. Thirteen out of fifteen flap gates of Bamni Regulator broke off and the gates are already lost. The type of failure was breaking of any one part e.g. link arm, hinge pins and base plates or combination of all of them. The remaining two also is almost to break off.

5. Skin plates of some flaps and lift gates being thinner than desired becomes bent/ warped under heavy water pressure and ultimately breaks off and allows saline water/silt intrusion.

6. The flap gates (8 vent-1500mmx1800mm) of Char Majid Regulator recently replaced by the project can't operate smoothly, as the gates have very small clearance between the wing wall and pier extension. The space available around the vent opening is hardly 60-80mm.

13.0 Suggestion for overcoming the discrepancies/defects:

The sketch drawings attached with the report indicate the ideas and outlines only. The detail for all these, if ideologically accepted, shall be worked out by the designers.

1. In general Flap gates and Lift gates should be standardized with following opening sizes: (i) 1500mmx1800mm (ii) 900mmx1200mm (iii) 1200mmx1200mm and (iv) 900mmx900mm.

2. Steel shutter shall only be used in construction of regulators/sluices as suggested in the standard specification of BWDB and the shuttering after fixation shall be checked by the concerned SAE and SDE.

3. Standard design (mechanical) suitable for extreme condition in coastal zone of Bangladesh shall be prepared as per size mentioned in sl. No.1 above. The civil engineering design shall only mention the reference drawing number for the work.

4. Gate size (Mechanical Design), shall also mention the opening size of the regulator/sluice.

5. Tender shall be invited for both civil and mechanical components of a structure on the same date, if ME is not able to perform the job in allotted time span.

6. Work order for construction of both civil and mechanical components shall be issued on the same day.

7. Preference shall be given to ME for manufacturing and installation of gates and embedded parts if agreement with Development Partners and regulations of PPR-2003 supports such actions.

8. ME or Contractor at one goal shall manufacture embedded parts and gate of standard size as specified. The whole unit shall be transported to work site as a complete set.

9. If any contractor other than ME is engaged for manufacture and erection of gates and embedded parts, the ME personnel and Mechanical Design Engineers should be specially engaged to check the manufacturing and erection of gates and embedded parts.

10. During installation of embedded parts and also gate itself at least one SAE/SDE from ME/ME, Design and the SAE/SDE in charge of the construction must be present at worksite.

11. The clear space around sluice opening and desired inclination of the gate with vertical in case of flap gates must be clearly shown (preferably enlarged) in all the civil engineering drawings. Appendix-VI.

12. The flap gate in vertical position faces abnormally high pressure on hinges during high water head. Sealing against water is also not fully effective. So an inclination of the flap at an angle of 5-7 ° may help to solve these problems. Appendix-VI.

13. Provision of second stage concreting shall be made for fixing the embedded parts as well as the gates. Use of epoxy may be made mandatory for second stage concreting. Appendix-VI (a).

14. Base plate, link arm, hinge pin and bush for flap gates shall be designed and erected in such a way that even under the extreme condition the damage is minimum. Quality of material and thickness and dimension shall be such that it needs minimum maintenance within at least five years. Appendix-VII, VII (a), VII (b) & VII (c).

15. The lower end of head wall where the upper end of vertical lift gate rests in closed position, shall be at least 25mm extended than the other part of the head wall as per detail of the standard design manual; Appendix-VIII.

16. A rubber flap, as shown in the sketch may replace the rubber seal at present used for vertical lift gates. The embedded channel may be lined with a stainless steel plate and the gate itself may be provided with stainless steel strip in place of rubber seal. Appendix-VIII.

17. A move upwards of the gate lift point (vertical lift gate) to shorten the length of the shaft may help to facilitate more even lift across the width of the gate. Appendix-VIII (a).

18. The clear space around the vent size 1500mmx1800mm may be increased to 200mm and for other smaller size 150mm may be maintained in exit faces of barrel where flap gates are provided.

19. To avoid blocking of flap gates by sediment deposition in a long outfall:

    - An earth cross-dam in downstream of the outfall channel can be constructed at the beginning of dry season, or
    - More clearance between the stop log groove and the flap gate can be created by modifying the design. The stop logs can be used as a silt barrier in the dry season to prevent accumulation of sediment against the flap gates.

20. Existing designs of drainage sluices and gates may be improved by taking into consideration the encountered problems and experience gathered during the last thirty years.

21. The TA consultants may be made co-responsible for furnish of design data and finalization of design for CDSP type of project.

22. Regulator maintenance must be made easier and cheaper. A modified design is required of the mechanical parts, which takes into account the limitations and possibilities of the WMCs.

23. Design and production of mechanical parts of all regulators must be drastically improved (frame, skin plate, anchor/base plate, rubber seal, hoisting mechanism etc).

24. The stilling basins of sluice is constructed with floor elevation equal to bottom level of the existing outfall or lower considering the average high tide level during critical drainage period. If water level in the polder is maximal, and there is low tide level outside the sluice, the tail water level downstream of the stilling basin is not sufficient to submerge the water jump. In such circumstances the energy is not sufficiently dissipated within the stilling basin, resulting in scouring in the sections of the outfall channel downstream of the stilling basin. In such cases a double stage stilling basin may be provided as per drawing shown in Appendix-IX.

25. Local organizations need to be able to maintain and even replace hoisting mechanism, including the gearboxes (if such boxes are required). It may be that another simpler mechanism should be designed, which may use a big wheel, rope or cable and which can be made and maintained locally.

26. A routine maintenance arrangement and service agreement with detail monitoring and maintenance schedule can be made with ME or any other competent organization to maintain the gates in order.

27. This issue should be looked into and various such mechanisms should be tested.

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7. Position Paper; a Review of Achievements and an Outlook to the Future; March 13, 1997.
8. Mechanical Aspects of sluice Design and Fabrication (Background and Concept Document); Technical Report No.15a; Char Development and Settlement Project-II; Stuart P. Pearson; Team Leader CDSP-II; April 2004.
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11. Southern Zone, Barisal, BWDB, Report on Repair and Replacement of Gates in Completed Projects.
12. South-Western Zone, Faridpur, BWDB, Report on Repair and Replacement of Gates in Completed Projects.
13. North-Western Zone, Rajshahi, BWDB, Report on Repair and Replacement of Gates in Completed Projects.
14. North-Eastern Zone, Comilla, BWDB, Report on Repair and Replacement of Gates in Completed Projects.
15. Northern Zone, Rangpur, BWDB, Report on Repair and Replacement of Gates in Completed Projects.
16. Central Zone, Dhaka, BWDB, Report on Repair and Replacement of Gates in Completed Projects.

Appendix-I

Terms Of Reference
for
Short term Missions
to
CDSP-II, Noakhali, Bangladesh

Title of Mission/Activity -

Development and Extension of Sluice Improvement Programme in CDSP-II and other areas

Planned commencement and conclusion dates -

Forty (40) days- between March, 2005 to June, 2005.

Member(s) of Mission/ Activity -

Mr. Mukhles uz Zaman.

Other CDSP-II project members concerned -

DME, SQE, FE (Mech) in particular and all CDSP-II Consultants, staff and GoB officials in general. Also reference to TL as required by the mission member.

Date of previous Mission/Activity {if any} -

Work done by TL and others on 'sluice pilot'.

Previous Report(s)/Reference(s) {if any} -

Technical Report No. 15a.

Principal objective of Mission/Activity -

1. The mission to be engaged by CDSP-II to develop an over view and report on the need to renovate sluices throughout Bangladesh with an opinion on the sluice pilot reported in TR15a to fulfil this need. In particular, comments are requested on the pilot concept, the sluice renovation work having been undertaken with particular reference to the as built outcome of the pilot, with recommendations for improvements and its suitability for other areas of Bangladesh.
2. Brief review of the BWDB mechanical design department.
3. Brief review of the BWDB ME workshop.

Appendix-I

The following details may assist with the broad objectives as set out above.

- Inspect the work done on the 'pilot sluice' undertaking by CDSP-II and also some undertaking of LRP and CERP in the vicinity of CDSP area.
- Make field inspections as the expert considers needed.
- Report on the strengths and weaknesses of the above work in respect of functioning and O&M in a form that would be a main text of the Technical Report 15b. The experts report to be included in full in this TR.
- Comment on the effects of successful and sustainable 'water management' by the beneficiaries an effective and easily operated sluice will have. This may be considered to be an essential part of the sluice improvement concept.

  The report to also include comment on

  - The advantages and disadvantages of establishing a standard design for mechanical components of sluices.
  - The range of sluice sizes the pilot design is suitable for use in.
  - The advantages and disadvantages of making the BWDB ME workshop the sole fabricator of the mechanical sluice components from which ALL contractors have to purchase these components and install them to the civil components under the direction of ME staff.
  - A possible system of 'certificates of approval' which may be considered to be given to suitable workshops if the workload is found too great for the ME workshop. It is noted that BWDB regulations do state that ME workshop should be the sole fabricator.
  - The modifications which would have to be made to the civil designs used by BWDB to incorporate the mechanical parts of the pilot sluice concept.
- Consider and briefly report on the potential of the sluice used in the pilot project to sluices in Bangladesh, this to indicate:
  - The magnitude of the problem sluices in Bangladesh.
  - The approximate numbers of sluices where the 'pilot' sluice would be effective in the rehabilitation of existing sluices.
  - The approximate number of newly constructed sluices where the pilot design should be utilised over the next five years.
- Finally to draft a proposal which would in two stages resolve the sluice problems of Bangladesh by:-
  1. Renovating the existing sluices.
  2. Ensuring the adaptation of the most suitable quality of fabrication of standard sluice designs.

  The above two stages are recognised to be a colossal renovation undertaking, in particular No. 2.

Appendix-I

Secondary objectives of Mission/Activity –
To review and checking BWDB Designs of sluices in CDSP-III (Boyer Char) including other infrastructure.

Expected outcomes and/or reporting format -

A written report (possibly in draft form) which would be the basis for debrief to The Royal Netherlands Embassy if such a de brief is required by The Embassy.

Additional comments -

None.

Signature

Team Leader / Co Team Leader

CDSP-II

Date

Appendix-1(a)

Proceedings of discussions on "Functioning of Gates in Regulators/Sluices and Remedial Measures for Sustainable Operation and Maintenance''

A technical session was organized on June 22, 2005 at 10.30 A.M. in the conference room of the Chief Engineer, Design under the Chairmanship of Mr. Md. Zulfiqure Haider, Chief Engineer, Design, BWDB, Dhaka. A list of participants attending the session is enclosed herewith in Appendix–A.

The Session commenced on schedule. Mr. Md. Habibur Rahman, Project Director, Char Development & Settlement Project–II (CDSP–II), BWDB, Mr. Stuart P Pearson, Team Leader, CDSP-II, Mr. M. A. Sekendar, Co-team Leader, Mr. A. C. Sarker, SQME, Mr. Md. Mahfujur Rahman, DME all from CDSP-II also attended the discussion session.

On request Mr. Nural Amin Talukder, Chief Engineer, South Eastern Zone, BWDB, Chittagong Mr. Md. Matiur Rahman, Chief Engineer, Dredger, BWDB, Narayanganj and Mr. Md. Shahjahan Ahmed, Executive Engineer, Chittagong ME Division, Madnaghat, Chittagong also attended the discussion session.

The discussion centered on the report, prepared by Mr. Mukhles uz zaman, consultant to CDSP-II, on "Functioning of gates of regulators/sluices constructed by BWDB" all over Bangladesh. The report mainly oriented to investigate the present condition of gates under CDSP and to suggest some remedial measures for repair and maintenance also covers the condition of gates of regulators/sluices all over Bangladesh under BWDB.

In the inaugural speech the Chief Engineer, Design, BWDB delivered a short introduction and background of the report prepared by the consultant and invited the consultant to present the salient features of the report.

The consultants presented the main features of the report in presence of the distinguished participants. The report covers the background of the study conducted, data on condition of gates, probable causes for deteriorated condition of a vast majority of gates both in coastal region and non-coast region, the deficiencies in construction and design, comments made by different missions, some inspection reports on functioning of gates and sustainable O&M of the gates and other infrastructures of the project. The report concluded with some suggestions to improve the design and construction of sluices in respect of design, erection, functioning and sustainable O&M of sluice gates constructed and now under operation throughout Bangladesh.

In the report it is stated that in the coastal region only 57.94% gates are operable and the rest are inoperable. Out of that 31.16% gates need replacement. In the non-coast region 76.56% gates are operable and rest are inoperable. Out of inoperable gates 8.67% gates need replacement. A reasonable percentage of gates, though some of them are operable, need repair to make them fairly operable. The performance and operation of the gates being the only tool for control of water level inside the project and means for sustainable O&M, emphasis were given to take measures that the requirement of repair and maintenance is minimum. Operation of the gate is easier so that the beneficiaries can take the responsibility of repair, maintenance and operation of the gates. A short handout containing all those information was also distributed among the participants.

After the presentation the floor was opened to the participants for discussion. The Chief Engineer, South Eastern Zone, the Chief Engineer, Dredger, the Project Director, CDSP-II, the Team Leader, CDSP-II, SQE of CDSP-II and participants from the design office took active part in discussion.

Mr. B. M. Nath, Executive Engineer, Design Circle-IV suggested to obtain written clearance from the competent authority (to be defined) of ME design against proper provisions for 2nd stage concreting, clear vent opening and gaps, alignment, fitting embedded parts etc. as per design before erection of gates.

Mr. M. A. Kashem, Executive Engineer, Design Circle-II suggested that after execution of mechanical gates, monitoring of gates should be done every three or six months forming a committee headed by one SAE/ME and one SAE/Civil from the project. After inspection they will inform about the defects of the said gates, if any, to the higher authority. Accordingly the repair and maintenance works should be taken up.

Mr. Md. Motahar Hossain, Executive Engineer, Design Circle-VI raised about the requirement of additional water head of about 60 cm against 5-7° inclination of flap gate for opening of the gate. The consultant and also the Executive Engineer, ME, Chittagong opined that this will not create any major problem for operation rather it will be of great help against sealing of gate against intrusion of silt laden saline water.

Mr. Md. Nurul Islam, Executive Engineer, Design Circle-III (M) expressed his concern about the increase impact dynamic load generally occurred during drainage period at gate inclined position. This increased load and its effect should be incorporate in the design. The design of the inclined gate should be done on the basis of load calculation as such the cost of fabrication and installation will be increased accordingly.

The Chief Engineer, South Eastern Zone, BWDB, Project Director, CDSP–II and the Team Leader, CDSP-II also expressed their opinions in respect of the defects of the gates, operational hazards and peoples' opinion about the operation and maintenance of the gates and other infrastructures of the project.

Participants in general expressed their concern about huge number of inoperable gates as mentioned in the report and opened in favour of restoring proper O&M as early as possible.

The Project Director and the Consultant summarized the discussions and the consultant also expressed his observation on the improved gates installed in Char Majid Regulator, Bamni Regulator and Gangchil Regulator.

Finally, the Chief Engineer, Design, BWDB, Chairman of the session summarized and concluded the discussion expressing his observations on performance of gates. He thanked the CDSP-II project authority and other participants for attending the discussion session and declared the session closed.

(Md. Zulfiqure Haider)
Chief Engineer, Design
BWDB, Dhaka.

List of participants in the technical session on ''Functioning of Gates in Regulators/Sluices and Remedial Measures for Sustainable Operation and Maintenance" of dated 22-06-2005.

Sl. No.	Name of the participants	***Designation***	**Office Address**
1	**2**	**3**	**4**
1.	Mr. A.Z.M. Nurun Nabi Khan	Superintending Engineer	Design Circle-1, BWDB, Dhaka
2.	Mr. Md. Korban Ali	Executive Engineer	-do-
3.	Mr. Syad Ahsan Ali	-do-	-do-
4.	Mr. Saeeda Nazneen	-do-	-do-
5.	Mrs. Yasmin Begum	Sub-divisional Engineer	-do-
6.	Mr. Md. Mahfuzur Rahman	-do-	-do-
7.	Mr. Md. Abul Quashem	Superintending Engineer	Design Circle-2, BWDB, Dhaka
8.	Mr. Kazi Tofail Hossain	Executive Engineer	-do-
9.	Mrs. Provati Mukharjee	-do-	-do-
10.	Mr. Md. Ashraf Jamal	-do-	-do-
11.	Ms. Jannatun Nahar	-do-	-do-
12.	Mr. Abdul Halim	Executive Engineer	Design Circle-3, BWDB, Dhaka
13.	Mr. Md. Sohrab Uddin	Executive Engineer	-do-
14.	Mr. K.M.Nurul Islam	-do-	-do-
15.	Mr. Khondhakar Monirul Islam	Sub-divisional Engineer	-do-
16.	Mr. Azfar Imam	-do-	-do-
17.	Mr. Md. Naushad Ali	Superintending Engineer	Design Circle-4, BWDB, Dhaka
18.	Mr. Md. Gulzer Hossain	Executive Engineer	-do-
19.	Mr. Alamgir Kabir	-do-	-do-
20.	Mr. Braza Mohan Nath	-do-	-do-
21.	Mr. Md. Shakil Mahamud	Assistant Engineer	-do-
22.	Mr. Partha Pratim Saha	-do-	-do-
23.	Ms. Farhana Begum	-do-	
24.	Mr. Md. Abdul Haque Sardar	Superintending Engineer	Design Circle-5, BWDB, Dhaka
25.	Mr. Md. Rafiqul Alam	Executive Engineer	-do-
26.	Mr. Md. Afjal Hossain	-do-	-do-
27.	Mr. Md. Zobaidur Reza	Sub-divisional Engineer	-do-
28.	Mrs. Halima Khatun	-do-	-do-
29.	Mr. Md. Mehedi Hassan	Assistant Engineer	-do-
30.	Mr. Md. Abdul Matin Bhuiyan	Superintending Engineer	Design Circle-6, BWDB, Dhaka
31.	Mr. Md. Motahar Hossain	Executive Engineer	-do-
32.	Mr. Jati Das Kundu	-do-	-do-
33.	Mr. Aminuddin Ahmed	-do-	-do-
34.	Mr. Md. Ansar Ali Mia	-do-	-do-
35.	Mr. Md. Anisur Rahman	Sub-divisional Engineer	-do-
36.	Ms. Areena Mannan	Assistant Engineer	-do-
37.	Ms. Umme Mahfuza Haque	-do-	-do-
38.	Ms. Umme Fahtema Rumana Afroz	-do-	-do-

Appendix-II

Conditions of Gates under CDSP Area

Polder-59/1A

1.		DS-3 (Sattaria Sluice); 3 Vent (1.50mx1.80m)
	a.	2 flap gates are operable
	b.	Hinge pin of 3rd gate is missing, needs replacement of hinge pin and repair of gate
2.		SS-1 (Char Hazari); 1 Vent (0.91m dia)
	a.	Flap gate missing, needs replacement.
3.		DS-8 (Machhuar Dona); 8 Vent (0.91m dia)
	a.	All the gates are broken from the anchor base and lost. Need replacement.
4.		DS-10 (Musapur); 2 Vent (0.91m dia)
	a.	One flap gate is already broken from base and lost, the condition of other one is also not repairable. Both need replacement.
5.		DS-11 (Char Darbesh); 3 vents (0.91m dia)
	a.	One gate is broken from the base and lost, the condition of other two are also not repairable, all three need replacement.
6.		DS-12 (Char Darbesh); 2 Vent (0.91 m dia)
	a	Both the flaps are not in operable condition; Need replacement.

Note: (1) None of the regulators are equipped with vertical lift gates. (2) In total 6 regulators are equipped with 19 flap gates of size 1.50mx1.80m and 0.90m dia; out of that only 2 flap gates are operable; remaining 17 need replacement/repair.

Polder-59/3C

1.		DS-1 (Musapur); 2 Vent (1.50mx1.80m)
	a.	Wall plate of one flap along with anchor bolt is broken and gate is lost, another one is repairable.
	b.	Out of two lift gates one can't be operated as the lock bush is broken and the gate is closed. Other one could be operated with difficulty. The hoisting mechanism needs to be changed to wheel system from pedestal system.
2.		DS-2 (Musapur); 1 Vent (1.50mx1.80m)
	a.	Flap gate and Vertical gate are in good condition. The vertical lift gates can be operated with difficulty; hoisting system needs change from pedestal to wheel.
3.		DS-3 (Bamni); 15 Vent (1.50mx1.80m)
	a.	Out of 15 flap gates 13 is already broken from the anchor and base plate and lost. Condition of other two are also not usable. Need complete replacement with some revised design.
	b.	13 lift gates could be operated with difficulty. Other two could not be opened. Need complete repair with change of hoist mechanism from pedestal to wheel.
4.		DS-4 (Char Lengta); 3 Vent (1.20mx1.20m)
	a.	Two flaps are already lost. The failure was at the base plate and anchor bolt. Need replacement with some revised design.
5.		DS-5 (Charjatra); 2 Vent (1.20mx1.20m)
	a.	Two flaps need repair.
6.		DS-6 (CharJatra); 2 Vents (1.20mx1.20m)
	a.	Flaps need repair.
	b.	Lift gates need repair of rubber seal and change of hoisting system from pedestal to wheel system.

Note: (1) Six regulators have 25 lift gates and 25 Flap gates of size 1.50mx1.80m and 1.20mx1.20m; (2) out of 25 flaps 19 are already lost; rest 6 also need repair with revised design; (3) 15 flap gates of Bamni Regulator are being replaced this year (2004-05) with modified design of gate itself, link arm hinge pin and anchor base. (4) already one lift gate broken and lost, other 24 could be operated with difficulty, need change of hoisting mechanism and easily operable condition.

Appendix-II

Polder 59/3B

1		Sluice no.SS-17 (Kalmi): 4- vent-0.90mx1.20m
	a.	Repair/modification needed in Flap gate link arm.
	b.	Vertical lift gate replacement with increased thickness of skin plate (minmum 9mm)
	c.	Khal re-excavation : downstream- needed
2		Sluice no.3 (DS-3): Gangchil; 12 vent-1.50mx1.80m;
	a.	Flap Gates- 6 replaced in 2003-2004, remaining 6 is planned for replacement this year 2004-05.
	b.	The Flaps (new) have two points, single hinge swing arrangement.
	c.	The retention level needs to be increased by at least 2.5ft (75 cm) according to local people. The present retention upto the top level of Lift Gates (i.e 1.8m over the invert level) does not serve any useful purpose
	d.	Lift Gate: Hoist system (pedestal system) needs replacement by wheel system. One vertical lift gate needs replacement.
	e.	Should have provision for removal of u/s and d/s silt removal.
	f.	No abnormal scour observed in u/s and d/s of the sluice.
3		Sluice no.DS-4; Zillar Khal; (2+1) = 3 vent-1.5mx1.8m
	a.	Flap Gates: Ok
	b.	One Vent added, to accommodate the excess inflow. At least 80% of the new gate is buried under silt. Needs to be cleared.
	c.	Lift gates need maintenance , change of rubber seal and painting, greasing.
4.		Sluice No. SS-16; Mantaj Khal; 3-vent (0.9mx1.2m)
	a.	One flap gate is already broken and detached from the base, other two also are not repairable, all the three need replacement with revised design
	b.	All the three lift gates have problems in fitting with gate guide channel because of improper clearance between the gate leaf and guide channel, gates are also damaged, need replacement of gate as per revised design.
5.		Sluice No.DS-5 ;Karim Khal; (2+1)= 3-vent (1.5mx1.8m)
		Flap Gates: needs major repair in wall bracket, link arm, hinge pin, bush etc
		Lift Gates: Hoist system needs to be changed from Pedestal to wheel.
6.		Sluice no.SS-14; Gopal Khal; 4-vent (0.90mx1.2m)
	a.	Flap Gates: needs change of rubber seal
	b.	Lift Gates: needs replacement with revised design..
7.		Sluice no.13; Akhtar Miar Khal; 3-vent (0.90mx1.2m)
	a.	Flap Gates: major repair needed.
	b.	No lift gate installed in the sluice.
8.		Sluice no.12; Farazi Khal; 3-vent (0.90mx1.2m)
		No lift gate installed
		Outfall channel is completely silted. Sluice is non-functioning
9.		Sluice no.8; Lakshmi Khal; 6-vent (1.5mx1.8m)
		No lift gate installed
		Outfall channel is completely silted. Sluice is non-functioning

Note: (1) Out fall of Gangchil Regulator (12 vent) and Zillar khal Regulator (3 vent) are silted up. New accretion at the outfall end of both the sluices is a considerable amount. The outfall river is more than 5 km away from the regulator outlet. The whole portion is also within the accretion zone. According to preliminary assessment elevation of most of the area is from 2.0m to 2.5m. So to overcome the maintenance problem of the outfall channel and also to bring more area under protection study should be conducted to extend the polder upto the present formation area not inundated by normal tide.
(2) 9 regulators have 41 flap gates and 29 lift gates; (3) almost all the outfall channel in this polder is heavily silted up, out of that 9 vents are inoperable due to siltation; other 16 are being operated after clearing silt every year. (4) 12 flaps replaced recently, 7 need major repair and 10 need minor repair in rubber seal. (5) All the vertical lift gates can be operated with difficulty, need change of hoisting system i.e. from pedestal to wheel and easy operable condition. (5) Retention of fresh water can be done only upto the top of lift gate, this need to be raised by at least 60 cm, as desired by the beneficiaries.

Char Majid Polder, CDSP

1.		Banshkhali sluice; 8 vent (1.5mx1.8m)
	a.	8 flap gates have been replaced in 2004-05, but the gates will have difficulties in operation as the clearance between installed gate and extension of wing wall and pier is insufficient, estimated to about 11mm to 20mm.
	b.	8 lift gates have been replaced in 2004-05 replacing the traditional rubber water stop used normally in all the sluices and pedestal hoist system replaced by wheel system. The functioning of the lift gate in respect of leakage and operation efficiency with new type of water stop and stainless steel lining need to be monitored closely.

Note: (i)The regulator has 8 flap and 8 lift gates. (ii) The flap gates are replaced this year as per revised design and ideas given by project TA team. There may be problem in operation of the gate as the clearance between the vent opening and pier/wing wall extension is inadequate to accommodate the gates. (iii) The operation of the gates need to be monitored continuously to incorporate any other change/revision required. (iv) The vertical lift gates are also replaced with different type of rubber seal other than the traditional seal used before, the performance of lining of guide channel and gate edge frame with stainless steel plate against sealing as provided in replaced gate need to be monitored carefully for further improvement.

Bhatirtek Polder; CDSP

1.		Nabagram Sluice- 2 vent (1.5mx1.8m)
	a.	One flap gate can open upto about 60% and other one max upto 40%, due to jamming between extension of wing and pier. Both the flap gates need replacement with revised dimension and design.
	b.	Two lift gates are already damaged, need replacement.

Note: 2 flap and 2 lift gate need replacement with revised design to accommodate the flap in the provided arrangement or making provision in the civil engineering part for smooth functioning of the gate; the lift gates also need replacement.

Baggar Dona Polder-2; CDSP

1		Sluice-CBD-2; 3-vent (1.5mx1.8m)
	a.	All the three vertical lift gates are completely damaged. Needs total replacement i/c the embedded parts.
	b.	Flap gates are in good shape. The gates cannot be operated properly because of influential local fisher.
	c.	The Baggardona canal could retain water atleast for about 3 km, if the vertical lift gates could be maintained in proper shape.

Note: 3 flap gates and 3 lift gates; 3 vertical lift gates need replacement along with embedded parts and hoisting system and also easy operable condition.

Baggardona Polder-1, CDSP

1.		Sluice CBD-1; 3-vent (1.5mx1.8m)
	a.	Vertical lift gates i/c embedded parts need complete replacement/repair. Vertical gates cannot be operated because of improper clearance.
	b.	The thickness of skin plate and also section of angles provided in the frame appear to be too slender.
	c.	Flap gates are found to be operable.
	d.	Head difference during drainage is never more than 0.25m, for that condition flaps are found to be in good shape.

Note: (1) 3 flap gates and 3 lift gates; 3 vertical lift gates i/c embedded parts need replacement with easy operable condition. (2) Flap gates appeared operable.

Appendix-II

Polder 73/1A & B; Hatiya

1		DS-34; 4 Vent (1.35mx1.35m)
	a.	Link arm and hinge pin of 2 flap gates are broken and gates are lost.
	b.	Rest 2 flap gates also are in bad shape,
	c.	All needs replacement
2.		DS-35; 3-Vent (1.35mx1.35m)
	a.	Link arm with hinge pin of 1 flap gate is broken and the gate is lost.
	b.	Rest 2 flap gates are not operable.
	c.	Replacement of all the three gates needed
3.		DS-61; 4-Vent (1.35mx1.35m)
	a.	3 flap gates are buried under silt, are not visible
	b.	1 gate is visible, but appear to be not in operable shape.
	c.	All the 3 gates need replacement, if drainage is needed.
4.		SS-7; 1 Vent (1.22m dia)
	a.	Gate damaged, needs replacement
5.		DS-62; 4-vent (1.35mx1.35m)
	a.	All the gates are buried under silt.
6.		SS-7A; 1 Vent (1.22m dia)
	a.	Gate is not operable, needs replacement.
7.		SS-3; 1 Vent (1.22m dia)
	a.	The gate needs replacement
8.		SS-15; 1 Vent (1.22m dia)
	a.	Gate is damaged; needs replacement.
9.		DS-49; 3 Vent (0.90m dia)
	a.	Need repair of Link arm, skin plate and frame of all the gates.
10.		DS-29; 3 Vent (1.35mx1.35m)
	a.	All the gates are damaged, need replacement
11.		DS-32; 2 Vent (1.52mx1.83m)
	a.	The sluice is non-functional as it is situated outside the retired embankment
12.		SS-1; 1 Vent (1.22m dia)
	a.	The sluice as a whole is unworkable, needs replacement.
13.		SS-14; 1 Vent (1.22m dia)
	a.	Gate needs major repair in link arm, rubber seal, and frame (angle).
14.		SS-7; 1 Vent (1.22m dia)
	a.	Gate is completely damaged, needs a new gate.
15.		SS-7B; 1 Vent (1.22m dia)
	a.	Sluice is completely damaged, needs replacement.
16.		SS-7D; 1 Vent (1.22m dia)
	a.	The sluice is unworkable, due to erosion of downstream apron.
17.		SS-2; 1 Vent (1.22m dia)
	a.	Gate needs replacement.
18.		SS-10; 1 Vent (1.22m dia)
	a.	In workable condition
19.		SS-6; 1 Vent (1.22m dia);
	a.	Gate needs maintenance
20.		SS-9; 1 Vent (1.22m dia)
	a.	Gate needs maintenance.
21.		DS-48; 2 Vent (1.52mx1.83m)
	a.	Needs major repair in link arm, rubber seal and frame.
22.		DS-26; 3 Vent (1.22m dia)
	a.	All the gates are damaged, needs complete replacement.

Note: (1) There is no lift gate in the above sluices. (2) 22 regulators have 41 flap gates of which 18 flap gates of size 1.35mx1.35m; 4 of size 1.52mx1.83m; 16 of 1.22m dia and 3 of 0.90m dia; (3) all the 18 of size 1.35mx1.35m need replacement with improved design and production; 2 sluices of size 1.22m dia and one sluice of 1.52mx1.83m (2 vent) are not required; 11 flap gates of 1.22m dia need replacement; 3 of 1.22m dia need minor repair; 3 of 0.90m dia need major repair; 2 flap gates of 1.52mx1.83m dia need major repair.

Polder 73/2: Hatiya
Appendix-II

1.		DS-36; 2 Vent (1.52mx1.83m)
	a.	2 gates are completely damaged, needs replacement.
2.		DS-44; 4 Vent (1.52mx1.83m)
	a.	2 gates are lost; needs replacement of two gates and rest two gates need repair in link arm, rubber seal and frame.
3.		SS-11; 1 Vent (1.22m dia)
	a.	The gate needs replacement.
4.		SS-16; 1 Vent (1.22m dia)
	a.	Needs minor repair.
5.		DS-46; 4 Vent (1.52mx1.83m)
	a.	Need minor repair and maintenance in link arm, rubber seal, hinge pin and painting.
6.		DS-42; 2 Vent (1.52mx1.83m)
	a.	Gates need major repair or replacement.
7.		DS-37; 3 Vent (1.52mx1.83m)
	a.	Date needs repair and paintings, new embankments constructed outside by CDSP
8.		DS-36A; 1 Vent (1.52mx1.83m)
	a.	Gate damaged, needs replacement.
9.		DS-55; 2 Vent (1.52mx1.83m)
	a.	Gates damaged, need replacement.
10.		SS-11A; 1 Vent (0.91m dia)
	a.	Gate is damaged, needs replacement.
11.		SS-16A; 1 Vent (1.22m dia)
	a.	Gate damaged, needs replacement.
12.		SS-16B; 1 Vent (0.91m dia)
	a.	Gate damaged, needs replacement.
13.		SS-16C; 1 Vent (0.91m dia)
	a.	Needs repair of link arm, rubber seal, frame and painting.
14.		SS-8; 1 Vent (1.22m dia)
	a.	Needs painting of gate.

Note: (1) No lift gate is installed in the sluices (2)14 sluices/regulators have in total 25 flap gates of which 18 gates of size 1.52mx1.83m; 4 gates of size 1.22m dia and 3 gates of size 0.91m dia.(3) 9 gates of size 1.52mx1.83m need replacement and other 9 of size 1.52mx1.83m need repair in link arm, hinge pin, bush and painting; 2 gates of size 1.22m need replacement and other 2 need minor repair ; all the three gates of size 0.91m dia need replacement.

Polder CDSP 73/2 (extension); Hatiya

1.		Burir Dona; 5 Vent (1.52mx1.83m)
	a.	Lift gates and flap gates are in good condition; needs greasing in hoist system
2.		Kalam Char; 2 Vent (1.52mx1.83m)
	a.	Lift gates and flap gates are in good condition; needs greasing in hoist system
3.		Sukhchar (Amtali); 2 vent (1.5mx1.8m)
	a.	Lift gates and flap gates are in good condition; needs greasing in hoist system
4.		Moktaria; 1 Vent (1.20mx0.90m)
	a.	Lift gates and flap gates are in good condition; needs greasing in hoist system.
5.		Kaderia; 1 Vent (1.20mx0.90m)
	a.	Lift gate and flap gates are in good condition; Hoist mechanism is inoperative. Needs repair
6.		Jangalia; 1 Vent (1.20mx0.90m)
	a.	Lift and Flap gates are in good condition, hoist system needs greasing.
7.		Shialer Gopart; 1 Vent (1.20mx0.90m)
	a.	Lift and flap gates are in good condition, hoist system needs greasing.

Note: (1) all the hoist system of vertical lift gates has pedestal system. (2) all the gates need minor repair and maintenance i/c greasing of gear box.

Appendix-II

Muhuri Accreted Area

1.		SS-1; 5 vent-1.20mx1.20m
	a.	All the 5 flap gates are recently (2004-05) re-inslalled; the gates as per field report was detached from the base at least 3 times after installation. The link arm has a hinge in upper end and the lower end is fixed with the gate frame angle. The welding arrangement with the gate does not appear to be sound. The link arm and anchoring arrangement need to be revised.
	b.	5 vertical lift gates appear to be OK.
	c.	Clearance between vent opening and pier/abutment extension for accommodating and playing flap gates are not uniform in all sides; Concrete finish in railing and in faces of wing walls and piers are also not uniform.
2.		SS-2; 3 vent (0.90mx1.20m)
	a.	3 flap gates installed appear to be in good shape, but its dimension and position in respect of vent opening appeared faulty. One edge of both the gates are touching the abutment extension, so during drainage either the gate or the pier extension or both will be damaged.
	b.	Clearance between vent opening and pier/abutment extension for accommodating and playing of flap gate is not uniform and adequate. This will be another agent for damaging the gate and also the structure.
	c.	Concrete surface finish in abutment, wing wall, barrel faces and railing is very poor and undulating.

Note: 2 sluice have 8 vertical lift gate and 8 flap gates of size (1.2mx1.2m) and (0.9mx1.2m); Instead of smaller vent size (multiple vent) a single and standard vent size preferably (1.5mx1.8m) could be investigated.

Appendix-III

Conditions of Flap and Vertical Lift Gates in Coastal Area under BWDB

CDSP Polders in Noakhali and Hatiya													
No of reg	flap gate	Lift gate	Operable(F)	Operable(L)	Repaira(F)	Repair(L)	Replace(F)	Replace(L)					
6	19	0	2	0	0	0	17	0					
6	25	25	0	0	6	24	19	1					
9	41	29	12	29	17	0	3	0	9 inoperable due to silt				
1	8	8	8	8	0	0	0	0	*CDSP*				
1	2	2	1	0	0	0	1	2	Estimated cost of repair & replacement of gates as per existing design = Tk. 5.745 million				
1	3	3	3	0	0	0	0	3					
1	3	3	3	0	0	0	0	3					
22	41	0	0	0	8	0	29	0	4 not reqd				
14	25	0	0	0	11	0	14	0					
7	13	13	13	13	0	0	0	0	CDSP Area				
2	8	8	8	8	0	0	0	0	Total gate			279	
70	**188**	**91**	**50**	**58**	**42**	**24**	**83**	**9**	Operable flap =			50	48.94%
									Operable Lift =			58	63.74%
CDSP Polders in Noakhali and Hatiya									Replaceable Flap =			83	44.15%
No of reg	flap gate	Lift gate	Operable(Flap &lift)		Repaira(Flap&lift)		Replace(Flap&lift)		Replaceable Lift =			9	9.89%
70	**188**	**91**	**108**	**-**	**66**	**-**	**92**	**-**					
Khulna O&M Circle													
Khulna O&M Division-II													
No of reg	flap gate	Lift gate	Operable(F)	Operable(L)	Repaira(F)	Repair(L)	Replace(F)	Replace(L)					
3	3	0	0	0	3	0	0	0					
15	25	0	3	0	8	0	14	0					
12	21	0	0	0	3	0	18	0	Khulna O&M Division-II				
4	9	0	0	0	4	0	5	0	No of Flap Gate			224	
11	23	0	0	0	13	0	10	0	No of Lift Gates			48	
10	18	0	11	0	7	0	0	0	Total No of Gates			272	

7	24	0	16	0	8	0	0	0		Operable Flap gates	81	36.16%
13	28	3	10	0	18	0	0	3		Operable Lift gates	31	64.58%
12	3	18	1	10	0	4	2	4				
2	1	2	1	2	0	0	0	0				
3	3	0	2	0	0	0	1	0				
4	3	3	2	2	0	0	1	1				
9	24	19	19	17	0	0	5	2				
10	14	1	6	0	4	0	4	1				
20	25	2	10	0	0	0	15	2				
135	**224**	**48**	**81**	**31**	**68**	**4**	**75**	**13**				
Bagerhat O&M Division												
No of reg	flap gate	lift gate	Operable(F)	Operable(L)	Repaira(F)	Repair(L)	Replace(F)	Replace(L)				
5	8	8	6	8	0	0	2	0		Bagerhat O&M Division		
9	17	5	15	4	0	0	2	1		No of Flap Gate	324	
13	25	11	16	9	0	0	9	2		No of Lift Gates	190	
59	70	70	49	65	9	0	12	5		Total No of Gates	514	
37	126	14	88	9	11	2	27	3		Operable Flap gates	229	70.68%
19	45	49	30	27	3	2	12	20		Operable Lift gates	150	78.95%
1	10	10	8	7	0	0	2	3				
9	23	23	17	21	3	0	3	2				
152	**324**	**190**	**229**	**150**	**26**	**4**	**69**	**36**				
Satkhira O&M Division-II, Satkhira										Satkhira O&M Division-II		
20	32	2	20	1	4	0	8	1		No of Flap Gate	223	
20	38	9	24	2	0	0	14	7		No of Lift Gates	75	
26	55	39	25	12	14	15	16	12		Total No of Gates	298	
8	10	0	4	0	0	0	6	0		Operable Flap gates	113	50.67%
15	22	0	3	0	5	0	14	0		Operable Lift gates	35	46.67%
9	21	17	13	17	4	0	4	0				
2	6	5	6	0	0	0	0	5		Satkhira O&M Division-I		
2	5	3	0	3	0	0	5	0		No of Flap Gate	217	
16	28	0	14	0	0	0	14	0		No of Lift Gates	64	

4	6	0	4	0	0	0	2	0		Total No of Gates	281	
122	**223**	**75**	**113**	**35**	**27**	**15**	**83**	**25**		Operable Flap gates	104	47.93%
										Operable Lift gates	19	29.69%
Satkhira O&M Division-I												
24	83	54	47	16	0	7	36	31				
31	68	3	32	1	2	0	34	2				
43	52	0	16	0	26	0	10	0				
5	5	0	2	0	2	0	1	0		Khulna O&M Circle		
3	9	7	7	2	0	3	2	2		Total flap& lift gate=	1365	
106	**217**	**64**	**104**	**19**	**30**	**10**	**83**	**35**		Operable flap& lift gate=	762	55.82%
										Inoperable flap & lift gate=	603	44.18%
										Replaceable flap & lift=	419	30.70%
Gate Position Under Khulna O&M Circle										*Khulna O&M Circle*		
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap&lift)			Estimated cost of repair/ replacement of gates as per existing design = Tk.40.073 million		
515	**988**	**377**	**762**		**184**		**419**					
Jessore O&M Circle;												
Khulna O&M Division-I												
No of reg	flap gate	lift gate	Operable(F)	Operable(L)	Repaira(F)	Repair(L)	Replace(F)	Replace(L)				
17	42	26	35	19	0	0	6	7		Khulna O&M Division-I		
12	26	35	17	32	0	0	7	2		No of Flap Gate	214	
7	12	12	11	11	0	0	1	1		No of Lift Gates	201	
11	11	11	8	8	0	0	1	2		Total No of Gates	415	
5	6	6	4	2	0	0	2	3		Operable Flap gates	185	86.45%
11	36	32	35	31	0	1	1	0		Operable Lift gates	173	86.07%
9	9	9	9	7	0	0	0	2				
3	10	10	10	10	0	0	0	0				
6	18	18	17	16	0	0	1	2				
5	11	9	11	9	0	0	0	0				
5	15	15	15	15	0	0	0	0				
10	18	18	13	13	1	1	3	3				

101	**214**	**201**	**185**	**173**	**1**	**2**	**22**	**22**					
Jessore O&M Division, Jessore										Jessore O&M Division			
16	63	29	54	29	0	0	7	0		No of Flap Gate		153	
4	13	11	13	11	3	3	0	0		No of Lift Gates		138	
16	50	38	50	38	3	5	0	0		Total No of Gates		291	
2	7	7	7	3	2	0	0	2		Operable Flap gates		144	94.12%
12	20	32	20	27	2	5	0	0		Operable Lift gates		129	93.48%
2	0	8	0	8	0	0	0	0					
4	0	13	0	13	0	0	0	0					
56	**153**	**138**	**144**	**129**	**10**	**13**	**7**	**2**					
Narail O&M Division										*Jessore O&M Circle*			
24	59	58	45	42	5	4	9	11		Estimated cost of repair/ replacement of gates as per existing design= Tk.1.576 million			
4	7	7	6	4	2	2	1	3					
28	**66**	**65**	**51**	**46**	**7**	**6**	**10**	**14**					
Gate Position Under Jessore O&M CIRcle										Jessore O&M Circle			
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)			Total flap& lift gate=		837	
185	**433**	**404**	**728**	**-**	**39**	**-**	**77**	**-**		Operable flap& lift gate=		728	86.98%
Southern Zone, BWDB, Barisal										Inoperable flap & lift gate=		109	13.02%
Barisal O&M Division										Replaceable flap & lift=		77	9.20%
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)						
3	4	5	4	-	5	-	0	-		Barisal O&M Division			
7	10	10	0	-	20	-	0	-		Total no of flap& lift gates		160	
5	6	6	4	-	8	-	0	-		Operable flap & lift gates=		70	43.75%
5	7	7	6	-	7	-	1	-		Inoperable flap & lift gates=		90	56.25%
4	29	1	15	-	14	-	1	-		Replaceable Gates=		7	4.38%
5	18	1	5	-	11	-	3	-					
3	5	5	3	-	6	-	1	-		Estimated cost of repair/replacement of gates as per existing design = Tk. 1.360million			
4	11	11	9	-	12	-	1	-					

3	12	12	24	-	0	-	0	-					
39	**102**	**58**	**70**	**-**	**83**	**-**	**7**	**-**					
Patuakhali O&M division													
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)						
12	20	20	26	-	5	-	9	-					
6	13	7	13	-	6	-	1	-					
11	24	12	7	-	5	-	24	-					
8	11	11	6	-	10	-	6	-					
6	24	0	2	-	8	-	14	-		Patuakhali O&M Division			
5	6	6	0	-	2	-	10	-		Total no of flap& lift gates		620	
8	21	21	8	-	10	-	24	-		Operable flap & lift gates=		151	24.35%
7	11	11	0	-	0	-	22	-		Inoperable flap & lift gates=		469	75.65%
5	7	7	2	-	2	-	10	-		Replaceable Gates=		326	52.58%
4	5	5	0	-	4	-	6	-					
1	6	6	2	-	2	-	8	-		Note: The number gates replaceable and also number of gates repairable do not indicate whether the gates are easily operable or not. The causes of replacement/repair is mainly non maintenance and also weathering action for long use.			
9	82	0	14	-	14	-	54	-					
9	18	18	4	-	8	-	24	-					
4	13	13	6	-	6	-	14	-					
6	17	17	6	-	11	-	17	-					
12	30	30	12	-	20	-	28	-					
7	20	20	12	-	8	-	20	-					
5	14	14	10	-	6	-	12	-		Estimated cost of repair/replacement of gates as per existing design = Tk.18.855million			
7	15	15	6	-	9	-	15	-					
3	6	6	6	-	3	-	3	-					
4	9	9	9	-	4	-	5	-					
139	**372**	**248**	**151**	**-**	**143**	**-**	**326**	**-**					
Barguna O&M Division													
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)						
11	49	5	18	-	0	-	36	-					

6	10	10	15	-	0	-	5	-					
6	14	14	18	-	0	-	10	-					
4	16	0	7	-	0	-	9	-					
8	25	17	17	-	0	-	25	-					
19	29	29	42	-	9	-	7	-					
21	31	31	42	-	17	-	3	-					
17	24	24	40	-	8	-	0	-					
13	23	8	17	-	4	-	10	-					
25	42	21	41	-	0	-	22	-					
15	29	29	36	-	0	-	22	-					
17	19	19	35	-	0	-	3	-		Barguna O&M Division			
13	17	17	30	-	3	-	1	-		Total flap and lift gates=		890	
12	17	17	22	-	4	-	8	-		Operable flap & lift gates=		606	68.09%
8	12	12	12	-	8	-	4	-		Inoperable flap & lift gates=		284	31.91%
13	14	14	12	-	6	-	10	-		Replaceable Gates=		204	22.92%
25	38	38	60	-	2	-	14	-					
6	9	9	10	-	4	-	4	-					
14	17	17	30	-	0	-	4	-					
14	20	20	31	-	9	-	0	-		Estimated cost of repair/replacement of gates as per existing design = Tk.11.022million			
15	35	35	60	-	6	-	4	-					
5	7	7	11	-	0	-	3	-					
287	**497**	**393**	**606**	**-**	**80**	**-**	**204**	**-**					
Pirojpur O&M Division										Pirojpur O&M Division			
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)			Total flap and lift gates=		76	
8	21	21	22	-	0	-	20	-		Operable Flap and lift=		44	57.89%
6	17	5	14	-	0	-	8	-		Inoperable Flap and Lift=		32	42.11%
3	6	6	8	-	0	-	4	-		Replaceable flap and lift=		32	42.11%
17	**44**	**32**	**44**	**-**	**0**	**-**	**32**	**-**		Estimated cost of repair and replacement of gates as per existing design = Tk. 2.56million			

Bhola O&M Division-I												
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)					
4	**10**	**10**	**14**	**-**	**0**	**-**	**6**	**-**	Estimated cost of repair and replacement of gates as per existing design = Tk. 0.38million			
Bhola O&M Division-II												
11	92	8	54	-	53	-	46	-	Bhola O&M Divn-II			
4	11	11	0	-	0	-	22	-	Total flap & lift gates=		162	
6	8	8	8	-	0	-	8	-	Operable flap& lift =		68	41.98%
5	9	9	0	-	0	-	18	-	Inoperable flap & lift =		94	58.02%
2	3	3	6	-	0	-	0	-				
28	**123**	**39**	**68**	**-**	**53**	**-**	**94**	**-**	Estimated cost of repair and replacement of gates as per existing design = Tk. 7.205million			
Regulator/Sluice Position in Southern Zone,BWDB, Barisal									Southern Zone, Barisal			
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)		Total flap& lift gates=		1928	
514	**1148**	**780**	**953**	**-**	**359**	**-**	**669**	**-**	Operable Flap & Lift Gate=		953	49.43%
									Replaceable flap&lift =		669	34.70%
									Southern Zone, Barisal			
South Eastern Zone, BWDB, Chittagong									Estimated cost of repair and replacement of gates as per existing design = Tk.41.072million			
Chittagong O&M Division-I												
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)					
5	30	0	11	-	0	-	19	-				
2	0	14	0	-	0	-	14	-	Chittagong O&M Division-I			
13	18	13	23	-	3	-	5	-	Total flap & lift gates=		289	
1	2	2	2	-	0	-	2	-	operable flap & lift gates=		92	31.83%
5	6	2	6	-	0	-	2	-	Inoperable flap & lift gates=		197	68.17%
25	45	0	30	-	0	-	15	-	Replaceable Gates=		194	67.13%
22	0	91	9	-	0	-	82	-				
6	48	0	6	-	0	-	42	-				
2	4	0	0	-	0	-	4	-	Estimated cost of repair/replacement of gates as per existing design = Tk.10.301million			
3	0	14	5	-	0	-	9	-				

84	**153**	**136**	**92**	**-**	**3**	**-**	**194**	**-**				
Chittagong O&M Division II												
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)					
22	75	22	67	-	7	-	23	-	Chittagong O&M Division-II			
10	24	36	56	-	0	-	4	-	Total flap& lift gates=		273	
24	35	2	36	-	0	-	1	-	Operable flap & lift gates=		234	85.71%
33	50	0	47	-	0	-	3	-	Inoperable flap & lift gates=		39	14.29%
9	27	0	26	-	0	-	1	-	Replaceable Gates=		32	11.72%
1	2	0	2	-	0	-	0	-				
99	**213**	**60**	**234**	**-**	**7**	**-**	**32**	**-**	Estimated cost of repair and replacement of gates as per existing design = Tk. 1.01million			
Rangamati O&M Division,												
21	152	10	150	-	10	-	2	-				
18	194	70	218	-	10	-	36	-	Estimated cost of repair and replacement of gates as per existing design = Tk. 0.923million			
39	**346**	**80**	**368**	**-**	**20**	**-**	**38**	**-**				
Coxs Bazar O&M Division												
14	16	1	12	-	0	-	5	-				
34	46	3	30	-	2	-	17	-				
22	35	10	26	-	0	-	19	-				
3	2	1	2	-	0	-	1	-				
9	17	17	28	-	0	-	6	-				
4	5	1	3	-	0	-	3	-				
1	5	0	3	-	2	-	0	-				
5	16	16	0	-	0	-	32	-				
2	6	6	0	-	0	-	12	-	Coxsbazar O&M Division			
3	9	9	0	-	0	-	18	-	Tota flap& lift gates=		678	
4	12	12	0	-	0	-	24	-	Operable flap & lift gates=		250	36.87%
6	18	18	0	-	0	-	36	-	Inoperable flap & lift gates=		428	63.13%
14	28	0	17	-	0	-	11	-	Replaceable Gates=		424	62.54%
2	7	0	4	-	0	-	3	-				

3	8	3	11	-	0	-	0	-	Estimated cost of repair /replacement of gates as per existing design = Tk. 20.488million				
8	11	0	2	-	0	-	9	-					
4	7	5	7	-	0	-	5	-					
4	11	11	18	-	0	-	4	-					
6	8	0	3	-	0	-	5	-					
9	20	6	7	-	0	-	19	-					
9	34	25	0	-	0	-	59	-					
26	17	60	20	-	0	-	57	-					
15	7	54	16	-	0	-	45	-					
10	18	18	12	-	0	-	24	-	Chittagong O&M Circle=		1666		
17	39	0	29	-	0	-	10	-	Operable flap & lift gates=		944		56.66%
234	**402**	**276**	**250**	**-**	**4**	**-**	**424**	**-**	Inoperable flap & lift gates=		722		43.34%
									Replaceable Gates=		688		41.30%
Chittagong O&M Circle									*Ctg. O&M Circle*				
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)		Estimated cost of repair /replacement of gates as per existing design = Tk. 32.722million				
456	**1114**	**552**	**944**	**-**	**34**	**-**	**688**	**-**					
Feni O&M Circle; Feni O&M Division									FeniO&M Division				
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap & lift)		Total flap & lift gates=		176		
1	9	9	6	-	12	-	0	-	Operable flap & lift gates=		127		72.16%
3	43	45	85	-	0	-	3	-	Inoperable flap & lift gates =		49		27.84%
1	20	20	34	-	6	-	0	-	Replaceable Gates=		3		1.70%
8	13	13	2	-	24	-	0	-	*Feni O&M Circle*				
2	2	2	0	-	4	-	0	-	Estimated cost of repair/replacement of flap & lift gates = Tk.2.05 million				
15	**87**	**89**	**127**	**-**	**46**	**-**	**3**	**-**					

Gates in Coastal Zone												
No of reg	flap gate	lift gate	Operable(Flap&lift)		Repaira(Flap&lift)		Replace(Flap&lift)		Gates in Coastal Zone			
1755	**3958**	**2293**	**3622**	**-**	**728**	**-**	**1948**	**-**	Total Flap& Lift=		6251	
									Operable flap& lift=		3622	57.94%
Estimated cost for repair & replacement of gates under coastal zone= Tk. 123.248 million									Inoperable flap & lift=		2629	42.06%
									replaceable flap & lift=		1948	31.16%

Appendix-IV

Conditions of Gates in Regulators/Barrage/Pump House in Non-Coast Area								
Chandpur O&M Circle								
No of Reg.	Flap gates	Lift gates	Operable(F)	Operable(L)	Repair(F)/(L)	Replace(F)/(L)		
Chandpur O&M Division								
7	35	48	33	38	19	8		
Meghna-Dhonagoda O&M Division								
120	25	155	22	129	18	16		
Chandpur O&M Circle								
127	**60**	**203**	**55**	**167**	**37**	**24**		
Estimated cost of repair of gates unde Chandpur O&M Circleas per existing design is Tk. 1.164 million								
Comilla O&M Circle								
Gumti O&M Division								
No of Reg.	Flap gates	Lift gates	Operable(F)	Operable(L)	Repair(F)/(L)	Replace(F)/(L)		
46	29	80	46	44	37	17		
Comilla O&M Division;								
18	3	47	0	26	19	20		
Comilla O&M Circle								
64	**32**	**127**	**46**	**70**	**56**	**37**		
Estimated cost of repair of gates under Comilla O&M Circleas per existing design is Tk.2.330 million								
Moulvibazar O&M Circle								
Habiganj O&M Division,								
24	0	56	2	14	36	4		
Moulvibazar O&M Division								
-	41	195	34	182	32	3		
Moulvibazar O&M Circle								
-	**41**	**251**	**36**	**196**	**68**	**7**		
Estimated cost of repair of gates under Mlbbazar O&M Circle as per existing design is Tk.2.160 million								
Sylhet O&M Circle								
Sylhet O&M Division								
6	20	19	20	14	3	5		
Sunamganj O&M Division								
79	20	163	3	105	122	31		
Sylhet O&M Circle								
85	**40**	**182**	**23**	**119**	**125**	**36**		
Estimated cost of repair of gates under Sylhet O&M Circle as per existing design is Tk.5.806 million								
Gates under North Eastwern Zone, Comilla								
-	**173**	**763**	**160**	**552**	**286**	**104**		
Note:(1) In North Eastern Zone, out of 936 flap and lift gates, 712 (76.07%) lift and flap gates are operable; others need major repair and some replacement.								
Estimated cost of repair of gates under NEZone as per existing design is Tk.11.46 million								
Central Zone, Dhaka								

Dhaka O&M Circle;								
Dhaka O&M Division-1								
No of Reg.	Flap gates	Lift gates	Operable(F)	Operable(L)	Repair(F)/(L)	Replace(F)/(L)		
20	3	35	3	31	9	2		
Dhaka O&M Division-2								
61	17	88	16	87	2	2		
Norsingdi O&M Division								
32	1	64	1	38	39	26		
Dhaka Pump House (Mechanical) Division								
	17	55	12	47	13	0		
Dhaka O&M Circle;								
-	**38**	**242**	**32**	**203**	**63**	**30**		
Estimated cost for repair of gates as per present design is Tk.4.644 million								
Mymensingh O&M Circle								
Mymensingh O&M Division								
No of Reg.	Flap gates	Lift gates	Operable(F)	Operable(L)	Repair(F)/(L)	Replace(F)/(L)		
27	0	72	0	45	27	0		
Tangail O&M Division								
106	12	177	10	115	114	5		
Netrakona O&M Division								
24	63	79	55	65	26	2		
Jamalpur O&M Division								
7	0	15	0	7	8	0		
Mymensingh O&M Circle (total)								
164	**75**	**343**	**65**	**232**	**175**	**7**		
Estimated cost for repair of gates as per present design is Tk.2.720 million								
Gate Position under Central Zone								
-	**113**	**585**	**97**	**435**	**238**	**37**		
Note: In Central Zone Dhaka out of 698 flap and lift gates 532 (76.22%) are operable, others need major repair and also some replacement; Estimated cost for repair only is Tk. 7.364 million								
South Western Zone, Faridpur								
Faridpur O&M Circle								
Faridpur O&M Division								
56	20	104	15	65	34	31		
Rajbari O&M Division								
120	0	120	0	106	41	14		
Madaripur O&M Division								
18	51	43	21	19	90	4		
Gopalganj O&M Division								
55	9	114	5	53	3	62		
Faridpur O&M Circle (total)								
249	**80**	**381**	**41**	**243**	**168**	**111**		
Estimated cost for repair of gates under Faridpur O&M Circle as per present design is Tk.11.436 million								

Kustia O&M Circle								
Kustia O&M Division								
144	0	148	0	124	15	10		
Amla O&M Division								
87	0	87	0	76	59	11		
Jhenaidah O&M Division								
107	0	139	0	107	28	4		
Chuadanga O&M Division								
125	7	118	3	10	103	9		
Magura O&M Division								
177	132	164	121	125	133	39		
Kustia O&M Circle								
640	**139**	**656**	**124**	**442**	**338**	**73**		
Estimated cost for repair of gates under Kustia O&M Circleas per present design is Tk.19.395 million								
Gates Under Faridpur and Kustia O&M Circle								
889	**219**	**1037**	**165**	**685**	**506**	**184**		
Note: (1)Total no of gates in Faridpu and Kustia O&M Circle (non coast structures under SWZone, Faridpur) is 1256 out of that only 850 (67.68%) are operable, the rest are inoperable; some of which need major repair and some need to be replaced; .								
(2) Estimated repair/replacement cost as per present design is Tk. 30.831 million								
North-Wester Zone, Rajshahi								
Rajshahi O&M Circle								
Rajshahi O&M Division								
No of Reg.	Flap gates	Lift gates	Operable(F)	Operable(L)	Repair(F)/(L)	Replace(F)/(L)		
53	0	104	0	73	28	3		
Natore O&M Division								
57	0	129	0	75	54	0		
Naogaon O&M Division								
62	16	115	14	114	86	0		
Nawabganj O&M Division								
17	9	62	7	60	43	4		
Rajshahi O&M Circle								
144	**25**	**410**	**21**	**322**	**211**	**7**		
Estimated cost for repairof gates under Rajshahi O&M Circle as per existing design is Tk.6.503 million								
Pabna O&M Circle								
Pabna O&M Division								
61	1	221	0	203	19	1		
Bera O&M Division								
70	0	87	0	74	13	0		
Pabna O&M Circle								
131	**1**	**308**	**0**	**277**	**32**	**1**		

Estimated cost for repairof gates under Pabna O&M Circle as per existing design is Tk.0.590 million								
Bogra O&M Circle								
Bogra O&M Division								
40	0	94	0	44	67	5		
Sirajganj O&M Division								
4	0	8	0	0	8	0		
Sirajganj BRE (Specealised) Division								
2	1	3	0	1	3	0		
Bogra O&M Circle								
46	**1**	**105**	**0**	**45**	**78**	**5**		
Estimated cost for repairof gates under Bogra O&M Circle as per existing design is Tk.3.143 million								
Gate condition under NWZone, Rajshahi								
321	**27**	**823**	**21**	**644**	**321**	**13**		
Note: (1) Total number of gates under NWZone, Rajshahi is 850; out of that 665 (78.24%) is workable and some of the rest need major repair and some need to be replaced.								
(2) Estimated cost to repair the gates under NWZone, Rajshahi as per existing design is Tk. 10.236 million								
Northern Zone, Rangpur								
Rangpur O&M Circle-1								
Rangpur O&M Division								
No of Reg.	F/R gates	Lift gates	Oper.(F/R)	Operable(L)	Repair(F)/(L)	Replace(F)/(L)		
56	26	70	24	38	13	16		
Lalmanirhat O&M Division								
25	0	107	0	76	20	11		
Kurigram O&M Division								
14	0	80	0	78	55	2		
Gaibandha O&M Division								
78	32	95	29	72	16	10		
Rangpur O&M Circle-1								
173	**58**	**352**	**53**	**264**	**104**	**39**		
Estimated cost for repairof gates under Rangpur O&M Circle-1 as per existing design is Tk.1.890 million								
Rangpur O&M Circle-2								
Dalia O&M Division								
62	6	84	6	84	35	0		
Syedpur O&M Division								
70	15	86	15	86	28	0		
Nilphamari O&M Division								
82	43	97	43	97	38	0		
Rangpur O&M Circle-2								
214	**64**	**267**	**64**	**267**	**101**	**0**		
Estimated cost for repairof gates under Rangpur O&M Circle-2 as per existing design is Tk.1.100 million								

Thakurgaon O&M Circle								
ThakurgaonO&M Division								
15	12	12	12	12	10	9		
Panchagarh O&M Division								
21	11	16	11	14	3	2		
Dinajpur O&M Division								
37	38	21	38	21	35	10		
Thakurgaon O&M Circle								
73	**61**	**49**	**61**	**47**	**48**	**21**		
Estimated cost for repairof gates under Thakurgaon O&M Circle- as per existing design is Tk.3.60 million								
Gate Position Under Nortern Zone, Rangpur								
460	183	668	178	578	253	60		
Note: (1)Total no of gates under Northern Zone is 851 out of that 756 (88.84%) is operable, others need repair and also some replacement.								
(2) Estimated cost for repair of gates under Northern Zone, Rangpur is Tk. 6.59 million								
Total Gate Position in non-coast area								
No of Reg.	F/R gates	Lift gates	Oper.(F/R)	Operable(L)	Repair(F)/(L)	Replace(F)/(L)		
-	**715**	**3876**	**621**	**2894**	**1604**	**398**		
(1) In Non-coast area total flap, lift and radial gate is 4591; of that 3515 (76.56%) are operable; the rest need repair and some replacement								
(2) Estimated cost of repair/ replacement of gate in non-coast area as per existing design is Tk. 66.481 million								

COST OF CIVIL & MECHANICAL WORKS IN REGULATORS **Appendix-V**

Division: Khulna O&M Division-2;

Project: Amirpur-Bhandarkot-Baliadanga; Construction year: 1999-2000 to 2004-2005

Cost in million Taka

Structure Details	Cost of Construction		Total cost	% of Mech. cost to total cost	Lifting Device	No and type of gate	Operating condition
	Civil Engg Part	Mech Component					
Drainage cum Flushing Sluice at Kharabad; (1-1.2mx1.5m)	3.162	0.032	3.194	1.00%	Pedestal/Flap	1 no lift gate, 1 no flap gate	Operable
Drainage cum Flushing Sluice at Thakurbari; (3-1.5mx1.8m)	6.520	0.095	6.615	1.44%	Pedestal/Flap	3 no lift gate, 3 no flap gate	Operable
Drainage cum Flushing Sluice at Bashbunia; (3-1.5mx1.8m)	6.106	0.095	6.201	1.53%	Pedestal/Flap	3 no lift gate, 3 no flap gate	Operable
Drainage cum Flushing Sluice at Halia; (3-1.5mx1.8m)	6.674	0.051	6.725	0.76%	Pedestal/Flap	3 no lift gate, 3 no flap gate	Operable
Drainage cum Flushing Sluice at Noailtala; (3-1.5mx1.8m)	11.903	0.286	12.189	2.35%	Pedestal/Flap	3 nos lift gate, 3 nos flap gate	Operable
Flushing Pipe Sluice at Badalbunia; (1-0.90m dia)	0.802	0.082	0.884	9.28%	Pedestal	1 no lift gate	Operable
Flushing Pipe Sluice at Charbunia; (1-0.90m dia)	0.802	0.082	0.884	9.28%	Pedestal	1 no lift gate	Operable
Flushing Pipe Sluice at Matbarkhali; (1-0.90m dia)	0.802	0.082	0.884	9.28%	Pedestal	1 no lift gate	Operable
Flushing Pipe Sluice at Ghogerkhali; (1-0.90m dia)	0.802	0.082	0.884	9.28%	Pedestal	1 no lift gate	Operable
Drainage cum Flushing sluice at Sheolabunia; (3-1.2mx1.5m)	10.825	0.490	11.315	4.33%	Pedestal/Flap	3 no lift gate, 3 no flap gate	Operable
Irrigation Inlet; (1-0.45m dia) at km.8.80	0.642	0.048	0.690	6.96%	Pedestal	1 no lift gate	Operable
Irrigation Inlet; (1-0.45m dia) at km.19.80	0.625	0.048	0.673	7.13%	Pedestal	1 no lift gate	Operable
Irrigation Inlet; (1-0.45m dia) at km.11.50	0.659	0.050	0.709	7.05%	Pedestal	1 no lift gate	Operable
Irrigation Inlet; (1-0.45m dia) at km.30.60	0.659	0.050	0.709	7.05%	Pedestal	1 no lift gate	Operable
Irrigation Inlet; (1-0.45m dia) at km.1.25	0.745	0.050	0.795	6.29%	Pedestal	1 no lift gate	Operable
Irrigation Inlet; (1-0.45m dia) at km.3.20	0.766	0.050	0.816	6.13%	Pedestal	1 no lift gate	Operable
Irrigation Inlet; (1-0.90m dia) at km.14.25	0.955	0.056	1.011	5.54%	Pedestal	1 no lift gate	Operable

Irrigation Inlet; (1-0.90m dia) at km.37.75	0.864	0.056	0.92	6.09%	Pedestal	1 no lift gate	Operable
	54.313	1.785	56.098	3.18%			

Project: Dabagyahati sub-project; SSFCDI-2nd phase; Division: Bagerhat O&M Division — Cost in million Taka

Structure Details	Cost of construction			Total cost of structure	% of gate cost to sluice cost	% of mech comp cost to total cost	No of gates
	Civil Engg cost	Mech cost of gates	Mech. cost of boat pass				
DS-1; Hargati Regulator cum Boat Pass; 4-1.50mx1.80m+1-5.0m	9.054	0.585	2.793	12.432	6.46%	27.17%	4-Lift, 4 Flap and 2 boat pass
DS-2; Harma Regulator cum Boat Pass; 4-1.50mx1.80m+1-5.0m	9.034	0.585	2.793	12.412	6.48%	27.22%	4-Lift, 4 Flap and 2 boat pass
DS-3; Kumarijola Regulator cum Boat Pass; 4-1.50mx1.80m+1-5.0m	8.247	0.585	2.793	11.625	7.09%	29.06%	4-Lift, 4 Flap and 2 boat pass
DS-4; Sonakhali Regulator cum Boat Pass; 3-1.50mx1.80m+1-5.0m	9.029	0.438	2.793	12.26	4.85%	26.35%	3-Lift, 3 Flap and 2 boat pass
DS-5; Sinnikhali Regulator; 2-1.50mx1.80m	4.695	0.292	0	4.987	6.22%	0.00%	2 lift and 2 flap
DS-6; Bishkhali Regulator; 7-1.50mx1.80m+1-5.0m	12.568	1.023	0	13.591	8.14%	0%	7 lift and 7 flap
	52.627	3.508	11.172	67.307	6.67%	21.81%	

Gates & Hoists under Chittagong O&M Circle — Cost in million Tk

Structure Details	Cost of construction		Total Construction cost	% of mech cost to civil engg cost	% of mech cost to total cost	No and type of gates	
	Civil Engg Cost	Cost of Gates & Hoists				Flap Gates	Lift Gates
Kumira Khal Regulator; 10vent-1.80mx2.40m	39.131	7.637	46.768	19.52%	16.33%	10-1.99mx2.61m	10-1.90mx2.58m
Chuarfari Regulator, 8 vent (1.50mx1.80m)	26.600	3.400	30.000	12.78%	11.33%	8-1.65mx1.95m	8-1.65mx1.95m
Regulator no.1 under Coxsbazar Town Protection; 3 vent (1.5mx1.8m)	8.818	1.182	10.000	13.40%	11.82%	3-1.65mx1.95m	3-1.65mx1.95m
Regulator no.2 under Coxsbazar Town Protection; 2 vent (1.5mx1.8m)	7.412	0.788	8.200	10.63%	9.61%	2-1.65mx1.95m	2-1.65mx1.95m

Sluice at Km.60.29 in polder 64/2B; 1 vent(1.5mx1.8m)	7.610	0.390	8.000	5.12%	4.88%	1-1.65mx1.95m	1-1.65mx1.95m
	89.571	13.397	102.968	14.96%	13.01%		

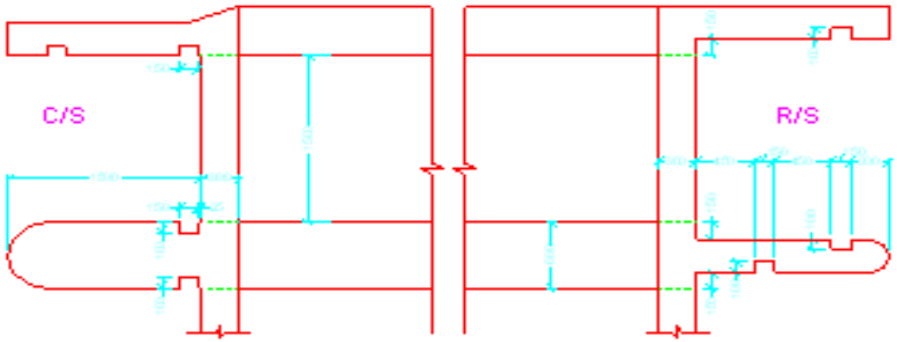
Gates & Hoists under Feni O&M Division; CDSP-II

Structure Details	Cost of construction		Total cost of construction	% of mech cost to civil engg cost	% of mech cost to total cost	No and type of gates	
	Civil engg cost	Cost of gates & hoistts				Flap Gates	Lift Gates
SS-1; 5 vent (1.20mx1.20m)	18.138	0.749	18.887	4.13%	3.97%	5-1.2mx1.2m	5-1.2mx1.2m
SS-2; 3 vent (0.9mx1.2m)	9.492	0.580	10.072	6.11%	5.76%	3-0.9mx1.2m	3-0.9mx1.2m
Total/Average	27.63	1.329	28.959	4.81%	4.59%		

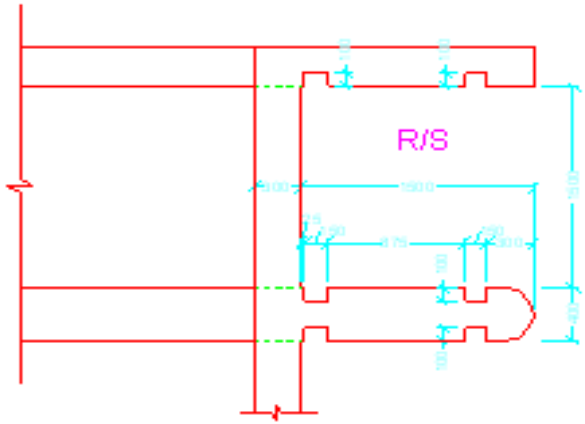
Gates and Hoists under CERP

Structure Details	Cost of construction		Total cost of construction	% of mech cost to civil engg cost	% of mech cost to total cost	No and type of gates	
	Civil engg cost	Cost of gates & hoistts				Flap Gates	Lift Gates
SS-2;2 vent (0.91mx1.22m)	20.590	0.148	20.738	0.72%	0.71%	2-0.91mx1.22m	2-0.91mx1.22m
Contract no.2; 10 Structures	111.171	3.887	115.058	3.50%	3.38%	gate size0.9mx1.2mto 1.5mx1.8m	
Total/Average	131.761	4.035	135.796	3.06%	2.97%		

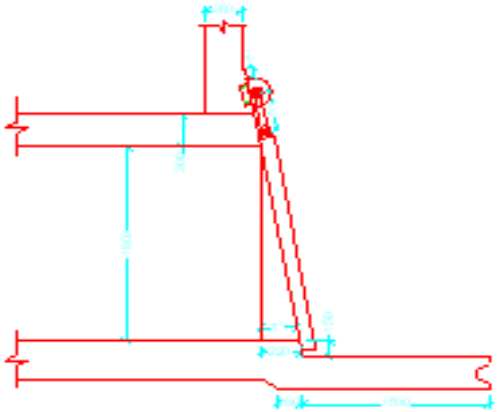
Appendix-VI



C/S Vertical Lift Gate & R/S Flap Gate

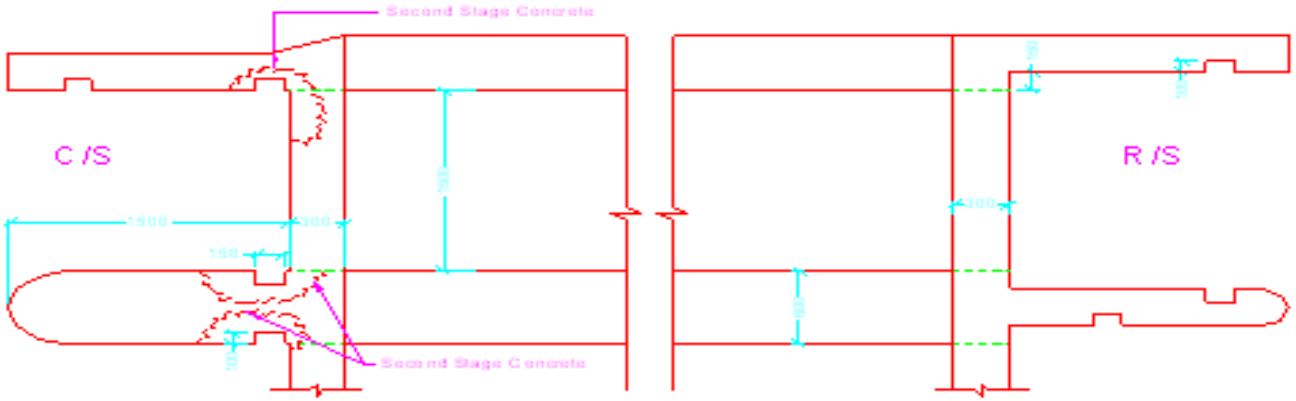


R/S Vertical Lift Gate

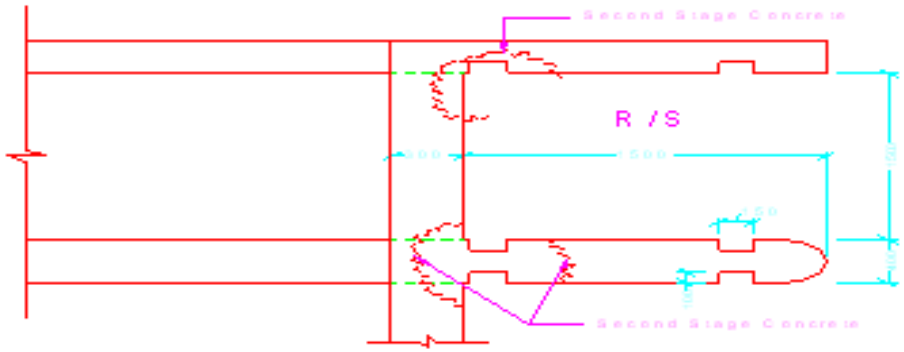


Typical Details for Accommodating Gates

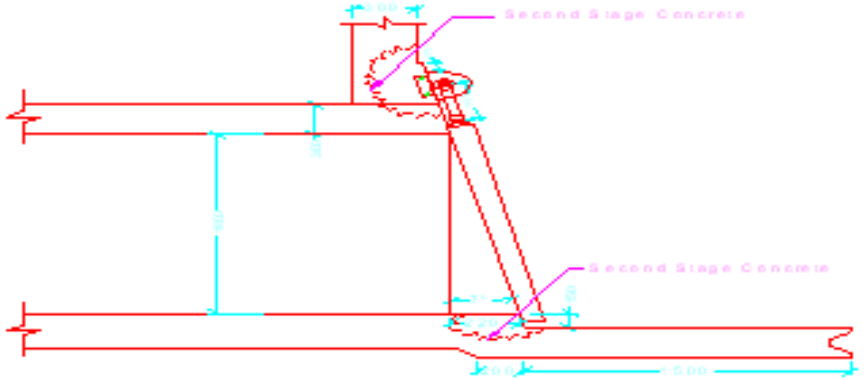
Appendix-VIa



C/S Vertical Lift Gate & R/S Flap Gate

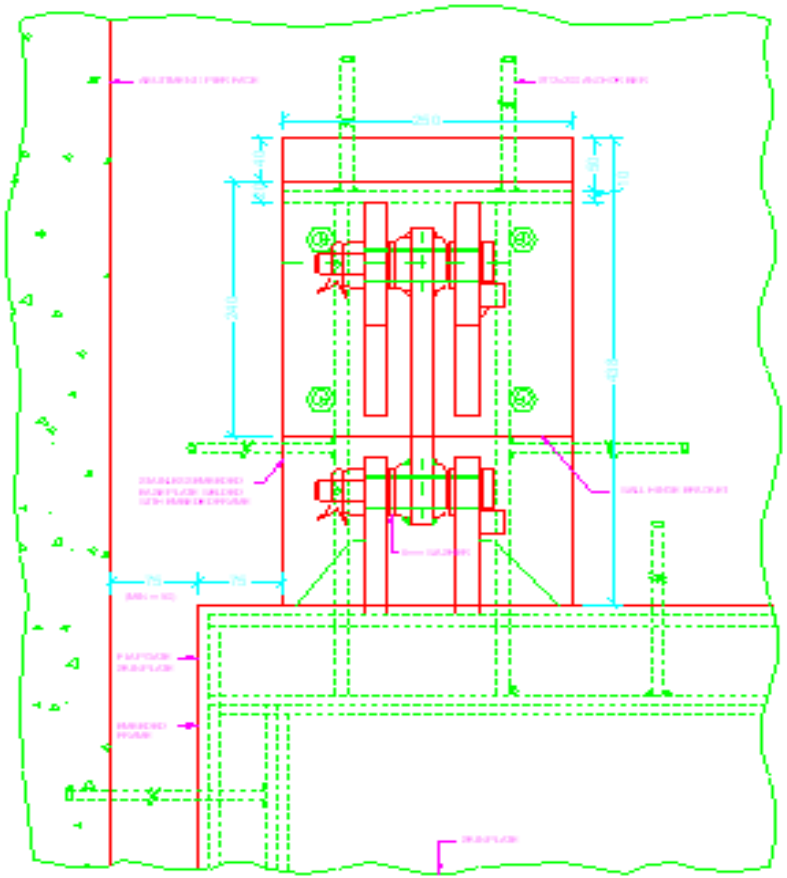


R/S Vertical Lift Gate

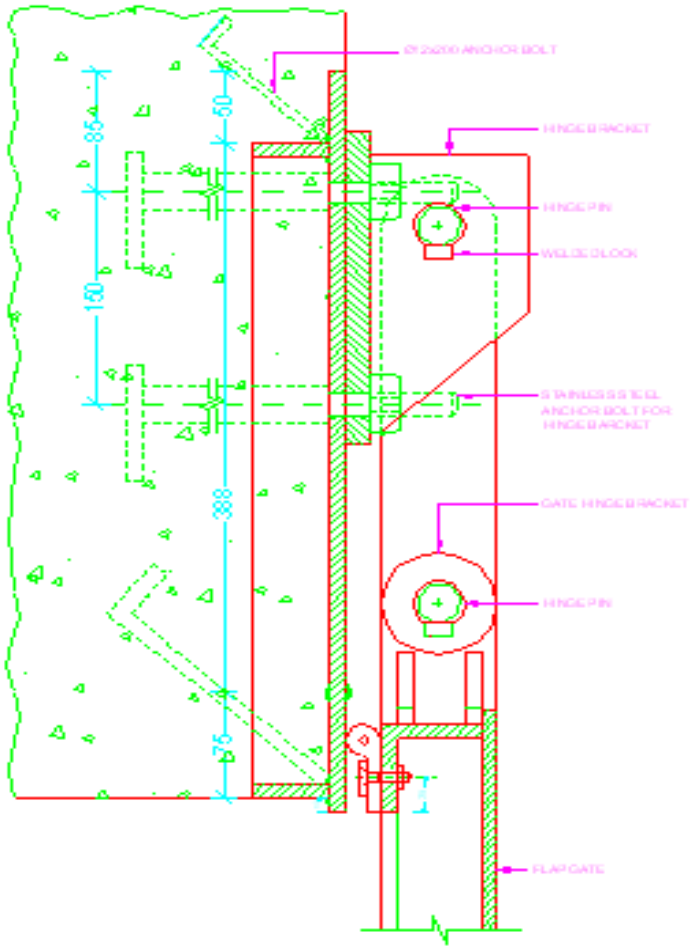


Typical Details for Accommodating Gates (Second Stage Concrete)

Appendix -VII



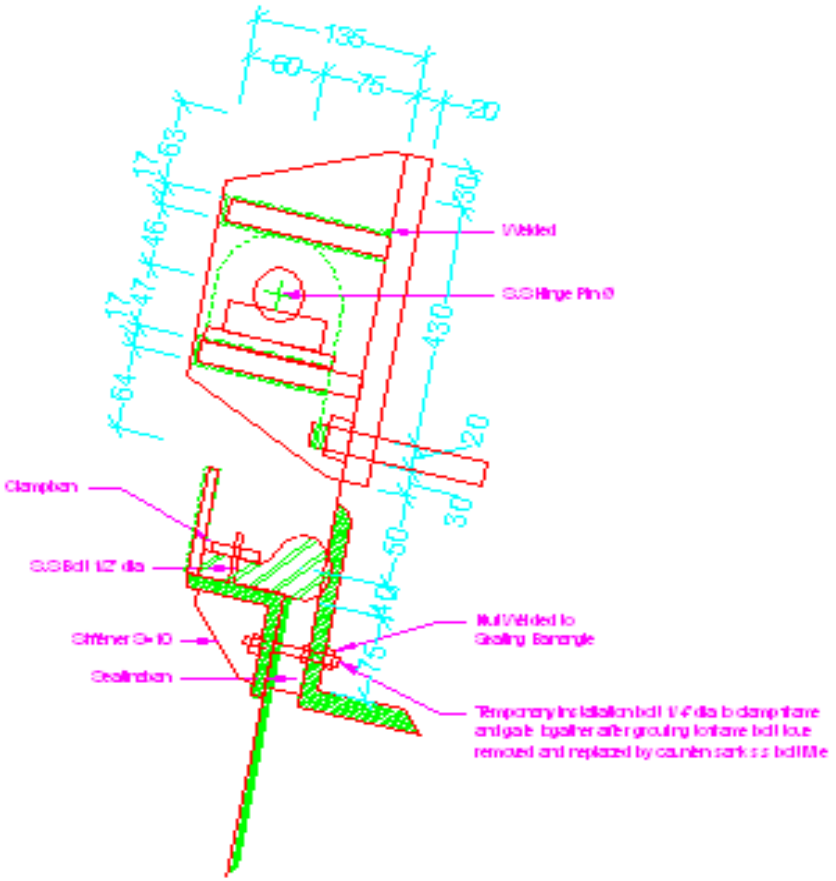
Detail - A

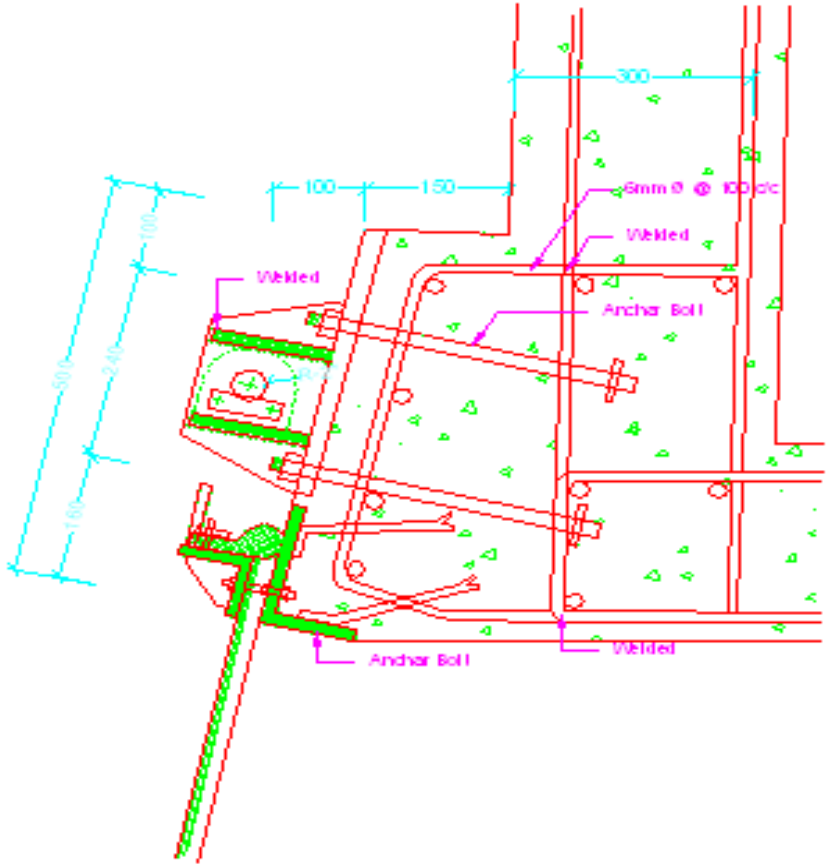


Detail - B

Typical Details for Flap Gate Hinge

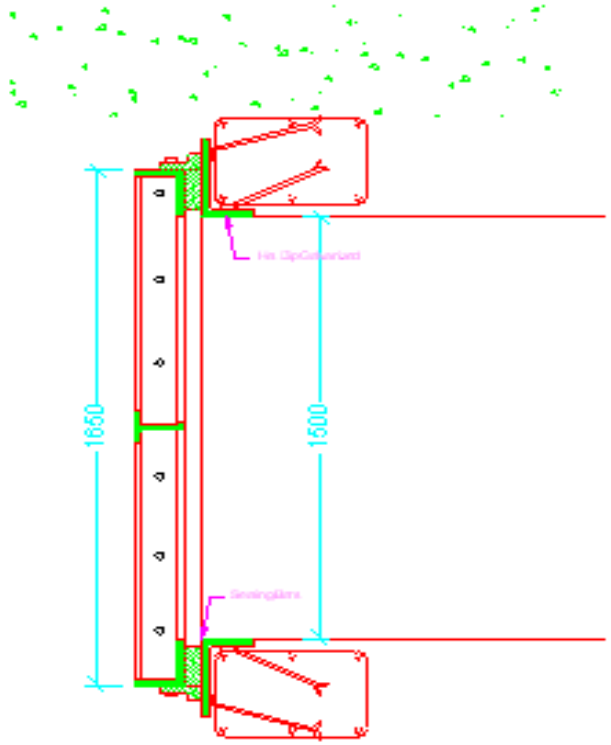
Apendix -VIIa



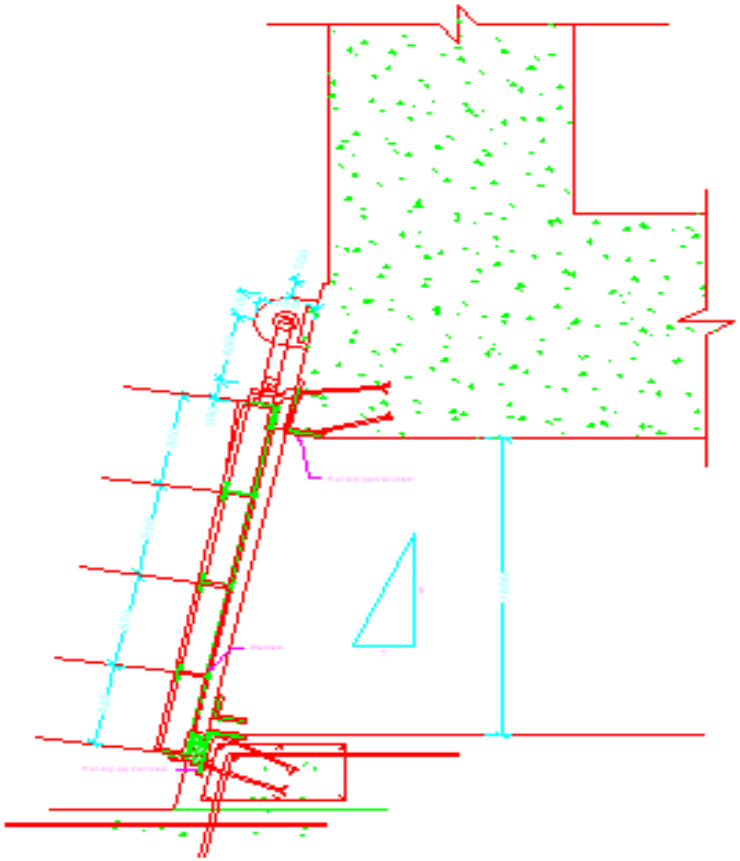


Flap Gate Details

Apendix -VIIb

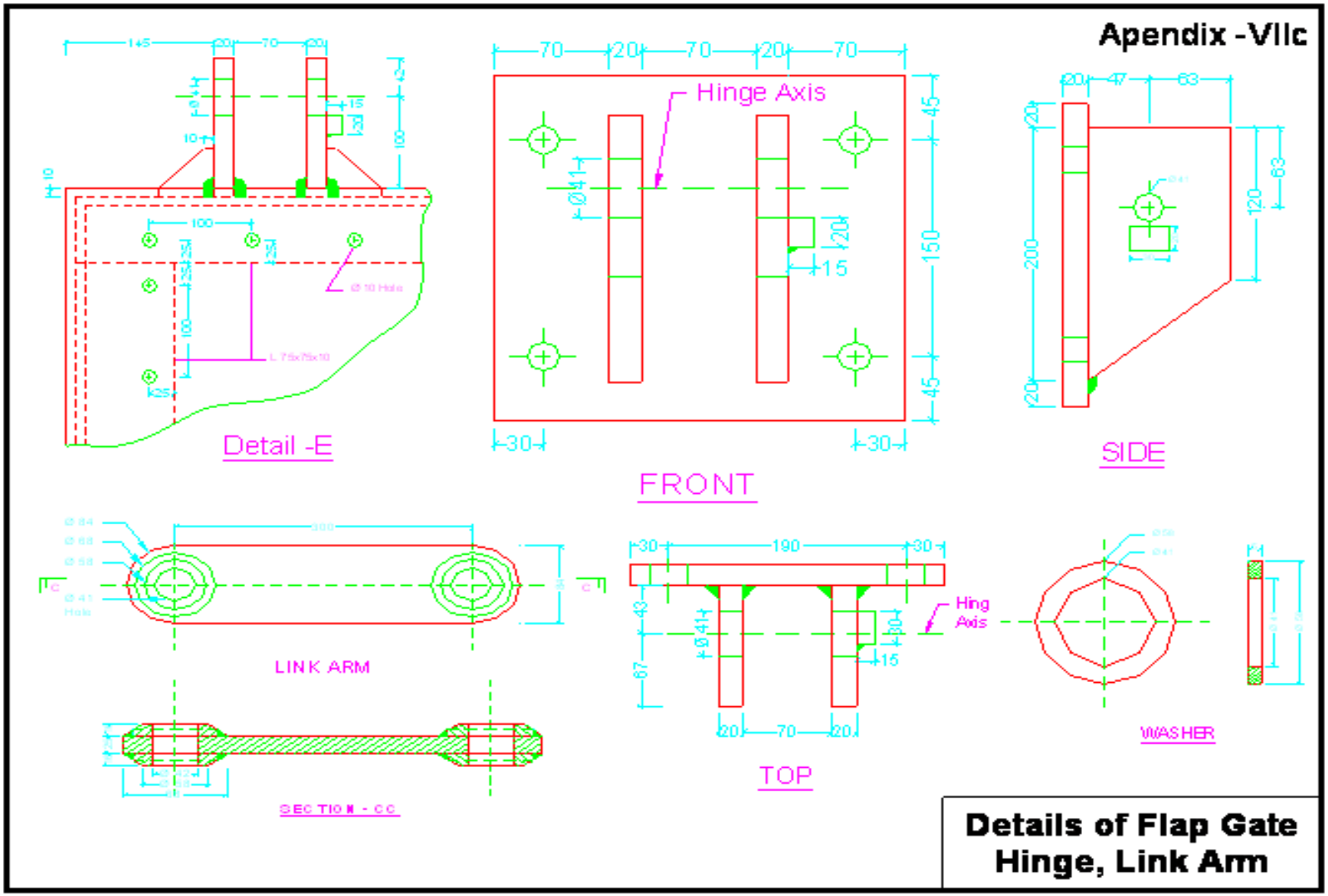


Section B-B'

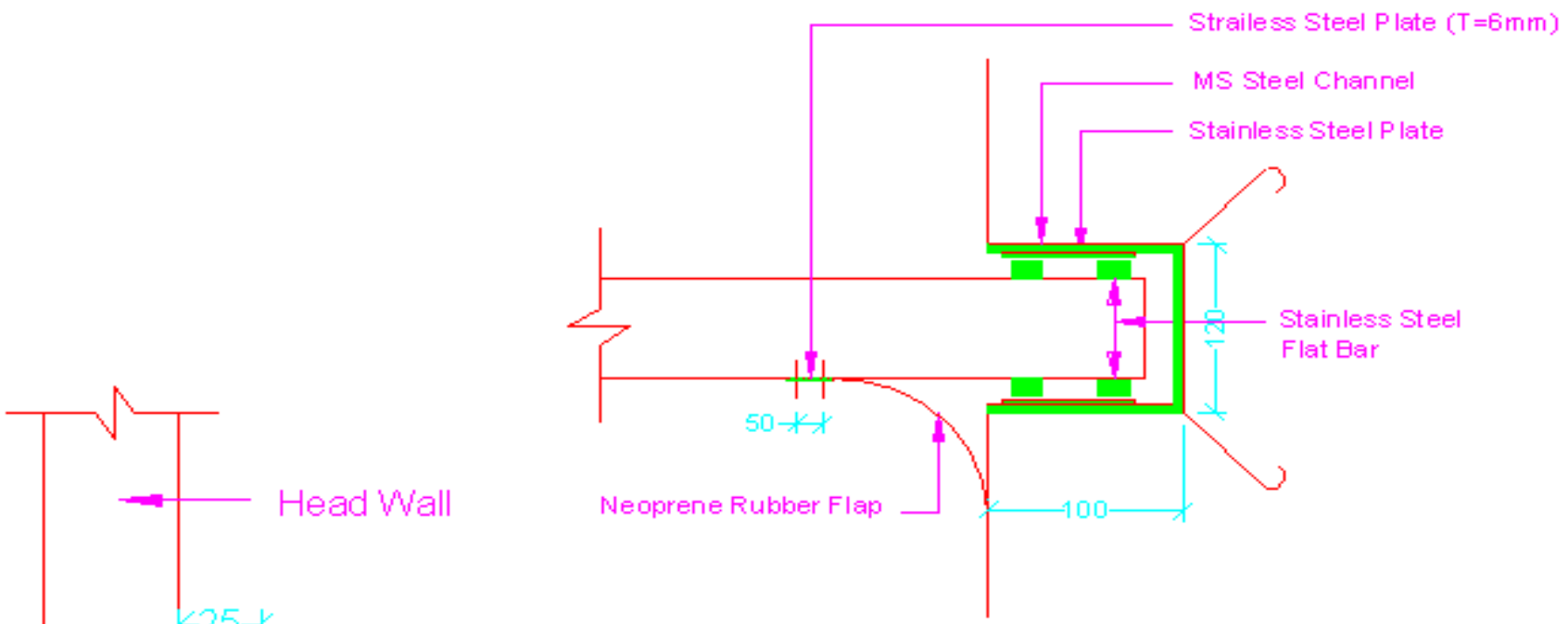


Section A-A'

Flap Gate Details

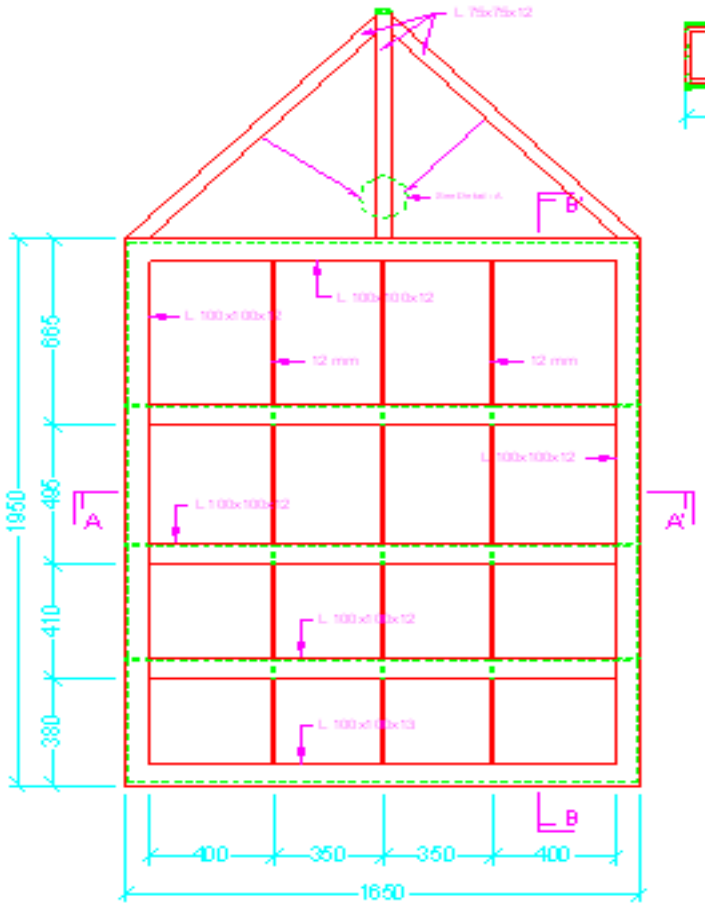

Apendix -VIIc
Detail -E
Hinge Axis
FRONT
SIDE
LINK ARM
SECTION - CC
TOP
WASHER
Hing Axis
Details of Flap Gate Hinge, Link Arm

Apendix -VIII

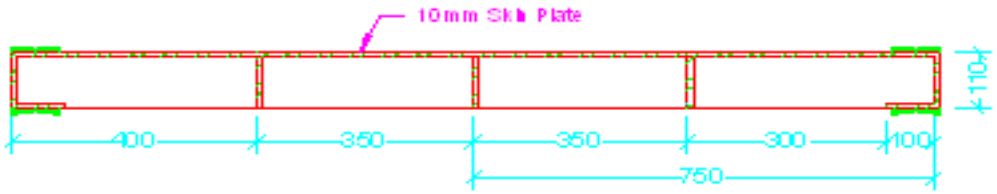


Typical Details for Accommodating V.L Gates

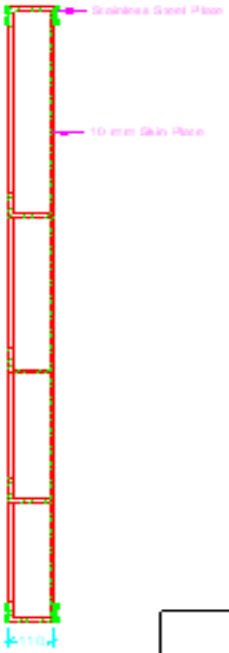
Apendix -VIIIa



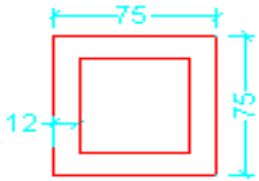
Plan



Section A-A'



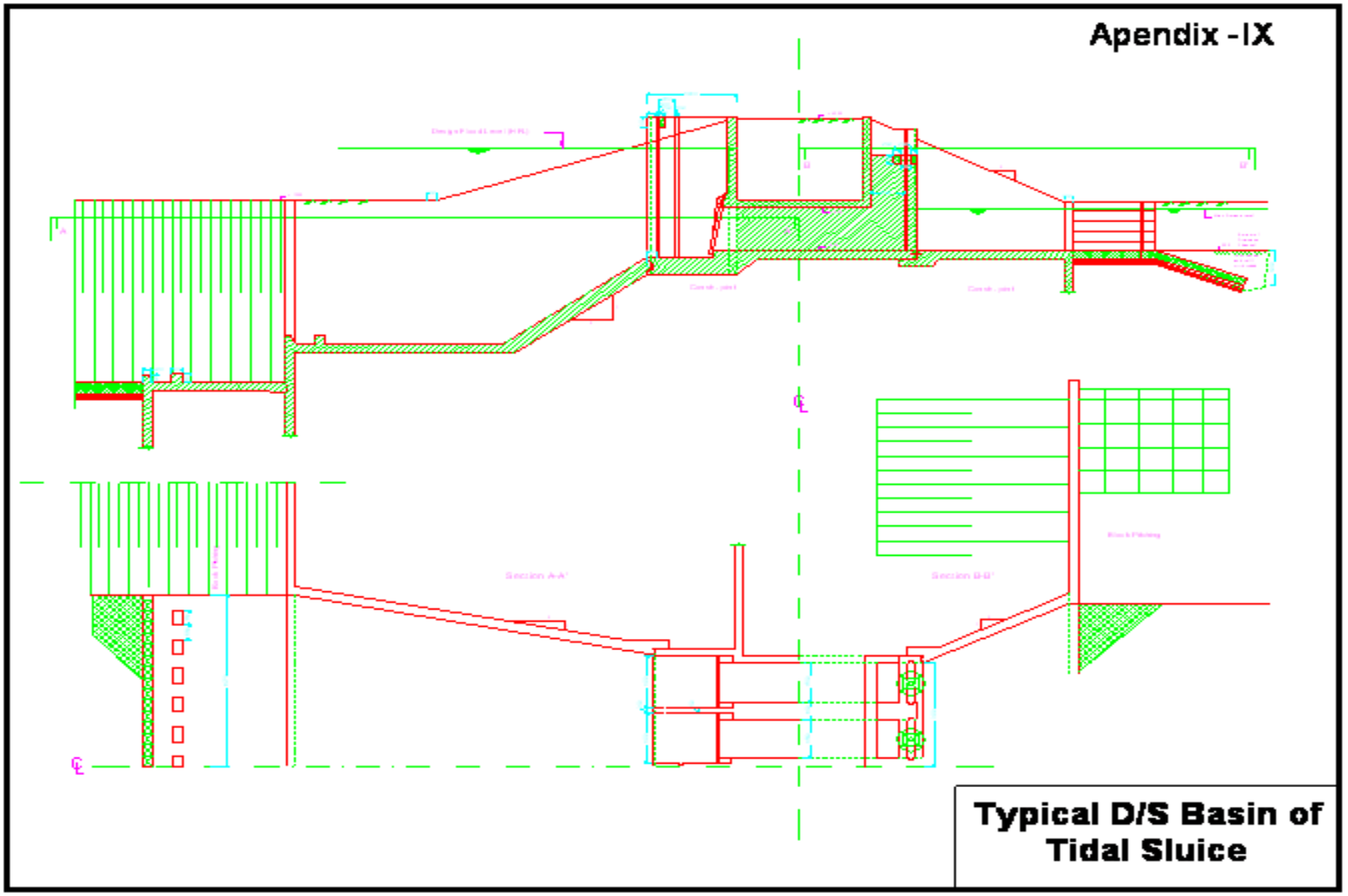
Section B-B'



Detail - A

Typical Vertical Lift Gate Details
Vent Size=(1500x1800)mm

Apendix -IX



Typical D/S Basin of Tidal Sluice