Government of Bangladesh World Food Programme Government of the Netherlands

CHAR DEVELOPMENT & SETTLEMENT PROJECT II

CDSP-II

চর উন্নয়ন ও বসতি স্থাপন প্রকল্প ২

BANGLADESH

Mechanical aspects of Sluice Design and Fabrication

{Background and concept document}

Technical Report No 15a

Prepared by
Stuart P. Pearson
Team Leader CDSP-II
CDSP-II

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CDP
Consultants for Development Programmes

Haskoning
Royal Dutch Consulting Engineers and Architects

Sheltech
Sheltech Consultants

1. Table of Content

List of abbreviation

ADP	: Annual Development Plan
BARD	: Bangladesh Academy of Rural Development
CDSP-II	: Char Development and Settlement Project-II
DC	: District Commissioner
DDCC	: District Development Coordination Committee
FY	: Fiscal Year
ICZM	: Integrated Coastal Zone Management
LLP	: Local Level Planning
LGED	: Local Government Engineering Department
LGRD	: Local Government Rural Development
MP	: Member of Parliament
NILG	: National Institute of Local Government
NGO	: Non-Government Organization
PIC	: Project Implementation Committee
PIO	: Project Implementation Officer
PRA	: Participatory Rural Appraisal
RNE	: Royal Netherlands Embassy
UDCC	: Upazila Development Coordination Committee
UDP	: Union Development Plan
UNDP	: United Nations Development Programme
UP	: Union Parishad
VDP	: Village Development Plan
VPC	: Village Planning Committee
WFP	: World Food Programme

1 Introduction.

1.1.1 The Char Development and Settlement Programme encompass the activities of six Implementing Agencies (IA's) 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 symbiotic reliance than that of the sluices being constructed to control the water levels and flows within the area enclosed (polders) by embankments.

1.1.2 It is important, in order to appreciate the crucial role of the sluice to firstly understand the function of the sluice. This is illustrated as follows.

The sluice enables:-

- The exclusion of saline water during the period when the saline water of the Bay of Bengal intrudes into the lower reaches of the main rivers of Bangladesh.
- The inflow of fresh water from the rivers into the enclosed polder areas when the river discharge is sufficient to push a saline/fresh water front far into the Bay of Bengal.
- The retention of fresh water within the polder which has flowed into the polder by either overland flow, inflow from the river or rainfall.

1.1.3 The function of the sluice, as simply set out above, enables the following activities to proceed within the polder area:-

- Agriculture/forestry activities.
- Supply of fresh water for human and livestock use.
- Fishing including shrimp farming.
- Transportation and material delivery by boat.
- The preservation of embankments, intended to restrain the devastating effects of tidal surge, by making cutting of embankments to drain water out of agricultural or human habitation areas unnecessary.
- The peaceful coexistence of persons within the polder by the reduction of social stress which a restricted and unreliable access to water does cause.

1.1.4 An interaction between various Governments of Bangladesh's Departments is seen from the above outline. The Departments concerned with the above and those also being Implementing Agencies of the CDSP-II programme are:-

1. Bangladesh Water Development Board (Lead body).
2. Department of Agricultural Extension.
3. Department of Forestry, (recently confirmed as an Implementing Agency).
4. Department of Public Health and Education.
5. Local Government Engineering Department.
6. Ministry of Land.

1.1.5 For successful interaction resulting in the principle objective of the CDSP programme, 'the improvement of the living condition of the peoples of the chars', not only must there be this sought interaction between the Departments but within each Department there must be a minimal weakness in the weakest link!

1.1.6 One such critical weakness is the 'mechanical aspects' of sluices! In particular, the design, construction and installation of the two types of gates fitted to the sluices; Flap Gates and Lift Gates.

1.1.7 The success of the work which the BWDB and CDSP-II are undertaking on the development of Water Management systems run by the peoples of the coastal Chars also requires the efficient operation of sluices.

1.1.8 It is the purpose of this technical report to firstly highlight the problem and its effects and secondly to propose and demonstrate a solution to the problem.

1.1.9 However, it should be emphasised in the initial stage of the Technical Report the intension is not to simply find fault but to give due regard to successful work on sluice gates carried out in the past (> 10years ago) and also draw attention to work done by others to address the problem. The intension is to also demonstrate where the re-adoption of previous good practise of the past plus additional strengthening of weaknesses is identified. Particular regard is given to the using of materials and engineering practise which is available and financially realistic within Bangladesh.

1.1.10 It should be noted that the cost of sluice gates 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 recognised.

2. The overriding fault found with sluice gates & observations made on the failings.

2.1 Simply stated is the fact that the gates neither exclude nor retain water when required to do so!

2.2 This brief statement is justified by the report on eleven sluices within the CDSP-II area of activity {refer to Appendix item No.1) and visual observations by the author of this report and others of sluices both within and outside the CDSP-II area.

3 The general mechanical failings of the sluices.

3.1 Flap gates.

The principle of operation of a flap gate is simple; a differential of hydraulic pressure caused by a difference of water head on either side of the gate causes the gate, which is hung vertically from hinges, to either swing open or close dependent upon which side the hydraulic pressure is greatest. A simple procedure which due to the demanding operational conditions under which the gate works must be guaranteed operational by the adoption of good design, suitable materials and quality fabrication standards with a suitable maintenance regime.

3.2 The failures observed leading to the gate failure are as follows:-

- Poor design which does not adhere to BWDB standard designs, which themselves need reviewing.
- Non adherence to the drawings produced.
- Examples of the use of substandard and ‘cheap’ materials.
- Poor manufacturing procedures, usually unsupervised.
- Poor installation.
- Extremely low level of maintenance.

3.3 Lift gates.

In all cases reviewed and inspected the gates were manual operated units where the concept is to lift or lower a rectangular gate in the channels to open or close the vent. This is not a complex concept and the failures are similar to those for the ‘flap gates’:

- Poor design which does not adhere to BWDB standard designs, which themselves need reviewing.
- Non adherence to the drawings produced.
- Examples of the use of substandard and ‘cheap’ materials.

- Poor manufacturing procedures, usually unsupervised.
- Poor installation.
- Extremely low level of maintenance.

In addition can be added:

- Use of 'gearboxes' which are not of a suitable quality where simple turn wheels are more suitable being simple, effective, require little maintenance and not prone to failure.
- A water seal material of a type and design which adds to the resistance to sliding movement of the gate by increasing the friction resistance to movement. This resistance not only increases the force required to move the gate but also increases the damage to the seal when the gate moves over it.

3.4 Sources of the listed general failings.

3.4.1 As an engineer the author of this Technical Report has both observed and made inspections of sluices in situ and of the manufacturing process used for the fabrication of both flap and lift gates. There have been a very few constructed during the past 15 years (an approximate time span) which may be considered of a satisfactory working condition.

3.4.2 The Appendix item No. 1 which is a report of sluices within the CDSP area indicates the failure of these units to operate effectively due entirely to the failure of the mechanical components of the sluice.

3.4.3 Senior officials some retired from and some still engaged by BWDB wholeheartedly agree with the statement made by the author that the gates of the vast majority of the sluices are not functional. They also, in most cases, refer to the decline in quality of the sluice gates over the past years.

3.5 Relevant Reports and Tour Reports.

- ✓ Field Trip Report to CDSP-II by Mr. Md. Habibur Rahman PD CDSP-II; Mr Md Enamul Hoque, SE Design Circle-IV BWDB Dhaka; Mr. Samir Kumar Bhattacharyya Ex Eng, PMU-ESPP BWDB Dhaka, on 24th – 25th March 2003. Appendix item No. 2.
- ✓ Inspection Report of Engineers of Design Circle-3 (Mechanical) to Gangchil Regulator Gate. Copy sent to Team Leader CDSP-II by PD CDSP-II 17th July 2003. Appendix No. 3.

- ✓ Flood Damage Rehabilitation of EIP Sub-Projects (EIP-FDR), Final Report January 2000 – November 2001). Not included as an Appendix item due to bulk.
- ✓ Report on eleven sluices in the CDSP-II area of operation, 2001????. Appendix item No. 1.
- ✓ Technical Note No. 2. 'The Problems Encountered due to the Mechanical Aspects of Sluices' Messrs Jensen, Sekendar, Pearson. July 2003. Not included as an Appendix item due to bulk.
- ✓ CDSP-II is much involved with the establishment of Water Management units consisting of peoples of the areas; a continual appeal from these units is for the major faults they observe in the gates to be remedied and for a small fund be made available to them to repair minor faults. It is these groups who are expected to operate the sluices so their opinions are based on practical experience.

4 The detail of the mechanical failings of the sluices.

The above has been a general reference to the failings; the following is the actual faults found which all contribute to the failure of the sluice gates either individually or collectively.

4.1 Firstly - Flap Gates.

- Design.

The standard BWDB design manual has many good illustrations of flap gates; examples being DWG.NN-DS-7-001; DWG.NN-DS-8-001; DWG.NN-DS-8a-001. However, these designs are not of a standard from which a quality end-product can be expected.

- Tolerances are omitted, examples – bush to hinge hanger arm (an interference fit), hinge pin it bush (a clearance fit).
- Local or International drawing projection used (if any) is not stated.
- Welding requirements indicated by standard symbols, are not included on the drawing.
- There is not a 'standard' design to be used for a range of vent size.
- The 'safety factor' used, it is suggested here, does not take any regard of the extremely poor maintenance record of sluice gates.
- A note on the drawings which states that the contractor must check the drawings and re-draw (this could be taken to mean re-design) before

fabrication. This would seem to take all responsibility and authority away from the BWDB design department and give a free hand to the contractor. It is reasonable to ask the contractor to check the drawings against what is found at the civil site but any differences should be referred back to the design department for rectification. The drawing should be a legal document by which the contractor can be held responsible for any fabrication failings.

Draft designs and drawings are being made for the 'pilot' project under the CDSP-II programme; these could form a basis for a standard flap gate unit. It is NOT the intention of the author to propose designs, materials or concepts which would be difficult to follow during future construction activities.

Fabrication.

Inspection of fabrication units in Feni was a cause of major concern. The workshop personnel were clearly incapable of reading an engineering drawing. (The fact that the drawing being used was of such a sub standard quality this was not a problem in this case, but it is important that the drawing can and must be read and understood. In fact, the workshop owner had made a significant improvement by for example, providing two hinges instead of one for the flap gate!). The material being used was very much second hand. Welding rods were of questionable quality, most likely bought on price not suitability. The material for the hinge pins were clearly not other than mild steel (this was tested by a simple hammer and punch impact test). No sustainable sluices can be expected from such as this! Cost reduction can be the only reason why such a workshop was chosen by the contractor but this would be unlikely to be reflected in either his tender or billing!

There are excellent workshop facilities in Bangladesh including the Mechanical Engineering Section of BWDB and this will be referred to later.

- Installation of gate into the mass of the sluice.

During casting it is apparent that anchor studs are not embedded at the time of casting, this should be expected and the use of a template would be normal. It appears to be the practise that studs are usually 'fixed' after the casting has cured. This is done by the chiselling out of the casting a cavity into which the stud is secured with a fill of cement. A poor practise which would be improved if a suitable drill and stainless steel expander bolt were used, however this is not the case.

4.2 Secondly – Lift Gates.

- General points.

Most of the above failings found with flap gates are also found to apply individually or collectively to lift gates and will not be repeated. Additional problems are indicated as follows:-

- Lift mechanism, (lift rod and attachment).

The means of attachment and position of the attachment point between the lift rod and the gate was usually found not to follow and BWDB design and was of a very poor concept and workmanship. The mass of the gate is carried on two shear faces of a mild steel bolt. The bolt which was used is seen to have no failsafe locking mechanism.

The position of the attachment point at the centre of the upper edge of the gate could be improved by elevating the lift point above the top of the gate to reduce jamming effects by the two top corners by tending to equalise the lift force across the width of the gate.

- Lift mechanism, (gearbox).

The gear box assembly being used on the sluices within the area of concern do not appear to be of a satisfactory quality, this is however difficult to verify as the units have not received any suitable maintenance seemingly since the time of installation. This lack of maintenance causes the bushes and bearings within the box to seize and fail and the gear teeth to corrode the result being it is extremely difficult or impossible to operate gates.

The question must be asked as to why such a unit is required when a vastly simpler wheel and threaded lift rod could be used. This simpler device would have a mechanical advantage made suitable to overcome the resistance to lift by the variance of the wheel diameter or in extreme cases the pitch of the screw thread on the lift shaft. The device would require the application of a grease or oil to the shaft by the operator and when oil is in short supply, perhaps due to lack of funds, the operator would be able to use waste oil without any significant detrimental effects to the unit.

- The conflict between water sealing and resistance to lift.

A conventional seal on a lift gate is on of a synthetic rubber strip pressing against a face usually steel. The force creating the seal being generated by the water pressure on the vertical face of the gate, this force is considerable even with a small head of 2 meters and generates a very high pressure on the sealing faces (rubber and steel). The combination between the high pressure and a high coefficient of friction (rubber / steel) results in:-

- A large resistance to lift of the gate, hence a strenuous labor requirement to operate the gate.
- A strong possibility of damage to the rubber seal causing leakage.

An alternative to this is suggested in the appendix item No. 4 (This is a discussion design document not proposed as the final solution.)

5 Proposed resolution.

5.1 General.

As has been previously mentioned (1.1.9) the examples of good practise of the past, the use of readily available materials and the fabrication skills which are clearly available in Bangladesh are the foundation upon which the problems can be resolved.

It is intended to conduct a pilot project within CDSP-II where the lift and flap gates of an existing sluice are replaced. The final design for these units will be given in Technical Report 15b but the draft design details are included in Appendix item No. 4, they are intended to initiate discussion, some of which has already taken place.

5.2 Flap gates. {refer to Appendix item No. 4}

The concept is to produce a 'standard' unit which will only vary in its size requirement for different vents. This standard unit will have replaceable parts (e.g. hinge pins, bushes and sealing materials) which are completely standard and interchangeable. This standard unit would be fabricated and fully assembled in the workshop, the unit would then be delivered on site and

- ✓ in the case of a new sluice mounted on anchor bolts which have been cast into the concrete structure;
- ✓ in the case of an existing structure the former hinges and bolts having been removed the unit would be secured onto the face of the sluice by drilling (not chiselling) the concrete mass and use of expanding anchor bolts. These anchor bolts to be of a known quality e.g. Hilti and of stainless steel.

In Appendix item No.4 it must be noted that this was the original draft and variations as suggested by The Design Circle BWDB, Mr J. Jensen Royal Haskoning and others will be incorporated in TR15b.

Concepts adopted for the flap gate design are as follows:-

- ✓ Double pin hinge hangers to avoid the damage caused when materials such as wood branches become stuck in the jab of the gate and the water pressure acting on the gate acts trough a leaver resulting a serious damage to hinge and/or anchor points. {Drawings F.G. 5a & F.G. 7a}
- ✓ A hinge pin and bush of very large size and suitable materials machined to recommended engineering tolerances being used to extend the replacement time to in excess of five to ten years. {Drawings F.G. 4a – F.G. 5a & F.G. 6a}
- ✓ Hinge pin securing devices which will guarantee the pin will not slip out causing the often seen gate damage. {Drawing F.G. 6a}

In addition to the above <u>new sluice design</u> should have a 5 to 7 degree slope in the vent exit face thus ensuring a positive close of the gate against the sluice wall.

These are not new ideas or concepts but ones which have fallen out of favour to the detriment of the quality of the gate production.

5.3 <u>Lift Gates.</u> {refer to Appendix item No. 4}

As with the flap gates there is suggested to be great merit in the use of a 'standard' unit which will vary in size alone. The minimal additional costs of over design of the smaller units are considered to be out weighed by the advantages standardisation gives.

- ✓ Simplification of lifting gear by the use of a turn wheel and square threaded lift rod mounted on simple frame. This to replace the gear box. {Drawings L.G. 3a & L.G. 3b}
- ✓ The water sealing device normally used (rubber seal sandwiched between steel gate edge and steel slide channel which is subject to full horizontal load and has high coefficient of friction) replaced with a sealing device which reduces resistance to lift of the gate. {Drawings L.G. 1a & L.G. 1b}
- ✓ A move upwards of the gate lifts point to facilitate more even lift across the width of the gate.

NOTE

The drawings shown in Appendix 4 are draft designs NOT proposed as final designs which will require detailed discussion between the parties involved before a demonstration sluice is renovated.

<u>A second report 15b will be published with final designs, pilot activity and outcome during 2004/5.</u>