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## I. Metal Works – The Lift Gate Assembly

### A. Introduction & Summary of Findings

The following section refers to the lift gate assemblies. Findings of the M&E team at polder 35/1 indicate that quality and sustainability of the lift gate assemblies are poor. At least three if not many more need to be repaired and/or substantially improved. At the time of the field visit the lift gates were installed probably for less than a year or thereabouts. The gates showed signs of severe rusting and decay. It is likely that most become dysfunctional within few months or years. A few are dysfunctional already now. Issues on Sluice Gate Structures reported in Quarterly Progress Reports prepared by the M&E Team are presented in Annex 1. An evaluation of compliance with specifications is presented in Annex 2. The ToR for review of the designs used under the CEIP 1 by LMTRA is presented in Annex 3. Three samples of lift gate assemblies observed at polder 35/1 are documented in the pictures presented in Annex 4.

There are a number of repairs or replacement of structures included under the CEIP 1. There are structures built after 2009 i.e the Aila cyclone at Polder 32 which now are dysfunctional. Reports on the reasons for the failure of these structures have not been available. One dysfunctional / abandoned sluice gate structure was observed at Polder 35 /1. The M&E review findings and ocular inspection of structures at polder 35/1 and the Aila structures suggest that failures were likely caused by failure of the steel works at the structures i.e. including the lift gates. Deficiencies of the lift gate assembly include (i) possibly also poor or deficient design, (ii) possibly deficient workmanship of the steelworks, (iii) possibly low quality steel of assembly parts (bolts, nuts, bearings, plate, shaft etc.), which may not have complied with specifications, a matter which may have to be verified and (iv) subsequent lack of application of corrosion control / painting.

*A lack of corrosion control / painting may also have been caused by difficulties caused by the design of the lift gate assemblies because these could not easily be dismantled and brought to a machine shop for regular painting. A lift gate shaft guide embedded in the concrete structure prevents easy pulling out of lift gates and thus hinders required regular painting. The lift gate plate is screwed by bolt and nuts to the shaft. These bolt and nuts have to be removed if the plate is to be pulled out. However, these bolt and nuts are seen rusted already at this time after few months after the installation. Prescribed washers are not provided. The material of the bolts and nuts is not of galvanized steel as prescribed by the specifications. It will likely be impossible to remove these after a year or two without destruction.*

*The upper lift gate assembly is fixed to the concrete structure by bolts embedded in concrete. This hinders regular maintenance as these bolts are easily damaged and subsequent repair works require specialized equipment and know how. Material requirements (galvanized steel) are likely not complied. Required washers are not provided (except in one instance – see pictures).*

From the findings of the M&E team follows that a review of the design, material and workmanship of the lift gate assemblies should be undertaken, including verification of their compliance with contractual drawings, Engineer's instructions, and specifications. Further, it is expected that most likely the following will be required:

- 1) Independent technical audit by an accredited international inspection, testing, and certification agency (ITCA) should determine if materials of bearings, nuts and bolts, shaft, plate, paints, and neoprene rubber seals have been compliant with specifications. Also, the ITCA will have to verify if specifications on welding have been complied. A complete compliance with specifications is not

likely given the appearance of parts of the lift gate assembly as documented in three instances at Polder 35/1 (see Annex 4).

- 2) A review of the lift gate assembly designs should also be undertaken and improvements made, if warranted. *Preparation of new shop drawings and review, approval and instruction by the Engineer to clarify specifications may be required. Conceivably some lift gate assemblies will have to be dismantled, checked in a machine shop and improved following new designs and shop drawings or possibly be replaced.*
- 3) *Further, the steel of the lift gate side guides embedded in the concrete structure must be regularly painted with specialized paints applicable for marine under water usage or they would best be of corrosion resistant steel used for marine applications as these are permanently exposed to sea water (also see the pictures of the Aila structures which show that these steel guides are rusted and will have to be replaced).*
- 4) A review of the quality of the materials that have actually been used for the lift gate assembly (embedded steel guides, neoprene rubber seals, bearings, bolts and nuts, shaft, wheel, plate and paints) may be warranted. The Quality Assurance Plan (DDCS&PMS Draft August 2016) requires certification by manufacturers. It may be warranted to review these certifications and inclusion in the IPC documentations (if not already done). Possibly, the contractors / manufacturers may be requested to submit manufacturer's certificates that have been verified by an independent inspection, testing and certification agency (ITCA).
- 5) *The above actions will be costly. However, the lift gates and structures will likely fail within a short period, if these efforts will not be made. Independent management and technical audit may have to determine if costs will have to be paid by the contractor because of lack of compliance with specifications and instructions of the Engineer or will have to be paid by the project following a contract variation (because the situation is determined not to be the fault of the contractor).*
- 6) It is also recommended that manufacturing of new lift gate assemblies or improvements or repairs of the old lift gate assemblies will be undertaken only at accredited machine shops and under tight supervision. Accredited machine shops should be selected which can demonstrate their capacity and document their internal Quality Assurance System and Plan (QAP). This should be verified by an independent inspection testing and certification agency and laboratory (ITCA).
- 7) It is also recommended that the minor improvement works required at the sluice gate structures (concrete works) be undertaken by a specialized and accredited firm. These minor concrete works (following design review and updated shop drawings) may be essential to enable easy dismantling of the lift gates for regular maintenance / painting / corrosion control at accredited machine shops.
- 8) An ITCA should continue to monitor the manufacturing arrangements and processes of lift gate assemblies to verify and ensure compliance with improved specifications, shop drawings, and Engineer's instructions.
- 9) Further, the Engineer should issue instruction on the verification and testing protocols of the parts of the lift gate assembly and the functioning of the whole assembly. These protocols should include tests at the manufacturing factory and after assembly at the structures. The protocol for tests at the structures should be detailed and consider the

relevant high water pressure level. Further, protocols and tests at the structures should verify the ease of dismantling, maintenance at a machine shop and replacement.

10) Questions regarding the steel gate assemblies prior to issuing completion certificates should include: (i) Are the specifications and Engineer's instructions on material of gates (lift gate and flap gate assembly and their parts) complied? (ii) Is a proper evaluation procedure and protocol of such compliance in place and are these complied? Specifically do these evaluation procedures include testing compliance of quality of materials requirements? (iii) Are institutional maintenance arrangements and procedures in place? Do maintenance protocols and manual exist? Are maintenance protocols and manual complied? (iv) Does an approved technical completion evaluation procedure and protocol exist? Is such procedure and protocol applied with the presence of approved representatives and properly documented? And (v) have the relevant representatives of WMA/WMG/BWDB / operators been trained on the O&M of the lift gate operation?

11) *Finally, it is likely that the many observed and costly failures of structures and requirements for repair were caused by failure of the steel works. This will continue if not addressed.*

## B. Detailed Assessments

### a. Overview

Detailed assessments include assessment of (i) design, materials used, and workmanship (iii) nuts and bolts and (iv) neoprene rubber seals, (iv) regular painting / coating against corrosion, (v) completion review and acceptance and (vi) O&M.

### b. Design, Materials and Workmanship

#### i. Statement by the M&E Team

The M&E Team has not reviewed (i) contract drawings regarding the lift gate assembly, (ii) shop drawings, or (iii) Engineer's instructions on designs or (iv) certificates on quality and source of materials. Likewise the capacity of the manufacturers and their quality assurance system was not assessed by the M&E team. All of these were beyond the ToR of the limited engineering input of the M&E team. The respective documents were not received. Review of the designs (standard and contract drawings and shop drawings) is included under the ToR of the LTMRA under component 6.1 see Annex 4. However, a report on this review has not been completed or available.

The specification on the Manufacturing & Installation of Vertical Lift Gate, Hoist & Shutter are provided in specifications 2.26. The specifications for the flap gate are in 2.27. Specification 2.26.6 Gates and Hoists prescribes compliance with a list of steel quality standards. These include steel of low corrosion resistance ASTM A 36 etc. which seems less appropriate (also see Specification 2.26.8 Wheel Type Lifting Devise in Annex 2). It should be noted that the lift gate steel plate steel plate and most of the assembly are permanently affected by saline sea water.

It may be reviewed if better designs are possible. A better solution could possibly include an improved joint of lift gate plate and shaft and a shaft guide not embedded in concrete but attached via bolt and nut to a base embedded in the concrete and thus also removable (or a stronger shaft with adequate diameter).

The specifications require compliance with material qualities of steel, bronze, paints and neoprene rubber seals following specified standards. However, the specifications do not prescribe specific test protocols to be undertaken under the supervision of the DDCS&PMS. The Quality Assurance Plan (Draft August 2016) of the DDCS&PMS refers under section 11.4 Certification of Materials by Manufacturer to a tentative list including paints but not including bearings, bolts and nuts and other parts of the lift gate steel assembly. There is no provision for verification of manufacturer's certificates. The manufacturers are not known to the M&E team. The manufacturer's factories have not been visited by the M&E team as this is likewise beyond the limited input and ToR of the M&E engineering team. The DDCS&PMS team has not reported on certificates. Such certificates have not been included in the documentation of the IPCs which the M&E team has received.

*The Field Team noted the need for repair of structures included under the project. Also six structures constructed in Polder 32 after the Aila Cyclone (of 2009) went out of operation during the implementation period of the CEIP 1 after a lifetime of some 5 to 7 years. The BoQs of contract packages 1 & 2 involve one standard type of drainage structure with Vent opening of 1.5 m x 1.8 m and two standard structures of flushing inlets with vent openings of 0.9 m x 0.9 m and 0.9m x 1.2 m.*

*These standard structure designs originate in the 1980s (see text box). BWDB has built these structures many times. Cost of the drainage structures is about \$250,000 each. Observations in the field showed that the hoisting assembly of flap gates often is not being used as per design, but makeshift arrangements are being used specifically for lifting the flap gates.*

*There may be several reasons for failure of structures. However, lack of maintenance often is cited as one of the reasons. Maintenance of these structures refers to maintaining the steel works assembly. Therefore, review of the suitability of the structure designs may consider ease of maintenance of the steelworks. The Tor of the LMTRA includes review of designs under Component 6.1 (see Annex 3). Once structures have been reviewed it may also be possible to work out a construction manual including method statements, equipment and manpower requirements, risk analysis, schedules and critical path analysis based on the experiences of the many constructions undertaken under the CEIP 1. Such manual could become part of bidding documents for future projects and thus standardize and economize construction approaches.*

## ii. Reference

LTMRA ToR Component 6.1. The Tor describes the requirement of review and improvement of designs. The report has not been available yet.

## iii. Comment by the DDCS&PMS

The requirement of review and improvement of the design of structures was discussed in relation to re-sectioning works, and river embankment works and not yet regarding the steel gate assembly at the structures.

## iv. Recommendations for the Ongoing Project

The maintenance requirements of the current design, materials and workmanship of the lift gate assemblies may be reviewed. *Early improvements may be warranted if the level of effort for maintenance is found to be higher than changes of design materials and workmanship and possibly replacement of parts of the lift gate assembly and/or improvements/repairs.*

#### v. Recommendations for Future Projects

It is recommended that a study be undertaken to ascertain the reasons for failure of sluice gate structures and the required early repairs or replacements included under the CEIP 1. This is in line with the ToR of the LMTRA Component 6.1. The LTMRA review and report should also include the sluice gate structures and steel gate assemblies. It should also include designs, materials and specifications. As a first step design optimization criteria should be developed which should include the ease, skill and capacity requirements and cost of maintenance.

#### c. Nuts and Bolts

##### i. Statement by the M&E Team

Specification 2.26.2 Nuts and Bolts requires External bolts and fixing rag bolts, nuts and washers shall be galvanized steel. Assemble nuts, bolts and washers or galvanized fittings or equipment shall be galvanized steel. 2.26.2 of package 1 also allows for sheradized steel. The appearance of the bolts and nuts suggests that the material requirement of galvanized steel (or sheradized) is generally not complied. It should be verified if the specification is complied.

2.26.2 Nuts and Bolts (of packages 1 & 2) refers to BS 4190 as regards dimension. It also prescribes that each bolt shall be provided with two washers and shall be long enough to show a full thread through the nut after fixing. This requirement of two washers is seldom complied. Usually washers are not provided. This affects maintenance and sustainability of the assembly.

##### ii. Reference

See Annex 1 & 2.

##### iii. Comments of the DDCS&PMS

Details of the lift gate assembly i.e. certification of material and workmanship regarding nuts and bolts were not discussed during the meeting on 29 May 2022.

##### iv. Recommendations for the Ongoing Project

The lift gate assembly requires frequent dismantling and maintenance. The workability of nuts and bolts and their robustness is key in this context. Major repair works become required if bolts embedded in concrete break. Designs and workmanship of installed steel gate assemblies should be reviewed, repaired and improved to ensure appropriate maintenance protocols can be implemented with ease.

#### v. Recommendations for Future Projects

Bolts embedded in concrete would be difficult to replace if destroyed. The mechanical design may be reviewed to avoid embedded bolts altogether. Improved designs would best ensure that lift gate assemblies can easily be dismantled, maintained at a machine shop and replaced. This would require design improvements that avoid bolts or parts of the lift gate assembly that are embedded in concrete. Thus the lift gate assembly would have to be fixed onto steel parts embedded in concrete from which the assembly can easily be removed. Details of such improvements will have to be shown in new shop drawings.

#### d. Neoprene Rubber Seals

##### i. Statement by the M&E Team

The contractual specifications “2.26.12 Neoprene Rubber Seals” seem to be incomplete. They end in the middle of a sentence which reads: “The seals shall be molded in one piece for each straight length, without the inclusion “. (both contracts).

The BoQ 5.14 lumps Manufacturing etc. of lift gates with a price of about \$1,000. The BoQ does not mention Neoprene Rubber Seals, yet these may be included under “etc.” The Specifications refer to a British Standard of BS2752-C40.

##### ii. Reference

Field observations see pictures in Annex 4.

##### iii. Comment by the DDCS&PMS

The TL noted the information on the absence of Neoprene Rubber Seals and observation of leakages. The TL announced that DDCS&PMS would review the concern and inform the M&E team accordingly.

##### iv. Conclusion

- The Contractors have completely neglected specification 2.26.12 Neoprene Rubber Seal
- Detailed Design Drawings of Sluice Gates do not include detail of the Neoprene Rubber Seal
- Details of the Neoprene Rubber Seal may be included in the “Mechanical Drawings”. This be reviewed and PMU / DDCS&PMS may be requested to provide such drawings.
- The specifications of the contracts of 2.26 Neoprene Rubber Seals are incomplete. DDCS&PMS may provide updated and complete specifications. Subsequently, DDCS&PMS may issue instruction to the contractors to comply with updated specifications and drawings (either issued already as part of the “Mechanical Drawings” or to be newly issued.).

#### e. Painting / Protective Coating for Corrosion Control

##### i. Statement by the M&E Team

The field team observed that steel works at structures were rusting. The protective paint coating appeared to be defective.

The specifications on painting of the steel works fill a page. However, they do not specify a standard or a method of verification of compliance. The specifications do not require material quality for marine and under water usage. Instead the specifications refer to the review and approval by the Engineer. The specification 2.26.22 of contract package 2 includes a measurement. “For painting measurement will be given in sqm”, but does not include a BoQ item.

It is likely that operational failure of sluice gate structures are often caused by rusting of the steel works due to lack of application of protective coatings for corrosion control (and lack of compliance with steel quality requirements). Steel placed in seawater that has no or inadequate protective coating is likely to rust within few years. Preventing corrosion of the steel works which are permanently embedded with the sluice gate structure require special attention, because repair of these is not possible and replacement is difficult.

There are steelworks embedded into the sluice gate structure and which are located permanently under water. These steelworks require special coating materials (Belzona etc.). The application of protective

coatings for corrosion control to submerged surfaces is not easy and will require clarity of methods. Other steel works including lift gate, flap gate and hoisting assembly may need to be dismantled to enable renewal / application of a new protective coating in a workshop. However, the lift gate shaft guide is embedded in concrete. The lift gate plate cannot pass this guide. Therefore removal of the lift gate plate for renewal of paintings would be difficult. Similarly replacement of a corroded and leaking lift gate plate would be difficult.

Overall, the lack of maintenance of the steel works appears to be treated as a trivial matter. The lack of budget is often cited as the key reason. However, the budget requirements are small. The main reason for the apparent lack of maintenance of the steel works appears to be (i) design that does not consider maintenance requirements, (ii) lack of knowhow and (iii) inadequate management and attention. As a first step the current state may be addressed by (i) review of the designs to enable easy removal and regular maintenance (painting) at a workshop, (ii) better specifications and compliance with steel quality requirements, and (iii) method statements and steel works maintenance manual. The contractual specifications and designs need to be reviewed and improved. Next a quality assurance system that ensures the compliance with specifications of materials of all parts of the lift gate assembly (including nuts and bolts and welding) need to be put in place.

#### ii. Reference

Specification 2.26.22 (lift gates see attached), 2.27.17 (flap gates), 2.33 Painting of Existing Steel Member and Gates & Hoist.

#### iii. Comment by the DDCS&PMS

The TL noted the information and announced that DDCS&PMS would review the concern and inform the M&E team accordingly. At the time the discussions focused on (i) the observed leakage of some lift gates, (ii) the absence of neoprene rubber seals, and (iii) the absence of protective coatings / painting of steel slice gate assemblies. The additional comments on the inadequacy of the design and specifications of the lift gate assemblies are based on further analysis

#### iv. Conclusion

Best practices would require that specifications include reference to a technical standard including method of testing and verification of compliance with the requirements of the standard. Therefore, compliance with best practices would require that the DDCS&PMS issue an update of the specifications. The specification of paint material should consider the marine and under water usage of steel parts which are permanently affected by sea water. This proposed update could be based on a proposal of the contractors in line with the specification which requires review and approval by the Engineer.

The measurement and payment of paint (in sqm) proposed under contract package 2 is inadequate, because the protective paint involves small areas of the hoist assembly which cannot be measured in sqm. It also requires a different approach for steel works which are permanently under water. Application and verification of adequacy of protective coatings is not a trivial matter but requires specialist know how. The website <https://store.ampp.org/> lists relevant literature on the subject.

#### v. Recommendation for the Ongoing Project

The LTMRA report 5 2A recommends annual “painting” of the steel works. The DDCS&PMS should review and update the specifications. These should consider the requirements of steel works that are



permanently embedded with the structure and are under water. The consultant should prepare a maintenance manual which elaborates the application of protective coatings under water and also the dismantling of steel works and the methods of applying protective coatings to the parts of the steel works by specialized contractors or in the workshops of BWDB. The budget requirements should be elaborated as well as the procedures and methods. Possibly BWDB need to develop appropriate capacity (workshops and permanent manpower) in each of the polders.

#### vi. Recommendations for Future Projects

The specification 2.26.22 should be reviewed. Reference to a standard should be added. The title should be changed from “Painting” to “Application of Protective Coating for Corrosion Control” or similar.

A method for measurements should be included possibly by material used. Methods of application should be added beyond using brush. Methods of verification of compliance with quality standards should be included. The BoQ should include (i) a separate item on protective coating of steel works, (ii) another on maintenance of the steelworks during the construction period, and (iii) another on preparing a maintenance manual and training of the WMA/WMG/BWDB on renewing protective coatings of the steel works.

The employer’s requirements and selection criteria should ensure sufficient know how of a prospective contractor regarding the steel works and required attention to protective coatings. The employer’s requirements and specification should be written with the support of a specialist.

#### f. Other Parts of the Lift Gate Assembly

Other parts of the lift gate assembly includes bearings, plate, shaft, steel side guides etc. These are reviewed in tabular format in Annex 2.

### Annex 1: Issues on Sluice Gate Structures Reported in Quarterly Progress Reports prepared by the M&E Team

- Issue QPR20-1 (Oct-Dec 2020): **Some Quality and Condition Issues Exist in the Construction Works of Package 1 & 2.** There are quality issues with some of the works. Due to excessive rain this year, many places of Package 1 & 2 have been found deteriorated where, for example, the top of the embankment is not in good shape and damaged, shaft rods are bent, etc. Further, undersized rods have been observed in several DS and FS and wheels of all sluices are oversized. The loose aprons of most of the sluices are damaged and existing slope protection works are also heavily damaged in some places. DDCS&PMS Consultants’ team should perform a global check on the quality of construction works (condition assessment) and give a comprehensive report for recommendation of reconstruction. **UPDATE:** Many DS of Polder 32 and 33 have been leaking and saline water coming inside of polder and farmers have made cross dam over the channels because if saline water come to the paddy field, their crop like Watermelon would be damaged. During emergency works in Polder 32, lower weight of geo-bags were reportedly being used (source from WhatsApp group and WMA president informed over phone).

- Issue QPR15-1 (Apr-Jun 2019): **Communities Near Newly-Constructed Drainage Sluices that are in Operation Are Experiencing Problems.** Five drainage sluices in Polders 32 and 35/3 have been completed and have been in operation since early 2019. At each location, community members are reporting that they continue to suffer from salinity and/or waterlogging because the gates do not fully close. The Contractor should rectify and monitor water quality (specifically, salinity and pH) in the area affected in the interior of the polder.

In cases where it is a social issue, the NGO responsible for the WMO formation and any ad hoc WMO committee already in place should be made aware of the issue so they may participate in its resolution

## Annex 2: Review of Specifications Lift Gate Assembly

Specification No	Summary	Comment Compliance	Ongoing Project	Future Projects
2.26.1	Provides a list of steel quality standards.	These include standards other than marine usage with low corrosive resistance.	Engineer may approve or instruct regarding steel quality	Steel parts that are in permanent contact with sea water should be of marine quality
2.26.2 Nuts and Bolts	(of packages 1 & 2) refers to BS 4190 as regards dimension. It also prescribes that @Each bolt shall be provided with two washers and shall be long enough to show a full thread through the nut after fixing.	This requirement of two washers is generally not complied. Usually, washers are not provided. This affects maintenance and strength of the assembly.		
2.26.2 Nuts and Bolts	requires External bolts and fixing rag bolts, nuts and washers shall be galvanized steel. Assemble nuts, bolts and washers or galvanized fittings or equipment shall be galvanized steel. 2.26.2 of package 1 also allows for sheradized steel.	The appearance of the bolts and nuts suggests that the material requirement of galvanized steel (or sheradized) is generally not complied.	It should be verified if the specification is complied. Bolts embedded in concrete would be difficult to replace if destroyed.	The mechanical design may be reviewed to avoid embedded bolts altogether.
2.26.3 Steel Plate	Prescribes conformity with ASTM A 36.	Steel of ASTM A 36 quality is low carbon and not specifically corrosion resistant. The protective coating for this steel quality is	The steel plates are in permanent contact with sea water. Renewal of the protective coating will require removal and	It may be explored if steel quality for marine usage such as SAE 316 would be better suited.

		therefore very important.	work in a machine shop.	
2.26.4 Water Level Gauges	prescribes the positioning of a steel water level gauge.	This specification is generally not complied.	An accurate water level reading is not possible. This will affect water management.	Water Level Gauges may be included with separate BoQ price.
2.26.5 Welding	Welding prescribes compliance with BS 5135 and BS 4360. Details are to be provided on the contract drawings. Also prescribes that the contractor will provide samples for tests and verification by the Engineer.	The standards refer to varying grades of tensile strength and other specific properties.	It could not be verified if the contractor has provided manufacturing drawings and the samples for approval by the Engineer. The M&E team has not received the contract drawings.	The TSCW of Design Circle II includes 1603 Manufacturing Drawing, 1610 Fabrication, 1613 Tests, and 1614 Tests at Manufacturing Shop. May be a requirement regarding the capacity of the manufacturing shop should be added.
2.26.6 Gates and Hoists	prescribes compliance with a list of steel quality standards.	Again, these include steel of low corrosion resistance ASTM A 36 etc. which seems less appropriate.	This seems partly repetitive. Clarity regarding each steel part depending on exposure to seawater would be better.	Specifications should not overlap.
2.26.7 Vertical Lift Gate	prescribes 10 mm thickness of the main plate and top and bottom beams and vertical stiffener etc., refers to design drawings and approval by the Engineer.	Compliance would have to be verified at the machine shop or prior to installation. This need to be scheduled prior to a field visit.	The Quality Assurance Plan Version 1.0 (Draft) August 2016 does not include manufacturing review of steel works.	See under 2.26.5, Specifications should include required test regime and including capacity requirements of

				manufacturer, knowledge of the relevant standard and internal quality assurance system
2.26.8 Wheel Type Lifting Devise	<p>Prescribes dimension For Package 1, 750 mm dia, Lift Screw 30 mm, Bronze Lift Nut 20   100 dia, H) 183 etc.</p> <p>For Package 2, 1300 mm dia, SS SQ Thread Lift Screw, 40 mm, Bronze Lift Nut etc.</p>	<p>According to 2.26.6 Stainless Steel AISI, 303 would apply to the Stem and Stem Coupling, Phosphor Bronze (ASTM, B139C) would apply to the Bush and Bearing etc. The Lift Screw diameter of 30 mm was found inadequate and was changed.</p>	<p>Manufacturers should be evaluated as to their capacity in complying to the required materials.</p>	<p>Manufacturers should be able to show their own internal quality assurance system, which should be verified by the DDCS&amp;PMS.</p>
2.26.9 Fitting/Fixing Gates	<p>Prescribes fitting &amp; fixing gates of different sizes as specified in the design or approved or directed by the Engineer</p>	<p>The BoQ includes only one size of lift gate.</p>	<p>There are no gates of different sizes.bushing</p>	<p>The designs should be standardized so that no fitting / fixing of gates is required (beyond the fitting of the embedded sluice gate guides).</p>
2.26.10 Bushing	<p>Prescribes grease ways and proper grease fitting for preventive maintenance</p>	<p>Compliance to be verified in mechanical drawings, also material (Bronze) to be verified.</p>		
2.26.11	<p>Prescribes self/lubricating bearing for the wheel assembly made of bronze.</p>	<p>Mechanical drawings will have to be verified.</p>		

## Annex 3: ToR of LMTRA Component 6.1

Component 6.1 Updating of design parameters and specifications for constructions works

Approach:

a) Improvement to design standards

- A desk study to get a better understanding of the most common failure mechanism(s), the required information on subsoil, embankment and loading conditions for the required calculations will be conducted.
- From activity 4D improved estimates of storm surge (cyclone) levels and wave conditions and thus required embankment crest levels will be provided.
- A review of the present design standards of BWDB will be carried out by comparing the present standards to the state of the art in this field, the design standards of the Army Corps of Engineering, the International Levee Handbook (ILH) and others if relevant. Additionally, the review will assess whether these international best practices are suitable to the Bangladesh context.
- Based on the above review, several design cases will be elaborated. State of the art techniques and the findings of the previous tasks will be applied to design dyke reinforcements in the selected pilot area.
- Finally, proposals to improve the BWDB design standard will be put forward, where relevant.

Cited LMTRA Task 6.1

## Annex 4: Pictures Concerning Lift Gate Assemblies at Polder 35/1:

