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No. PFJV/FKNL/007 Date: 11/03/2022

To

The Project Director (JMVP)
Inland Waterways Authority of India,
A-13, Sector – 1,
Noida – 201301, India

Subject: Submission of Revised Inception Report of Consultancy Services for Preparation of Detailed Project Report (DPR) for the work of Renovation/Modernization of Existing Navigation Lock at Farakka.

Ref: Contract agreement dated 11.01.2022

Dear Sir,

Please find enclosed herewith the Revised Inception Report of Consultancy Services for Preparation of Detailed Project Report (DPR) for the work of Renovation/Modernization of Existing Navigation Lock at Farakka for your kind perusal.

Submitted against Deliverable 1 of the Contract Agreement please.

Thanking You

Yours Sincerely,

11.03.2022
(Er. A K Bajaj)
Team Leader

Encl: As Above

सत्यमेव जयते
Ministry of Shipping
Government of India

INLAND WATERWAYS AUTHORITY OF INDIA

CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION/MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

Inception Report

March 2022

Submitted By:
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DOCUMENT/REPORT CONTROL FORM

Report Name	Inception Report
Project Name	Consultancy Services for Preparation of Detailed Project Report (DPR) for the work of renovation/modernization of existing navigation lock at Farakka
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Consultant	PKS Floodkon JV
Agreement Date	11th January 2022
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Version	Date	Author	Review & Submission	Initials
0	25-02-2022	VR, SG, SK, AU, MM, AK, AS, HT, SPR, DKS, BCN	Er. A K Bajaj, Team Leader	
1	11-03-2022	VR, SG, SK, AU, MM, AK, AS, HT, SPR, DKS, BCN	Er. A K Bajaj, Team Leader	

EXECUTIVE SUMMARY

Inland Waterways Authority of India has assigned M/s PKS-Floodkon JV to carry out Consultancy Services for Preparation of Detailed Project Report (DPR) for the work of renovation/modernization of existing navigation lock at Farakka Project funded by the World Bank under Jal Marg Vikas Project.

2. As per Terms of Reference (ToR) of this Consultancy Project assignment, the Inception Report has been prepared for submission before the project authority for its perusal, offering suggestion, if any, and according approval to this report. This approval will facilitate the Consultant in taking up the activities needed to achieve the second milestone i.e. submission of the second deliverable as per the TOR.

3. The Inception Report covers an appreciation of the work involved, a background of the project, a study of the project area both digital well as visit to the project by the team. It also lists out the data requirement as well as data available. It has also been listed out how to proceed for the preparation of DPR, the studies and surveys that will be carried out including hydraulic balance and environmental impact.

4. The expert members of PKS Floodkon JV Team has conducted site visit to the existing Farakka Lock Gate during 27-29 January 2022 and visually inspected the entire components of the Lock Gate, Control Room, upstream and downstream bank condition of the navigation channel, the construction activities, and the facilities being created in the new Navigation Lock undertaken by L&T.

5. It has been observed that there was a profuse gap between the rubber seals provided along the nose of the Mitre Gate at both mouths of the existing navigation lock. The wooden pads provided on the base of the rubber seals got warped unevenly at different locations all along its vertical height of both the Mitre Gates.

6. In continuation, it was found that the water was also leaking profusely through the moving interface of the radial gate of the emptying tunnel located on the left side of the lock chamber.

7. Such water leakages either through both the Mitre Gates, particularly in the downstream side of the lock chamber as well as radial gate of the emptying tunnel would adversely affect the filling as well as emptying time of the lock chamber.

8. The external faces of the skin plates of both the Mitre gates were visibly found rusted to that portion constantly in submerged condition.

9. Based on the physical inspection during the site visit a preliminary assessment of the navigational lock and its components has been carried out. The assessment on the hydromechanical equipment which forms a major component of work indicates the requirement of a complete overhaul of the existing system including fully replacing the mitre gates, radial gates and their bulk head gates and their hoisting systems. This will be firmed up based on detailed condition survey.

10. The concrete face inside the lock chamber was manifested with cavities and honeycombs all along its length at different locations both in submerged and unsubmerged condition. Even at some minor location, the reinforcement of the vertical face of the lock chamber got exposed. However, the detailed condition survey of the existing Lock structure would be conducted subsequently to ascertain about the epoxy treatment, etc. to cover the internal deficiencies of the concrete for sustaining its longevity.

11. It is proposed that the Cassion gates being fabricated for use at the new (under construction) lock structure can be deployed in case mitre gates are to be inspected or if some maintenance works are to be done in the existing navigational lock. This resources sharing is beneficial to the project from both time line and cost aspects, as the mitre gates of both existing and under construction lock are to be maintained on very few occasions and the cost of parking space shall be saved during the rehabilitation of existing lock structure.

12. To feasibly use the gates at existing Lock structure the gate groves and embedded parts of present gates shall be replaced keeping in view the design of new Cassion gates.

13. For assessing the morphological changes in the project vicinity, two datasets of the Year 2011 (Landsat 7 Data) and Year 2020 (Landsat 8) have been studied. Some minor changes are observed in the three critical points and it would be further analyzed in the detailed project report.

14. Based on the site reconnaissance and inputs from the condition survey team the following tests have been proposed in order to assess the overall structural health of the navigational lock:

- Comprehensive assessments of the various components of the navigation lock as per REMR OM-7 and OM-17.
- Underwater visual inspection (VI) of the lock chambers including the side walls and base slab, lock gates (mitre and radial gates) using Remotely Operated Vehicle.
- To carry out above water and Underwater non-destructive tests of the concrete walls of Lock using Ultrasonic Pulse velocity (UPV) technology.
- To carry out Underwater non-destructive tests of the steel gates walls (mitre and radial gates) of lock using Ultrasonic Thickness Gauging (UTG) technology.

15. By taking into consideration the fluctuation of water levels in the upstream and downstream of the Navigation Lock during average High and Low water condition, the overall depth of water to filled to the depth of around 1.9 m to 2.0 m in the lock chamber before entry of the vessel coming from upstream side of the navigation channel.

16. Considering the inner dimension of the Lock Chamber, the water requirement for filling would be around 1.3 % of the discharge capacity [40,000 cusecs (1132.70 cumecs)] of the Feeder canal. The same quantum of water is also going to be discharged in the downstream of the navigation channel during emptying operation of the Lock chamber.

17. Since the same capacity of Lock Chamber has been provided in the new Navigation Lock under construction by L&T, the same quantum of water would be needed both for filling and emptying operation of this Navigation Lock as that of the old existing Navigation Lock.

18. Therefore, even when both the Navigation locks would start operating for movement of the Vessels through the NW-1 waterway both sides, the total water

requirement for filling or emptying the Lock Chamber would be limited to 2.6 % of the discharge capacity of the feeder canal plus unavoidable leakage to the tune of around 10 % of this total water requirement of 2.6 % as indicated above through the Mitre Gates as well as the Radial Dates of the filling and emptying tunnels.

19. Since the navigation channel of NW-1 is having confluence with the feeder canal at a distance of around of 2.3 Km in the downstream from the existing Navigation Lock, the water to be used during filling and emptying operation will augment the discharge of the feeder canal. This additional flow routed through both the Navigational locks would enrich in maintaining the Least Available Depth in the feeder canal through which the vessels would move to and fro through NW-1.

20. For hydraulic balance imbalance study, the various scenarios which shall be assessed have been provided in the report. A total of eight cases will be evaluated for coherence in operation of parallel navigation locks. The need for detailed model studies (Physical Scale Model/ CFD based Numerical Model) will be assessed and proposals will be submitted to the Client for approval, if any.

21. The automation of regulating the operation of Mitre Gates as well as the radial gates is missing in the existing lock, it has been intended to introduce water level sensors both in the upstream and downstream of the Navigation Lock in tandom with the automation being devised in the new Navigation Lock. The introduction of this automation will help in bringing down the total operational time of Navigation Lock in passing a vessel through it either from upstream to downstream or vice versa to touch the International Standard Limit well within 30 to 45 minutes. This navigation lock time limit is being maintained by navigation lock expert countries like Netherland, Belgium, USA, Italy, Australia, etc. across the world.

22. The operational scenario of vessel movement through both the navigation locks including the new one shall be worked out with due consideration on the overall morphological changes going to happen in the navigation channel both in the upstream and downstream of the Navigation Lock.

23.The coffer dam earth material, which was found to be provided both in the upstream and downstream of the new Navigation Lock during construction, may be utilized in getting inner vertical faces of the lock integrated by providing suitable protection measures both in the upstream as well as in the downstream side. This integration would also help in free access to both the navigation locks from either side for carrying out regular supervision and maintenance the operating system of the Navigation Lock. The rest earth material could be planned to utilize in stabilizing the both bank slopes of the navigational channel in the upstream and downstream of both the navigation locks.

24. The consultant will undertake a capacity building, institutional strengthening & knowledge enhancement study tour to region which have well developed inland navigation systems and have state of the art structure / design / architecture / equipment / instruments / system in the navigation systems. The Consultant proposes to undertake study tour visit to IJmuiden Sea Lock, in Netherlands which has parallel navigation locks and is one of the largest locks in the World. However, the location of study tour and knowledge transfer visit shall be finalized in consultation with the Client.

25. The report also covers the work plan and schedule of the deliverables so that the work can be completed as per the timelines set out in the TOR.

26. The comments/suggestions offered and communicated during the meetings and presentations held on 27th February and 08th March 2022 on the Draft Inception Report of Preparation of Detailed Project Report (DPR) for renovation/modernization of existing navigation lock at Farakka, have been incorporated in the Revised Inception Report.

27. Therefore, the approval of this Revised Inception report may please be communicated at the earliest.

11.03.2022
(Er. A K Bajaj)
Team Leader

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CHAPTER 1

1. INTRODUCTION

1.1 Project Appreciations

The Inland Waterways Authority of India has awarded PKS FLOODKON JV to carry out the project "Preparation of Detailed Project Report (DPR) for the work of renovation / modernization of existing navigation lock at Farakka" under the Jal Marg Vikas Project (JMVP) with financial assistance of The World Bank. In this inception report includes project appreciation, brief about study area, assessment of data requirement and its availability, morphological assessment, site appreciations and work plan and schedule.

1.2 Background of the Project

Farakka Barrage Project (FBP) was commissioned in the year 1975 with the primary objective of improving the navigation facilities of river Hooghly and maintaining Kolkata Port. As part of FBP, a navigation lock was constructed and commissioned in the year 1987 at Farakka (in Murshidabad district of West Bengal) to facilitate movement of inland vessels on National Waterway-1 (NW-1) through Feeder Canal. The navigation lock along with all ancillary assets was taken over by the Inland Waterways Authority of India from FBP Authority in April 2018.

The navigation lock has: (a) an internal length of 179.8m & a width of 25.14m and consists of two (2) sets of mitre gates on upstream (u/s) and downstream (d/s) side (two (2) leaves per set, each hinged about a vertical axis); (b) two (2) floating caisson type stop log gates; (c) four (4) sets of radial valve gates with maintenance bulkheads; (d) eight (8) sets of mooring bits; and (e) a control tower for remote control operation.

Since the commissioning of navigation lock in the year 1987, no major repairs of hydraulic and electro-mechanical components have been carried out. As a result, mitre gates, radial valve gates, bulkheads, floating caissons and other mechanical components including electro-mechanical operating system are in dilapidated condition. Hence, it is required to renovate/modernize the existing navigation lock at Farakka.

Since it is an important part of NW-1 and renovation of the navigation lock will helps to achieve overall goals of JMVP and improve the navigability of NW-1 through: (i) fairway development by providing an assured depth of 2.2m to 3.0m throughout the corridor for at least three hundred thirty (330) days in a year to make it navigable for comparatively larger vessels of 1,500-2,000 DWT and (ii) civil structures, logistics and communications interventions required that includes multimodal terminals, jetties, navigational locks, barrages, channel marking systems etc.

1.3 Objectives of the Assignment (As Per TOR)

The major objective of the consultancy is to Preparation of Detailed Project Report (DPR) with the objective to

(a) Renovate and modernize the existing navigation lock at Farakka to the latest technology based on the best practices followed worldwide; and

(b) Synchronization of the operation of existing navigation lock with the new navigation lock being developed to ensure optimum utilization of both the locks, at the same time, for safe navigation & passage of vessels.

1.4 Organization of the Report

Chapter 1 deals with the introduction background of the project. This chapter includes the project appreciations with background of the project and its objectives as per the terms of reference.

Chapter 2 deals with the location of the study area and project location.

Chapter 3 deals with the data requirements to complete the project and its availability with the client or to be collected by the Consultant.

Chapter 4 deals with the site visit and reconnaissance survey along with the preliminary observation and findings.

Chapter 5 deals with the methodology for assessment of morphological changes in the project area and preliminary results have also been provided

Chapter 6 deals with the section of Condition Survey i.e., the various tests to be carried out in order to assess the heath of the navigational lock and its appurtenant structures.

Chapter 7 deals with the details of the approach methodology for hydraulic balance/imbalance study along with the various scenarios which shall be assessed for synchronized operation of the existing and new navigation lock

Chapter 8 deals with the approach methodology for assessment of environmental impacts through rapid EIA and preparation of environmental management plans to mitigate the impacts.

Chapter 9 deals with the approach methodology for engineering and designs of the structural/ hydromechanical/ electrical/ instrumentation components based on the inputs from condition survey as to which components needs to be repaired/replaced/modernized. The Indian and International Standards/ Codes/ Manuals/ etc. which shall be adopted for the design and drawings of the components have been discussed.

Chapter 10 deals with the aspect of cost estimation of the various components based on the design and standard rates.

Chapter 11 deals with the Project Planning & Tender Document preparation

Chapter 12 deals explores the major navigation systems in the world with focus on and parallel navigation systems with a proposal for capacity building study tour.

Chapter 13 deals with the work plan & schedule including the timeline of project deliverables.

CHAPTER 2

2. STUDY AREA

2.1 Brief about the Project Area

Farakka Barrage Project with headquarters at Farakka in Murshidabad district of West Bengal is a subordinate office under the Union Ministry of Water Resources, River Development & Ganga Rejuvenation. The Farakka Barrage Project Authority was set up in 1961 with the mandate to execute and thereafter operate and maintain the Farakka Barrage Project Complex comprising of Farakka Barrage, Jangipur Barrage, Feeder Canal, Navigation Lock and associated structures. The Barrage comprises of 112 nos. of Gates and 11 Nos. Head Regulator Gates for diversion of approximately 40,000 cusec (1035 cumec) of discharge into the Feeder Canal. The project construction commenced in 1961 and the project was commissioned and dedicated to the Nation in May 1975.

Figure 2.1 Plan View of Study Area

Main objective of the Farakka Barrage Project complex is to divert adequate quantity of Ganga waters to Bhagirathi-Hoogly river system through 38.38 km long feeder canal for preservation and maintenance of Kolkata Port by improving the regime and navigability of the Bhagirathi-Hoogly river system. The increased upland supply from Ganga at Farakka into Bhagirathi reduces salinity and ensures sweet water supply to Kolkata and surrounding areas. The Hoogly-Bhagirathi river system, the Feeder Canal and the Navigation Lock at Farakka form part of the Haldia-Allahabad Inland Waterway (National Waterway 1). The Feeder Canal also supplies water to 2100 MW Farakka Super Thermal Power Project of NTPC Ltd. at Farakka. An index map of the project area is shown in Fig 2.1, 2.2 and 2.3 with important project features.

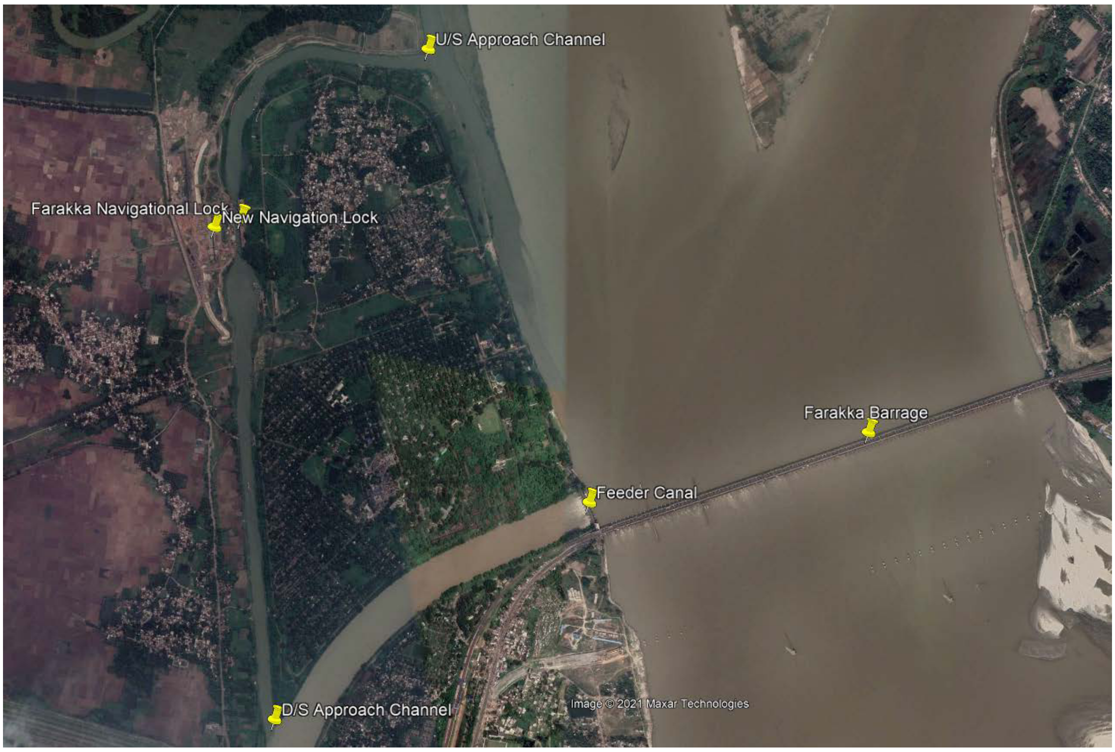


Figure 2.2 Plan Map of Farakka Barrage and Navigation Lock

Figure 2.3 Close up view of existing and new Navigation Lock

CHAPTER 3

3. DATA REQUIREMENT & AVAILABILITY

The Consultant is in the process to collect the past available data, reports and information on the project from Client in both soft and hard copies including topographical, hydrographical, hydrological, meteorological, sediment pertaining to the study from the Client and relevant Authorities.

The data and information shall be collected, compiled and reviewed by the Consultant with particular reference to the requirements of the study. Furthermore, the Consultant will ascertain the sufficiency of this data so that any additional data like topographical data of project area, hydrographic data, geotechnical data and supplemented from other sources or be collected during the field investigations and surveys.

So far, the following reports have been received from the Client:

1. Detailed Feasibility Study for Capacity Augmentation of National Waterway-1 and Detailed Engineering for its Ancillary Works and Processes between Haldia to Allahabad (Jal Marg Vikas Project): Detailed Project Report - New Navigation Lock at Farakka prepared by M/s Howe Engineering Projects (India) Pvt. Ltd. in Joint-Venture with PMC Projects Pvt. and HR Wallingford Ltd.

2. Final Report on Consultancy services for the work of renovation/modernization of existing navigation lock at Farakka under Farakka Barrage Project – Scoping Study by M/s WAPCOS Ltd.

After the detailed review of past data and reports received from the Client the following has been proposed:

3.1 Topographic Data

DGPS survey/drone survey shall be undertaken based on the site conditions and suitability to carry out the topographic survey. Contour plan of project area will be neatly prepared with 1m contour interval on the basis of topographic survey. The survey shall be carried out up to the water line as per standard norms and practices. The Topographic Survey plan will be prepared in the scale of 1:1000 which shall include lay-outs, General Arrangement (GA) drawings, sections and elevations and other important physical features.

3.2 Hydrographic Data

The Consultant has requested for latest longitudinal thalweg and detailed hydrographic survey data at the approach u/s and d/s navigation channels of the navigation lock from the Client to carry out hydraulic balance imbalance study. Additional hydrographic survey, if required will be proposed by the Consultant to the Client for approval after preliminary assessments.

3.3 Hydrological Data

The hydrological data pertaining to water level, discharge and sediment characteristics has been requested from the Client to assess the working conditions of the navigational lock as well as hydraulic balance imbalance study.

3.4 Geotechnical Data

Geotechnical investigation is an integral part of the construction process which is done to obtain information about the physical characteristics of soil/rock around the project site. These are required both for deciding the type of structure to be provided and also its safety. The requirement for additional geotechnical testing will be worked out on the basis of condition survey report and the proposed changes in the navigational lock based on the condition survey report.

CHAPTER 4

4. SITE VISIT & RECONNAISSANCE SURVEY

4.1 Reconnaissance Site Visit

The Consultant Team of Experts visited the Farakka Lock during the last week of January commencing from 27th January 2022 to 29th January 2022 and inspected the existing navigation lock and its appurtenant structures.

The team comprising of experts from Hydromechanical, Structural, Electronics & Instrumentation, Hydraulics, Hydrology, Bathymetry survey and Condition Survey had conducted the site visit. The purpose of the site reconnaissance survey was to observe and record the present status of navigation lock with respect to hydromechanical, structural, electrical, instrumentation, type of operations, etc. The team had reviewed the documents received from the Client to acquaint themselves about the project and the possible challenges before the site visit.

Figure 4.1 Team of Experts with IWAI Officials during Site Visit

The following components were observed at the site:

A. Lock Gates (Mitre Gates) - Two Pairs forming the primary navigation gates for each end of Lock, each hinged about a vertical axis & operated via twin Wire rope Operating Mechanism.

B. Cassion Stoplogs Gate - Two No., intended to be floated into position to isolate mitre gates and lock structure for inspection, repair and maintenance. These gates were never operationalized and have been abandoned since commissioning.
C. Radial Gate - 4 no. at each end of F/E culverts to control the equalization of water. Each gate is operated using rope drum mechanism.
D. Bulkhead Gate – 8 no., to isolate radial gates for Repair & Maintenance. These are slide type and some are not operational.
E. Lock Structure including the base slab and side walls to hold the water and allow for the passage of vessels
F. Electrical and Instrumentation system for operation of the gates

Also, as informed in the TOR a new Lock structure is being constructed parallel to the existing lock. The team also visited the new under construction navigational lock during the site visit.

The questionnaire and inspection checklist adopted during the field reconnaissance and filled by the team of experts has been attached at **Annexure I**.

4.2 Preliminary Findings

During the site visit, based on the visual inspection, observation, measurements, survey and discussions at the site the following findings have been arrived at:

4.2.1 Mitre Gates

Two set of vertical Mitre gates with mechanical hinges driven by twin rope mechanism form the primary navigational gates for Farakka Lock (Figure 4.2). The dimensions of the gates as per the O&M manual are 15.354 m (B) X 11.880 (H) X 1.3 M (T) at U/S and 15.354 m (B) X 10.110 (H) X 1.3 M in D/S with weights of 90 T (U/S) and 85 T (D/S) (Figure 4.3). The material properties and design elements of the gate components are not known hence could not be ascertained at site.

During visual survey it was observed that the submerged portion of gates have significant leakages from bottom and front portion and structural components of these portion were found to be severally corroded (Figure 4.4). The wooden & rubber seals were found to be damaged and to be not effectively sealing openings/gaps between the structure and skin plates from both ends (b/w gates and b/w gate and corner (Figure 4.5)

Figure 4.2 Mitre Gates of Farakka Lock

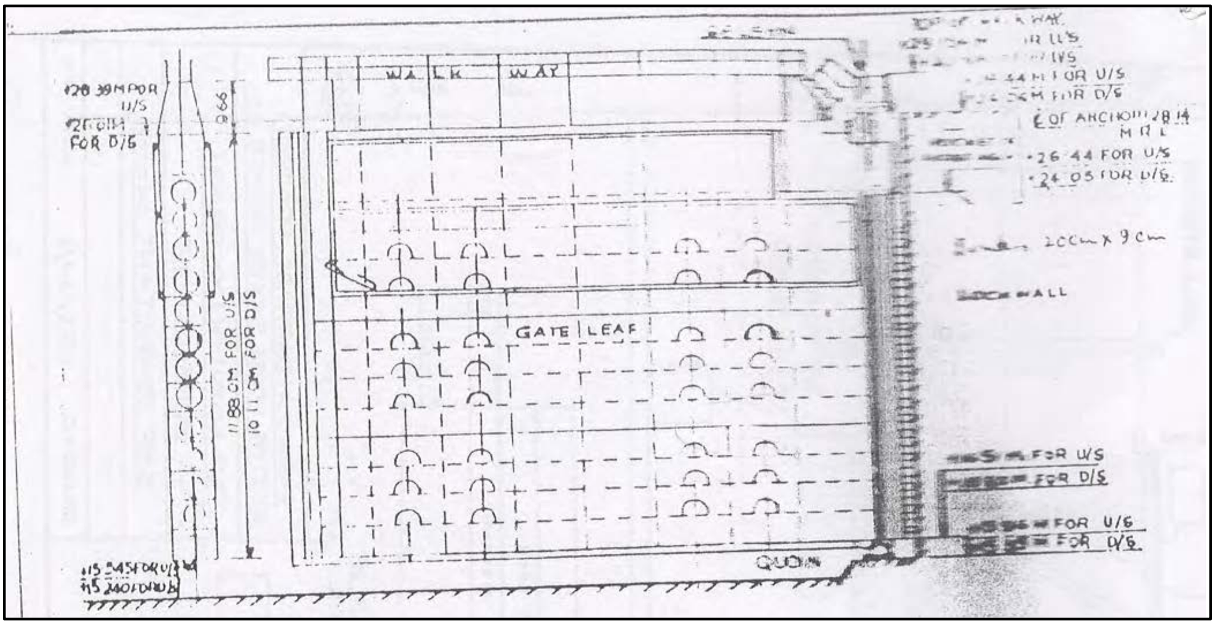


Figure 4.3 Sketch of Mitre Gates in O&M Manual of Farakka Lock

Figure 4.4 Corrosion of Submerged Section of Mitre Gates of Farakka Lock

Figure 4.5 Condition of Seals of Mitre Gate of Farakka Lock

The embedded parts of gate groove could not be inspected due to restricted access and presence of water during the site visit however the condition of the visible areas is not confidence inducing and rusting in exposed parts can be seen. The opening and closing of the gates were demonstrated to the team and the operation periods of the lock gates are noted as below.

U/S Lock Gate: Opening time: 12:19 pm – 12:29 pm (Appx. 10 minutes)

Closing time: 12:34 pm – 12:44 pm (Appx. 10 minutes)

These timings are quite high compared to the proposed Opening/Closing Time of 3-5 min for new lock's Mitre Gates, and the operational capability and reliability of present mechanism is doubtful in future if the traffic across the Lock is further increased. During the operation of the gates, it was noted that top hinges of both gates are almost in the end period of their use and significant part of them is corroded with noise being observed for some period of operations from top bearings (Figure 4.5 and 4.6). It was noted that the greasing arrangement for the bearing is abandoned and has never been used. Hinges of one of the gate was damaged subsequently replaced in 2020.

The operating mechanism (Figure 4.7) of the mitre gates is found to be based on incredibly old technology principles and the components and consumables are in dire need of replacement. The rope dismantles from the guides during operation and has to be put back on guides manually. The double rope guided pulley mechanism is not dependable and can create operation hazard/bottlenecks easily. There is no automatic supervisory control mechanism for mitre gate operation and human intervention/interpretation is required to assess the U/S and D/S water level at gate and to decide the right time for closing and opening operation.

Figure 4.6 Top Bearing of Mitre Gates of Farakka Lock

Figure 4.7 Operating Mechanism of Mitre Gates of Farakka Lock

Preliminary Suggestions

After these preliminary assessments and background data study it is suggested that both mitre gates should to be replaced which will be further firmed up after the detailed condition survey. The new set of gates should be designed as per the modern design practices. The new gates should have components with high working life and such material shall be chosen for fabrication which require less maintenance and have more operational reliability.

The condition of embedded parts will be evaluated using underwater survey by visible means during the conditional assessment survey and if deemed un serviceable new embedded parts shall installed in concrete after removal of all previous embedded sections. Also, dimensioning of the HM equipment will be done to reconfirm the size of structural components. Positive Material Identifications of Structural Components such as Plates and Girders shall be done to identify the materials grade. Ultrasonic Testing of gate structural members shall be performed at site to measure the thickness of the plates and to study the loss of material to corrosion.

The current Gate/Groove Thickness of Mitre gate is 1.3 m. It has to be increased to accommodate a manhole for inspection with minimum 600 mm. Providing this provision in the new gates is must for internal inspection (the current ones don't) gate members during maintenance. Accordingly, the width of the gate grooves will have to be changed and the nature and shape of embedded parts shall also be required to be modified/replaced. This will lead to complete change in gate design, fabrication and erection as the concrete will have to cut out using wire saws and new anchorage with grouted anchor bolt may be required to be adopted.

The operating mechanism of the Gates shall also need to be replaced with a hydraulic system with axial-piston pumps & cylinders for quick operation speeds and durable components. There are many other choices such as a hydraulic motor based operating mechanism, but pump & cylinder mechanism is favorable due to ease of synchronization with new lock equipment and good serviceability during the operation. Also, an automatic supervisory system to continuously monitor operating parameters and status of interlocks shall be deployed to make the functioning of gates free of human error. After going through various national and international codes of practices for navigational Lock gates design, following are the recommended system updation:

Table 4.1 Suggested System Modifications for Mitre Gates

S. No.	Present System Type	Suggested System Modifications
1.	Horizontal gate leaf	Horizontal Gates (Material with suitable strength)
2.	Vertical hinges for bottom	Bottom pintle having cast steel body with pin and self-lubricating bearings
3.	Vertical hinges for top	Top hinge having pin and self-lubricating bearings
4.	Operating Mechanism (Sector Arm at top of gate leaf with pulleys and wire ropes to hoisting drums rotated by gear boxes driven by gear motors)	Hydraulic system with axial-piston pumps & cylinders
5.	Manual Operation	SCADA System

4.2.2 Cassion Gates

Two set of Cassion Gates were fabricated to be used to isolate the mitre gate for their inspection & maintenance. The gates are of size 26.05 m (L) X 4.0 m (B) X 0.8 m (W). However, due to the gate groove being not constructed properly during the initial stages, the gates were never lowered and hence have been abandoned with little to no care for their structural elements and operating mechanism (Figure 4.8).

The condition of gate grooves & embedded (in sections visible above water) seems to be good. It was reported that some reinforcement is exposed at the bottom of the gate grooves but this could not be verified. Corner angles are not present which would strike and damage the concrete of the grooves if gates are lowered. Currently, the gates are kept anchored at the side of lock structure and have no provision for parking.

These gates cannot be used at any point in future keeping in mind the operational hazard they can create. Also, the current position of gates is not right and if these gates are to be used suitable parking mechanisms and structure needs to be created at site.

Figure 4.8 Cassion Gates for Mitre Gate Maintenance at Farakka Lock

Preliminary Suggestions

After deliberations at the site it is proposed that the Cassion gates being fabricated for use at the new (under construction) lock structure can be deployed in case mitre gates are to be inspected or if some maintenance works are to be done in the existing navigational lock.

This resources sharing is beneficial to the project from both time line and cost aspects, as the mitre gates of both existing and under construction lock are to be maintained on very few occasions and the cost of parking space shall be saved during the rehabilitation of existing lock structure. To feasibly use the gates at existing Lock structure the gate groves and embedded parts of present gates shall be replaced keeping in view the design of new Cassion gates. The embedded parts and the underwater sections shall be surveyed during the conditional assessment survey in order to ascertain their conditions. Also, dimensioning of the HM equipment shall be done to reconfirm the size of structural components.

4.2.3 Radial Gates

To facilitate equalisation of water levels at opening and closing of lock 4 nos of Radial gates (2 Nos each at U/S & D/S end) are provided. These gates were for long duration manually operated. However; the mechanism was changed to electrically operated rope drum hoist. The Radial Gates of the Lock are found in dire need of replacement and rehabilitation. Bare minimum maintenance has been performed on the radial gates due to non-functioning of bulkhead gates.

The structural members are mostly found to be corroded and misaligned. This has caused the gates to be inefficiently used for their functioning. Due to misalignment in most of the trunnions has caused the gates structure to rub against the piers causing further damage to both. The seals of most of the gates are not functioning and are damaged due to use in unaligned and inappropriate way. Sketch of Radial Gates in O&M Manual of Farakka Lock shown in Figure 4.9 and Lifting brackets and limb arms of Radial Gates of Farakka Lock Figure 4.10.

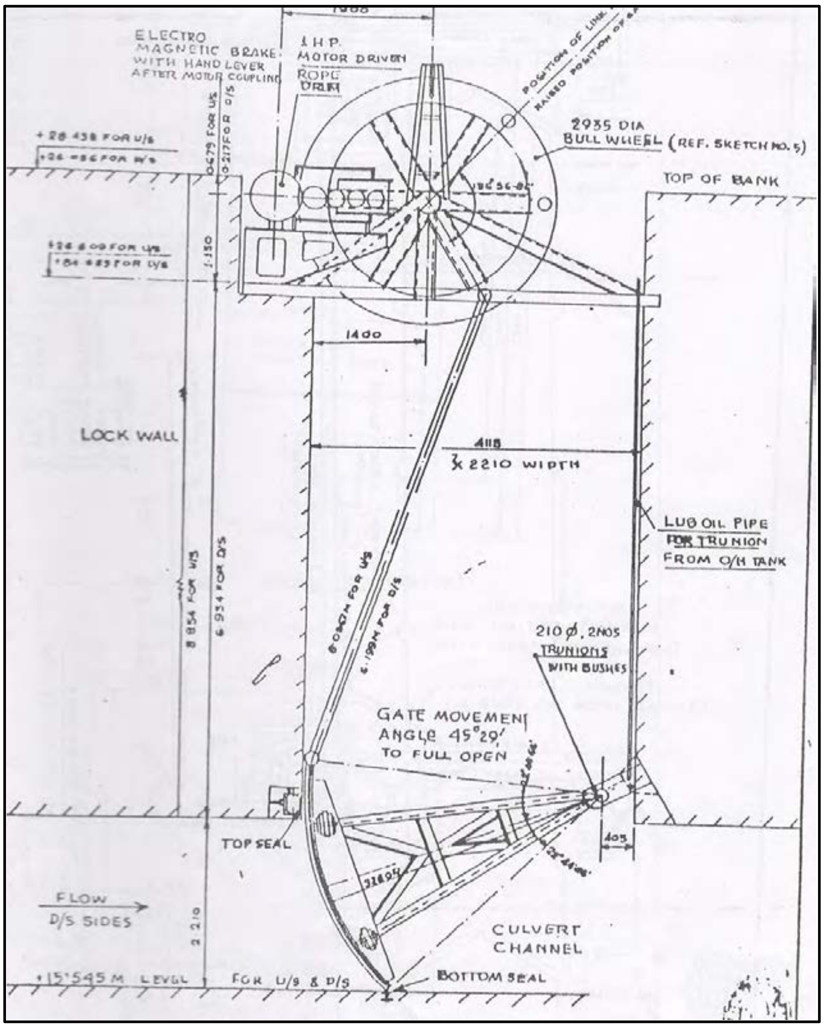


Figure 4.9 Sketch of Radial Gates in O&M Manual of Farakka Lock

Figure 4.10 Lifting brackets and limb arms of Radial Gates

The embedded parts of these gates could not be inspected due to lack of access and most of structure being underwater. Detailed conditions of embedded parts shall be evaluated during the conditional assessment survey using underwater survey techniques. The dimensioning of gates and associated works shall also be performed at that stage only.

The operation time of the radial gates as observed is given below:

Left Side - U/S radial Gate	Right Side - D/S radial Gate
Opening time: 13:31 PM - 13:34 PM – 3 min	Opening time:
Closing time: 13:37 pm – 13:40 PM - 3 min	Closing time: 13:53 PM – 13:56 PM – 3 min

These durations could not be confirmed with operation and maintenance manual and is determined to be on higher side compared to the proposed Opening/Closing Time of 1 min for New Lock’s Radial Gates. The operating mechanism of these gates is electrically operated rope drum hoist of very old technological design. Also, the operating equipment i.e., hoists, motors, ropes is found to be very bad and the system has been very poorly maintained.

Preliminary Suggestions

The entire radial gate and all structural members should be replaced with new parts and the gates have to be completely reconstructed to suit the site needs. This shall be firmed up after detailed condition survey.

Opening comparison of Radial Gates of Old and New Lock

Existing Lock Structure Radial Gates Opening	New Lock Structure Radial Gates Opening
2.21 m	2.0 m (H) X 4.0 m (W)

As the openings in both structures are of different sizes, the filling time shall vary in both the locks. The sizes of both openings and radial gate and filling characteristics for both structures shall be studied in detail so as to facilitate the synchronous operation of both structures. The same size radial gates in both structures shall be suitable from both operation and maintenance standpoint and would also be cost and logistically (spare purchase) effective as both gates can share resources.

Detailed conditions of embedded parts and trunnion shall be evaluated during the conditional assessment survey using underwater survey techniques. The dimensioning of gates and associated works shall also be performed at that stage only. After this methodology for rehabilitation as per the identified scope shall be proposed. The operating mechanism shall also be changed to a hydraulically operated system in order to reduce the occupational hazard risk associated with current mechanism. The need for sophisticated electronic operating system shall also be evaluated techno-commercially. After going through various National and International code of practices for balancing radial gates design, following are the suggested system updation:

Table 4.2 Recommended System Modifications for Radial Gates

S. No.	***Present System Type***	***Suggested System Modifications***
1	Radial Gates	Radial Gate having skin plate and other parts as per IS 2062
2	Trunnion arrangement	Trunnion with Pin and Radial Spherical Plain/Self Lubricating bearing
3	Operating Mechanism (Pin Jointed Arm connecting gate and bull wheel rope drum driven through gearboxes connected to electrical motors)	Electro Hydraulic system with axial-piston pumps & cylinders
4	Manual Operation	Electrical Operation through local control equipment and also through remote operation from control room

4.2.4 Bulkhead Gates

To isolate the existing radial gates for inspection and maintenance 8 Nos Bulkhead gates (4 Nos each at U/S and D/S End) have been provided (Figure 4.11). These gates are critical to proper functioning of the Lock as they reduce the risk in case of failure of radial gate. These are fixed wheel type gates and there is no information regarding their operating mechanism. Bulkhead Gates for Radial Gate Maintenance at Farakka Lock shown in Figure 4.11.

All gates were observed and reported to be of different dimensions with not all of them being interchangeable (Figure 4.12). Most of the gates were in dogged position with each gate having different dogging arrangement.

Type A	4.138 m (L) X 0.322 m (B) X 2.5 m (H)
Type B	3.748 m (L) X 0.322 m (B) X 2.5 m (H)
Type C	2.690 m (L) X 0.322 m (B) X 2.5 m (H)

All structural members of loose bulkheads were inspected and were found to be heavily corroded and not in a position of rehabilitation. The seals of all gates are damaged conditions (Teflon cladding worn out) beyond any chances use in operation (Figure 4.13)

Figure 4.11 Bulkhead Gates for Radial Gate Maintenance

Figure 4.12 Dimensioning of Bulkhead Gates of Farakka Lock

Figure 4.23 Rubber Seals of Bulkhead Gates of Farakka Lock

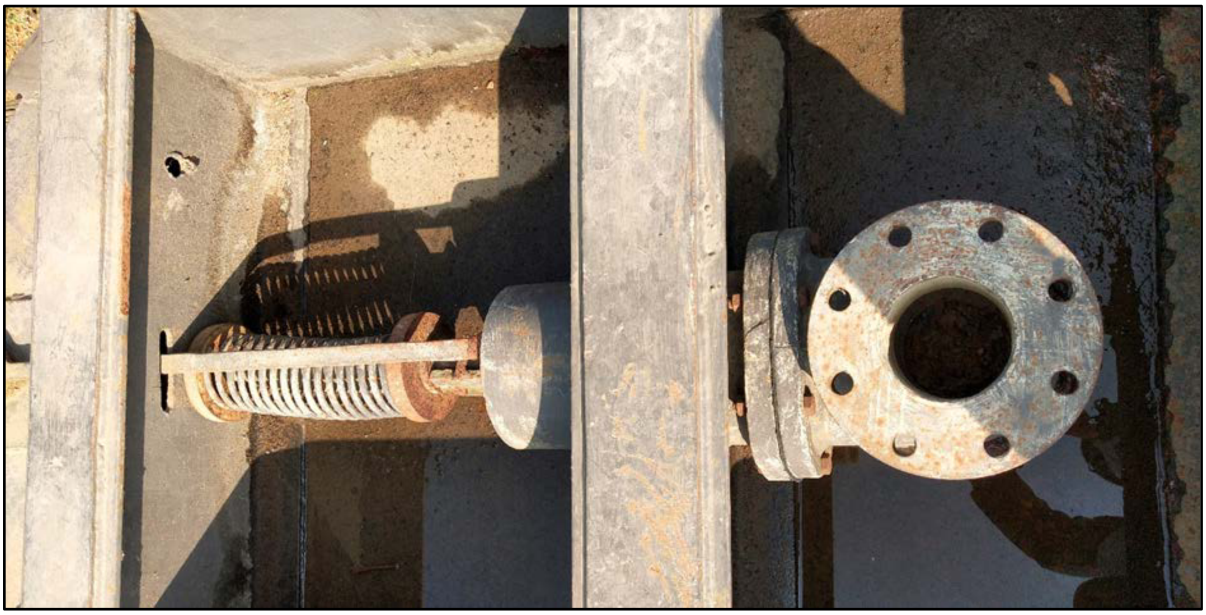


Figure 4.34 Filling Valve of Bulkhead Gates of Farakka Lock

The filling valve arrangement of gates was also in depilated state with corrosion on all sides (Figure 4.14). The Wheels are jammed and not rotating freely, greasing system was not functioning and with bearings needs to replaced. After going through various national and international codes of practices for bulkhead fixed wheel gates design, following are the suggested system updation:

Table 4.3 Recommended System Modifications for Bulkhead Gates

S. No.	*Present System Type*	*Suggested System Modifications*
1.	Fixed wheel Gates	Fixed wheel Gates
2.	Sealing arrangement – Bulb type rubber seals for sides, top and flat type for bottom	Sealing arrangement – Hollow bulb type rubber seals for sides, top and flat type for bottom
3.	Gate operation - Temporary chain pulley block Hoisting arrangement	Electrically operated rope drum hoist
4.	Manual Operation	Electrical operation through local control equipment and also through remote operation from control room

Preliminary Suggestions

Bulkhead gates needs to be redesigned with proper dimensioning and proper functioning at site in mind. All gates are to replace with gates and grooves of equal dimensions. Also, a suitable lifting mechanism that can be easily deployed at site shall also be developed based on the inputs from all stakeholders.

The docking arrangements of all gate needs to be similar with all changes in civil structures to be accounted for. The gate groves and embedded parts shall also be reconstructed to suit the new dimensions and design. For this proper dimensioning and conditional survey of embedded parts needs to be carried out.

The Size of Bulkhead gates proposed to be used at the new navigation lock is 2.2 m (H) X 4 m (W). The Bulkhead gate shall match the dimensions required by the size of the openings and shall have to be suitably engineered. Having bulkhead gates of equal size for both navigation locks will be very cost and time effective and shall benefit the project in the long run.

4.2.5 Lock Chamber

The lock chamber was constructed primarily of unreinforced mass concrete, although reinforcement was used where necessary. The chamber structure is fitted with recesses for the mitre gates, caisson stop lock gates and floating bollards. The chamber is fitted with 8 sets of mooring hooks at three different levels, as well as ladders and wooden fenders rubbing strips.

The Lock head structures forming the entrances to the lock are also mass concrete structures and are integrated with the lock chamber structure. These are shaped to provide robust rounded bull nose approach structure, and are also fitted with wooden fender rubbing strips. The chamber walls incorporate the culverts of the lock filling and emptying system, with inlets and outlets at each end of the lock chamber and the lock head structures. The lock floor is also constructed of reinforced concrete, although this cannot be inspected without de-watering the lock, or by underwater investigations.

The condition of all of the concrete structures in the lock complex is poor. There were cracks, honey combing, spalling of concrete, and possible corrosion of reinforcement in underwater portions. Corrosion is typically worst in areas subject to wetting and drying, i.e. between the upper and lower water levels in the lock chamber. The lock chamber has never been emptied since its commissioning and the condition of the lock floor and the underwater parts of the lock walls is required to be observed by underwater investigated technologies.

Figure 4.15 Vegetation in Lock Chamber

Figure 4.46 Honey Combing in Lock Walls

The condition of Retaining /Side Walls in the lock chamber is poor. There are patches of Honey Combing in concrete, cracks, gaps at different locations. Submerged portions require underwater investigations.

Figure 4.57 Lock Chamber side walls damaged

Figure 4.68 Depth measurement in lock chamber for silt deposition over base slab

Base Slabs show siltation in the downstream portion as per preliminary depth measurement in the lock chamber. Heavy siltation and deposit near caissons also is visible and also during preliminary depth measurements in nearby area in lock chamber. Vegetation can also be seen near caissons on the silt deposited.

Preliminary Suggestions

The condition of all of the concrete structures in the lock complex is poor. Due to presence of cracks, honey combing, broken gaps, possible corrosion of reinforcement in underwater portions.

The lock chamber requires underwater visual inspection to assess the condition of the base slab and side walls which are underwater. Non Destructive Testing (NDT) investigations are also required at different points to ascertain condition of concrete and corrosion.

4.2.6 Lock Approach Structures

The lock approach structures are integrated into the lock chamber structure. The general condition of these structures is the same as the lock chamber described above and the same comments apply. The navigational approaches to the lock are adequately arranged to provide safe approach channels for vessels, and there is no requirement for additional approach structures for individual vessels using the lock. If traffic levels were to increase to the extent that vessels were queuing to enter the lock, consideration should be given to providing mooring facilities for queuing vessels or alternatively managing the timing of arrivals to ensure that queuing does not occur.

Preliminary Suggestions

Guide Walls /Side Walls show patches of honey combing in concrete, cracks, and gaps in concrete. Presence of vegetation in adjacent portions is also visible. The lock approach structures require NDT investigations at different points to ascertain condition of concrete and corrosion.

Figure 4.79 Guide Walls Damaged & Vegetation

Figure 4.20 Guide Walls Damaged – Honey Combing & Cracks

4.2.7 Filling / Emptying Systems

The lock is filled using filling culverts running either side of the upstream mitre gates, with inlets on each side of the lock head structure, and outlets in the walls inside the chamber and downstream of the upstream mitre gates. These culverts are controlled using radial gates as described earlier on the downstream of the downstream mitre gates.

The filling/emptying (f/e) appeared to operate at an adequate speed, and the lock levelling process (filling or emptying) took about 6.5 minutes including the time required for opening the radial gates. The hydraulic conditions created by the f/e system, i.e. currents and turbulence, appeared to provide acceptable conditions for vessels moored in the lock. No changes to the designs of the filling / emptying culverts are recommended.

Tunnel and inlet & outlet structure may have blockages, broken portions due to water movements erosion. They require underwater investigations; possible leakages need to be investigated. These structures may require civil repairs.

Preliminary Suggestions

It was not possible to inspect the condition of the f/e culverts, which could have deteriorated due to erosion caused by water flows or mechanical damage from abrasion and impact of water-borne sediments and debris. These structures may require civil repairs. The key factors affecting performance of the f/e systems are the operating speeds of the radial gates controlling flows in the f/e culverts, and more importantly their safety and reliability. Further underwater investigations will be explored based on the dimension of the tunnel.

CHAPTER 5

5. MORPHOLOGICAL ASSESSMENT

5.1 Introduction

The term river morphology and its synonym fluvial geomorphology are used to describe the shapes of river channels and how they change in shape and direction over time. The rivers of India reveal certain special characteristics because they undergo large seasonal fluctuations in flow and sediment load. The rivers are adjusted to an array of discharges, and most rivers exhibit morphologies that are related to high-magnitude floods. Understanding of river behaviour is complicated due to integrated geo- morphologic, hydrologic, hydraulic and sediment parameters. It may be observed that the different plan forms i.e., straight, meandering, braided etc. depend on the river geometry, sediment load, slope and flow in the river.

Remotely sensed imagery has long been used in river morphological assessment. These applications have involved the delineation of open water using thematic information extraction techniques. There are various methods for the extraction of water information from remote sensing imagery, which, according to the number of bands used, are generally divided into two categories, i.e., single-band and multi-band methods. The single-band method usually involves choosing a band from a multispectral image to extract open water information. A threshold is then determined for the band to discriminate water form land. However, the subjective selection of the threshold value may lead to an over- or under-estimation of open water area and the extracted water information is often mixed with shadow noise.

The multi-band method takes advantage of reflective differences of each involved band. There are two ways to extract water information using the multi-band method. One is through analysing signature features of each ground target among different spectral bands, finding out the signature differences between water and other targets based on the analysis, and then using an if-then-else logic tree to delineate land from open water. The other one is a band-ratio approach using two multispectral bands. One is taken from visible wavelengths and is divided by the other usually from near infrared (NIR) wavelengths. As a result, vegetation and land presences are suppressed while water features are enhanced. However, the method can suppress non-water features but not remove them, and therefore the normalized difference water index (NDWI) was proposed by McFeeters to achieve this goal.

5.1 Satellite Data

The different time period data set will be collected to assess the change in morphological behavior of river near by lock location. Data of 2011 to 2021 will be accessed for the river behavior change analysis. Data for similar time period (Jan-Feb) will be considered with actual hydrological & meteorological forcing. Cloud free data will be considered for higher reliability of feature analysis. Data of Landsat-7, Lansat-8 and Landsat-9 will be used for the detailed analysis and interpretation.

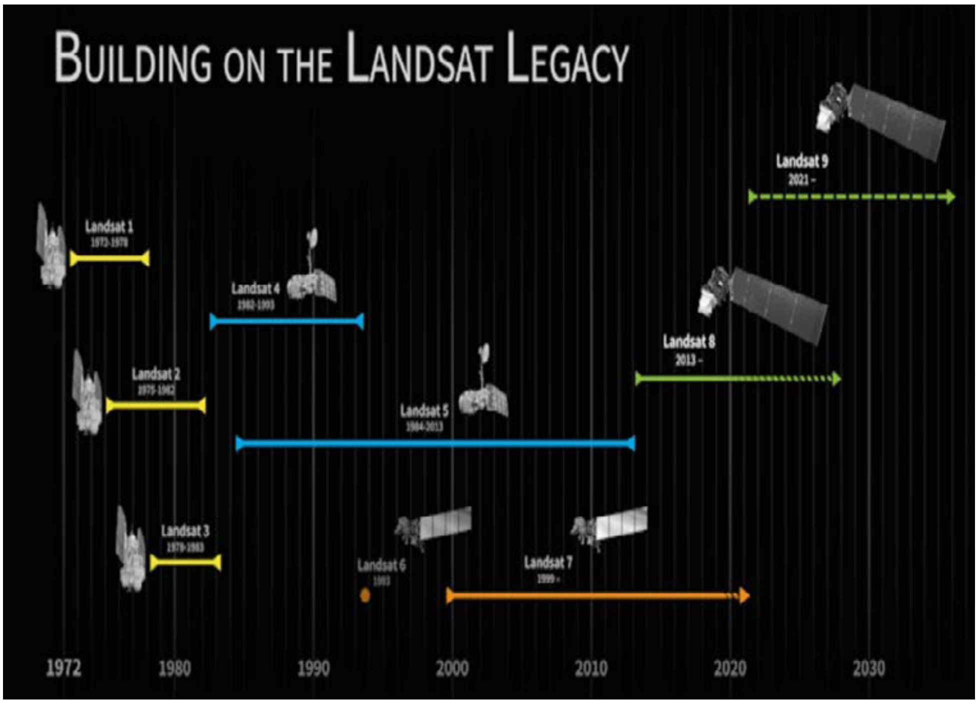


Figure 5.1 Time Line of Landsat Data

Landsat 7- It carries the Enhanced Thematic Mapper Plus (ETM+) sensor, an improved version of the Thematic Mapper instruments that were onboard Landsat 4 and Landsat 5.

Eight spectral bands, including a pan and thermal band:

- ✓ Band 1 Visible (0.45 - 0.52 µm) 30 m
- ✓ Band 2 Visible (0.52 - 0.60 µm) 30 m
- ✓ Band 3 Visible (0.63 - 0.69 µm) 30 m

- ✓ Band 4 Near-Infrared (0.77 - 0.90 μm) 30 m
- ✓ Band 5 Short-wave Infrared (1.55 - 1.75 μm) 30 m
- ✓ Band 6 Thermal (10.40 - 12.50 μm) 60 m Low Gain / High Gain
- ✓ Band 7 Mid-Infrared (2.08 - 2.35 μm) 30 m
- ✓ Band 8 Panchromatic (PAN) (0.52 - 0.90 μm) 15 m

Landsat 8 – Operational Land Imager (OLI) - Built by Ball Aerospace & Technologies Corporation. There are nine spectral bands present in the satellite to analyses different feature of land and water from space.

- Nine spectral bands, including a pan band:
- ✓ Band 1 Visible (0.43 - 0.45 μm) 30 m
- ✓ Band 2 Visible (0.450 - 0.51 μm) 30 m
- ✓ Band 3 Visible (0.53 - 0.59 μm) 30 m
- ✓ Band 4 Red (0.64 - 0.67 μm) 30 m
- ✓ Band 5 Near-Infrared (0.85 - 0.88 μm) 30 m
- ✓ Band 6 SWIR 1(1.57 - 1.65 μm) 30 m
- ✓ Band 7 SWIR 2 (2.11 - 2.29 μm) 30 m
- ✓ Band 8 Panchromatic (PAN) (0.50 - 0.68 μm) 15 m
- ✓ Band 9 Cirrus (1.36 - 1.38 μm) 30 m

Landsat-9 – A partnership between NASA and the U.S. Geological Survey— will continue the Landsat program's critical role in monitoring, understanding and managing the land resources needed to sustain human life. Today's increased rates of global land cover and land use change have profound consequences for weather and climate change, ecosystem function and services, carbon cycling and sequestration, resource management, the national and global economy, human health, and society. Since reducing the risk of a Landsat data gap is a high priority of the U.S. Sustainable Land Imaging Program, Landsat 9 has a design very similar to Landsat 8's; allowing the Landsat 9 build and launch to be expedited. Landsat 9, launched September 27, 2021, joins Landsat 8 in orbit; the satellite orbits will be 8 days out of phase. Landsat 9 will replace Landsat 7 (launched in 1999), taking its place in orbit (8 days out of phase with Landsat 8). The combined Landsat 8 + Landsat 9 revisit time for data collection with be every 8 days, like it currently is for Landsat 8 + Landsat 7.

5.2 Approach & Methodology

The Normalised Difference Water Index (NDWI) is a graphical indicator used in the analysis of remote sensing data to isolate water bodies from other entities. The NDWI has been comprehensively used by water practitioner in remote sensing studies for liquid water from space. NDWI has been defined as in Eq. (1). Here, NDWI represents the Normalised Difference Water Index, and Green and INR represent the green band and near infrared band respectively

NDWI = (Green - NIR) / (Green + NIR) …. (1)

This index is designed to

(1) Maximise the reflectance of water by using green wavelengths,

(2) Minimise the low reflectance of the NIR by water features and

(3) Take advantage of the high reflectance of the NIR by vegetation and soil features

As a result, water features have positive values and thus are enhanced, while vegetation and soil usually have zero or negative values and therefore are suppressed (Figure 5.2).

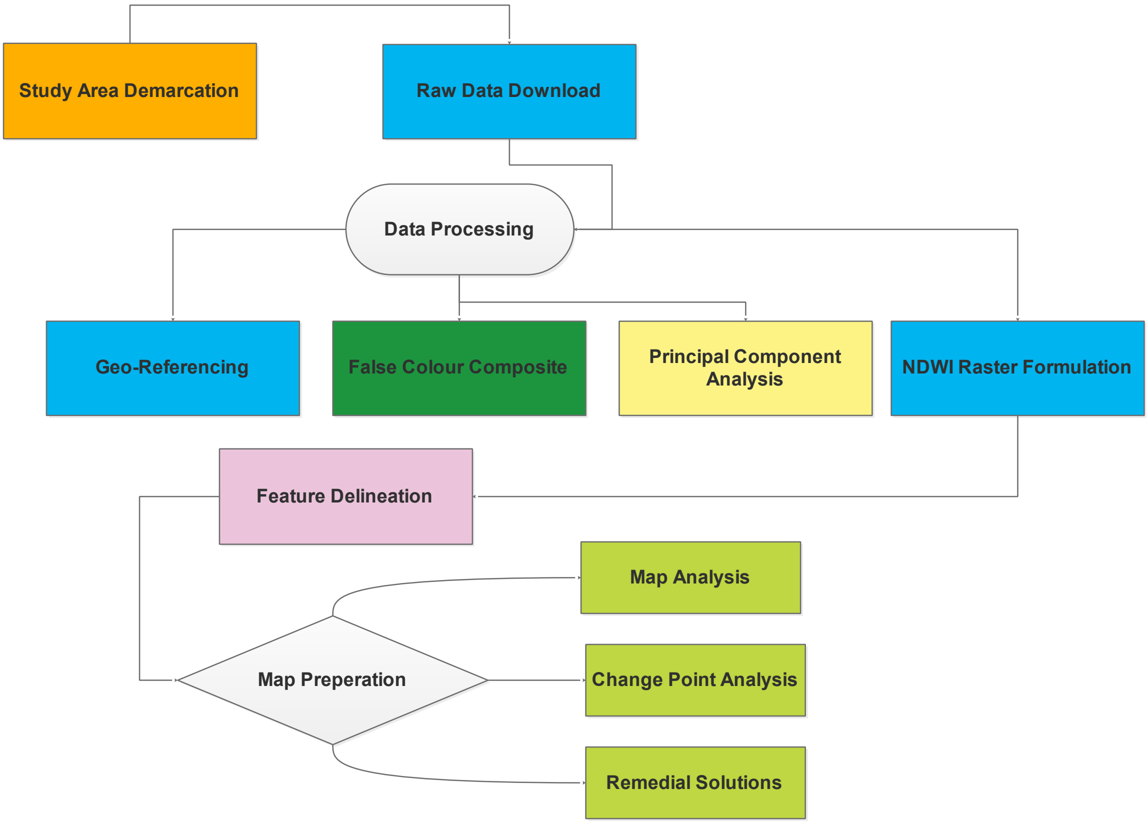


Figure 5.2 Methodology of Morphological Assessment

5.3 Preliminary Results

One decade data is extracted and then analysed to get glimpse of water line and its changes in the vicinity of lock system. In Figures 5.3 & 5.4; two dataset's results are presented from the Year 2011 (Landsat 7 Data) and from Year 2020 (Landsat 8). Some minor changes are observed in the three critical points and it would be further analysed in the detailed draft report. Analysis will be also carried out with respect to time also. Water Line Map of years 2011 and 2020 with critical points are shown in Figure 5.3 and 5.4.

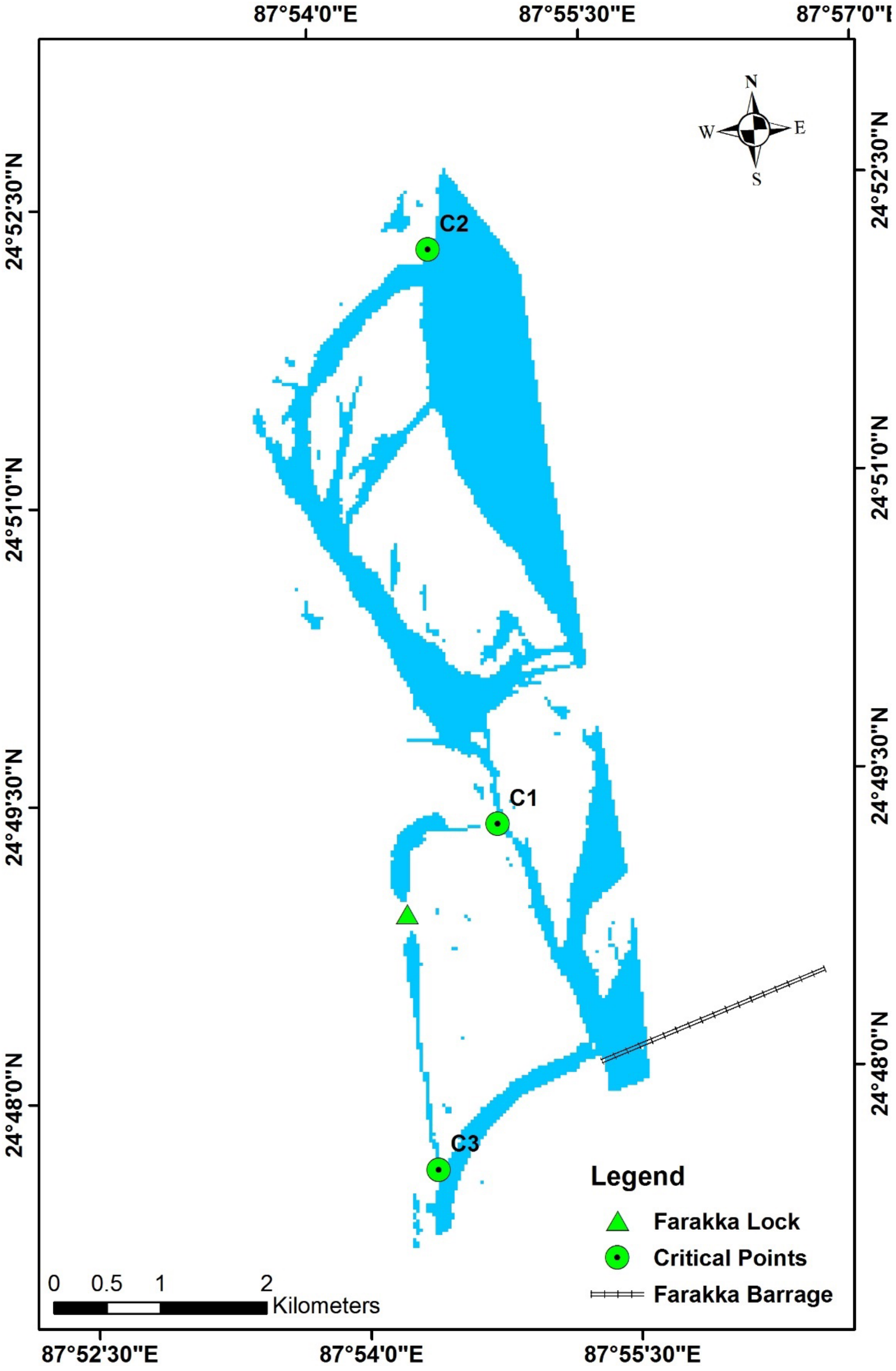


Figure 5.3 Water Line Mapping (Year: 2011)

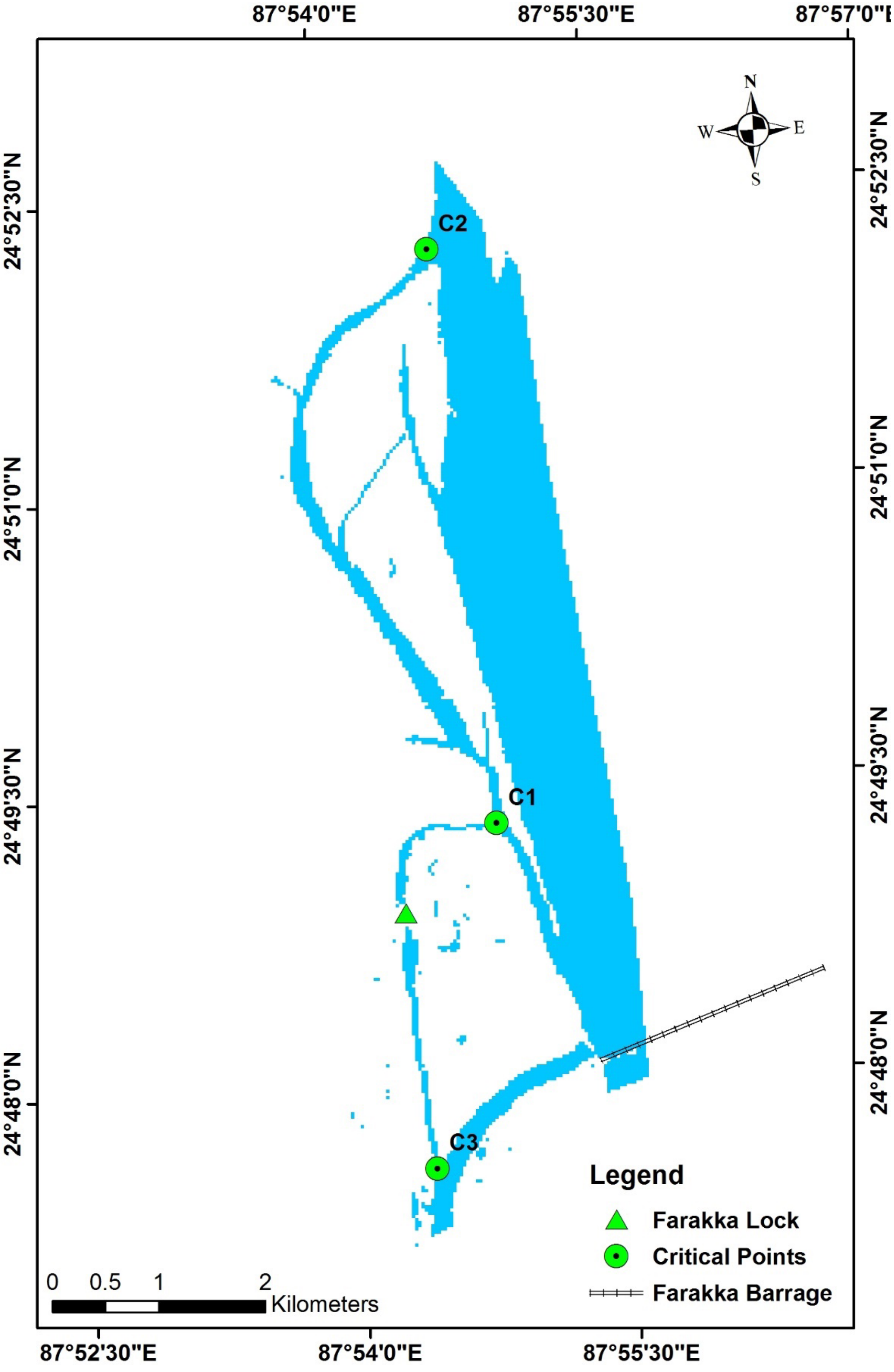


Figure 5.4 Water Line Mapping (Year: 2020)

CHAPTER 6

6. CONDITION SURVEY AND INDICATORS

6.1 Structural Health Assessment

Structural Health Assessment (SHA) aims to assess the behaviour of structures, evaluate the performance of materials during the life cycle and give a diagnosis of the "state" of the constituent materials, of the different parts, and the structure as a whole. It refers to the process of implementing a damage detection and characterization strategy for various engineering structures. In an effective Structural management program, strategies for life extension, upgrade, and replacement strategies must be developed.

Any structure after its construction deteriorates due to loading or environmental impacts. Thus, there is a variation in the strength of the structure after it is built in place. If this variation is under a certain threshold limit, the structure is considered as damage-free; otherwise, the structure is considered as damaged, which, eventually may fail. Here, the damage is defined as changes to the material and/or geometric properties of a structural system, which adversely affects the system's performance.

The methods used are based on Visual Inspection and instrument-based Non-Destructive Testing (NDT). The instrument-based NDT included Schmidt's Hammer Test, Ultrasonic Test, Radiographic Test, Eddy Current Test, Magnetic Particle Test, Thermal Infrared Test, etc.

Different parts influence the selection of the monitoring method used. Structural phenomena to be studied which include Inclinations, Crack detection and localization, Crack widths, Foundation settlements, Corrosion. The parameters causing these phenomena can be forces, stresses, displacements, rotations, vibrations, and strain or environmental parameters such as temperature, humidity, precipitation, wind etc.

The available SHA procedures for damage detection are classified into four levels as:

Level 1- Determination if the damage is present in a structure,

Level 2- Determination of the geometric location of the damage,

Level 3- Assessment of severity of the damage and

Level 4- Prediction of remaining (residual) life of the structure.

The condition survey and assessment will include the following components:

- Visual Inspection
- Non-Destructive Testing
- Ultrasonic Testing

6.1.1 Visual Inspection

Visual Inspection (VI), or visual testing (VT), is the oldest and most basic method of inspection. In its simplest form, visual inspection is the process of examining a component or piece of equipment using one's naked eye to look for flaws. Visual inspections are generally performed as a precursor to more advanced inspection techniques that are capable of detecting flaws beyond what the human eye can see, such as subsurface cracks. Optical aids such as illuminators, mirrors, borescopes, etc. can be used to enhance one's capability of visually inspecting equipment. Cameras, computer systems, and digital image analyzers can also be used to further the capabilities and benefits of visual inspection.

Remote Visual Inspection (RVI) is an advanced form of visual inspection that uses various types of videoprobes, video borescopes, remotely operated cameras, robotic crawlers, and other specialized tools in order to remotely examine components. In doing so, the risks associated with confined space entry are considerably reduced.

In recent years, Remotely Operated Vehicle, commonly known as ROV, have seen increased adoption and usage for remote visual inspections of underwater structures that are difficult to reach by traditional means. This proposed methodology for underwater inspection has various advantages over manual operations including the ability to inspect in dark and flooded areas, otherwise constricted and risky zones with unlimited endurance, enhanced stability, and reliable data acquisition with repeatability. The results can aid the authorities rapidly make key decisions concerning repair, maintenance, and safety of the structure.

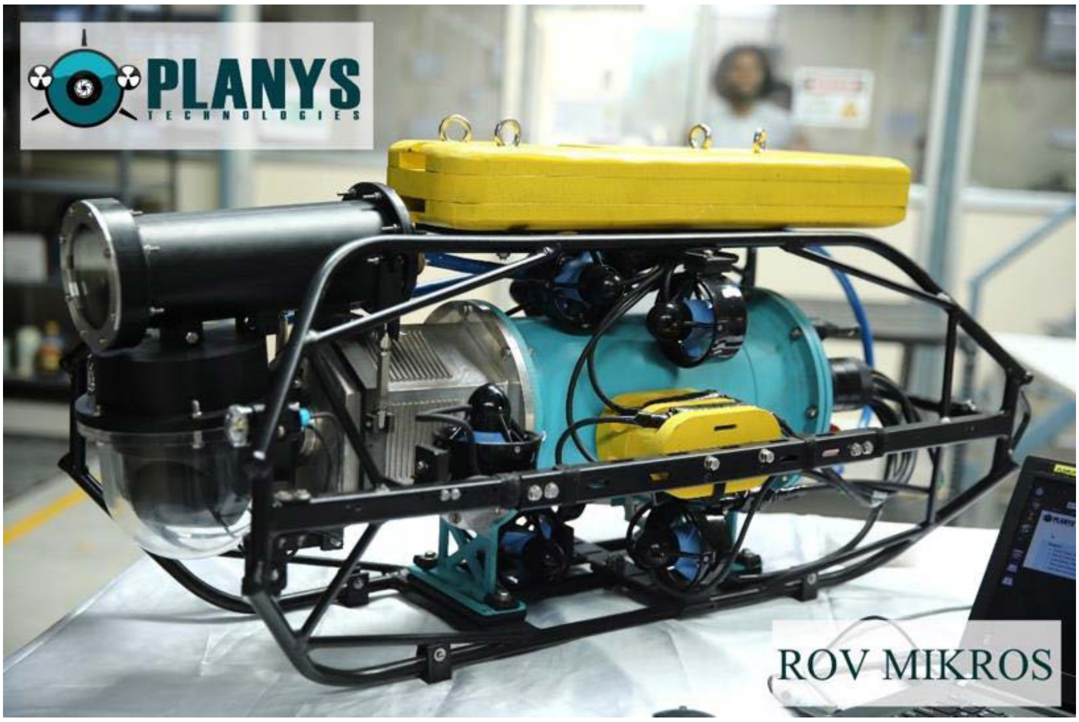


Figure 6.1 ROV Mikros from Planys Technologies

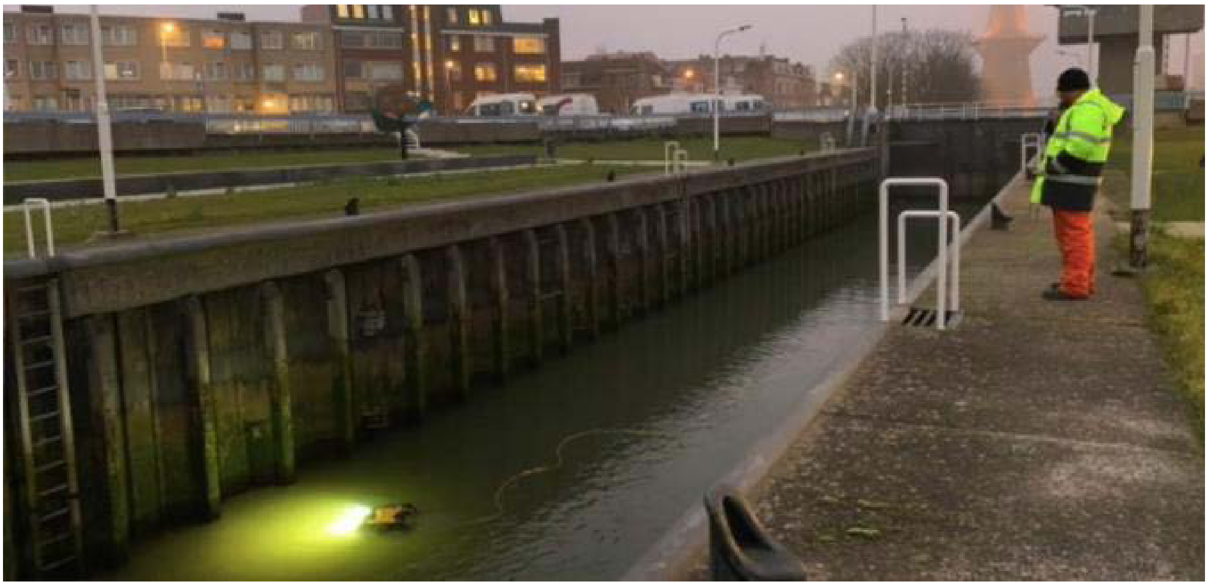


Figure 6.2 Schematic of the overall setup for the ROV

6.1.2 Non-Destructive Testing: Ultrasonic Pulse Velocity Method

Non-destructive testing (NDT) methods are techniques used to obtain information about the properties or internal condition of an object without damaging the object. Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness.

The principal objectives of the non-destructive testing of concrete in situ are to assess one or more of the properties of structural concrete. The ultrasonic pulse velocity (UPV) method is used for non-destructive testing of plain, reinforced and prestressed concrete whether it is precast or cast in-situ

An ultrasonic pulse velocity (UPV) test is an in-situ, non-destructive test to check the quality of concrete. It is used to examine the homogeneity, quality, cracks, cavities, and defects in concrete. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure. This test is conducted by passing a pulse of ultrasonic through concrete to be tested and measuring the time taken by pulse to get through the structure. Higher velocities indicate good quality and continuity of the material, while slower velocities may indicate concrete with many cracks or voids.

Figure 6.3 Sample image of conducting UPV tests above water

The ultrasonic pulse is generated by an electro acoustical transducer. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves is developed which includes longitudinal (compressional), shear (transverse) and surface (rayleigh) waves. The receiving transducer detects the onset of the longitudinal waves, which is the fastest. Any damage to the concrete will also be measured and recorded. The field measurement data is representative of the current state of the structure.

Planys has built the World's first underwater UPV testing equipment and has conducted successful field trials for the same. This helps disrupts the underwater NDT world and thus supports authorities in charge of billions of aging submerged assets worldwide take decisions on repair and maintenance.

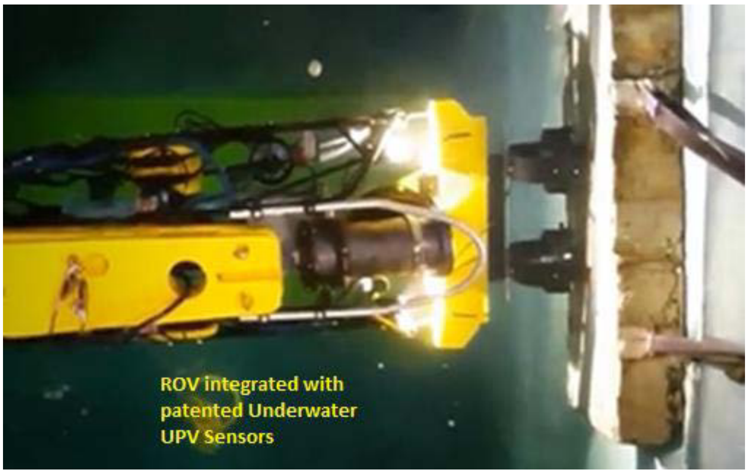


Figure 6.4 Sample image of conducting underwater UPV tests

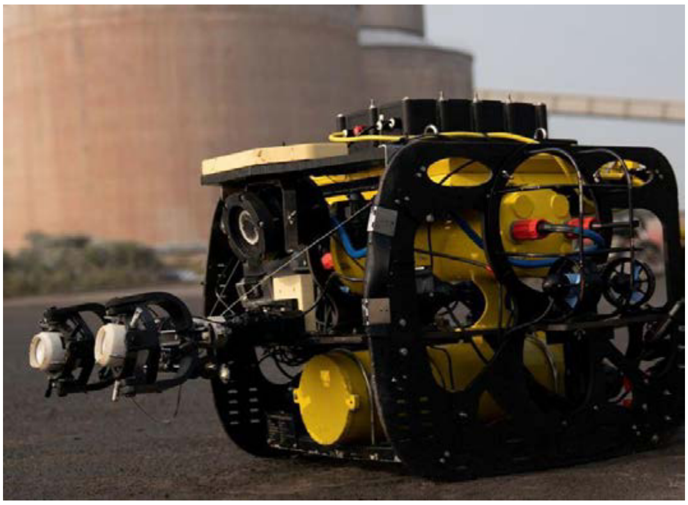


Figure 6.5 Snapshot of Planys ROV integrated with indigenous UPV payload conducting underwater UPV tests.

Figure 6.6 Planys ROV integrated with indigenous UPV payload conducting underwater UPV tests.

6.1.3 Inspection for Corrosion

Appropriate tools to assist in measuring and defining corrosion damage include a depth micrometer (for pitting), feeler gages (for crevice corrosion), an ultrasonic thickness gage (for thinning), a ball peen or instrumented hammer (for corroded or loose rivets), a camera, a tape measure, and a means to collect water samples. When corrosion is observed, the type, extent, severity, and possible cause should be reported. If the corrosion is severe, the specific locations should be noted and the severity (amount of thinning, etc.) should be quantitatively determined. Common NDT methods that can be applied for inspecting structures for corrosion damage include Visual Testing inspection and Ultrasonic Testing inspection.

The extent of paint system failure and regions of localized discoloration of structural components should be recorded. In areas where paint failure has occurred, the surface should be visually examined for pitting. When pitting is present, it should be quantified using a probe type depth gauge following guidance specified in ASTM G46

Ultrasonic inspection is useful when corrosion appears to have caused significant thickness loss in critical components and can be used to obtain a baseline reference for thickness. The thickness of a steel plate or part can be determined to an accuracy of ±0.01 cm (0.005 in.). The technique can be performed through a paint film or through surface corrosion with only a slight loss in accuracy. Ultrasonic transducers are available in a number of sizes. Ultrasonic inspection is useful in determining both general and localized thickness loss due to corrosion, even on curved skin plates. Ultrasonic inspection can be used when only one side of a component is accessible. The open surface can be scanned with the transducer to identify thickness variation over the surface and to determine where corrosion has occurred. Ultrasonic inspection to determine thickness is generally not reliable when pitting corrosion is prevalent, because the size and depth of the pitting impair the output signal of the transducer.

Underwater Ultrasonic Thickness Gauging (UTG) technology can be used to determine the thickness of the steel material submerged under water. UTG sensor is attached in the front side of the ROV and integrated with the ROV systems. The ROV will be lowered at the Gate locations where UT measurements are to be performed and accordingly the ROV would will take readings across the all the submerged portions of the gate structures.

6.2 Proposed Condition Survey Tests

Based on the site reconnaissance and inputs from the condition survey team the following tests have been proposed in order to assess the overall health of the navigational lock:

1. Underwater visual inspection (VI) of the lock chambers including the side walls and base slab, lock gates (mitre and radial gates) using Remotely Operated Vehicle.

2. To carry out above water and Underwater non-destructive tests of the concrete walls of Lock using Ultrasonic Pulse velocity (UPV) technology.

3. To carry out Underwater non-destructive tests of the steel gates walls (mitre and radial gates) of lock using Ultrasonic Thickness Gauging (UTG) technology.

Table 6.1 Proposed Condition Survey Tests

S. No	Test	Length m	Max depth m
1	Underwater visual inspection of lock chamber Walls and Base slab	-	6
2	Underwater visual inspection of Gates	-	6
S. No	**Test**	**Length m**	**Freeboard Height**
3	Above water UPV on lock chamber Walls	440	6
4	Underwater UPV lock chamber Walls	440	6
S. No	**Test**	**Length m**	**Max depth m**
5	Ultrasonic Thickness on Gates - Underwater	-	6

6.3 Critical Inspection Areas: Hydro-Mechanical Components

For the inspection of hydraulic steel structure, critical area checklist has been developed prior to inspection as part of the reinspection assessment. Critical areas are likely common for a given type of hydraulic steel structure

General

- All nonredundant and/or fracture critical components. These typically include main framing members and lifting and support assemblies.
- Corrosion-susceptible areas:
    - Normal waterline
    - Abrasion areas
    - Crevices
    - locations with dissimilar metals.
- Lifting connections or hitches.
- The lifting chain or cable used to lift the gate is also critical.
- Support locations:
    - Trunnion (Radial gate, valves)
    - Top anchorage

- Pintle areas (miter gate)
- Intersecting welds
- Previous cracks repaired by welding
- Locations of previous repairs or where damage has been reported

Mitre Gate

- Horizontal girder-to-miter and quoin post connections (thick plates, high constraint, high stress).
- The ends of diaphragm flanges were attached to downstream girder flanges (high stress, stress concentration).
- Connections at ends of diagonal members (high stress, fracture critical).

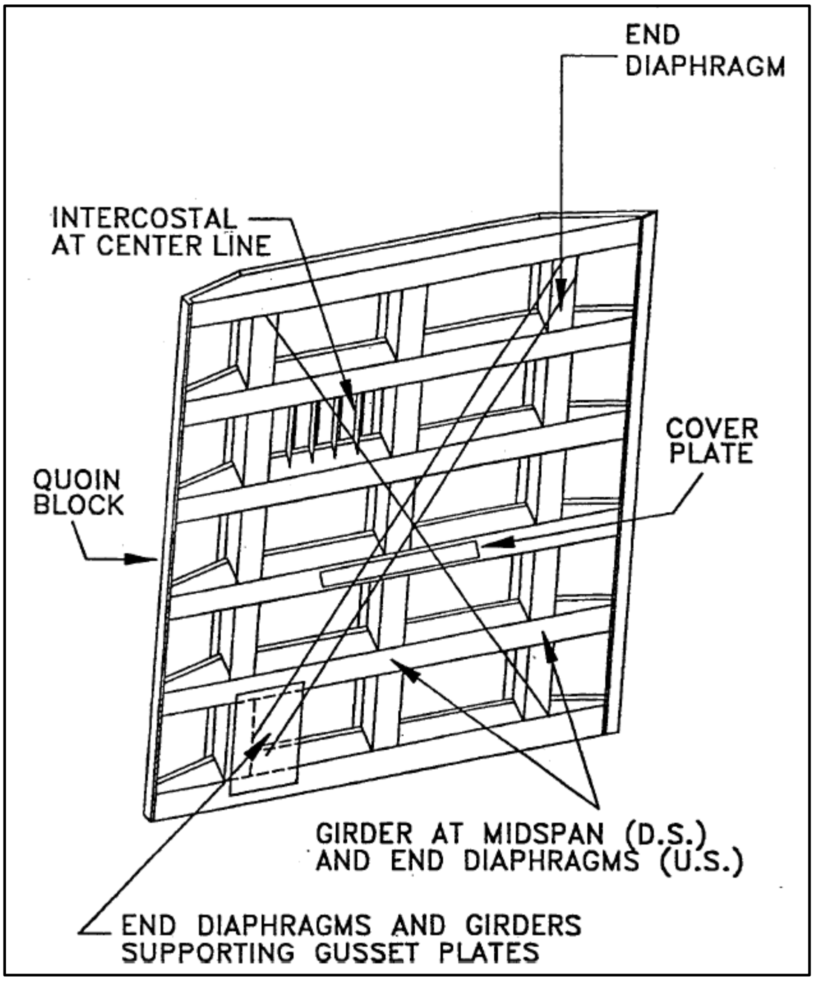


Figure 6.7 Critical Areas of Mitre Gates

Radial Gates

- Girder-rib-skin-plate connection on the upstream girder flange near the end frames and the bracing-to-downstream-girder-flange connection near mid span (critical tension stress/detail combinations).
- Connections of main framing members such as the girder-to-strut connection (fracture critical, high moments).
- Seal lip plate if it is fabricated from stainless steel or other dissimilar metal (galvanic and/or crevice corrosion).

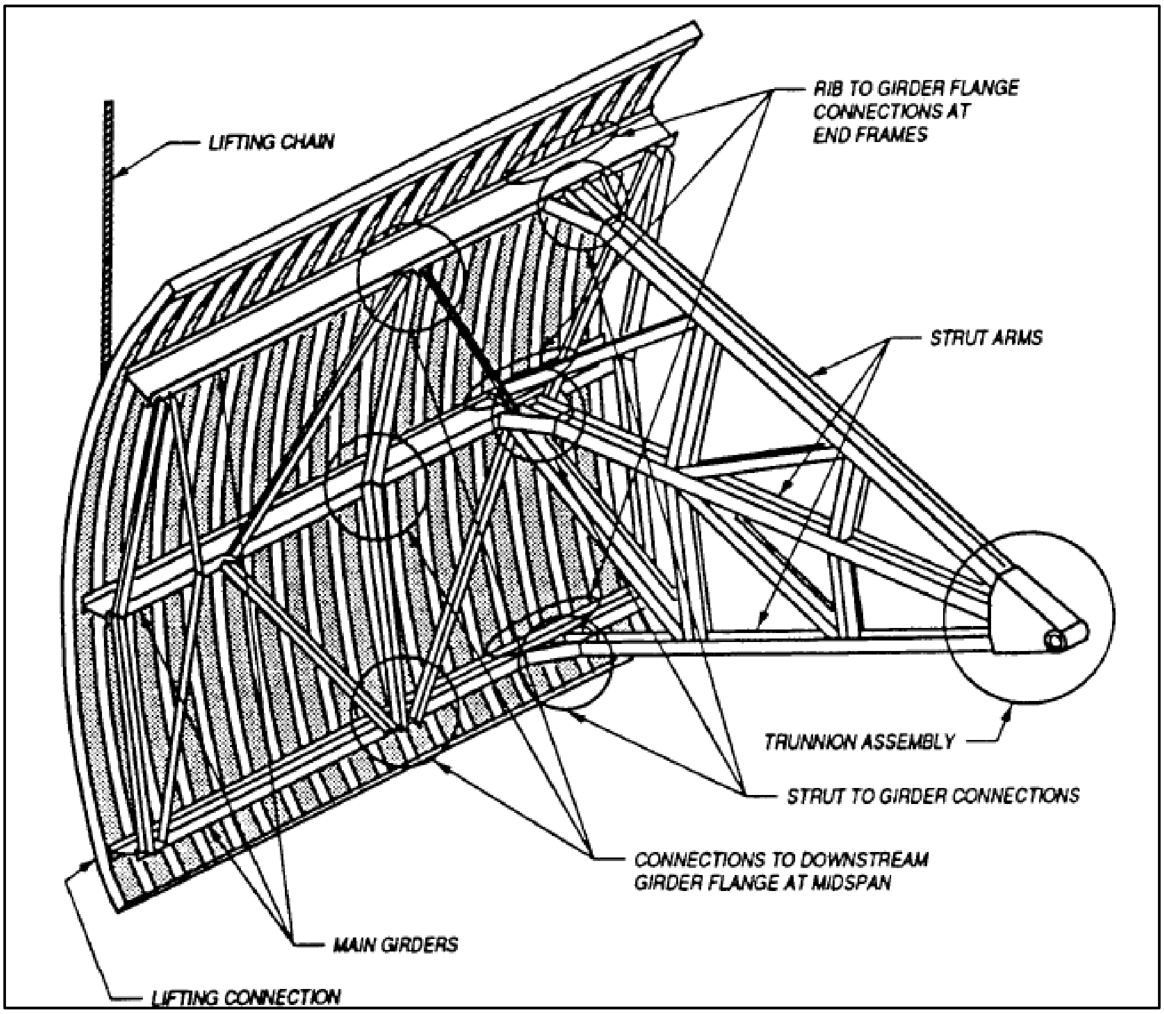


Figure 6.8 Critical Areas of Radial Gates

The effectiveness of NDT depends on the capabilities of the person who performs the test. Inspectors performing NDT should be qualified in accordance with the American Society for Nondestructive Testing (ASNT) Recommended Practice

No. SNT-TC-1A (ASNT 1980). The SNT-TC-1A document is a guide to establish practices for training, qualification, and certification of NDT personnel. IS 13805 (2004): General Standard for Qualification and Certification of Non-Destructive Testing Personnel. ISO 9712: 1999 'Non-destructive testing, qualification and certification of NDT personnel' issued by the International Organization for Standardization.

Item wise Evaluation Matrix for Hydromechanical Components (Mitre Gates, Radial Gates and Bulkhead Gates) has be provided at Annexure II. The field measurement protocols for condition survey (adopted from REMR Guidelines) have been provided at Annexure III.

6.4 Performance Indicators

The information gathered from this type of an inspection is used to calculate a condition index CI. A Condition Index (CI) is a snapshot look at the condition of a part or component of infrastructure. A condition index (CI) is the numerical measure used to rate the current state of a gate. The ratings are based primarily on physical deterioration as determined by distresses that can be seen or measured. A condition index will be used to assess the present condition of navigation lock.

The field measurement data is representative of the current state of the structure. The information gathered from this type of an inspection is used to calculate a condition index CI. A Condition Index (CI) is a snapshot look at the condition of a part or component of infrastructure. A condition index (CI) is the numerical measure used to rate the current state of a gate. The ratings are based primarily on physical deterioration as determined by distresses that can be seen or measured. A condition index provided by U.S. Army Corps of Engineers will be used to assess the present condition of navigation lock.

The Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program of the U.S. Army Corps of Engineers has developed a condition index which is a numerical scale, ranging from a low of 0 to a high of 100. The numbers indicate the relative need to perform REMR work because of deteriorating characteristics of the structure. For management purposes, the CI scale is also calibrated to group structures into three basic categories or zones (Table 6.2).

Table 6.2: Condition index scale and zones

Zone	Condition Index	Condition Description	Recommended Action
1	85 to 100	**Excellent:** No noticeable defects. Some aging or wear may be visible	Immediate action is not required
	70 to 84	**Good:** Only minor deterioration or defects are evident	
2	55 to 69	**Fair:** Some deterioration or defects are evident, but function is not significantly affected	Economic analysis of repair alternatives is recommended to determine appropriate action
	40 to 54	**Marginal:** Moderate deterioration. Function is still adequate	
3	25 to 39	**Poor:** Serious deterioration in at least some portions of the structure. Function is inadequate	Detailed evaluation is required to determine the need for repair, rehabilitation or reconstruction. Safety evaluation recommended
	10 to 24	**Very Poor:** Extensive deterioration. Barely functional	
	0 to 9	**Failed:** No longer functions. General failure or complete failure of a major structural component	

The functional condition index is generated using expert analysis and judgement of field data. The experts take many factors into account as they evaluated the functional condition index like:

a) Its performance at normal and below-normal service conditions on a day-to-day basis.
b) Subjective Safety

A series of critical measurements are made on each gate to quantify the functional condition index. The functional condition index is quantified by

Functional CI = 100(0.4) X/Xmax

where Xmax is some limiting value of X.

According to the previous description of action zones (**Table 6.3**), Xmax is defined as the point at which the functional condition index is 40, that is, the dividing point between Zones 2 and 3.

Figure 6.9 illustrates the equation and zones from Table 2. If X is 0, that is, no distress, the condition index is 100.

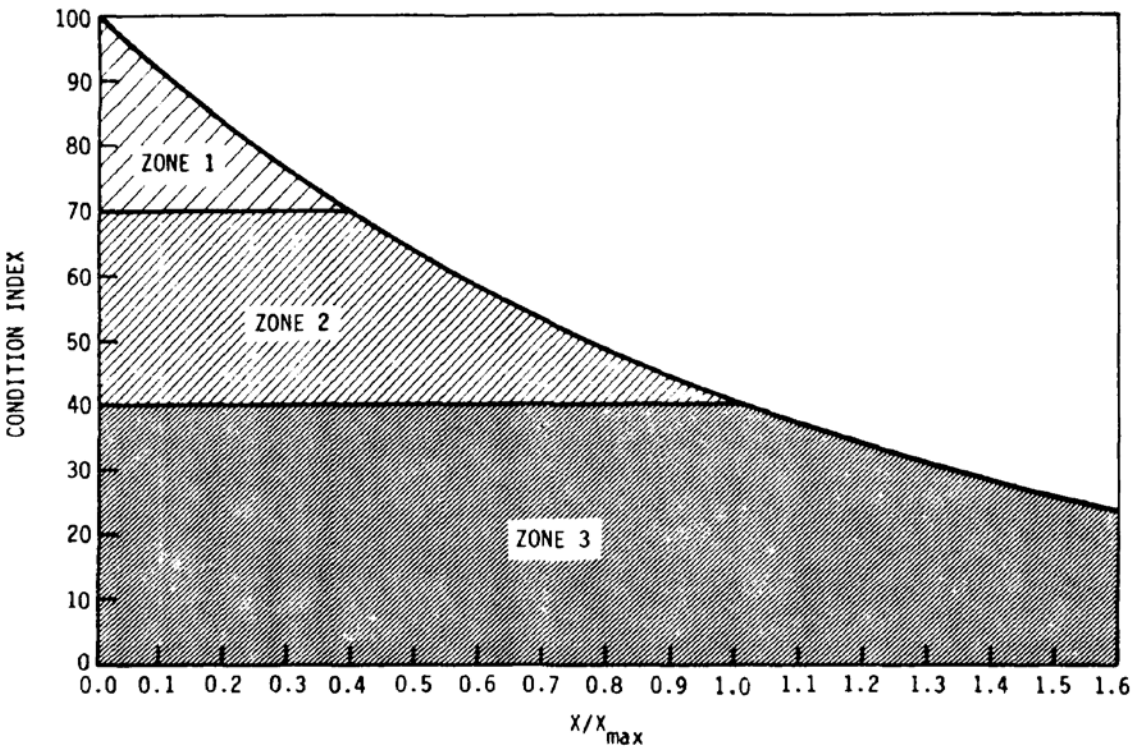


Figure 6.9 Functional condition index related to X/Xmax

Notes

1. If a structure is designed and constructed properly, it has an initial condition index of 100.

2. The functional condition index never quite reaches 0.

3. The judgment for Xmax based on serviceability or subjective safety considerations. The mix and weight of serviceability versus safety are incorporated.

Table 6.3 Condition Matrix: Hydromechanical Components

Sl No	Items	By Visual Inspection/Estimation	By Underwater Inspection	By Underwater Testing (UTG)
1	Corrosion	Yes (Mostly on Splash Zone)	Will be Carried Out	Will be Carried Out
2	Noise/Vibration	Yes	NA	NA
3	Strength	Will be Estimated based on Standard Design	Will be Estimated	Will be Estimated
4	Dents	Yes	Will be Carried Out	Will be Carried Out
5	Leaks/Boil	Yes	Will be Carried Out	Will be Carried Out
6	Seal Condition	Yes	Will be Carried Out	Will be Carried Out
7	Cracks	Yes	Will be Carried Out	Will be Carried Out
8	Misalignment	By Measurement	NA	NA
9	Maintenance Easiness	No	NA	NA
10	Operation	Yes	NA	NA
11	Synchronization	By Analytical Means (Will be Carried Out)	NA	NA

Table 6.4: Condition Matrix: Civil Components

Sl No	Items	By Visual Inspection/Estimation	By Underwater Inspection	By Underwater Testing (UPV)
1	Bar Exposure	Yes	Will be Carried Out	Will be Carried Out
2	Honeycombing	Yes	Will be Carried Out	Will be Carried Out
3	Strength	Will be Estimated based on Standard Design	Will be Estimated	Will be Estimated
4	Leaks/Boil	No	Will be Carried Out	Will be Carried Out
5	Cracks	Yes	Will be Carried Out	Will be Carried Out
6	Misalignment	No	Will be Carried Out	Will be Carried Out
7	Operation	Yes	NA	NA

8	Synchronization	By Analytical Means	NA	NA

CHAPTER 7

7. HYDRAULIC IMBALANCE / BALANCE STUDY

7.1 Introduction

Hydraulic balancing is a process that regulates the distribution of water throughout a system. This balancing helps ensure water is supplied to various system in accordance with design values. Balancing valves/system is used to reliably distribute the system's total flow. Balancing valves/system are accessories that are not only essential in distributing flow but in metering hydraulic systems as well.

7.2 Flow Pattern near Locks

With the development of new navigational lock, it is pertinent of critically examine the synchronization of the simultaneous operations of the existing and new lock. This is critical because, when a flow change occurs, acceleration of the water causes depth fluctuations. The larger the canal, the smaller these fluctuations will be. A larger canal will also provide additional volume in which to store extra water. This in-channel storage provides a buffer for absorbing flow changes because flow imbalances can be accommodated by adding or draining water from storage.

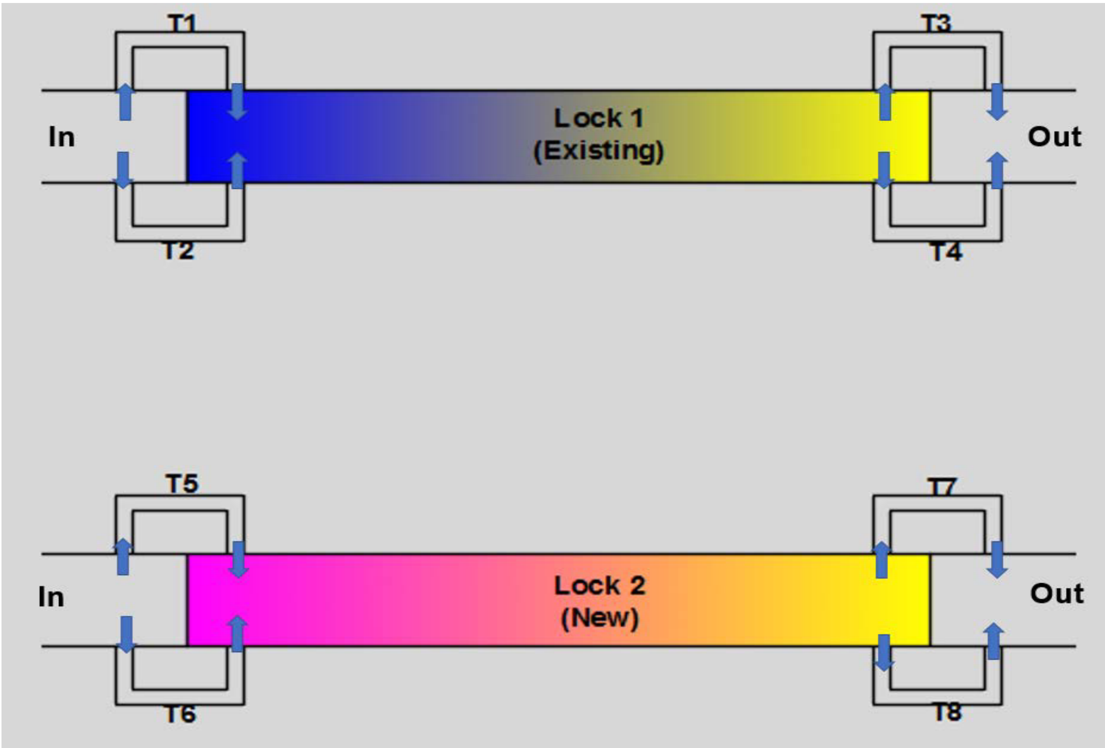


Figure 7.1 Plan of Lock System (Not to Scale)

The phenomenon of parallel flow behaviour is of interest for the renovation, modernization and operation of parallel locks. In the present study a two parallel lock channels setup will be analysed for hydraulic balance/imbalance (Fig. 7.1).

Each lock system consists of four tunnels to carry water in/from the lock. Two tunnels are present in the upstream side (T1, T2 in Existing Lock (Lock 1) and T5, T6 in New Lock (Lock 2) to fill the lock chambers. Two tunnels are present in the downstream side (T3, T4 in Lock 1 and T7, T8 in Lock 2) to empty the lock system.

7.3 Hydraulic Balance/Imbalance Assessment

In the current situation one navigational lock is present to guide the flow through T1 & T2 to fill the Lock 1 and T3 & T4 to empty the system. Both the system can be used in isolation as per requirement of ship to move either up to down or down to up. After completion of Lock 2, the simultaneous operation of different tunnel systems may create flow behaviour change of hydraulic characteristics. For a smoother and coherent operation of parallel system, we will analyse the cases where the simultaneous working of tunnel system affects the hydraulic behaviours.

All the required data will be collected for hydraulic study of channel and associated system from the topographic and bathymetry surveys, hydrological inputs, water levels, operating conditions, past reports, operation manuals and DPR drawings, etc.

Table 7.1 Lock 1 System (From Operation Manual)

Features	Value
Lock Width	25.145 m
Lock Length	179.800 m (Mitre Gate to Mitre Gate)
Mitre Gate Leaf Length	15.354 m
Mitre Gate Top Width	1.300 m
Mitre Gate Height (U/S)	11.880 m
Mitre Gate Height (D/S)	10.110 m
Mitre Gate Bottom Level (U/S)	15.545 m above MSL
Mitre Gate Bottom Level (D/S)	15.240 m above MSL
Mitre Gate Weight	85 ton (D/S) to 90 Ton (U/S)
Mitre Gate Angle from U/S wall at Full Closure	60 Degree
Radial Gate Bottom Level (U/S and D/S)	15.545 m above MSL

Radial Gate Opening Height (U/S and D/S)	2.210 m
Radial gate Movement Angle to full open	45 Degree 29 Minutes
Radial Gate Radius	3.26 m
Radial Gate Weight	20.2 ton
Cassion Gate Length	26.05 m
Cassion Gate Width	4.000 m to 0.800 m
Cassion Gate Weight	240.5 Ton
Bulk Head Gates (A)	L=4.138 m B =0.322 m and H=2.5 m
Bulk Head Gates (B)	L=3.478 m B =0.322 m and H=2.5 m
Bulk Head Gates (CC)	L=2.690 m B =0.322 m and H=2.5 m
Datum Level	15.400 m above MSL
Depth of Lock	18.89 m at U/S to 10.89 m D/S
Lock Bed Level	15.34 to 15.64 m above MSL

The details (design and drawings) of the new navigational lock has been requested from the client and shall be incorporated in the hydraulic balance imbalance study for synchronized operation of both the locks.

7.4 Scenario Generation

To analyse the different operating scenarios, several cases will be studied. The following cases will be studied to assess the flow behaviour near lock system:

Table 7.2 Scenarios for Hydraulic Balance Imbalance Study

Case Code	Case Details
C-1	T1 & T2 Opened, Rest Tunnels Closed
C-2	T1, T2, T5, T6 Opened, Rest Tunnels Closed
C-3	T1, T2, T7, T8 Opened, Rest Tunnels Closed
C-4	T3, T4, T5, T6 Opened, Rest Tunnels Closed
C-5	T5& T6 Opened, Rest Tunnels Closed
C-6	T3 & T4 Opened, Rest Tunnels Closed
C-7	T7 & T8 Opened, Rest Tunnels Closed
C-8	All Tunnels Closed

Analysis of all eight cases will be evaluated for coherence in operation of parallel navigation locks. The need for detailed model studies (Physical Scale Model/

CFD based Numerical Model) will be assessed and proposals will be submitted to the Client for approval.

The regulating structures can change velocity patterns in the system. Care must be taken to not create a system that could result in hazardous navigation conditions. The multidimensional numerical hydrodynamic models are tools that allow for the analysis and evaluation of alternatives. The numerical model is developed using the bathymetric and topographic information. Numerical models have undergone significant developments and have the ability to output information on flow & velocity patterns and sediment movement in the existing and proposed channel systems.

CHAPTER 8

8. ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Introduction

The initial appraisal of the development works required in the project was done, through the field visit of the site along with an examination of the documents. This was done according to the scope as detailed out in the TOR. The developmental works envisaged, as per the TOR are related to the renovation and modernization of the existing navigational lock. This shall include repair/renovation work at the hinges of the gates, the repair or renovation of the gates itself, replacement, repair, or installing additional mechanical or electronic equipment on the site or in the control room and other associated works.

The Ministry Of Environment And Forests, New Delhi vide their Notification dated14th September 2006 (S.O. 1533) stated that from the date of publication of the notification, the required construction of new projects or activities or the expansion or modernization of existing projects or activities listed in the Schedule to the notification entailing capacity addition with change in process and or technology shall be undertaken in any part of India only after the prior environmental clearance from the Central Government or as the case may be, by the State Level Environment Impact Assessment Authority, duly constituted by the Central Government under sub-section (3) of section 3 of the said Act, under the procedure specified hereinafter in this notification.

The proposed works do not come in any items mentioned in the schedule of the above notification. These works shall not involve any breaking of land, cutting of trees, disturbance to the riverbed and riverbanks (mainly erosion & disturbance to the habitats), or displacement of people. As per TOR, it only involves the renovation of the existing navigational lock. During the execution phase of the project, there may be a nominal increment in the decibel levels of sound and levels of particulate matter and other chemicals in the air which are likely to be very insignificant. However, it will be clear after the finalization of the DPR of the project, that what will be the details of the works on the site. Accordingly, the procurement and collection of the baseline environmental data will be done and the impact on various environmental parameters will be assessed.

Based on the extent of disturbance on various environmental parameters, related rules and regulations, and discussion with the project authorities, as necessary, rapid EIA studies will be carried out. Based on rapid Environmental Impact Assessment (EIA), the Environmental Management Plan (EMP) will be prepared.

8.2 Baseline data

The first step would be the assessment of the primary data and critical examination of the available data and documents related to environmental studies. These will include:

- Topographical features;
- Environmental features of concern;
- Rainfall
- Rivers and large bodies of water (ponds, reservoirs, dams, lakes)
- Flora and fauna;
- Soils,
- Habitat;
- Monuments in the area;
- Prevailing norms and practices in the country, and,
- Places of historical and religious importance,

The information and inferences derived from the above study would be supplemented and augmented with the field studies proposed to be carried out by the Consultants. The data and information collection from the field study would generally cover the following aspects:

- Terrain;
- Land-use;
- Water Bodies
- River basins;
- Ecologically sensitive areas;
- Endangered species;

- Fishery;
- Sanctuary;
- Places of importance; and,
- Number of trees, if any
- Data related with air, water and noise pollution

Based on a preliminary study of the available data and maps (topographic, geology) supplemented by data from the visits in the project vicinity (10 km radius), it is proposed to prepare an assessment of environmental and ecological features in the project.

8.3 Anticipated Environmental Impacts & Mitigation Measures

The methodology will involve data collection, impact assessment, and based on the impact of works to be carried out, on the environment and ecology, an EIA and environmental management plans (EMP) will be prepared. To make the methodology project-specific, various statutes, acts, rules, and regulations will be studied. Their compliance will be ensured. The site-specific measures will be incorporated in the EMP thereof. It is proposed to study the following parameters:

i) **Natural Environment:**
ii) **Physical Environment**
iii) **Social Environment**

The Consultants shall carry out an analysis of the relevant data and assess the environmental impacts. This will include short and long-term effects, direct and indirect, and positive and negative effects concerning various parameters such as physical, (air, water, etc.) natural (vegetation, wetlands, conservation area); and, social (land use, noise, topography, etc.)

The objective of the study is to ascertain the existing baseline conditions and assess the effects as a result of the construction/developmental works. As per the legal provisions, if necessary, local people will also be consulted.

Based on project particulars and the existing environmental conditions, potential impacts would be identified that are expected to be affected, and wherever possible, these will be quantified. Both positive and negative impacts would be evaluated to have an idea about resultant impacts. These impacts would be assessed for various phases of the project cycle namely, location, design, construction and operation. The standard methodology will be adopted for impact prediction and assessment.

The issues in each phase will be considered as follows:

a) Impacts due to Project Location

b) Impact due to Project Design

c) Impacts due to Project Construction

Although environmental hazards related to construction works seem to be negligible and mostly of a temporary nature, this does not mean that these should not be considered. This shall include:

- The hazards related to the construction sites,
- Soil pollution at construction sites,
- Pollution by construction spoils,
- Health risks,
- Cultural hazards and
- Noise and air pollution,

d) Impacts due to Project Operation

8.4 Analysis of Alternatives

It is proposed to compare various project alternatives if available on the basis of environmental parameters. Based on the outputs from the preceding tasks, the Consultants would, if so required, study possible alternatives which are safer, cost-effective and have less severe negative impacts on the environment. The best alternative shall be adopted.

8.5 Environmental Management & Monitoring Plan

The consultant would based on the studies carried out in the preceding task and in consultation with the IWAI, prepare an Environmental Management Plan (EMP) covering implementation plan for mitigation, protection, and/or enhancement measures brought out in the rapid Environment Impact Assessment (EIA) study. Accordingly, as per the environmental impact assessment, the EMP would propose, that how the different protective and corrective measures should be operated, also the resources required, and the implementation schedule.

The EMP document would be based on the project-specific need and requirements containing an implementation plan for each of the selected mitigation, protection, and enhancement measures and would address the following major aspects:

- Objective;
- Work plan;
- Implementation schedule; and,
- Monitoring

An environmental management strategy would be developed to mitigate the adverse impacts on the environment and will be integrated as a part of project implementation.

The management/mitigation measures will include the cost of mitigation, time frame, implementing agency, and specifications to be built in contract documents, if any. These will be further integrated in to the preparation of bill of quantities and cost estimates for inclusion in project costs.

CHAPTER 9

9. FRONT END ENGINEERING DESIGNS

The front-end engineering / preliminary engineering of the components of the navigation lock has two aspects in the modernization scheme. The first aspect is the modernization of the existing navigation lock and second is based on the hydraulic imbalance / balance study for systematic and efficient synchronization of the existing and new navigation lock. The modernization of the existing navigation lock has two components. The first component consists of hydromechanical and electrical components including power and control systems, instrumentation and communication system along with remote control system. The second aspect is the civil component which will be altered and designed based on the requirement of the first component and allowable modifications in the lock structure.

The relevant BIS code, design manuals, reports, case studies, research literature will used by the consultant to prepare the design calculation which are safe, economical, and as per the local site conditions, environmental requirements, social needs and have considerable design life & economic rate of return.

9.1 Modifications in Hydro-Mechanical Components

Design of the remedial measures proposed above shall be carried out as per established engineering principles. A brief description of design aspects for each component follows:

Mitre Gates

The planning of design and rehabilitation of mitre gates shall be as per the established design practices of international or equivalent national standards such as: BS: 6349: Part 3 - Code of practice for the design of shipyards and sea locks USACE EM 1110-2-2703: Lock Gates and Operating Equipments, Erbisti, P. C. F. (2004): Design of hydraulic gates For embedded parts, a suitable provision shall be kept in civil design. Sill and side walls at gate grooves shall be constructed as per IS:14223 (Part-I). The rubber/timber seal of suitable grade shall be selected.

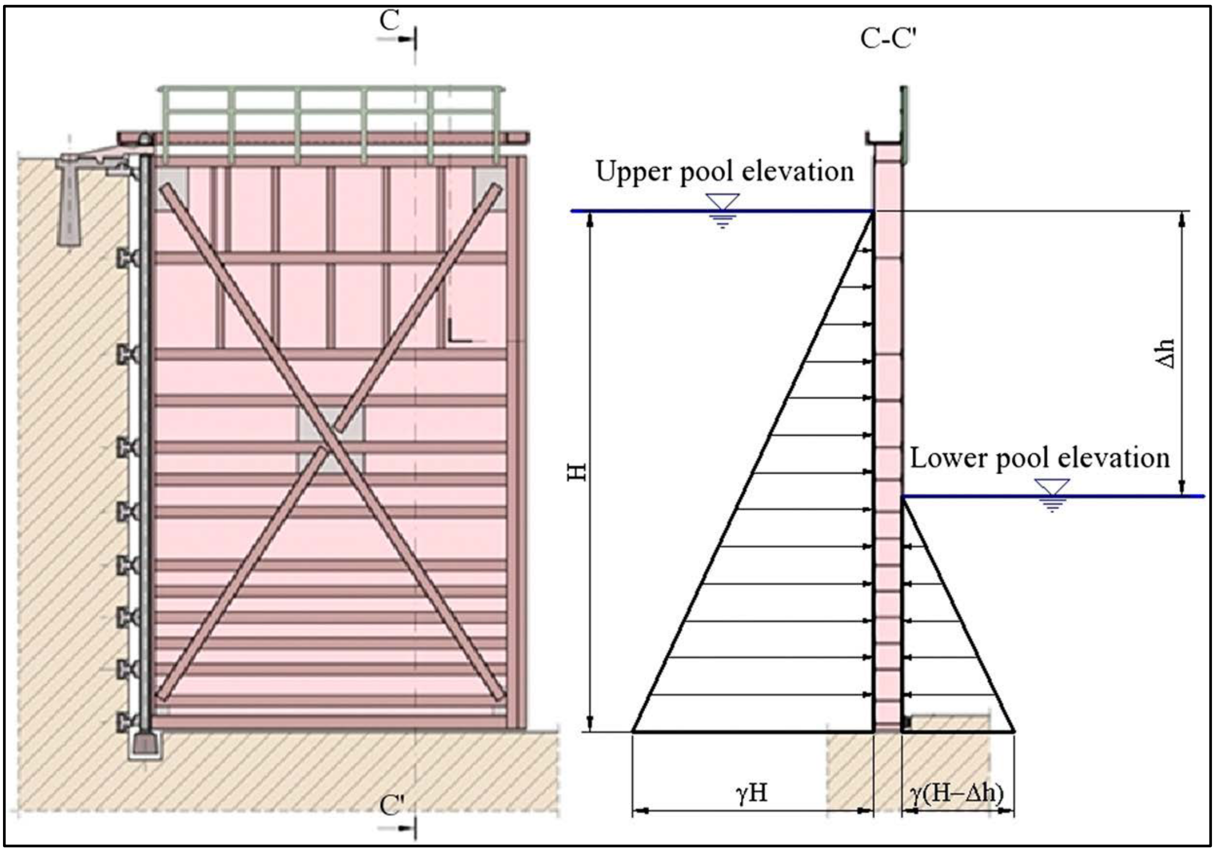


Figure 9.1 Typical back view and vertical static scheme of a Mitre gate

Design Life

For gate structure a design life of 30 years shall be considered with the Hydraulic components of operating system being designed for an optimum life of 15 years.

Design Differential Water Levels

IWAI shall confirm the conditions for differential water levels before they are taken in account for design of HM components.

Table 9.1 Range of Differential Water Level (Based on Design Features) from O&M Manual

Static Conditions		
U/S Gates	U/S Water Level	+26.3 m
	Lock W.L.	+18.288 m
D/S Gates	D/S Water Level	+24.38 m

	Lock W.L.	+18.288 m
Operating Conditions		
U/S Gates	U/S Water Level	+24.38 m
	Lock W.L.	+18.288 m
D/S Gates	D/S Water Level	+24.38 m
	Lock W.L.	+18.288 m
Maintenance Condition		
U/S Gates	U/S Water Level	+ 22.5 m
	Lock W.L.	+15.545 m
D/S Gates	D/S Water Level	+15.545 m
	Lock W.L.	+21.5 m

The level shall be confirmed by topographical survey or during the conditional survey of the project with the Client reconfirming them before they are used for design purpose.

Table 9,2 Summarized Datum and Height of Level From O&M Manual

Lock Bed (Bottom)	+15.45 m to +15.088 m
High W.L. In Lock	+26.3 m
D/S Bank Top	+26.95 m
U/S Bank Top	+28.44 m
Low W.L. in Lock	+18.28 m (Operating Condition)

Loads for Structural Design

Mitre Gates shall be designed for the following loading conditions:

Table 9.3 Structural Loads for Mitre Gate Design

S. No.	Type of Load	Loading from
1	Static Load	Differential Water Head
2	Dynamic Load	Differential Water Head
3	Impact Load	Direct Impact of Loaded Barge (Accident)*
4	Seismic Load	Of the Area
5	Temperature Load	As applicable

* IWAI shall provide the estimated load of fully loaded barrage that is able to pass thorough the navigation lock. The gates shall be designed so that the combined stresses (max.) are less than the allowable stresses given in BS-5400 Part 3 or any equivalent Indian/international Standards.

Operating Equipment & Control System

Modern Hydraulic power packs units shall be designed as per IS: 10210 and are envisaged to use axial pumps with hydraulic cylinders. The system shall be suitably designed for safety and latest instrumentation system. A remote-control operation (using PLC) of the gate is envisaged from Control Room and also Local Control Panel where hydraulic power packs will be located. The new gates shall be designed to be operated with the use of electro-hydraulic system to achieve opening and closing time closer to the gates of new navigational lock.

Cassion Gates

The Cassion Gates are proposed to be shared with the New Navigational Lock structure hence only embedment shall be designed to be accommodated at the site. Sill and side walls at gate grooves shall be designed as per IS code 14223 (Part-I). BS: 6349: Part 3 - Code of practice for the design of shipyards and sea locks shall also be employed wherever necessary references are required.

As all equipment necessary to operate the gate is moveable it is not required to have much equipment at site. However, some minor modification in civil structure might have to be designed for mooring equipment of Cassion gate.

Radial Gates

The gates shall be designed as per the recommendation of IS: 4623 Recommendations for Structural Design of Radial Gates. The radial gates shall have following structural components:

- ✓ Curved skin plate conforming to IS:2060 steel quality cladded with corrosion resistant steel confirming to IS:1570 (Part-5).
- ✓ Support for skin plate by spaced vertical stiffeners

- ✓ Horizontal girders (IS: 800-1984.) against Vertical stiffeners.
- ✓ Radial arms supporting HG from the Trunnion hubs located at the axis of the skin plate
- ✓ Yoke girder.

Suitable sealing arrangement shall be fixed with the help of stainless-steel screws so as to ensure positive water pressure to prevent leakage. The anchorages shall be provided in the 1st stage concrete, with suitable block out openings to hold the 2nd stage embedded parts. The anchor bolts in 2nd stage concrete shall be with double nuts and washers.

Design Life

For gate structure a design life of 30 years shall be considered with the Hydraulic components of operating system being designed for an optimum life of 15 years.

Design Differential Water Levels

The gate shall be designed to be opened in unbalanced condition water on U/S side and other side considering empty. The Radial gates should be designed for the differential water head considering maximum water level i.e., 8.01 m as per the issued O&M manual of the Lock.

Loads for Structural Design

Radial Gates shall be designed for the following loading conditions:

Table 9.4 Structural Loads for Radial Gate Design

S. No.	Type of Load	Loading from
1	Static Load	Differential Water Head
2	Dynamic Load	Differential Water Head
3	Dead Weight & Frictional load	Gate Structure
4	Seismic Load	Of the Area
5	Temperature Load	As applicable

Operating Equipment & Control System

Modern Hydraulic power packs units shall be designed as per IS:10210 and are envisaged to use axial pumps with, hydraulic cylinders the system shall have suitably designed safety and instrumentation system. A remote-control operation (using PLC) of the gate is envisaged from Control Room and also Local Control Panel where hydraulic power packs will be located. The new gates shall be designed to be operated with the use of electro-hydraulic system to achieve opening and closing time closer to the gates of new navigational lock.

Bulkhead Gates

The design of Bulkhead gate shall be as per IS: 4622 Recommendations for Structural Design of Fixed-Wheel Gates. The gate frame consists of:

- ✓ Guide rollers/Guide shoe shall be provided at the sides of the gates both near the top and bottom.
- ✓ Thrust Rollers shall be provided in the end girder of the gates.
- ✓ Side seal seat face shall be in common plane without off sets or gaps at joints.
- ✓ The bottom seal seat shall be flush with adjoining concrete surface.
- ✓ The bottom seal seat shall be provided on a suitable girder of structural steel & the structure shall be welded construction.

Design Life

For gate structure a design life of 30 years shall be considered.

Design Differential Water Levels

The gate shall be designed to be opened in unbalanced condition water on U/S side and other side considering empty. The bulkhead gates should be designed for the differential water head considering maximum water level i.e., 8.01 m as per the issued O&M manual of the Lock.

Loads for Structural Design

Bulkhead Gates shall be designed for the following loading conditions:

Table 9.5 Structural Loads for Bulkhead Gate Design

S. No.	Type of Load	Loading from
1	Static Load	Differential Water Head

2	Dynamic Load	Differential Water Head
3	Dead Weight & Frictional load	Gate Structure
4	Seismic Load	Of the Area
5	Temperature Load	As applicable

9.2 Modifications in Civil Components

The required modifications in civil structure based on the degree of modifications in the hydromechanical systems which shall be firmed up after detailed condition survey. Further, structural deterioration if any shall be repaired and retrofitted based on the non-destructive testing of the concrete.

9.3 Modifications in Electrical & Instrumentation Components: Automated System Operation

This project consists of the automation of:

- ✓ No. 2 sets mitre gates (each with No.2 leaves) powered by HPU's (Hydraulic Power Units) and driven by hydraulic cylinders
- ✓ No. 4 radial gates powered by HPU's (Hydraulic Power Units) and driven by hydraulic cylinders
- ✓ Control centre (remote control) with CCTV and Data Acquisition
- ✓ Pushbutton control (local control)
- ✓ Mains and Emergency power provisions
- ✓ Telephone (EPABX)

General

A redundant PLC network is constructed based on RIO and Copper cabling RS485

- ✓ One central redundant PLC is located in the Control Room, which manages safety and control of the lock and uses.
- ✓ No. 4 RIO elements will be installed in local cabinets (LCR1, LCR2, LCR3 and LCR4), linked in a redundant way (ring topology) through RS485 multidrop signal (type MODBUS).
- ✓ No. 1 Server station, connected to a redundant set of Ethernet switches, No. 1 Operating Cum Programming terminal also connected to a redundant set of

Ethernet switches and No.1 CCTV station as well connected to a redundant set of Ethernet switches.

Safety functions

Emergency stop buttons are provided at all CP's and all HPU's, they function in all operating modes. The emergency stop system is an integral part of the safety functions of the lock. All emergency push-buttons shall be stay put/latching type. To detach, master key provision shall be provided. After unlocking the emergency push-button, the reset button needs to be applied to re-arm the emergency circuit and restart the motion by renewing the execution commando. The emergency stop circuit implies upon activation, the immediate stop of the relevant equipment. This means that the electrical power is cut to all relevant parts. In the case of the Farakka lock this means the stopping of all relevant HPU's and the closing of all hydraulic valves pertaining to the drive system of de gates in question.

Functionality

a. Operating modes

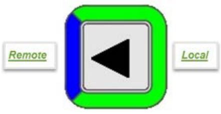
There shall be two operating modes

- ✓ **Remote:** the lock is operated from the control room situated on the first floor of the control building (HMI/SCADA).
- ✓ **Local:** the lock is operated from the control buildings near each leaf of the mitre gates (PUSHBUTTONS) (local control room 1 to 4).

The motion of the cylinders propagating the mitre gates and the radial gates are powered by HPU's and controlled by the redundant PLC in both modes. Dependant on the selected mode, the local pushbuttons ("LOCAL") or the remote HMI/SCADA system ("REMOTE") control the lock. In case of controlling the lock in "LOCAL" mode, the HMI/SCADA system always gives an exact representation of the state and the position of the individual elements as described later.

b. Selection of the operating modes

Selection of the mode of operation is done by a rotary switch. The rotary switch is located on the control desk and has 2 possible positions:



In case of changing the operation mode whilst operating the lock, the emergency stop functions are activated and the lock operation is stopped immediately.

Only one operating mode can be active at the same time: no operation is possible in the other mode. In case of “local” operation mode, both lock heads (U/S and D/S) can be operated separately by using the local pushbutton command.

c. Local Control

Local control is activated from the central control desk, therefore excluding remote control after activating. In local control each separate actor (i.e. leaf of a mitre gate or radial gate) is activatable via the pushbuttons situated on the respective Local Control Panels. The big difference between the remote control and the local control is that:

- ✓ Local control allows separate movements of parts of the installation (for example one radial gate only)
- ✓ There is no interlocking between the separate items (for example: one can open all 4 radial gates at the same time)
- ✓ The gates can be stopped at any position which is an advantage for maintenance purposes.
- ✓ Local control is managed by the (redundant) PLC and the (redundant) network.

d. Remote Control

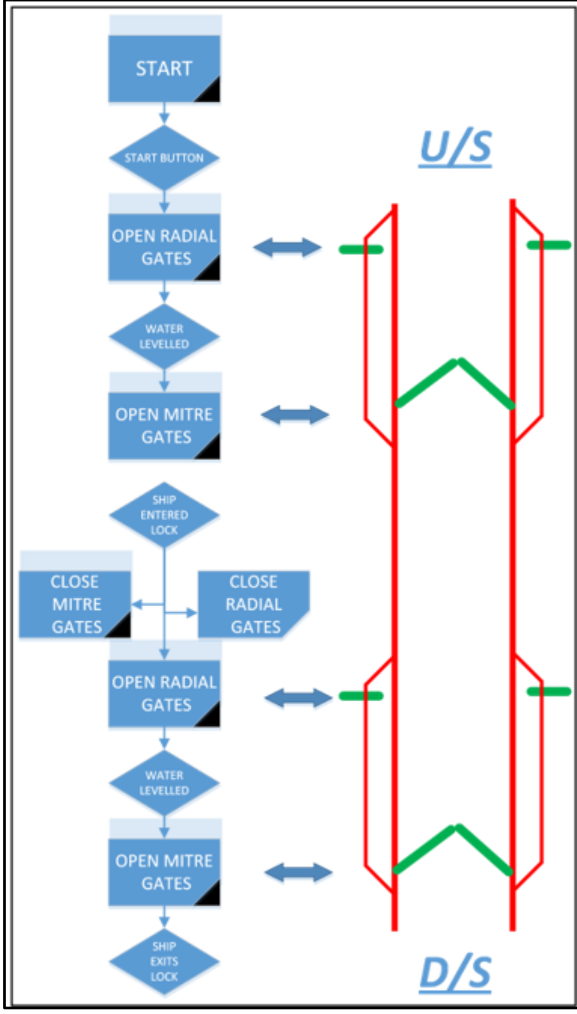
Remote control is activated from the central control desk, therefore excluding local control after activating. In remote control each separate actor (i.e. leaf of a mitre gate or radial gate) is not activatable via the pushbuttons situated on the respective Local Control Panels. The big difference between the remote control and the local control is that:

- ✓ Remote control facilitates exploitation in a safe and controlled manner of the entire lock
- ✓ Remote control does not allow separate movements of parts of the installation (for example one radial gate only)

The PLC and HMI/SCADA system shall have all these functions incorporated.

Functional & Operational Graph

Remote control is operated from the central control desk, and offers the possibility of locking ships U/S to D/S and vice versa: This example gives insight in locking a vessel U/S to D/S. Figure 9.2 explains the different sequences that need to be programmed in the (redundant) PLC and the HMI/SCADA to fulfil the necessary functionality.



START: this command on the HMI starts the sequence of locking.

OPEN RADIAL GATES U/S: this function opens the radial gates U/S thus letting water into the lock chamber. This process is continued until the water level is the lock chamber is equal to the U/S water level.

WATER LEVELLED U/S: From this moment on the lock chamber water level equals the U/S water level.

OPEN MITRE GATES: The mitre gates U/S are opened so that the vessel can enter the lock chamber

LOCKING AND MOORING: If the ship has entered the lock, it will be moored. The mitre gates U/S and radial gates U/S will be closed

OPEN RADIAL GATES: This function opens the radial gates D/S thus lowering the water in the lock chamber.

WATER LEVELLED D/S: From this moment on the lock chamber water level equals the D/S water level.

OPEN MITRE GATES: the mitre gates D/S are opened so that the vessel can leave the lock chamber

Figure 9.2 Functionality Graph of Lock Operation

The automation of regulating the operation of Mitre Gates as well as the radial gates is missing in the existing lock. It has been intended to introduce water level sensors both in the upstream and downstream of the Navigation Lock in tandom with the automation being devised in the new Navigation Lock. The introduction of this automation will help in bringing down the total operational time of Navigation Lock in passing a vessel through it either from upstream to downstream or vice versa to touch the International Standard Limit well within 30 to 45 minutes.

Further, the consultant will get all the designs, including design basis reports of all the components and sub-components of the navigation lock reviewed, proof checked and vetted by any IIT/NIT/ or any other reputed Engineering Institute as approved by the Client. The consultant will coordinate and attend meetings with the Proof Consultant and respond to their queries and furnish the necessary details for vetting of the design.

CHAPTER 10

10. COST ESTIMATION

The General Arrangement Drawings (GAD) and preliminary drawings with various minor details of works shall be prepared. The bill of quantities (BOQ) shall be determined based on these drawings. The various item rates shall be taken from the Schedule of Rates (SoR) and / or Delhi Schedule of Rates (DSR). Market Rates will be adopted for those items for which SoR is not available. The value of leads and lifts and other taxes etc. shall also be added as per specified standards. The cost of construction works shall be determined based on BOQ and item rates. The cost of project shall be determined considering all other major and minor head as per normal provision. This shall amount to the Capital Expense (CAPEX) estimated for the modernization of the navigation lock.

Operating Expense (OPEX) required for the operations of the navigation lock system will also be worked out by the consultant in consultation with the Client. Operating expenses are incurred during regular functioning of a lock system, such as general and administrative expenses, power consumption, lubricants and consumables, stock & supply of spares, research and development, etc.

Unit Rates

The unit rates for different items of works would be analysed based on the material survey conducted by the consultants and the relevant data collected from the Client and the concerned departments in the construction and maintenance of navigation lock. While working out the unit rates, the inputs of man (labour), material and machine would be computed and considered. The basic rates worked out for the study would be compared with those obtained in other similar projects and recently completed/awarded/on-going construction and maintenance works in the area.

Construction Costs

The costs for modernization/renovation of the navigation lock would be worked out on the basis of design proposals. The item-wise construction costs would be computed using the bill of quantities derived from the designs, drawings and specifications and the unit rates worked out. The construction costs would also include the costs of ancillary works, costs for shifting of utilities and provisions for lock management and diversion works necessary for vessel movement during the construction of works.

Environmental Costs

The costs of environmental mitigating measures, management and monitoring would be worked out on the basis of the Environmental Impact Assessment (EIA) study. These will be budgeted for and incorporated in project cycle in order to safeguard the environment.

CHAPTER 11

11. PROJECT PLANNING & TENDER DOCUMENT

11.1 Organizational Structure

The consultant will suggest an institutional mechanism in the form of organizational structure based on the best suited management practices for the execution phase of the project as well as post construction phase. The execution phase shall also include a supervision plan to monitor the physical and financial progress of the project while the post construction phase shall operation & maintenance/ management plan of the lock after its commissioning.

11.2 Construction Planning

Planning for a project must include not only consideration of time but also consideration of cost, quality, health and safety and other aspects such as design and production. Depending on the work involved as per design and methodology, construction planning is done. It involves arrangement of man, material, machine, buildings, infrastructure etc. for the project. Infrastructure involves buildings, road, electricity, phone, water supply, sewer lines etc. required for the smooth running of the project. Planning for man power required is done which involves engineers, supervisors, workers, account people, admin and support staff. Depending on the volume of work involved number of each type of man power is decided and deployed at site as per requirement of the project. For example, a civil engineer will be required at the start of the project where as a hydromechanical engineer will be required at a later stage. Such judicious planning is required to execute it economically.

Material planning is very important to facilitate uninterrupted progress of work at site. Volume of material required, its source, procurement, transport, storage and making it available at site on time when required is one of the keys to success for a project. Similarly, the machine required should be properly assessed as per the different types of work involved so that work is not hampered due to lack of machine at the same time it should not be idle at site without being utilized. Spare parts are a very important component and many a time a case of delay in work in spite of having the best kind of machines available. So, sufficient number of spares should always be available at site.

11.3 Construction Scheduling

Scheduling has been defined as the process of 'quantifying the programme. Scheduling is concerned with sequencing and timing. It must expose difficulties likely to occur in the future. A good schedule must enable the unproductive time of both labour and machines to be minimised. Construction schedule of the project should be prepared keeping in view the optimum use of equipment, chalk out parallel activities and start working on them simultaneously to complete it in least feasible time. It must be suitable for use as a control tool against which progress may be measured. The schedule must be sufficiently accurate to enable its use for forecasting material, manpower, machines, and money requirements. It must show an efficient work method based on an optimal cost, bearing in mind the availability of the resources Construction activities is planned in such a way that the project will be completed in the shortest possible time. The construction methodology and equipment planning for various works is based on the site conditions prevailing in the project area.

11.4 Tender Document Preparation

The consultant will prepare the tender documents for the execution of the project on EPC and/ or Item rate mode in consultation with the Client and as per the guidelines of the funding agency including the scope of work, technical specifications and terms of reference, BOQ, Price Schedule, General & Special Conditions of Contract. Extreme care will be taken during the preparation of Tender Documents including defining the terms of the tender procedure, as well as the terms for execution of the contract. The tender documents will provide clear and detailed information on the following three issues:

- ✓ Scope of the contract to be awarded: Description of the purpose and objectives of the contract, of the environment within which it shall be implemented, and of its scope, deliverables and delivery times.

- ✓ Eligibility and method for participation of interested parties in the tender procedure and method for their evaluation: Determination of the award procedure, of the selection and award criteria, and of the contents of tenders and their evaluation procedure.
- ✓ Terms of cooperation for implementation of the contract: Identification of the special (value, time, delivery and payment method, penalties for delay etc.) and general conditions (guarantees, subcontracting, obligations of the contracting parties, contract termination etc.) of the agreement to be entered into by the Contracting Authority and the economic operator selected to execute the contract.

CHAPTER 12

12. CAPACITY BUILDING STUDY TOUR

12.1 Water Navigational Lock System

A lock system is a mechanism used in water navigation to transfer boats and similar vehicles from one level of water to another. These devices are typically located along rivers and canals. Locks function through the use of a special chamber that holds ships and other watercrafts while the device either fills with water to lift the vessel or empties in order to lower the vessel. Locks are an important component of water navigation and serve to improve the cost effectiveness of trading goods while making riverways less dangerous to navigate and unlevel lands easier to cross.

Locks date back to the 3rd century BC and have played an important role in trade and economic development ever since. These mechanisms serve to make water transportation faster, thereby reducing the cost of transporting traded goods.

12.2 Major Navigation Locks in the World

IJmuiden Sea Lock

The IJmuiden sea lock (Dutch: zeesluis IJmuiden) is one of the largest locks in the world. The lock, situated in the municipality of Velsen, was opened on 26th January 2022 in the presence of King Willem-Alexander of the Netherlands.

The new sea lock has been built to replace the Noordersluis. This lock is almost at the end of its service life. With this new sea lock, the Port of Amsterdam will remain accessible to the sea-going vessels. This is of great economic importance. The Port of Amsterdam is the fourth-largest port in Europe in terms of volume, and is linked to no less than 3 corridors. The new lock is 500 m long, 70 m wide and 18 m deep. This makes IJmuiden the largest sea lock in the world.

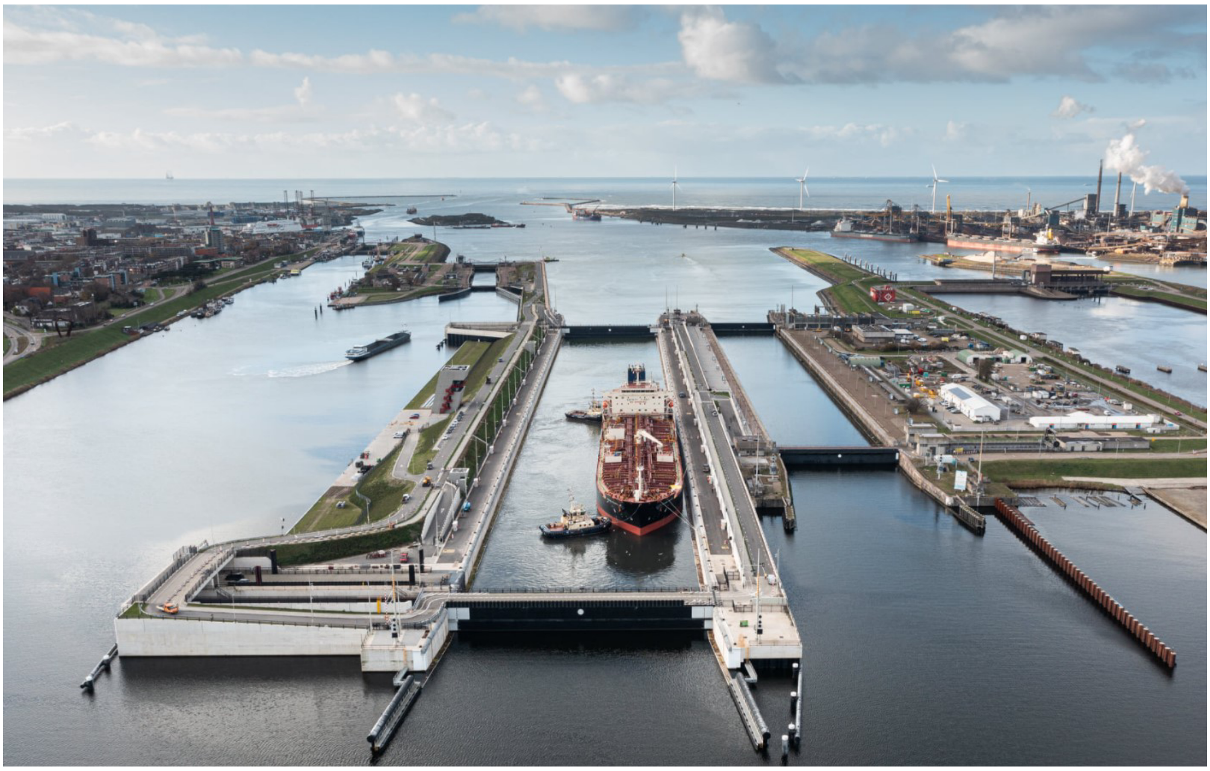


Figure 12.1 The IJmuiden Sea Lock

Kieldrecht Lock

The Kieldrecht Lock, located in the Port of Antwerp in Belgium, is the largest in the world. It was opened in June of 2016 to provide users of the Left Bank docks access to the sea between the Waasland and Schelt canals. Construction of this mechanism began in November of 2011. The port has four, sliding gates managing the locks, as well as bridges on both sides of the lock that operate in sync to ensure that vehicular traffic doesn't get stopped up by these locks' mammoth operations. The Kieldrecht measurements are: Length 1600 ft Width 223 ft Depth 58 ft 1,600 feet in length, 223 feet in width, and 58 feet in depth.

Figure 12.2 The Kieldrecht Lock

Oskemen Lock

The highest lock in the world is the Oskemen Lock and lies at Ablaketka where it allows river traffic to pass around a hydroelectric dam on the Irtysh river. It has a drop of more than 40m. It is apparently the deepest ship lock in the world, at 40-42m.

Figure 12.3 The Oskemen Lock

Caen Hill Locks

Caen Hill Locks are a flight of locks on the Kennet and Avon Canal, between Rowde and Devizes in Wiltshire, England. The 29 locks have a rise of 237 feet in 2 miles or a 1 in 44 gradients. The locks come in three groups. The lower seven locks, Foxhangers Wharf Lock to Foxhangers Bridge Lock, are spread over ¾ of a mile. The next sixteen locks form a steep flight in a straight line up the hillside and are designated as a scheduled monument. Because of the steepness of the terrain, the pounds between these locks are very short. As a result, 15 locks have unusually large sideways-extended pounds, to store the water needed to operate them. A final six locks take the canal into Devize.

Figure 12.4 The Caen Hill Locks

Three Gorges Dam Lock

The Three Gorges Dam, dam on the Yangtze River (Chang Jiang) just west of the city of Yichang in Hubei province, China allows the navigation of oceangoing freighters. Navigation of the dam and reservoir is facilitated by the five-tier ship locks at both ends of the complex, which allow vessels of up to 10,000 tons to navigate past the dam, and a ship lift, which allows vessels of up to 3,000 tons to bypass the ship locks and travel past the dam more quickly.

Figure 12.5 The Three Gorges DamLocks

Panama Canal Lock

The Panama Canal locks originally opened in 1914 when it was considered one of the most challenging engineering projects and largest concrete constructions of its time. In 2007, an expansion project began and in June of 2016, the 3rd set of locks was opened for commercial use. The Panama Canal now houses 12 separate locks. The newest of these had a construction cost of $5.2 billion and allows for the transportation of the New PANAMAX ship which has a larger cargo load than the other locks are capable of handling. It consists of 2 lock chambers, which are filled by 18 water basins and closed off by 3,200-ton rolling gates. This newest set of locks can accommodate ships of up to 160 feet. The Panama measurements are: Length 1200 ft Width 160 ft Depth 50 ft.

Figure 12.6 The Panama Canal Lock

Berendrecht Lock

The Berendrecht Lock is one of the largest lock in the world. This mechanism is located on the right-side banks of the Port of Antwerp in Belgium. It was built in 1989 when the Post-Panamax ship was introduced with a wider-than-average size. In addition to servicing this new ship, the Berendrecht facilitated the development of the right-side bank. The Berendrecht measurements are: Length 1600ft Width 223 ft Depth 44 ft.

Figure 12.7 The Berendrecht Lock

12.3 Parallel Navigation Locks in the World

As there will be two navigational locks at Farakka after the commissioning of the new navigational lock, the Consultant has reviewed the parallel navigation facilities (with more than one lock chamber) across the world. The details are:

IJmuiden Sea Lock (discussed above)

Berendrecht Lock (discussed above)

Panama Canal Lock (discussed above)

Three Gorges Dam Lock (discussed above)

Hiram M. Chittendon Locks, Seattle

The most heavily used locks in the United States carry everything from kayaks to barges while connecting salt water from Puget Sound with the fresh water of Lake Washington and Lake Union, both situated about 20 feet above sea level. Located north of Seattle's famed Space Needle and known locally as the Ballard Locks, the complex includes two locks—one 30 feet by 150 feet and the other 80 by 825—as well as an integrated fish ladder to help salmon traverse the gap.

Figure 12.8 The Hiram M. Chittendon Locks

The Soo Locks

The St. Marys Falls Canal and Soo Locks are located at Sault Ste Marie, Michigan and were constructed by the U.S. Army Corps of Engineers. The canal and locks enable ships to bypass rapids on the St. Marys River and safely pass between Lake Superior and Lake Huron, a 21 foot elevation change. There are two parallel locks operating at the Soo. The MacArthur Lock is 800 feet long, 80 feet wide, and 29.5 feet deep. The Poe Lock is 1200 feet long, 110 feet wide, and 32 feet deep.

Figure 12.9 The Soo Locks

Maxwell Locks & Dam

Maxwell Locks and Dam is one of nine navigation structures which provide for year-round navigation on the Monongahela River between Pittsburgh, Pa., and Fairmont, W.Va. It maintains a pool for 20.8 miles upstream to Grays Landing Lock and Dam near Grays Landing, Pennsylvania.

Figure 12.10 The Maxwell Locks & Dam

Locks & Dam 3, Mon River

Figure 12.11 The Locks & Dam 3, Mon River

Locks and Dam 3 is one of nine navigation structures which provide for year-round navigation on the Monongahela River between Pittsburgh, Pennsylvania., and Fairmont, W.Va.. It maintains a pool for 23.8 miles above the mouth of the Youghiogheny River, just above Elizabeth, Pennsylvania.

Locks & Dam 4, Monongahela River

Charleroi Locks and Dam is one of nine navigation structures which provide for year-round navigation on the Monongahela River between Pittsburgh, Pennsylvania, and Fairmont, W.Va. It maintains a pool for 19.7 miles upstream to Maxwell Lock and Dam just south of Brownsville, Pennsylvania.

Figure 12.12 The Locks & Dam 4, Monongahela River

Emsworth Locks & Dams

Figure 12.13 The Emsworth Locks & Dams

Emsworth Locks and Dams is one of six major river facilities on the Ohio River in the Pittsburgh Engineer District. This facility stands at the head of the Ohio River navigation system and forms a 24-mile pool on the three rivers around the city of Pittsburgh.

The Corps rebuilt and converted the dam to a gated structure between 1935 and 1938. This action raised the pool an additional 7 feet to accommodate larger, more modern barges. From 1981-86, some $30 million was invested in a major rehabilitation of the facility. Rehabilitation included the replacing of electrical systems, operating machinery and buildings and re-surfacing of the lock walls. Another rehab of the project is currently underway, and will improve scour protection, vertical lift gates, gate operating machinery and emergency bulkheads.

Dashields Locks & Dam

Dashields Locks and Dam is one of six major Pittsburgh District river facilities on the Ohio River. It is the only fixed crest type dam still in service on the Ohio River. This facility maintains the navigation pool for 7 miles from Glenwillard, Pa., upriver to the Emsworth Locks and Dam near Pittsburgh.

Figure 12.14 The Dashields Locks & Dam

New Cumberland Locks & Dam

New Cumberland Locks and Dam are located on the right descending bank of the Ohio River, just off Ohio State Route 7 at the small town of Stratton, Ohio. Across the river and two miles downstream lies New Cumberland, W.Va.. The New Cumberland project has two locks and a gated dam, one of the two major types of dams in service in the Pittsburgh District.

Figure 12.15 The New Cumberland Locks & Dam

Pike Island Locks & Dam

The lock chambers lie on the West Virginia side of the Ohio River along West Virginia Route 2, just north of the Warwood district of the city of Wheeling. The villages of Yorkville, site of a large steel plant, and Tiltonsville are across the river in Ohio.

Figure 12.16 The Pike Island Locks & Dam

Hannibal Locks and Dam

Hannibal Locks and Dam is one of six major river facilities on the upper Ohio River. An observation platform and visitors facility are at the lock site. The visitors center includes a unique wicket dam and maneuver boat depicting the history of navigation on the Ohio River.

Figure 12.17 The Hannibal Locks and Dam

Marmet Locks and Dam

Marmet Locks and Dam, built in 1934, are currently the busiest locks in the Ohio River System in terms of commercial lockage cuts. It is located at mile 67.7 of the Kanawha River. An improvement to Marmet Locks was authorized in 1996. The project is a new 110' x 800' lock chamber to go with the existing pair of 54' x 360' chambers. This project contains a number of innovative features which have greatly reduced expected construction costs. These features include long-span prefabricated beams for the upper approach wall; sill face intakes for the filling and emptying (F&E) system (which eliminates mass concrete upper approach walls), a central culvert F&E system (which permits smaller chamber monoliths), and a minimal cofferdam footprint. The new lock chamber became operational in 2008 and all construction was completed in 2009.

Figure 12.18 The Marmet Locks and Dam

12.4 Study tour

The consultant will undertake a capacity building, institutional strengthening & knowledge enhancement study tour to region which have well developed inland navigation systems and have state of the art structure / design / architecture / equipment / instruments / system in the navigation systems. The Consultant proposes to visit IJmuiden Sea Lock, in Netherlands which has parallel navigation locks and is one of the largest locks in the World. However, the location of study tour and knowledge transfer visit shall be finalized in consultation with the Client. The capacity building will be aimed at holistic system that works together focusing on the following three aspects:

- Institutional and legal framework development: making legal and regulatory changes to create an enabling environment for organizations at all levels and in all sectors to enhance their capacities. (safety and security guidelines, institutional and organization management system for safe & secure navigation lock)
- Organizational development: the elaboration of management structures, processes and procedures, not only within organizations but also the management of relationships between the different organizations and sectors (public, private and community). (Understanding the concept of navigation lock and use of modern technology; economic and business aspects; asset risk management strategies)
- Human resource development: the process of equipping individuals with the understanding, skills and access to information, knowledge and training that enables them to perform effectively.

13. WORK PLAN & SCHEDULE

13.1 Overall Work Plan

No	DELIVERABLES	TIME PERIOD (MONTH & WEEK)																															
		M1				M2				M3				M4				M5				M6				M7				M8			
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W 10	W 11	W 12	W 13	W 14	W 15	W 16	W 17	W 18	W 19	W 20	W 21	W 22	W 23	W 24	W 25	W 26	W 27	W 28	W 29	W 30	W 31	W 32
1	**INCEPTION REPORT**																																
a	Kick-off Meeting																																
b	Collection and Review of Data, Reports and Studies																																
c	Initial Site Visit																																
d	Detailed Methodology & Work Plan																																
e	Assessment of changes in River Course																																
D1	**Submission of Inception Report**																																
2	**CONDITION SURVEY ASSESSMENT REPORT**																																
a	Reconnaissance Visit																																

b	Conduct Condition Survey & Investigations																															
c	Conduct Topographic & Hydrographic Survey and Geotechnical Investigation																															
d	Assessment of Current Performance Levels																															
e	Conduct Hydraulic imbalance/balance Study																															
D2	**Submission of Condition Survey Assessment Report**																															
3	**DRAFT DPR**																															
a	Prepare Preliminary Engineering Design & Drawings																															
b	Conduct Numerical Modelling for Hydraulic imbalance / balance Study																															
c	Conduct Rapid EIA/EMP Study																															
d	Organize Capacity																															

	Building Study Tour																																
e	Preparation of Cost Estimation, Execution Plan & Tender Documents																																
D3	**Submission of Draft DPR**																																
4	**FINAL DPR**																																
a	Address & Incorporate the Comments / Observations																																
b	Proof Checking / Vetting by IIT/NIT																																
c	Assist in Statutory Clearance																																
D4	**Submission of Final DPR**																																

13.2 Deliverables

Sl. No	Deliverable	Timeline	Due Date
1	Inception Report	T+1 Month	25-02-2022
2	Condition Survey Assessment Report	T+3 Month	25-04-2022
3	Draft DPR	T+6 Month	25-07-2022
4	Final DPR	T+8 Month	25-08-2022

13.3 Organization and Staffing

The scope of work requires involvement of Experts of different skills. From our extensive experience of hydraulic infrastructures, we believe that success of the team depends on three key factors. Firstly, there should be efficient integration, direction and control of the separate professional skills to achieve a balanced team; secondly close working links between the project team and Client and; lastly it is important to build upon the strength of qualified and experienced team. Consultant is aware that the success of project is largely determined by the caliber of the individual professional and their capability of functioning within the team. The resource people have been selectively chosen from and amongst the best in industry having long-term working relationship.

The team shall be led by Team Leader having expertise in planning, design and project management of hydraulic infrastructure including dams, barrages and hydel power schemes. The Team leader will be supported by seven key experts (Structural Engineer, Geotechnical Engineer, Hydrography Expert, Electronics and Communication Expert, Mechanical Engineer, Environment Expert and Procurement Expert). Non key expert shall be involved like Hydraulic Expert, Hydrologist, Cost Estimator, RS & GIS Specialist, surveyor and draughtsman. The team will be ably supported by two technical and one administrative support staff. The structured team is adequate and fulfils the assignment requirement. Based on the understanding of the job and our past experience, we allocate specific responsibilities to the team members.

Team Leader

Overall responsibility for the project would rest with the team leader who will ensure its successful completion and also handle crucial decision making. The task of managing and controlling the Consultancy assignment would be the responsibility of the team leader who will have the role of directing, coordinating, supervising, technical control and management. He will interact with Client and will be the leading partner in contact with the stakeholders of the project. He will be exercising technical control of the entire project team. The team Leader will be in charge for:

- ✓ Preparing the inception report that will develop the Consultant's methodology for execution of the contract.
- ✓ Reviewing the input required for carrying out the assignment
- ✓ Organizing in detail the studies and the participation of all the specialists, making sure that the most appropriate engineers will carry out the tasks.
- ✓ Making sure that actual progress is in accordance with the project schedule.
- ✓ Organizing the internal quality control for the deliverables.
- ✓ Organizing the liaisons and co- ordination between Client and Consultant.
- ✓ Establish coordination with the proof consultant

Structural Engineer

The expert will be mainly responsible for:

- ✓ Review of available data and designs
- ✓ Undertake site visit and reconnaissance survey
- ✓ Assess the requirement / tests to be conducted in condition survey
- ✓ Coordinate and supervise the condition survey of civil components of the lock
- ✓ Performance Assessment of civil components of the lock
- ✓ Design of civil components based on modernization / renovation in the lock

Geotechnical Engineer

The expert will be mainly responsible for:

- ✓ Review of available geological and geotechnical data

- ✓ Undertake site visit and reconnaissance survey
- ✓ Coordinate and supervise the condition survey of geotechnical aspects
- ✓ Assess the requirement of geotechnical investigations
- ✓ Coordinate and supervise the geotechnical investigations
- ✓ Performance Assessment of geotechnical aspects of the lock
- ✓ Design of geotechnical aspects based on modernization / renovation in the lock

Hydrographic Expert

The expert will be mainly responsible for:

- ✓ Review of available hydrography data like thalveg data, water depth, etc.
- ✓ Coordinate and supervise additional hydrographic survey
- ✓ Review the additional bathymetry survey data, charts, etc.

Electronics & Communication Expert

The expert will be mainly responsible for:

- ✓ Review of available data, reports and designs
- ✓ Undertake site visit and reconnaissance survey
- ✓ Assess the requirement / tests to be conducted in condition survey
- ✓ Coordinate and supervise the condition survey of electrical and electronics components of the lock
- ✓ Performance Assessment of electrical and electronics components including remote operation of the lock
- ✓ Design of electrical and electronics components including remote operation based on modernization / renovation in the lock

Marine/Mechanical Engineer

The expert will be mainly responsible for:

- ✓ Review of available data, reports and designs
- ✓ Undertake site visit and reconnaissance survey

- ✓ Assess the requirement / tests to be conducted in condition survey
- ✓ Coordinate and supervise the condition survey of hydro-mechanical components of the lock
- ✓ Performance Assessment of hydro-mechanical components of the lock
- ✓ Design of hydro-mechanical components based on modernization / renovation in the lock

Environment Expert

The expert will be mainly responsible for:

- ✓ Review of available data, reports and designs
- ✓ Undertake site visit and reconnaissance survey
- ✓ Collection of field data for Rapid EIA
- ✓ Conduct Rapid EIA including EMP

Procurement Expert

The expert will be mainly responsible for:

- ✓ Coordination with bidders for bathymetry survey, geotechnical investigations, etc.
- ✓ Preparation of tender documents for execution of the work

Annexure I

Under the Project Preparation of Detailed Project Report (DPR) for the work of Renovation / Modernization of Existing Navigation Lock

Name of Lock: Farakka Navigation Lock Chamber	State Inventory ID (If Any): _
Owner of Lock: Inland Waterways Authority of India	Purpose of Lock:
Address: Farakka	Hazard Classification:
City/State/ZIP West Bengal	
County: India	Inspected By:
Legal Location:	Date of Inspection:
Latitude:	Estimated Level:
Longitude	Weather Conditions:

NAVIGATIONAL LOCK INSPECTION CHECKLIST

Note: Latitude-Longitude should be measured using a GPS and taken on the crest of the navigational lock at the center.

	Item	Yes	No	N/A	[1]Condition (Satisfactory-Fair-Poor-Unsatisfactory)	Remarks
1	**General Conditions of Navigational Lock**					
A	Alterations to the navigational lock?		No		Poor	
B	Condition of surface water?				Fair	
C	Excessive Vegetation?	Yes			Poor	
D	Settlements, misalignments, or cracks?	Yes			Poor	Investigations Required
E	Recent high-water marks		No			Elevation from MSL
2	**Upstream of Navigational lock**					
A	Erosion, slides, or depressions?	Yes			Poor	
B	Trees or excessive vegetation?	Yes			Poor	
C	Cracks, settlement, or bulges?	Yes			Poor	Investigations Required
D	Evidence of slides or scarps?		No		Poor	
E	Adequate and sound slope protection (rip-rap)?		No		Poor	
3	**Chamber Area of Navigational lock**					
A	Longitudinal or transverse cracking?	Yes			Poor	Investigations Required
B	Trees or excessive vegetation?		No		Poor	
C	Arching or bowing?		No		Poor	
D	Erosion or ruts?	Yes			Poor	Investigations Required
E	Low areas or depressions?	Yes			Poor	Investigations Required
4	**Downstream of Navigational lock**					
A	Erosion, slides, or depressions?	Yes			Poor	
B	Trees or excessive vegetation?	Yes			Poor	
C	Cracks, settlement, or bulges?	Yes			Poor	
D	Drains or wells flowing?		No			
E	Seepage or boils?		No			
5	**Abutment Contacts**					
A	Erosion, cracks, or slides?	Yes			Poor	Investigations Required
B	Seepage or boils?		No			
6	**Inlet Structure**					
A	Concrete? Yes Metal? No					
B	Spalling, cracking, or scaling?	Yes			Poor	Investigations Required
C	Exposed reinforcement?	Yes			Poor	Investigations Required
D	Corrosion present?	Yes			Poor	Investigations Required
E	Coating adequate?	Yes			Poor	Investigations Required
F	Leakage?	Yes			Poor	Investigations Required
G	Trash rack adequate, if any?			NA	Poor	

H	Obstacles to inlet?	Yes			Poor	Investigations Required
7	**Conduit & Outlet**					
A	Concrete? Yes Metal?					
B	Spalling, cracking, or scaling?	Yes			Poor	Investigations Required
C	Exposed reinforcement?	Yes			Poor	Investigations Required
D	Joints displaced or offset?	Yes			Poor	Investigations Required
E	Joint material lost?	Yes			Poor	Investigations Required
F	Leakage of valve or gates?	Yes			Poor	Investigations Required
G	Other leakage?	Yes			Poor	Investigations Required
H	Conduit misaligned?	Yes			Poor	Investigations Required
I	Outlet or channel obstructed?	Yes			Poor	Investigations Required
J	Outlet channel eroding?	Yes			Poor	Investigations Required
8	**Concrete Items (Walls, Slabs)**					
A	Spalling, cracking, or scaling?	Yes			Poor	Investigations Required
B	Exposed reinforcement or deterioration?	Yes			Poor	Investigations Required
C	Joints displaced or offset?	Yes			Poor	Investigations Required
D	Joint material lost?	Yes			Poor	Investigations Required
E	Leakage (joints, cracks, other)?	Yes			Poor	Investigations Required
F	Wall displaced?		No		Poor	
G	Erosion at toe?		No		Poor	
9	**Gates (Gate Leaf, Guide frame Anchorage**					
A	Gates broken or bent?	Yes			Poor	Investigations Required
B	Gates eroded or rusted?	Yes			Poor	Investigations Required
C	Gates operational?	Yes			Poor	Investigations Required
D	Operation Time?				Poor	
E	Gates leaking?	Yes			Poor	Investigations Required
F	Abrasion Present?	Yes			Poor	Investigations Required
G	Deformation?	Yes			Poor	Investigations Required
H	Looseness of the Auxiliary Gate Items?	Yes			Poor	Investigations Required
I	Inspections Frequency and Maintenance Records Present	Yes			Poor	
10	**Instruments**					
A	Structure instrumented?		No		Unsatisfactory	
B	Monitoring performed?		No		Unsatisfactory	
C	Instruments operational?		No		Unsatisfactory	
11	**Development Around Navigational lock**					
A	Are there homes, businesses, or habitable structures located down-stream of the navigational lock?		No		Unsatisfactory	
12	**Emergency Action Plan**					
A	Emergency action plan?		No		Unsatisfactory	
B	Emergency services contacts up-to-date?		No		Unsatisfactory	

Remarks:

1. **NDT Investigations – Rebound hammer Test, Ultasound Tests, Ultrasound Pulse Velocity, Tests required for concrete (lock chamber components) & Ultrasonic Tests for steel mitre/radial/bulkheads gates.**
2. **Crack measurements, settlements, corrosion affect on steel plate thinning.**

[1]**Condition**: Please rate the condition of Sections 1 – 10 on inspection form either: Satisfactory, Fair, Poor or Unsatisfactory.

Satisfactory - No existing or potential navigational lock safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.

Fair - No existing navigational lock safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a navigational lock safety deficiency. Risk may be in the range to take further action.

Poor - A navigational lock safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. Poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential navigational lock safety deficiency. Further investigations and studies are necessary.

Unsatisfactory - A navigational lock safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

CHECK LIST FOR MITRE GATE

Classification	Inspection Portion	Kind Of Inspection / Frequency	Inspection Item	Inspection Method	Inspection Point and Criterion for Judgment	Note
Gate Leaf	General		Cleaning Condition	Visual	There is no drift wood, rubbish and sand around crest, seal section inside a gate leaf, roller section and hinge section. Confirming there is no remarkable dirty mark and adhesion of rope oil.	Wood, rubbish found around gate leaf, hinge section Dirty marks are found on gate structure
	Welding		Crack	Visual And Non-Destructive Testing	Confirming there is no damage causing any obstacle to the function. When visual inspection is not satisfying enough for the judgement, Non-destructive test such as penetrate test and magnetic parcel test should be done.	Weld crack not possible check visually, NDT shall be done to check the same.
	General Structure		Vibration	Visual/Manipulation	Confirming there is no vibration under operation.	Vibration found during operation
			Unusual Sound	Acoustic	Confirming there is no unusual sound under operation.	Unusual sound noticed from hinge bearings
			Hang In One Side	Visual/Measurement	The example allowance of the left-right difference of the top of gate leaf are follows gate span: gate height 1:1, 2:1. 10:1. 20:1 difference (mm) 20 40 100 100	Some hang is observed shall be measured during conditional survey
	Bolt/Nut/Rivet		Looseness・Fall ing Off	Visual And Test Hammer	Confirming there is no looseness using test hammer and visual inspection.	Visually observed that Many bolts are not properly fitted or looseness due

CHECK LIST FOR MITRE GATE

Classification	Inspection Portion	Kind Of Inspection / Frequency	Inspection Item	Inspection Method	Inspection Point and Criterion for Judgment	Note
						to lack of maintenance
	Skin Plate		Deformation	Visual And Scale	In addition to visual inspection, measuring the deformation using scale.	Deformation observed Shall be, measured during conditional survey
			Leakage From Joint	Visual	Confirming there is little leakage by visual inspection.	Leakage found
			Decrease Of Thickness	Visual/Measurement	Confirming there is no remarkable corrosion and wear. Decrease of thickness can be allowed within the permitted range or less.	Heavy corrosion at bottom portion of skin plate, Thickness shall be verified by NDT.
	Main Beam and Other structure		Drain Hole and Air Vent	Visual	Confirming the nozzle keeps clear.	Not applicable
			Defection・Def ormation	Visual/Measurement	In addition to visual inspection, measuring the deformation using scale.	Cannot be observed as this is a box type gate
			Decrease Of Thickness (More Than15years)	Visual/Measurement	Confirming there is no remarkable corrosion and wear. Decrease of thickness can be allowed within the permitted range or less.	
	Relative Dimension (Gate Leaf-Guide Frame）		Relative Dimension	Visual	Confirming that gate leaf open and close without friction.	Cannot be observed may be verified during conditional survey

CHECK LIST FOR MITRE GATE

Classification	Inspection Portion	Kind Of Inspection / Frequency	Inspection Item	Inspection Method	Inspection Point and Criterion for Judgment	Note
	Bearing Of Top hinge		Grease	Visual	Confirming that grease supply system is working correctly. Relevant grease should be used. The amount of grease should be within permitted range or less. There is no grease leakage. (In the case of oil free bearing, grease supply is not necessary.)	Grease supply system is not working, using oil in place of grease
	Rubber Seal		Leakage	Visual	Confirming there is no leakage by visual inspection.	Heavy leakage observed
			Deterioration	Visual	Confirming there is no deterioration of rubber by visual inspection.	Rubber seals are found damaged
			Damage	Visual	Confirming there is no damage of rubber by visual inspection.	Rubber seals are found damaged
			Deformation	Visual And Scale	Confirming there is no deformation by visual inspection. When a deformation is detected, it should be measured using a scale.	Deformations observed by visual inspection
			Abrasion	Visual	Confirming there is no wear by visual inspection	Rubber wears out
Gate Leaf	Clamp Bolt ・Nut		Looseness	Visual And Test Hammer	Confirming there is no looseness using test hammer and visual inspection.	Visually observed that Many bolts are not properly fitted or looseness due to lake of maintenance
			Damage	Visual	Confirming there is no scratch, deformation and corrosion by visual inspection.	found damaged and corroded

CHECK LIST FOR MITRE GATE

Classification	Inspection Portion	Kind Of Inspection / Frequency	Inspection Item	Inspection Method	Inspection Point and Criterion for Judgment	Note
			Falling Off	Visual	Confirming there is no falling off.	
			Leakage	Visual	Confirming there is no leakage from bolt section.	Leakage found
	Clamp Bar		Deformation	Visual And Scale	Confirming there in no deformation. When a deformation is detected, it should be measured using a scale.	Not possible to visualize
Guide frame Anchorage	General		Cleaning Condition	Visual	Confirming there is no draft wood, rubbish and sand. Confirming there is no remarkable dirty mark and adhesion of rope oil.	Wood, rubbish found around gate leaf, hinge section dirty marks are found on gate structure
	Guide Frame		Leakage	Visual	Confirming there is no leakage.	Leakage found
			Damage	Visual	Confirming there is no corrosion, dirty mark and crack by visual inspection.	Heavy corroded and dirty found
			Deformation	Visual /Measurement	Confirming there is no obstacle to gate operation. When recognizing some deformations, measurement of the deformations using scale should be done	Not possible to check visually shall be verified during conditional survey
			Abrasion	Visual /Scale	Confirming there is no remarkable wear by visual inspection.	Little wear observed on support frame
			Leakage	Visual	Confirming there is no leakage by visual inspection.	Leakage observed
	Hinge Support		Damage	Visual	Confirming there is no corrosion, dirty mark and crack by visual inspection.	Some deformation and abrasion

						were noted shall be verified during conditional survey
			Deformation	Visual/Measurement	Confirming there is no obstacle to gate operation. Confirming the rollers support the load uniformly. When recognizing some deformations, measurement of the deformations using scale should be done.	
			Abrasion	Visual/Scale	Confirming there is no remarkable wear by visual inspection.	

CHECK LIST FOR THE SLIDE GATE/FIXED WHEEL GATES – BULKHEAD GATES				
Sl. No.	**Item**	**Yes**	**No**	**Remarks**
Hoist				
a.	Is the operation of hoist smooth?			**No hoist available for operation gate.**
b.	Whether the indicator is provided?			
c.	Is the stop nut provided?			
d.	Check nut and bots of the king post			
e.	Check lubrication			
f.	Observe the king post nut while lifting the gate			
g.	Is correct Tommy bar used?			
Stem Rod				
a.	Are the stem rods in plumb?			**Not Applicable**
b.	Whether the guide bracket bushing touch the stem rods			
c.	Are all the flange bots tight?			
d.	Weather the top stem rod portion is well lubricated and fitted with the indicator.			
Embedded Parts				
a.	Are the seal seats intact?			**All embedded parts were submerged and shall subsequently be check during Conditional Survey**
b.	Have you noticed any pitting, corrosion on these parts?			
c.	Do seals indicate the normal wear and tear			
Leaf				
a.	Inspect the leaf when the water level depletes			**Cannot be done as gates were not in operation**
b.	Check the leaf for the pitting and corrosion.	**Y**		**Heavy pitting and corrosion all over the leaf was observed**
c.	Check the stem rod and leaf connection			**Not Applicable**
d.	Check the leaf seals for the wear and tear	**Y**		**Badly damaged**
e.	Check if there are any foreign particles accumulated near the leaf bottom seal which may obstruct the gate closure.			**Cannot be observed as gates were not in operation**
f.	Does the gate seal properly seat on the embedded part seal			**Cannot be observed as gates were not in operation**
g.	Check the rollers for wear and tear	**Y**		**Rollers were jammed and non-functional**
h.	Check the rollers properly rest & rotate on its track			**Cannot be observed as gates were not in operation**
General				
a.	Are there any leakages from seals or the structure?			**Cannot be observed as gates were not in operation**
b.	Check for the noise			
c.	Check for the vibrations			
d.	Check for the extra effort, if any, during its operation			

CHECK LIST FOR THE SLIDE GATE/FIXED WHEEL GATES – BULKHEAD GATES				
Sl. No.	**Item**	**Yes**	**No**	**Remarks**
e.	Does the gate close due to water pressure or needs adjustments			
f.	Are kaddi shutters provided			
g.	Is the ladder provided safely placed			
h.	Are there any beehives near the gate			NA
i.	Are there any poisonous snakes in the well or near the structure			NA
j.	Are the air vent provided clear			NA
k.	Is the locking arrangement provided on the hoist?			NA
l.	Are the log books properly maintained?		N	No records are maintained as the gates are abandoned for a long time
m.	Is the maintenance properly done?		N	No record of maintenance and the structure is completely scraped
n.	Is any emergency plan drawn to meet the unexpected gate or dam failure?		N	

CHECK LIST FOR RADIAL GATES				
Sl.No.	**Item**	**Yes**	**No**	**Remarks**
Hoist (Mech.)				
a.	Electric	**Y**		**Rudimentary Arrangement is available**
b.	Is the motor working properly?	**Y**		
c.	Are the foundation bolts tight?	**Y**		
d.	Does it draw excess current?			**Shall be analysed during conditional survey**
e.	Is properly earthed?			
f.	Are all phases working?			
g.	Is the generator set working properly?			
Brake				
a.	Are the brakes properly functioning?		**N**	**Rudimentary Arrangement is available to stop the gates' no proper braking mechanism is available.**
b.	Are they tested by lifting the gate load for few centimetres?			
c.	Does it get unlocked while manual cranking?			
Gear Train				
a.	Is adequately lubricated?	**Y**		
b.	Are any foreign particles accidentally left in the train?		**N**	
c.	Is a self-locking hoist?	**Y**		**Rudimentary Arrangement is available**
d.	Is working smoothly?	**Y**		
e.	Do bearing /Bushes get heated?			**Shall be analysed during conditional survey**
Limit Switches				
a.	Are the switches well-adjusted / maintained?	**Y**		**Rudimentary Arrangement is available**
b.	Are these tested?	**Y**		
c.	Is the audio indicator fitted in case upper limit switch fails?		**N**	
Wire Ropes				
a.	Are these properly lubricated?	**Y**		
b.	Whether these are properly clamped?		**N**	
c.	Is there any breakage of strand; found during inspection?		**N**	
d.	Have you inspected the lifting bracket?		**N**	**These were submerged and shall subsequently be check during Conditional Survey**
Trunnions				
a.	Is the pin properly lubricated?			**These were**

CHECK LIST FOR RADIAL GATES				
Sl.No.	**Item**	**Yes**	**No**	**Remarks**
b.	Have you ensured that there are no foreign particles in between the pin end and the inside bracket face?			
c.	Are pin locking nuts tight?			
d.	Does it make any noise while in action?	**Y**		
Anchor Bolts				
a.	Are all anchor bolts tight?			**These were submerged and shall subsequently be check during Conditional Survey**
b.	Are these well protected against aging?			
Seals				
a.	Have you checked the rubber seals for cracking / wear/tear?			**These were submerged and shall subsequently be check during Conditional Survey**
b.	Are the leakages if any within the permissible limit?			**Cannot be verified and may be subsequently be check during Conditional Survey**
Guide Rollers				
a.	Are the rollers free?			**Cannot be verified and may be subsequently be check during Conditional Survey**
b.	Are these well lubricated?			
c.	Are the nut and bolts tight?			
Welding				
a.	Have you inspected all important welded joints?			**Cannot be verified and may be subsequently be check during Conditional Survey**
b.	Do they show signs of distress?			
Embedded Parts				
a.	Are all embedded parts checked for the corrosion / pitting?			**Cannot be verified and may be subsequently be check during Conditional Survey**
b.	Do they need anti corrosive treatment?			
Gate Assembly				
a.	Are gate parts free of rusting and corrosion?			**Cannot be verified and may be subsequently be check during Conditional Survey**
b.	Are all drain holes clear?			
c.	Are all nut and bots tight?			
d.	Does the gate leaf vibrate while opening and closing?	**Y**		
e.	Are there any jerks while lifting or closing the gate?	**Y**		

CHECK LIST FOR RADIAL GATES				
Sl.No.	**Item**	**Yes**	**No**	**Remarks**
Painting				
a.	Does the gate need painting?			**Cannot be verified and may be subsequently be check during Conditional Survey**
b.	Are any signs of corrosion?			
c.	Is Ph value of water checked?			
General				
a.	Are stop log gates provided?	**Y**		**Stoplogs are available but abandoned**
b.	Are the ladders provided are properly placed and safe?		**N**	
c.	Are there any beehives on or near the gate?		**N**	
d.	Is the structure inhibited by snakes?		**N**	
e.	Is the locking arrangement for the gate provided?			**Not applicable**
f.	Are the log book and other record properly maintained?		**N**	**No records were found**
g.	Are you aware of the emergency plan in the event of the gate/dam failure?		**No**	

Annexure II

CONDITIONAL SURVEY OF NAVIGATIONAL LOCK

Purpose

To evaluate for the present condition and operational capabilities of existing hydromechanical components of Farakka navigation lock.

References

TECHNICAL REPORT REMR-OM-7 INSPECTION AND RATING OF MITER LOCK GATES (USACE)

TECHNICAL REPORT REMR-OM-17 REMR MANAGEMENT SYSTEMS—NAVIGATION STRUCTURES, CONDITION RATING PROCEDURES FOR RADIAL DAM AND LOCK GATES

Condition Index (CI)

A condition index is a numerical measure of the current state of a structure. It is part of the goal of this project to define a condition index that uniformly and consistently describes and ranks the condition of mitre lock gate structures. The condition index is primarily a planning tool, with the index values serving as an indicator of the general condition level of the structure.

A common CI definition for the Repair, Evaluation, Maintenance & Rehabilitation (REMR) work has evolved: The REMR condition index is a numbered scale, from 0 to 100, indicating the relative need to perform REMR work because of functional and structural deterioration.

The condition index scale in

Table A2:*1* has been adopted. For management purposes, the condition index scale is calibrated to group structures into three categories or zones (**Table A2:2**).

Table A2:1 Condition Index Scale

VALUE	CONDITION DESCRIPTION
85-100	Excellent--No noticeable defects, some aging or wear visible
70-84	Very Good--Only minor deterioration or defects evident
55-69	Good--Some deterioration or defects evident, function not impaired
40-54	Fair--Moderate deterioration, function not seriously impaired
25-39	Poor--Serious deterioration in at least some portions of structure, function seriously impaired
10-24	Very Poor--Extensive deterioration, barely functional
0-9	Failed--General failure or failure of a major component, no longer functional

Table A2:2 Condition Index Zones

ZONE	CI RANGE	ACTION
1	70-100	Immediate action not required
2	40-69	Economic analysis of repair alternatives recommended to determine appropriate maintenance action
3	0-39	Detailed evaluation required to determine the need for repair, rehabilitation or reconstruction, safety evaluation required

Quantification

The functional condition index is generated using expert analysis and judgement of field data. The experts take many factors into account as they evaluated the functional condition index like:

a) Its performance at normal and below-normal service conditions on a day-to-day basis.
b) Subjective Safety

A series of critical measurements are made on each gate to quantify the functional condition index. The functional condition index is quantified by

$$\text{Functional } CI = 100(0.4)\ X/X_{max}$$

where Xmax is some limiting value of X.

According to the previous description of action zones (**Table A2:2**), Xmax is defined as the point at which the functional condition index is 40, that is, the dividing point between Zones 2 and 3.

Figure A2:1 illustrates the equation and zones from Table 2. If X is 0, that is, no distress, the condition index is 100.

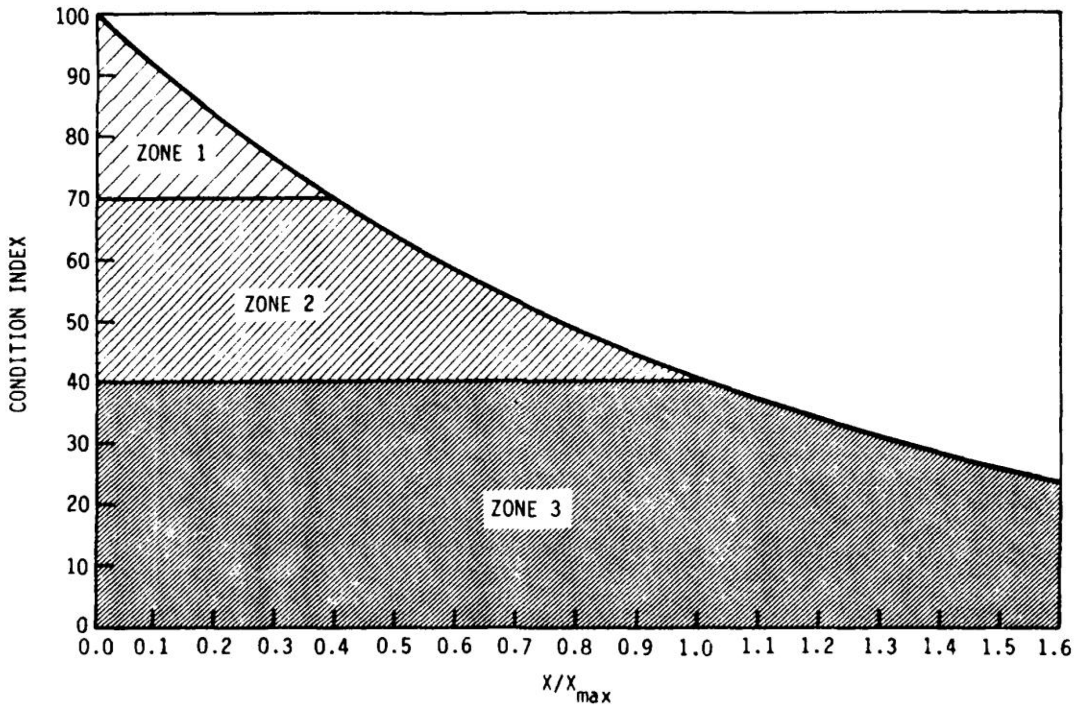


Figure A2:1 Functional condition index related to X/Xmax

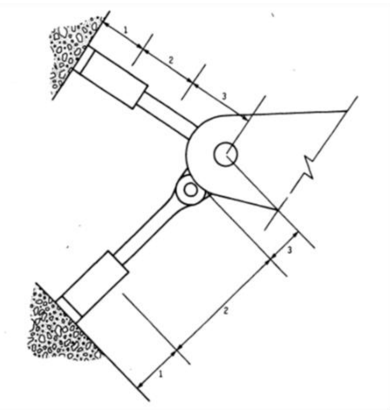
Notes

1. If a structure is designed and constructed properly, it has an initial condition index of 100.
2. The functional condition index never quite reaches 0.
3. The judgment for Xmax based on serviceability or subjective safety considerations. The mix and weight of serviceability versus safety are incorporated.

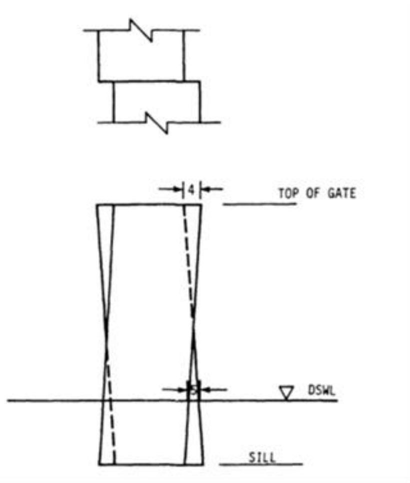
Evaluation Matrix for Hydromechanical Components

Following distress hydromechanical components have been identified and shall be studied to develop the conditional index for them:

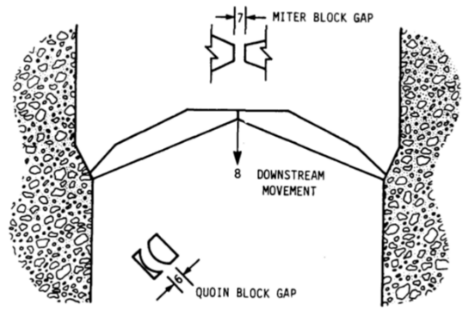
Table 3 Evaluation Matrix for Hydromechanical Components

EVALUATION OF MITRE GATES						
DISTRESS CODE	**DISTRESS**	**BRIEF DESCRIPTION**	**POSSIBLE CAUSES**	**MEASUREMENT**	**LIMITS**	**CI CALCULATION**
1	Top anchorage movement	Motion of the upper anchorage system during gate operation (Dim 1,2 & 3) 	▪ Location 1: Interface of embedded steel with concrete. • Corrosion of steel within embedment. • Failure of concrete at embedment. • Movement of steel within concrete. ▪ Location 2: Embedded steel to eye bar connection. • Wedge pin wear. • Linkage pin or bolt wear. ▪ Location 3: Eye bar to gate leaf connection. • Gudgeon pin wear. • Gudgeon pin bushing wear.	The anchorage dimensions will be measured at the three locations on each anchor bar (parallel and perpendicular): X1: Location 1: X2: Location 2: X3: Location 3: Dimensions will be recorded on the inspection form when the gate leaves are in four positions: Recessed (Fully Open), Near Mitred, Mitred With 1-Ft Head, And Mitred With Full Head (Fully Closed)	Xmax1 = 0.762 mm Xmax2 = 8.63mm Xmax3 = 6.09mm	CI = minimum (CI1, CI 2, CI 3)
2	Elevation change	Vertical displacement of the gate during operation (Dim 4 & 5)	▪ Quoin bearing failure if the elevation change occurs at the quoin as the	Measurement of elevation changes will be made at mitre (M) and (Q) quoin of each gate leaf with the	XQ = maximum ((El 4 – El 2), (El 4	CI = minimum (CIQ, CIM).

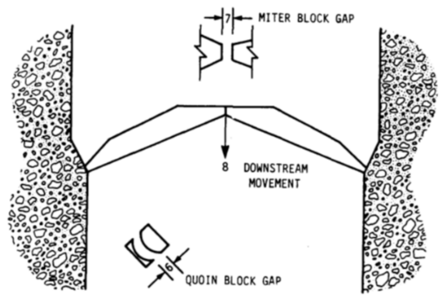
EVALUATION OF MITRE GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
			head is applied. ▪ Premature quoin contact if the elevation change occurs at the mitre as the gate is brought into mitre. ▪ Blocking out a floating pintle if the elevation change occurs at the quoin as the gate is brought to mitre and head is applied.	leaves in four positions: EL1: Recessed (Fully Open), El2: Near Mitred, EL3: Mitred With 1-Ft Head, And EL4: Mitred with Full Head (Fully Closed)	– El 3)] XmaxQ = 0.015 m XM = maximum ((El 3 – El 1), (El 3 – El 2)] XmaxM = 0.032 m	
3	Mitre offset	Misalignment of the bearing blocks at the mitre point (Dim 4 & 5) 	▪ Improper diagonal prestress. ▪ Blockage of sill. ▪ Improper closure. ▪ Improper gate alignment. ▪ Deformed gate. ▪ Malfunctioning mitring device.	For a horizontally framed leaf, the mitre offset will be measured at O1: the top of the gate 02: at the water level with 1 ft of head Y1 and Y2: The distance from the walkway will be recorded at each measurement location	OS = [O1(Y2 - H) + O2 (H – Y1)] / (Y 2 - Y 1) XC = maximum of absolute value (O1, OS) XmaxC = 50.8 mm XA = absolute value of (OS - O1) XmaxA = 50.8 mm	CI = minimum (CIC, CIA)

EVALUATION OF MITRE GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
4	Bearing gaps	Gaps between the bearing blocks at the quoin and mitre (Dim 6,7) 	▪ Anchorage system wear. ▪ Bearing block wear (quoin or mitre). ▪ Shifting of a floating pintle. ▪ Blockage at the sill. ▪ Improper gate alignment. ▪ Deformed gate. ▪ Improper adjustment of anchorage system. ▪ Improper adjustment of gate seals (on vertical frame gates).	For a horizontally framed gate, measurements of the mitre (M) & quoin (Q) block gap will be made at: M/Q G1: the top of the gate M/Q G2: and at the water level under a 1-ft-head situation Y1 and Y2: vertical locations	M/O GS = [M/O G1(Y2 - H) + M/O G2 (H – Y1/Y 2 - Y1) XM = maximum (MGI, MGS) XQ = maximum (QGI, QGS) XmaxM = 12.7 mm XmaxQ = 12.7 mm	CI = minimum (CIM, CIQ)
5	Downstream movement	Downstream displacement of the mitre point as the head is applied (Dim 8)	▪ Shifting of floating pintle. ▪ Failed pintle anchorage (fixed pintle). ▪ Bearing block wear (quoin or mitre blocks). ▪ Sill wear (vertically framed gate). ▪ Blockage at sill.	Measurements of the horizontal movement of the mitre point will be taken at two locations on the downstream face of the mitre point in the mitred position. Longitudinal location will be measured near the top of	LS = [L1 (Y2 - H) + L2(H-Y1)] /Y2 -Y) X = LS Xmax = 101.6 mm	CI = 100(0.4) X/Xmax

EVALUATION OF MITRE GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
			▪ Improper gate alignment at mitre.	the gate and as close to the downstream water surface as possible. A downstream displacement is considered positive L1 and L2 are found by subtracting the measurements at the 1-ft head and full-head positions Y1 and Y2: Displacement and distance from the walkway(respectively)		
6	Cracks	Breaks in the structural steel components	Cracks are caused by fatigue, brittle fracture, or overstressed structural steel components. Often barge or vessel impact is responsible.	The number of occurrences of cracks in the girders (G), skin (S), or intercostals (I) will be recorded on both the upstream and downstream faces of the gate leaf. Size and location of cracks are also recorded but are not used in the calculation of the condition index. That is, one crack in a girder is considered critical. The skin and intercostals are highly redundant and	XmaxG – 1 XmaxS = 10 XmaxI =10	CI = minimum (CIG, CIS, CII)

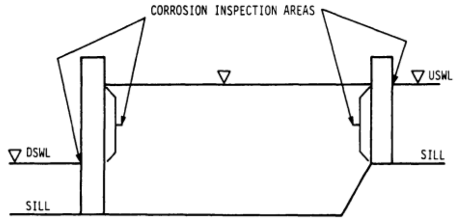
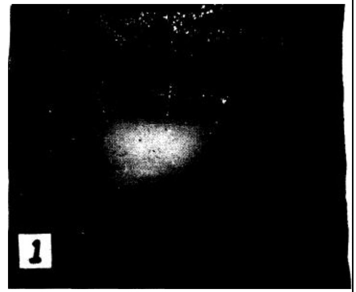
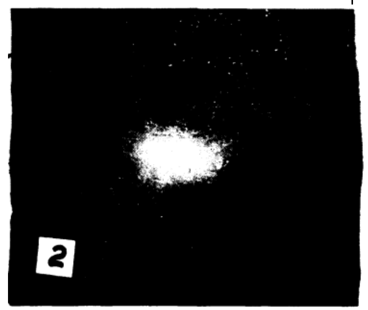
EVALUATION OF MITRE GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				can tolerate more cracks with less severe consequences.		
7	Leaks/boils	Water passing through or around the gate	▪ Corrosion. ▪ Structural cracks. ▪ Vessel impact. ▪ Bearing block wear. ▪ Shifting of a floating pintle. ▪ Blockage at the sill. ▪ Improper gate alignment. ▪ Improper adjustment at anchorage system. ▪ Quoin-bearing material failure. ▪ Seal wear. ▪ Concrete failure behind quoin-bearing plate.	The location and length m, LS, of skin plate leaks are recorded. Point or very short leaks are recorded with a length equal to zero. Point leaks and leaks shorter than 1 ft are added as 1-ft leaks. The location and total length of quoin block, LQ, and mitre block, LM, leaks are also recorded. Boils are leaks that occur underwater (XB)	XS = sum of LS XmaxS = 4.572 m XQM = LQ + LM XmaxQM = 0.33 m X maxB = 3	CI = minimum (CIS,CIQM, CIB)
8	Dents	Disfiguration of the steel components	Dents can be caused by several factors; most often, barge or vessel impact is responsible.	The number of occurrences of dents on the girders, skin, or intercostals will be recorded on both upstream and downstream faces of the gate leaf. Size and location of dents	XmaxG= 1 XmaxS = 10 XmaxI = 3	CI = minimum (CTG, CIS, CII)

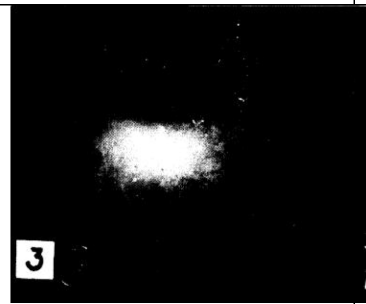
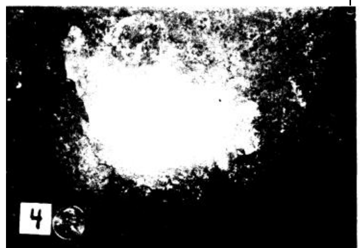
EVALUATION OF MITRE GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				are also recorded but are no, used in CI calculation.		
9	Noise/Vibration	Abnormal noise, vibration, or jumping during gate operation	▪ Load shift in the anchor bars. ▪ Seizing of pintle. ▪ Poorly lubricated pintle system. ▪ Loss of diagonal prestress. ▪ Obstructions at sills or quoins	Noises (other than flapping diagonals) occurring between the fully recessed (0-percent-mitered) and the 25-percent-mitered positions are not used in determine the condition index. Between the 30- and 90-percent-mitred positions, any abnormal noise will affect the condition index. Noises occurring when the gate is over 90 percent closed are not recorded because several routine or normal noises occur at or near the fully mitred position	**Noise, Vibration and Jumping** None Yes, for either of the three Yes, for any two Yes, for all three	**CI** 100 70 40 30
10	Corrosion	Loss of steel due to interaction with the environment	Corrosion generally occurs due to interaction of metal with its environment	The corrosion levels of the girders (G), skin (S), and intercostals (I) will be recorded on both upstream and downstream faces of the gate leaf. The corrosion levels represent the X values.	XmaxG = 3 XmaxS = 4 XmaxI = 4	The condition index for the girder, skin, and intercostal corrosion will be the minimum of the downstream (D) and the upstream (U)

EVALUATION OF MITRE GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				Level 1 : Minor surface scale or widely scattered small pits  Level 2: Considerable surface scale and/or moderate pitting  Level 3: Severe pitting in dense pattern, thickness reduction in local areas		corrosion condition indexes; this is similarly true for the skin and intercostals. CIG = minimum (CI DG, CIUG) CIS = minimum (CIDS CIUS) CII = minimum (CIDI, CIUI) CI = minimum (CIG, CIs, CI 1

EVALUATION OF MITRE GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				 Level 4: Obvious uniform thickness reduction  Level 5: Holes due to thickness reduction and general thickness reduction. 		

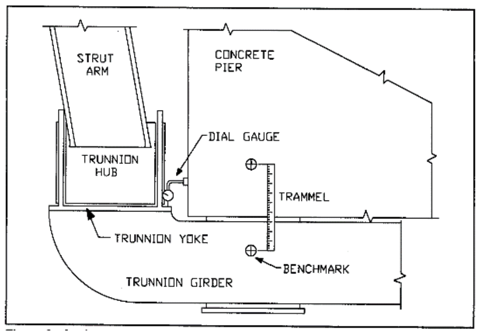
EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS / CI CALCULATION
01	Noise/jump/vibration	Abnormal noise, jumping, or vibration during gate operation	▪ Improper lubrication ▪ Misalignment of gate ▪ Floating debris ▪ Damaged gate	The presence of any noise, jumping, and vibration are recorded as the gate is opened and closed through a 2-ft cycle.	**Noise, Vibration and Jumping** — **CI** None — 100 Yes, for either of the three — 70 Yes, for any two — 40 Yes, for all three — 30
02	Vibration With Flow	Vibration of gate as water flows underneath	▪ Loose Connections ▪ Poor Inflow Conditions ▪ Poor Lip Design ▪ Trash Or Debris.	The level of gate vibration is recorded on the inspection form. The severity of gate vibration and the corresponding CI are determined by comparing sensory observations.	**CI** — **Level** — **Level Description** 100 — 0 — No vibration . 90 — 1 — Feel with finger tips, hear humming noise, or standing water in strut arm ripples 70 — 2 — Large ripples, approximately 1/2 in. high,

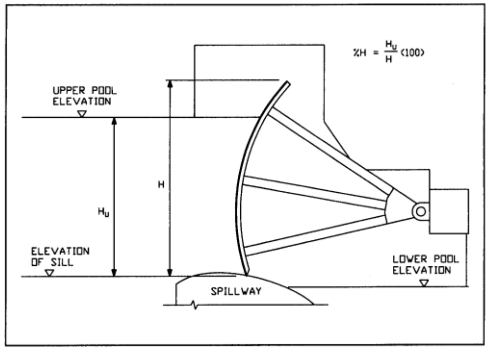
EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
					 40 3 30 4	on upper pool Rattles grating, handrails, and bracing, etc Vibrates or shakes pier
03	Misalignment	Twisting of gate between piers or lock walls during lifting	▪ Cable or chain tension ▪ Trunnion problems ▪ Pier shifting.	Measure a vertical distance from the skin plate to a fixed reference point for the closed, XC, and 2-ft open positions, XO XU = distance each edge of the skin plate rises = XC - XO X = Height differential between the edges of the skin plate = [XUleft – XURight] The absolute value of the difference in the angles for the closed, AC, and the 2-ft open, AO, positions is used to determine the difference	**Xmax = (0.25 in.)(W/H)**	CI = 100(0.4) X/Xmax

EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				in height between each edge of the skin plate as W= Width of the gate X = W tan([AC – AO])		
04	Anchorage Assembly Deterioration	Movement of embedded anchorage system and damaged components 	▪ Corrosion ▪ Concrete Cracking and Spalling ▪ Anchor Bolt Elongation or Movement ▪ Loose Or Missing Casting Bolts ▪ Additional Load	Short- and long-term motion measurements are made under two distinct conditions: ▪ Normal operating conditions Dial gauge measurements are taken in the closed and 2-ft open positions and then again in the closed position. The short-term movement, XS, is found by taking the difference between the 2-ft open and the closed measurements. Trammel measurements are used to measure long-term displacements and are recorded in the closed position after the gate has	▪ NOC If anchorage movement is Rigid, XmaxR(S) = 0.127 mm XmaxR(L) = 3.175 mm If anchorage movement is Flexible, XmaxF(S)= 0.0001(L) mm XmaxF(L)= 0.0025 (L) mm ▪ Bulkhead Condition	CI = Minimum {CIS, CII)

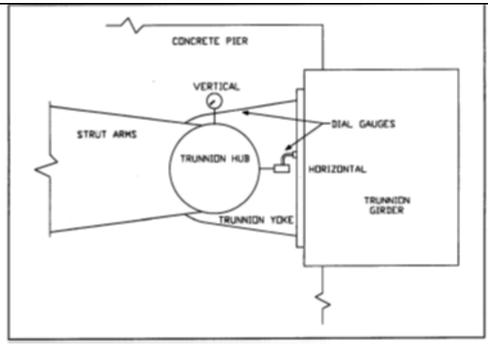
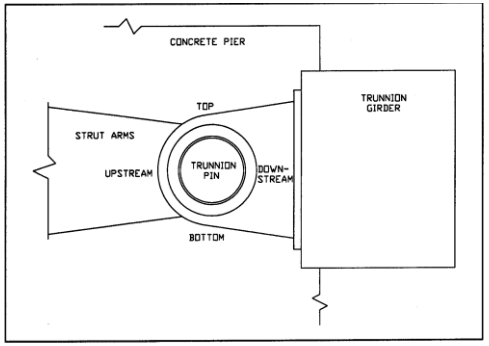
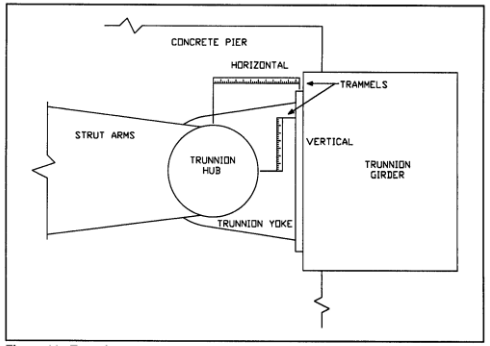
EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				been lifted and reset. This motion, XL, is found by taking the difference between the maximum and minimum trammel measurements (normal operating and bulkhead conditions) since the last repair. At best, trammel measurements can probably be made with 1/32 in. accuracy. ▪ Bulkheaded conditions Dial gauges are used to measure short-term movement under bulkheaded conditions. This displacement, XS, is the difference between the full-head and no-head readings. The limiting value is dependent upon the percent of head present on the gate, %H, which is equal to the head applied to the gate when the bulkhead is removed,	If Head ≤ 20 % XmaxR(S) = 0.127 mm If 20 % ≤ Head ≤ 50 % XmaxR(S) = Refer Eq 3.12 of REMR-OM-17 If Head ≥ 50 % XmaxR(S) = 0.127 mm If Head ≤ 20 % XmaxF(S) = 0.0001 (L) mm If 20 % ≤ Head ≤ 50 % XmaxR(S) = Refer Eq 3.15 of REMR-OM-17 If Head ≥ 50	

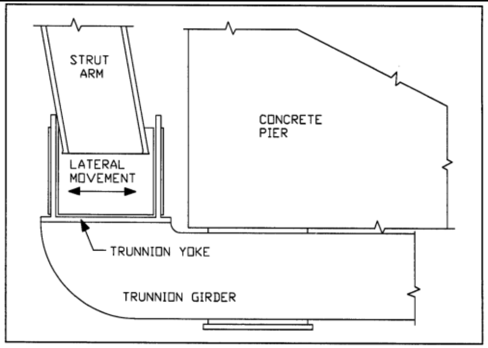
EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				expressed as a percent of gate height, H. If anchorage movement becomes significant, it can be detected by visually inspecting the interface around the anchorage connections. This is usually the first indicator of a significant problem. Any structural cracking or spalling of the concrete in this area will reduce the CI by a factor of 0.85. If any of the anchor or casting bolts and nuts are corroded, loose, or missing, the CI decreases by a 0.70 factor.	% XmaxR(S) = 0.0006 (L) mm	
05	Trunnion Assembly Wear	Displacement between pin and bushing	▪ Improper lubrication ▪ Improper gate alignment ▪ Opening and closing motion	Measurements of relative movement are made in the horizontal, vertical, and lateral directions. As with anchorage	XmaxLAT = 8.12 mm XmaxTOT=	CI = Minimum (CILAT,CTOT)

EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
		  	▪ Jumping and vibration.	assembly deterioration, trunnion assembly wear measurements can be made under normal operating conditions or bulkheaded conditions. The lateral measurement, XLAT, is estimated using a ruler. Measurements taken in the horizontal, XH0R, and vertical, XVER, directions can be made using feeler or dial gauges and trammels XTOT = √(XH0R)^2 + (XVER)^2 The condition of the lubricating system is recorded on the inspection form. If the lubrication system is not functioning properly, it may not be critical, but over a long period of time it can cause accelerated wear in the trunnion assembly. Therefore, a reduction factor of 0.85 is used if lubrication is inadequate	3.125 mm	

EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
						
06	Crack Distress	Breaks in structural steel components	▪ fatigue ▪ brittle fracture ▪ overstressed components.	The number of cracks in the upstream skin (U), downstream skin (D), ribs (R), main girders (M), bracing (B), strut arms (S), trunnion hub (H), trunnion yoke (Y), or trunnion girder (G) are recorded on the inspection form. Length and location of cracks also are recorded but are not used in the calculation of the CI. The limiting values of cracks are handled differently for the remaining components. These components include the strut arms, trunnion	XmaxM = 1 XmaxR = 1 XmaxB = 1 XmaxU = 3 XmaxD = 3	CI = Minimum (CIS, CIG, CIH, CIY, CIM, CIR, CIB, CIU, CID)

EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				girder, trunnion hub, and trunnion yoke. If a crack is present in these components, it could critically affect the overall structural integrity of the gate, should a crack be present on any one of these components, the individual CI for the crack distress should be reduced to 30. But, more importantly, the combined CI for the entire gate should also be reduced to 30.		
07	Dents	Disfiguration of the steel components	▪ Vessel or barge impact ▪ Debris impact ▪ Operation with ice.	The number of dents on the upstream skin plate (U), downstream skin plate (D), strut arms (S), main girders (M), bracing (B), and ribs (R) will be recorded. Size and location of dents also will be recorded, but are not used in the CI calculation.	XmaxM = 1 XmaxR = 3 XmaxB = 3 XmaxU = 10 XmaxD = 10 XmaxD = 1	CI = Minimum (CIS, CIM, CIR, CIB, CIU, CID)
08	Corrosion/Erosion	Loss of steel due to interaction with the environment		To measure the amount of material loss due to corrosion or erosion, the one square foot with the greatest material loss is	On the strut arms, main girders, and trunnion girders	CI = Minimum (CIG, CIB, CIS, CIM, CIR, CID, CIUZ, CIUT, CIUB)

EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				selected. The material loss in this square foot should be designated as corrosion (C) or erosion (E). The average pitting depth, D, and the average pitting diameter, d, are recorded. Within the square foot, either the percent of area, P, that is affected or the number of pits, N, is recorded. Information for this distress is recorded for a variety of radial gate components: upstream skin (U), downstream skin (D), strut arms (S), trunnion girder (G), main girders (M), ribs (R), and bracing (B). Corrosion on the upstream skin is measured at the top (UT), splash zone (UZ), and bottom 2 ft (UB). The X value for this distress is the percent volume of steel loss due to corrosion X = P x D / T T = Thickness of Plate D = Avg. depth of Pit	Xmax = 10% The ribs, upstream and downstream skin plates, and bracing Xmax = 20%	

EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
09	Cable/Chain Plate Wear	Wear on the skin or bearing plate due to sliding action of cable or chain	▪ The wear is caused by the sliding contact between the cable or chain and the surface it bears on while the gate is being raised or lowered	Measurement of this distress is based on the reduced thickness of the bearing surface. The X value is the maximum percent of wear depth on the bearing surface. If a bearing plate is attached to the skin plate, only the thickness of the bearing plate is used to determine the percent of wear depth	Depth loss for a bearing plate XmaxBP = 50 % When a bearing plate is not present, the skin plate acts as the bearing surface and the limiting percent of wear depth is XmaxSP = 50 %	CI = 100(0.4) X/Xmax
10	Leaks	Water passing around the gate	▪ Improper gate alignment ▪ Seal damage.	The length, height, and location of leaks are recorded on the inspection form. Only the length of leaks is used in the calculation of the CI. The X value is the percent of total length with seal distress (that is, the total length of all leaks) divided by the length of the wetted perimeter multiplied by 100.	XmaxS = 30%	CI = 100(0.4) X/Xmax

EVALUATION OF RADIAL GATES

DISTRESS CODE	DISTRESS	BRIEF DESCRIPTION	POSSIBLE CAUSES	MEASUREMENT	LIMITS	CI CALCULATION
				If the gate is submersible, the X value is the total length of all side leaks divided by the length of the wetted side perimeter multiplied by 100.		
11	Seal Condition	Condition of seals	▪ floating debris ▪ improper lifting ▪ normal use over time	Seals are visually inspected for damaged and missing sections. The length and location of these sections are recorded.		

Weighted Conditional Index

When several types of distress occur simultaneously, such as both anchorage movement and offset, he conditions indexes are combined into a single value.

Weighting factors are introduced to reflect the importance of the various distresses.

Functional CI = W1CI 1 + W2CI2 +…….

Table 4 Unadjusted Weighting Factors for Distress (Mitre Gate)

DISTRESS CODE	DISTRESS	WI (%)
1	Top anchorage movement	18
2	Elevation change	14
3	Mitre offset	8
4	Bearing gaps	13
5	Downstream movement	11
6	Cracks	10
7	Leaks/boils	5
8	Dents	2
9	Noise/Vibration	11
10	Corrosion	8

Table 5 Unadjusted Weighting Factors for Distress (Radial Gate)

DISTRESS CODE	DISTRESS	WI (%)
1	Noise/Jump/Vibration	10.6
2	Vibration with flow	11.2
3	Misalignment	8
4	Anchorage assembly deterioration	19.3
5	Trunnion assembly wear	16.4
6	Cracking	11.3
7	Dents	1.6
8	Corrosion/erosion	13.2
9	Cable/chain plate wear	5.8
10	Leaks	2.6
11	Seal condition	--

Annexure III

FIELD MEASUREMENT PROTOCOLS

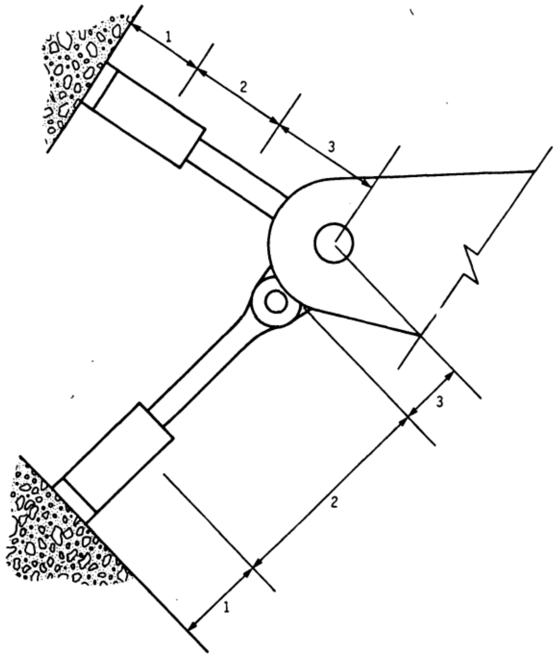
FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL				
Name of Project			**Construction Year**	
Location				
Inspection Date		**Inspected By**		
Gate Identification	**Upstream**		**Downstream**	
Structural Framing	**Horizontal**		**Vertical**	
Type of Pintle	**Fixed**		**Floating**	
Type of Skin Plate	**Single**		**Double**	
Length of Lock Chamber (m)		**Width of Lock Chamber (m)**		
Height of Gate Leaf (m)		**Gate Width (m)**		
Present Pool Water Levels (m)	**U/S Pool**		**D/S Pool**	
Record Low Water Levels (m)	**U/S Pool**		**D/S Pool**	
Record High Water Levels (m)	**U/S Pool**		**D/S Pool**	
Do You Routinely Dewater the Lock Chamber?	**(Y/N)**	**If Yes, What Year Was the Lock Last Dewatered?**		**Interval Period ……. Yrs.**
Are Original Gate Leaves Currently in Place? (Y/N)				
If Not, Identify Current Gate Leaf History				
Are Drawings Available for Gate Leaves in Place? (Y/N)				
Are The Drawings Included with This File? (Y/N)				
Past 10-year History	**Major Maintenance, Repairs, Or Other Modifications**			
Date	Description			

FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL	
Previous Inspections or Structural Reviews (Attach Copies If Available)	
Date	Description
Type Of Fender Protection and Condition of Fenders:	
Type Of Walkway on Gate Leaf and Condition of Walkway:	
Other Comments	
Facing Downstream at Upper Gate, Identify Leaf as Land or River Side	
Left Gate Leaf	
Right Gate Leaf	

Opening And Closing of Gate Leaves				
	Left Gate	Closed	Right Gate	Closed
Do The Diagonals Flap?				
Does The Gate Jump?				
Is There Gate Noise?				
Does The Gate Vibrate?				
Elevations Of Gate Leaf (Measurement In mm)				
Left Leaf	Recessed	Near Mitre	Mitre (1 Foot Head)	Mitre (Full Head)
Quoin				

FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL				
Mitre				
Right Leaf				
Quoin				
Mitre				

Anchorage System Measurement (Dim. 1, 2, 3)

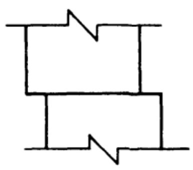


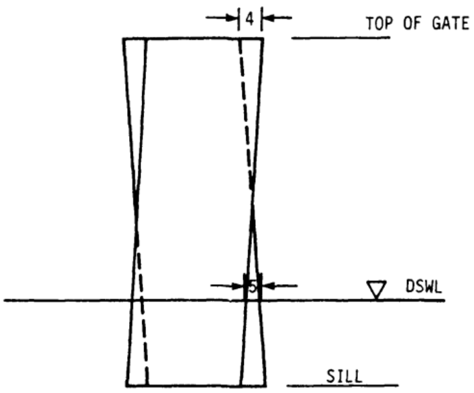
Is The Concrete Cracked or Spalled At Location 1?		
	Left Gate	Right Gate
Parallel Arm	(Y/N)	(Y/N)
Perpendicular Arm	(Y/N)	(Y/N)

Left Gate (Measurement in Mm)				
	Recessed	Near Mitre	Mitre (1 Foot Head)	Mitre (Full Head)
Parallel Arm 1				
Parallel Arm 2				
Parallel Arm 3				
Perpendicular Arm 1				

FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL				
Perpendicular Arm 2				
Perpendicular Arm 3				
Right Gate (Measurement in Mm)				
	Recessed	Near Mitre	Mitre (1 Foot Head)	Mitre (Full Head)
Parallel Arm 1				
Parallel Arm 2				
Parallel Arm 3				
Perpendicular Arm 1				
Perpendicular Arm 2				
Perpendicular Arm 3				

Offset Of Mitre Blocks with Gates At Mitre (1 Foot Head), (Dim. 4, 5)

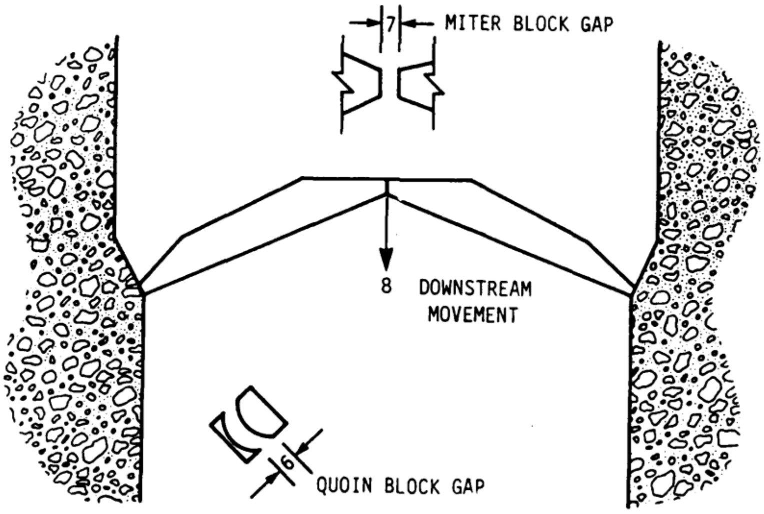




Location	Measurement (mm)	Walkway Distance (m)	Gate Downstream

FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL			
Top			(L/R)
DSWL			(L/R)
(DSWL – Downstream Water Level With 1 Foot Head On Gates)			

Gap Between Bearing Blocks Gates at Mitre (1 Foot Head), (Dim. 6, 7)

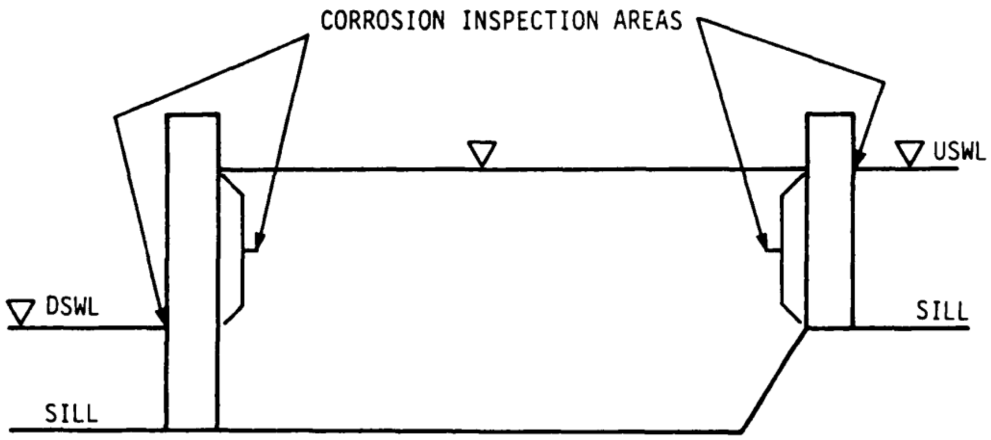


Location	Measurement (Mm)	Walkway Distance (M)
Left Quoin @Top		
Left Quoin @Dswl		
Right Quoin @Top		
Right Quoin @Dswl		
Mitre @Top		
Mitre @Dswl		

Longitudinal Position of Mitre Point

Location	Head (1 Foot)	Full Head	Walkway Distance (M)
Top			
DSWL			
Lock Chamber Filling or Emptying			
Does The Gate Vibrate			

<table>
<tr><th colspan="4">FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL</th></tr>
<tr><td colspan="2">Left Gate</td><td colspan="2">(Y/N)</td></tr>
<tr><td colspan="2">Right Gate</td><td colspan="2">(Y/N)</td></tr>
<tr><td rowspan="3">Does A Leak Follow the Rising or Emptying Water Level & Then Closes Again as The Water Continues to Rise (Empty)</td><td rowspan="3"></td><td>Left Quoin</td><td>(Y/N)</td></tr>
<tr><td>Mitre</td><td>(Y/N)</td></tr>
<tr><td>Right Quoin</td><td>(Y/N)</td></tr>
<tr><td colspan="3">Does the Gap between the Mitre Blocks Changes?</td><td></td></tr>
<tr><td colspan="3">If Yes, Select the most accurate description of the change (No.)</td><td></td></tr>
<tr><td colspan="3">Top Gap opens and remains open</td><td></td></tr>
<tr><td colspan="3">Top of Mitre is closed & gap opens between water line & top</td><td></td></tr>
<tr><td colspan="3">Top of Mitre is closed and Gap between water line & top closes</td><td></td></tr>
<tr><td colspan="3">Estimate The Maximum Width of The Gap (Mm)</td><td></td></tr>
<tr><td colspan="3">Estimate The Location of The Maximum Gap from Walkway (M)</td><td></td></tr>
<tr><td colspan="4">Corrosion at Splash Zone (Level 0,1,2,3,4 and 5)</td></tr>
</table>



	Left Gate (LG)		Right Gate (RG)	
	U/S	D/S	U/S	D/S
Skin plate				
Girder				

FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL				
Intercostal				

Dents - Skin Plate (S), Girders (G), Intercoastal(I)

Gate (L/R)	Component (S, G & I)	Location, Distance from (m)		Size (m)	
		Walkway (m)	Quoin (m)	Height	Width

Dents - Skin Plate (S), Girders (G), Intercoastal(I)

Gate (L/R)	Component (S, G & I)	Location, Distance from (m)		Size (m)	
		Walkway (m)	Quoin (m)	Height	Width

Bearing Blocks Leaks @ Left (L), Mitre (M), or Right (R)

Type – L, M, R	Distance from Walkway (m)	Length (m)

Skin Leaks @ Left Gate (L), Right Gate (R)

Gate (L/R)	Type (H)or/(V)ert	Shortest Distance from		
		Walkway (m)	Quoin (m)	Length (m)

Boils @ Left Gate (L), Right Gate (R), Mitre (M)

Type (L, R, or M)	Distance From Quoin (m)

FARAKKA NAVIGATION LOCK MITRE GATE FIELD MEASUREMENT PROTOCOL	

FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL					
Name of Project				**Construction Year**	
Location					
Inspection Date		**Inspected By**			
Inspection Condition	**Normal Operating**			**Bulkheaded**	
Functional & Location of Gate	**Dam**			**Lock**	
Type of Project	**Powerplant**			**Non Powerplant**	
Type of Gate	**Submersible**			**Non-Submersible**	
Type Framing	**Horizontal**			**Vertical**	
Type of Skin Plate	**Single**			**Double**	
Type of Lifting System	**Chain**			**Cable**	
Gate Width (m)		**Gate Height (m)**		**Gate Radius (m)**	
Upper Pool (m)		**Lower Pool (m)**		**Elevation of Sill (m)**	
Do You Routinely Bulkhead the Gate? (Y/N) If Yes, What Year _______Was the Gate Last Bulkheaded? _________Interval Prd.? ___________					
Is the Original Currently in Place? (Y/N)					
If So, What Year Was It Put into Operation?					
If Not, Identify Current Gate History					
Are Drawings Available for Gate in Place? (Y/N)					
Are The Drawings Included with This File? (Y/N)					
Past 10-year History	**Major Maintenance, Repairs, Or Other Modifications**				
Date	Description				

FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL

Previous Inspections or Structural Reviews (Attach Copies If Available)

Date	Description

Condition Of Lifting Equipment

Condition Of Greasing System

Other Comments

Opening And Closing of The Gate

			Is It Normal?	
Noise?	Y	N	Y	N
Jumping?	Y	N	Y	N
Vibration?	Y	N	Y	N

Vibration With Flow

Gate Vibration (Level 0, 1, 2, 3, Or 4):	
Can Vibration Be Eliminated by Gate Opening Adjustment? Y/N	

Misalignment

How Will Measurements Be Taken? (No.) 1. Tape Measures 2. Electronic Levels	

Complete If Tape Measures Are Used

	Closed	2 Foot Open	Closed
Left Edge (m)			

FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL

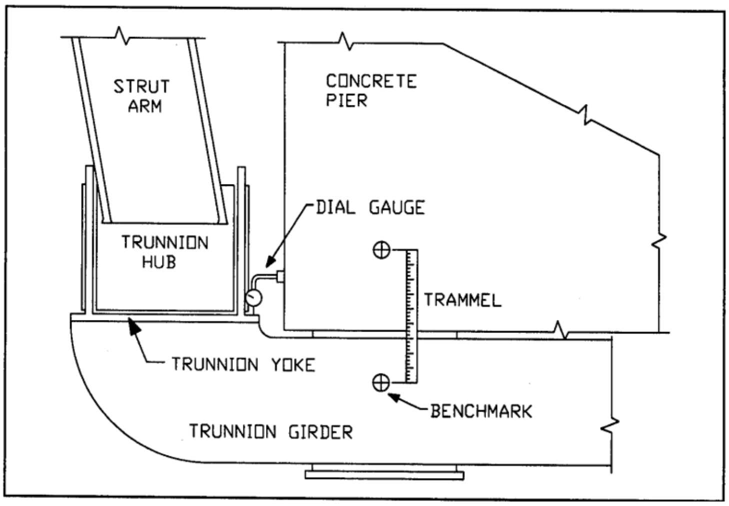
Right Edge (m)			
Complete If Electronic Level Is Used			
	Closed	2 Foot Open	Closed
Angle (Degrees)			

Anchorage Assembly Deterioration

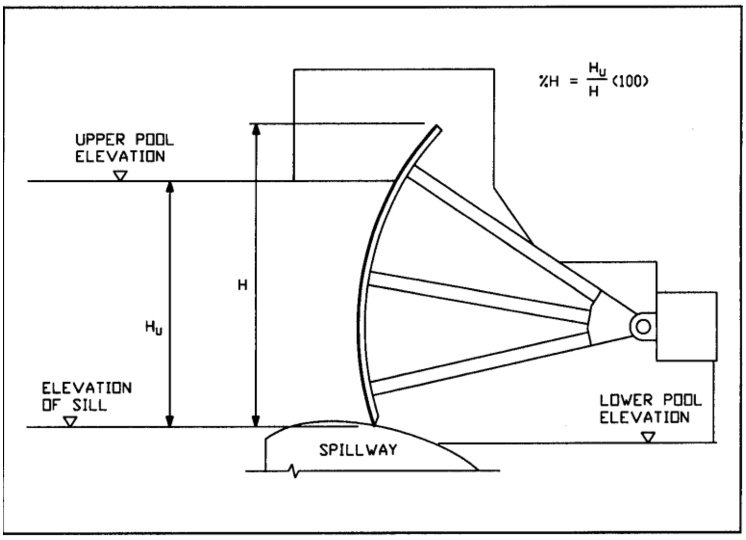
		Left Side		Right Side	
Concrete Cracked or Spalled?		Y	N	Y	N
Bolts/Nuts	Corroded?	Y	N	Y	N
	Loose?	Y	N	Y	N
	Missing?	Y	N	Y	N

Is The Embedded Anchorage Flexible or Rigid?	F	R
If Flexible, Length of Embedment (mm)		

Anchorage Measurement (Measurements are taken in the downstream direction.)



FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL



Complete If Normal Operating Conditions

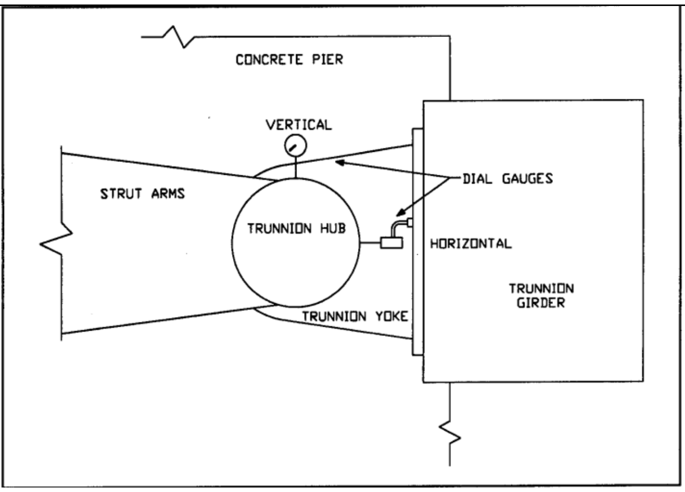
	Left Side (mm)			Right Side (mm)		
	Closed	2 Foot Open	Closed	Closed	2 Foot Open	Closed
Dials						
Trammels						

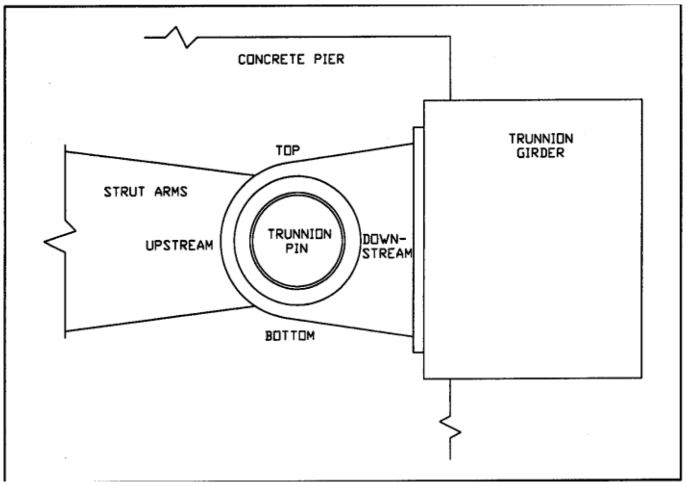
Complete If Bulkheaded Conditions

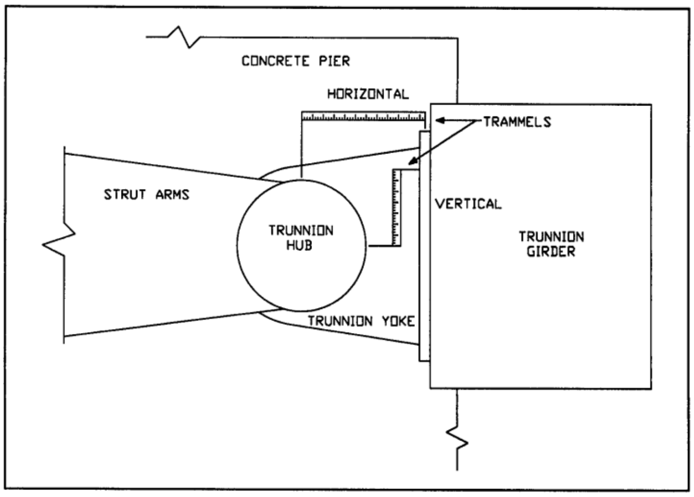
	LEFT SIDE (mm)		RIGHT SIDE (mm)	
	No Head	Full Head	No Head	Full Head
Dials				
Trammels				

Trunnion Assembly Wear

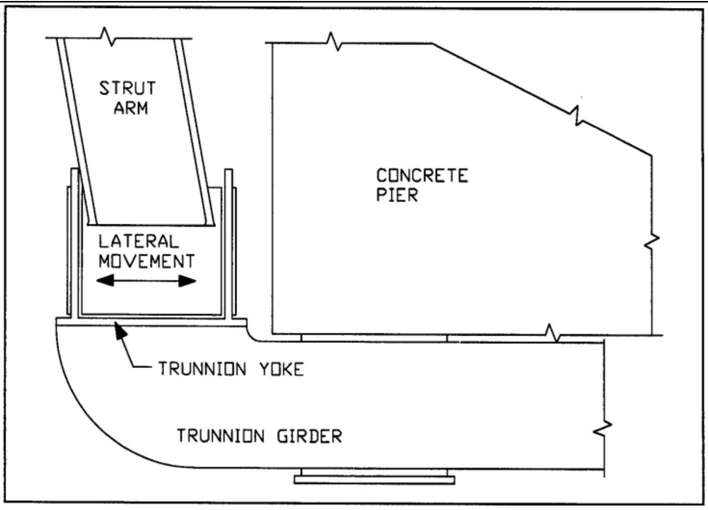
FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL







FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL



Any Problems with The Lubrication System?	Left Side			Right Side		
	Y	N	NA	Y	N	NA
Indicate How Vertical And Horizontal Measurements Will Be Taken: (No.) 1. Feeler Gauges & Trammels 2. Dial Gauges & Trammels						
Complete If Normal Operating Conditions						
	Left Side (mm)			Right Side (mm)		
	Closed	2 Foot Open	Closed	Closed	2 Foot Open	Closed
Horizontal:						
Dials						
Feeler Us						
Feeler Ds						
Trammels						
Vertical:						
Dials						
Feeler Us						
Feeler Ds						
Trammels						

FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL

Lateral	0	1/16	1/8	1/4	3/8	1/2	0	1/16	1/8	1/4	3/8	1/2
Is Any Gouging Noticeable?			Y		N		Y			N		

Complete If Bulkheaded Conditions

	Left Side (mm)			Right Side (mm)		
	Closed	2 Foot Open	Closed	Closed	2 Foot Open	Closed
Horizontal:						
Dials						
Feeler Us						
Feeler Ds						
Trammels						
Vertical:						
Dials						
Feeler Us						
Feeler Ds						
Trammels						

Lateral	0	1/16	1/8	1/4	3/8	1/2	0	1/16	1/8	1/4	3/8	1/2
Is Any Gouging Noticeable?			Y		N		Y			N		

Corrosion (O) Or Erosion (E)

Components	C or E	Sect. Thick	Max. Depth	Avg. Depth	% Area	No. of Pits	Avg. Dia
Us Skin Plate							
Top							
Splash Zone							
Bottom 2 Feet							
Ds Skin Plate							

FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL							
Ribs							
Girders							
Strut Arms							
Bracing							
Trunnion Girder							
Trunnion Hub							
Trunnion Yoke							
Seal'g Surface Stl_							
Lifting Bracket							
Cable/Chain Plate Wear							
Is There a Bearing Plate Attached to The Skin Plate? (Y/N)							
If Yes, What Is the Original Bearing Plate Thickness							
Otherwise, What Is the Original Skin Plate Thickness							
Is The Wear Visible? (Y/N)							
If Yes, Circle the Max. Depth Of Wear							
Left Side (mm)	0	1/16	1/8	1/4	3/8	1/2	0
Right Side (mm)	0	1/16	1/8	1/4	3/8	1/2	0
Cracks							
Record Component, Length, And Location Component U/S Skin Plate (U), D/S Skin Plate (D), Ribs (R), Main Girders (M), Bracing (B), Strut Arms (S), Trunnion Hub (H), Trunnion Yoke (Y), Trunnion Girder (G)							

Component	Length (mm)	Location

FARAKKA NAVIGATION LOCK RADIAL GATE FIELD MEASUREMENT PROTOCOL		

Dents

Record Component, Length, And Location Component: U/S Skin Plate (U), D/S Skin Plate (D)

Component	Height (mm)	Width (mm)	Depth (mm)	Location

Record Component, Length Of Dent, Out Of Plane Distance, And Location

Component: Ribs (R), Main Girders (M), Bracing (B), Strut Arms (S)

Component	Length Of Dent (mm)	Out Of Plane Distance (mm)	Location

Leaks

Record Type, Length, And Location Type: Bottom (B), Left (L), Right (R)

Location (B, L, R)	Length (mm)	Distance From Top/Left (Mm)

Seal Condition

How Many (If Any) Seal Bolts Are Missing? Record Length and Location of Damaged(D) And Missing(M) Sections. Location: Bottom (B), Left (L), Right (R)

Condition (D, M)	Location (B, L, R)	Length (mm)	Distance From Top/Left (mm)