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Investigational and developmental study regarding implementation of sensor based hydraulically operated stainless steel lock gates for controlling salinity and hydraulic particulars

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Abstract –Conventional lock gates are used for both navigational and irrigation purposes. By incorporating modern technologies into conventional methods technically viable and economically feasible efficient canal lock system can be implemented. This system intents to implement automatic more precise and efficient operation to the conventional system with modern design aspects. The proposal is the design and implementation study of an innovative sector lock gate using SS304 material which specifically chosen considering salinity factor. Operated with hydraulic sensor based hoisting mechanism which is more transparent to automation and more efficient both in terms of precision and energy efficiency. The study also details cost estimation and process of fabrication.

Key Words:Lock gates, Hydraulic hoist, Stainless steel lock gates, Salinity, Lock gate design, Fabrication of lock gates

1. INTRODUCTION

Locks are structures used for raising and lowering boats, ships and other watercraft between stretches of water of different levels on river and canal waterways. The difference in water levels may due to tidal variations or can be manmade such as barrage. Sometimes there will be variations in salinity across the two sides of the dam/weir. The most important part of a navigational lock is the operating gates. Fabricated steel structures of different shapes are used widely as lock gates.

Due to the increase in water transports the need arises for constructing larger vessels. Consequently, the marine and inland infra structures should be strengthened to facilitate ship navigation efficiently. These rapid developments bring new challenges on structural design of these infrastructures specifically on lock gates. Many of the lock projects in India are approaching or have exceeded fifty years of age, and it requires improvement or rehabilitation. The engineering considerations for modernization or improvement of navigational lock gates will be identified and studied in this project and presented in the report

2. NEED FOR INNOVATION OF LOCK GATES

The design and implementation of lock gates need to be continuously improvised and innovatively structured so as to meet the changing economic and environmental aspects and to improving the overall functionality such as reliability of the system reduced lock operation time, saltwater intrusion, minimizing energy use, avoiding negative environmental impact, safety and security etc.

3. TECHNICAL ASPECTS OF SECTOR GATES

The material proposed for the fabrication of the lock gates is SS304 having four leaves two each at upstream and downstream relatively. SS304 material is chosen in order to tend to the salinity factor so as to minimize corrosion. As the materials used are corrosion resistant maintenance cost can be considerably reduced in the long run. Also the need of painting and other corrosion resistance techniques that arises in using MS Structural steel can also be eliminated by the use of SS304 material.

3.1 TERMINOLOGIES

- Frame: A structural member embedded in the surrounding supporting structure of a gate, which is required to enable the gate to perform desired function.
- Leaf: The main body of gate consisting of skin plate, stiffeners, horizontal girders and end girders.
- Sill: The top of an embedded structural member on which the gate rests when in closed position.
- Bottom Rollers: Rollers provided on the bottom of the gate to facilitate movements.
- Embedded Part: A structural member embedded in the surrounding supporting structure of a gate which is required to enable the gate to perform desired operations.
- Skin plate: Membrane which transfer the water load on a gate to other components.

- Trunnion Pin: A horizontal axle about which a trunnion hub rotates
- Trunnion tie: A structural tension member connecting two trunnionassembies of a radial gate.

3.2 MATERIAL SPECIFICATION

Table 4.1 Material Specification

Components	Material	Specification
All structural parts such as Skin plate, Vertical stiffeners, Horizontal girders, bracings, arms etc.	Stainless steel	04Cr19Ni9 IS 1570 part V
Guide rollers, Trunnion hub	Cast steel	IS 1030 Grade 280-520W
Roller Pins, Lifting pins etc.	Stainless steel	20Cr13 IS 1570 Part V
Trunnion pin	Stainless steel	20Cr13 IS 1570 Part V
Trunnion bearings	Leaded Tin bronze	LTB1 Is318
Gate Seals	Synthetic rubber with Teflon cladding	IS 11855
Seal seats	Stainless steel	04Cr19Ni9 IS 1570 part V

3.3 MATERIAL DESCRIPTION

Grade 304 "18/8" stainless. It is the most versatile and most widely used stainless steel available. It has an excellent forming and welding characteristics. The balanced austenitic structure of grade 304 enables it to be severely deep drawn without intermediate annealing. Grade 304 can be readily braked or roll-formed into a variety of components

4. HYDRAULIC HOIST FOR SECTOR GATES

The opening and closing of sector gates can be achieved with the aid of hydraulic Hoisting Mechanisms. Thus the speed of shutter operation can be increased without any manpower requirement. The main part of a hydraulic hoist is a double acting hydraulic cylinder, the to and fro motion of the piston regulates shutter operations. Hydraulic cylinders get their power from pressurized hydraulic fluid, which is typically oil.

4.1 COMPONENTS OF A HYDRAULIC HOIST

- Double acting hydraulic cylinder
- Hydraulic power pack
- Control panel

4.2 SPECIFICATIONS OF HYDRAULIC HOUST

Hydraulic Hoist capacity	: 30Tons
Hydraulic cylinder bore diameter	: 180mm
Diameter of the road	: 110mm
Total Stroke	: 4350mm
Working Pressure at head side	: 200Kg/cm2
Test Pressure at head side	: 300Kg/cm2
Working Pressure at cap side	: 125kg/cm2
Test Pressure at cap side	: 188Kg/cm2
Type of hydraulic hoist	: Double Acting
Normal Cylinder closing speed	: 300mm in one minute
Cylinder Opening speed	: 300mm in one minute

5. TENTATIVE DESIGN

The objective of the design process is to achieve an optimal design of a lock and lock approaches that meet the program of requirements in technical, economical and three-dimensional respect, via a structured procedure.

5.1 TECHNICAL DETAILS

No. of gates	: 4 Nos.
Vent width	: 7000mm (14000 / 2)
Vent height	: 4990mm
Height of gate	: 4990 + 150 = 5140mm
Radius to outside of skin plate	:11000mm (from C/L of trunnion)
Apron level	: - 4.270M
Sill level	: - 3.770M
Maximum flood level	: + 1.220M
Shutter level	: + 1.370M
Top level of lock pier	: + 2.000M
Operated by	: Hydraulic hoist

5.2 LAYOUT OF THE GATE

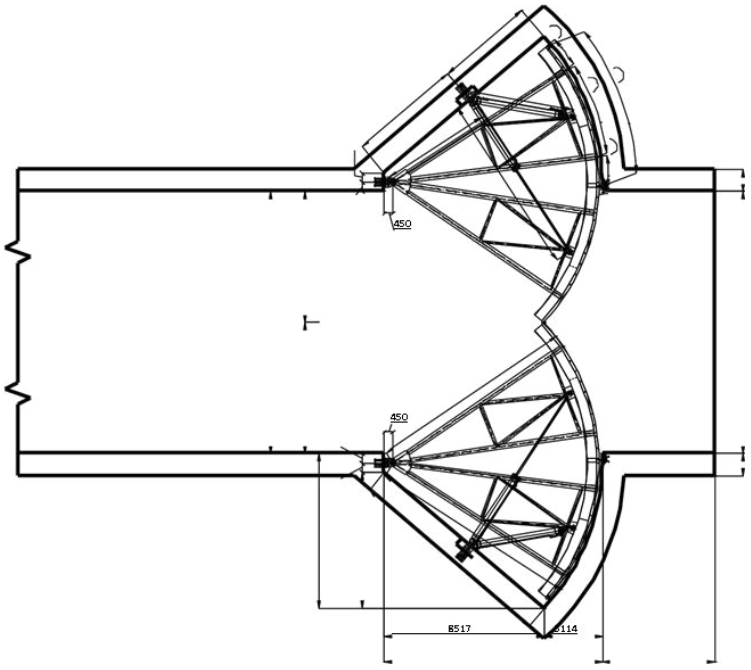

Fig-1: Layout of the gate

Curved length = 8250mm Design head = 4.990M
W = 8.25 X 4.992 / 2 = 102.713t
Lever arm = 5867mm.
Actual stroke = 9695 – 5470 = 4225mm
Stroke provided with adjustment = 4225 + 125 = 4350mm

5.3 LAYOUT OF RADIAL GATE

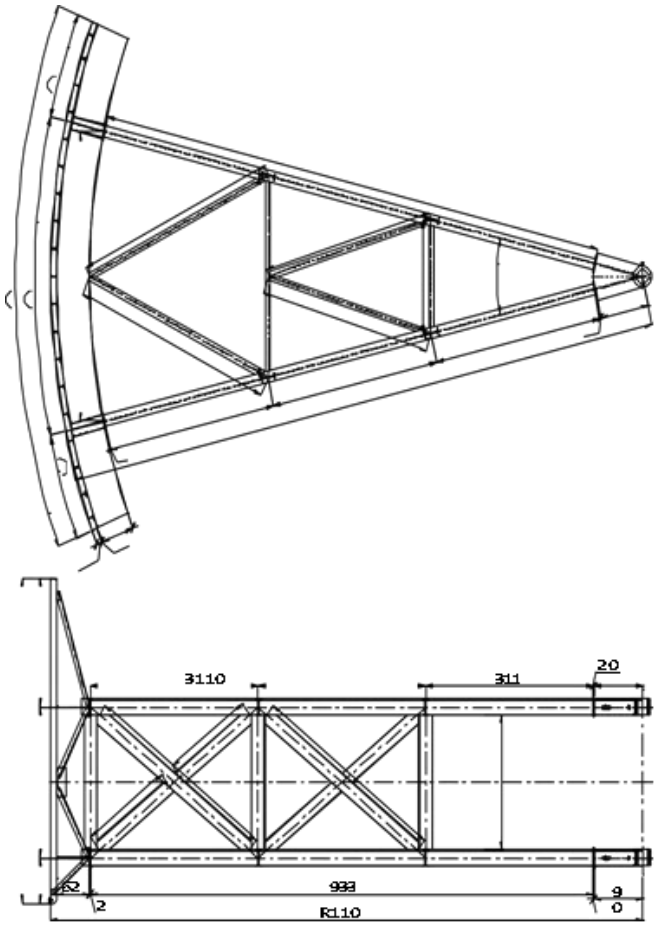

Fig 2: Layout of radial gate

5.4 LAYOUT OF ARM

The load on bottom arm = 28870kg
The load on top arm = 20540kg

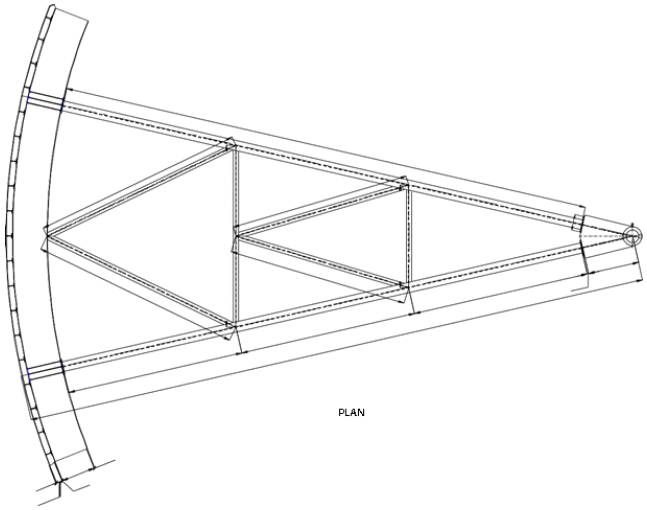

Fig 3: Layout of arm

6. FABRICATION

Structural steel Lock gates are created by performing certain continuous processes in line such as cutting, bending, drilling, machining, welding etc. Each processes have its own significance and all this processes are together known as fabrication. The steps involved in fabrication of Stainless Steel lock gates are explained below.

6.1 SHOP DRAWING:

This drawings include parts & views containing measurements, welding / bolting information, manufacturing standards, descriptions, and are produced to simplify the manufacturing and erection process and steps for the manufacturing teams and erection teams of contractors.

6.2 CUTTING PLAN OF STAINLESS STEEL:

Initially the steels are supplied as steel plates & steel sections of standard dimensions, we may require steels plates in different cut to shapes accordingly the fabrication drawing.

6.3 CUTTING:

Once the cutting plan is ready cutting over stainless steel can be carried out. Plasma cutting machines are used generally for cutting stainless steel. Plasma cutting is a process that cuts through electrically conductive materials by means of an accelerated jet of hot plasma. The high-intensity plasma jet melts a very localized area. The force of the jet (or arc) pushes through the steel and removes the molten metal. This arc easily cuts through metals with poor heat conductivity (stainless steel).

6.4 GRINDING:

After cutting the face of the steel where cutting was carried out is grinded well to make a smooth edge without any projections or surface imperfections.

6.5 WELDING:

Stainless steel gate of required dimension can be obtained by welding the different SS Plates & Sections as per drawing. The technique required to weld stainless steel is not much different from that required to weld standard carbon steel, with two exceptions. First, you must exercise more care and control with regard to heating and cooling stainless steel. Second, it's more important to properly match filler metals with the material being welded. Selecting a filler metal to use with this base metal is a little less straightforward, because there is no 304 filler metal. Instead, the filler metal to use in this case is 308L. It has a slightly different chemistry that allows the filler metal to undergo the rapid solidification and cooling associated with welding without cracking.
Arcaloy 308/308H-16 electrodes were designed for the welding Types 304H & 304 where temperature in excess of 700°F (371°C) requires additional creep strength. The basic-rutile thin coating of Arcaloy 308/308H-16 gives an excellent combination of welding performance in all positions and a high resistance to cracking. Operates on AC or DC current.

10.6 DRILLING:

Holes should be drilled in stainless steel to entrap rubber seals and bolting other associated steal structures. This can be achieved with the help of a magnetic drilling machine. Stainless steel is a very hard material and therefore difficult to cut. the tool steel should be made of HSSE-Co 5 (5% cobalt content), HSSE-Co 8 (8% cobalt content) or solid carbide.
A tool steel that is too soft would immediately overheat.

7. COST ESTIMATION

SL NO.	ITEM DESCRIPTION	QUANTITY	UNIT	RATE	AMOUNT
1	Supply and Fabrication of approved grade AISI 304 SS Plate, Tees, Angles, Joists, ISMB, ISMC including Straightining, Cutting to size, Shaping, Drilling holes, Assembling, Welding, Grinding and Finishing etc. As per approved design and drawing. And conveyance charges.	14300	Kg	395	5648500
3	Conveying and Erecting the SS Fabricated lock gate to the grooves consisting of hoist bracket, Horizontal guider, Vertical guider, arm assembly, guide rollers and brazings and aligning for operaton including Labour charges, Conveyance charges etc. Complete	14300	Kg	15	214500
4	Supply & Fabrication of Primary & Secondary embedded parts such as MS Materials with nut, J hanger shaft and ISMC etc. As per approved Design and Drawing as directed by departmental officers at site including cost of all materials, Labour charges, Conveyance charges etc. Complete.	4500	Kg	120	540000
5	Supply & Fabrication of Secondary Embedded parts using Stainless Steel Gr.304 as per approved Design and Drawing as directed by departmental officers at site including cost of all materials, Labour charges, Conveyance charges etc. Complete.	1200	Kg	395	474000
6	Erection of primary and secondary Embedded parts including Labour charges, Lead and Lift and as directed by departmental officers at site	5700	Kg	7	39900
7	Supplying and Fixing SS Bottom rollers with GM Bush.	5	Nos	30000	150000
8	Supply and Fixing of flat type rubber seal confirming to IS:11855	52	Meter	2000	104000
9	Supply and Fixing of L type rubber seal confirming to IS:11855	48	Meter	3500	168000
10	Supply and Fixing of Z type rubber seal confirming to IS:11855	12	Meter	3500	42000
11	Supply, Installation, Erection, Testing and Commissioning of Double acting Hydraulic hoist (IS10210) 25T Capacity 1 No. for each gate with single power pack and it's accessories including cost of all materials Labour charges, Conveyance charges etc.	4	Nos	2000000	8000000
Total					15380900

Table 2: Cost Estimation

8. CONCLUSION

In this study all the design and technical aspects of implementation of the project is researched and detailed. The most suitable material that has to be fabricated is identified as SS 304and found ideal for preventing salinity. A tentative design is made by considering all the hydraulic particulars and keeping all the Govt./PWD/IWA Norms and standards. The lock gates are designed to prevent saline water ingression as well as transportation of Vessels with change of water levels. Radial shape of the lock gates is capable of withstanding larger water heads and sufficient supports and bracings were given in tentative design so that the gates can be used for high head applications. A bill of quantities of the material is prepared with drawing along with a detailed schedule which involves the description of works that has to be carried out in prescribed quantity with costing.

Cost of the project is comparatively higher than mild steel, but for a long Span it found economically viable and technically feasible.

The hydraulic Hoist operations enables smooth opening and closing of shutters in a faster manner with minimal manpower

New technologies are implemented with advanced production systems and high speed operations which finds advantages over conventional Navigational lock system.

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