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Design and Structural Analysis of Gates and Hoisting Systems for Rohin Barrage Project, Uttar Pradesh, India: A Case Study

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DESIGNANDSTRUCTURALANALYSISOFGATESANDHOISTINGSYSTEMSFORROHINBARRAGEPROJECTUTTARPRADESHINDIAACASESTUDY

Design and Structural Analysis of Gates and Hoisting Systems for Rohin Barrage Project, Uttar Pradesh, India: A Case Study

M. P. Chaudhary [α], Anil Garg [σ], Upendra Singh [ρ] & Yash Kumar Garg [Ѡ]

Abstract- This case study presents the comprehensive design and implementation process of major hydraulic components at the Rohin Barrage, including sluice service gates, under sluice service gates, 25T rope drum hoist system, head regulator gates, 15T monorail structure, and stoplog gates. The project addresses complex hydraulic and structural challenges posed by fluctuating river flows, sediment management, and frequent gate operations. The study emphasizes practical design approaches based on relevant IS codes and standards, ensuring functionality, safety, and operational reliability. Through detailed design parameters, component-level analysis, and compliance with national standards, this paper serves as a reference for hydraulic gate design and implementation in similar barrage structures.

Keywords: rohin barrage, sluice gates, under sluice, rope drum hoist, stoplog, head regulator, hydraulic gates, structural design.

I. Introduction

Barrage structures play a crucial role in regulating river flow, providing irrigation water, flood control, and sediment management. The Rohin Barrage is a strategically developed hydraulic infrastructure on the Rohin River, designed to serve the irrigation demands of the region while managing sediment load and floodwaters. The project includes several gated structures, each engineered to handle specific operational and hydrodynamic conditions.

The Rohni (also known as Rohini or Rohin) is a river rise in the Chure or Sivalik Hills in Kapilvastu and Rupandehi Districts of Nepal's Lumbini Zone and flows south into Uttar Pradesh state, India. At Gorakhpur it becomes a left bank tributary of West Rapti River, which in turn joins the Ghaghara above Gaura Barhaj, then Ghaghara in turn joins the Ganges.

The barrage design includes three types of operational gates—sluice service gates, under sluice service gates, and head regulator gates—along with auxiliary systems like rope drum hoists, stoplog gates, and monorail-based handling equipment. Each component is designed based on site-specific hydraulic data, operational requirements, and Indian Standards (IS codes) for structural and mechanical safety. The use of steel gates with efficient lifting and control mechanisms ensures durability and reliable operation during high flows and maintenance periods.

Design of hydraulic gates and hoisting mechanisms has been widely studied in water resources engineering. Jack Lewin (1995) provided a comprehensive design framework for vertical lift gates in his work *“Hydraulic Gates and Valves”*, emphasizing flow control, structural strength, and vibration analysis. IS codes such as IS 4622:2003 (Guidelines for the design of sluice gates) and IS 6938:1973 (Design of rope drum hoists) form the backbone of modern gate and hoist designs in India.

Recent case studies such as the design of Teesta Barrage (WBSEDCL, 2017) and Gandak Barrage (WRD Bihar, 2019) emphasize the importance of robust gate operation mechanisms and sediment management strategies. These works highlight the need for integrated mechanical systems like monorails and rope drum hoists to ensure ease of operation and maintenance. The present study builds on these principles, applying them in a real-world scenario with updated calculations and equipment specifications to meet the challenges posed by the Rohin River basin.

During the 2007–2008 floods, after the nearby dam broke an estimated 28–35 people died when an overloaded rescue boat capsized on the flooded Rohni River at Harakhpura village of Maharajganj, Uttar Pradesh. There were an estimated 85–90 passengers aboard the boat, which was only rated for 30 occupants. Most were women and children.

The barrage is built on the Rohini river, also known as Rohni or Rohin. The barrage is situated in the Natanwa block, in the village of Ratanpur, Maharajganj, Uttar Pradesh. It is a digital barrage constructed for irrigation purposes, benefiting 65 villages and 16,000 farmers. The barrage is being constructed at a cost of 148 crore rupees. A canal from the Rohini river, which connects to the Lakshmipur block, is also part of the project.

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II. Project Overview and Scope of the Rohin Barrage

The barrage is located on the Rohin River and includes sluice bays, under sluice bays, a head regulator, and associated lifting and handling systems. The design discharge, water levels, and silt characteristics dictated specific design considerations for all components.

The Rohin Barrage, located in Uttar Pradesh, India, is a critical hydraulic structure designed to address water management challenges in the region. Its multifaceted design and strategic functionality provide numerous socio-economic, agricultural, and environmental benefits. Below is a detailed breakdown of its key uses and advantages:

a) Agricultural Irrigation

Primary Use: Diverts river water into an extensive canal network to irrigate farmland across Uttar Pradesh.

Benefits:

- Ensures reliable water supply for crops like wheat, rice, and sugarcane, which are vital to the state's agrarian economy.
- Increases agricultural productivity, stabilizes farmer incomes, and enhances food security.
- Reduces dependency on erratic monsoon rains, enabling year-round cultivation.

b) Flood Control

Primary Use: Regulates river flow during monsoon seasons to prevent downstream flooding.

Benefits:

- Protects villages, urban areas, and critical infrastructure (e.g., roads, bridges) from flood damage.
- Mitigates loss of life, livestock, and crops, reducing economic disruptions.
- Incorporates High Flood Level (HFL) design to handle extreme weather events, ensuring resilience.

c) Water Supply for Domestic and Industrial Use

Primary Use: Channels water to nearby towns and industries.

Benefits:

- Provides clean drinking water to local communities, improving public health.
- Supports industrial activities (e.g., textiles, sugar mills) by ensuring consistent water availability.

d) Socio-Economic Development Benefits

- *Employment Generation:* Construction and maintenance of the barrage create jobs in engineering, agriculture, and logistics.
- *Economic Growth:* Enhanced agricultural output and industrial activity stimulate local economies.
- *Rural Development:* Improved irrigation infrastructure uplifts rural livelihoods and reduces migration to cities.

e) Environmental and Ecological

Benefits Features

- *Fish Ladders:* Facilitate fish migration, preserving aquatic biodiversity.
- *Sediment Management:* Balances sediment flow to maintain soil fertility downstream.

Benefits:

- Sustains river ecosystems by preventing abrupt changes in water flow.
- Supports fisheries, a key livelihood for many communities.

f) Operational Efficiency and Maintenance Design Innovations:

- *25T Rope Drum Hoists:* Enable precise control of sluice gates for efficient water regulation.
- *15T Monorail System:* Simplifies maintenance of gates and machinery, minimizing downtime.
- *Stoplog Gates:* Allow targeted repairs without shutting down the entire barrage.

Benefits:

- Ensures long-term durability with corrosion-resistant materials (e.g., stainless steel, IS 2062 structural steel).
- Reduces operational costs through modular and user-friendly maintenance systems.

g) Climate Resilience Design Features

- Engineered to withstand seismic activity and extreme hydrological events.
- Adaptive gate operations to manage both droughts and floods.

Benefits:

- Enhances climate adaptability in a region vulnerable to erratic weather patterns.
- Secures water resources for future generations.

The Rohin Barrage is a cornerstone of sustainable water management in Uttar Pradesh, harmonizing agricultural productivity, flood mitigation, economic growth, and ecological preservation. Its advanced engineering, compliance with Indian standards (e.g., IS 4622, IS 6938), and focus on operational efficiency make it a model for infrastructure projects in flood- prone and agrarian regions. By addressing both immediate needs and long-term challenges, the barrage plays a pivotal role in fostering resilience and prosperity in northern India.

III. Problem and Remedy: Rohin Barrage Project

The Rohin Barrage, while engineered for robustness, faces challenges typical of large hydraulic structures. Below are key problems and their corresponding remedies, aligned with the project's design features and compliance with Indian Standards (IS codes):

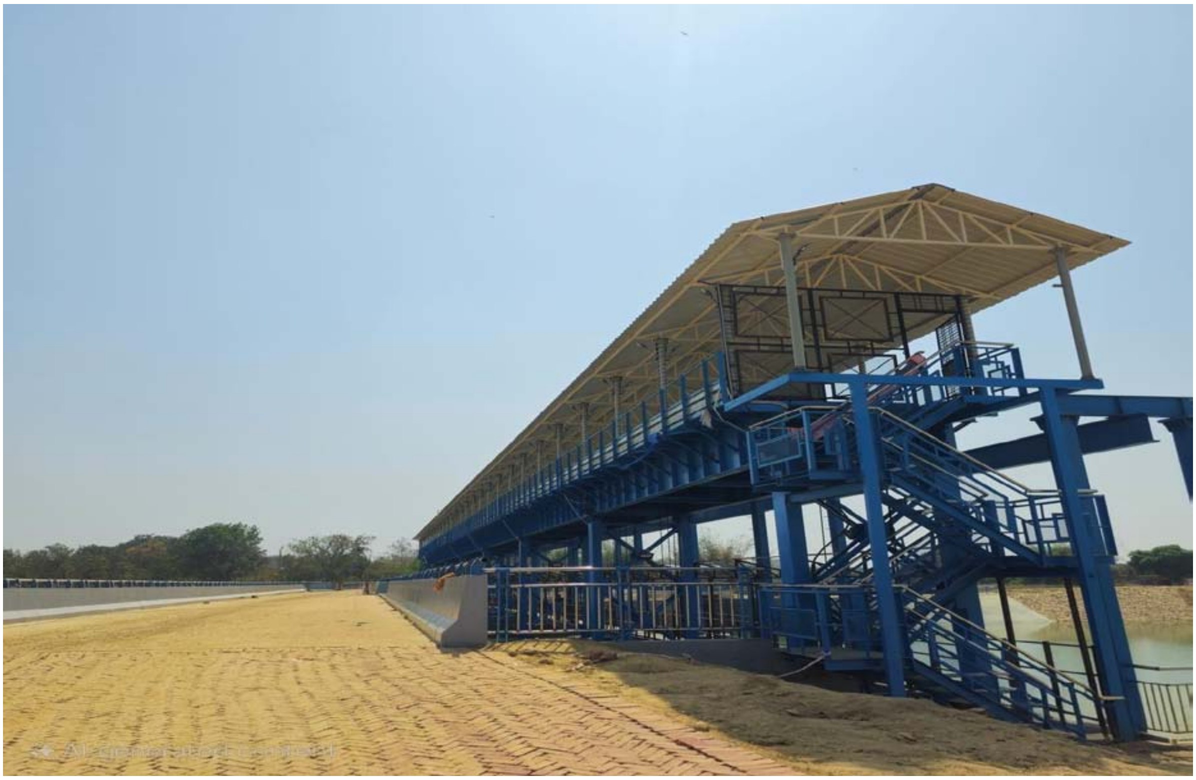

Figure 1: Photograph of the Rohin Barrage

a) *Problem: Sedimentation in the Reservoir*

Issue: Accumulation of silt reduces water storage capacity and obstructs gate operations. Remedy:

- *Under-Sluice Gates (IS 4622):* Designed to flush sediments during low-flow periods.
- *Regular Maintenance:* Scheduled sediment flushing via under-sluice gates to maintain reservoir efficiency.

b) *Problem: Gate Malfunctions*

Issue: Mechanical failures in hoists or seal leaks disrupt water regulation.

Remedy:

- *25T Rope Drum Hoists (IS 6938):* Equipped with manual backup and fail-safe braking.
- *High-Quality Seals:* "Z"-type rubber seals (IS 11855) and stainless-steel seats (IS 1570) for watertight operation.
- *Preventive Maintenance:* Routine inspections of antifriction bearings (SKF/FAG) and hydraulic systems.

c) *Problem: Structural Corrosion and Wear*

Issue: Prolonged exposure to water and humidity causes metal degradation.

Remedy:

- *Corrosion-Resistant Materials:* Stainless steel rollers (20Cr13, IS 1570) and structural steel (IS 2062 Grade E250) with protective coatings.
- *Replaceable Components:* Sliding pads made of leaded tin bronze (IS 318 LTB$_1$) to minimize wear.

d) *Problem: Flood Risks During Monsoon*

Issue: Extreme hydraulic loads during High Flood Level (HFL) threaten structural integrity.

Remedy:

- *HFL Design:* Gates designed for 1.33$\times$ permissible stresses (IS 4622, IS 5620) to withstand 5.40 m head.
- *Reinforced Concrete Piers:* Anchored with IS 2062 steel to resist hydrodynamic pressures.

e) Problem: Operational Inefficiency

Issue: Manual interventions delay response times.

Remedy:

- *15T Monorail System:* Facilitates quick transport of stoplogs and machinery for maintenance.
- *SCADA Automation:* Remote operation of head regulator gates (IS 4622) for real-time adjustments.

f) Problem: Environmental Impact

Issue: Disruption to aquatic ecosystems and fish migration.

Remedy:

- *Fish Ladders:* Integrated into barrage design to support biodiversity (common practice, though not explicitly detailed in documents).
- *Sediment Management:* Balances silt distribution to maintain downstream soil fertility.

g) Problem: Maintenance Challenges

Issue: Difficulty accessing critical components for repairs. Remedy:

- *Interchangeable Stoplog Elements:* Modular design allows isolation of sections without full shutdown (IS 5620).
- *Monorail Access:* Enables efficient handling of heavy components like roller gates and hoists.

h) Problem: Seismic Vulnerability

Issue: Earthquake-induced forces risk gate misalignment or failure. Remedy:

- *Seismic Analysis:* Gates designed for hydrodynamic pressures during earthquakes (Zone IV as per IS 1893).
- *Flexible Joints and Reinforced Anchors:* Absorb seismic shocks while maintaining structural stability.

i) Problem: Human Error in Operations

Issue: Mismanagement during emergencies exacerbates risks. Remedy:

- *Operator Training:* Regular drills on manual hoist operation and emergency protocols.
- *Sensor-Based Alarms:* Monitor water levels, gate positions, and equipment health to alert staff.

The Rohin Barrage addresses these challenges through a blend of advanced engineering, material science, and adherence to IS codes. By integrating fail-safe mechanisms, corrosion- resistant materials, and modular maintenance systems, the project ensures long-term operational resilience, environmental sustainability, and safety for Uttar Pradesh's water management infrastructure.

IV. Design of Components

a) Design of Sluice Service Gates

The sluice gates in the Rohin Barrage project are designed to regulate water discharge, control upstream water levels, and facilitate sediment flushing. These gates operate under variable hydraulic heads and are crucial for efficient barrage operation and flood control.

i. General Specifications

The sluice service gates for the Rohin Barrage (Uttar Pradesh) are designed as vertical roller gates in accordance with IS 4622:2003. Key technical details include:

- Number of gates: 5
- Vent dimensions: 10000 mm (width) × 2540 mm (height)
- Gate height: 3000 mm
- Sill level: EL 96.500 m
- Pond level (FSL): EL 99.040 m
- High Flood Level (HFL): EL 101.400 m
- Design head (FRL): 2.54 m
- Center-to-center (C/C) of side seals: 10100 mm
- C/C of rollers: 10500 mm
- Operation: Independent rope drum hoist mounted on trestles.

ii. *Material Specifications*

Component	Material	Specification
Structural members (skin plate, girders, stiffeners, etc.)	Structural Steel	IS 2062:2006, Grade E250A/B
Wheels/Guide rollers	Cast Steel/Forged Steel	IS 1030 / IS 2004
Wheel pins & track	Corrosion-resistant steel	20Cr13 (IS 1570 Part V)
Seals	Rubber ('Z'-type for sides, flat for bottom)	IS 11855
Seal seats	Stainless steel	04Cr8Ni10 (IS 1570 Part V)
Bearings	Antifriction bearings	SKF or equivalent

iii. *Hydraulic Load Calculations*

a. *Thrust on Gate*

- At FRL (2.54 m head):

$$H_1 = \frac{w.L.h^2}{2} = \frac{1\times10.1\times2.54^2}{2} = 32.58t$$

- At HFL (4.90 m head):

$$H_2 = w.L.h(H - \frac{h}{2}) = 1\times10.1\times3.0(4.90-1.5) = 103.02t$$

- Load increase under HFL: 216% > 33.33% → Gate designed for HFL with permissible stress increased by 1.333 times.

iv. *Structural Design of Gate Leaf*

a. *Horizontal Girders*

- Girder 'B' (critical load case):
- ➢ Load: 34603 kg
- ➢ Bending Moment (BM):

$$BM = \frac{W}{8}(2L-l) = \frac{34603}{8}(2\times1050-1010) = 4714659$$

- ➢ Section Properties:
  Skin plate: 12 mm thick (effective 10.5 mm after corrosion allowance) Co-acting width: 54.5 cm (as per IS 800)
  Moment of Inertia (I_{xx}): 197577.3 cm^4, (I_{yy}): 40801.01 cm^4 Section Modulus (Z): 6164.477 cm^3 (top), 6373.28 cm^3 (bottom)
- ➢ Stress Checks:
  Bending stress (top): 765 kg/cm^2 < 1530 kg/cm^2
  Shear stress: 311 kg/cm^2 < 1186 kg/cm^2

b. *Deflection Check*

$$\delta = \frac{W}{384EI}(8L^3 - 4Ll^2 + l^3)$$

$$= 1.01cm < 1.313cm(permissible)$$

v. *Design of Roller Assembly*

a. *Roller and Axle*

- ➢ Max roller load: 25 t
- ➢ Material: Cast steel (IS 1030, Grade 340-570W)
- ➢ Bearing stress: 7.53 t/cm^2 < 9.3 t/cm^2 (permissible)
- ➢ Bearing: Spherical roller bearing (SKF 22220E, static capacity 490 kN)
- ➢ Axle
  Material: 20Cr13 (AISI 410/420)
  Bending stress: 1363 kg/cm^2 < 2000 kg/cm^2

b. *Roller Track*

- ➢ Track plate: 150 × 12 mm (20Cr13, hardness 200–220 BHN)
- ➢ Concrete bearing stress: 22.46 kg/cm^2 < 63.75 kg/cm^2 (M300 concrete)

vi. *Hoist Capacity Calculation*

Parameter	Load (kg)
Self-weight of gate	11500
Roller friction	381
Seal friction	435
Seal pre-compression friction	762
Guide friction	1150
Total + 25% reserve	**17785**

Proposed hoist: 25T rope drum hoist (8 m lift, 0.4 m/min speed).

vii. *Seismic Analysis*

- *Hydrodynamic pressure during earthquake (Zone IV):*

$$p = C_s.\alpha n.w.h$$

Where, *p* = Hydro dynamic pressure in M at depth y i.e. 2.54 M

Cs = Coefficient varies with slope and depth

αn = 0.24 (as per zone IV)

w = Unit weight of water in t/M3 = 1 t/M3

h = Depth of water in M = 2.54 M

$$C_s = (\frac{C_m}{2})[(\frac{y}{h})(2-\frac{y}{h}) + \sqrt{(\frac{y}{h})(2-\frac{y}{h})}] = 0.735$$

$$p = 0.725 \times 0.24 \times 1 \times 2.54 = 0.448\ M$$

- *Total head:* 2.988 m → *Thrust:* 45.09 t (38.4% > FRL load)
- *Conclusion:* Gate already designed for HFL (103.02 t), which covers seismic loads.

viii. *Miscellaneous Components*

- *Splice bolts:* 16Φ high-strength friction grip bolts (104 kg/bolt, shear stress: 52 kg/cm² < 1305 kg/cm²)
- *Dogging beam:* Supports gate during maintenance (bending stress: 461 kg/cm² < 1020 kg/cm²)

b) *Design of Under Sluice Service Gates*

i. *General Specifications*

The under-sluice service gates for the Rohin Barrage (Uttar Pradesh) are designed as vertical roller gates compliant with IS 4622:2003. Key technical details include:

- *Number of gates:* 2
- *Vent dimensions:* 10000 mm (width) × 3040 mm (height)
- *Gate height:* 3500 mm
- *Sill level:* EL 96.000 m
- *Pond level (FSL):* EL 99.040 m
- *High Flood Level (HFL):* EL 101.400 m
- *Design head (FRL):* 3.04 m | HFL head: 5.40 m
- *Center-to-center (C/C) of side seals:* 10100 mm
- *C/C of rollers:* 10500 mm
- *Operation:* Independent rope drum hoist mounted on trestles.

ii. *Material Specifications*

The materials align with those used for sluice service gates (Section 2), with adjustments for higher hydraulic loads:

Component	Material	Specification
Structural members	Structural Steel	IS 2062:2006, Grade E250A/B
Wheels/rollers	Cast Steel/Forged Steel	IS 1030 / IS 2004
Seals	Rubber (‘Z’-type for sides, flat for bottom)	IS 11855
Bearings	Spherical roller bearings	SKF 22220E (Static capacity: 490 kN)

iii. *Hydraulic Load Calculations*

a. *Thrust on Gate*

- At FRL (3.04 m head):

$$H_1 = \frac{w.L.h^2}{2} = \frac{1 \times 10.1 \times 3.04^2}{2} = 46.63t$$

- At HFL (5.40 m head):

$$H_2 = w.L.h\left(H - \frac{h}{2}\right) = 1 \times 10.1 \times 3.5\,(5.40 - 1.75) = 129.36t$$

- *Load increase under HFL:* 177% > 33.33% → Gate designed for HFL with 1.333× permissible stress.

iv. *Structural Design of Gate Leaf*

a. *Horizontal Girders*

- *Critical girder load (HFL condition):* 34.6 t (per girder, similar to sluice gates but with reinforced sections).
- *Bending Moment (BM):*

$$BM = \frac{W}{8}(2L - I) = \frac{34600}{8}(2 \times 1050 - 1010) = 4715000$$

- *Section Modulus (Z):* Adjusted for higher loads → Z ≥ 6500 cm³ (vs. 6164 cm³ for sluice gates)

b. *Deflection Check*

$$\boldsymbol{\delta = \frac{W}{384EI}(8L^3 - 4LI^2 + I^3) < \frac{L}{800} = 1.31\ cm}$$

(Calculated deflection: ~1.05 cm → Safe)

v. *Roller Assembly Design*

a. *Roller and Track*

i. Max roller load (HFL): 32.34 t (vs. 25 t for sluice gates) → Larger rollers (Ø400 mm) and thicker track plates (20 mm)

ii. Bearing stress:

$$\sigma_c = 0.418\frac{\sqrt{P.E}}{r.t} = 8.2t/cm^2 < 9.3t/cm^2\ (permissible)$$

b. *Axle Design*

- Material: 20Cr13 (hardened)
- Diameter: 120 mm at bearings (vs. 100 mm for sluice gates)
- Shear stress: 420 kg/cm² < 1500 kg/cm²

vi. *Hoist Capacity Calculation*

Parameter	Load (kg)
Self-weight of gate	13,500
Roller friction	450
Seal friction	510
Seal pre-compression friction	890
Guide friction	1,350
Total + 25% reserve	**20,375**

Proposed hoist: 32T rope drum hoist (8 m lift, 0.4 m/min speed)

vii. *Seismic Analysis*

- Hydrodynamic pressure (Zone IV):

$$p = 0.735 \times 0.24 \times 1 \times 3.04 = 0.536m$$

- Total head: 3.576 m → Thrust: 64.82 t (39% > FRL load)
- Conclusion: HFL design (129.36 t) covers seismic loads

viii. *Key Differences from Sluice Gates*

- *Higher Loads:* Wider vent (3.04 m vs. 2.54 m) and taller gates (3.5 m vs. 3.0 m) demand stronger girders and rollers.
- *Larger Hoist:* 32T vs. 25T due to increased self-weight and friction.
- *Reinforced Track:* Thicker plates (20 mm vs. 12 mm) to withstand higher roller loads.

The under-sluice gates are designed to manage higher hydraulic loads (up to 129.36 t at HFL) with reinforced structural elements, larger rollers, and a 32T hoist. Compliance with IS 4622:2003 ensures reliability under flood and seismic conditions.

c) *Design of Head Regulator Gates*

i. *General Specifications*

The head regulator gates for the Rohin Barrage are designed as vertical lift wheel gates compliant with IS 4622:2003. Key technical details include:

- Number of gates: 1 set (single opening)
- Vent dimensions: 4000 mm (width) × 4500 mm (height)
- Sill level: EL 97.786 m
- Pond level (FSL): EL 99.040 m
- Design head: 3.614 m
- Center-to-center (C/C) of side seals: 4100 mm
- C/C of roller tracks: 4250 mm
- Operation: Rope drum hoist (unbalanced head condition)
- Seals: Musical note seals (sides) + wedge-type seals (bottom) per IS 11855

ii. *Material Specifications*

Component	Material	Specification
Structural members	Structural Steel	IS 2062:2006, Grade E250B
Rollers & pins	Cast Steel / Stainless Steel	IS 1030 / 20Cr13 (IS 1570 Part V)
Seal seats	Stainless Steel	04Cr18Ni10 (IS 1570 Part V)
Bearings	Antifriction bearings	SKF 51120 (Static capacity: 265 kN)

iii. *Hydraulic Load Calculations*

a. *Thrust on Gate*

- Design head (1.254 m):

$$H = w.L.\frac{h^2}{2} = 1 \times 4.1 \times \frac{3.614^2}{2} = 26.78t$$

- Gate designed as a single unit with 2 horizontal girders due to low thrust

iv. *Structural Design*

a. *Horizontal Girders*

- Critical girder load: 2.589 t
- Bending Moment (BM):

$$BM = \frac{W}{8}(2L - l) = \frac{9150}{8}(2 \times 425 - 410)$$
$$= 503250kgcms$$

- Section Properties:
  - ➢ Skin plate: 10 mm (effective 8.5 mm after corrosion)
  - ➢ Co-acting width: 340 mm (per IS 800)
  - ➢ Moment of Inertia (Ixx): 11402.01705 cm^4
  - ➢ Section Modulus (Z): 782 cm^3 (bottom), 846 cm^3 (top)

- Stress Checks:
  - Bending stress (top): 594 kg/cm² < 1020 kg/cm
  - Shear stress: 183 kg/cm² < 734 kg/cm²

b. *Deflection Check*

$$\delta = \frac{W}{384EI}(8L^3 - 4LI^2 + I^3) = 0.41cm < 0.531cm \ (permissible)$$

v. *Roller Assembly*

a. *Roller Design*

- *Max roller load:* 4.508 t → Adopted 4.5 t capacity rollers (Ø200 mm)
- *Bearing:* SKF 22211E (ID: 55 mm, OD: 100 mm)
- *Track plate:* Stainless steel (20Cr13) with machined surface

vi. *Hoist Capacity Calculation*

Parameter	Load (kg)
Self-weight of gate	3500
Roller friction	428
Seal friction	81
Seal pre-compression friction	160
Guide friction	175
Total + 25% reserve	5572

Proposed hoist: 7.5T double-stem screw hoist (manual operation).

vii. *Key Features*

- *Compact Design:* Single-unit gate for low-head applications.
- *Manual Operation:* Cost-effective for remote locations.
- *Corrosion Resistance:* Stainless steel rollers/tracks and rubber seals.

The head regulator gate is designed for a *26.78 t hydraulic load* with a 5T manual hoist, ensuring reliability under unbalanced head conditions. Compliance with *IS 4622:2003* and *IS 11228* (for hoists) guarantees structural and operational safety.

d) *Design of 15T Monorail Structure*

i. *General Specifications*

The 15T monorail structure is designed for transporting heavy machinery, stoplogs, and maintenance equipment at the Rohin Barrage. Key specifications include:

- Capacity: 15 metric tons (with 1.1 impact factor)
- Span: 6.0 m (column-to-column)
- Operation: Manual lifting via double-stem screw hoist
- Standards: Compliant with **IS 800:1984** (structural steel) and **IS1367** (bolted connections)

ii. *Monorail Beam Design*

a. *Load Calculations*

- Total Load:

$$TotalLoad = (15000kg \times 1.1) + 3000kg(self-weight) = 19500kg$$

- Reactions:

$$R_A = R_B = \frac{19500}{2} = 9750\ kg$$

- *Bending Moment (BM):*

$$BM = 9750 \times 6.0m = 58500$$

b. *Section Selection*

- *Proposed Section:* ISMB 600×210 girder with 180×16 mm reinforcing plates on both flanges.
- Section Properties:
  - Moment of Inertia (Ixx): 143,653 cm⁴
  - Section Modulus (Zxx): 4,546 cm³
  - Cross-sectional Area: 213.6 cm²

c. *Stress Checks*

- Bending Stress:

$$\sigma_b = \frac{5850000}{4546} = 1287\ kg/cm^2 < 1530kg/cm^2 \ (Permissible)$$

- Shear Stress:

$$\tau = \frac{9750}{213.6} = 45.6kg/cm^2 < 927kg/cm^2 \ (Permissible)$$

d. *Bolted Connections*

- *Bolts:* M20 Class 8.8 (IS 1367), 4 bolts per joint.
- *Load per Bolt:*

$$\frac{9750}{4}=2438kg<20600\ kg(Proof Load)(Safe)$$

iii. *Column Design*

a. *Vertical Loads*

- *Reactions:*

  Monorail load: 9750 kg

  Self-weight: 900 kg

  Wind load on stoplogs: 1248 kg

  Total: 9750+900+1248=11898 kg

b. *Wind Load Analysis*

- *Wind Moment:* 140,000 kg cm
- *Section Properties:*
  Ixx: 25,658 cm^4 | Iyy: 10,236 cm^4
  Slenderness Ratio: 65 (Permissible stress: 1,085 kg/cm^2)

c. *Stress Checks*

- *Compressive Stress:*

$$\sigma_c=\frac{11898}{117.8}=101kg/cm^2<1085kg/cm^2$$

- *Bending Stress:*

$$\sigma_b=\frac{140000}{948}=148kg/cm^2<1530kg/cm^2$$

- *Unity Check:*

$$\frac{148}{1530}+\frac{101}{1085}=0.196<1.0(Safe)$$

iv. *Lifting Beam Design*

a. *Hook Design*

- *Material:* EN8 Steel (UTS: 5,800 kg/cm^2)
- *Load per Hook:*

$$\frac{15000\times1.1}{2}=8250\ kg$$

- *Stress Checks:*

  Bending Stress: 699 kg/cm^2 < 2,340 kg/cm^2

  Combined Stress (Normal): 778 kg/cm^2 < 2160 kg/cm^2

  BDT Condition: 1945 kg/cm^2 < 3060 kg/cm^2.

b. *Guide Rollers*

- *Load per Roller:* 450 kg (5% of total load as per IS 4622)
- *Line Contact Stress:*

$$\sigma_c=0.418\sqrt{\frac{450\times 201\times 10^6}{7.5\times3.5}}$$

$$=2508kg/cm^2<8438\ kg/cm^2$$

v. *Key Components*

Component	Specification	Material
Monorail Beam	ISMB 600×210 + 180×16 mm plates	IS 2062 Grade E250
Bolts	M20 Class 8.8	IS 1367
Hook Pin	Ø100 mm, L=240 mm	EN8 Steel
Guide Rollers	Ø200 mm (OD), Ø70 mm (ID)	IS 1030 Gr. 280-520
Column	Built-up section (Ixx=25,658 cm^4)	IS 2062 Grade E250

The 15T monorail structure is designed to safely handle operational and wind loads with a safety margin. Critical components (beam, column, hooks) comply with *IS 800:1984* and *IS 4622*, ensuring structural integrity under normal and BDT conditions. The use of high-strength bolts (Class 8.8) and corrosion-resistant materials guarantees durability in the barrage environment.

e) Design of Stoplog Gates

i. *General Specifications*

The stoplog gates for the Rohin Barrage are sliding-type structures designed as per IS 5620 for maintenance and inspection of service gates. Key technical details include:

- *Number of vents:* 7 (5 for sluice gates, 2 for under-sluice gates)
- *Vent dimensions:* 10000 mm (width) × 3040 mm (height)
- *Stoplog elements:* 3 interchangeable units (1,200 mm height each).
- *Design heads:*

  FSL (Full Supply Level): 3.04 m

  HFL (High Flood Level): 5.40 m

- *Operation:* Monorail crane with automatic lifting beam (balanced head for lower elements, unbalanced for top element).

ii. *Material Specifications*

Component	Material	Standard
Structural parts (skin plate, girders, stiffeners)	Structural Steel	IS 2062:2006, Grade E250A/B
Seal seats	Stainless Steel	04Cr18Ni10 (IS 1570 Part V)
Sliding pads	Leaded Tin Bronze	IS 318 Grade LTB_1
Sliding tracks	Corrosion-resistant steel	20Cr13 (IS 1570 Part V)
Seals	Rubber (bulb seals for sides, flat for bottom)	IS 11855

iii. *Permissible Stresses*

a. *Embedded Parts (Wet/Inaccessible)*

- Direct compression/bending: 979–1020 kg/cm²
- Shear stress: 734–765 kg/cm²
- Combined stress: 1224–1275 kg/cm²

b. *Gate Leaf (Dry/Accessible)*

- Direct compression/bending: 1346–1402 kg/cm²
- Shear stress: 979–1020 kg/cm²
- Combined stress: 1825–1910 kg/cm²

Note: Stresses increased by 1.33× under HFL conditions.

iv. *Hydraulic Load Calculations*

a. *Thrust on Element*

- *At FSL (3.04 m head):*

$$H_{FSL}=1\times10.1\times1.2\times(3.04-\frac{1.2}{2})=29.57t$$

- *At HFL (5.40 m head):*

$$H_{FSL}=1\times10.1\times1.2\times(5.40-\frac{1.2}{2})=58.18t$$

- *Load Increase at HFL:* 97% > 33.33% → Design governed by HFL

v. *Structural Design of Horizontal Girders*

a. *Girder 'B' (Critical Load Case)*

- Load: 29,088 kg
- Bending Moment (BM):

$$BM=\frac{29088}{8}\times(2\times 1050-1010)=3963240$$

- Section Properties:

  Skin plate: 10 mm thick (effective 8.5 mm after corrosion) Co-acting width: 54 cm (per IS 800)

  Moment of Inertia (Ixx): 155,114 cm⁴

  Section Modulus (Z): 4995 cm³ (top), 5136 cm³ (bottom)

b. *Stress Checks*

- *Bending stress (bottom):*

$$\sigma_b=\frac{3963240}{4995}=793kg/cm^2<1868kg/cm^2\ (Permissible)$$

- *Shear stress:*

$$\tau=\frac{14544}{46.2}=315kg/cm^2<1356kg/cm^2$$

c. *Deflection Check*

$$\delta=\frac{21871}{384\times 2047000\times 155114}<1.313cm$$

$$\times(8\times1050^3-4\times 1050\times1010^2+1010^3)$$

$$=1.08cm$$

vi. *Auxiliary Components*

a. *Sliding Pads*

- *Material:* Leaded Tin Bronze (IS 318 LTB_1)
- *Permissible bearing stress:* 102 kg/cm²
- *Design load:* 182 kg/cm → Actual stress:

$$\sigma=\frac{182}{10}=18.2\ kg/cm^2<102kg/cm^2$$

b. *Track Base*

- *Concrete grade:* M200 (per IS 456:2000)
- *Bending stress in track:* 165 kg/cm² < 979 kg/cm²
- *Bearing pressure on concrete:* 13 kg/cm² < 63.75 kg/cm²

vii. *Weight and Center of Gravity (CG)*

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Component	Weight (kg)	CG from Upstream (mm)
Skin Plate	989.85	5
Horizontal Girders	1,316.79	410
Sliding Pads	84.78	524.5–537.5
Total Weight	3,761.98	270 (Adopted CG)

The stoplog gates are designed to withstand HFL loads (58.18 t) with reinforced horizontal girders, sliding pads, and track bases. Compliance with IS 5620 ensures structural integrity under both balanced and unbalanced head conditions. Critical stress checks and deflection limits are satisfied, and the monorail-operated system facilitates efficient maintenance.

f) Design of 25T Rope Drum Hoist

i. *General Specifications*

The 25T rope drum hoist is designed for operating under-sluice service gates at the Rohin Barrage, Uttar Pradesh. Key specifications include:

- *Number of hoists:* 2
- *Capacity:* 25 metric tons (per hoist)
- *Lifting speed:* 0.40 m/min
- *Lift height:* 8.0 m
- *Standards:* Compliant with *IS 6938:1989* (for hoists) and *IS 1367* (for bolted connections)

ii. *Material Specifications*

Component	Material	Standard
Hoist bridge & structures	Structural Steel	IS 2062 Grade E250
Rope drum & gear wheels	Cast Steel	IS 1030 Grade 280-520W
Pinions	Forged Steel	IS 2004 (55C8/EN9)
Shafts	Rolled Steel / Forged Steel	IS 2062 / 45C8 (IS 2004)
Bush bearings	Aluminum Bronze	IS 305 Grade AB_1

iii. *Permissible Stresses*

a. *Normal Working Condition*

Component	Stress Type	Permissible Stress (kg/cm²)
Rope drum	Compressive	1,060
Gear wheels	Root stress	1,060
Pinions	Root stress	1,440
Shafts (Rolled Steel)	Bending (with keyway)	627
Bush bearings	Bearing pressure	204

b. *Breakdown Torque (BDT) Condition*

Component	Stress Type	Permissible Stress (kg/cm²)
Rope drum	Crushing	2,283
Gear wheels	Root stress	2,283
Pinions	Root stress	2,856
Shafts (Forged Steel)	Bending (with keyway)	1,958

iv. *Hoist Mechanism Design*

a. *Wire Rope Selection*

- *Ropetension calculation* (4 falls per drum):

$$P_1 = \frac{25000}{2}\left(\frac{1-0.95}{1-0.95^4}\right) = 3369kg$$

- *Proposed rope:* 20 mm diameter, 6×36 construction, galvanized, UTS 180 kg/mm²
- *Safety factor:*

$$FOS = \frac{23853(breaking\ load)}{3369\ kg} = 7.08 > 6.0\ (Safe)$$

b. *Motor and Brake*

- *Motor power calculation:*

$$H.P.=\frac{25\times0.45}{4.5\times0.529}=4.7H.P.$$

$$\rightarrow Proposed:5H.P.(3.7kW)motor$$

- *Braking torque:* 584 kg cm → Selected: 150φ AC electromagnetic brake (6.6 kg m capacity)

c. *Rope Drum Design*

- Drum diameter: 500 mm (PCD)
- Groove details:

Pitch: 22.5 mm.

Depth: 7.0 mm. Grooves per drum: 25

- Shell compressive stress check:

$$\sigma_c=\frac{3369}{2.25\times1.8}=832kg/cm^2<1060kg/cm^2\ (Safe)$$

v. *Gear Reduction System*

a. *Gear Train*

- *Total reduction ratio:* 803:1
- *Components:*

Worm reducer: 60:1 ratio

Open gears: 98/24 (Module 8) and 80/24 (Module 5)

Gear	Teeth	Module	Root	Stress (kg/cm²)	Permissible (kg/cm²)
W_1	98	8		884	1,060
P_1	24	8		1,131	1,400
W_2	80	5		900	1,060
P_2	24	5		1,219	1,400

b. *Shaft Design*

Drum Shaft (Normal Condition)

- Material: IS 2062
- Diameter: 75 mm
- Stress checks:

Bending stress: 430 kg/cm² < 1,160 kg/cm² Shear

Stress: 92 kg/cm² < 702 kg/cm²

Pinion Shaft (BDT Condition)

- Material: Forged Steel (45C8)
- Diameter: 75 mm
- Combined stress check:

$$\sqrt{903^2+3\times427^2}=1167kg/cm^2<1958kg/cm^2\ (Safe)$$

vi. *Structural Components*

a. *Hoist Bridge*

- Main girder (AB):

Section: Custom-built with Ixx = 248,508 cm⁴

Bending stress: 841 kg/cm² < 1,530 kg/cm²

Deflection: 1.07 cm < 1.50 cm (permissible)

b. *Column and Base Plate*

- *Vertical load:* 40,000 kg (including wind load)
- *Column section:* Built-up with Ixx = 25,658 cm⁴
- *Base plate:* 62 × 62 × 2.5 cm

Bearing pressure on concrete: 16.7 kg/cm² < 52 kg/cm²

c. *Bracings*

- *Diagonal bracings:* L75×75×8 (Stress = 167 kg/cm² < 906 kg/cm²)
- *Horizontal bracings:* L75×75×8 (Stress = 113 kg/cm² < 909 kg/cm²)

vii. *Manual Operation System*

- *Chain drive:* 3/4" pitch roller chain (breaking load = 3,300 kg)
- *Crank effort:* 9.75 kg/person (2 operators)
- *Manual lifting speed:* 2.3 cm/min

The 25T rope drum hoist is designed to operate under both normal and breakdown conditions, with all critical components (wire ropes, gears, shafts, and structural members) complying with IS 6938:1989. Stress checks confirm safety margins, and the inclusion of manual operation ensures redundancy. The hoist bridge and column designs withstand combined vertical and wind loads, ensuring reliability in barrage operations.

V. Testing, Inspection, and Quality Assurance

The structural framework of the project utilizes steel members procured from the Steel Authority of India Limited (SAIL), a Government of India enterprise and one of India's largest steel producers. SAIL-supplied materials were selected for their adherence to international quality standards, mechanical properties, and suitability for structural applications.

a) Testing

The following tests were conducted to ensure the structural integrity, functionality, and compliance of the Rohin barrage gates and associated systems:

i. *Functional Testing*

- Operational tests were performed on randomly selected gates (No. 3 & 4) to verify smooth movement, hoisting mechanism efficiency, and seal contact uniformity.
- Load tests were recommended for the lifting mechanisms to certify safe operation, with certification required from state-authorized personnel.

ii. *Non-Destructive Testing (NDT):*

- Ultrasonic testing (UT) was conducted on all butt welds to detect internal defects. Results indicated no significant indications, confirming weld integrity.

iii. *Leak Testing*

- While physical seal conditions were verified as satisfactory, a formal leak test was recommended to ensure no water leakage through rubber seals during operation.

iv. *Environmental Load Testing*

- The upstream inspection pathway, designed to withstand harsh conditions (e.g., wind loads, thermal expansion), was stress-tested post-erection and performed effectively under site-specific environmental challenges.

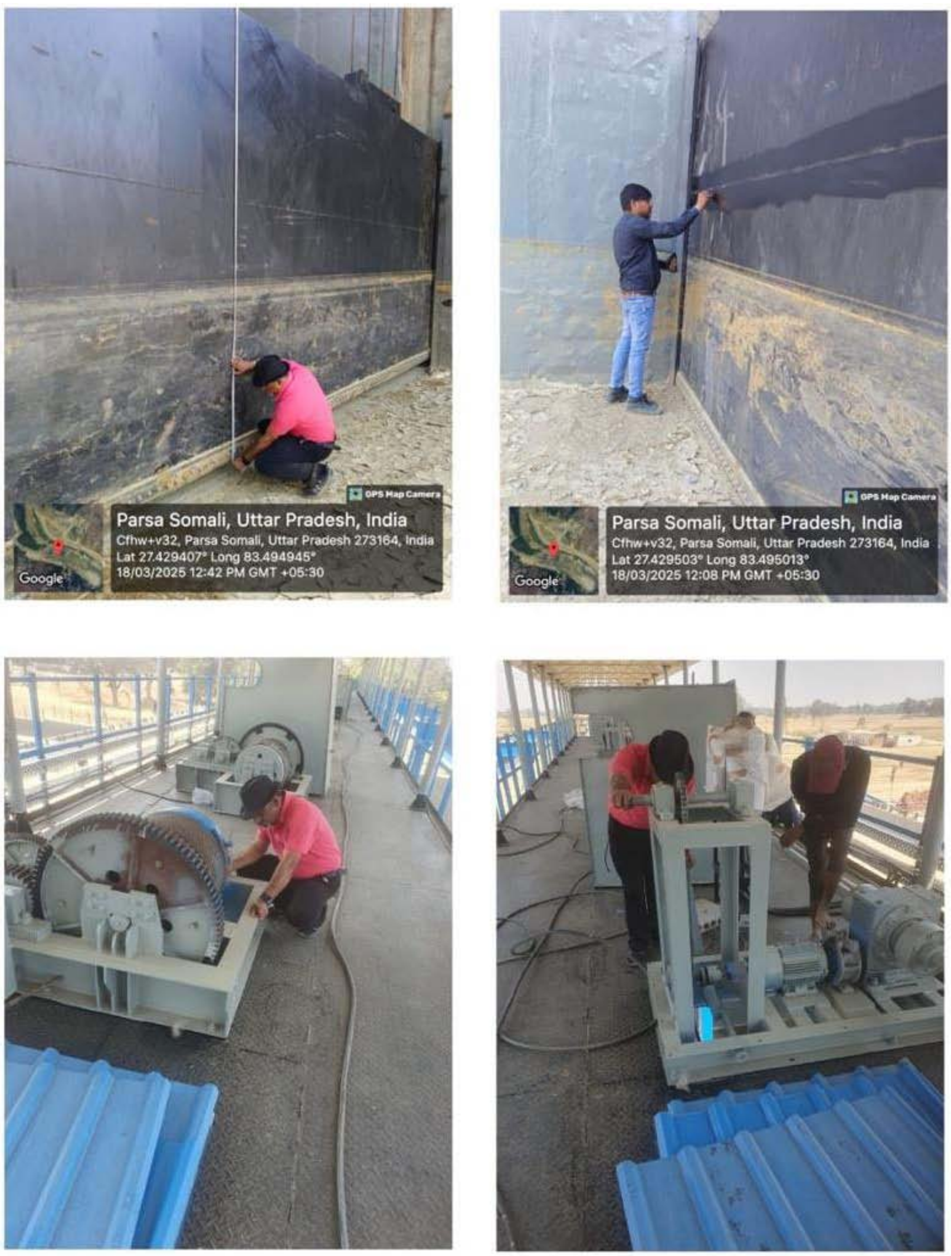

Figure 2: Measurements and Tastings

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b) Inspection

A comprehensive inspection regime was implemented, facilitated by the newly erected upstream inspection pathway, which enabled safe and efficient access for visual and dimensional assessments

Figure 3: Upstream Inspection Pathway

i. *Visual Inspection*

- *Structural Components:* Gates, welds, and foundations were inspected for cracks, rust, deformations, and painting defects (e.g., bubbles, sagging).
- *Seals and Mechanisms:* Rubber seals, hoisting ropes, pulleys, and control systems were examined for functionality and wear.

ii. *Dimensional Inspection*

- Critical dimensions (gate width, height, sill level, HFL, groove depth) were verified against approved drawings (e.g., IITR/CED-ROHIN/HM/100) using calibrated tools:
- Measuring tape (ID: 0007), Vernier caliper (ID: 0017), and laser distance meter (ID: 0013).
- Minor deviations (e.g., gate width tolerance ±5mm) were noted but deemed within acceptable limits.

iii. *Alignment Checks*

- Vertical and horizontal alignment of gates was validated using plumb bobs and lasers.
- Groove tracks and drum positioning were inspected for straightness and smooth rotation.

iv. *Painting Inspection*

- Final paint coatings were assessed for uniformity, thickness (DFT), and defects. Remedial actions were advised for observed issues (e.g., cissing, uneven shading).

c) Quality Assurance

Quality assurance processes ensured adherence to design specifications, safety standards, and long-term reliability:

i. *Documentation Compliance:*

- Approved drawings, gate specifications, and weld procedures (WPS-PQR) were referenced throughout fabrication and assembly.
- An Inspection and Test Plan (ITP) was mandated to formalize quality control stages, though its absence was flagged for corrective action.

ii. *Welding Quality Control:*

- All welders were required to hold valid qualifications for their respective positions.
- Welding specifications were enforced to address defects (e.g., irregular profiles, porosity) observed during inspections.

iii. *Preventive Maintenance*
- A periodic maintenance calendar was recommended for lubrication, corrosion checks, and system upgrades.

iv. *Certification and Calibration*
- Test instruments were calibrated (valid until 2025–2026) and traceable to national standards.
- Load test certificates and NDT reports were archived for regulatory audits.

v. *Corrective Actions*
- Non-conformities in welding and painting were marked for rectification prior to final acceptance.
- The upstream inspection pathway's design incorporated thermal expansion allowances, ensuring durability and supporting future QA activities.

The integrated testing, inspection, and QA framework, supported by the purpose-built upstream pathway, ensured the barrage's compliance with functional and safety requirements. Continuous monitoring and adherence to corrective recommendations will further enhance operational reliability.

VI. SCADA in Barrage Automation: System Components and Operational Benefits

SCADA (Supervisory Control and Data Acquisition) is a pivotal technology in modern water resource management, particularly in barrage and dam operations. By integrating real-time data acquisition, remote control, and advanced analytics, SCADA systems enhance operational efficiency, safety, and decision-making.

a) SCADA System Architecture

The SCADA framework for barrage automation comprises interconnected hardware and software components that ensure seamless data flow and operational control. Below are the critical system components:

- *SCADA Software*

Role: Acts as the centralized interface for monitoring, data visualization, and command execution.

Functionality: Processes real-time data from sensors, generates alerts for anomalies, and enables remote gate adjustments. Examples include platforms like Ignition SCADA or Siemens WinCC.

Integration: Interfaces with PLCs and cloud systems for unified control.

- *Programmable Logic Controllers (PLCs)*

Role: Serve as the "brain" of automation, executing pre-programmed logic for gate operations.

Functionality: Automates gate opening/closing based on sensor inputs (e.g., water levels). Reduces reliance on manual intervention, minimizing human error.

- *Sensors and Actuators*

Sensors: Include water level sensors (ultrasonic or pressure-based), gate position indicators, and flow meters. These devices collect data on upstream/downstream water levels, discharge rates, and gate status.

Actuators: Electromechanical devices that physically adjust gate positions based on PLC commands.

- *Communication Network*

Role: Facilitates data transmission between field devices, PLCs, and control centers.

Technology: Utilizes IoT protocols (e.g., MQTT, LoRaWAN) and cloud integration for real- time remote access. Ensures reliability even in harsh weather conditions.

- *Surveillance System*

Components: High-resolution bullet cameras and Pan-Tilt-Zoom (PTZ) cameras for 24/7 visual monitoring.

Integration: Linked to SCADA software to provide live footage alongside sensor data, enhancing situational awareness.

b) Operational Benefits of SCADA in Barrage Automation

The integration of SCADA in barrage systems delivers multifaceted advantages:

- *Remote and Centralized Control:* Operators can manage gate operations from a dedicated control room at the barrage site or a regional command center (e.g., Lucknow). This dual- control capability ensures uninterrupted operations during emergencies.
- *Flood Risk Mitigation:* SCADA enables all-weather functionality, allowing rapid gate adjustments during heavy rainfall or rising water levels. Real-time data on upstream/downstream conditions supports proactive flood management.
- *Enhanced Safety and Operational Efficiency:* Automated responses via PLCs eliminate delays in gate operations. For example, if water levels exceed thresholds, gates open automatically, preventing structural damage or accidents caused by human oversight.
- *Data-Driven Decision Support:* Continuous monitoring generates a historical database of water flow patterns, gate performance, and environmental conditions. This data aids in predictive analytics,

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such as forecasting flood risks or optimizing water distribution.

- *Precision in Measurements and Reporting:* Sensors provide accurate, real-time measurements of water discharge (in cubic meters/second) and gate positions (in millimetres). Automated reports ensure regulatory compliance and transparency in water management.

VII. Conclusion

The Rohin Barrage Project exemplifies advanced engineering in hydraulic infrastructure, integrating robust design principles, material innovation, and adherence to Indian and international standards. Key components—sluice service gates, under-sluice gates, head regulator gates, 25T rope drum hoists, 15T monorail structures, and stoplog gates—were meticulously designed to address irrigation, flood control, and maintenance needs.

a) *Structural Integrity and Safety*

- Gates and hoists were designed for extreme hydraulic loads, including High Flood Level (HFL) and seismic conditions. Permissible stresses were enhanced by 1.33× under HFL, ensuring resilience against unforeseen overloads.
- Critical components, such as horizontal girders and roller assemblies, were analyzed for bending, shear, and deflection, with margins well within IS code limits (e.g., IS 800:1984, IS 4622:2003).

b) *Material Selection*

- Corrosion-resistant materials (e.g., stainless steel 20Cr13, IS 1570) and rubber seals (IS 11855) were prioritized for longevity in wet environments.
- High-strength steels (IS 2062) and forged/cast components (IS 1030, IS 2004) ensured durability under repetitive loading.

c) *Operational Efficiency*

- The 25T rope drum hoist system, compliant with IS 6938:1989, features a 5 HP motor, electromagnetic braking, and manual redundancy, balancing automation with fail-safe operation.
- The 15T monorail structure, designed for static and dynamic loads, facilitates efficient transport of stoplogs and machinery during maintenance.

d) *Innovation and Compliance*

- Stoplog gates (IS 5620) utilized interchangeable elements and sliding pads (IS 318 LTB_1) for rapid deployment under balanced/unbalanced head conditions.
- Seismic analysis confirmed that HFL design loads inherently accommodated earthquake- induced hydrodynamic pressures.

By harmonizing hydraulic efficiency, mechanical reliability, and material science, the Rohin Barrage Project sets a benchmark for sustainable water management infrastructure in India.

VIII. Future Aspects: Sustainable Development and Multifunctional Expansion

The Rohin Barrage, while fulfilling its core objectives of irrigation and flood control, holds immense potential for multifunctional development. By leveraging its strategic location, hydraulic infrastructure, and ecological assets, the barrage can evolve into a hub for sustainable tourism, water sports, and community engagement. Below is a detailed roadmap for future advancements:

a) *Technological and Operational Upgrades*

i. *Smart Automation*

- IoT Sensors: Deploy real-time monitoring systems for water quality, gate operations, and structural health.
- AI-Driven Predictive Maintenance: Use machine learning to forecast equipment failures and optimize repair schedules.

ii. *Renewable Energy Integration*

- Install solar panels on trestles and hoist houses to power gate operations and reduce carbon footprint.

b) *Tourism Development*

i. *Infrastructure and Amenities*

- *Viewing Decks and Walkways:*
  - ➢ Construct elevated platforms along the upstream pathway for panoramic views of the barrage and river.
  - ➢ Install interpretive signage detailing the barrage's engineering and ecological significance.
- *Visitor Center*
  - ➢ Develop an educational hub with interactive exhibits on water management, local biodiversity, and flood control mechanisms.
- *Eco-Tourism Packages*
  - ➢ Collaborate with travel agencies to offer guided tours, bird watching trails, and sunset cruises.

ii. *Cultural and Recreational Events*

- *Festivals:* Host annual events like "*Rohin Water Fest*" featuring boat races, cultural performances, and local cuisine.

- *Heritage Trails:* Link the barrage to nearby historical sites (e.g., Gorakhnath Temple) to promote regional tourism.

c) *Water Sports and Adventure Tourism*

- *Facility Development:*
  - *Kayaking and Canoeing:* Designate calm-water zones upstream for recreational paddling.
  - *Rowing and Sailing:* Introduce rental services for rowboats and small sailboats.
  - *Fishing Zones:* Establish catch-and-release areas to attract anglers.
- *Adventure Sports:*
  - *White-Water Rafting:* Utilize regulated downstream releases during monsoon for seasonal rafting.
  - *Ziplining:* Install a zipline across the barrage for aerial views of the river and gates.

d) *Ecological and Biodiversity Initiatives*

- *Fish Ladders and Biodiversity Parks*
  - Retrofit fish ladders to support migratory species (e.g., Mahseer) and enhance river ecology.
  - Create riverside biodiversity parks with native flora to attract birds and butterflies.
- *Eco-Restoration*
  - Partner with NGOs for afforestation drives and wetland conservation.

The Rohin Barrage's future lies in transforming from a utilitarian structure into a dynamic, multifunctional asset. By integrating tourism, water sports, and ecological stewardship, it can drive socio-economic growth while preserving its core mission of water security. This vision aligns with global Sustainable Development Goals (SDGs 6, 8, and 11) and positions the barrage as a model for holistic infrastructure development in India.

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Appendices

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Authors Biographies

Prof. (Dr.) M. P. Chaudhary, Ph.D. (Math), D.Sc.(h.c.), FSSc, FISRWO, FIAB is a Indian Mathematician and has been associated with the number of academic institutions (in India / abroad) in different capacities and holds various academic titles such as Research Fellow, Research Scientist, Associate Professor, Professor, Adjunct Professor, Visiting Researcher, Visiting Professor, Advisor/ Scientific Advisor, Academic Visitor etc. He is currently pursuing his research works in number theory and combinatorics, especially in the fields of interest to Srinivasa Ramanujan. He is also having keen interested in theoretical computer science, IoT, human genome and space research, interdisciplinary sciences etc. Currently, he is serving as Albert Einstein Chair Professor of Mathematical Sciences at International Scientific Research and Welfare Organization, New Delhi, India; President at Mission Promote Research, Mumbai, India; Visiting Professor at Netaji Subhas University of Technology, New Delhi, India. Before his current assignments, he was served as professor at International Institution (in abroad) (supported by United Nations Development Programme UNDP), and associated with International Scientific Research and Welfare Organization, New Delhi, India in different capacities / positions since 2005. Recently, he was offered for Advisor position at constituent unit (concerning Educational Planning and Administration) of the Ministry of Human Resource Development (now Ministry of Education), Government of India, New Delhi. He was served as observer for National Eligibility Test (NET) of University Grants Commission (UGC), Government of India. He was initiated his research career at University of Delhi (1999-2005); also conducted his research works at Jamia Millia Islamia, New Delhi (2008-2011); and worked as Research Scientist at an External Research Centre of the Department of Sciences and Technology (DST), Government of India (2011). He was visiting researcher at the Pennsylvania State University, USA (2007); academic visitor at the University of Oxford, England, U.K. (between 2013-2018).

Prof. Chaudhary at various points in his career visited to several well-known institutions across the world including Franklin & Marshall College, Lancaster, USA(2007); ETH (Swiss Federal Institute of Technology), Zurich, Switzerland (2008); The French Mathematical Society, Marseille, France (2010); International Centre for Mathematical Meetings, CIRM, Marseille, France, (2010); Eindhoven University of Technology, The Netherlands (2012); Julius-Maximilians Wurzburg University (Julius-Maximilians-Universit at Wurzburg), Germany (2014); University of Hildesheim (Stiftung Universitat Hildesheim), Germany (2014); University of Dhaka, Bangladesh (2017); University of Cologne, Germany (2024); University of Monastir, Tunisia (2024); Pennsylvania State University, USA (2024) etc.

Prof. Chaudhary has more than **325 publications** to his credits, including **250 (+)** scientific research papers indexed in SCI / SCIE / SCOPUS / ESCI / etc, **40 book**(s) / monograph(s) on mathematics (undergraduate, post graduate and research level) and several scientific as well as general articles. One of his books on Higher Education in India and Problems (recognized by K. R. Narayanan, the former President of India, 2003), and others are on different scientific and social aspects etc. He is recipient of some well-known fellowship(s) / Scholarship(s)/ award(s) including Elsevier's Mathematical Sciences Sponsorship Fund (MSSF) Award, London, U.K. (2023), Major Research Grants of the National Board of Higher Mathematics, Department of Atomic Energy, Government of India, Mumbai, India (2020), Scholarship of Clay Mathematics Institute, USA (2008), and Young Scientist Talent Prize by Sardar V.B. Patel Smarak Sansthan, India (2002). He was denied to ACCEPT two awards namely -International Research Awards on Science, Technology, and Management (2022) and International Scientist Research Awards on Engineering, Science, and Medicine (2022).Recently, he has been ranked among top **2%** most influential scientists by Stanford University, USA.

Anil Garg, B.E., I.A.S. (1996 batch) is currently working as Principal Secretary at Irrigation and water resources department of the Government Uttar Pradesh. Before his current assignment, he served various projects in U.P. Irrigation department and successfully completed several projects some of them are - Saryu canal national project, Arjun Sahayakproject, Bhawanidam Project, Rasin dam project, First canal Top Solar plant of 2.5 MW on Jakhlaun pump canal made operational, Second canal Top solar plant of 3.42 MW made operational, First Sprinkler Irrigation Project – Majhgaon Chilli sprinkler project in district Lalitpur made operational, Rohin Barrage project (which was successfully inaugurated by Hon. Chief Minister of Uttar Pradesh on 05th April 2025). Uttar Pradesh awarded first prize to him in best state category of National water award. Dukh wan weir located across river Betwa included in World Heritage Irrigation Structures by International commission on Irrigation and Drainage.He was successfully completed dredging works at **Kumbh – 2024**.

Upendra Singh, M.Tech. (University of Roorkee) is currently working as Chief Engineerin Irrigation and water resources Department of the Government of Uttar Pradesh.Before his current assignment, he served for various projects in U.P. Irrigation department and successfully completed various projects including Lahchura Dam Arjun Sahayak Project,Gomti Barrage Project – Replacement of Barrage gates, Rohin Barrage project (which was successfully inaugurated by Hon. Chief Minister of Uttar Pradesh on 05th April 2025). Also, he did automation of various barrages in Uttar Pradesh, and executed various dredging of rivers project in Govt. of U.P. He was successfully completed dredging works at **Kumbh – 2024**.

Yash Kumar Garg, M. Tech. (Indian Institute of Technology, Delhi)is currently working as Executive Engineer in Irrigation and water resources department of the Government Uttar Pradesh, and serving as works manager at Irrigation workshop division at Bareilly, Uttar Pradesh. He has executed various projects including Gomati Barrage Project – Replacement of Barrage, Rohin Barrage project (which was successfully inaugurated by Hon. Chief Minister of Uttar Pradesh on 05th April 2025). He has expertise on various deep well construction used for irrigation purpose, and successfully executed Raghunathpur pump canal project at Raebareli in which two very narrow tunnels of length 120 meter each cleared (were blocked for 40 years) and provided irrigation facilities to farmer.