CLIMATE-RESILIENT DAMS AND
HYDROPOWER INFRASTRUCTURE
INTEGRATING
ENVIRONMENTAL SUSTAINABILITY
IN PLANNING AND DEVELOPMENT

Innovative Corrosion Protection System to Gates of Middle Vaitarna, Barvi & Ransai Dams

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Middle Vaitarna Dam, Mal, Maharashtra

Barvi Dam, Badlapur, Maharashtra

Ransai Dam, Raigad Maharashtra

Dams have different types of steel gates

1. Radial Gates
2. Vertical Lift gates
3. Spillway gates
4. Slide gates
5. Automatic tilting gates and many other types

Gates corrode quickly because they are constantly exposed to a harsh environment with fluctuating water levels.

Main factors for corrosion are

1. Electrochemical corrosion
2. Water chemistry
3. Abrasion from sediments
4. Cavitation erosion
5. Temperature fluctuation
6. Poor maintenance.

In the world there are more than 62000 large Dams and out of this 5700 dams are in India.

Corrosion of dam gates can lead to

i. Significant losses including reduced water storage capacity due to leakage - Corrosion can create small cracks and crevices on the gate surface resulting into loss of stored water and potential downstream flooding issues.
ii. Increased maintenance costs - Gates coatings which are not kept in good condition may also lead to localized corrosion that could ultimately result in the loss of the members over all section.

iii. Potential for catastrophic gate failures,

iv. Disruption of water supply,

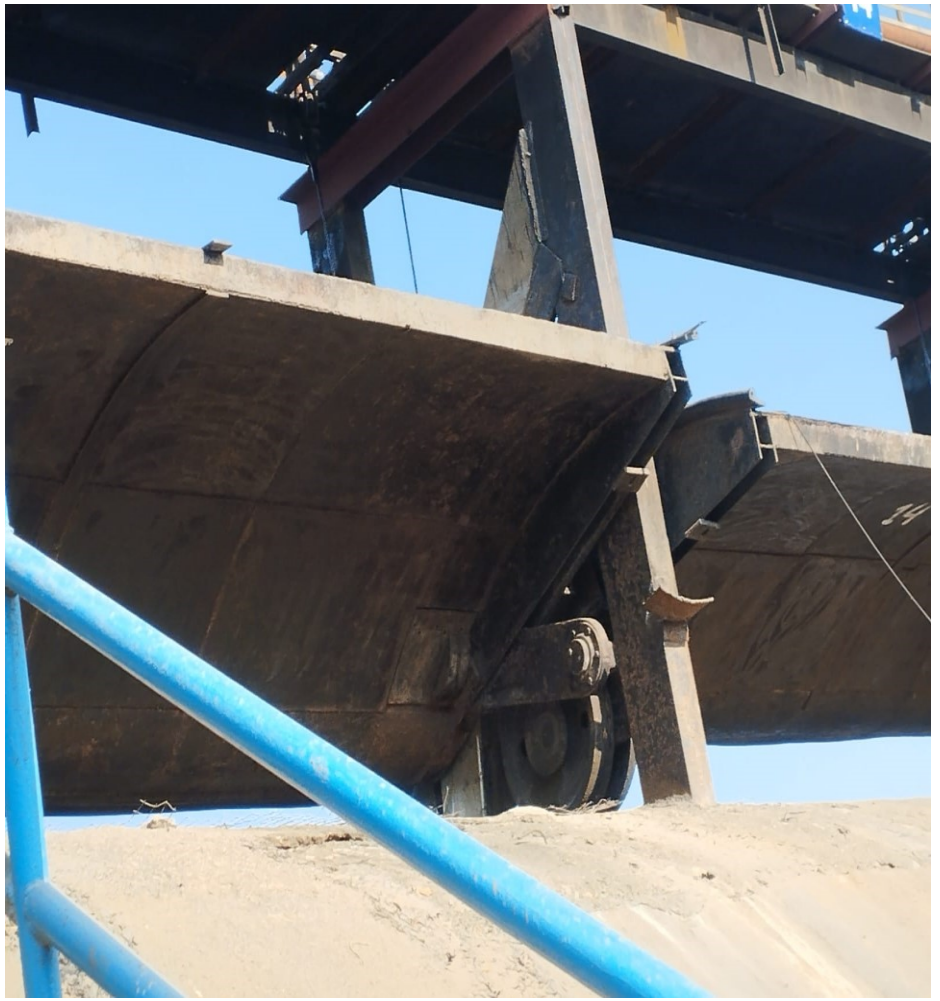
v. Environmental damage from uncontrolled water release and in extreme cases loss of life due to flooding, if the gates fails completely due to severe corrosion.

vi. Corrosion products such as rust, oxides, salts pollute water bodies, rivers, dams, canals etc.

Corroded Gates - Middle Vaitarna Dam

Barvi Dam

Ransai Dam



Corrosion Mitigation Measures of Dam Gates

- Material selection
- Design consideration (features like smooth surface to resist stagnation and sedimentation build up)
- Regular maintenance
- Cathodic protection

As per US army corp of engineers report, protective coatings are considered as one of the successful way to avoid corrosion of dam gates.In India also there are several options practiced and are referred in respective national codes. However they are inadequate to take care of extreme conditions and wear and tear

Reference : US Army Corps of Engineers - Use of Coatings on Hydraulic Steel Structures EM 1110-2-2022

Guidelines as per BIS 14177 of 2023 for corrosion protection

1. Gate, stoplog and Exposed embeded parts :

One coat of Inorganic zinc silicate primer or two coats of zinc rich primer. Two coats of solvent less coal tar epoxy.

2. Lifting beams, lifting tackels:

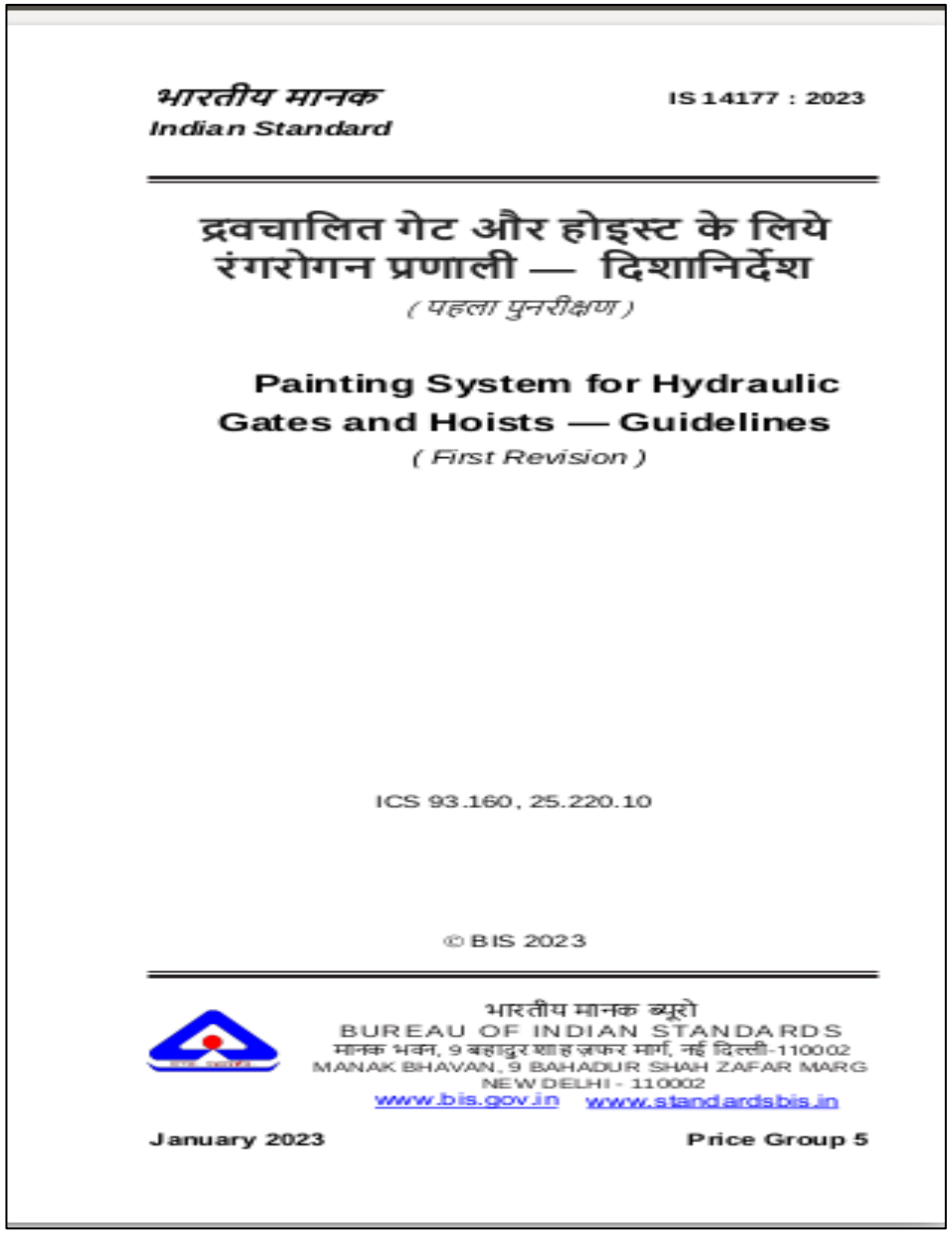
Two coats of Zinc phosphate primer, Two coats of alkyd based micaceous iron oxide paint.

3. Hoist & supporting structure :

Two coats of Zinc phosphate primer, Two coats of alkyd based micaceous iron oxide paint. Followed by synthetic enamel paint

4. Hydraulic hoist

a. Ferous surface open to water : 1 coat of inorganic zinc silicate primer and two coats of solvent less coaltar epoxy
b. Ferous surface not open to water : Two coats of zinc phosphate primer, one coat of alkyd based micaceous iron oxide paint.



भारतीय मानक
Indian Standard

IS 14177 : 2023

द्रवचालित गेट और होइस्ट के लिये रंगरोगन प्रणाली — दिशानिर्देश

(पहला पुनरीक्षण)

Painting System for Hydraulic Gates and Hoists — Guidelines

(First Revision)

ICS 93.160, 25.220.10

भारतीय मानक ब्यूरो
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- It has been observed that for the severe conditions of water flow and friction due to sedinemention the generics like coaltar epoxy, zinc phosphate, alkydes with micacious iron and zinc silicate base coatings were proved to be indequate though those were the options in the time of technology avilable then.

For example

Zinc Rich Primer Coat :

- Primer coat of any coating system is a soul of the protection system. The structure like mild steel gates are subjected to very high magnitude of abrasion due to high velocity of water along with suspended solids.

- In such scenario following things happen in the sequence given.

1. Abrasion creates scratches in the coating material exposing the mother surface of steel.
2. Zinc by itself is a sacrificial material to protect the steel.
3. On abrasion and scratching two electrodes are formed viz. steel (cathode) and zinc (anode) and water as the electrolyte which completes the electrochemical cell and sacrifice of zinc begins.
4. Being in thickness of marginal microns the sacrificial zinc layer exhausts rapidly resulting into initiating further major electro chemical deterioration of steel that leads to corrosion and heavy sectional loss.
5. Zinc rich epoxy was the remedy in earlier times when there were no other options of potent polymer coatings available.

Solvent less Coal Tar Epoxy :

Coal tar epoxy is for ordinary protection. Coaltar replaces epoxy content partially (in the coating) in order to economize the cost. This replacement compromises the structural and chemical resistant properties of pure epoxy coatings.

- The steel gates & hoisting equipments, if exposed to sunlight the epoxy as well as coaltar coatings are very vulnerable to UV attack and are not UV stable and will start degradation immediately due to UV rays, as such the top coating by itself will get weakened & can not prevent the damage to primer coat.

- As a result of above sacrificing activity, ultra violet radiation attack & inadequate strength of epoxy the protection will prematurely fail resulting in to heavy corrosion & substantial loss in cross section.

Limitations for Use of Coaltar Epoxy Coating

1. The World Health Organization International Agency For Research on Cancer has published a report in IARC monographs on the Evaluation of Carcinogenic Risk to Humans.
2. As per requirements of OSHA, EPA, and FDA environmental and health standards have also played a significant role in eliminating or reducing the use of bituminous enamels and coal tar epoxies. **(Ref: Water and Wastewater Program West Virginia University, PA May 15, 2001)**

Thus the state of the art protective coatings should be devoid of shortcomings experienced in the past and based on latest parameters on **"Selection of Corrosion Protection Scheme"**

Selection of Corrosion Protection Scheme

1. Surface Preparation:
2. Coating material complying to
   i. High adhesion
   ii. High corrosion resistant
   iii. Chemical resistant
   iv. Abrasion resistant
   v. UV resistant
   vi. Durable (based on test parameters and past track records of innovative systems.)

vii. Meets requirements to health safety and environment

viii. Properties related to application conditions, equipment and personnel.

ix. Availability and economics of coating materials.

Innovative Corrosion Protection Scheme as per the Selection Criteria (referred in Previous Slide)

1. One coat of Rusticide	- Surface Preparation
2. One coat of Sungard LCNR primer	- High adhesion
3. Two coats of Sunepoxy HB and abrasion	- High corrosion, chemcial resistant
4. Top 2 coats of Sungard APR and UV	- High corrosion, abrasion resistant

Corrosion protection scheme is followed in this innovative system as under

One coat of Rusticide

One coat of Sunepoxy LCNR

Two coats of Sunepoxy HB

Two coats of Sungard APR

Corrosion protection scheme is followed in this innovative system as under

- The total DFT of the system is in the range of 650 to 700 microns.
- Depending on sediment quality and extent of chemical contents the system can be enhanced to higher micron thickness
- Sungard LCNR, Sunepoxy HB and Sungard APR are reinforced epoxies/ polyurethans and are based on co-reactive polymers that provides higher corrosion resistant matrix. These polymers are further augmented with various mineral and synthetic reinforcements to improve specific properties such as erosion /abrasion resistance, flexibility or permeability
- This chemical engineering is as per the guidelines from US corp of engineers

Advantages of Corrosion Protection Coating

1. One coat of **Rusticide** - loosens rust, removes rust & converts into stable compound of iron.

2. One coat of **Sungard LCNR** primer - This molecule has extended chains and hence mechanical properties are improved. Increases weather resistance and anti aging properties.

3. Two coat of **Sunepoxy HB** - Is a high build protective epoxy coating to take care of continuous abrasion.

4. Top 2 coats of **Sungard APR -** This is a acyclic polyurethane coating resistant to ultra violet attack, abrasion and corrosion. Being acyclic additional degree of protection is offered to tendency of general disintegration.

5. The total DFT of the system is in the range of 650 to 700 microns.

Innovative Corrosion Protection Systems to Gates & Supplimentory Steel Structures

The Gate portion open to water : One coat each of Rusticide, Sungard LCNR, 2 coats of Sunepoxy HB & 2 coats of Sungard APR (PU)

Other supporting steel structures not open to water like hoist, cranes, pylons etc. One coat each of Rusticide, Sungard LCNR, & 2 coats of Sungard APR (PU)

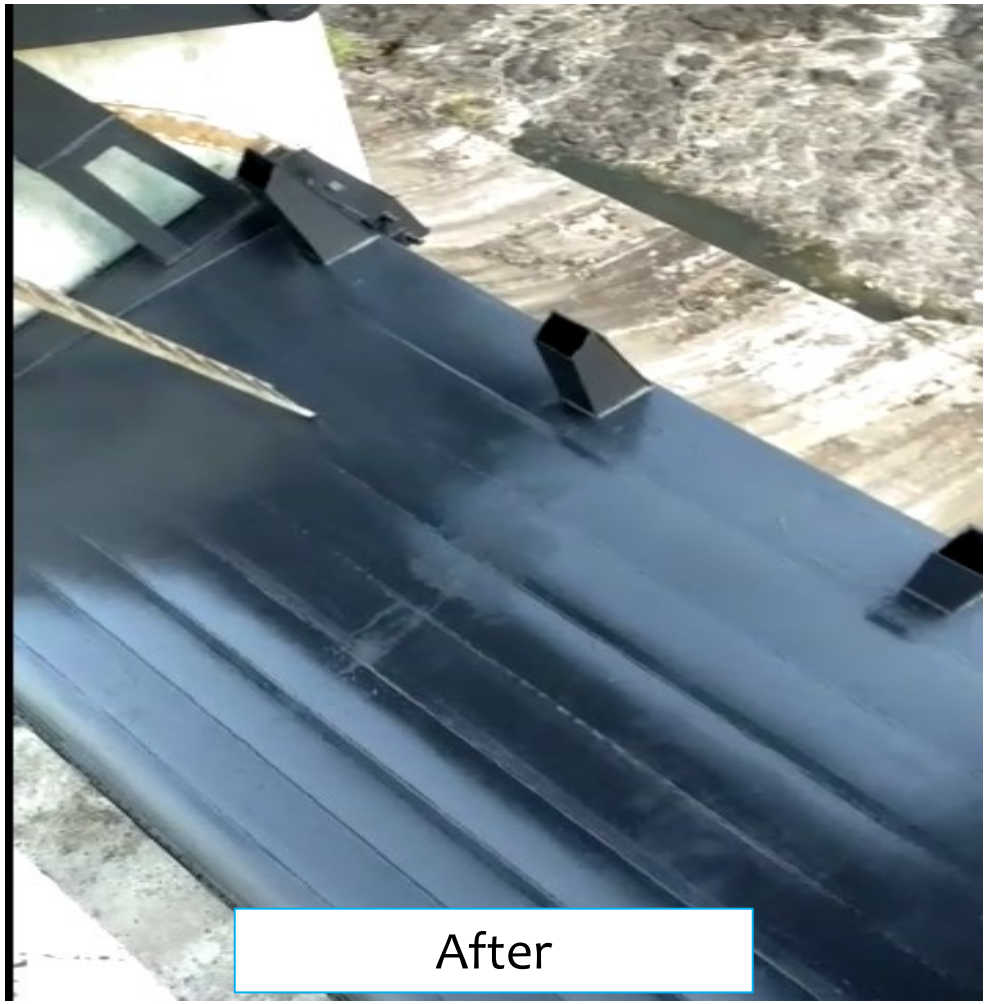
Embedments of gates: One coat each of Rusticide, Sungard LCNR & 2 coats of Sunepoxy HB

Case Study
Corrosion Protection - Ransai Dam

Final View - Ransai Dam

Barvi Dam, Badlapur, Maharashtra - MIDC
Before and After Treatment

Before



After

Corrosion Protection to Middle Vaitarna Dam, BMC

Remommendations for Corrosion Inhibiting Admixture Polyalk CP 293 & Sacrifcial Anodes - Sunanode

Additional corrosion protection to embedded parts of gates in RCC piers is also necessary. This can be achieved using bipolar corrosion inhibiting admixture while casting the concrete for piers. The molecules of this admixture will protect the steel from corrosion in concrete.

The life of gates can be further enhanced by installing galvanic sacrificial anodes at appropriate locations.

Monitoring System

The performance of the treatment to the gates was monitored after monsoon of 2024 through visual observation, The performance of the coating system will be monitored using half cell potential & cathodic disbondment testing.

Conclusion

- In conclusion a novel method of using modified epoxy and polyurethane polymers shows the promise to resist corrosion in the gates of the dam.
- In addition it highlights the importance of thorough corrosion removal by physical as well as chemical treatment before the polymeric treatment.
- This procedure can be extended to other connected steel structures of the gates/dams.

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