1.0 सामान्य / General

Among the metals categorized as ferrous and non-ferrous, the steel as a ferrous metal is extensively used for engineering purposes and comes under attack of corrosion mainly because of environmental changes thereby affecting durability of the structure.

When the structural steel work is exposed in a dry interior environment, the corrosion is virtually insignificant and does not require protective coating. When the structure is exposed to high humidity and atmosphere, the anti-corrosive paints should be applied.

2.0 संक्षारण मेकेनिज्म / Corrosion Mechanism

Corrosion can be defined as degradation of an engineering material (generally, metals) due to an electrochemical reaction with the environment that usually produces rust or other metal oxides. The process as illustrated in figure requires the simultaneous presence of water and oxygen. In the absence of either, corrosion does not occur.



Following types of corrosion are generally occurred:

- **Pitting Corrosion** restricted to an extremely minute area occurs at anodic area due to presence of moisture aided by improper detailing or constant exposure to alternate wetting and drying.
- **Crevice Corrosion** occurs when oxygen content of water trapped in a crevice (a narrow opening) is less than that of water which is exposed to air.
- **Bimetallic Corrosion** occurs when two dissimilar metals (for e.g. Iron and Aluminium) are joined together in an electrolyte. For example, use of steel screws in stainless steel members and also using steel bolts in Aluminium members.
- **Stress Corrosion** occurs under the simultaneous influence of a static tensile stress and a specific corrosive environment. This corrosion is not common with ferrous metals though some stainless steels are susceptible to this.
- **Fretting Corrosion** occurs when two oxide coated films or rusted surfaces are rubbed together. The oxide film is mechanically removed from high spots between the contacting surfaces initiating corrosion.
- **Bacterial Corrosion** generally occurs in soils and water as a result of microbiological activity mostly in pipelines, buried structures and offshore structures.

3.0 ट्रेक अवयवों की संक्षारण सुरक्षा / Corrosion Protection of Track Elements

a) As per CE's circular No. 262 of South Eastern Railway, the **General Rail Corrosion** that happens due to aggressive environmental conditions, mostly in the coastal areas due to salinity, in the tunnels & cuttings due to dampness, in the industrial belts due to chemical pollution and in the sidings where corrosive goods are handled, shall be prevented/ or controlled as per the following scheme.

Areas prone to severe corrosion, where rate of corrosion is so severe that replacement of rails becomes necessary within 5-6 years on account of corrosion, shall be considered for treatment. Rails with Zinc metallization are required to be used at the time of rail renewal. The Zinc metallization shall be done as per procedure laid down in RDSO Circular No. CT/ACP, dated 24.02.2006.

If the necessary facility for Zinc metallization is not available, then the treatment as prescribed below for **corrosion prone areas** may also be followed for areas prone to severe corrosion.

In **corrosion prone areas** identified in accordance with the sub Para (2) of Para 250 of IRPWM as modified vide Advance Correction Slip No. 124, dated 14.02.2011, the anti-corrosive treatment in these areas should be given (a) before the new rails are laid in the track (during track renewals/doublings/ other construction projects), and (b) when rails are already laid in track and subject to corrosion.

The most important part of treatment is the surface preparation of rails (removal of rust and scales), which shall be done with the help of hand operated or power operated tools i.e. scrappers, wire brushes, sand paper, pumice stone, etc. Wire brushing shall invariably be done at end to obtain uniform rubbed surface. Special care should be taken in surface preparation at weld collars and liner contact areas. Surface preparation should not be done when ambient temperature is below 10^0C or above 50^0C, in rainy season, during night, in winter before 8AM, in summer between 11AM to 3PM and in extremely windy/misty/dusty conditions. Chemical should not be used for surface preparation.

The painting should be done in **two coats of thickness of 100 microns each by anti-corrosive bituminous black paint conforming to IS: 9862 after an interval of 8 hours between two coats.** All the liners and Elastic Rail Clips shall also be painted with anti-corrosive black bituminous paint after duly cleaning the surface.

In identified corrosion prone areas, bituminous painting of rails shall be done **once in a year on inside of gauge face including web and foot and once in three years on non-gauge face side of rail including web and foot**.

b) Apart from the general rail corrosion, **Rail corrosion at fastening locations** (as per CE's circular No. 262 of SER) occurs sometimes in the yards due to drainage problems, which causes



dampness conditions, thereby resulting corrosion mainly in the rail foot area. In addition, in stretches where passenger trains run in the early morning hours, due to toilet droppings, there is reduction in the rail foot area which is in contact with the liner. The remaining section of the rail is normally not affected in such cases.

Preventive measures in accordance with CE's circular No. 262 of SER –

- **Graphite grease grade '0' to IS:408** as an initial provision and at the time of periodic cleaning of central leg of elastic rail clips, shall be applied on the underside of liners and also the corresponding areas of rail foot on gauge face side to prevent the ingress of toilet droppings in the gap between liner and rail foot.
- **Shifting of rail from its position by de-stressing** will result into stopping of further development of corrosion mainly near the liner location on the gauge face side and will result into increase in life of rails. This is to be done when the rail is relatively new and reduction in rail foot area is less than 1.5 mm.
- **Changing/turning of rail** will result into making the gauge face as non gauge face which will result into increase in life of rail as the reduction of foot thickness at gauge face side will get stopped. This should be done when the rail is relatively old and sufficient wear in rail foot area has already taken place.

4.0 पुल संरचनाओं की संक्षारण सुरक्षा / Corrosion Protection of Bridge Structures

In accordance with the document 'Painting of Bridges' available on IRICEN website (Encyclopedia Home), the new girders provided during doubling of lines have more corrosion problems than old girders. Corrosion is more where steel comes in contact with wood and water stagnation in pockets formed on account of structural form. For this reason plate girder has less corrosion problem than open web girder. Steel girder bridges situated in the following locations are prone to severe corrosion:

- Where humidity in atmosphere is more than 80%
- Coastal areas
- Bridges across creeks
- Bridges surrounded by chemical industry
- Bridges near metropolitan city on account of public nuisance.

In addition to above, type of traffic carried on bridges i.e. salt, fish, manure and chemicals also cause severe corrosion. Corrosion may be prevented by any one of the following means:

A- Protective Coatings by painting of girder bridges

In accordance with the document 'Bridge Inspection and Maintenance' prepared by IRICEN, the Girder painting is essentially an application of surface coating to the steel work so as to inhibit corrosion. The basic principle underlying maintenance painting is not to allow deterioration of existing paint film to reach such a stage that rusting starts underneath the paint film. Removal of rust, oil, grease and dirt is necessary to ensure adequate adhesion of paint film to the surface.

A1 – Painting scheme as per IRS Code

a) In areas where there is no severe corrosion

- **Priming coat:** One coat of ready mixed paint **zinc chromate** primer to IS: 104 – 1979, followed by one coat of ready mixed paint **red oxide zinc chrome** primer to IS: 2074 – 1992 or two coats of zinc chromate red oxide primer to IRS–P–31.
- **Finishing coat:** Two finishing coats of red oxide paint to IS: 13607 with colour/shade* to be specified by Zonal Railway or any other approved paint applied over the primer coats. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site the second finishing coat shall be applied after touching up the primer and the finishing coat if damaged in transit.

b) In areas where corrosion is severe - To avoid frequent painting, **metalizing or epoxy painting** for existing girders is recommended but when there are no facilities available for the same, protective coating by oil painting with following painting scheme should be applied.

- **Priming Coat:** One coat of ready mixed paint **zinc crome** primimg to IS: 104 followed by one coat of **zinc crome red oxide** primimg to IS: 2074.
- **Finishing coat:** Two coats of **aluminium** paint to IS: 2339 – 1963

c) In case where the priming coat is in good condition, the steel work is painted with two coats of paint to IS: 13607 with colour/shade* to be specified by Zonal Railway or paint aluminium to IS: 2339 depending on the severity of corrosion.

Note:

1. *The **red lead** paint to IS: 102 has been removed from IRBM vide correction slip no. 12.*
2. *The **red oxide** paint to IS;123 has been withdrawn from IRBM vide advance correction slip no.26, dated 23.08.2013.*
3. **(i)The colour/shade of finishing coat should be generally matching with the smoke Grey colour/ shade No.ISC 692 mentioned in IS:5-2004 (ii) The colour/shade can be changed by CBE as per the local requirements.*

A2 – Protective Coatings by metalizing with spraying a metal either Zinc or Aluminium

In accordance with the document 'Painting of Bridges' available on IRICEN website (Encyclopedia Home), metalizing is one of the superior methods of corrosion protection and will be more effective and economical, if carried out in workshop during fabrication of new girders. The minimum thickness of metal coating applied shall be 115 microns and average thickness 150 microns. The protective coating is to be provided as given in the **Appendix VI of IRS–B1–2001** or as per **Para 218 of IRBM** followed by oil painting over metallised component as per schedule given below:

- One coat of *etch primer* conforming to IS: 5666–1970 is applied after doing some etching of the surface so that the surface gets rough to receive further paint layers.
- One coat of *zinc chrome primer* conforming to IS: 104–1979 is applied as a primer.
- Two coats of *aluminium paint* conforming to IS: 2339–1963 is applied as top coats. [One shall be

applied in the workshop and the other in the field after touching up portions damaged during the erection/ launching process.]

In accordance with the document 'Inspection and Maintenance of Steel Girders' prepared by IRICEN, the following members of steel girder are to be provided with the above protection.

- Floor system (cross girders and rail bearers) of open web through girders in all cases.
- Top flange plates of plate girders and under slung girders in all cases.
- Top bracing system of open web through spans (i.e. top laterals, sways, portal bracings) in electrified section, as it is difficult to get power block for frequent oil painting.
- Entire Steel girders, subjected to salt spray such as in the close vicinity of the sea and/or over creeks, as well as in industrial, suburban or coastal areas which are prone to severe corrosive environment.

B- Epoxy based Paints

Epoxy paints have good adhesion and abrasion power and can be used in lieu of metalizing in the field for existing girders. The surface is prepared by removal of oil/grease from the metal surface by using petroleum hydrocarbon solvent to IS: 1745 and by sanding or grit blasting or wire brushing operated by pneumatic power or electricity to near white metallic surface.

Epoxy painting: Use of epoxy painting system for railway girders has been introduced recently. Real benefit of epoxy painting can be achieved with longer life of paint than frequent oil painting which is more costly for maintenance of steel girders on existing bridges.

The painting scheme for locations where girders are exposed to corrosive environment is as under. The RDSO Specifications has been replaced vide Addendum & Corrigendum Slip No. 5, dated 30.08.2013 (IRS:B1-2001)]

- **Primer coat** - Apply by brush two coats of epoxy zinc phosphate primer to RDSO specification No. M&C/PCN/102/2009, to 60 microns minimum dry film thickness (DFT) giving sufficient time gap between two coats to enable first coat of primer to hard dry.
- **Intermediate coat** - Apply by brush one coat of micaceous iron oxide paint to RDSO specification No. M&C/PCN/103/2011 to 100 microns min. DFT and allow it to hard dry.
- **Finishing coat** - Apply by brush two coats of polyurethane aluminium finishing to RDSO specification No. M&C/PCN-110/2006 for coastal locations or polyurethane red oxide to RDSO specification No. M&C/PCN-109/2009 for other locations to 40 microns minimum DFT giving sufficient time gap between two coats to enable the first coat to hard dry.
- **Initial painting of weld collar** can be done with high build Epoxy paint consisting of two pack as per RDSO's specification No. M&C/PCN/ 111/2006 in Heavy Corrosion prone area.

5.0 कंक्रीट संरचनाओं की संक्षारण सुरक्षा/Corrosion Protection of Concrete Structures

The steel embedded in the concrete structure whether as reinforcement or pre-stressed tendon, is prone to corrosion that cannot be totally eliminated.

Remedial measures: The deterioration of concrete may be due to either corrosion of concrete/ reinforcement steel or formation of expansive chemical compounds such as calcium silicate hydrate in aggressive environments. The following steps, if implemented scientifically will help to produce durable concrete –

- **Improving the Quality of Concrete**
  a) Designing the best suitable Mix Proportion
  b) Efficient Compaction during Casting
  d) Leak proof Formwork
  e) Adopting Salt Free Sand
  f) Using Plasticizers
  g) Using sulphate resisting cement and pozzolana cement.
- **Increasing Depth of Concrete Cover to Reinforcement:** Concrete cover thickness as prescribed in IS Codes should be provided when surfaces of concrete members are exposed to the action of harmful chemicals, acids, vapours, saline atmosphere, sulphurous smoke, etc.
- **Coatings for Concrete:** In accordance with the document 'Durability of Concrete Structures' prepared by RDSO, the protective surface coating, as the name implies, protects the concrete surface from aggressive chemical attack. The surface coating for concrete is an effective method of protecting life of reinforcement steel.
  - **Epoxy-phenolic IPN (**Inter-penetrating Polymer Network) coating as developed by CBRI, Roorkee is an excellent protective coating for concrete structures and can be used for the protection of various structures exposed to aggressive environments.
  - **Integrated four coat system developed by CECRI, Karaikudi** consists of (a) epoxy polyamide iron oxide, (b) epoxy polyamide MIO (micaceous iron oxide) undercoat, (c) epoxy polyamide, (d)TiO_2 top coat and aliphatic. It has high alkali resistance and good adhesive.
  - **Epoxy coating** when formulated with liquid epoxy resin, liquid curing agents and highly penetrating solvents gives good performance. Epoxy coating is cured either by amines or by polyamides. They are classified as under:
    - Solvent base epoxy with relatively high molecular weight
    - Thin thrixotropic liquid epoxy based primer.
    - Thick epoxy coating applied by trawl or by spray.
  - **Coal-tar epoxy:** They have both properties of coal-tar and epoxy. They have good adhesion to concrete and chemical resistance. They are applied by roller, conventional means or by airless spray.

5.1 Corrosion of Steel in Concrete Sleepers (Para 1410 of IRPWM): Both the ends of concrete sleepers should be painted with an approved type of anticorrosive paint periodically to prevent corrosion of the exposed ends of pre-stressing wires. In case of two-block sleepers, tie bars should be examined every year and if any sign of corrosion is noticed, the affected portion should be painted with an approved type of paint.

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भारत सरकार – GOVERNMENT OF INDIA

रेल मंत्रालय – MINISTRY OF RAILWAYS

स्टील की संक्षारण सुरक्षा

CORROSION PROTECTION OF STEEL

कैमटेक / सि / 2013 / सी.पी.एस / 1.0
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If you have any suggestion & comments on contents of the pamphlet, please write to: ***Dy. Director (Civil), CAMTECH, Maharajpur, Gwalior (M.P) – 474 005***

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