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EXPERIMENTAL STUDY ON ANTI-CORROSIVE COATINGS FOR STEEL BRIDGES

[1]Prathyusha Yadali, [2]Dinesh Kankipati
[1]Assistant Professor,
SRK Institute of Technology,
Vijayawada, India
[2]Assistant Professor,
Narasaraopeta Engineering College,
Guntur, India

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Abstract

Structural Steel has become a widely used construction material for heavy structures like Bridges, skyscrapers, industrial buildings, often favored over concrete. Despite all the Advantages, Steel carries a major setback i.e.: Susceptibility to Corrosion. However this setback is compensated by the usage of various paints, anti-corrosive coatings all around the world. These products form a layer over the steel thus separating the corrosive medium to that of the steel surface. Researchers around the world have been working on various types of coatings which would completely isolate the steel surface from the corrosive medium and decrease the maintenance cost of the steel structures. The paper discusses a total of 5 economical anti-corrosive coatings which were trail mixed. These were applied on sample pieces of corroded bridge girders. Electrochemical study is conducted on these 5 coatings using AUTO LAB apparatus. Electro-chemical Impedance

Spectroscopy (EIS) and TAFEL Slope Technique were conducted on these specimens and results were plotted. Coating 4 has given the best results.

***Keywords*:**Anti-corrosive coatings, AUTO LAB, Bridges, Corrosion, Electro-chemical Impedance Spectroscopy (EIS), Electrochemical study, Structural Steel, TAFEL Slope Technique.

1 INTRODUCTION

Structural Steel is a green material that has become a major part of the Construction Industry since late 19th century. It was used in the construction of major projects during late19th, 20th centuries. But, in recent years, Structural steel is proposed for even small projects like showrooms, offices etc, so that the construction costs can be minimized. Besides, it has got many advantages over Reinforced Cement Concrete (RCC). The major advantages include: high tensile strength, high strength to weight ratio, durability, earthquake resistance and most importantly the ease of construction and re-usability. Likewise, it has very few disadvantages, the major one being its susceptibility to Corrosion.

Corrosion in steel is highly dangerous as it poses threat to the stability of the structure. The oxidized compounds occupy 6 times the volume of the original steel thus destabilizing the structure. This process of corrosion is highly active in coastal areas. The sea spray carries moisture in air in addition to salinity that aggravates the corrosion process. Sea Bridges are highly susceptible to such harsh conditions of corrosion.

In this study, a corroded bridge girder previously used in The Godavari Bridge, Rajahmundry located in the state of Andhra Pradesh, India is collected.

1.1 PREPARATION OF THE STEEL SAMPLES

The girder was cut into 10cm long pieces. The corrosion on the pieces was removed using Pickling solution (or) Clark solution.

Figure 1.1: The Godavari Bridge, Rajahmundry, Andhra Pradesh, India.

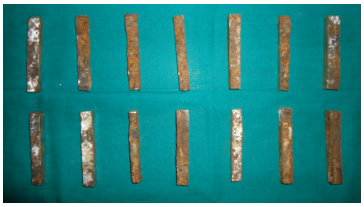

Figure 1.2: Cut samples of corroded steel girder

Figure 1.3: Samples after cleaning

1.1.1 PICKLING SOLUTION (OR) CLARK SOLUTION

The solution is prepared using Hydrochloric acid (HCl), Water, hexamine, Antimony trioxide. The cut steel samples are cleaned and corrosion is removed by placing them in Pickling solution. They are then cleaned. After cleaning, the steel samples are washed with tap water twice. These are then wiped clean and dry and stored in airtight container till coatings were applied. Fig1. 2 and Fig 1.3 shows the cut samples of the corroded steel girder in its original state and after the removal of corrosion using pickling solution respectively.

1.2 PREPARATION OF COATINGS

5 Coatings were prepared with various mix proportions of different materials. These materials were selected for the use in this research after thorough study of their material properties. Table 1 shows the mix compositions of the Coatings.

Table 1: Compositions of Trial Mixed Coatings.

S.NO	COMPOSITION OF COATINGS
C1	Cement + Latex + Silicafume + Microsilica + Nano Silica
C2	Aluminium Paint
C3	Geopolmer 10 M Solution
C4	Cement + Latex + Zinc Phosphate + Titaniumdioxide + Silicafume + Nanosilica + Micro Silica
C5	Geopolymer 0.5 M + Nanosilica + Microsilica + Silicafume + Titaniumdioxide

1.2.1 OBSERVATIONS

Coating 1: Silica Fume, Micro Silica, Nano Silica are lighter materials and they have lesser Specific Surface Area and Latex is bonding material that combines all these materials. The obtained slurry is coated twice by using brush.

Coating 2: For Aluminium Paint coating, Red Oxide is used as a primer.

Coating 3: Geopolymer based coating has the problem of drying.

Coating 4: Zinc Phosphate is used, as it is a well known corrosion inhibitor.

Coating 5: This GeoPolymer based coating dried faster.

Fig 1.4 to Fig 1.8 shows the coated samples of steel pieces.

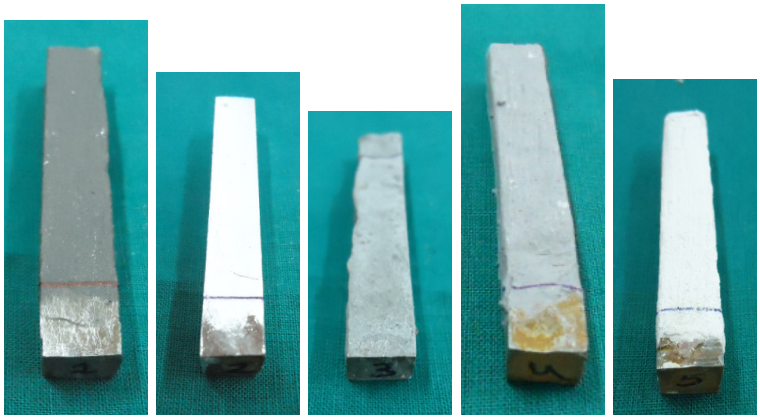

Figure 1.4: Coating 1 Figure 1.5: Coating 2 Figure 1.6: Coating 3 Figure 1.7: Coating 4 Figure 1.8: Coating 5

2 ELECTRO CHEMICAL STUDIES

Electro chemical studies were carried out using AUTO LAB apparatus. Fig 2.1 and Fog 2.2 shows the apparatus and sample setups.

The apparatus contains three different electrodes namely working electrode, cathode electrode and reference electrode. Working electrode is mild steel coated plate and the coated test specimens act as a cathode where corrosion takes place. And there remaining electrode is a reference electrode which is saturated calomel electrode. The AUTO LAB equipment is used for measuring corrosion (i_{corr}), corrosion density (I_{corr}), and corrosion rate (mm/year).

The electrolyte used here is 3% NACl solution, equivalent to sea water.

The coated 5 samples are tested individually and the results are noted in tabular form.

3 RESULTS AND DISCUSSIONS

The values of corrosion (icorr), corrosion density (Icorr), and corrosion rate (mm/year) are plotted in Table 3.1.

Figure 2.1: AUTO LAB SETUP

Figure 2.2: Sample setup

Table 3.1: Corrosion values obtained from AUTO LAB APPARATUS

S.No	Coating	I_{CORR} (Amp)E^{-3}	I_{CORR} (A/cm^2)	$E_{CORR\ OBS}$ (V)	$E_{CORR\ CAL}$ (V)	Corrosion Rate (mm/Year)
1	U1* (SALT H_2O)	4.95	2.22	-1.05	-1.04	2.525
2	U2* (TAP H_2O)	1.045	41.45	-0.725	-0.727	0.47
3	C1	1.662	65.95	-1.097	-1.095	0.75
4	C2	0.00944	0.00426	-0.988	-0.993	0.005
5	C3	1.338	62.25	-1.094	-1.094	0.706
6	C4	0.5578	0.3065	-1.069	-1.076	0.348
7	C5	4.591	21.26	-1.101	-1.094	2.411

U1, U2 – Uncoated samples in Salt water electrolyte and Tap water electrolyte respectively.

Fig 3.1 and 3.2 shows the Test values obtained after TAFEL slope Technique using AUTO LAB

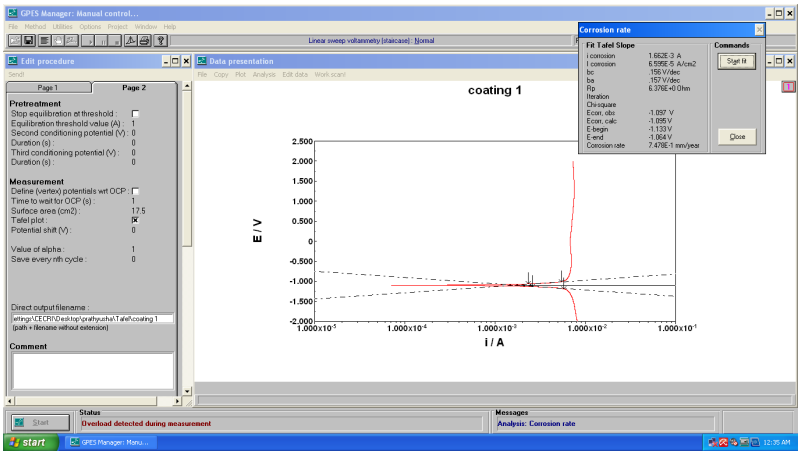

Figure 3.1: TAFEL Slope Technique results for coating 1

4 CONCLUSION

As already stated earlier, the main aim of the study is to experiment different coating which would inhibit corrosion in steel bridges. From this study, out of the 5 coatings, all the coatings performed well except C5. This may be attributed to the fact that void spacing is high in the coating. The best performance was

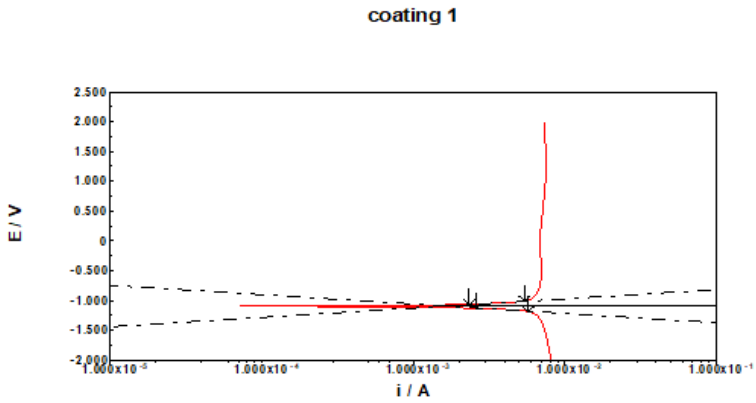

Figure 3.2: Graph obtained from the TAFEL Slope Technique

exhibited by C2- Aluminum paint followed by C4 Latex based coating (with Zn. Phosphate). It is recommended that Latex based coatings (with Zn. Phosphate) have a huge scope for further research in Anti-corrosion coatings.

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