Corrosion resistance of Structural Steel using Waste Plastic Oil

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Abstract. The failure of reinforced concrete structures is due to various surface damage or structural damage. The common problem identified for the repair of concrete structures is mainly because of Corrosion. In order to prevent the steel from corrosion effect, the various methodologies are being adopted. Core-shell theory was used to protect the steel material from the effect of corrosion by the application of cobalt oxide with zinc oxide on silica and alumina layer. According to this theory, the formation of effective protective layer is made to behave an anticorrosive coating. The combined effect of core and shell compounds enhances the efficacy of properties as a film of coating material for the steel used in the construction industry. The present study is an attempt on coating the steel reinforcement used in the construction industry using plastic oil extracted from the waste plastic which possesses the property of adhesion and resistance against corrosion.

Keywords: Corrosion, Coating, Adhesion and Reinforcement

1. Introduction

Corrosion is a damage observed on the steel material on exposure condition to the atmosphere. Generally corrosion is the effect of low water pH. The key parameters involving the causes of corrosive action of steel metal or pipes are content of O2, presence of chemicals in water, temperature, water pressure in pipes and pH. To minimize the corrosion, various techniques are being adopted such as application of coating layer, galvanizing technique, tinning method, electroplating technology, etc.

The disposal of plastics is a common problem throughout the world and huge amount of plastics has been disposed which long lasts as an environmental hazard for the next thousands of years. The major quantity of plastics is thrown in the water bodies which disturbs the life of aquatic animals.

In the past 50 years, the rate of production of plastics in the market increased at a faster rate. Hence the determination of techniques or methodology in recycling the waste plastics is an essential requirement from the point of view of environmental preservation. The main objectives of this study are to study the behavior of corrosion resistance of steel coated waste plastic oil by conducting Adhesion test, Salt Spraying test, Glossy Retention test and Rockwell Hardness test and also to compare the corrosion resistance of Normal Steel and Waste Plastic Oil coated Steel.

Various research works has been carried out in studying the corrosive behavior of steel using natural and artificial coating materials. The report of Ali (2011) gives the processing of plastics along with coal and petroleum residue at a high boiling point into the product of coating in liquid form. The
investigation of Miskolczi (2009) presents the process of pyrolysis of waste plastics in the reactor at high temperature in the presence of catalyst and produced the coating oil. The similar study has been made by Murfyk (2009) that using thermal pyrolysis process, an extraction of plastic oil used for performing the test on single cylinder diesel engine. An alternate solution is suggested by Glogovic et al (2011) for the preparation of aluminium coating for the protection of steel used in the structures in marine environment. A review study on the effects of atmospheric conditions, adsorption and corrosion is detailed by Malik et al (2010). Toma et al (2001) analysed that the effect of cermet coatings to protect the machine parts against wear and tear and corrosion. Joseph (2002) made a comparative study on the performance of corrosion resistance by galvanizing technique and spraying method. Babutsky et al (2015) tested two kinds of structural metals treated with pulsed electric current (PEC) of high density to study the intensity of corrosion. Nurnberge (2012) studied that the water content present in the building materials lead to corrosion of metals in contact. Hence this review shows the necessity of an alternate material to be searched for the protection of metals against the effect of corrosion.

2. Materials

Structural steel is a construction material available in variety of shapes. The shape and size of Structural steel and its strength properties are described by the standards. The materials selection for the study is the steel rod of 12 mm diameter and steel plate of 70 mm in length, 50 mm in breadth and 5 mm in thickness.

Waste Plastic Oil: The preparation of waste plastic oil involves the process of pyrolysis in which the hydrocarbons present in the plastics are broken down from long chains into short molecular chains at medium temperature in the absence of oxygen. This process replicates the preparation of fossil fuels. Hence this process helps in extraction of plastic oil from complex organic materials by fractional distillation.

| SPECIFICATIONS         | UNITS     | VALUE |
|------------------------|-----------|-------|
| Kinematic Velocity     | CST       | 13.0  |
| Flash point            | °C        | 60    |
| Water content          | % by WT   | 1.0   |
| Pour point             | °C        | 15    |
| Sedimental deposits    | % BY MASS | 0.10  |
3. Results and Discussion

The steel rod has been checked for corrosion resistance by various tests like Salt spraying test, Adhesion test, Glossy retention test & Hardness test. The various corrosion tests were carried out on steel specimen before coating and after coating with waste plastic oil.

**Salt Spraying Test:** The salt spray test is a standard and famous test method performed to study the corrosive behaviour of materials.

Fig. 2: Salt Spraying Testing Chamber

| S.NO | PARAMETERS               | VALUES          |
|------|-------------------------|-----------------|
| 1.   | NaCl                    | 5.2% NaCl       |
| 2.   | Chamber Temperature     | 33.8 – 35.0 C   |
| 3.   | pH of salt              | 6.7             |
| 4.   | Air Pressure            | 15 psi          |
| 5.   | Quantity of Solution    | 1.4 ml per hour |
| 6.   | Required exposure period| 24 Hrs          |
| 7.   | Exposure period         | 24 Hrs          |

Table 3: Salt Spraying test Observations for Steel Specimen before and after coating

| S.No | TIME     | Observation Before coating | Observation After coating |
|------|----------|-----------------------------|---------------------------|
| 1.   | At 12Hrs | No Corrosion                | No Corrosion              |
| 2.   | At 24Hrs | Red Corrosion               | No Corrosion              |

- No red corrosion observed at the end of 12 Hrs, 24 Hrs & 48 Hrs of testing after coating

**Adhesion Test:** The resistant against the substrates of paintings and coating application is determined using this test. Since the layer preparation and substrata have an adverse effect on the coating material of adhesion, this method evaluates the adhesive behaviour of coating with the layers of bases, coating
material or surface coating. Hence the adhesion test gives the usefulness of coating material in terms of bonding strength with the lower existing layers.

**Fig. 3: Image of Steel plate coated with waste plastic oil subjected to Adhesion test**

**Grade 5B:**
As per ASTM D5539 standards, the surfaces of the cuts of steel plate are found to be smooth and neatly finished.

**Fig. 4: Observation of Adhesion test results in comparison with ASTM D5539**

**Gloss Retention Test:** Glossy is a appearance of the material observed by emitting a light beam at a known angle and intensity. And the emission of light beam reflected to the source will be determined. The glossy measured using three different geometries 200, 600 and 850, is to provide clear differentiation from low glossy to high glossy levels. The angle recommended for the measurement depends on the value of the measurement obtained at 60 degree.

**Table 4: Glossy Retention values for different geometries**

| Range of Glossy       | Degree for Different Geometry |
|-----------------------|------------------------------|
| 10 – 70 glossy units  | 600                          |
| >70 glossy units      | 200                          |
| <10 glossy units      | 850                          |
Table 5: Test results of Gloss retention test

| TRIAL | GLOSSY VALUES |
|-------|---------------|
| 1     | 24.3          |
| 2     | 21.6          |
| 3     | 22.4          |
| 4     | 23.8          |

It is observed from the result obtained on the gloss retention test that for 600, observed range of Glossy is between 10 and 70 glossy units for the waste plastic oil coated steel plate.

Rockwell Hardness Test:

Table 6: Test results of Rockwell hardness test

| TRIAL | Rockwell hardness Number |
|-------|--------------------------|
| 1     | 90                       |
| 2     | 93                       |
| 3     | 93                       |

The maximum Rockwell hardness value for is 100 HRB (Rockwell hardness B grade)

4. Conclusion

The following conclusions are made based on the above study:

- After salt spraying is done, it is proved that the normal steel rod gets corroded at 24 Hrs and the Plastic oil coated rod doesn’t gets corroded even after 48Hrs. Hence the Plastic oil coated rod is 4 times effective than the normal rod.
- From the adhesion test observation, it is inferred that the lattice pattern on the steel plate is found to be of GRADE 5B which gives the bonding between waste plastic oil and Steel plate.
- The gloss retention of the waste plastic oil coated steel plate have been checked at the angle of 600 is 24 which have the glossy value in the range of 10 to 70 glossy units. Hence the plastic oil coated steel plate has a medium glossy surface.
- The Rockwell hardness number for the waste plastic oil coated steel plate has the average of 93 HRB, which is nearest to the maximum range of Rockwell hardness number of 100 HRB. So the hardness property of waste plastic oil coated steel plate is also found to be good.

Hence it is proven that the Steel plate and Steel rod coated with Waste Plastic Oil presents the beneficial result in the aspect of resistance against corrosion, improved adhesion with substrata, harder and best glossy nature. Also the use of waste plastic oil is a solution to recycle the plastics and reduces the problems associated with environmental issues.

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