

Corrosion Resistance for Different Types of Steels Under, Alkaline Solution

V. Swamy Nadh¹, K. Vasugi²

School of Mechanical and Building Science, Vellore Institute of Technology, Chennai, India^{1,2}

Abstract: Steel gets corroded under the action of chemical reaction with the environment. All the transition metals, iron, copper, zinc and nickel are slower to oxidized, they form passivation layer of oxide that protects the interior. Methods to reduce the activity of the exposed surface are by passivation and chromate conversion [2]. The main aim is to compare the corrosion resistance of different types of steels available carbon steel, stainless steel, galvanized steel, electroplated steel, tool steel, Damascus steel, wootz steel, MMFX steel as a part of that, we compared carbon steel, stainless steel and MMFX steel for research. The tests carried out for these steels are ASTM B117 and ASTM B895 to study the behavior under corrosion. The principal reason for selecting a new reinforcement material for concrete structures is to improve both the life span of the structure and cost effectiveness of the structural system. This paper is focusing on different types of steels under corrosion tests.

Keywords: ASTM B117, ASTM B895, corrosion salt spray, Steel.

I. INTRODUCTION

Corrosion of steel reinforcement is the primary and most costly form of deterioration currently impacting the performance of RC Bridge structures. Eliminating or slowing the deterioration of RC Structures due to the corrosion of steel reinforcement requires the use of innovative Methodologies, which are commonly subdivided into two categories. First, Deterioration is slowed through methods that lengthen the time it takes chloride ions to reach the steel reinforcement, the second includes methods that lengthen the time between initiation of corrosion and the end of service life. To study the properties of different steel we need to know the chemical composition of steel, which differs in different steels, we commonly use TMT (THERMO MECHANICALLY TREATED) bars for construction of structures. Among all the metals, iron is second only to aluminum in natural abundance, making up to 4.7% of the earth's crust, When we go through the chemical properties of steel we will can see different chemical compositions like carbon, manganese, silica, phosphorus, molybdenum, aluminum, nickel, sulfur, chromium, tungsten. All the alloys are most important in making good steel. As history says steels are of different types which have their own importance, i.e. carbon steel, stainless steel, galvanized steel, electroplated steel, tool steel, Damascus steel, wootz steel. Carbon steel and the stainless steel are the structural steels so we considered both of them for testing under corrosion.



Fig. 2. Stainless steel rebar's (ER 308L)

II. MATERIALS AND METHODS

Steel is alloy of iron with 1% carbon, we are going through different types of steel to study the chemical properties for observation consider three different types of steels i.e., carbon steel, stainless steel and MMFX steel. Carbon steel and stainless steel are structural steels these can be used for construction of buildings, culverts, steels and MMFX steel [7] majorly used for construction of high rise buildings, construction in coastal areas, construction of bridges etc. As there are many kinds of steels are there in market, select these three types of steel i.e., in carbon steel major percentage is occupied by carbon as shown in table 1, in stainless steel there is a change in manganese percentage which has more tensile strength than the carbon steel and the MMFX steel is uncoated, corrosion resistant, high strength steel reinforcing product the properties are much varied from other two materials carbon and stainless steel as shown in Table 1.

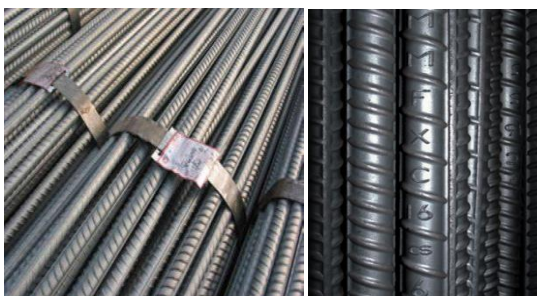


Fig. 1. MMFX steel rebar

TABLE I. MATERIAL PROPERTIES FOR DIFFERENT STEELS

NAME	C%	CR %	Mn %	Si%	S%	P%
CARBON	0.25	-	0.8	0.25	0.05	0.05
STAINLE SS STEEL	0.03	19.5	2.5	0.5	0.03	0.03
MMFX	0.074	9.3	0.619	0.147	0.014	0.009

The above chemical composition of each type of steel represents their importance, when compare those there is fluctuating in carbon % in all the steels, steel with more than 0.2% considered as carbon steel and the steel with chromium% is well known as corrosion resistant material, material with high percentage of manganese gives hardness and molybdenum improves wear resistance to steel.

The methods followed to compare the properties of steel; here we considered the standard tests for testing the steel under corrosion.

A. CHEMICAL TESTS

ASTM B895 (immersion in 5% NaCl) and ASTM B117 (salt spray testing) this tests gives the chemical reactions corrosion values.

III. METHODOLOGY

Select the materials required, according to ASTM B895[8] there are two methods for evaluating the ability of steel parts/specimens to resist corrosion when immersed in an aqueous solution of sodium chloride (5% NaCl) and in salt spray experiment.

A. IMMERSION TEST

Test specimens are examined periodically and the time of the first appearance of rust is used to indicate the end point. Continual exposure to the specimens to sodium chloride solution to know when the full corrosion occurs as a function of time.

B. SALT SPRAY TESTING

Salt spray testing was conducted in accordance with ASTM B117 at assuring testing services; this practice provides a controlled corrosion environment that has been utilized to produce relative corrosion resistance information for specimens exposed in salt spray chamber. One test specimen was placed in ASTM B117 (Salt spray chamber) continues fog of NaCl is passed through the salt solution reservoir to fog chamber as shown in fig.

A supply of suitably conditioned compressed air, specimen supports, provision for heating the chamber, the drops of solution that fall from the specimen shell not be returned to the solution reservoir for re-spraying.



Fig. 3. Salt Spray Chamber ASTM B 117 (high pressure)



Fig. 4. Salt Spray Chamber with solution tank (ASTM B 895)

IV. RESULTS AND DISCUSSIONS

Steel Specimens are allowed for corrosion testing under the salt spray experiment showing results for various amounts of rust or stain from ASTM B895. Test conducted in this equipment are to be referred for every hour to get the accurate results.

A. Steel 1 (carbon steel)

Carbon steel specimens are allowed for corrosion testing under ASTM B117, first rust of formation is observed at 12th hour as shown in table 2, specimen is observed for every hour and continuous exposure to sodium chloride gives full rust formation at 24th hour. As the chemical composition of carbon steel says that it consumes 2% of carbon from that the rust formation is observed at 24th hour as shown in table II.

TABLE II. TEST TIMINGS OF CARBON STEEL

Carbon steel	Test conducted	Initial rust hours	Final rust hours
Specimen 1	ASTM B117 and ASTM B119	12	24
Specimen 2	ASTM B117 and ASTM B119	11.45	24
Specimen 3	ASTM B117 and ASTM B119	12	23



Fig. 5. Sodium Chloride Solution tank (5% NaCl)



Fig. 6. Corroded Specimen in Salt Spray Chamber

B. Steel2 (stainless steel)

When the stainless steel specimen was tested for corrosion resistance it gives us the inter granular corrosion since the corrosion proceeds at the grain boundaries, basically we will test for inter granular corrosion only.

TABLE III. TEST TIMINGS OF STAINLESS STEEL

Periods	I	II	III	IV
Initial weight	18.4850	18.4730	18.4654	18.4543
Final weight	18.4730	18.46547	18.4543	18.448
Difference in weight	0.0120	0.0077	0.0111	0.0095
Corrosion rate/mm/month	0.0215	0.0138	0.0198	0.0170
Corrosion rate/miles/year	10.1306	6.4904	9.3687	8.0142

The above results are produced by cyclic performance of one sample over a period of 8days that is about 192 hours. At this time we made 4 cycles to under the results better. First cycle (I) corrosion occurred at 46th hour and the second cycle (II) corrosion is of greater than 1% and third cycle (III) corrosion rate in between 1-25% and last cycle (IV) corrosion rate is about greater than 25% according to ASTM B895 corrosion rate graph. ASTM D610-1 in fig 7.

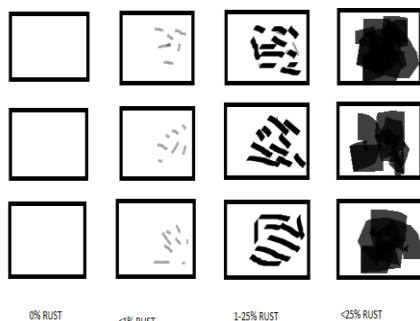


Fig.7. Rating of rust, according to ASTM D 610-1

C. Steel 3 (MMFX 2)

It is a low carbon steel, it is patented, proprietary steel technology forms a matrix that is almost a carbide free so the formation of micro galvanic is lasts in MMFX Steel , it was tested under the AASHTO MP 18[3] which gives the chloride threshold level in table 4, (CCTL the chloride in concrete that initiates corrosion) as shown.

TABLE IV. TEST RESULTS OF MMFX STEEL

Corrosion Performance Measurement Under ASTM A 1035	Test Time Length	Test Sample
Chloride threshold ratio	24wks	3.9
Time to corrosion initiation ratio	31wks	6.2
Time to corrosion ratio	35wks	2.7
Southern exposure test (µm/yr)	96wks	0.49
Percent weight loss ratio	26wks	0.24

As the above results are concerned, there is a cross of 100 years’ service life when MMFX steel rebar’s are used for construction, there is a difference of 3.3:1 ratio between the service life of MMFX of Carbon Steel, chloride threshold is about 5 to 6 times that of black bars (stainless steel) and 2 times that of MMFX BARS.

V. CONCLUSIONS

It is clear there is considerable scatter in the results .ASTM B895 is suitable for those that have an extended life prior to the appearance of corrosion products. Structural reinforcement should resist to corrosion. The corrosion rate in carbon steel is 20-30 miles/year, when it is in stainless steel it is 6-10 miles/year and in MMFX steel it is 0.2-6 miles/year. A structure made of carbon steel has a life span of about 40-50years, when we use stainless steel we have a life span of 90-100years and when we use MMFX steel has a life span of greater than 100years. Construction with MMFX steel has a service life of more than 100 years and have no repairs until the service life has been crossed.

REFERENCES

- [1] U. Angst & Ø. Vennesland, “Critical chloride content in the reinforced concrete – State of the art,” Concrete Repair, Rehabilitation and Retrofitting II – Alexander et al (Eds) © 2009 Taylor & Francis Group, London.
- [2] David McDonald, “Do epoxy-coated bars provide cost-effective corrosion protection?,” Epoxy Interest Group of CRS.
- [3] Michael F. Hurley, John R. Scully, Investigation of the Corrosion Propagation Characteristics of New Metallic Reinforcing Bars”.
- [4] Jianxin Ji, David Darwin, JoAnn P. Browning, “corrosion resistance of duplex stainless steels and mmfx microcomposite steel for reinforced concrete bridge decks”.
- [5] Lien gong, David Darwin, Joann p. Browning, Carl e. Locke, jr. University of Kansas, “Evaluation of mechanical and corrosion Properties of mmfx reinforcing steel for Concrete”.
- [6] Authors: Patrick J. Brennan, Steven J. Grossman and Russell C. Raymond – Q Panel Lab Products, Nick Harkness – Nick Harkness Pty Ltd, “The Development and Application of Corrosion/Weathering Cyclic Testing. ranzo j. Taylor, Jr, “
- [7] MMFX 2 rebar – product guide specification”
- [8] AMEC Earth and environmental, a division of AMEC emetic limited, “Comparative performance of MMFX microcomposite reinforcing steel and other types of steel with respect to corrosion resistance and service life prediction in reinforced concrete structures”.