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COMPARATIVE ANALYSIS OF STEEL CORROSION RESISTANCE

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ABSTRACT

The objective of the study was to conduct the comparative analysis of steel types corrosion resistance. Three selected steel types were used in the study. The selected types were structural steel, stainless steel, and MMFX steel. The methodology we adopted is that we evaluated the steel parts resistance towards corrosion by doing in-salt spray experiment and the immersion of aqueous solution of sodium chloride. For salt spray test, we used guidelines by ASTM B117. This practice provides a controlled corrosion environment which is used for exposing specimen to salt spray chamber. For immersion test, test specimens are analyzed at regular time interval as the first rust is appeared. For carbon steel, we used three specimen and mostly initial rust appeared in initial 13 to 15 hours. For stainless steel, inter granular corrosion were analyzed. The results show that the first cycle started after about 46 hours; the second cycle started about 1% and the third cycle started with the rage of about 2 to 30%. For MMFX 2 steel, the results show that for MMFX carbon steel, the chloride threshold ratio is about 6 times higher than black bars and more than double of other types. The conclusion of the study is that in big structures like bridges, the MMFX steel should be used.

Keywords: Steel Structures, Comparison, Salt Spray, Immersion

INTRODUCTION

For large steel structures, corrosion of steel is the most expensive depreciation which influence the performance of such bridges. There is greater interest in method which can reduce the

corrosion related deterioration. One method is to slow down the process of corrosion by increasing the time between initiation of corrosion and end of service life; while, the second method is to increase the time it takes chloride ions to reach the steel reinforcement. For understanding various steel types characteristics, we need to the chemical composition referred as Thermos Mechanically Treated bars. It is estimated that aluminum is available in plenty of quantity on earth with known quantity of about 4.8% of earth crust (Angst & Vennesland, 2008). The different chemical properties of the steel can be seen based on various chemical compositions such as tungsten, chromium, sulfur, nickel, aluminum, molybdenum, phosphorus, silica, manganese, and carbon. These various alloys make what is known as good steel. Various types of steel include tool steel, wootz steel, Damascus steel, electroplated steel, galvanized steel, stainless steel, and carbon steel based on different uses. Among these different types of steel, our interest is in structural steel, stainless steel, and MMFX steel which are used in steel structure and therefore, the main focus of the study.

Figure 1: Structural Steel Bars

Figure 2: Stainless Steel Bars

Figure 3: MMFX Steel Bar

MATERIALS AND METHODS

Steel is alloy of iron with carbon of about 1 percent. In this study, we analyze three of steel for understanding their chemical properties. Among various steels, the carbon and stainless steel are structural steels has most of its consumption from construction industry (Scully, Hurley, & Sharp, 2007). The MMFX steel is very strong steel and used for heavy purpose such as construction in coastal areas, steel bridges, and the skyscrapers. The properties of these three types of steel are provided in the table below.

Table 1: Steel Types and Properties

Name	C%	CR%	MN%	Si%	S%	P%
Carbon Steel	0.23	9.5	1	0.04	0.04	0.04
Stainless Steel	0.02	17.6	2.7	0.06	0.04	0.02
MMFX Steel	0.081	10.4	0.723	0.02	0.01	0.08

The table shows that in terms of C%, carbons steels stands highest (0.23); followed by MMFX Steel (0.08); followed by stainless steel (0.02). In terms of CR%, stainless steel is turned out to be highest with 17.6%; followed by MMFX steel with 10.4%; followed by Carbon steel with 9.5%. In terms of MN%, the stainless steel turned out to be highest with 2.7%; followed by carbon steel with 1%; followed by MMFX steel with 0.723%. For Si, the highest is stainless steel with 0.06%; followed by carbon steel with 0.04%; followed by MMFX steel with 0.02%. The S% wise, the carbon steel and the stainless steel are equal with value of 0.04% followed by MMFX steel with value of 0.01%. For P%, the MMFX steel turned out to be the highest with value of 0.08%; followed by carbon steel with value of 0.04%; followed by stainless steel with value of 0.02%. Overall, it shows that three types of steel have different qualities and resistance and hence they are different from each other in terms of strength and usage. The ASTM B895 and ASTM B226 for measuring the chemical reactions corrosion values.

The methodology we adopted is that we evaluated the steel parts resistance towards corrosion by doing in-salt spray experiment and the immersion of aqueous solution of sodium chloride.

Figure 4: In-Salt Spray Test

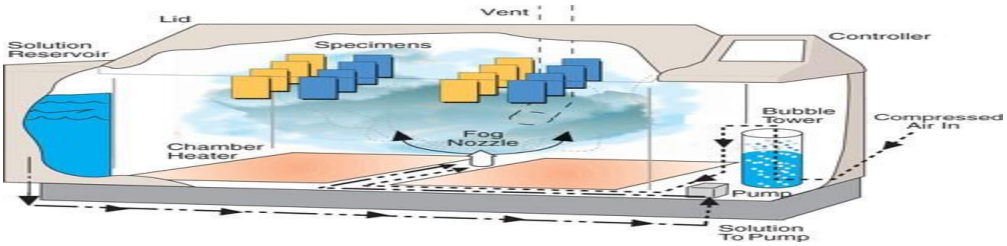

Figure 5: Procedure of In-Salt Spray Test

For salt spray test, we used guidelines by ASTM B117. This practice provides a controlled corrosion environment which is used for exposing specimen to salt spray chamber (Ji, Darwin, & Browning, 2005). The test specimen is placed in salt spray chamber and fog of NaCI is continued passing through the chamber to fog chamber. The chamber is supplied with specimen support and compressed air.

Figure 6: Immersion Test

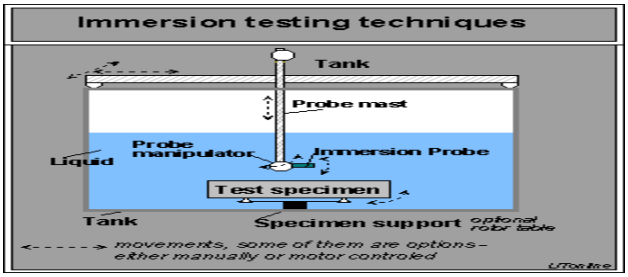

Figure 7: Immersion Test Procedure

For immersion test, test specimens are analyzed at regular time interval as the first rust is appeared (gong, Darwin, Browning, & Locke, 2004; Nadh & Vasugi, 2014). The specimen is continually exposed to the sodium chloride solution for getting to know when the full corrosion occurs as a function of time.

RESULTS

Tests conducted in the equipment used for this experiment were monitored every hour for getting the result. The steels specimens were allowed for corrosion under various salt spray experiment for varying amount of rust.

Carbon Steel

Carbon steels were permitted for corrosion. The first observed rust is after 15 hours. The specimen was continuously exposed to the rust and gave full formation at 24 hours. The results based on the carbon steel composition shows that 2% of carbon is consumed based on the 24 hours of observation.

Table 2: Results

Carbon Steel	Test Conducted	Initial Rust Hours	Final Rust Hours
Specimen 1	• Salt Spray Test • Immersion Test	15	30
Specimen 2	• Salt Spray Test • Immersion Test	13	28
Specimen 3	• Salt Spray Test • Immersion Test	15	28

Stainless Steel

The stainless steel is subject to the inter granular corrosion as the corrosion moves from the grain boundaries so we were required to test the inter granular corrosion only.

Table 3: Results

Time Interval	I	II	III	IV
Initial Weight	24.55	24.55	24.55	24.55
Final Weight	24.43	24.46	24.47	24.43
Difference in Weight	0.12	0.09	0.08	0.12
Corrosion rate/mm/month	0.011	0.012	0.03	0.04
Corrosion rate/miles/year	9.58	8.64	9.99	10.23

The sample is conducted under observation for about 200 hours and results shows that the first cycle started after about 46 hours; the second cycle started about 1% and the third cycle started with the rage of about 2 to 30%. The last cycle started with the rate of higher than 30%.

MMFX Steel

For MMFX 2 which is a low carbon steel, is patented steel matrix which is almost a carbide free so the formation of micro galvanic is lasts in MMFX steel. We used the ASSHTO MP 18 for the testing. Under this test, the chloride threshold level is provided.

Table 4: Results

Corrosion Performance Measurement under ASTMA 1035	Test Time Length	Test Sample
Percent weight loss ratio	30 weeks	0.30
Southern Exposure Test	96 weeks	0.51
Time to corrosion ratio	40 weeks	2.9
Time to corrosion initiation ratio	29 Weeks	5.1
Chloride threshold ratio	26 weeks	4.1

The results show that the for MMFX carbon steel, the chloride threshold ratio is about 6 times higher than black bars and more than double of other types.

CONCLUSION

The objective of the study was to test the three types of steel under various tests for their resistance to corrosion. The results show that MMFX has extended life as it shows greater resistance towards corrosion. In general, we found that for carbon steel, the corrosion rates come to about 25 to 35 miles/year whereas in MMFX steel, it is hardly about 0.1 to 0.5 miles/year. Thus, we can conclude that a structure which is made of carbon steel has life span of about 50

years; whereas stainless steel has life span of about 100 years; whereas, the MMFX steel has life span of 120 years and above. Thus, our study suggests that in big structures like bridges, the MMFX steel should be used.

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