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COMPARATIVE STUDY OF TMT STEEL IN TWO DIFFERENT SOLUTIONS

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Abstract Concrete admixtures can be prepared in distilled water samples such as normal distilled water and other aggressive media. Corrosion behaviour of TMT immersed in SCP solution evaluated by polarization study. It is concluded from these study that it is better to use distilled water to prepare concrete admixtures than 3.5%NaCl.

Key words: Simulated concrete pore solution, TMT steel, polarization study.

I. INTRODUCTION

Reinforced concrete structures exposed to marine environment are subjected to simultaneous action of number of physical, chemical and electrochemical deterioration process. In the view of immense cost involved in initial construction and in repair and rehabilitation, it is quite important that these structures should able to resist the ravages of time and deleterious effects of harsh environmental condition with minimum maintenance cost and hence reinforcement corrosion has been identified as the predominant deterioration mechanism for reinforced concrete structures, which seriously affects the serviceability and the safety of the structures. It has long been recognized that carbon steel reinforcing bars have a low resistance to corrosion in chloride-bearing environments, resulting in many and marine structures having been severely damaged by corrosion of the reinforcement. Although concrete provides protection for embedded steel, the penetration of oxygen, water and chloride to the carbon steel allows rapid deterioration of the entire structure (Castro, 2003) [1]. Out of various types of applications of low and medium carbon steels, their use as reinforcement in concrete is of significant proportion. An estimate of 2007 shows that out of 1500 million tons of total world consumption of steel, about 13% goes for use as re-bars [2]. Concrete

reinforcement by embedding steel is known since last more than a century. Reinforcement steel bars (also known as re-bars) with high carbon (>0.5 and <1.0 wt. % content) were initially manufactured in round shapes. High level of carbon was added in steels to achieve strength. However, it was realized that higher content of carbon created problem of brittleness and accelerated rate of corrosion due to the presence of higher proper-ion of cementite phases in steels which are brittle and also very effective cathode for oxygen reduction reactions during the corrosion process [3]. This problem was partially overcome by reducing carbon content to less than 0.3 wt. % and twisting re-bars (cold working which hardened steels and improved their yield strength). Such treatment however was quite expensive and also distorted the crystal structures of iron resulting in increased susceptibility to uniform and localized corrosion. A further improvement took place where during process of rolling, quenching and tempering treatments are provided. This treatment yields composite micro-structure of steels. The process popularly known as thermo mechanical treatment (TMT) transforms about 5–10% of outer diameter of re-bars in to hard tempered martensite structure (fast quenching and slow tempering of surface due to heat flow from core of the bars) whereas their core remains in the form of soft pearlite-ferrite[4]. This dual structure imparts strength as well as ductility to TMT re-bars. They are free from any distortion of crystals of steels and therefore expected to be more resistant to corrosion. Production of TMT type of re-bars is associated with some drawbacks such as the process is huge capital intensive and needs regular input of consumables. To overcome it, in recent years a new trend in development of re-bars has emerged where small content of copper, vanadium and other alloying elements are added in steels [5]. These elements improve the properties of steels by grain refinement and precipitations hardening due to formation of



carbides and nitrides. The corrosion of metals and alloys in natural and chlorinated seawater has long presented challenges for those responsible for materials selection and has been much studied. A number of alloys have been successfully used in seawater services. Copper-nickel alloys and the 300-series austenitic stainless steels are normally considered minimum starting points for materials selection in seawater, with duplex stainless steels, nickel-based alloys, and titanium specified for the more severe services. The choice of an appropriate

material for seawater service is a difficult decision that has to be made by a designer prior to specification of the system. The main reason of this work to know the corrosion behaviour of TMT rebar in marine environment.

II. MATERIALS

TMT rebar is to work for the whole experiment. The composition of bar is listed in table1 and mechanical properties in table2.

Sample	C	Si	Mn	P	S	Cr	Cu	Ni	Mo	Fe
1	0.26	0.08	1.03	0.05	0.04	0.41	0.24	0.04	0.03	Bal
2	0.23	0.16	0.94	0.03	0.03	0.16	0.001	0.01	0.01	Bal

Table: 1 Composition of samples

Sample	Yield Strength Mpa	Ultimate strength (UTS) Mpa	tensile EI	Hardness BHN
1	493	566	18	203
2	508	616	14	227

Table: 2 Mechanical properties

III. EXPERIMENTS

Simulated concrete pore solution

A saturated calcium oxide solution is used in the present study as SCP solution. The electrodes made of TMT were immersed in SCP solution and Potentiodynamic polarization study was carried out.

Potentiodynamic

PDP is an electrochemical technique commonly used for corrosion rate. The polarization curve displays the relationship between the current and the potential over a relatively wide range. In a PDP measurement, the electrochemical reactions that occur on the sample surface can be controlled, i.e. to cause it to act independently as either an anode or a cathode. Thus, by studying the anodic and the cathodic processes separately, the corrosion behaviour of the sample can often be further understood. Generally, the polarisation curves can be determined either by scanning the potential and recording the current or vice versa [6-8]. Therefore, the corrosion could be predicted by observing the response to a controlled change from steady state behaviour; which is created by application of potential (voltage) or current [9-

12]. If the scanned potential method is adopted, a PDP measurement is performed by slowly scanning the specimen potential through several hundred millivolts from the OCP in either the anodic or cathodic direction, and the potentials are plotted versus the log of the measured current to generate a polarization curve similar to Figure 1 [13-17].

Corrosion current density (i_{corr}) and corrosion potential (E_{corr}) can be estimated from this polarisation curve by Tafel extrapolation (slope of the linear regions) of the anodic and/or the cathodic lines as demonstrated in Figure 1. Further details may be derived from the polarization curves. For example, passivity of the metal/alloy due to formation of a thin protective film on the surface can be indicated from the polarisation curve (dotted lines) displaying a passive limiting current ($i_{passive}$) with increase in potential at the anodic region. Also, break-down of passivity due to either pitting attack or reaching the transpassivity region can be indicated from the polarization curve when the current density increased sharply. Also, an examination of Figure 1 reveals that other details can be derived concerning the cathodic processes. For a corroding system under diffusion control, adequate approximations are sometimes



possible with limited Tafel behaviour and, i_{corr} is always is equal to the limiting current (i_L).

The potential difference across an open circuit cell (ΔE_n) could be determined thermodynamically. When a device which generates current (I) is applied, the voltmeter will read a value, (ΔE) which is different from (ΔE_n). If I positive then ΔE will be larger i.e more positive than (ΔE_n) and so E will be more positive than E_n . On the other hand, negative current flow through the cell could result in a reductive electrode reaction at the working electrode and thus causing a negative shift in the electrode potential. This shift is called polarization. Polarization has

ohmic polarization which reflects the resistance of the whole cell [18-20]. The activation polarization effect arises at different locations in the cell and it has its origin at the electrode interface. When a reference electrode is introduced into the cell, the polarization could be reduced. The polarization was performed potentiodynamically by starting at a negative potential (0.25V) and then moving to the positive (1.6V) direction in steps height of 0.5 mV, with the scan rate of 0.01 mV/sec and the step time is 1s.

Equilibrium(E)	Cathodic tafel slope potential range(b_c)	Anodic tafel slope potential range(b_a)	Cathodic tafel slope(b_c)	Anodic tafel slope(b_a)	Linear polarization resistance	Corrosion current(A)	Corrosion rate(m/yr)
-0.662	-0.836to 0.736	-0.612 to 0.512	4.374	6.62	6.5836	0.0806	96.7479

Table: 3 Potentiodynamic result

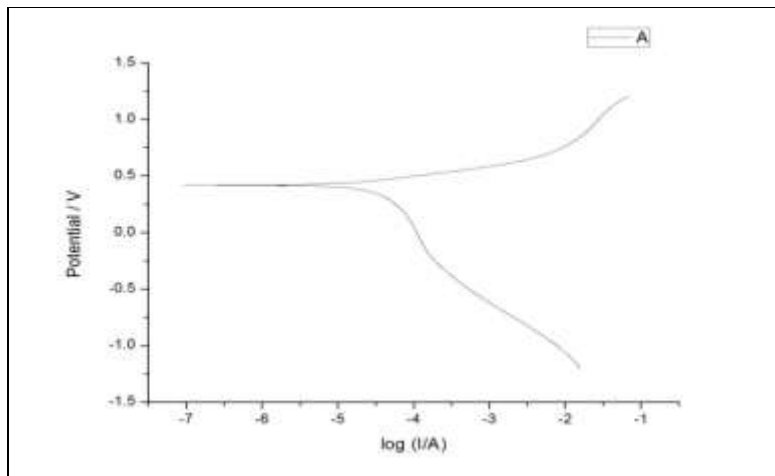


Figure: 1 Potentiodynamic graph of TMT bar

IV. CONCLUSIONS

The alloy shows different corrosion behaviour with considerable difference in their corrosion resistance in all the solutions. This was confirmed by the different patterns in the polarization curves from the electrochemical techniques. The alloy shows different active to passive transition behavior in polarization. The passivity of alloy seems to remain

unstable with passivity breakdown and pitting in concentrations of all the solutions. E_{corr} of the alloys in all the solutions reached a stable value after a certain period of exposure. This indicates that the corrosion processes of the alloys remain constant with time and they formed relatively stable corrosion products in the media studied.



V. REFERENCES

1. Castro, P., Weva and Balancim, M. (1997). "Corrosion of reinforced concrete in a tropical marine environment and in accelerated tests". *Journal of Construction and Building Materials*, 11(2), 75-88. Angel Rey, IISI-Short Range Outlook-March 2007, Available at www.steelonthenet.com (accessed on 20.07.11).
2. H.H. Uhlig, R.W. Revic, *Corrosion and Corrosion Control*, third ed., John Wiley and Sons, New York, 1985. p. 22.
3. P. Simon, M. Economopoulos, P. Niles, Tempcore: a new process for the production of high quality reinforcement bars, *Iron Steel Eng.* (1984) 53–57.
4. D. Russwurm, Development and Use of Vanadium in Micro-Alloyed Reinforcing Bar, Vanitech Monograph No. 1, Publication No. V121, available at <http://www.vanitec.org/pdfs/b5b1b4c2a6885a0b89ab1c13373ce08c.pdf>.
5. P. Simon, M. Economopoulos, P. Niles, Temp core: a new process for the production of high quality reinforcement bars, *Iron Steel Eng.* (1984) 53–57.
6. Jones, D. A. (1996). Principles and prevention of corrosion, Prentice-Hall, Inc., USA, 75-80, 143 153.
7. Cottis, R. A., *Electrochemical Methods, in Shreir's Corrosion (Corrosion in Liquids, Corrosion Evaluation)*, M. Graham R. Cottis, R. Lindsay, S. Lyon, T. Richardson, D. Scantlebury and H. Stott, Editor. 2010, Elsevier. p. 1341.
8. Silverman, David C., *Practical Corrosion Prediction Using Electrochemical Techniques*, in Uhlig's Corrosion Handbook, R. W. Revie, Editor. 2000, John Wiley and Sons, Inc: Canada. p. 1179-1225.
9. Al-Refaie, Abdullah, *Inhibition Mechanisms of Molybdate and Nitrite (Phd Thesis)*, in School of Materials, Corrosion and Protection Centre. 2009, The University of Manchester.
10. ASTM E 1251-94, Standard Test Method for Optical Emission Spectrometric Analysis of Aluminium and Aluminium Alloys By The Argon Atmosphere, Point-To-Plane, Unipolar Self-Initiating Capacitor Discharge, (1994), Vol 03.06
11. ASTM Standards G1-03 (Standards Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens). 2003.
12. Malik, A.U., Andijani, I.N. and Ahmed, S. (1994). Corrosion monitoring in SWCC plants Al Khafji plant. Research & Development Center, Al-Jubail and Madeeh Al-Khalidi and Khalid A. Al-Maeeli Al-Khatji Desalination Plant. Technical Report, 34, 1040-1056.
13. C. Andrade, C. Alonso, D. Garcia, J. Rodriguez, Remaining lifetime of reinforced concrete structures: effect of corrosion on the mechanical properties of steel, *International Conference on Life Prediction of Corrodible Structures*, 1991, pp. 12/ 1–12/11, Cambridge, UK.
14. C. Andrade, C. Alonso, F.J. Molina, Cover cracking as a function of bar corrosion: Part 1. Experimental test, *Material and Structures* 26 (1993) 453–464.
15. J. Rodriguez, L.M. Ortega, J. Casal, Corrosion of reinforcing bars and service life of reinforced concrete structures: corrosion and bond deterioration, *International Conference on Concrete across borders*, Odense, Denmark, 1994, Vol.2, pp.315–326.
16. J. Rodriguez, L.M. Ortega, J. Casal, Load carrying capacity of concrete structures with corroded reinforcement, *Construction and Building Material* 11 (4) (1997) 239–248.
17. X. Fu, D.D.L. Chung, Effect of corrosion on the bond between concrete and steel rebar, *Cement and Concrete Research* 27 (12) (1997) 1811–1815.
18. L. Amlleh, S. Mirza, Corrosion influence on bond between steel and concrete, *ACI Struct J* 96 (3) (1999) 415–423.
19. F. Paradis, V. Lapointe, M. Jolin, J. Marchand, Accelerated test methods to investigate chloride-induced steel corrosion damage in reinforced concrete—a brief review, in: V.M. Malhotra (Ed.), *Seventh CANMET/ACI International Conference on Durability of Concrete*, 2006, pp. 357–373, May 28–June 3, Montreal.
20. T. Vidal, A. Castel, R. Francois, Corrosion process and structural performance of a 17 year old reinforced concrete beam stored in chloride environment, *Cement and Concrete Research* 37 (2007) 1551–1561.

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