Technical Talk on:

Learning from the Past: the Delhi Iron Pillar

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Inauguration of IIM website www.iimpc.com

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ABSTRACT

The Delhi Iron Pillar has attracted the attention of metallurgists and corrosion scientists for its excellent resistance to corrosion. The talk will first summarize new insights, relating to its history, astronomical significance, engineering details and manufacturing methodology, on the Delhi Iron Pillar based on the researches of the author. The effect of manufacturing methodology and non-homogeneous microstructure on the corrosion resistance will be touched upon. The corrosion resistance of the Pillar will be discussed in detail, with a brief review of earlier theories of its excellent corrosion resistance. A mathematical model of the role of environment on the corrosion resistance will be presented. The results of a detailed characterization of the Delhi Iron Pillar's rust clearly established that the major constituents of the scale were crystalline iron hydrogen phosphate hydrate ($FePO_4.H_3PO_4.4H_2O$), goethite, lepidocrocite, amorphous delta-FeOOH and magnetite. The iron oxide/oxyhydroxides were present in the amorphous form. The process of protective rust formation on Delhi pillar iron will be understood and compared with that of mild steel and weathering steel, based on the rust analysis. Some notable characteristics of the protective passive film on the Delhi Iron Pillar will be summarized.

Based on the known beneficial effect of phosphorus on corrosion of the Delhi Iron Pillar, the final section of the talk will be devoted to understanding the possible use of phosphoric irons in a modern application, namely for concrete embedment. Three phosphoric irons (Fe-0.11P-0.028C, Fe-0.32P-0.028C and Fe-0.49P-0.028C, wt.%) were ingot melted (85 kg ingots) and forged between 1050 and 1100 degree Celsius in the dual phase region (of the iron-phosphorus phase diagram) to minimize grain boundary segregation of phosphorus. The importance of this heat treatment in inducing ductility will be explained, touching upon mechanical testing and associated studies of fracture surfaces. The phosphorus distribution in the microstructure will be understood by detailed microstructural characterization. The results of potentiodynamic polarization, linear polarization and electrochemical impedance spectroscopy (EIS) studies in two different simulated concrete environments (a) saturated calcium hydroxide of pH 12.5 and (b) 0.3M $NaHCO_3$ + 0.1M Na_2CO_3 solution of pH 9 will

be presented and discussed. The electrochemical behavior has been contrasted with two commercial reinforcement steels of composition Fe-0.18%C-0.8% Mn (mild steel) and Fe-0.18%C-0.34%Cu-0.09%P-0.8%Mn (equivalent to weathering steel). The threshold chloride contents for passive film breakdown were higher for phosphoric irons. The phosphoric irons were particularly superior in chloride containing high pH environments. The superior corrosion resistance of the phosphoric irons will be discussed in terms of phosphorus maintained in solid solution in the matrix and a bipolar passive film model. Future directions for research and development on phosphoric irons will be set forth in the concluding section.

Prof.R. Balasubramanium inaugurated and launched IIM website www.iimpc.com

Prof.R. Balasubramanium delivering a talk on Delhi Iron Pillar

Left to Right: Dr.N.K.Nath, Dr.P.P.Deshpande, Dr.M.J.Rathod, Dr.E.C.Subbarao, H.K.Panigrahi, Prof. R. Balasubramaniam, Dr.A.K.Singh, Dr.N.B.Dhokey. Dr.S.T.Vagge, N. Thakare