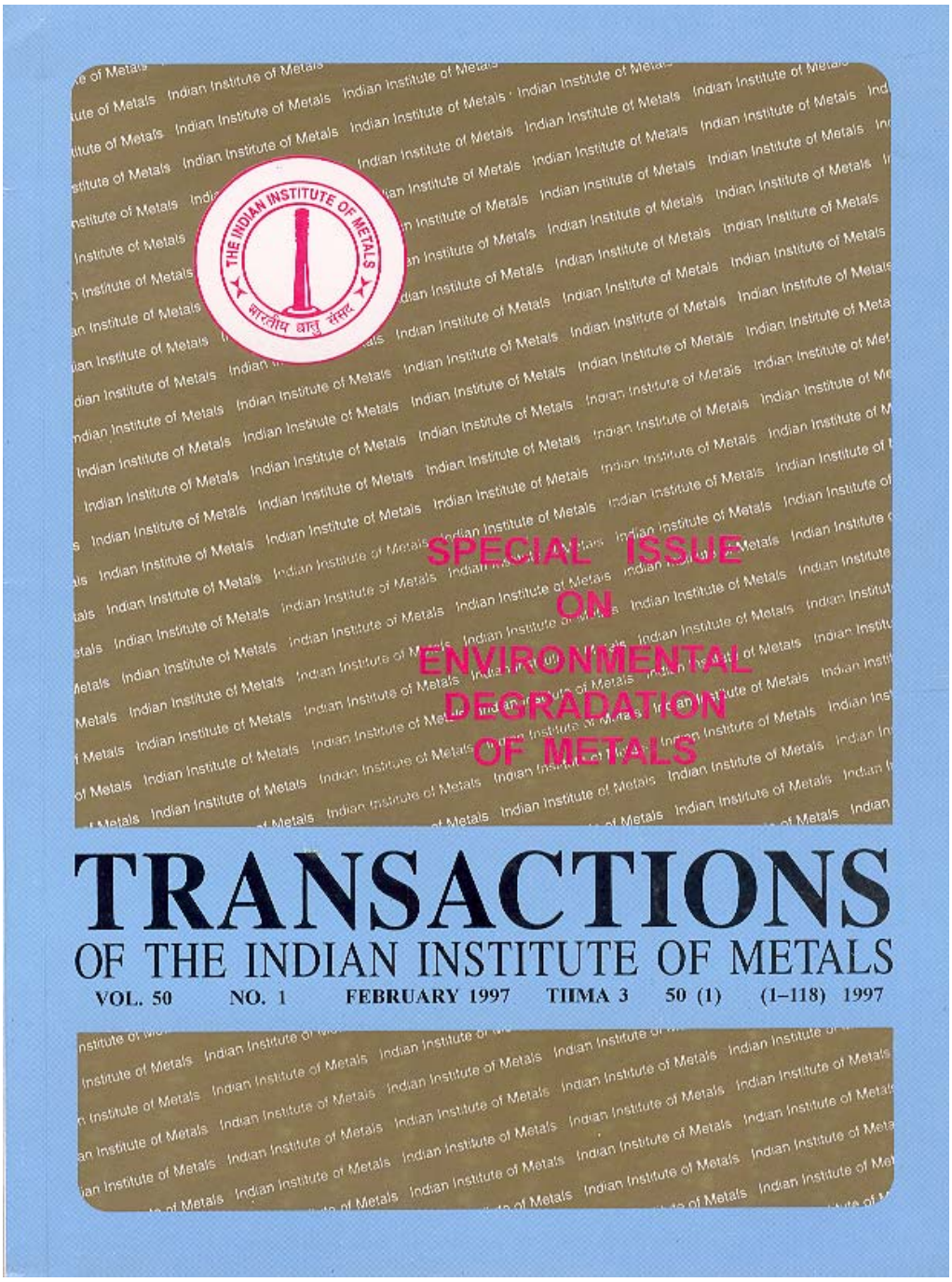

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MIXED POTENTIAL THEORY ANALYSIS OF THE CORROSION RESISTANCE OF DELHI IRON PILLAR

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ABSTRACT

The famous Delhi iron pillar has withstood corrosion for the last 1600 years. The theories that have been proposed to explain the corrosion resistance of the pillar have been critically reviewed. However, the theories fail to explain why the heterogeneous structure of the iron pillar (wrought iron with entrapped slag inclusions) is resistant to corrosion whereas it should be very prone to corrosion. This anomaly has been addressed in this paper which presents a new theory for the corrosion resistance of the Delhi iron pillar based on mixed potential theory. The analysis reveals that the enhanced cathodic reduction reactions due to the presence of slag particles aid the formation of a passive protective film, thereby providing corrosion resistance. Experimental support for the analysis is provided by electrochemical potentiodynamic polarization studies on a 700 year old ancient Indian iron, with and without slag inclusions. The possible mechanism of protective film formation on the iron pillar's surface has also been discussed.

1. INTRODUCTION

The iron pillar situated at Meharauli in the south of New Delhi has been the centre of attraction for historians and metallurgists all over the world as it has withstood corrosion for nearly 1600 years. The pillar is 737.5 cm high of which 50 cm is below the ground level and 45 cm is surrounded by a stone platform (**Fig. 1**). The diameter of the pillar at the ground level is 41.6 cm and it tapers upwards to 30.4 cm just below the decorative capital which tops the column (**Fig. 2**). The detailed dimensions of the pillar are provided by Ghosh[1] . The decorative column at the top appears to have been forced into a hollow cylinder provided in the main pillar. Moreover, there is a rectangular slot (15 cm x 5 cm and 40 cm deep) at the top of the pillar (**Fig. 3**), which must have originally contained an idol of Garuda. This is reasonable because Garuda idols are usually found on the top of stone pillars erected as flagstaffs in Vishnu temples constructed during the Gupta period. For example, there is a stone pillar dated from the year 484 AD at Eran in Madhya Pradesh in the central part of India which bears a double-sided image of Garuda on top of the decorative column which, incidentally, is of a design similar to the decorative top column of the Delhi iron pillar[2]. The pillar widens to a diameter of 62 cm below the ground level and its rests on a thick lead plate laid over a heavy slab of stone[1]. At the flat base of the pillar, eight small projections protrude and penetrate into the thick lead plate. The lead plate base provides a cushioning effect against seismic disturbances[1]. The weight of the pillar is estimated to be about 6096 kgs.

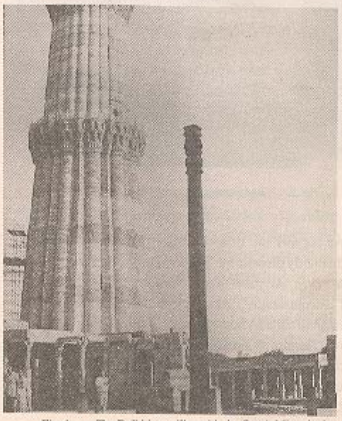

Fig. 1. The Delhi iron pillar with the Qutub Minar in the background