

# SOME OBSERVATIONS ON USE OF SILICEOUS MINERAL WASTES IN REDUCTION OF CORROSION IN RCC STRUCTURES

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*The corrosion-resisting characteristics of reinforcement in cement blended with siliceous mineral wastes viz. gold tailing and flyash have been evaluated by using an accelerated corrosion technique. The additions of these mineral admixtures to cement varied between 0 and 20 % with difference of every 5 %. Results of the test show that the blending of gold tailing and flyash to cement significantly improves the corrosion resistance performance of concrete exposed to sea water. Maximum reduction in the corrosion rate was observed in the concrete mixed with 10 % gold tailing together with 10 % flyash.*

*The corrosion rate and polarisation resistance of the control concrete specimen was found to be 0.285 mpy, 35.08  $k\Omega \cdot cm^2$  whereas for the concrete with 10 % gold tailing together with 10 % flyash, the values were 0.127 mpy, 83.5  $k\Omega \cdot cm^2$  respectively.*

## INTRODUCTION

Durability of concrete is one of the major concern among scientists and corrosion engineers from 18th century till now. Recent trends in the materials research show importance to the utilisation of various waste minerals/admixtures for enhancing the durability of concrete structures [1-3]. This, apart from enhancing durability, also helps in effective utilisation of mineral wastes. A lot of research activity have been already directed towards the improvement of the performance of concretes through the addition of mineral wastes such as flyash, silica fume, blast furnace slag etc. [4-8]. However, very few documented research data is available on the utilisation of mine wastes such as gold tailing in producing various building materials and concrete [9,10].

Gold tailing is a fine siliceous mineral waste of gold ore beneficiation plant which has no potential use. In India about 0.5 million tons of gold tailings are produced annually at about 100 Gold mines and its disposal is an acute problem. The utilisation of the waste is attractive since it promises resources conservation

and minimises disposal costs. Several researchers found that gold tailing is an useful siliceous material in producing building material and concrete. Watanabe et al [10] have recommended the production of autoclaved concrete by replacing 40 % cement by these tailings. Hansen [11] has also reported the feasibility of the utilisation of gold tailing with portland cement as a binding material. Hence in the present investigation it was expected that the addition of gold tailing along with flyash may have some modifying effect on the corrosion of steel in concrete. Thus an investigation is carried out in the laboratory to determine the utility of these mineral wastes in enhancing the corrosion resistance of steel in concrete in sea water. The results obtained would help to determine their suitability as an admixture to cement concrete in order to enhance the durability of concrete in marine environment. This paper gives data on the corrosion of steel in various concrete mixes blended with gold tailing and flyash materials.

## EXPERIMENTAL

### Materials and Specimens

The reinforced concrete specimens for the investigation contained ordinary portland cement, crushed granite jelly (10 mm), locally available river sand in the ratio 1:1:2 and water-cement ratio of 0.45. The mineral wastes gold tailing and flyash were obtained from Hutti gold mines and Raichur thermal power plant respectively. These mineral wastes contained about 50 - 55 % silicate (SiO<sub>2</sub>) in their chemical composition. Gold tailing was powdered to 45 microns size and burnt at a temperature of 500°C in a furnace. The dried powder is then blended with the cement in the required proportions and the concretes have been prepared. The main effect of heat treatment may often be to calcine any clay impurities present, changing them from deleterious constituents to inert/pozzolanic one. The artificial pozzolanas can be obtained by the heat treatment of natural materials such as clays and shales and certain siliceous rocks [12, 13]. Specimen of size 250 mm length and 50 mm diameter with centrally embedded steel of 10 mm diameter was used. The concrete was poured layer by layer into the mould and compacted thoroughly using steel rods. 24 hours after the completion of casting, the cylindrical mould was detached and kept for the exposure in sea water. The exposed portion of the steel bar was painted with chlorinated rubber paint to prevent corrosion by moisture. All specimens were exposed for a period of 90 days in natural sea water. The various concretes under study are indicated in Table I.

### Accelerating Corrosion Tests

For the corrosion behaviour of embedded steel in various mixes, polarisation studies were carried out using a potentiostat with a software SOFTCORR. A standard three electrode configuration was used, consisting of working electrode, a graphite electrode and a saturated calomel reference electrode [14].

Table I - Concretes under test

Concrete reference	Particulars
C1	Control specimen
F1	Cement with 5% GT
F2	Cement with 10% GT
F3	Cement with 15% GT
F4	Cement with 20% GT
G1	Cement with 5% [GT & FA]
G2	Cement with 10% [GT & FA]
G3	Cement with 15% [GT & FA]
G4	Cement with 20% [GT & FA]

GT= Gold Tailing FA = Flyash

## RESULTS AND DISCUSSIONS

Table II gives the electrochemical parameters obtained for different concrete specimens with various percentages of gold tailing and fly ash contents. The percentage of replacement

Table II : Electrochemical parameters obtained for various concretes in sea water

Specimen reference	Corrosion current [ $I_{corr}$ ] ( $\mu\text{A}/\text{cm}^2$ )	Polarisation Resistance [Rp] ( $\text{K}\Omega\text{-cm}^2$ )
C1	0.62	35.08
F1	0.43	52.83
F2	0.59	36.78
F3	0.57	38.11
F4	0.71	30.50
G1	0.50	43.36
G2	0.27	81.69
G3	0.28	80.07
G4	0.26	83.50

varied between 0 and 20% with an interval of 5%. A comparison of the corrosion behaviour of the concrete specimens with different gold tailing and flyash contents was made in sea water. It can be seen that the corrosion rate of rebar embedded in concrete is significantly influenced by the addition of the mineral waste gold tailing and flyash (Fig. 1).

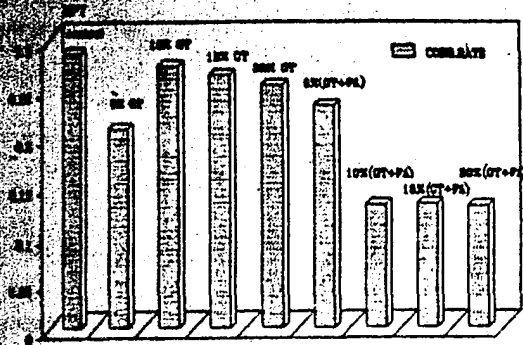


Fig.1 Corrosion of steel in various concretes

The corrosion current [ $I_{corr}$ ] values for concretes with partial replacement of gold tailing of 5, 10, 15 and 20 % are 0.43, 0.59, 0.57 and 0.51  $\mu A/cm^2$  respectively, whereas the  $I_{corr}$  value for the control specimen was 0.62  $\mu A/cm^2$ . The polarisation resistance values obtained for concretes C1, F1, F2, F3, F4 are 35.08, 52.80, 36.78, 38.11 and 30.50  $K\Omega \cdot cm^2$  respectively. This clearly indicates the beneficial effect of the mineral waste gold tailing. Furthermore addition beyond 25% did not show any improvement in the corrosion of rebar in concrete. Hence, the gold tailing blended cements of 5, 10, 15 and 20 % respectively performed 1.44, 1.05, 1.08 and 1.21 times better in terms of corrosion resistance compared to the control concrete mix. The decrease in corrosion reactions and the corrosion rate of steel in various concrete, as indicated by the value of corrosion current ( $I_{corr}$ ), can be explained on the basis of the nature of the pozzolanic activity. The addition of this fine mineral waste particles block the interstices, that could hinder the free move-

ment of chloride and other ions. This phenomenon appears to be primarily associated with the changes in the mix microstructure, presumably due to the continuing pozzolanic reaction which is due to the replacement of cement by the gold tailing. Although the replacement of gold tailing enhances the corrosion resistance of rebar in concrete to some extent, a larger replacement had no influence and enhanced the corrosion rate of reinforcement. The concrete containing 5% gold tailing replacement to cement exhibited maximum increase in terms of corrosion resistance of rebar in concrete exposed to sea water and the  $I_{corr}$  values obtained are in the order  $C1 > F2 > F3 > F4 > F1$ . The lower  $I_{corr}$  values in concretes containing gold tailing particles is attributed to the lower permeability and the water absorption of concrete.

The blending of flyash with gold tailing with equal proportions in concrete significantly altered the corrosion resistance of rebar in various concretes. The  $I_{corr}$  values obtained for concretes containing 5, 10, 15 and 20 % of gold tailing and flyash are 0.5, 0.27, 0.28 and 0.26  $\mu A/cm^2$  respectively. The polarisation values obtained for concretes G1, G2, G3 and G4 are 43.36, 81.69, 80.07 and 83.5  $K\Omega \cdot cm^2$  respectively. Hence the blending of flyash with gold tailing enhanced the corrosion resistance of rebar in concrete. This is clearly indicated by the performance of 10, 15 and 20 % flyash and gold tailing concretes. The reason for the lower corrosion rates may be due to the alteration in the pore structure of the concrete matrix. The fine siliceous particles have produced very fine pores that make it difficult for reacting ions to move freely to the steel bar. The chemistry of the concrete might have also been changed.

The results are obtained based on short term exposure conditions. But at longer exposure periods the research needs to be done to understand the long term durability of concretes made with gold tailing and flyash.

## CONCLUSION

The addition of mineral wastes gold tailing to reinforced concrete mix reduces the corrosion of mild steel bar embedded in it. Furthermore, the blending of flyash to gold tailing particles in concrete enhances the corrosion resistance of the reinforcement. This has been attributed to the bonding and pozzolanic effect of the gold tailing and flyash particles in concrete.

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