Corrosion of reinforcement in a mixture of limestone-clay and perlite based blended concrete

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ABSTRACT

This paper reports the results of experiments evaluating the corrosion resistance of a mixture of limestone-clay (MLC) and perlite in concrete mixes. Variables were MLC and perlite additions of 0–15% as cement replacement and cement contents. Electrochemical measurements tests were used to monitor the corrosive behaviour of embedded steel bars in concretes. Results showed that additions of MLC and perlite are effective in inhibiting corrosion of reinforcing bars. The superior performance in inhibiting corrosion in reinforcing steel is attributable to the densification of the cement-paste matrix due to pozzolanic action in the additives concrete mixes.

INTRODUCTION

Mild steel embedded in concrete is protected against corrosion by both a chemical and a physical mechanism. Chemical protection is provided by the high pH of the concrete, which causes passivation of the reinforcing steel. Concrete also provides physical protection, by hindering the access of aggressive agents. Severe corrosion problems occur in many concrete structures. Most frequently, corrosion is induced by the ingress of chloride ions which leads to a local destruction of the passive film [1]. Addition of ash, slag, silica fume as a pozzolanic material to concrete has become common practice in recent years [2-9]. These materials can also improve the durability of concrete and the rate of gain in strength and can also reduce the rate of liberation of heat, which is beneficial for mass concrete [4,5]. Studies have been published concerning the effect of fly ash on concrete porosity and resistivity [10], pore solution chemistry [12], oxygen and chloride ion diffusivity [11–14], carbonation rates [15], passivation [16] and corrosion resistance [17] especially chloride-induced corrosion.

The aim of this study is to investigate effects of a mixture of limestone-clay (MLC) and perlite on corrosion of reinforcing steel embedded in concrete mixes. In this study has investigated the effect of adding MLC and perlite in different proportions (5%, 10% and 15% on behavior of reinforcement mild steel in concrete.

MATERIALS AND METHODS

ASTM C 150 Type I Portland cement was utilized in all the concrete mixtures. MLC, and Perlite were used as fillers. Table 1 shows the chemical composition of Type I Portland cement, MLC and perlite. Potable water was used for mixing the concrete constituents.

Table 1 Chemical composition of Type I Portland cement, MLC and Perlite Constituent (wt.%)

Constituent	MLC	Perlite
SiO_2	10,60	74.76
TiO_2	-	0.027
Al_2O_3	1,07	0.027
Fe_2O_3	0,59	13.59
FeO	-	0.13
MnO	-	0.075
MgO	1,11	0.02
CaO	48,99	0.75
Na_2O	12,90	4.16
K_2O	-	4.14
P_2O_5	-	0.004
SO_3	10,60	-

The concrete ingredients were mixed in a revolving drum mixer for approximately five to seven minutes to obtain a uniform consistency and flowable characteristics.

Reinforced Specimens

Reinforced specimens measuring 100 mm in diameter and 150 mm high, were prepared 12 mm diameter 3 steel bar placed at the center. Reinforcement corrosion was monitored by measuring the corrosion potentials, according to ASTM C 876, and by the Tafel polarization method.

Corrosion Potentials

The corrosion potentials were measured using a saturated copper/coper sulfate reference electrode (Cu/CuSO4). The electrical lead from the reference electrode was connected to the negative terminal of a high impedance digital voltmeter while the steel bar in the concrete was connected to its positive terminal Figure 1.

Tafel Polarization Method

The three electrode method was utilized to measure the corrosion rate using a Potentiostat/Galvanostat. The steel rod was connected to the working electrode terminal while a steel plate and a reference electrode were connected to the counter and reference electrode terminals of a Potentiostat/Galvanostat, respectively. The steel was polarized from -1.0 V 1,0 V at a scan rate of 2 mV/s and the resulting corrosion rate.

The tests were continued over a period of 12 months. Open circuit potential measurements were monitored with reference to saturated Copper/Copper sulfate electrode periodically with time as per ASTM C876. From the results potential vs. time plot is drawn using the average potentials obtained.

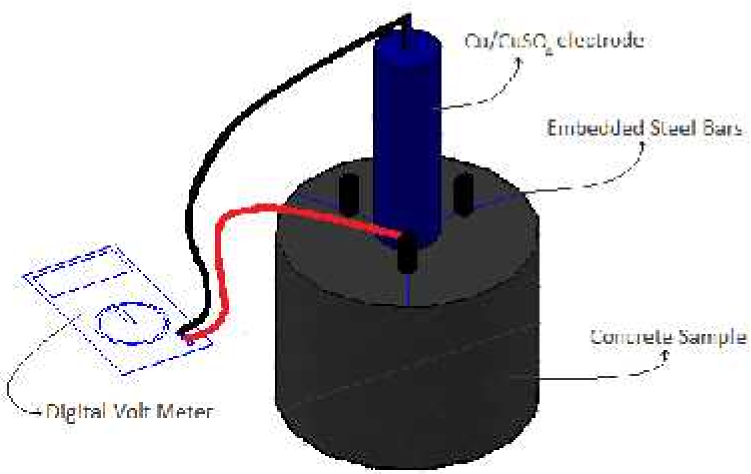

Figure 1 Schematic representation of specimens

RESULTS AND DİSCUSSİON

The corrosion of the samples was estimated by monitoring the corrosion potential vs. exposure time (Figs. 2 and 3). During the 12 months of exposure the potential values range between -250 and -500 mV. Just after the immersion in the NaCl solution, cement specimens exhibit corrosion potential values ranging between -250 and -350 mV Cu/CuSO4 for perlite and MLC specimens, whereas that of the non-additive ones equals -500 mV. Then a decay of Ecor to more electronegative values is observed, which is faster for non-additve specimens.

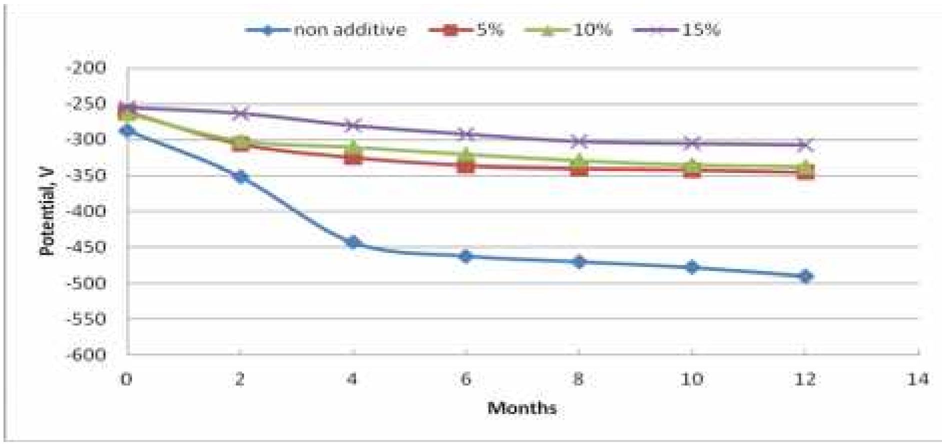

Figure 2 Open Circuit Potentials on reinforcement in different proportion replaced MLC specimens

After about 4 months of exposure, all the specimens reached to more or less stable Ecor value ranging between about -325 mV for perlite contain specimens and 400 mV for MLC contain specimens, while that of non additive ones is equal to about -500 mV. The steeper decay of Ecor of the uncoated specimens and their more electronegative final Ecor value imply an increase in the electrochemical activity of the system, that can be attributed to an increased corrosion of the steel rebars.

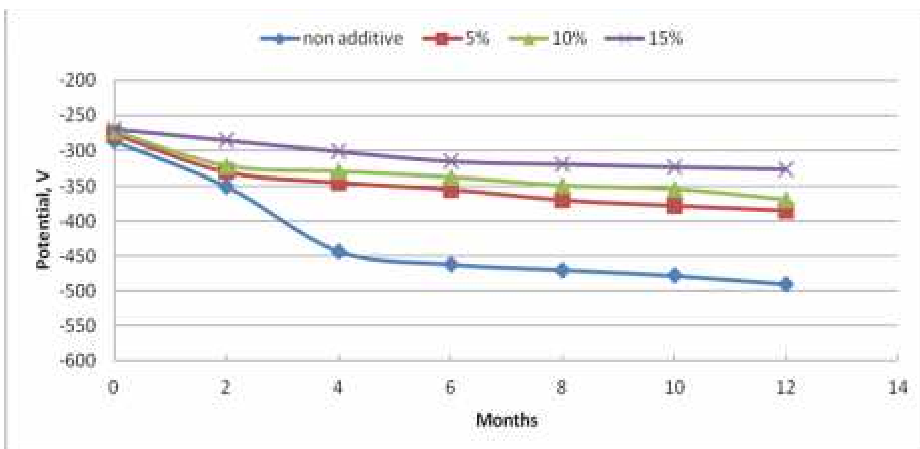

Figure 3 Open Circuit Potentials on reinforcement in different proportion replaced perlite specimens

Fig 4 shows that the differences between containing perlite and MLC specimens. As it is shown in Figs 3and 4, the specimen prepared MLC and perlite resisted better against corrosion than the ones prepared with no additive specimen.

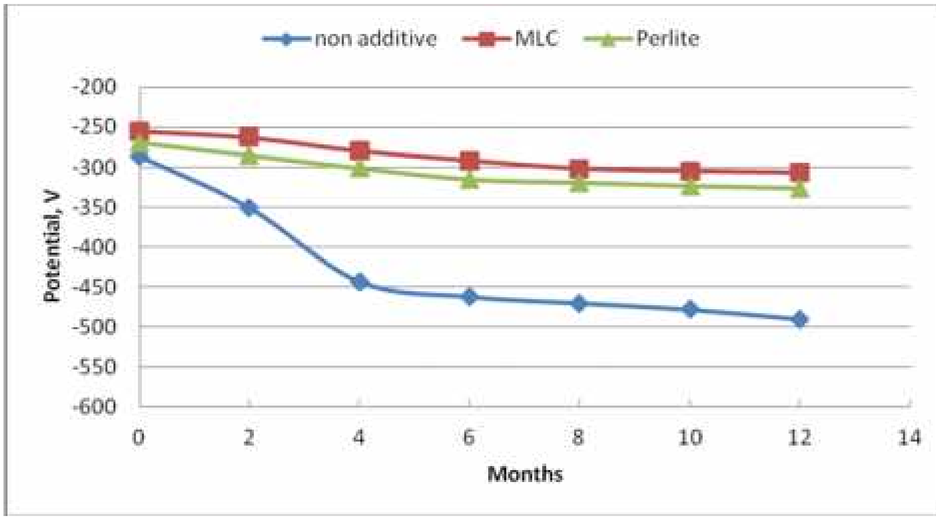

Figure 4 Open Circuit Potentials on reinforcement
in specimens non additive, specimens with replaced MLC and perlite

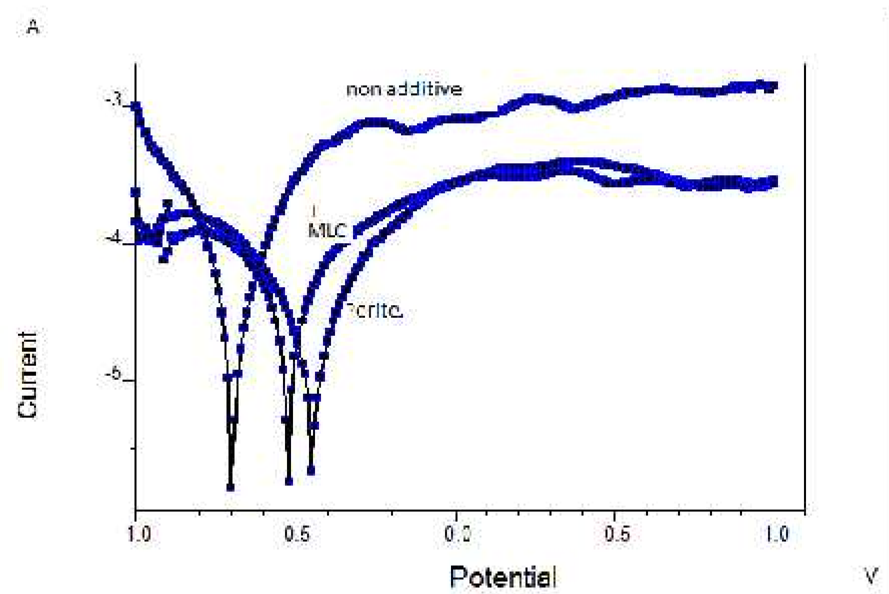

Figure 5 Tafel polarization cuırves for
specimens non additive, specimens replaced MLC and perlite

Specimens replaced MLC from the beginning of the exposure more electropositive Ecor values than the non additive one and more electronegative values than the corresponding specimens replaced Perlite. Fig 5 shows Tafel polarization curves. As it is shown in Fig 5, corrosion rate decreases the specimen prepared MLC and perlite. The corrosion rate measured by Tafel Polarizatin method and determined the corrosion rate 0.08, 0,02 and 0,015 respectively for non additve, replaced MLC and replaced perlite specimens. Perlite resisted better against corrosion than the MLC.

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