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Sulfur concrete for repair works

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In this paper, it is shown that unmodified sulfur concrete can be a candidate material for repair of deteriorated reinforced concrete structures provided rebars are coated with inhibited cement slurry to prevent sulfur corrosion. An epoxy resin bonding layer is also needed.

Key words: Sulfur concrete, steel corrosion, cement coating, slant shear test

INTRODUCTION

Sulfur concrete can be considered as an alternate material for conventional concrete for repair and rehabilitation of reinforced concrete bridges. It was earlier shown that the chemical resistance of unmodified sulfur concrete was comparable to that of M45 OPC concrete in nitrate, sulphate and sulphuric acid media [1]. However its alkali resistance was found to be very poor. Another major disadvantage in sulfur concrete is that sulfur by itself can promote reinforcement corrosion. It has been reported that modified sulfur concrete is superior to elemental sulfur concrete [2].

In this paper, the usefulness of coating the steel rebar with inhibited cement slurry to prevent sulfur corrosion has been examined. The various properties of sulfur concrete which are important from the point of view of its use for repair work namely Slant shear strength, Splitting tensile strength, Pullout strength have been studied.

EXPERIMENTAL

Potential-time studies

Mild steel specimens (0.9 cm dia and 2.5 cm long) either uncoated or coated with patented inhibited cement slurry coating were centrally embedded in sulfur concrete specimens of size 5 cm dia and 5 cm long. 4% NaCl by weight of cement was added to the concrete mix at the time of casting. The specimens were immersed in 3.5% NaCl solution and potential was followed with respect to SCE for 60 days.

Pullout test

10 cm dia and 38 cm long mild steel plain bars were derusted and centrally embedded in 10 cm size concrete cube. Pull-out was performed as per I.S: 2770 (Part I)–1967.

Slant shear test was performed mainly to test the adhesive strength of repair mortar/concrete to the substrate concrete as per B.S. 6319 by conducting compression test in 2000 KN capacity Compression Testing Machine. For this test 10 × 10 × 20 size prism with repair/substrate adhesion line at 30° to the vertical was used.

Cylinder-splitting tensile test

This test was performed to know the true tensile strength of concrete. In this test, 7.5 cm dia × 15 cm height cylindrical sulfur concrete specimen was placed horizontally between the loading surfaces and compression load was applied until failure.

RESULTS AND DISCUSSION

Corrosion studies

The potential-time behaviour of both coated and uncoated steel specimens are shown in Fig. 1. It is seen that the potential of uncoated steel stabilises quickly in 0% as well as 4% Cl^-. On the other hand the potential of the coated steel specimens tend to become more positive with time. For 0% Cl^-, it is –200 mV vs SCE and for 4% Cl^-, it is around -500 mV. Visual observation at the end of 60 days showed severe rusting on the uncoated specimens while coated specimens remained unaffected.

Mechanical properties

Table I shows that the pullout strength increases with sulfur concrete whereas splitting tensile strength remains more or less same at all sulfur contents except in 12%. It can be seen from Table II that only epoxy resin serves as the most effective bonding layer.

CONCLUSIONS

It is shown that unmodified sulfur concrete can be a candidate material for repair and rehabilitation of deteriorated concrete structures, provided steel rebars are coated with inhibited cement slurry, and an epoxy resin bonding layer is introduced between substrate and sulfur concrete.

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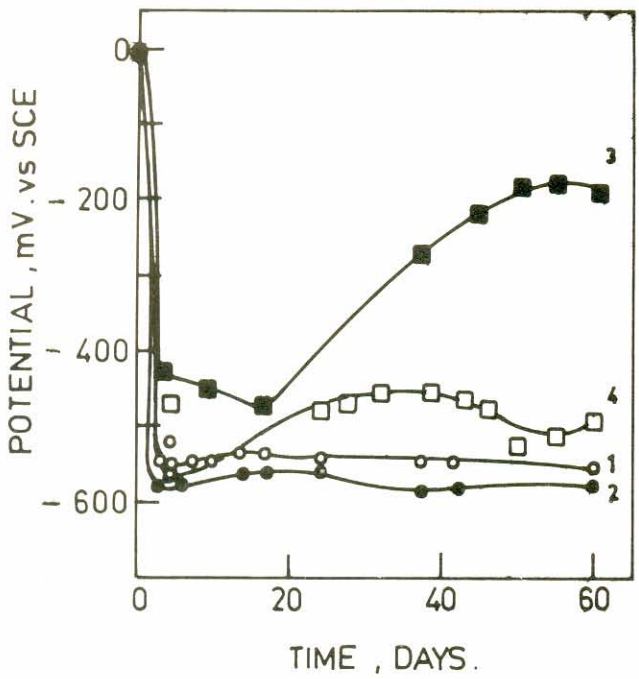

o—o 0% Cl^- (uncoated)
■—■ 0% Cl^- (coated)
•—• 4% Cl^- (uncoated)
□—□ 4% Cl^- (coated)

Fig. 1: E vs t on 20% sulfur concrete in 3.5% NaCl

TABLE–I: Data on bond strength and tensile strength

Sulfur content %	Pullout strength ($N.mm^{-2}$)	Splitting tensile strength ($N.mm^{-2}$)
20	6.48	4.57
18	5.04	5.04
16	5.43	4.58
14	4.54	4.78
12	3.80	2.94
Minimum required	1.20	3.10

TABLE–II: Slant shear strength on 20% sulfur concrete

Type of bonding layer	Bond strength ($N.mm^{-2}$)	Mode of failure
Epoxy resin	23.00	Prism failed monolithically rather than along the bond line
Beeswax-resin	3.70	Failed along the bond line
Molten sulfur	5.00	-do-
Control (without any bonding layer	5.86	-do-

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