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EFFECT OF SULFATES ON BOND BEHAVIOR BETWEEN CARBON FIBER REINFORCED POLYMER SHEETS AND CONCRETE

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Introduction

The presence of sulfate in soils, groundwater, sea water, decaying organic matter, and industrial effluent surrounding a concrete structure pose a major threat to the long term durability of the concrete exposed to the environments, represented in Cracking, Spalling, Increased permeability and Strength loss.

Rehabilitation techniques have been used to regain shear strength capacity and prevent failure of reinforced concrete members. The behavior of the interface between the FRP and the concrete is the key factor controlling debonding failures in FRP-strengthened RC structures.

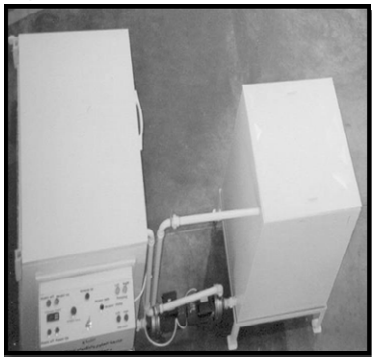
Effective repair with external FRP reinforcement requires a strong bond between the repair laminates and the sulfate-damage concrete substrate. Consequently, evaluating the reduction in bond at various levels of sulfate attack is fundamental for a successful repair design.

Experimental Program

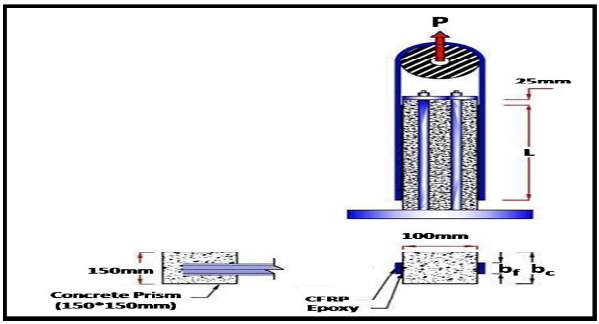
A single concrete mixture was prepared at w/c ratio of 0.65 using Type I ordinary cement with coarse limestone aggregate, and a mixture of fine limestone and silica sand, before used to prepare specimens (150x150x100 mm) and standard cylinder (150x300 mm) specimens. Specimens were cured in water for 28 days before treated in 2.5%

Na_2SO_4 and 2.5% Mg_2SO_4 solution using a special treatment chamber before bonded to CFRP sheets. Other set of specimens were cured in lime water for specific period before bonded to CFRP sheets and transferred to the sulfate solution chamber for treatment. A third set of specimens without and with bonded CFRP were kept in lime water, as controls. The compressive mechanical properties were evaluated for control specimens as well as for those subjected to different stages of sulfate treatment (stages I to II) using standard cylinders (150x300 mm), whereas shear strength-slip relationship evaluated for prismatic pull-off specimens using a special setup. The experimental results obtained for control and sulfate-treated concrete specimens were compared to determine the effectiveness of sulfate in controlling the bond strength.

Experimental Program



The conditioning unit used for cyclic treatment in the sulfate solution.



Effect of Sulfate Treatment on Bond-Slip Behavior

✓ Bond-slip behavior of pull-off specimens bonded to CFRP sheets after sulfate cyclic treatment.

Concrete specimens	Width (mm)	Length (mm)	Pu (kN)	τmax (MPa)	Slip (mm)
Control	50	85	16.20	3.82	0.18
	100	85	25.90	3.05	0.14
	150	85	30.74	2.41	0.11
	100	65	22.02	3.39	0.13
Stage I	50	85	12.96	3.05	0.14
	100	85	20.72	2.44	0.11
	150	85	24.60	1.93	0.09
	100	65	17.62	2.71	0.10
Stage II	50	85	9.72	2.29	0.11
	100	85	15.54	1.83	0.09
	150	85	18.44	1.45	0.07
	100	65	13.21	2.03	0.05

Effect of Sulfate Treatment on Bond-Slip Behavior

✓ Percent Reduction in bond stress and bond slip under several parameters

Concrete specimens	Width (mm)	Length (mm)	Loss in τmax	Loss in Slip
Control	50	85	0 %	0 %
	100	85	0 %	0 %
	150	85	0 %	0 %
	100	65	0 %	0 %
Stage I	50	85	20%	22%
	100	85	20%	22%
	150	85	20%	22%
	100	65	20%	31%
Stage II	50	85	40%	40%
	100	85	40%	40%
	150	85	40%	40%
	100	65	40%	66%

Effect of Sulfate Treatment on Bond-Slip Behavior

Concrete specimens	Width (mm)	Length (mm)	Pu (kN)	τ_{max} (MPa)	Slip (mm)
Control	50	85	16.20	3.82	0.18
	100	85	25.90	3.05	0.14
Stage I	50	85	14.04	3.60	0.16
	100	85	22.49	2.65	0.13
Stage II	50	85	10.50	2.47	0.12
	100	85	16.87	1.99	0.10

Effect of Sulfate Treatment on Bond-Slip Behavior

Percent Reduction in bond stress and bond slip under several parameters

Concrete specimens	Width (mm)	Length (mm)	Loss in τ_{max}	Loss in Slip
Control	50	85	0%	0%
	100	85	0%	0%
Stage I	50	85	6 %	11%
	100	85	13%	11%
Stage II	50	85	35%	31%
	100	85	35%	31%


Conclusion

The trend behavior for bond-slip curves for double shear pull-off specimens showed no noticeable change after being exposed to sulfate attack.

Exposure of double shear pull-off specimens to sulfate cyclic treatment influenced negatively bond behavior as bond strength was reduced by 20% and 40% after stages I and II, whereas slip at failure was reduced by 22% and 40%, respectively.

Bonding of CFRP to concrete prior to sulfate treatment imparted higher bond strength as compared to that when concrete was subjected to sulfate treatment prior to bonding to CFRP sheets.

The percentages reduction in bond stress and corresponding bond slip at failure were not affected by CFRP bonded width.

As bond length was increased the bond strength and corresponding slippage were decreased and increased significantly.