EXPERIMENTAL STUDY ON INFLUENCE OF MOISTURE ON SHEAR BOND PROPERTIES AT FRP/CONCRETE INTERFACE

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1. INTRODUCTION

The increasing use of fiber reinforced polymer (FRP) for the structural retrofit of concrete members such as beams, columns, slabs, and bridge decks have become the necessity to investigate the FRP-concrete bond performance in long term environmental exposures. In marine environment, the moisture could be one of the most important factors which can accelerate the deterioration process thus intriguing premature bond failure at FRP/concrete interface. But the moisture related damage mechanism of the FRP composites is complex phenomenon and the previous studies on the long term durability of these materials in civil applications are limited. Therefore, understanding the mechanism of moisture degradation is essential to enhance the interfacial bond performance thus ensuring safe, economic and durable design of the structures.

2. EXPERIMENTAL PROGRAM

The experimental study consists of determination of FRP-concrete bond strength by single lap shear bond test with and without the exposure of different period. The concrete blocks were casted and CFRP tow sheets were attached following the normal procedure of sheet bonding. Two different epoxy primers were used which are polythiol hardener epoxy resin named as Type-E and poly-amine hardener epoxy resin named as Type-F but in both cases same epoxy resin was used for FRP impregnation and adhesion. After proper curing, half of the specimens were immersed in normal water maintaining the constant temperature of 20 °C whereas remaining specimens were left in dry place in the laboratory until the test. The overall dimension of the specimen and the test setup are shown in Fig. 1 and the study parameters are shown in Table 1. Material test of the resins were also performed to know the effect of water in the mechanical properties of the resins (tensile strength, shear strength and Young's modulus) but the results are not included in this paper.

Table 1: Experimental parameters

S.No.	***Specimen***	***Primer***	***Exposure condition***	***Time (months)***
1	B*ND0	Type-E/ Type-F	Dry	0
2	B*ND1			1
3	B*ND2			2
4	B*ND3			3
5	B*ND4			4
6	B*NW1		Wet	1
7	B*NW2			2
8	B*NW3			3
9	B*NW4			4

*stands for "E" in case of "Type-E" primer & "F" in case of "Type-F" primer

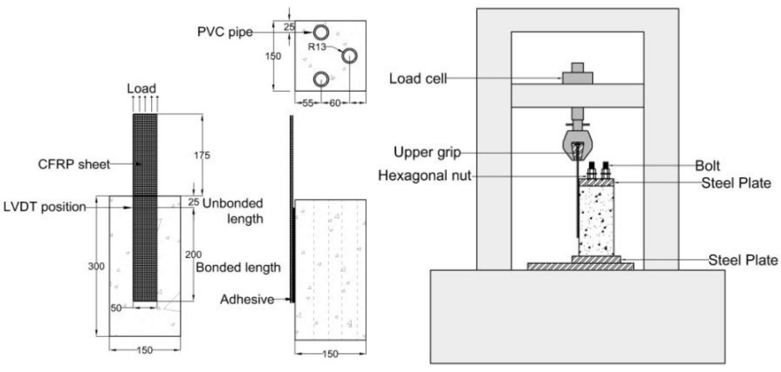

Fig.1 Specimen geometry and test setup

3. RESULTS AND DISCUSSIONS

The comparisons of peak load with and without water immersion at different duration of time are shown in Fig. 2. Clearly there is an indication of reduction of peak load in case of water immersed specimens. This decrease in bond strength was found to vary from 3% to 13% when compared to non-immersion cases of same period. In past few studies, deterioration of mechanical properties of the epoxy resins were reported due to absorption of water in prolonged

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exposure (Sciolti, Frigione, & Aiello, 2010). This absorption of water could cause plasticization, hydrolysis, cracking and craving of the matrix thus breaking the polymer chains and ultimately reducing the polymer's strength, modulus etc. But in the current study the effect of water in the mechanical properties (tensile, shear, elastic modulus) of the resins were either none or minimal after 4 months of immersion. Therefore the slight decrease in the bond strength for water immersion cases could be attributed to the deterioration of adhesion strength between the primer and concrete interface. The water at the primer-concrete interface region may have displaced the bulk adhesive materials causing the reduction in adhesive strength between the FRP and concrete (Petrie, 2006). This phenomenon can also be supported by observing the failed surface of FRP sheets after the complete debonding.

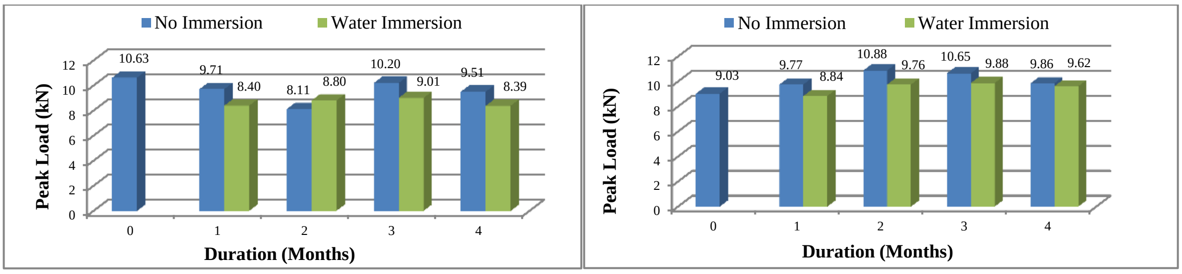

Fig. 2 Comparison of peak load at different time periods for Type-E specimens (left) and Type-F specimens (right)

Fig 3 shows fracture surface of failed FRP sheets at different exposure conditions. For Type-E specimens, the failure mode shifted from pure concrete shear failure in no immersion case to the mixed primer-concrete interfacial failure in water immersion specimens. In case of Type-F specimens, the failure mode changed from mixed primer-concrete interfacial failure in no immersion case to almost complete primer-concrete separation in water immersion specimens. Au et al. (2006) and Dai et al. (2010) also observed this kind of shift in failure modes when specimens were immersed in water which could be explained by the loss in adhesion property at the primer-concrete interface due to water.

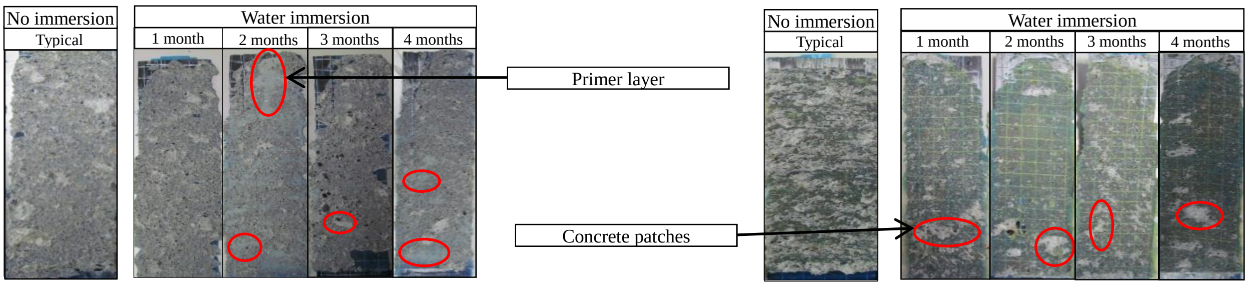

Fig. 3 Failure surfaces for type-E bond specimens (left) and type-F bond specimens (right) for both non immersion and immersion cases

4. CONCLUSIONS

Based on 4 months exposure program, the following conclusions can be drawn:

a) The bond strength was reduced when the specimens were immersed in water for two types of primers tested in this study. This reduction in strength was due to deterioration of the bond at FRP-concrete interface caused by the water.

b) After exposure in water, the bond failure of FRP-concrete interface occurred at the primer-concrete layer showing loss in adhesion properties.

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