DEVELOPMENT OF BOND STRESS-SLIP MODELS FOR CFRP/CONCRETE BOND EXPOSED TO MILD ACIDIC EXPOSURE

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Carbon Fiber Reinforced Polymer (CFRP) is widely used in various industries due to its excellent mechanical properties, including a high tensile strength-to-weight ratio and resistance to corrosion. However, the bond performance of CFRP with concrete can be adversely affected by exposure to mild acidic environments, which can originate from sources such as acidic rains, soil, sewage, and industrial activities. This study focuses on developing an understanding of the bond stress-slip behaviour of CFRP/concrete joints exposed to acidic conditions, specifically examining the impact of different bond curing temperatures and exposure periods in a mildly acidic environment.

The experimental results, obtained from a previous study, involved CFRP/concrete single-lap shear specimens exposed to a sulphuric acid solution with a pH value of 2 for 15, 30, and 90 days. Those specimens were cured at ambient temperature (28 °C), 65 °C, and 75 °C to investigate the effects of curing conditions on bond performance. The experimental results from that study provided data on load-displacement behaviour and failure modes under those varying conditions. Complementing the experimental work, a finite element model (FEM) was developed using a commercially available finite element software to simulate the bond behaviour of CFRP/concrete joints. A modified version of Simplified concrete damage plasticity model was used as the material model for concrete, while a linear elastic model was employed for the CFRP, and the adhesive was modelled using a damage evolution model to account for potential degradation. The numerical model was validated against the experimental data, showing a strong correlation in predicting the load-displacement behaviour of the joints under different curing and exposure conditions.

The results of the study indicated that curing temperature significantly influenced the bond strength of CFRP/concrete joints. Specimens cured at 65 °C exhibited the highest failure loads, suggesting that elevated temperature curing enhanced the bonding mechanism. However, curing at temperatures beyond the glass transition temperature (T_g) of the epoxy resin resulted in a reduction of bond strength. Furthermore, prolonged exposure to acidic environments degraded the bond strength, with noticeable reductions observed after 90 days of exposure. This degradation is due to chemical reactions with the acid that weaken the bond interface.

Parametric studies were also conducted to assess the effects of adhesive layer thickness and different types of CFRP on bond performance. An adhesive thickness of approximately 1 mm was found to be optimal for maximising bond strength. Additionally, the use of CFRP with a higher modulus showed marginal improvements in joint strength but did not significantly alter the overall failure behaviour when exposed to a mildly acid environment.

Keywords: CFRP / Concrete joints, Finite element modelling, Bond-slip variation, Mild acidic exposure

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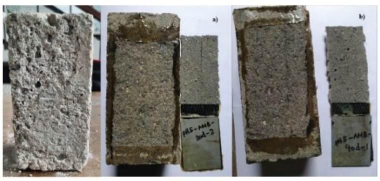
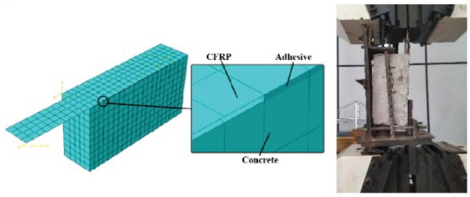
Environmental Impact on CFRP/Conrete Bonds

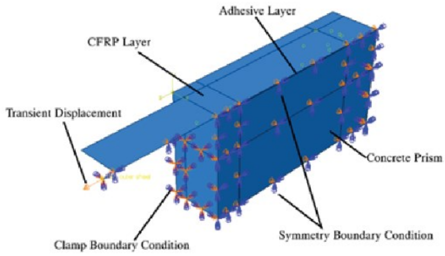
Carbon Fiber Reinforced Polymer (CFRP), known for its high strength-to-weight ratio, is used to reinforce concrete structures, improving durability and performance in demanding and corrosive environments



Mild acidic exposure from rain, soil, and industrial activities can degrade CFRP-concrete bonds, compromising structural integrity

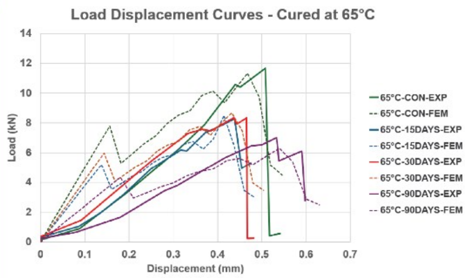
Simulation Approach

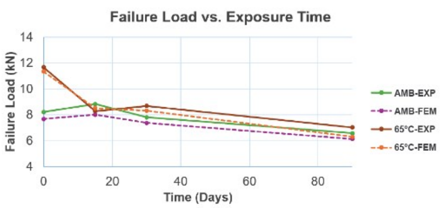




Finite element modeling simulated CFRP-concrete bond behavior under various curing conditions and acidic exposure, accounting for material degradation

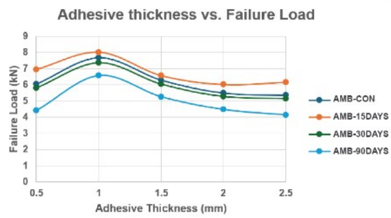
Model Validation



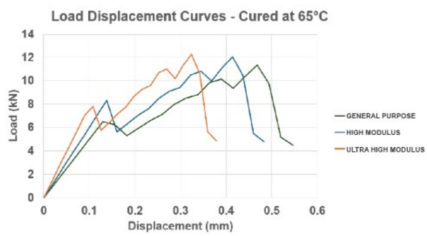


The finite element model accurately predicted load-displacement behavior under both ambient and elevated curing conditions, confirming its reliability

Key Findings



An optimal adhesive thickness of 1 mm maximizes bond strength by balancing coverage and stress within the bond line



Higher modulus CFRP slightly increased peak load, but overall failure behavior remained consistent, indicating a dominant adhesive failure mode