BOND PERFORMANCE OF CFRP/STEEL COMPOSITE AT ELEVATED TEMPERATURES

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Degree of Master of Science

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other university or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters under my supervision

Name of the supervisor: Dr. (Mrs.) J.C.P.H. Gamage

Signature of the supervisor: Date:

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ABSTRACT

Carbon Fibre Reinforced Polymer (CFRP) is being used as a retrofitting material for different structures such as, concrete and steel. Glass transition temperature (T_g) of the bond between CFRP and steel influences on the service and fire performance of strengthened members. A total of eighty-two CFRP/steel double strap joints were prepared and tested under elevated temperature. They were cured under a range of elevated temperature conditions in the control laboratory environment and in the open environment which is practically feasible in large civil engineering structures. The test results showed a similar trend of reductions in the bond strength, Poisson's ratio and Elastic modulus of CFRP/steel joint with the exposure to the elevated temperature. More than 50% reduction in the Poisson's ratio, elastic modulus and the bond strength was noted when the bond line temperature exceeds T_g + 15 ^{0}C, irrespective of the curing time and curing conditions. Initial elevated temperature curing also causes for shifting the curves in the right-skewed direction. A significant increase in T_g of bond was noted with 4 hours initial curing at 75 ^{0}C, i.e. T_g +20 ^{0}C.
Then a numerical model develops to predict the bond characteristics of CFRP/steel composites cured under different curing conditions and their behaviour at elevated temperatures. The measured material properties and their degradation with the temperature exposure were considered. The predicted bond performance was in a good agreement with the test results. The strain variation in the CFRP sheet was used to develop the bond shear stress-slip variations. Parametric studies were also conducted to evaluate the effects of bond line parameters on the bond shear stress-slip relationship at elevated temperature. The results indicate that the maximum bond shear stress of the joint lies in the range between 25 MPa and 28 MPa at ambient conditions, irrespective of the curing type. A rapid decrease in the maximum bond shear stress appears with exposure to the elevated temperature. Maximum shear stress reaches 10 MPa when the bond line temperature exceeds 90 ^{0}C. The elevated temperature curing, exposed temperature during service and the bond thickness notably affects on the bond slip behavior.

Key words: CFRP/steel bond, Glass transition temperature, Elevated temperature curing, elevated temperature testing, Fire, Bond characteristics, Bond stress-slip, Bond line properties

LIST OF PUBLICATIONS

International Journals

1. Mechanical characterization of CFRP/steel bond cured and tested at elevated temperature – Composite Structures – Published
2. Numerical modelling of bond shear stress slip behavior of CFRP/steel composites cured and tested at elevated temperature – Composite Structures – Under review
3. Effects of elevated temperature curing on glass transition temperature of steel/CFRP joint and pure epoxy adhesive – Electronic Journal of Structural Engineering (EJSE) – Under review

International Conferences

1. Bond slip models for corroded steel/CFRP double strap joints - 6th International Symposium on Advances in Civil and Environmental Engineering Practices for Sustainable Development (ACEPS-2018) – Published
2. Fire performance of CFRP strengthened steel I beams cured at elevated temperature - The 9th International Conference on Sustainable Built Environment 2018 (ICSBE) - Submitted

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