



Experimental investigation on CFRP-steel bond properties using ionic liquid

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Contents

- ✓ Introduction
- ✓ The Purposes of The Research
- ✓ Methodology
- ✓ Conclusion



Introduction

Concrete structures are facing many challenges due to many factors that may affect their durability and reduce strength of the concrete structure with time.

Example:

- Continuous upgrading of service loads.
- The increase of the traffic volume as in bridges.
- Corrosion caused by the de-icing.
- Codes requirements and new load cases and conditions of loading.
- Errors in the mix design





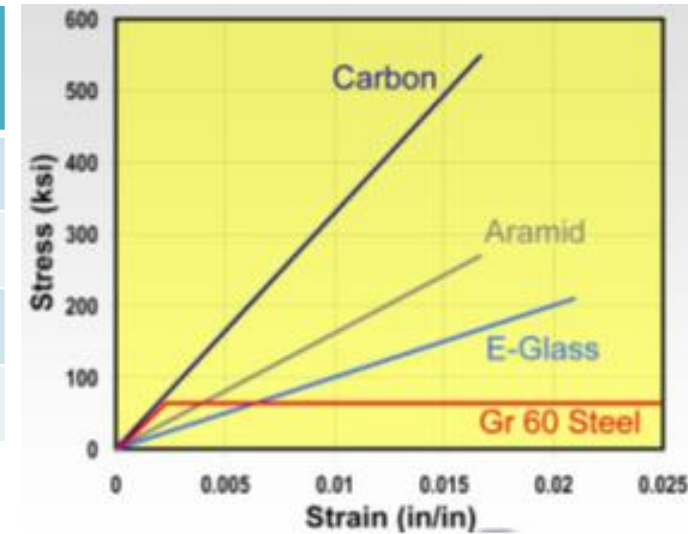
Introduction

- The carbon fibre reinforced polymer (CFRP) is now considered an efficient material for strengthening and rehabilitation of the existing and the new infrastructure members.
- The reliability of this material depends on the integrity of the bonding agent to transfer stress between the retrofitted member and the CFRP laminate.
- The brittleness and poor toughness properties of the epoxy resin are responsible for the premature failure



Common Types of FRP

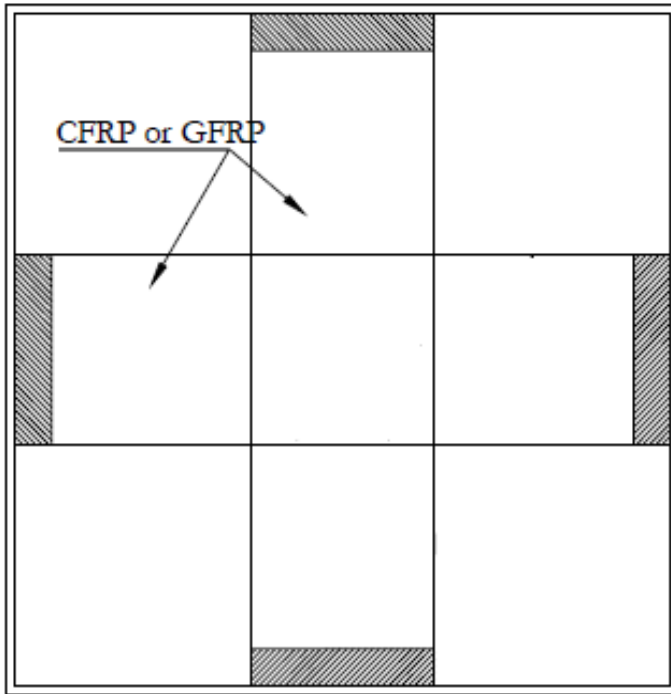
Type of fibre	Modulus of elasticity (GPa)	Tensile strength (MPa)
Carbon	240 – 640	2,500 – 4,000
Aramid	120	3,000 – 4,000
Glass	65 – 70	1,700 – 3,000
Polyester	12 – 15	2,000 – 3,000



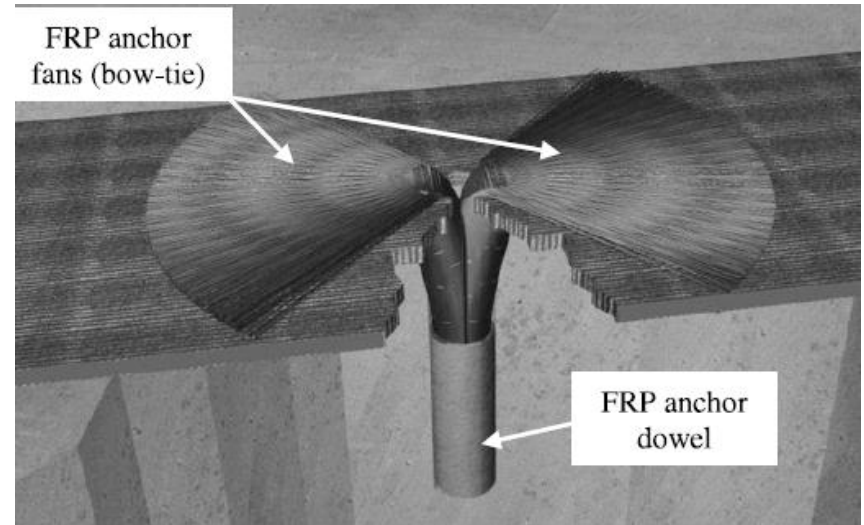
FRP do not exhibit any plastic behaviour → No bending capacity → early deboding
 → ineffective use to the FRP capacity.



Techniques to Prevent De-bonding Failures RC Slabs Strengthened by CFRP



End Anchoring Technique



FRP Anchors.



The Research Goal

- ✓ The premature failure can be overcome by *Getting softer epoxy with reduced brittleness that allow CFRP/ concrete interface slip* than ordinary types used for FRP attachment.
- *Ionic Liquid modified epoxy (IL+neat epoxy).*
- *Rubber modified epoxy.(rubber liquid + neat epoxy).*

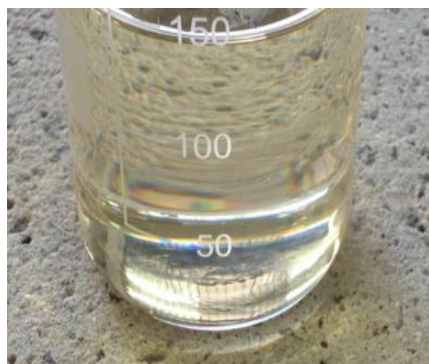


Methodology

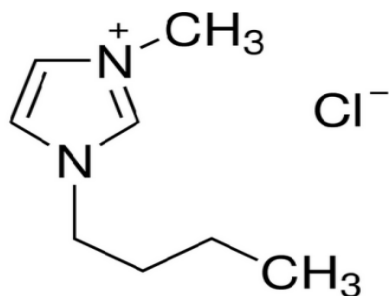
- CFRP laminates with 1mm thickness.
- 3 series tests were conducted:
- The first series was prepared by attaching CF laminates to the hosting surface using neat epoxy.
- The second series was prepared by attaching CF laminate using 20% of IL.
- The third series was prepared by attaching CF laminate using 30% of IL.



Ionic Liquid (IL)



$C_8H_{15}ClN_2$ Ionic Liquid.



Chemical compound of ($C_8H_{15}ClN_2$).

What is Ionic Liquid IL?

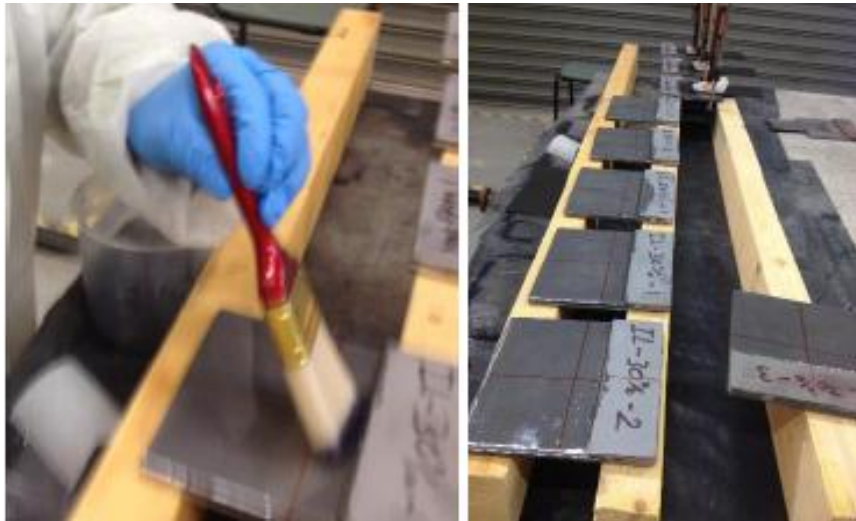
“ionic, salt-like materials” that are liquid below 100 ° C.

Physical properties:

- 1- It possesses a transmittance to yellowish color.
- 2- At the room temperature, it exposes the liquid state, but in cold weather, it is solid.
- 3- The ionic liquid has no characteristic odor.
- 4- Friendly Environmental material.



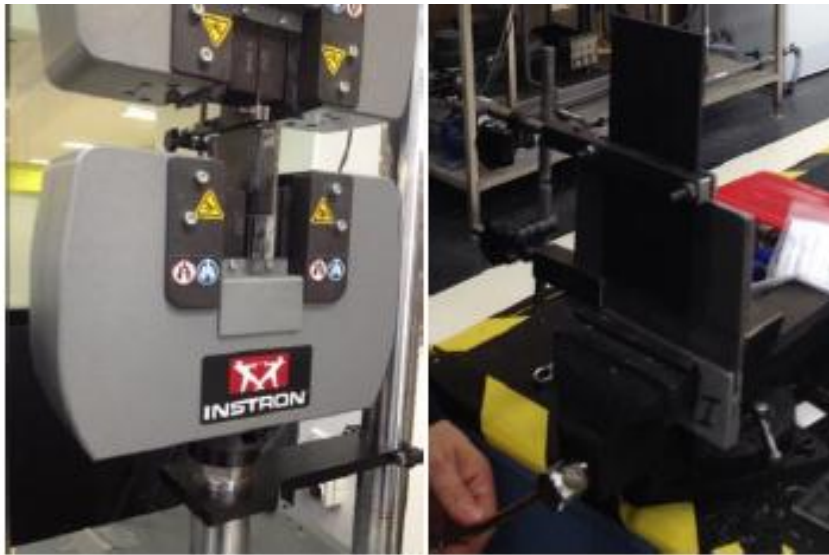
CF laminate Attachment



Applying IL modified epoxy to the steel surface



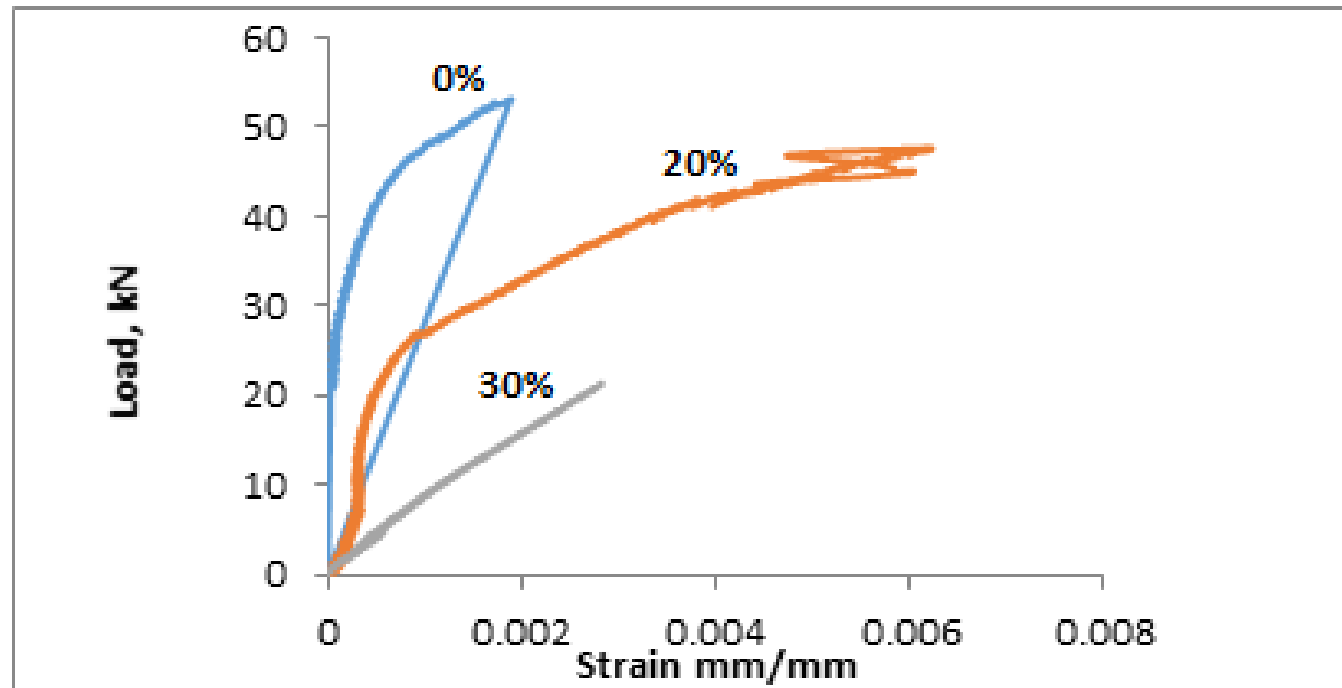
Composite CFRP/Steel specimen



Pull-out test set up of CFRP/Steel specimen



CFRP Laminate debonding of 20%IL



Load-strain curves for bonding test of CFRP laminate and steel plate using different percentages IL



Test Results

Epoxy composition Ionic liquid / MBrace resin part A	Number of specimens	Average failure tensile load	Ductility Index
0:100	3	60	1
20:100	3	57	14.14
30:100	3	23	2.85



On going researches:

- Modifying the neat epoxy using **rubber liquids**:

Examples:

- **ATBN**
- **CTBN**



Conclusion

- Early debonding of CFRP is regarded as a main setback for their use in strengthening and retrofitting structure.
- Modifying the bonding agent composition an effective way to improve the behaviour of CFRP strengthened elements.
- IL improved the toughness and ductility of unmodified epoxy.
- 20% of IL is the best ratio in terms of higher ductility.



Thank you for your Attention