

Carbon fibre fabric used for combined flexural strengthening and cathodic protection anode for reinforced concrete beams

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Carbon fibre fabric used for combined flexural strengthening and cathodic protection anode for reinforced concrete beams

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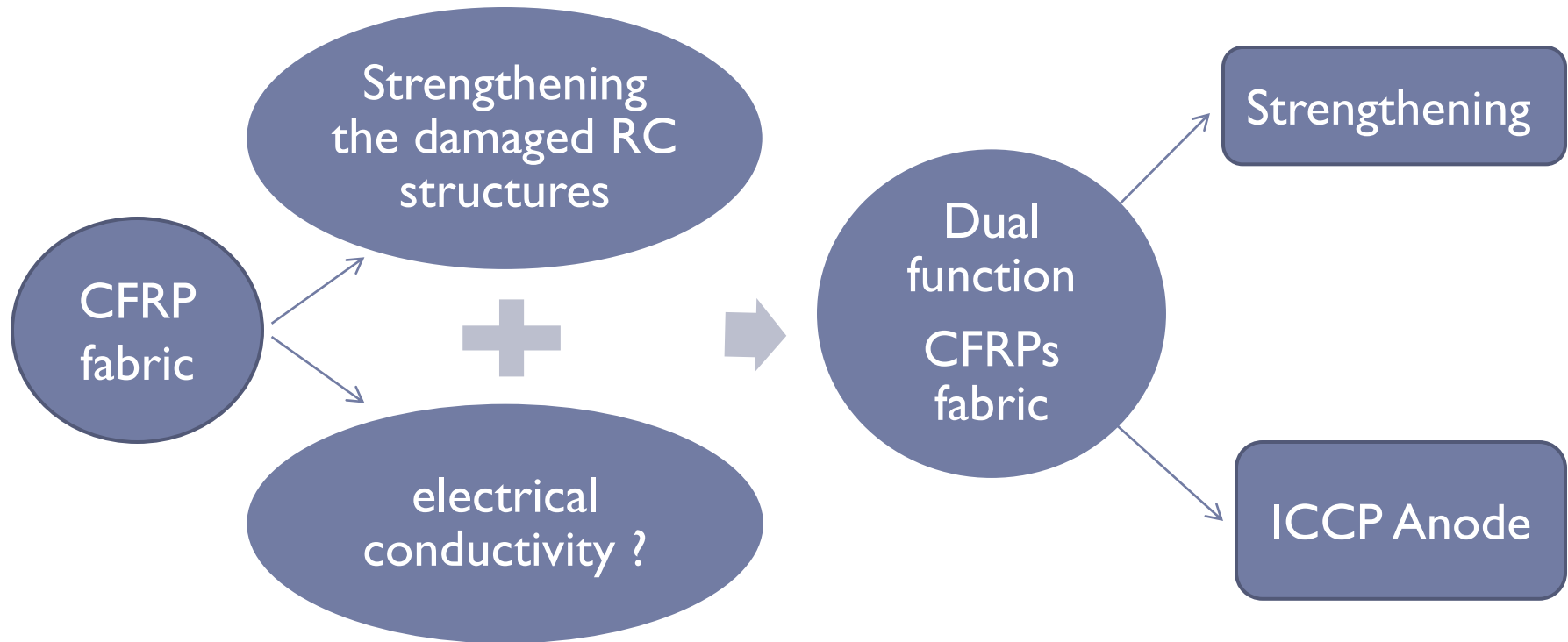
June 2014

- ▶ 1.Introduction
- ▶ 2.The aims of project
- ▶ 3.Experiment
- ▶ 4.Conclusion
- ▶ 5.Contribution

1.Introduction

- ▶ Worldwide, there are many reinforced concrete (RC) structures which are being deteriorated. It costs a lot of money to repair the corroded RC.
- ▶ Corrosion of reinforcing steel in concrete is one of the main reasons causing damage to RC.

2.The aim of project

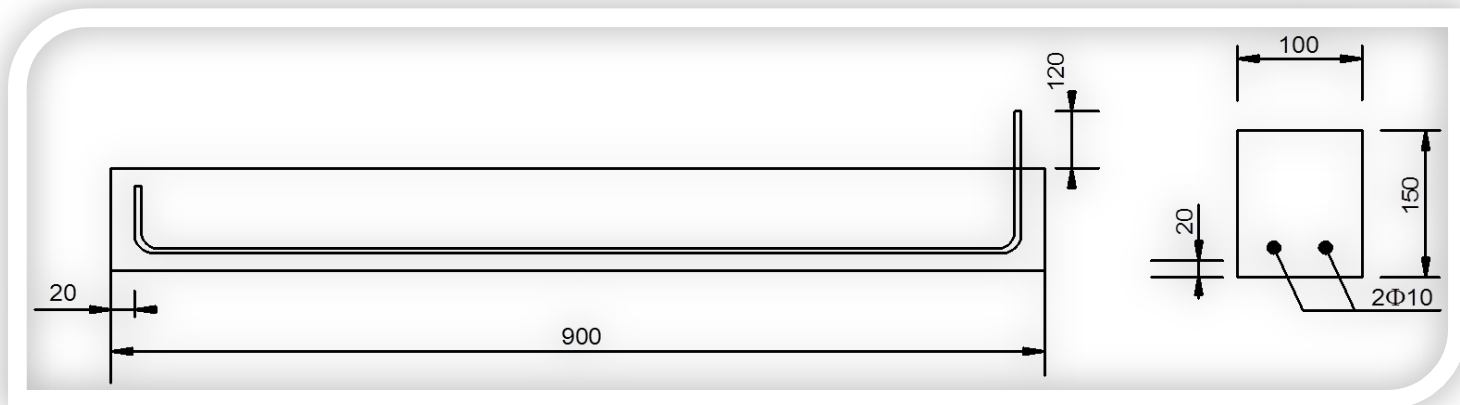


3. Experiment

- ▶ To investigate the effectiveness of CFRPs fabric which works as an anode of ICCP while using for flexural strengthening for concrete beams.
- ▶ 2 parameters were used:
 - +Electrochemical parameters: distribution of protection current to reinforcing steel, potential decay.
 - +Structural parameters: load-deflection relationship and failure of beams under bending test.

Test details

Beam ID	Pre-degree of Corrosion (%)	Repair method		Comments
		CFRP fabric strengthening	ICCP	
1.1	0	None	None	Un-corroded control
1.2	2.5	None	None	Corroded control
1.3	2.5	CFRP fabric in epoxy	None	Strengthening only
1.4	2.5	CFRP fabric in epoxy	None	Strengthening only
1.5	2.5	CFRP fabric in epoxy	ICCP	Dual function
1.6	2.5	CFRP fabric in epoxy	ICCP	Dual function

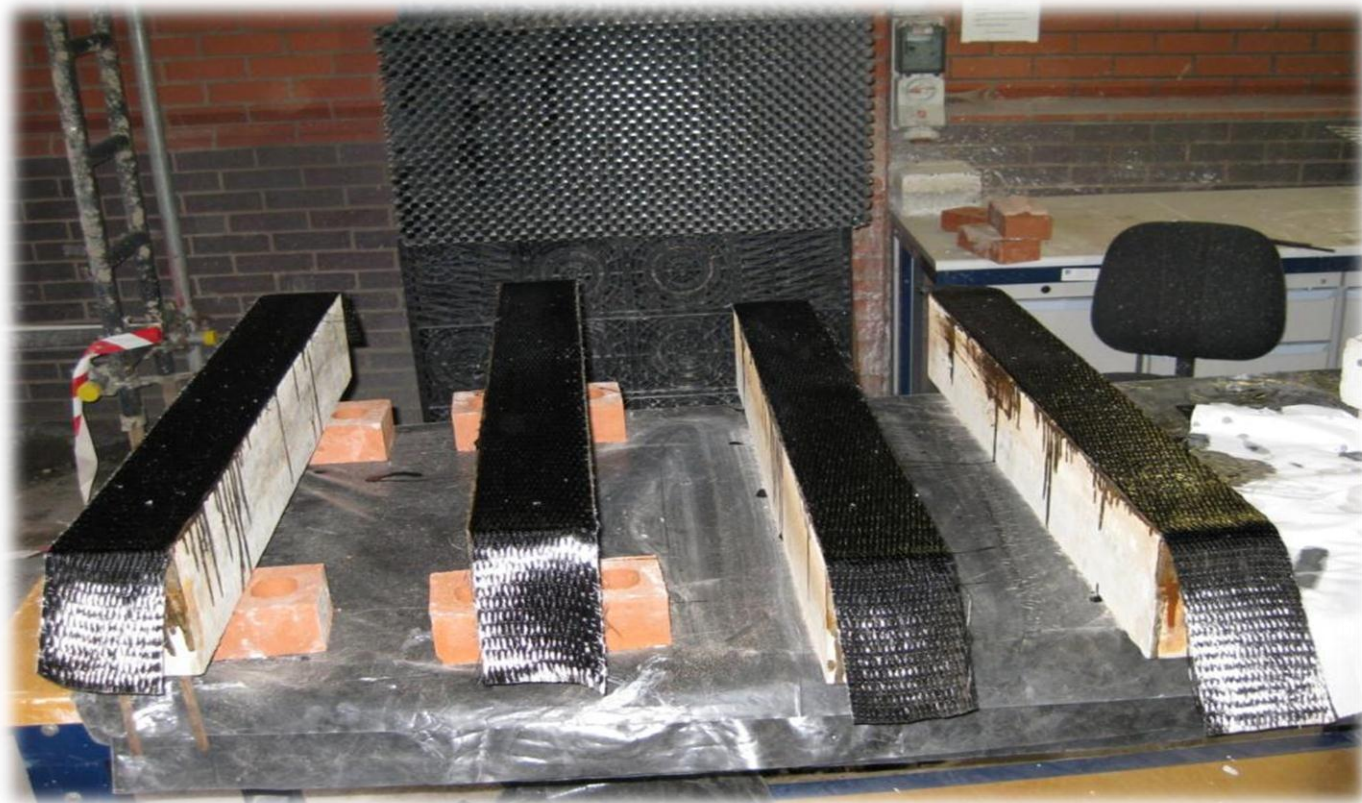


Accelerating corrosion of reinforcing steel



- ▶ Techniques: impressed anodic current, aim to make 'general corrosion'
- ▶ The target: 2.5% degree of corrosion.
- ▶ A current density of $1\text{mA}/\text{cm}^2$ was used

Application of CFRPs.



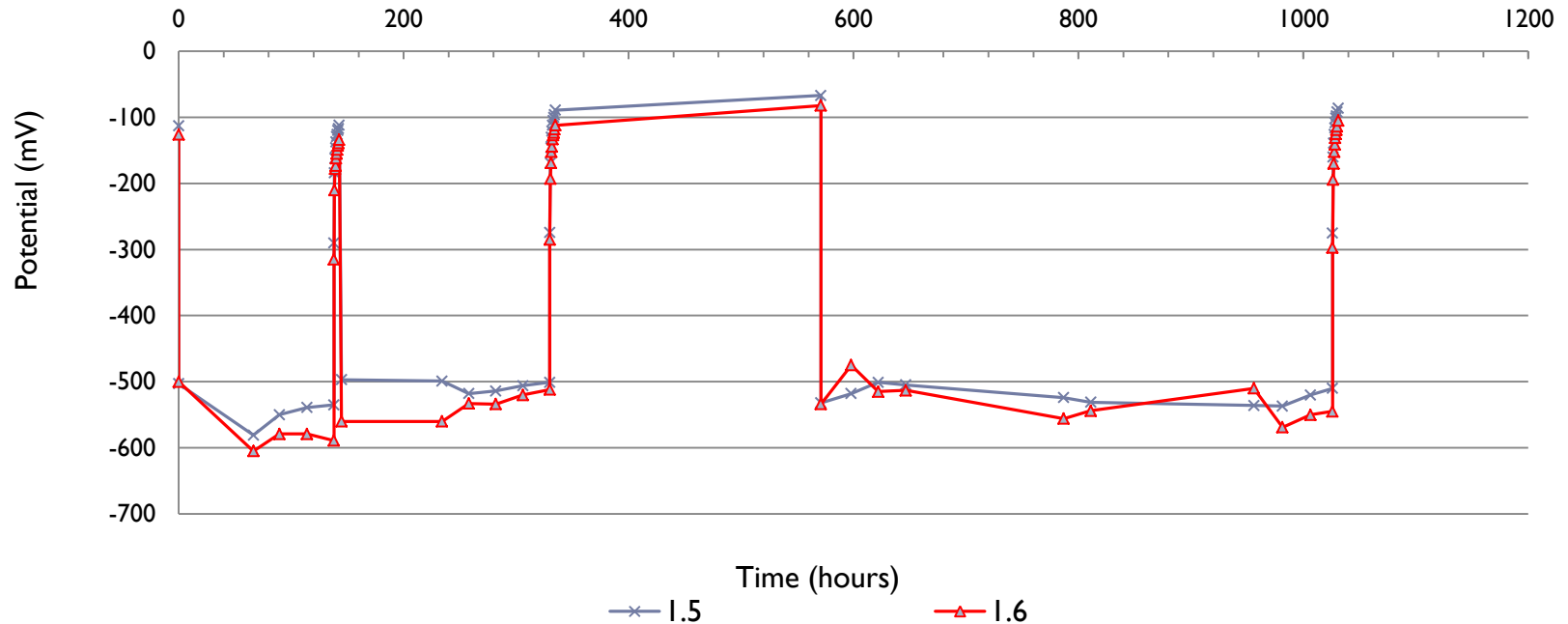
'dry lay-up' method.

Application of Impressed Current Cathodic Protection (ICCP)



The applied currents density: 128.42mA/m^2 of steel area for CFRP fabric anode

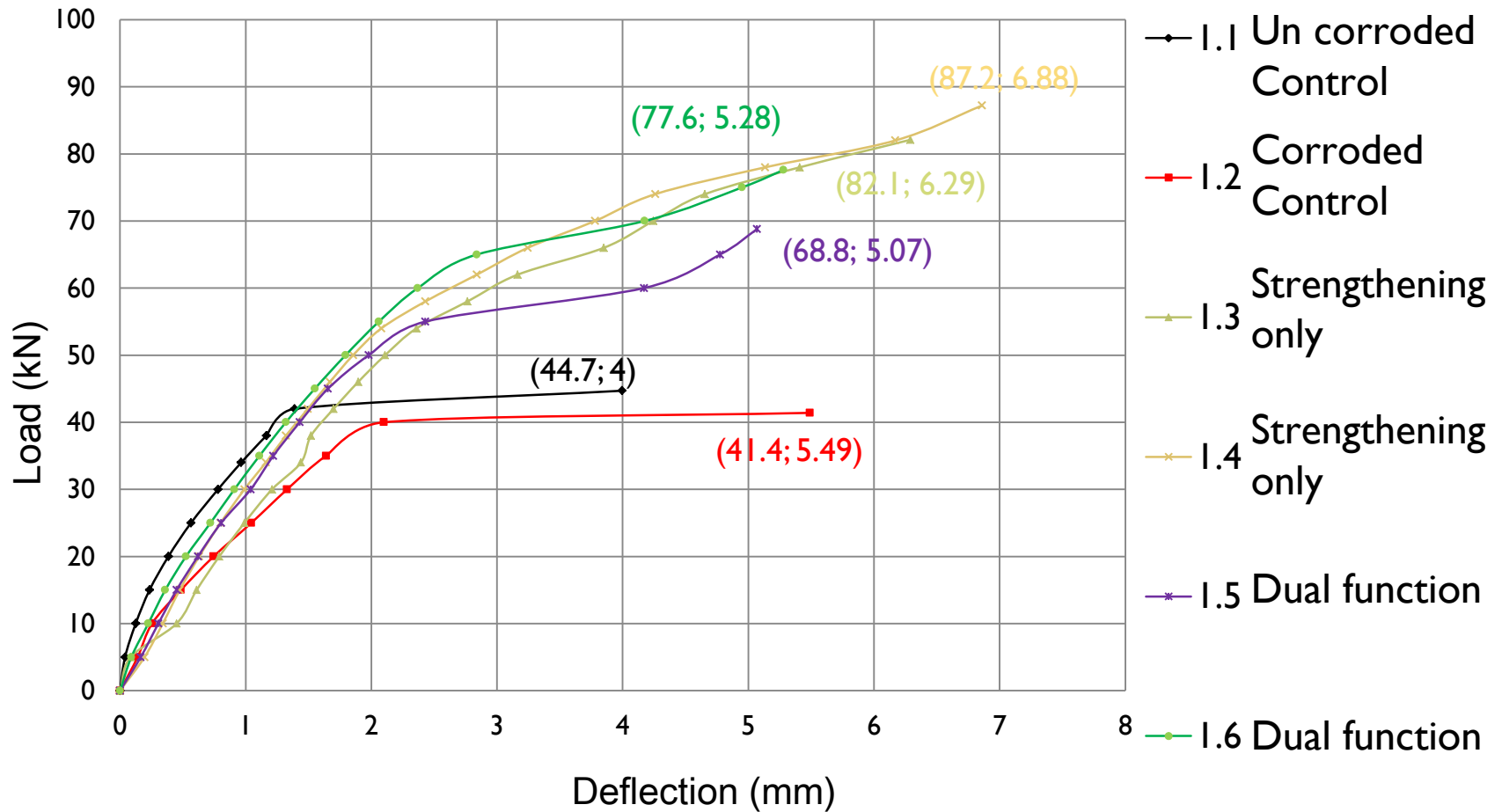
Cathodic protection monitoring



Potential of steels during operation of ICCP
(Reference electrode: Ag/AgCl/0.5M KCl)

The potential decays are more than 150mV after 4 hours at the three times of monitoring. According to the BS EN 12696-2012, it means that CP has been achieved.

Load- deflection curves



Ultimate load capacity and deflection of beams

ID	Corrosion rate	Age at test	Load failure	Deflection
	(mA/cm ²)	(days)	(kN)	(mm)
I.1	0	220	44.7	4.00
I.2	I	205	41.4	5.49
I.3	I	220	82.1	6.29
I.4	I	221	87.2	6.88
I.5	I	235	68.8	5.07
I.6	I	244	77.6	5.28

4. Conclusion

- Epoxy can be used to bond CFRP fabric anode to the concrete surface.
- CFRPs fabric can be used as impressed current cathodic protection (ICCP) anodes for reinforced concrete structures. The potential decays can meet the specification of the BS EN 12696-2012 resulting in ICCP being achieved.

- CFRP fabric is capable of operating at very high current densities $>128\text{mA/m}^2$ of steel area with only a small loss of mechanical bonding.
- CFRP fabric can be used to strengthen corroded RC beams, maintaining the structural integrity and increase the ultimate strength of damaged beam. CFRPs increase the stiffness of beams and reduce their ultimate deflection.

5. Contribution

- In comparison with traditional CP for reinforced concrete, the CFRP anode appears to be capable of operating at much higher current densities.
- By combining the function of strengthening and CP within a single component, the system is significantly simpler and should also deliver cost savings in addition to easier maintenance.

▶ **Thank you!**