FLEXURE BEHAVIOUR OF DAMAGED REINFORCED RUBBERISED CONCRETE BEAMS STRENGTHENED WITH CARBON FIBRE REINFORCED POLYMERS

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Developing rubberised concrete (RuC) for structural applications is an excellent solution for the scarcity of natural aggregates and the discharge of rubber waste in bulk volumes into the natural environment. With the successful applications of rubberised concrete in structural elements, it is important to explore successful alternatives for restoration in case of deficiencies met in their service life. This study investigates the flexure behaviour of damaged reinforced rubberised concrete beams strengthened with Carbon Fibre Reinforced Polymer (CFRP) fabric which is one of the best solutions that can be implemented to strengthen cracked reinforced rubberised concrete beams. To prepare RuC, rubber particles having three different size ranges, were obtained from outdated vehicular tires through the process of mechanical shredding. The first range, consisting of fine rubber particles ranging from 0-5 mm, was used to replace fine aggregate. The second and third ranges, consisting of coarse rubber particles ranging from 5-10 mm and 10-20 mm, respectively were utilised to replace gravel. The average measured 28 days compressive strength of rubberised and normal concrete was 40.54 MPa and 51.7 MPa, respectively. A total of four medium-scale non-strengthened reinforced RuC beams, and a normal concrete beam were preloaded until a 0.3 mm crack occurs. All beams had the same dimensions with 1650 mm×180 mm×130 mm for length, depth, and width, respectively. Then the damaged beams were strengthened using CFRP with and without polymer anchors at the ends of bonded fabric. Four-point bending test was conducted subsequent application of cyclic load with the amplitude of 50% and 75% of the ultimate load. The beams were considered as simply supported with a clear span of 1500 mm.

CFRP-strengthened reinforced rubberised concrete beams could reach a 53% higher load with 61% less displacement until a 0.3 mm crack occurs than non-strengthened reinforced RuC beams. It was found that the U-wrap end anchorage system increased the ultimate load by 5% than without end anchorage, delaying the debonding of CFRP fabric. CFRP-strengthened reinforced RuC also exhibited a similar load-deflection curve as strengthened normal concrete beams. When considering the crack patterns, vertical flexural cracks first formed when the load is 20 kN-40 kN in the middle third of the beam, between two-point loads, and then propagated towards the compression zone when the load increased. Additionally, flexural-shear cracks originated near the supports and subsequently propagated at an incline throughout the compression zone. Beams failed in two failure modes, which are debonding of the CFRP fabric near the support region and cover delamination. The strengthened RuC beams using CFRP could reach the required strength enhancement similar to reinforced concrete beams. Overall, the experimental results exhibited the feasibility of strengthening rubberised concrete beams in structural applications with CFRP fabric. However, further investigations are required to evaluate fire and durability performance.

Keywords: Rubberised concrete, Damaged concrete beams, Flexural strength, CFRP

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Flexure behavior of damaged reinforced rubberized concrete beams strengthen with Carbon Fiber Reinforced Polymers

Scarcity of natural aggregates

Discharge of waster tire rubber

Rubberized Concrete

Still NOT used in structural elements

With the successful applications of rubberized concrete in structural elements

Important to explore successful alternatives for restoration

Investigates the flexure behaviour RuC beams strengthened with (CFRP) fabric

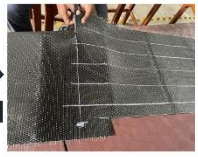
Experimental Program

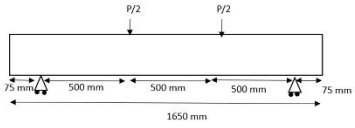
Material	Quantity (kg/m3)
Cement	340
Silica fume	42.5
Fly ash	42.5
Fine aggregate (0-5 mm)	820
Coarse aggregate (5-10 mm)	364
Coarse aggregate (10-20 mm)	637
Water	150
Superplasticizer	7.66

Rubberized concrete by replacing both fine and coarse aggregate by 10% of the volume

0-5 mm 5 - 10 mm 10 - 20 mm

Rubber aggregates





Loading Sequence

Load until 0.3 mm crack occurs (load - P) and then unload to zero

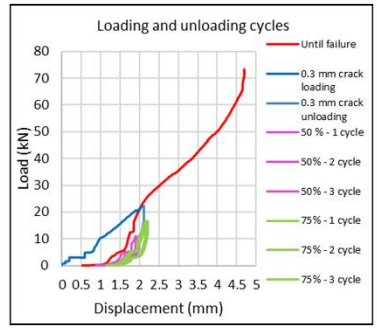
Load until 50% of P and then again unload to zero

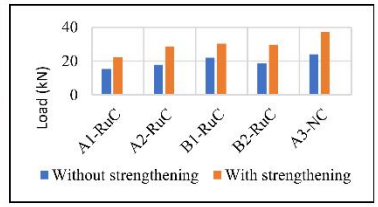
Repeated this for two more load cycles

Repeated the procedure for 75% of P

Load from zero to failure

Results and Analysis





Debonding & Cover delamination

Conclusion

U-wrap end anchorage system increase the ultimate load by 5% than without end anchorage successfully

It is feasible to strengthen rubberized concrete beams in structural applications with CFRP fabric.