PERFORMANCE OF MECHANICALLY REPAIRED RC-BEAMS

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1. INTRODUCTION

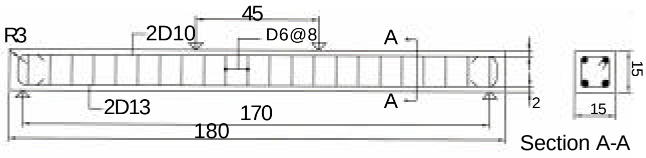
With the increase in use of mechanical repair techniques in repairing deteriorated portions of structural elements, the study of the performance of mechanically repaired section has become grate concern among the research community.

This paper presents important aspects of structural compatibility of mechanically repaired flexural elements, repaired with two different repair materials commonly used in the industry. The paper also makes an attempt to compare the experimental results of the flexural element repaired in the tensile face with that of similar sections with tensile reinforcements exposed. Reinforcement exposed condition would be a condition that a deteriorated beam would most likely to have experienced before it is repaired, because corrosion decrease the bond and hence the composite action of the beam. This is also the condition during repair. The ability of the structure to carry significant portion of ultimate load with reinforcement exposed is a very important aspect as it is a well known fact that the concrete structures carry more of its own load than the load that it supports.

The main objective of this paper is to clarify the importance of the mechanical repair in structural view point. The ability of repaired section to restore the shape of the stress path and stiffness before yield are considered as the key parameters to judge the effectiveness of repaired beams.

2. EXPERIMENTAL PROGRAM

As a part of the experimental program on performance evaluation of mechanically repaired RC flexural elements, beams with different length of exposed reinforcement in the tension face as well as in the compression face were cast. The concrete faces coming into contact with the repair material were made rough by using a high pressure water jet, so as to make sure good bond between parent concrete and the repair material. Repair details of the beams with the results of the static loading test that forms this discussion were shown in table1. The properties of the concrete and the two repaired material shown in the table 2 were the test results of the tests performed at the time of beam tests. Repair material A is a Cement modified mortar while B is Polymer modified mortar. Depth of repair and the depth of exposure were 60mm in all beams and were symmetric about the centre. Figure 1 shows typical details of the tested beams with the four point loading arrangement. All the beams had identical reinforcement arrangement and were under reinforced sections with x/d <0.63. The load arrangement was to make sure flexural action with a/d>5.



All Dimensions are in centimeter

Figure 1:-Typical Reinforcement Details of the Beams tested

3. OBSERVATION OF THE EXPERIMENTAL STUDY

Stress path reversal and stiffness reduction were observed when reinforcements are exposed. The structural action of these reinforcement exposed sections were no longer bending but a tied arch with the increasing uniform tension force developed in the exposed reinforcements with the incremental loading. Reduction in ductility and non occurrence of cracks between load point and supporting points were all important observations to support our claim.

No	Description	Ultimate load (kN)	Ultimate load/ Ult. control	Ultimate load/ Ult. exposed
1	Control	36.13	1.00	-
2	Exposed 40%	31.50	0.87	1.00
3	Exposed 60%	29.51	0.82	1.00
4	Exposed 80%	26.46	0.73	1.00
5	Repair (TF) (A) 40%	35.32	0.98	1.12
6	Repair (TF) (B) 40%	34.65	0.96	1.10
7	Repair (TF) (A) 80%	32.47	0.90	1.24
8	Repair (TF) (B) 80%	32.75	0.91	1.24
9	Repair (CF)(A) 40%	38.80	1.07	-
10	Repair(CF) (B) 40%	36.60	1.01	-
11	Repair (CF)(A) 80%	42.00	1.16	-
12	Repair(CF) (B) 80%	36.60	1.01	-

***Notes:- TF= Tensile face repair, CF= Compression face repair A= Cement modified material, B= Polymer modified material

Table 1: - Summery of Test Results

Material	Compressive Strength(MPa)	Young's kN/mm2	Poison (u)	Tensile Strength
Concrete	38.8	29.0	0.2	4.15 MPa
Repair A	105.2	33.6	0.24	6.67 MPa
Repair B	67.7	27.7	0.23	4.47 MPa

Table 2:- Summery of Mechanical properties of Materials

Key word: Mechanical repair, RC-Flexural element, Stress path, Stiffness before yield
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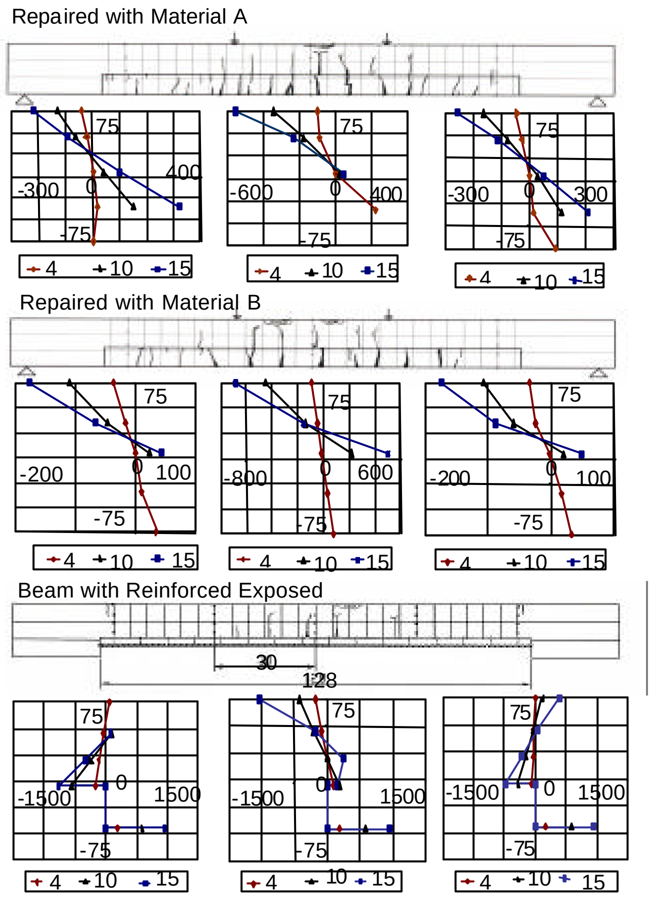

Figure 2:- observed strain (me) thorough sections at the centre and 60cm either side of the centre when applied loads were 4, 10 and 15 k N. Y-axis represent depth of the section with 0 being the middle of the beam

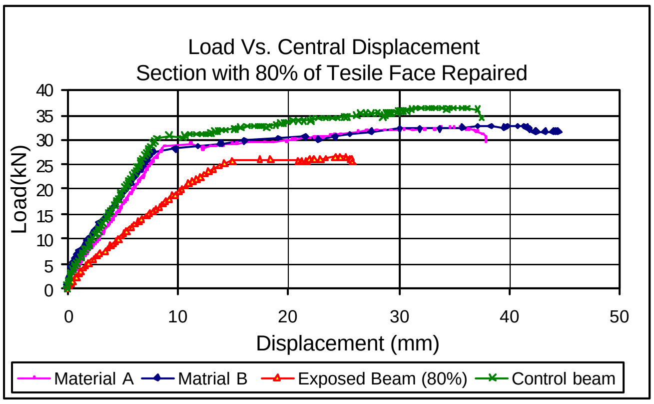

Figure 3:- Performance comparison of beams with tensile face repaired over 80% of the spanning length.

Eight beams with repaired section have shown a stress path recovery and the recovery of initial stiffness comparable with the control beam. The interface of repair and concrete acted as a crack trapping device not allowing the cracks to penetrate into the next layer for a while. This was observed especially when the section repaired was tension side. Further cracks reaching the interface often deviated form its original path and there were instances where crack bifurcation through the interface layer was noticeable. It is no doubt that these observations support the vital role of the bond in the performance of the mechanically repaired section. Figure 2 is one example of stress path change observed in mechanically repaired section.

According to table 1, none of the beams repaired in tension side recover its full strength despite the different mechanical properties of material A and B. Figure 3 illustrate the load vs. central displacement of beam repaired in the tension side over 80% of its spanning length compared with the reinforcement exposed beam with similar length and control beam. In the case of section with compressive face repaired, larger ultimate strength and ductility values compared to the control beam were recorded in the beam repaired with Material A as shown in figure 4.

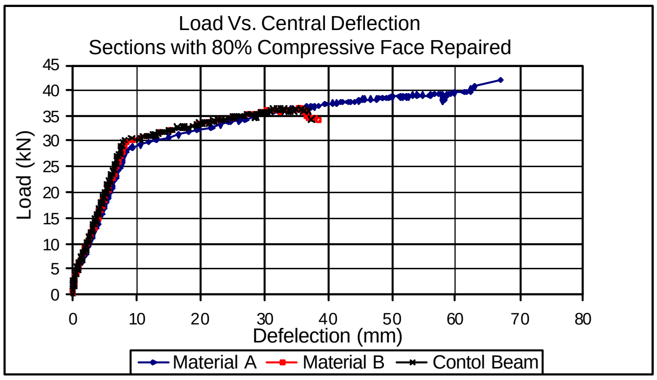

Figure 4:-Performance comparison of beams with compressive face repaired over 80% of the spanning length

4. DISCUSSION & CONCLUSION.

Mechanical repair when applied on the tension side has been found unable to restore the ultimate load that of a fully bonded concrete beam of the same detail. But it was evident that the mechanically repaired section restores the stress path and the stiffness of the section before yielding. Increase in ductility and ultimate strength observed in the sections with compressive face repaired may be attributable to different mechanical properties of the material. Bond between the repair material and concrete plays a vital role in the performance of the mechanically repaired section.

Mechanical repair should not be interpreted as a technique of strengthening and improving ultimate strength of the repaired section unless there is addition of reinforcing bars but rather as a technique improving the structural action of the deteriorated section. Performance characteristics of mechanically repaired section should be judge by its ability to restore the stress path and all important stiffness characteristics of the beam. Numerical analytical technique with proper attention given to modeling of bond between repair and parent concrete is essential to analyze the true behavior of the mechanically repaired section.

5. REFERENCES

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