324. Repair of RCC Beams with Locally Available Polymer Modified Cementous Mortar and Ordinary Portland Cement

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Abstract

Repair of the damaged or vulnerable reinforced concrete structures has utmost importance in order to promise the safety of inhabitants and to increase the life of structure which eventually results in the saving of resources by reducing the environmental impact on natural resources for sustainable development. This study reports the experimental study of total 24 RC beams at 28 days curing period and having different steel configurations, with central point loading. Total 12 beams were tested up to deconstructing, remaining 12 beams were loaded up to 70% of ultimate load as obtained in the virgin beams to have cracking at deformation. Two repairing materials were used i.e .ordinary Portland cement (OPC) and Fospak (polymer modified Cementous mortar) Cracked beams then repaired with OPC and Polymer modified Cementous Mortar and retested to know the performance of damaged beams after the application of OPC and fospak. The results depicted that the beam repaired with Fospak are capable of taking more load by 4% - 13.7% and shown better load deflection then beams repaired with OPC.

Keywords: *Reinforced concrete; Beams; Deterioration; OPC; Fospak ; repair.*

1. Introduction

Concrete is a constructional material which has been used for many years to build a wide variety of structures from houses to bridges [5]. If no reinforcement is provided then it will be only suitable for compressive load. In order to overcome the issue of tensile forces, concrete is reinforced with steel bars. Deterioration in the R.C C is mainly due to rusting of rebar, chemical attack, Accidental loading and aggressive environmental effects.

The repairing of damaged concrete is a world-wide problem and million rupees are annually being spent on the repair and restoration of RCC structures. To restore the integrity of damaged structures various techniques are in practice although adherence to the substrate concrete and protection against the rusting of steel play key role towards the stability of repaired concrete [5].

One of the most common concrete repairing materials in country like Pakistan is OCM (Ordinary Cement Mortor) which is a composite material made by using cement and fine aggregates but due to several discontinuities, cracks and cavities in OCM has limited use in RCC repair work [1]. For many years polymer modified mortar (PPM) is being used in the repairing work of RCC structures. Use of PPM as concrete repairing material has proved the better flexural and compressive strengths, good adhesion and better resistance to extreme weather changes [6].

Present study is to test fospak (Expanmortar S) as a bonding material which is advocated in literature and manufacturer has claimed its suitability. Present research is aimed to see experimentally suitability of bonding material in rehabilitation so that construction industry of Pakistan can get benefit of that.

2. Materials

2.1. Ordinary Portland Cement

The OPC used in this study was obtained from the local market with brand name Falcon Cement. Normal consistency and setting time were determined by using standard procedure of vicat apparatus. As explained in detail by various standard books [2]. Test results are summarised in table 1.

2.2. Coarse Aggregates

Coarse Aggregates (CA) was taken from Nooriabad crusher plant. Basic aggregate tests were conducted to find the properties of coarse aggregates i.e Specific gravity and water absorption. Results showed the normal range as per BS-882 in table 2. Though, the size of CA was not in compliance with BS-882, to have a same nominal maximum size of coarse aggregate an artificial method of compliance was done for all the beams. The artificial method was adopted in such a manner so that the CA confirms nominal maximum size of 20 mm of BS-882.

2.3. Fine Aggregates

Fine Aggregates (FA) were taken from well-known source of hill Bholari for the study which satisfied the Zone-II of BS-882. Specific gravity and water absorption of FA are shown in Table 2.

Table 1. Test Results of OPC

Name of Test	OPC
Normal Consistency	33%
Initial Setting Time	86 Min
Final Setting Time	200 Min

Table 2. Specific Gravity and Water Absorption of Coarse and Fine Aggregates

Aggregates	Specific gravity	Water absorption	Zone / Size
Coarse Aggregates	2.6	1.09%	20 mm
Fine Aggregates	1.66	2.5%	II

3. Methodology

Total 24 R.C.C beams were casted with 3 different arrangements of stirrups i.e. 2, 4, and 6 stirrups with the same no of main bars and hanging bars i.e. 8 identical beams for each combination. In these arrangements 2 main bars were kept constant with cross sectional area of 6”x6” and 6”x9”. The length was kept as 36” with ½” clear concrete cover for all beams.

All 24 beams were casted with ordinary port land cement (O.P.C) the ratio between cement fine aggregate and coarse aggregate was kept as 1:2:4 with water cement ratio of 0.50. All beams were casted in steel molds.

The undamaged or virgin beams of dimension 6”x6”x36” with 2 main bars and 2 hanging bars named as A1, A2, A3 for the 2,4 and 6 no of stirrups respectively whereas beams having dimensions of 6”x9”x36” with 2 main bars and 2 hanging bars named as B1, B2 and B3 showing the 2,4 and 6 no of stirrups respectively in beam

The beams were brought in water tank for the curing after 24 hour of casting by stripped off from the molds. All beams kept in curing tank for 28 days and then carefully checked for damages. A beam which found with no damages considered for test and such beams are named as virgin beams. A day before testing the beams were washed with water and then white washed to visualized cracks on surface. After examine the outer appearance the beams were tested by applying center point load using universal testing machine (UTM) to obtain the load carrying capacity and load deflection behavior of beams.

Deflection of beams with loading was measured by gluing an aluminum strip 9” long and 1” wide at the mid bottom of beams, aluminum strip was glued by using Epoxy resin. To measure the deflection a dial gauge was set with inner wall of UTM in such a way that its tip was touching the aluminum strip.

The beams were then loaded up to 70% of ultimate load carrying capacity of identical virgin beam and then repaired after the loading. First of all cracks line were chopped with the help of chisel and hammer and then repairing materials was applied carefully. 4 beams from each combination were repaired i.e. 2

beams repaired with OPC paste with normal consistency and 2 beams with Expanmortar S. All the repaired beams were kept for curing for 3 days by using gunny bags. The same process of loading and deflection was applied on the repaired beams after shifting them in UTM to compare the performance of beams repaired with Expanmortar S and OPC paste at the ultimate load carrying capacity.

4. Results and Discussion

4.1. Effects of Repairing Material

The influence of repairing material on beams is shown in table11 detail shows the maximum load carrying capacity of repaired beams before failure and comparison of measured load of repaired beams with OPC and Expanmortar S having dimensions of 6" x 6" x 36" and 6" x 9" x 36" with different no of stirrups i.e 2,4 and 6 stirrups. It is observed that the beams repaired with OPC have taken less load as compare to beams repaired with Expanmortar S. This is due to Expanmortar S provides improved bonding between two layers of concrete than OPC. Table3 shows the %age difference among ultimate load of beams repaired with OPC and ExpanmortarS, Results shows that % variance among beams repaired with Expanmortar S and OPC paste is remained between 4.7% - 13.7%, it is also observed that more the no stirrups are used less the percentage difference in ultimate loads. The difference between percentages of repairing materials remained high for the beams with less no of stirrups.

Table 3. Ultimate Load on beams

S.no	Repaired Beams	Ultimate Load. (KN)	Difference Between OPC and Fospak Repair (%)
1	A1 Repaired with OPC	50	13.7%
2	A1 Repaired with Fospak	58	
3	A2 Repaired with OPC	58	12.5%
4	A2 Repaired with Fospak	63	
5	A3 Repaired with OPC	62	7.4%
6	A3 Repaired with Fospak	67	
7	B1 Repaired with OPC	96.3	11%
8	B1 Repaired with Fospak	107	
9	B2 Repaired with OPC	108	6%
10	B2 Repaired with Fospak	115	
11	B3 Repaired with OPC	118	4%
12	B3 Repaired with Fospak	123	

4.2. Effects of Stirrups

Total of 12 Virgin beams, having different stirrup configuration were tested and their load at failure was noted. Remaining 12 samples of the beams, having stirrup configuration similar to their virgin counterpart were tested up to 70% of the average failure load. It was later seen that, the deflection of beam having 02 stirrups configuration was greater than that of 04 stirrup configuration which was also greater than that of 06 stirrup configuration. The behaviour of load deflection of beams can be seen in figure 1(a-f). It is observed that with the increase in no of stirrups increases the load carrying capacity of beams.

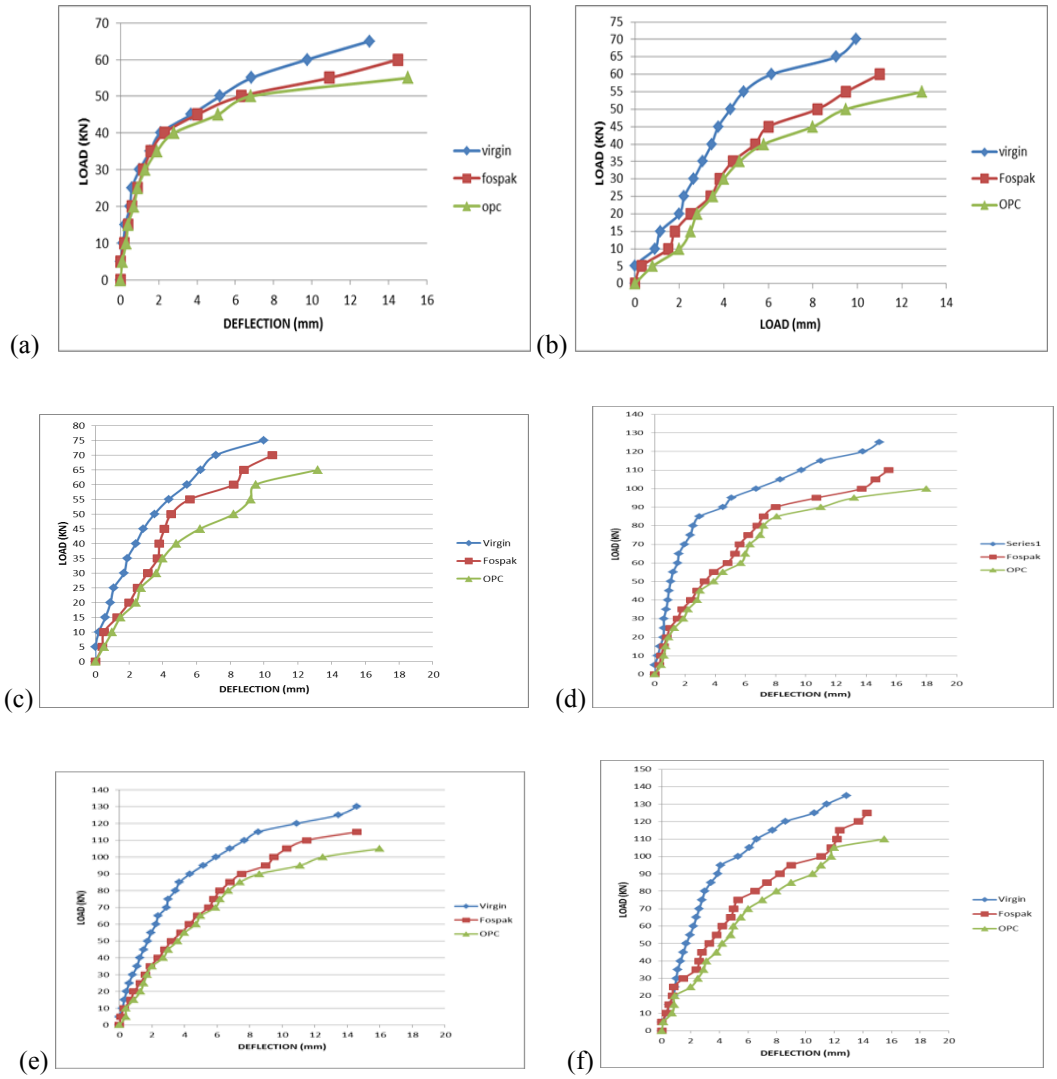

Fig. 1. Comparison between Virgin, OPC and Expanmortar S in Load and Deflection (a) beam A1 (b) beam A2 (c) beam A3 (d) beam B1 (e) beam B2 and (f) beam B3.

5. Conclusions

This study estimates the performance of Fospak as compared to OPC for the repair of structural component. Following conclusion are drawn on the basis of experimental outcomes found in this study.

i. It is determined that with the increase in no of shear stirrups increases the load carrying capacity of beams and beams can be strengthen by adding the no of stirrups.
ii. It is also found that with the increase in depth of beams increases the load carrying capacity.
iii. It is observed that beams repaired with Expanmortar S were capable of taking more ultimate load than that of beams repaired with OPC by 4% - 13.7%.
iv. It is also found that the efficiency of Expanmortar S repairing materials remained high for the beams with less no of stirrups.

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