Studies on Polymer Based Repair Material by Experimental Approach

Mr. Varun TN[1] Mr. Venugopal GT[2]
[1,2]Assistant Professor
[1,2]Department of Civil Engineering
[1,2]AIT, Tumkur

Abstract— Repair of concrete structures is a composite process involving repair materials and old concrete components. The mechanical and durability properties of concrete and repair materials have to be considered before the selection of repair material for any specific repair. An effort to analyze the physical and mechanical properties of native concrete and repair materials is made. The durability of bond by analyzing the compatibility between native concrete and repair materials has been studied and checked through finite element methods. In the present study, the properties such as compression, tension, bond strength and bending strength of concrete, mortar and repair materials i.e. Styrene Butadiene co-polymer rubber (SBR) modified mortar and Acrylic based polymer modified mortar have been evaluated. The results and mode of failure of composite cylinders and composite beams are compared. These results directly reflects the compatibility between the applied repair materials when it is patched with the native concrete and provides a scope for further research works.

Key words: Repair, Rehabilation, Slant Shear, Modular Ratio

I. INTRODUCTION

Mortar and concrete made with Portland cement have become the popular building materials. But mortar and concrete made up of OPC have some deficient characteristics as less chemical resistance to weathering, undesirable drying shrinkage, delayed hardening and weak tensile strength. To overcome the above undesirable properties, many improvements have been done by adding polymers. It alters few properties when mixed with cement mortars and concrete. The polymer modified mortar is produced by altering few properties of cement mortar or concrete with the addition of calculated amount of polymer additives. With the addition of polymers on to the cement, hydration takes place with the formation of films or membrane. Few monomers are added to the mortar with the addition of water cement hydration takes place. Also the process of polymerisation takes place in the monomers and liquid resins. The Polymer modified mortar (PMM) are made by the addition of calculated amount of monomer and a polymer in a mixing these with fresh cement mortar.

II. RESEARCH NEED

From the literature review, it is noticed that the solid repair is an intricate procedure. Cracking and de-lamination are the two main and common symptoms of failure of repaired concrete. The poor repair may lead to the activity of chlorides, moisture and chemical attack and accelerate the damage of repaired Structure. Furthermore, the loss of structural integrity and compatibility between repair material and native concrete imparts variation in load carrying capacity of the repaired system.

III. OBJECTIVES

- Selection of cementitious and polymer modified mortars for repair of concrete structures.
- Characterization of selected materials and ranking of the repair materials and recommendations.
- Evaluation of strength and properties of selected repair substances.
- Critical analysis of the performance of the selected repair materials.
- Test methods to find out the compatibility between repair polymers and native concrete.

IV. RESEARCH METHODOLOGY

- Find out the properties of repair material and controlled concrete.
- Determination of slant shear strength for checking the bond capacity using experimental and FE approach.
- Determination of compatibility between repair polymer and native concrete using a two point loading test for bending stress.

Cement	M Sand	CA	Water
1	1.56	2.38	0.45

Table 1: Mix proportions of concrete of grade M30 as per IS 10262-2009.

Cement	M Sand	polymer	Water
1	3	0.2	0.2

Table *2:* Mix proportions of polymer and cement mortar as per technical data sheet.

V. EXPERIMENTAL RESULTS

A. Setting Time

Vicat apparatus is used to determine the initial setting time and final setting time as per ASTM standards. The initial setting time is the time taken by the vicat needle to achieve 1inch penetration. Final setting is the total time taken by the needle not to sink into the paste.

Sl.no.	Repair Material	Initial setting time in minutes
1.	SBR	32
2.	Acrylic	34
3.	Epoxy bonding agent	65

Table 3: initial setting time of different repair materials:

B. Compressive Strength

The concrete is good in compression. Also the PMM compressive strength compressive strength can be find out using 70.5mm size cube as per standard practice. After casting, the cube is placed for curing and tested at 7 days and 28 days.

The cube after curing is placed in a compression testing machine. The compressive load is applied at the

gradual increment of 140 kg/sqcm. The maximum load that the cube can resist before its breakage is noted. The compressive stress is calculated by dividing compressive load by area of the surface of the cube in contact with the load represented in N/sqmm.

Sl.no	Type of Mortar	7 days	28 days
1	Controlled specimen	9.63	23.31
2	Acrylic	25.85	32.36
3	SBR	20.78	28.13

Table 4: Compressive strength with age

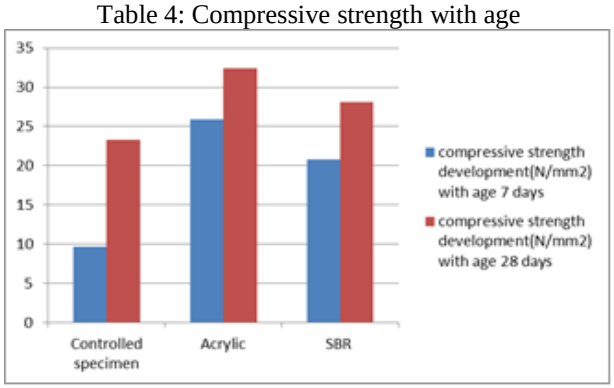

Fig. 1: The compressive strength development with age

C. *Slant Shear*

In this test method the PMM mortar is bonded to the native concrete in the inclined surface of 30° with respect to the vertical plane by using epoxy bond. In doing so the cylinder of 101mm diameter and 202 mm height is cast and cured for 7 days and 28 days. The specimen after curing is placed in a compressive testing machine and breaking load is noted. This load is matched with the maximum load of its respective substrate concrete. The compressive stress ratio is made to compare how strong in bond the specimen is when compared to its native concrete.

Sl. no	Type of Mortar	Slant shear strength (28 days) N/mm^2	Compressive strength ratio (28 days)	Mode of failure
1	Substrate concrete	30.27	-	Edge
2	SBR	15.7	0.52	Repair material
3	Acrylic	12.51	0.41	Repair material
4	Old-new concrete patch	23.76	0.79	Bond

Table 5: Slant shear strength at 28 days of curing:

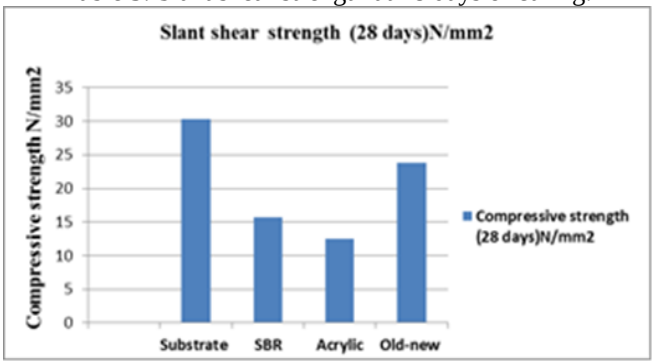

Fig. 2: Shows slant shear strength at 28 days of curing.

D. *Split Tensile Strength*

This test is carried out to determine the resistance of the specimen under tension. For this a PMM cylinder of size 101mm diagram and 202 mm height is cast and cured for 7days and 28days. These specimens are placed in a compression testing machine and the maximum load that a material can resist before splitting is termed as split tensile load and tension stress can be calculated.

Sl. no	Type of Mortar	Split tensile strength (N/mm^2)
1	Controlled specimen	2.36
2	SBR	3.99
3	Acrylic	2.17

Table 6: Split tensile strength at 28 days of curing

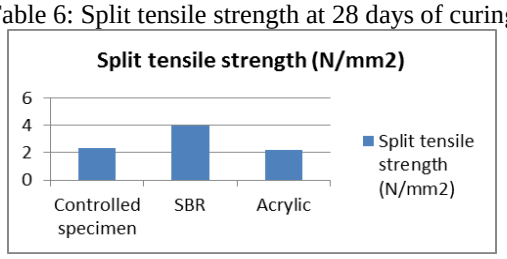

Fig. 3: Split tensile strength.

E. *Flexural Strength*

The bending stresses are determined using two point load beam method. The PMM which is patched with native concrete with an epoxy bond, a beam of size 500mm x 100mm x 100mm is casted and cured for 7 days and 28 days. These beams are placed in a flexure testing machine. The load is applies gradually in very small amount as concrete is weak in tension. The deflection is measured by keeping dial gauge at the Bottom of the beam as shown in figure.

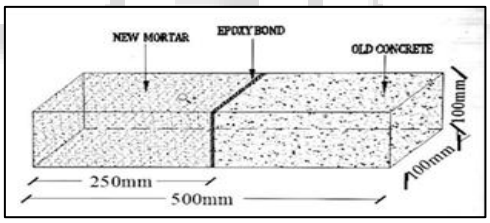

Fig. 4: Composite Beam

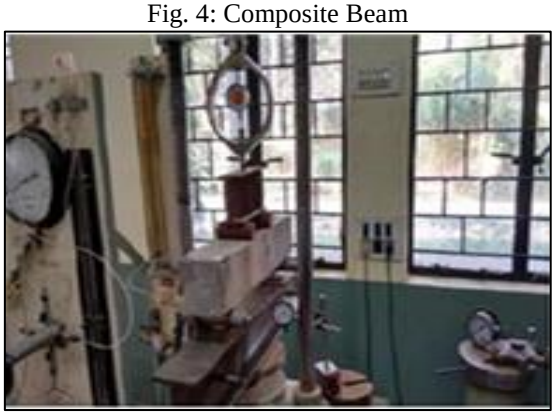

Fig. 5: Composite beam with a two point loading.

Sl. no	Type of composite beam	Flexural strength (N/mm^2)
1	SBR	1.43
2	Acrylic	0.64
3	Old –new composite	1.07

Table 7: Flexural strength of composite beam

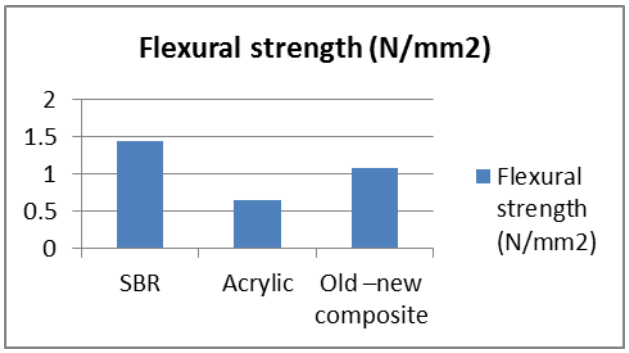

Fig. 6: Flexural strength of composite beam at 28 days of curing

VI. Conclusion

- A plenty of repair materials are available with different material properties. But selection of appropriate material is very important. The properties such as compressive strength, bond strength, bending strength and tensile strength are important as it exhibits the compatibility of repair material with the substrate concrete.
- The compressive strength ratio and modular ratio are the main criteria for the maximum stress concentration and failure modes of composite cylinders and beams observed in experimental results.
- From the experimental and analytical findings it is observed that SBR modified mortar improves the efficiency of the repair mortar and concrete as it gives better results in compression with 1.39% increment, split tension 0.91% increment, bond strength of 0.52% variation and bending strength of 0.42% variation when compared to its respective controlled specimens.
- It is observed that the SBR modified mortar gives superior results when compared to acrylic co polymer modified mortar in the engineering properties.
- It is observed from the experimental findings that SBR is a better repair material as compared to Acrylic co polymer as the SBR modified mortar gives better results in terms of modular ratio, compressive strength ratio, tensile strength and bending strength.

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