EXPERIMENTAL STUDY ON EPOXY INJECTION ON CONCRETE

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ABSTRACT

Many of the existing reinforced concrete structures throughout the world are in need of repair, rehabilitation or reconstruction because of deterioration due to the various factors like corrosion, failure of bonding between beam and column joints and increase in service loads etc.

The main aim of the present investigation is to increase the strength of Concrete cubes when it is subjected to heavy loads by using injection technique. In the Project work, we use epoxy resin in repair works. Epoxy resin is the bonding material. The use of epoxy is to seal the cracks, Bolt anchoring, Base plate levelling and Acidic environments. The epoxy resins are widely used in repairing of cracks, Patching and grouting of concrete, Industrial Flooring, of concrete, Structural adhesives, Anti-Corrosive linings, etc.

In this study, eighteen concrete cubes were casted and tested after proper on curing of concrete cubes at 21 days. Nine cubes were normal testing cubes, Nine cubes were three cubes were epoxy resin injected cubes for 7,14 and 21 days. After curing took place the cubes were tested for compressive strength and the results obtained have been compared.

Keywords: Compressive Strengthening, Epoxy Resin


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1. INTRODUCTION

Minor to moderate cracks in the concrete cubes, due to imperfections are generally developed which may not be detrimental from the strength point of view but may be undesirable. The concrete structures has been caused by a variety of factors including corrosion of reinforcement bars, substandard detailing of reinforcement, marine environment, high chloride content in the air, poor initial design or poor construction and maintenance. In other words, older reinforced concrete columns can be especially vulnerable structural elements.
because of insufficient lap splice in the longitudinal reinforcements, lack of confinement in flexural hinge zones, and also having 90° hooks

The loss of cementitious material, as well as the corrosion-induced reduction in cross-section areas of steel reinforcements leads to drastic reductions in the structural integrity and load-carrying capacity of columnar supporting elements. To remedy for insufficient capacity the structures need to be replaced or strengthened. Different types of strengthening materials are available in the market. Examples of these are Ferro cement, steel plates, fibre reinforced polymer (FRP) laminate, Latex and Epoxy resin.

**Epoxies** are high-strength plastics with properties that meet or exceed those of concrete. Epoxy injection provides a permanent structural repair to cracked or fractured concrete; cracks just visible to the eye can be injected. The added benefit is that it waterproofs structures, prevents water infiltration and re-bars corrosion and spall formation. As a result, this process essentially preserves concrete and prevents continual damage. Epoxy injection is not limited to repairing cracks in concrete structures. Wood beams have been successfully injected, honeycombs and similar voids are also filled using injection techniques, floor overlays can be rebonded, and loosened metal plates and bolts can also be secured.

An epoxy crack injection grout comprising a base component containing solvent-free epoxide resin plus a low viscosity liquid hardener. Can be placed by free flow under gravity or may be injected using a suitable hand or mechanical pump. Grouting of gap dimensions 0.1mm to 10mm may be easily achieved. The system gives rapid strength gain obtaining mechanical properties several times those of high quality concrete. The material is non-shrink enabling complete fill of the grouting area. The hardened grout is resistant to most chemicals, stable to sea water, petroleum products and resists freeze-thaw cycles. Uses include crack injection applications, filling and bonding cracked concrete, structural support where thin section grouting is required, structural support where dynamic load resistance is required and bonding of lifted floor toppings.

Epoxy injection is a resin based sealer that is forced into cracks within concrete to protect the rebar from becoming damaged, and to stop water from pooling into the foundation. Cracks and weak rebar will cause the concrete foundation to weaken, which will make the building affected unsafe for occupancy. The epoxy that is injected into the cracks effectively seals them while allowing the concrete foundations to retain their original strength and integrity. Epoxy injection repairs are the only way to fix a cracked foundation without having to tear the building down and re-pour the concrete.

The process involved in the epoxy resin process is precise and has to be done with an epoxy that is rated at least Grade A Type A for most applications. In order to effectively repair the crack, and to shield the rebar from premature deterioration, only the best products are used. The majority of epoxy injection repairs are done with injection machines or guns that are set at an air level suitable for the given application. There are maximum and minimum settings that are recommended, so all tools have to be adjusted before beginning each specific job.

The epoxy injection process can be performed in any weather and environment as long as special precautions are used to ensure that the temperature stays within the range for optimum application. Different chemicals can be added into the epoxy to allow for extremes in weather, such as hot or cold. Additives can also allow the epoxy to repair foundations cracks in dams and canals. In these specific cases, epoxy injection is the only type of feasible repair in order to prevent disastrous results if the foundation should fail.

The main purpose of this study is to experiment with the use of epoxy compounds to restore the integrity of a cracked member by Injection of the crack, emphasizing on the physical characteristics of epoxies as well as the importance of surface preparation,
temperature conditioning of the substrate and epoxy compound, and alterations of the hardening rate of epoxies. Furthermore, all lab tests and results on concrete cubes will be fully documented and interpreted.

**Objectives**
1. The structural improvement such as strength and ductility of concrete cube with a series of experiment.
2. The main aim of this study is to identify the characteristics strength of cube by epoxy injection and different grouting materials.
3. And restore the structural integrity and resistance to the concrete element

**Scope of the study:**
1. To design a model cube with self-induced crack on it for Injection technique using the existing models available in the literature.
2. To identify various materials available for sealing the cracks in concrete structures.
3. To study the properties of different grouting materials and their behaviour under various circumstances.
4. To conduct an experimental study by injecting these self-induced crack in cube model by various grouting material.
5. To summarize the effect of Epoxy grouting in the cracked structure and also compare other grouting materials.
6. When a structural repair is required, conditions that cause the crack must be corrected prior to proceeding with the epoxy injection.

**2. MATERIALS**

**A. General:**
The properties of different materials used namely cement, fine aggregate, coarse aggregate, Cement mortar and Epoxy resin were studied. As per IS 383-1970, Sieve analysis was done for fine aggregate, Coarse aggregate to test their suitability

**D. Water:**
Casting and curing of specimens were done with the potable water that is available in the college campus.

**E. Epoxy:**
Epoxy is known as polyepoxide, is a thermosetting polymer formed from reaction of an epoxide “resin” with polyamine ”hardener”. Epoxy is a co-polymer, means that it is formed from two different chemicals. These are referred to as the “resin” or “compound” and the “hardener” or “activator”.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Types of grouting material</th>
<th>Quantity (No.of cubes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Normal testing cubes (without filling)</td>
<td>9</td>
</tr>
<tr>
<td>2.</td>
<td>Epoxy grout</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td><strong>Total No of cubes</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

Table 1
Epoxy resin is a kind of thermosetting (solid) resin. When main agent is blended with the hardener of appropriate ratio, after cross linkage for hardening, a network structure of three-dimensional space is formed. Therefore, this product has equipped with a special physical property, mechanical property, and chemicals-resistant, etc.

Properties of epoxy resin:
1. Viscosity.
2. Epoxy equivalent.
3. Oxyhydrogen equivalent.
4. Average molecular weight and its distribution.
5. Softening point.
6. Temperature of heat deformation after crosslinkage.

3. METHODOLOGY
- Review of literature
- Preliminary test on cement, fine and coarse aggregates.
- Concrete mix design
- Casting of concrete specimen. (cube, cylinder, and prism)
- Test on harden concrete
- Comparison of results with controlled specimens
- Discussion
- Conclusion

4. SPECIMEN DETAILS
A Concrete mix is prepared with the proportions suggested such as 1:1.5:3 with water cement ratio 50% by mechanical mixer. A tested cube is prepared make sure that they are clean and greased or oiled thinly. Metal moulds should be sealed to their base plates to prevent loss of water. The Cubes are filled in three layers, tamping each layer with 25 strokes using a tamper, occasionally stir and scrape together the concrete remaining in the mixer to keep the materials from separating. Fill the moulds completely, smooth off the tops evenly, and clean up any concrete outside the cubes. Mark the specimen by a slip of paper on which is written the date and the specimen identification. The specimens is leaved in the curing room for 24 hours. After that open the moulds and immersed the concrete cubes in a water basin for 7,14 and 21 days. After Curing period, the specimens take out from the water and place it separately.

A. Compression Test
It is the most common test conducted on hardened concrete and an easy test to perform. Most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The tests were carried out on 150x150x150 mm size cube, as per IS 516-1959.

5. PREPARATION OF SPECIMEN
Before placing the concrete in the mould, its interior surface should be oiled. The concrete is filled into the mould in layers of approximately 5cm deep. Each layer is compacted either by hand or by vibration. For compaction by hand, the standard tamping rod should be used for 25 blows in each layer.
Curing of Specimen
After preparation of specimen, the specimen should be cured for 28 days in the curing tank.

Injection of the Specimen
After the curing of the cubes the injection of the specimen is to be conducted. Injection materials are epoxy, latex and cement mortar with Cebex 100.

Drilling the Cubes
The cubes were drilled on all faces using drilling machine. During drilling, all holes meet in all faces. All the cubes were drilled properly without damaged the cubes.

6. RESULTS AND DISCUSSION

A. Compressive Strength
The cubes were moulded as per IS 10080-1982 and cured. The cubes were tested on 7th, 14th and 21st day as per IS 516-1959.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Cubes</th>
<th>Ages Of Cubes</th>
<th>Load (Kn)</th>
<th>Stress (N/Mm²)</th>
<th>Average Compressive strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal cubes</td>
<td>A1 7 days</td>
<td>320</td>
<td>14.22</td>
<td>14.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A2 7 days</td>
<td>328</td>
<td>14.57</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>A3 7 days</td>
<td>339</td>
<td>15.06</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Epoxy chemical</td>
<td>B1 7 days</td>
<td>356</td>
<td>15.82</td>
<td>16.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B2 7 days</td>
<td>367</td>
<td>16.31</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B3 7 days</td>
<td>384</td>
<td>17.06</td>
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</table>
Table 3 Compression Strength of Concrete Cubes for 14 Days

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Cubes</th>
<th>Ages Of Cubes</th>
<th>Load (Kn)</th>
<th>Stress (N/MM²)</th>
<th>Average Compressive strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal cubes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A1 14 days</td>
<td>375</td>
<td>16.67</td>
<td></td>
<td>17.63</td>
</tr>
<tr>
<td></td>
<td>A2 14 days</td>
<td>392</td>
<td>17.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A3 14 days</td>
<td>423</td>
<td>18.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Epoxy chemical</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1 14 days</td>
<td>423</td>
<td>20.27</td>
<td></td>
<td>21.54</td>
</tr>
<tr>
<td></td>
<td>B2 14 days</td>
<td>478</td>
<td>21.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B3 14 days</td>
<td>520</td>
<td>23.11</td>
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</tbody>
</table>

Table 4 Compression Strength of Concrete Cubes for 21 Days

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Cubes</th>
<th>Ages Of Cubes</th>
<th>Load (Kn)</th>
<th>Stress (N/MM²)</th>
<th>Average Compressive strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal cubes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A1 21 days</td>
<td>389</td>
<td>17.28</td>
<td></td>
<td>19.24</td>
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<tr>
<td></td>
<td>A2 21 days</td>
<td>425</td>
<td>18.88</td>
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<tr>
<td></td>
<td>A3 21 days</td>
<td>437</td>
<td>19.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Epoxy chemical</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1 21 days</td>
<td>743</td>
<td>33.02</td>
<td></td>
<td>32.93</td>
</tr>
<tr>
<td></td>
<td>B2 21 days</td>
<td>694</td>
<td>30.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B3 21 days</td>
<td>786</td>
<td>34.93</td>
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</tr>
</tbody>
</table>

Figure 1 Compressive Strength (N/mm²)
7. CONCLUSION

1. Epoxy materials achieved the objective of increasing strength with a negligible change of global mass.
2. External confinement of concrete specimen with Epoxy resulted in an increase in the strength and ductility.
3. Epoxy strengthening of concrete cubes improves the strength than that of the conventional concrete cubes. So it can be used as an alternative strengthening method.
4. The provision of injection resulted in a substantial reduction in the measurement of cracked concrete specimens.
5. Epoxy Resin is the best material to give more strength compared to other injecting materials.
6. Epoxy adhesives are the most common adhesives used for repair crack by Injection Technique.
7. It was proven to be a very successful one.
8. Thus, the use of Epoxy is increase compressive strength across a crack, if further cracking is not anticipated.

REFERENCES

[2] IS 516 – 1959 Method of Test for Strength of Concrete


