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Prevention and Repair of Cracks in Concrete Structure by Using Epoxy Resin

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ABSTRACT

The Cracks are more important factor which we have to consider to avoid the complete failure of building structure or any other structure. Cracks are not controlled by the any external mean once the building construction is completed .There are so many reasons are their due to which crack may cause in the constructed structure. If cracks are of large depth then that will become the cause for the failure of building or any other structure and sudden failure of building or other structure will cause the loss of wealth and loss of human being also, so to avoid such harmful effect we have to timely focus on the entire structure to check that whether there is any cracks on the structure. If we have found any cracks then we have to immediately think on the repairing of that crack otherwise if time passes out then size of crack will increase day by day and it will cause the failure of structure but if we timely repair that cracks then there will no chances of failure of the structure. To rapier the cracks there are so many methods and so many materials are available in the recent market trend. One of the important method to fill the crack is nothing but the epoxy filling method. Epoxy repair methods for concrete are becoming widely popular in world.. In this research work we have provided additional information on the assessment and repair of cracks for concrete from various fibers. Upon 28 days of curing, the cubes, beams, and cylinders undergoes the compression test, flexural strength, and split tensile strength however, the compression test, flexural test, and split tensile test will be timed and monitored only until obvious cracks appears from the author's naked eyes. At this juncture the Ultimate Testing Machine's (UTM) power will be killed immediately and the sample removed thereafter. The samples will be repaired by applying epoxy at cracks and will be left for drying at ambient temperature in the laboratory. The repaired sample will be once again tested under compression using UTM, however, at this pointthe sample will be tested until failure and the strength recorded. The outcome suggests that the repair method using epoxy was able to sustain at least 80% to 85% of total strength achieved when cracks appeared during testing

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Keywords – Compressive Strength, Concrete, cracks, epoxy, Flexure Strength, Tensile Strength,

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I. INTRODUCTION

Crack is the factor which affects the strength of the overall structure. There are generally two types of crack Structural and Non-structural. Structural type of crack may endangered the safety of the building itself. While a non-structural crack means crack due to induced stresses inside the concrete but it is generally do not affect the weakness of the building. Moreover, non-structural cracks may because of the environmental value such as weathering, corrosion of reinforcement and shrinkage. Crack often happen inconcrete building. Sometime crack will occur even three to four hours after the building is fully finished and crack does not exactly happen within three to four years. Cracks happen due to temperature, volume change, drying shrinkage, thermal contraction and many more. The crack needs to be repaired in order to maintain our reputation, aesthetic value, and even to decrease the amount of fatal accident such as collapse's building.

This research used epoxy resin for concrete repair. Epoxy resin used was in the form of sticky-liquid form Conbextra EP10 (M). Conbextra EP10 (M) is a solvent free thatalso contain epoxy. This Conbextra have a lot of advantages which are harden without shrinkage, easy to apply, high strength, and high humidity could not be affected by the hardening. This research used 1 to 3 ratio of compartment A and B. Epoxy resins are also known as poly epoxides, there are in a class of reactive pre-polymers and polymers which include epoxide groups. The epoxy resin is being injected inside the crack occur.

A) Objective-

- The structural improvement such as strength and ductility of concrete cube with a series of experiment.
- To study the prevention of different type of cracks produced on concrete surface by using the epoxy resin.
- The main aim of this study is to identify the characteristics strength of cube by epoxy injection.

B) Crack Ccategorization-

Cracks develop due to deterioration of concrete or corrosion or reinforcement bars due to poor construction or inappropriate selection of constituent material and by temperature and shrinkage effects. Internally induced stresses in building components lead to dimensional changes and whenever there is a restraint to movement as is generally the case cracking occurs. Depending on width of crack, these are classified as:

Table 1.1: Classification of cracks based on width

Types of Crack	Crack width
Thin crack	Less than 1mm
Medium crack	1mm to 2mm
Wide crack	Greater than 2mm

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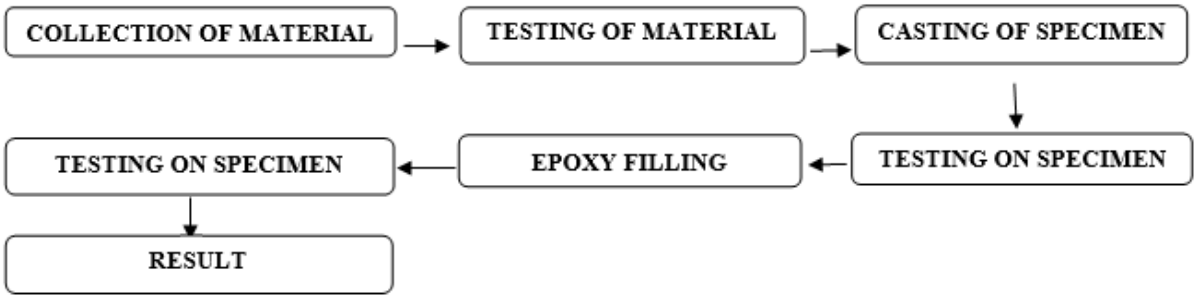
II. MATERIALS AND METHODOLOGY

To carry out the present work we have used the following work flow:



A) Material selected and number of specimen casted:

Following materials are selected for forming the required number of beam, cylinder and cubes

1. **Cement**: - Ultratech Cement Opc 53 Grade.
2. **Sand**: - Sand Of Pravara River.
3. **Aggregate:-**Obtain Aggregate Locally Available Size 20mm.
4. **Glass Fiber: -** Zart glass fibre, Size -12 mm**.**
5. **Steel Fiber: -** Hooked type steel fiber, length 300 mm, diameter 0.5 mm.
6. **Epoxy Resin:-** Conbextra EP10(M) is a two part epoxy resin system for grouting gaps ranging from 0.25mm to 10mm.

As the above materials are selected for casting the of cubes, beam and cylinder. Following number of cubes, beam and cylinder are casted and keep for curing of 28 days. For the present work we have considered three different types of concrete and based on that concrete we have categorized the specimen as normal concrete specimens, specimen of normal concrete with the addition of glass fiber and specimen of normal concrete with the addition of steel fiber. The mixing of steel and glass fiber is taken in the percentage of volume of concrete.

Steel fiber and Glass fiber is added in the 0.5%, 1% and 1.5% by the volume of concrete and the number of specimen casted are given in following table:

Table 2.1: Number of Specimen Casted

Sr. No.	specimen	Specimen		
		Cube	Beam	Cylinder
1	Normal	6	6	6
2	Steel Fiber	18	18	18
3	Glass Fiber	18	18	18

B) Testing on Concrete:

a) Compressive strength -The testing was carried out on 150x150x150 mm size cube as per IS516-1959.This testing have help us to find out the Compressive strength of cubes when epoxy is not applied and epoxy is applied on cubes.

b) Splitting tensile strength- The testing was carried out on 150x300 mm size Cylinder as per IS516-1959.This testing have help us to find out the Splitting tensile strength of cubes when epoxy is not applied and epoxy is applied on cylinder.

c) Flexural strength- The testing was carried out on 700x150x150 mm size Beam as per IS516-1959.This testing have help us to find out the Compressive strength of cubes when epoxy is not applied and epoxy is applied on beam.

Experimental Study:

In this paper the methodology for casting the specimen and after curing period the testing of specimen is defined in the following steps, so we can measure the strength of the specimen,

Step 1: Place cube, beam, and cylinder at the universal testing Machine to be tested.

Step 2: Apply load until crack occurs and quickly push the stop button before it fully breaks.

Step 3: Observe and record the strength of the concrete until the crack occurs.

Step 4: Repeat steps 1 to 3 for the strength test on the concrete to take an average of the strength. Applying epoxy Conbextra EP10 (M) at the crack occurs in order to repair it and leave it for one day.

Step 5: The concrete that have been injected or applied by the epoxy Conbextra EP10 (M) is placed on the universal testing Machine to be tested again.

Step 6: Apply load until it failed.

Step 7: Observe and record the strength of the concrete after applying the epoxy.

Step 8: Repeat step 5 to 7 for the strength test on the concrete to take an average.

With the help of above steps we have calculated the different strength of the concrete and the results achieved through this work are explained in the next chapter.

III. RESULT AND DISCUSSION

This chapter will discuss about all the results from testing and laboratory works that had been done. Compressive strength, flexural strength, split tensile strength, epoxy Conbextra EP10 (M) and percentages of reduction strength had been discussed in this chapter. There are different fibers that had been used which was steel fiber and glass fiber. Every each of these fibers had 18 samples of concrete cubes 150 x 150 x 150 in size, 18 samples of concrete beams 700 x 150 x 150 in size, and 18 samples of concrete cylinders 300 mm x 150 in size. Regarding to the place of the experiment had been done; the only machine that was very suitable to be used was universal testing machine. The only problem of using this machine was the crack occurred only a small crack before it achieved the failure limit.

Epoxy resin used was in the form of sticky-liquid form. Epoxy resins are also known as polyepoxides, there are in a class of reactive pre-polymers and polymers which include epoxide groups. In this reseach, Conbextra EP10(M) had been used. Conbextra EP10(M) has many different types of grade. This Conbextra has high modulus, high strength, structural epoxy paste and to harden concrete. It can be used for a sealant agent, used for erection and for bridges. The surface must be cleaned before applying the epoxy at the concrete. Conbextra EP10 (M) have two components which are component A and component B. Component A is black in color. This part is quite dangerous to human system if the precaution did not emphasize and can cause a lot of problem which are skin sensitization, skin or eye irritant, respiratory problem, and liver injury. Conbextra EP10(M) : Contains resins which may cause sensitization by skin contact. Avoid contact with skin and eyes and inhalation of vapour. Wear suitable protective clothing, gloves and eye/face protection. Barrier creams provide additional skin protection. Should accidental skin contact occur, remove immediately with a resin removing cream, followed by soap and water. Do not use solvent. In case of contact with eyes, rinse immediately with plenty of clean water and seek medical attention immediately - do not induce vomiting.

By the testing with different machines for getting different strength following results were obtained:

Compressive strength test(For Cubes):

Table 3.1: Results obtained for compression strength test

Sr.no	cube	Age of specimen	% of fibers	Compressive strength (Stress), MPa (before Appling epoxy)	Compressive strength (Stress), MPa (after Appling epoxy)
1	Normal	28 Days	0.00	**27.46**	**27.87**
		56 Days	0.00	**28.2**	**29.7**
2	Steel fiber	28 Days	0.5%	**27.35**	**27.43**
		28 Days	1%	**27.87**	**28.01**
		28 Days	1.5%	**27.28**	**27.43**
		56 Days	0.5%	**27.7**	**27.81**
		56 Days	1%	**28.05**	**28.13**
		56 Days	1.5%	**27.44**	**27.52**
3	Glass fiber	28 Days	0.5%	**27.06**	**28.3**
		28 Days	1%	**28.46**	**28.59**
		28 Days	1.5%	**26.98**	**27.9**
		56 Days	0.5%	**27.9**	**28.9**
		56 Days	1%	**29.16**	**29.16**
		56 Days	1.5%	**27.68**	**28.5**

Flexural strength test(For Beam):

Table 3.2: Results obtained for Flexural strength test

Sr.no	Beams	Age of specimen	% of fibers	Flexural strength (Stress), MPa (before Appling epoxy)	Flexural strength (Stress), MPa (after Appling epoxy)
1	Normal	28 Days	0.00	**6.3**	**6.93**
		56 Days	0.00	**28.2**	**29.7**
2	Steel fiber	28 Days	0.5%	**6.6**	**6.92**
		28 Days	1%	**7.12**	**7.4**
		28 Days	1.5%	**6.96**	**7.24**
		56 Days	0.5%	**7.36**	**7.96**
		56 Days	1%	**8.17**	**8.56**
		56 Days	1.5%	**7.96**	**7.93**
3	Glass fiber	28 Days	0.5%	**6.5**	**6.85**
		28 Days	1%	**6.9**	**7.25**
		28 Days	1.5%	**6.8**	**7.13**
		56 Days	0.5%	**7.25**	**7.8**
		56 Days	1%	**7.85**	**8.3**
		56 Days	1.5%	**7.7**	**7.8**

Split tensile strength test:

Table 3.3: Results obtained for split tensile strength test

Sr.no	Cylinder	Age of specimen	% of fibers	Split Tensile strength (Stress), MPa (before Appling epoxy)	Split Tensile strength (Stress), MPa (after Appling epoxy)
1	Normal	28 Days	0.00	**4.1**	**4.8**
		56 Days	0.00	**4.86**	**5.6**
2	Steel fiber	28 Days	0.5%	**5.06**	**5.21**
		28 Days	1%	**5.13**	**5.43**
		28 Days	1.5%	**5.3**	**5.29**
		56 Days	0.5%	**5.28**	**5.38**
		56 Days	1%	**5.67**	**5.97**
		56 Days	1.5%	**5.45**	**5.8**

3	Glass fiber	28 Days	0.5%	**4.8**	**4.93**
		28 Days	1%	**5.12**	**5.35**
		28 Days	1.5%	**4.93**	**5.05**
		56 Days	0.5%	**5.15**	**5.45**
		56 Days	1%	**5.43**	**5.67**
		56 Days	1.5%	**5.22**	**5.52**

IV. CONCLUSION

As the results obtained from the different testing on the different specimen for 28 days and 56 days of curing period we have done following comparative study for all the specimen as follow and following conclusion are made based on the experimental study and obtained results;

A) For 28 Days Of curing Period:

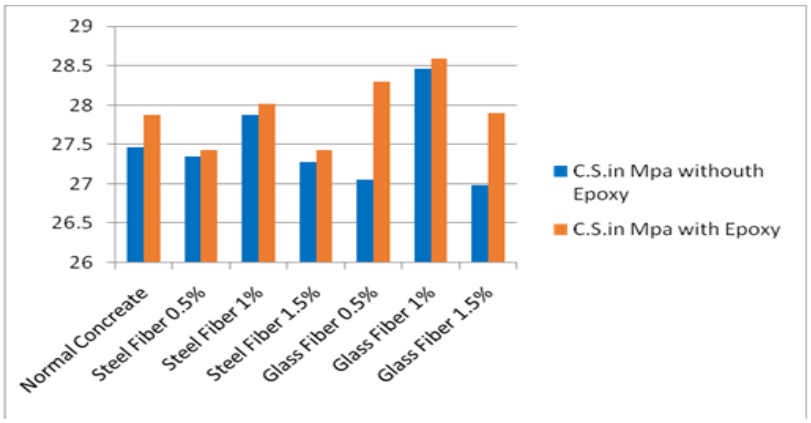


Fig.3.1.Comparative study between Compressive strength of cube Specimen for 28 days curing of period without and with Epoxy Resin

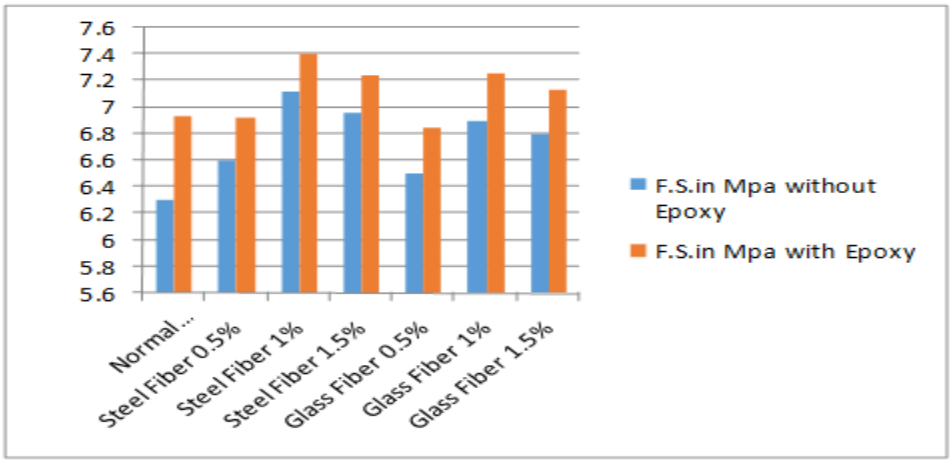


Fig.3.2.Comparative study between Flexural strength of Beam Specimen for 28 days of curing period without and with Epoxy Resin

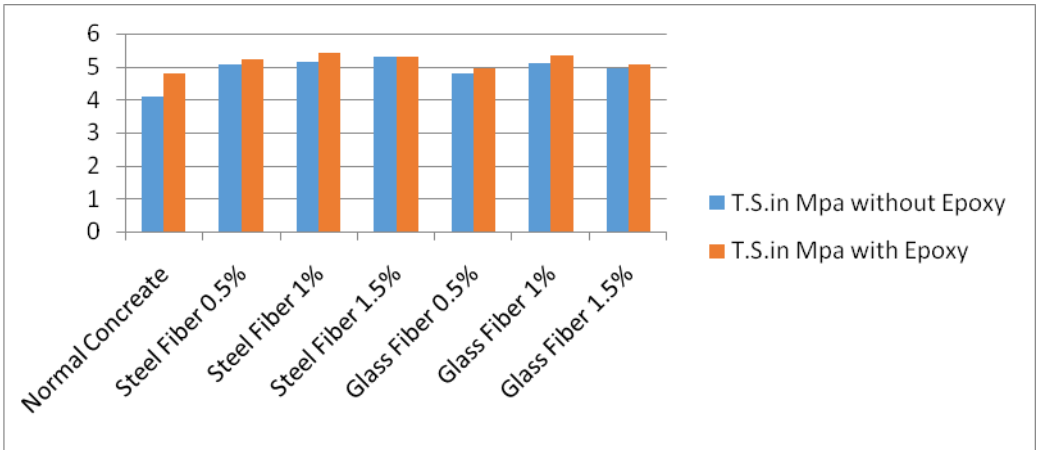


Fig.3.3.Comparative study between Split Tensile strength of Cylinder Specimen for 28 days of curing period without and with Epoxy Resin

B) For 56 Days of Curing Period:

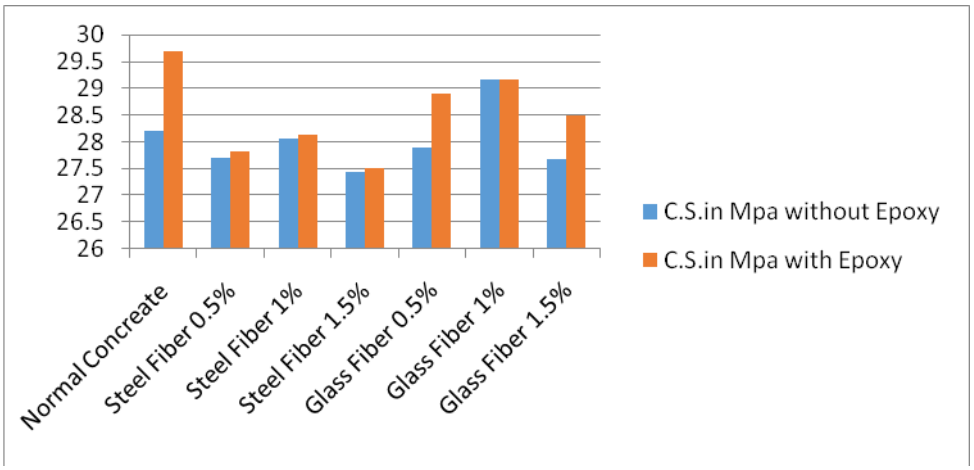


Fig.3.4.Comparative study between Compressive strength of cube Specimen for 56 days curing of period without and with Epoxy Resin

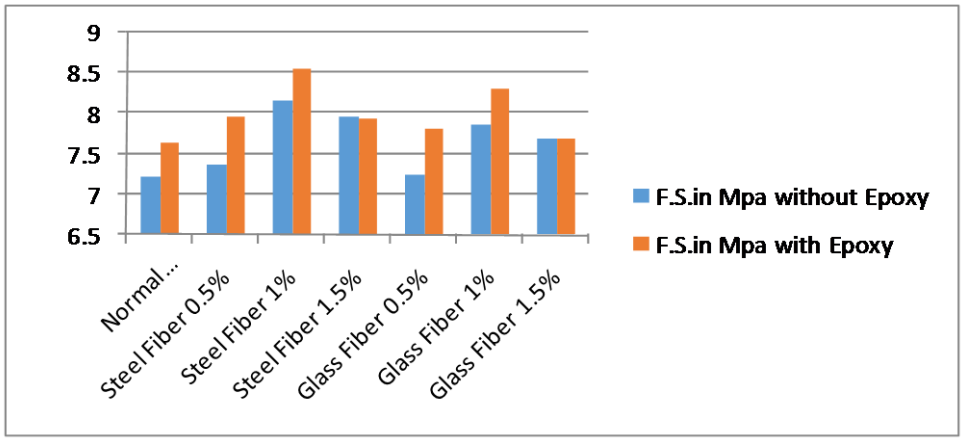


Fig.3.5..Comparative study between Flexural strength of Beam Specimen for 56 days of curing period without and with Epoxy Resin

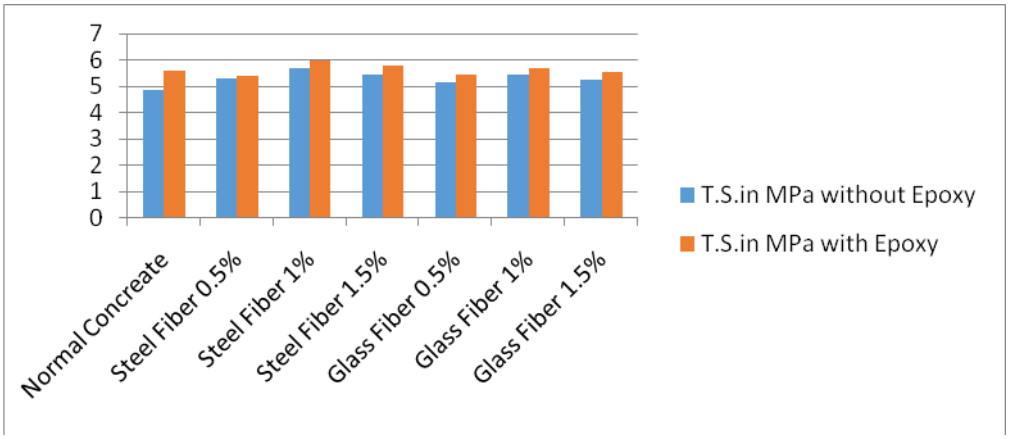


Fig.3.6.Comparative study between Split Tensile strength of Cylinder Specimen for 56 days of curing period without and with Epoxy Resin

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 with Ductality.
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.

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