

Experimental Study on Interfacial Bond behavior between Concrete to Concrete by using Different Epoxy

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Abstract: Concrete is the most extensively used construction material globally, so its demand grows. But the concrete life span is decreased due to overloading or hazardous environmental condition. So, the restoration of concrete is required after some duration. However, the new construction every time is uneconomical. This type of problem can be avoided by repairing/strengthening the structural members made of concrete. Repair materials help in extending the life and durability of concrete structures, reducing costs, and improving safety. However, the interference layer i.e., the weakest part between substrate concrete and overlay concrete behaviour needs to be understood clearly. Various materials are often used in construction to repair large cracks, defective components, and holes in damaged concrete surfaces with the bonding agent. However, bonding agents are not beneficial because the bond coat creates an extra plane, which reduces the effective interlocking of new and old concrete and leads to cohesiveness failure due to micro-cracks.

The cohesiveness failure can be reduced by suitable surface treatment. Several methods for measuring the bond strength between substrate concrete and overlay concrete are available we used bonding admixtures are Lapox Hardener, Lapox Lacrete, Cera Bond EP. Being simple, the Cylindrical SST is used with a 45° angle. In this study, various types of surface treatment like Lapox Resin, Lapox Hardener, and Cera Bond EP are considered because the repair fails due to poor surface preparation more frequently than any other reason. In this regard, experimental investigation has been carried out and concludes that Lapox Hardener shows better bonding behavior as compared to.

Keywords: Lapox Hardener, Lapox Lacrete, Cera Bond EP. Being simple, the Cylindrical SST is used with a 45° angle.

I. INTRODUCTIONS

The most typical kind of concrete restoration involves removing deteriorated concrete and replacing it with overlay or repair materials. One of the most crucial requirements for any sort of restoration system is having enough bond strength between the overlay and the underlying concrete base during the service life. The bond strength and stress distribution during the repair will be impacted by the two materials' different properties. Differences in thermal movement, elastic modulus, and shrinkage are all significant. Substrate, overlay, and bond zone are the three stages of the repair system. The bond zone refers to the area immediately surrounding and interacting with the bond plane. The system's stresses must be able to be supported by the bond zone. Numerous factors have an impact on the connection. Since the failure modes are either in tension or in shear, two test techniques are more

appropriate. The first is the "Pull off test," which is a tensile test that may be carried out both in situ and in the lab. The second test, known as the "slant shear test(SST)," can only be carried out in a lab and features a shear failure mechanism. A relatively recent test technique for determining interface bond strength is the so-called Twist test. The test has the advantage of being portable, making it possible to conduct it on a building site. The assessment has to be enhanced even more. The bond strength(BS) is the adhesion between the overlay and the substrate, which is often the system's weakest connection. A monolithic structure requires excellent binding strength. Shear resistance and tensile resistance are two ways to express a bond. It is crucial to pick the option that can adequately describe the pressures the structure experiences in the field. It is more practical to employ tensile strength for bonding in structural works even if shear stress occurs often in the real world. After repairing the concrete structure and adding the new layer, the damaged portion of the substrate has already been removed, and the new layer has been designed and installed in accordance with the project requirements. As a result, both layers should be strong enough. The interface is susceptible to damage and could even be the weakest link in the system despite both levels having great strength. Because the modulus of elasticity of two layers differs, it shows different strains when subjected to the same load. This difference should be accommodated by the interface. The temperature strains have the same difficulty. In addition, the new coating has shrunk, which is another aspect that contributes to interface weakness. Because the interface is the system's plane of discontinuity, it is subjected to all these additional forces, and must be strong enough to maintain the layers' integrity. As a result, good surface adhesion is a key requirement of repair material. Several factors determine bond strength(BS), as well as various test techniques for defining bond strength and quality. Concrete is the most common building material, so demand is rising. However, when concrete is overloaded or exposed to dangerous conditions, its life span is cut short. After a while, concrete needs to be repaired. When you build something new, on the other hand, it's always too expensive. People often repair and strengthen structures by adding new concrete to an existing concrete base to make them stronger. This type of problem can be avoided by doing this. The most common way to do this is to make the surface of the substrate rougher. In many cases, an adhesion promoter is also used. However, this is an experimental procedure, and the second step hasn't been proven to work. When adhesive coatings are used in structural applications, regulations usually set limits on the design shear strength at the surface of the substrate and the coating. If the composite is made with enough shear strength at the interface to be modeled the same way monolithic parts can be modeled, the same methods can be used to model it.

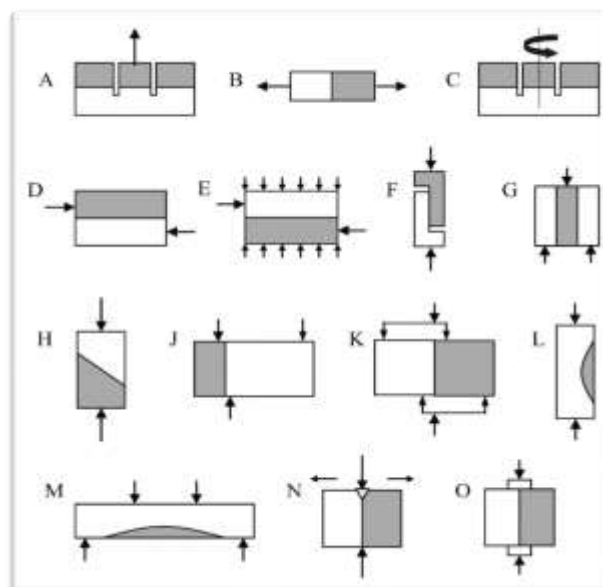


Fig 1: A Variety of Test Methods to Assess Bond Strength(BS) in the Interface Zone

- The effect on bonding at different ages of concrete will be studied.
- The effect of adhesives will be studied to check the bonding performance.

- The effect of surface treatment will be considered to investigate the bonding behavior
- Several aspects affecting inter layer bond strength at the interface of the concrete rebuildswill be investigated
- Suitable test methods to determine the bond strength will be identified

II. MATERIALS AND METHODS

Material study: Basic tests will be carried out.

Preparation of substrate layer

M25, and M30 concrete will be used in this study. (As per IS 10262, 2019)[27]

Different types of tests will be conducted to check the properties of casted concrete at 7,28 days.

Bi surface shear test samples will be used for the bonding behavior.

Slant shear test samples will be used to evaluate the bonding behavior.

Preparation of the surface

Grove of 2mm size.

Preparation of overlayer

It will be prepared with fresh concrete.

A. Materials

Cement: In the present study, OPC 43 grade with the product name ‘J.K. SUPER CEMENT’, according to IS 8112-1989[29], was used. The cement was of uniform colour, i.e., grey with a light green shade.

Fine aggregate(FA): Fine aggregates are locally available natural river sand of the size less than 4.75mm. The various properties conformed to IS: 383-1970[30].

Coarse aggregate(CA): CA is the material that does not pass through a 4.75 mm sieve. In most cases, rounded aggregate is used as coarse aggregate. In this experiment, nearby available CA with a maximum size of 16mm was used, which met the requirements of IS: 383-1970[30]

Water: Concrete was made with drinking-quality water. It was clean of organic impurities and suspended particles, which might have affected the properties of freshly set and properly cured concrete.

Superplasticizer: To expand the workability of the fresh concrete, **Master Gallium SKY 8777** superplasticizer is used. It helps to produce high workability, high performance, and high early strength. It is mostly used with all PPC, OPC, and PSC.

Epoxy's : Lapox Hardener: Epoxy systems are renowned for their exceptional versatility, strength, and durability, making them a popular choice in various industries, from construction to electronics and marine applications. However, to unleash the full potential of epoxy resins, they need to be cured or hardened through a chemical reaction known as curing. This is where epoxy hardeners transform liquid epoxy resins into robust, solid structures. This blog will delve into the role and importance of epoxy hardeners in epoxy resin applications.

Lapox Resin: A two-component, high performance, fast-setting epoxy adhesive used for multiple applications. It provides excellent bond strength for various substrates including granite, marble, wood, synthetic and ceramic tiles.

Cera Bond EP: Cera Bond EP is highly useful for bonding fresh concrete to old concrete that is fully cured. Cera Bond EP can be used to bond sprayed concrete/mortar to old concrete surfaces. Cera Bond EP can be used on horizontal and vertical surfaces as a repair ingredient to corroded or spalled concrete.

B. Mix design

M25 and M30 concrete mix designs have been carried out using references: IS10262-2009, IS 383-1970 and IS 456-

2000[31].

Table 1: Mix proportion of M25 and M30

Concrete Mix	Cement	FA	CA	Water	Superplasticizer
M25	1	1.79	3.32	.46	—
M30	1	1.52	3.74	0.37	1%

C. Specimen preparation

The ingredients were weighed using a weighing machine according to the design mix. Machine mixing was employed to mix concrete in the current study. The materials were mixed using a motorized mixer. After adding all the coarse material to the drum, the fine aggregate was added, followed by the cement and bagasse ash, and finally, water. After pouring the elements into the drum, mixing begin, and continued until uniform concrete formed. Specimen were produced in cast iron mould as used to cast the samples. The table vibrator was used to compact the material for 1-2 minutes. An iron rod was used to remove excess material. Floats and trowels were used to smooth the top surface. In this experiment, a wooden block of 75*150*150mm dimension is used in the cast iron cube mould for preparing the substrate concrete specimen.



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concrete mixture. Only around 20% of the entire volume of concrete mix is made up of it. The most important kind of cement is OPC. Depending on the strength of 28 days, OPC is divided into 3 grades: 33 Grade, 43 Grade, and 53 Grade. OPC of 43 grade conforming to Indian Standard IS 8112- 2013 has been used in this experiment with a brand name of J K Super Cement. The different physical characteristics of cement are the following:

Table 1: Properties of cement

S. No.	Test Name	Cement	IS 8112:1989 specification
1	Specific gravity	3.14 g/cm ³	---
2	IST	170 minutes	30 min (minimum)
3	FST	215 minutes	600 min (maximum)
4	Consistency	29%	----
5	Fineness (%)	2	10(maximum)
6	Soundness	2mm	10(maximum)
7	Compressive Strength	Obtained	Minimum
	7 days	34.9 MPa	33 MPa
	28 days	43.7 MPa	43MPa

A. Compressive strength

After drying at room temperature, the specimen was tested in a CTM at the ages of 7 and 28 days according to Indian Standard 516- 1959 [32] to get the compressive strength of concrete M25 and M30 grades were used for substrate layer of concrete and M40 grade of concrete is used for overlay concrete.

Table 2: CS at 7 days and 28 days for various mix proportions

Samples	CS (M25) (MPa)		CS (M30) (MPa)		CS (M40) (MPa)	
	7Days	28Days	7Days	28Days	7Days	28Days
S1	19.66	33.29	28.97	40.08	38.97	50.16
S2	20.34	34.09	29.16	43.71	39.16	53.64
S3	21.85	35.56	30.57	44.59	40.57	54.63
S4	20.44	34.13	32.53	45.99	42.53	56.02
S5	18.65	32.39	29.11	42.57	39.11	52.53

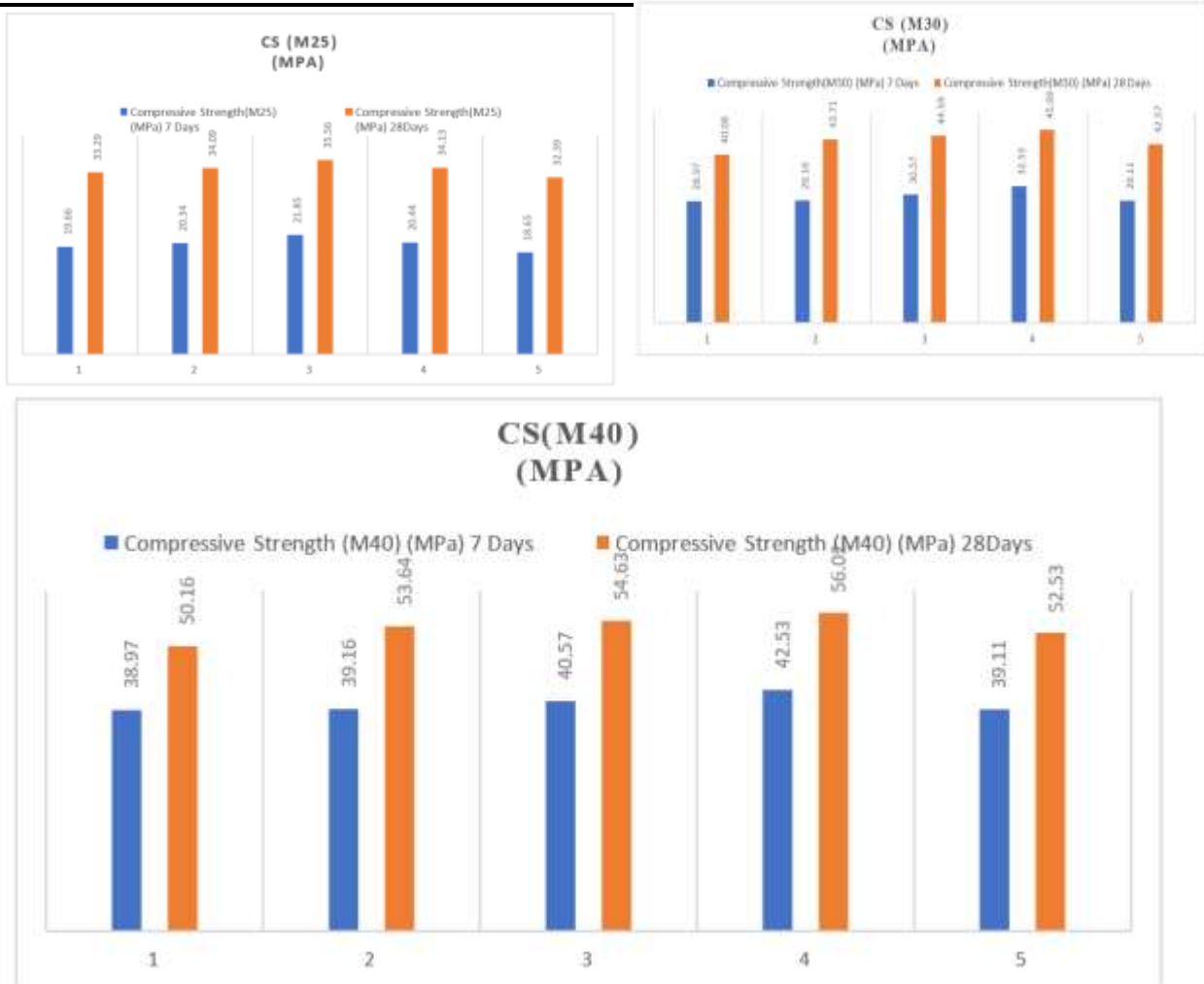


Figure 2: CS of M25,30 and 40 grade at 7 days and 28 days

It can be seen directly that maximum CS was found at 21.85 MPa and 35.56 MPa with 7 and 28 days curing at sample 3 (S3) and minimum Compressive Strength was found 18.65 MPa and 32.39 MPa with 7 and 28 days of curing at sample 5(S5).

It can be seen clearly that maximum CS was found 32.53 MPa and 45.99 MPa with 7 and 28 days of curing at sample4 (S4) minimum Compressive Strength was found 28.97 MPa and 40.08 MPa with 7 and 28days of curing at sample 1(S1).

It can be seen clearly that maximum Compressive Strength was found 56.02 MPa and 42.53 MPa with 7 and 28 days curing at sample 4 (S4) minimum Compressive Strength was found 38.97 MPa and 50.16MPa with 7 and 28 days of curing at sample 1(S1). M40 grade of concrete is used for the overlay concrete.

- B. Bond Strength
- C. Slant shear Test

SST and bi surface shear tests have been used to get the average bond strength of the compositeNC substrate and overlay specimens. These tests show the average bond strength. The maximum force was divided by the bonded area to get the

slant shear strengths. Formula 1 shows how the bonding shear strength has been calculated in the bi-surface test. This is how you get the maximum force applied and how big the bonded surface is.

Table 3: Bond strength of concrete in slant shear test

Sample	Days	Bond Strength			
		Without Treatment	Lapox Hardener	Lapox Resin	Cera Bond EP
M25	7 Days	4.11	4.97	4.65	5.25
	28 Days	4.28	5.4	5.4	6.22
M30	7 Days	4.31	5.35	4.62	5.43
	28 Days	4.95	5.9	5.22	6.1

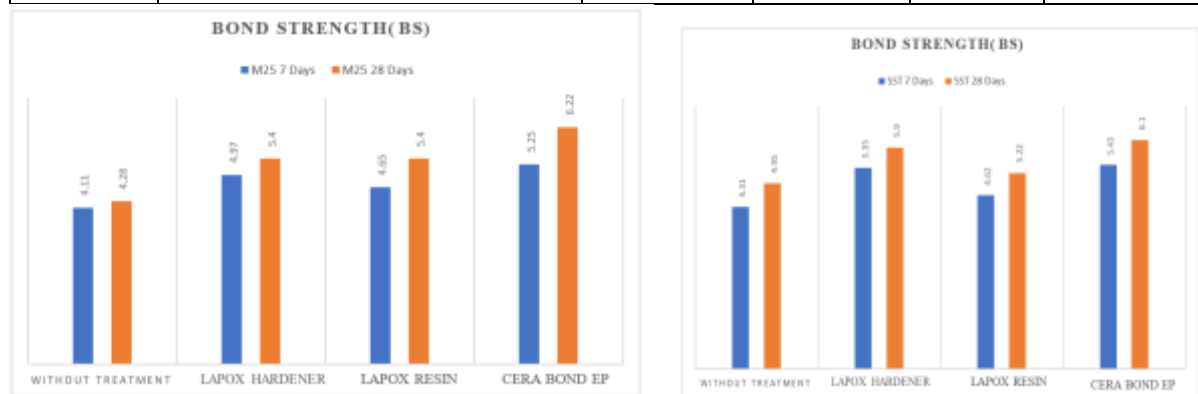


Figure 3: Bond strength of M25, 30 grade concrete in shear slant test at 7 and 28 days

SST bond strength and different types of surface treatments at 7 and 28 curing days. It is defined directly that maximum SST bond strength was found 5.25 MPa and 6.22 MPa with 7 and 28 days of curing with Cera Bond EP surface treatment, but the minimum Slant Shear bond strength was found 4.11 MPa and 4.28 MPa with 7 and 28 days curing with no surface treatment. The Slant Shear bond strength was increased by 27.73% and 45.32% as compared to no surface treatment to Cera Bond EP. This strength was increased due to the better adhesive properties of glue. relationship between SST bond strength and different types of surface treatments at 7 and 28 curing days. It is defined directly that the maximum Slant Shear bond strength was found 5.43 MPa and 6.1 MPa with 7 and 28 of days curing with Cera Bond EP surface treatment, but the minimum Slant Shear bond strength was found 4.31 MPa and 4.94 MPa with 7 and 28 days curing with no surface treatment. The Slant Shear bond strength was increased by 25.9% and 23.4% as compared to no surface treatment to Cera Bond EP. This strength was increased due to the better adhesive properties of glue.

D. Bi-surface Shear Test

These Four composite specimens with different surface treatments were put through a bi- surface shear test to see how they would hold up. This table shows the results of some surface-treated samples like Cera Bond EP, sandblast, Lapox Hardener , and without treatment.

Table 4: Bond strength of concrete in Bi-surface shear test

Sample	Days	Bond Strength			
		Without Treatment	Lapox Hardener	Lapox Resin	Cera Bond EP
M25	7 Days	3.01	3.72	4.02	4.11
	28 Days	3.17	4.2	4.11	4.68
M30	7 Days	3.32	4.56	3.6	4.9
	28 Days	3.87	4.9	3.9	5.1

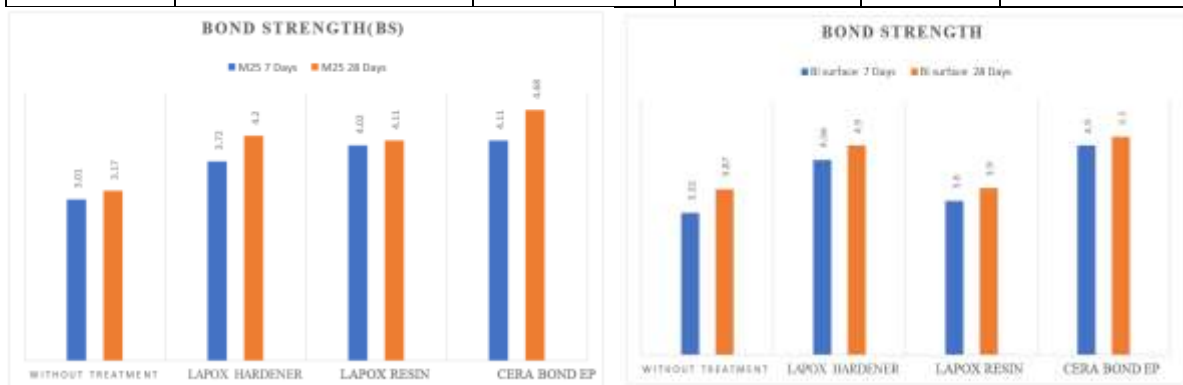


Figure 4: Bond strength of M25, 30 concrete in Bi-surface shear test at 7 and 28 days

Bi surface shear test bond strength and different types of surface treatments at 7 and 28 curing days. It is defined directly that the maximum Bi-surface shear test bond strength was found 4.9 MPa and 5.1 MPa with 7 and 28 days curing with Cera Bond EP surface treatment, but the minimum Slant Shear bond strength was found 3.32 MPa and 3.87 MPa with 7 and 28 days of curing with no surface treatment. The bi-surface shear test strength was increased by 47.5% and 31.7% as compared to no surface treatment to Cera Bond EP. This strength was increased due to the better adhesive properties of glue.

IV. CONCLUSIONS

They show that the bond strengths measured by SST were stronger than those measured by bi surface shear for all overlay material and surface treatments. There are more friction forces and interlock in a slant shear test because of the high compressive stresses. This means that the shear failure load increases.

- SST bond strength was increased by 27.73% and 45.32% as compared to no surface treatment to Cera Bond EP for the grade of M25 concrete.
- SST bond strength was increased by 25.9% and 23.4% as compared to no surface treatment to Cera Bond EP for the grade of M30 concrete.
- The bi surface shear test bond strength was increased by 36.5% and 47.6% as compared to no surface treatment to Cera Bond EP for the grade of M25 concrete
- The bi surface shear test strength was increased by 47.5% and 31.7% as compared to no surface treatment to Cera Bond EP for the grade of M30 concrete.

The bond strengths measured by SST were stronger than those measured by bi surface shear for all overlay materials and surface treatments and comparison between the surface treatment, Cera Bond EP surface treatment has more bond

strength than the other treated surfaces and this strength was increased due to the better adhesive properties of Cera Bond EP.

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