INVESTIGATION OF SLANT SHEAR STRENGTH OF A REPAIRED STRUCTURE BOND DUE TO EPOXY

A

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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DECLARATION

I hereby declare that the work presented in the Project report entitled **"INVESTIGATION OF SLANT SHEAR STRENGTH OF A REPAIRED STRUCTURE BOND DUE TO EPOXY"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Sugandha Singh**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"INVESTIGATION OF SLANT SHEAR STRENGTH OF A REPAIRED STRUCTURE BOND DUE TO EPOXY"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Jeewan Biswa (191625) and Karma Choden(191626)** during a period from July, 2022 to May, 2023 under the supervision of **Dr. Sugandha Singh(Assistant Professor),** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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"No one who achieves success does so without acknowledging the help of others. The wise and confident acknowledge this help with gratitude"

-Alfred North Whitehead.

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ABSTRACT

The aim of this project is to investigate the slant shear strength of a repaired structure bonded by using epoxy resin. After any natural or man-made disaster events, structures may undergo various stages of damage. To safeguard the economic as well as physical well–being of all stakeholders, proper repair and rehabilitation strategies of damaged concrete structures are required. Various studies have focused on repairing concrete members by bonding different substrates with epoxy resin. The main use of epoxy resin is to reduce the concrete use while repairing and giving at least the same strength as that of concrete mix. In this study, experiments are conducted to test the slant shear strength of repaired concrete block based on two main parameters, thickness of epoxy resin bond, and grade of concrete of the two substrates. The different grade of cylindrical slant was cast and cured for 28days. After curing, The two substrates were bound together with epoxy resin of 1mm, 2mm and 3mm thickness. The samples were kept at room temperature for one week and after a week of binding compressive test were done as per specifications given in ASTM C882. Based on the experiments, it is observed that with increase in thickness; the strength of epoxy resin also increases. Failure in the epoxy resin bond is observed when two same grades of substrates are bonded together whereas the material of lower grade of concrete fails whenever two substrates of different grades are bonded by epoxy resin.

***Key words: Bond strength, Slant shear, Repair, Concrete*.**

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CHAPTER 1

INTRODUCTION

General

Many materials are used in the construction world today such as reinforcement, woods, cement, sand aggregates, etc. Concrete is widely utilized building material due to its strength and durability. However, over time concrete structures can experience wear and tear due to factors such as weathering, corrosion and impact. Concrete repairs are therefore essential to maintain the integrity and functionality of the structure. One of the important aspects of concrete repair is the bond between the new and the existing concrete. This project investigates the bond strength of a repaired structure bond due to epoxy resin. In order to gain the structural integrity and increase the compressive strength and stiffness of cracked concrete, epoxy is used as the repair material.

Concrete

Concrete is a very essential material in construction world. It is used to make a large number of infrastructural assets such as buildings, bridges, dams and roads which is crucial for normal civilian functioning. The properties of concrete can vary depending on the mix design, the materials used, and the curing process. Proper design, construction, and maintenance practices can help to maximize the desirable properties of concrete and ensure the safety and durability of concrete structures.

These are the properties of concrete:

1) Consistency: it is the degree of wetness or fluidity of concrete or the ability of the concrete to flow.
2) Segregation: it is the tendency of separation of the various components, such as cement, sand, and aggregate, which happens when the mixture is not proportioned properly or when it is handled inappropriately during usage.
3) Bleeding: it is a condition where water rises on top of a freshly laid concrete. Bleeding can take place due to the difference in specific gravities of solid and liquid particles

4) Workability: it is vital for the concrete to have consistency such that it can be easily transported, placed and finished sufficiently without any segregation, bleeding, or excessive resistance to deformation. A concrete is said to be workable if it satisfies these conditions.
5) Setting time: there are two setting time initial setting time and final setting time. Initial setting time is the time when the concrete starts losing its plasticity i.e. concrete starts to solidify. Final setting time is the time at which concrete turns solid and holds its shape.
6) Unit weight:The unit weight of concrete varies depending on the mix design, the density of the aggregates used, and the moisture content of the concrete. Typically, the unit weight of normal weight concrete ranges from approximately 2,240 to 2,400 kilograms per cubic meter (kg/m^3).
7) Uniformity:Uniformity in concrete refers to the degree of consistency in the properties of the concrete mix throughout the batch, as well as across batches. A uniform concrete mix is one in which the materials are evenly distributed and well-proportioned, resulting in a consistent quality of concrete.

Concrete is a widely used building material that possesses a range of desirable characteristics, including:

1) Strength: Concrete is strong and can endure huge loads and resist deformation thanks to its high compressive strength. The use of reinforcement, such as steel bars or fibers, can strengthen concrete even further.
2) Durability: Concrete is a resilient substance that can withstand erosion, abrasion, and weathering. Concrete constructions that are built properly can survive for decades or even centuries.
3) Workability: : Concrete is a flexible material for a number of building applications since it is easily molded and sculpted to fit a variety of forms and sizes.
4) Fire resistance: Due to its great fire resistance, concrete is a preferred building material for projects that must adhere to stringent fire safety regulations.
5) Thermal mass: Concrete has a large thermal mass, which allows it to absorb and store heat, which helps buildings use less energy by regulating inside temperatures.

6) Sound insulation: Concrete is a useful material for decreasing noise transmission between floors or rooms in a structure because it has good sound insulation capabilities.
7) Sustainability: Concrete is a somewhat sustainable building material since it can be built with locally accessible materials and recovered and reused.

Failure in Concrete Structure

Numerous factors can cause concrete buildings to collapse, and the reason for the failure will determine the sort of failure that might happen. The following are some typical failures that can happen in a concrete structure:

1) Cracking: The most frequent form of failure for concrete constructions. There are several different causes of cracks, including shrinkage, thermal movement, overloading, and settling. If not fixed, these fissures can cause water seepage, corrosion of the reinforcing, and eventually collapse of the concrete structure, which can impair its strength and longevity.
2) Corrosion: Concrete reinforcement can corrode when exposed to moisture and air, especially in humid climates or near coastlines. Corrosion can cause the reinforcing and concrete structure to lose strength, which can cause fissures and eventually collapse.
3) Deflection: When a structure is under load, it deforms. Beams and slabs, which are structural components, may fracture or break as a result of excessive deflection. It may happen as a result of poor design or weak reinforcement.
4) Buckling: Buckling is the fast breakdown of a structural component caused by compressive stress. Walls, columns, and other structural elements may experience it as a result of excessive loading or inadequate design.
5) Fatigue: When a concrete structure is repeatedly loaded and unloaded over an extended period of time, fatigue failure happens. Due to this, tiny fractures may start to appear and spread over time, eventually resulting in the building failing.
6) Shear failure: Shear failure occurs when the concrete structure fails due to lateral forces that exceed the shear strength of the concrete or the reinforcement. Shear failure can occur in beams, slabs, or other structural elements.

Types of Shear Failure

There are several types of shear failure that can occur in concrete structures:

1) Flexural shear failure: When the shear forces within a beam are greater than the concretes shear strength in the vicinity of the supports, flexural shear failure results. This may eventually result in the failure of the beam by causing diagonal cracking close to the ends of the beam.
2) Punching shear failure: A slab will fail in shear around a concentrated load when a concentrated load is applied to it, which is known as punching shear failure. This kind of failure frequently happens in flat slabs, such the flooring of parking garages, and can be brought on by insufficient reinforcing or thin slabs.
3) Torsional shear failure: When a member is subjected to torsional or twisting forces, shear stresses that are greater than the concretes shear strength develop, leading to torsional shear failure. The member may crack or fail as a result, especially around corners or edges.
4) Diagonal shear failure: When inclined or diagonal structural components, such as beams or columns, are used in reinforced concrete structures, such failures can cause diagonal cracking or shear failure at the intersection of these parts.

Repair Methods

The size and type of the damage or deterioration, as well as the structures design and intended usage, will all influence the repair method that is chosen. The best repair strategy for a specific circumstance should be determined in consultation with a trained engineer or contractor. The state of concrete structures can be improved or restored using a variety of restoration techniques:

1) Surface repairs: Surface repairs entail patching or filling small areas of localized damage or deterioration to the concretes surface, such as cracks or spalls, utilizing epoxy or cementitious materials. These fixes can assist stop additional damage while also enhancing the concrete surfaces longevity and looks.

2) Structural repairs: In order to maintain the structural integrity of the structure, structural repairs entail repairing or replacing deteriorating or broken concrete structural parts, such as columns, beams, or slabs. This could entail adding more steel or carbon fiber reinforcement to the structure or replacing deteriorated concrete with fresh concrete.

3) Cathodic protection: The technology of Cathodic protection is used to stop or delay the corrosion of steel reinforcement in concrete constructions. By adding an electrical circuit to the reinforcement, corrosive chemicals are drawn away from the steel and towards a sacrificial anode, a less valuable metal that will corrode in place of the steel.

4) Crack injection: Crack injection is the process of sealing and reinforcing concrete cracks by injecting a liquid resin or epoxy into them. By doing this, it may be possible to stop water and other impurities from damaging the concrete further.

5) Carbon fiber reinforcement: To strengthen the strength and longevity of the structural components of a concrete construction, carbon fiber reinforcement entails wrapping them with carbon fiber sheets or strips. This technique is frequently employed in locations where installing and maintaining conventional steel reinforcement is challenging.

Types of Repair Materials

The selection of repair materials depends on various factors, including the type of damage, the material being repaired, and the environmental conditions. It is crucial to use appropriate repair materials and techniques to ensure that the repaired structure is structurally sound and durable.

In the construction industry, various types of repair materials are used to repair and maintain structures. Some of the common repair materials used in construction includes:

1) Concrete repair materials: These materials are used to fix cracked, spalled, and potholed concrete structures. Examples include cementitious grouts, epoxy resins, and concrete repair chemicals.

2) Mortar repair materials: Brick and stone walls, as well as other masonry constructions, are frequently repaired and gaps filled with mortar. Depending on the use, mortar repair materials may contain cement, lime, sand, or other ingredients.

3) Polymer repair materials: For repairs requiring a high degree of flexibility and durability, such as joint sealants and crack fillers, polymer-based repair solutions are frequently employed. Repair compounds based on silicone, acrylic, and polyurethane are some examples.

4) Asphalt repair materials: To maintain and repair asphalt pavements, including potholes, Cracks, and surface imperfections, asphalt repair materials are utilized. Examples include hotmix asphalt, asphalt emulsion, and cold patching materials.

5) Steel repair materials: Materials for steel repair are used to maintain and repair steel structures, such as pipelines, buildings, and bridges. Examples include coatings, welding rods, and steel patching chemicals.

6) Wood repair materials: Wooden furniture, flooring, and decks may all be repaired and maintained using wood repair supplies. Sealants, epoxy resins, and wood fillers are a few examples.

Bond Strength

Bond strength is the capacity of two substances or surfaces to adhere to one another or the capacity of are pair substance, such as concrete or mortar, to stick to the substrate already in place. For instance, the binding strength of the repair material to the existing substrate is essential to guarantee that the restored structure is lasting and structurally sound. If the link is poor, the repair might break too soon, causing more damage and safety risks. Surface preparation, the kind and quality of the repair material, application method, and climatic conditions are just a few of the variables that might have an impact on bond strength. It is common practice to evaluate the bond strength using a variety of techniques, such as pull-off tests or shear tests, to make sure the repair material has a strong enough connection with the substrate already in place.

CHAPTER 2

LITERATURE REVIEW

General

The following literature materials were reviewed and it was concluded that epoxy is a good repair material for repairing cracks and restoring the compressive strength of the structure. Repeated application of load can cause cracks which can propagate until it fractures or failure results. These cracks reduce the strength of the structure significantly. Use of epoxy restore the structural integrity and increases the compressive strength and stiffness of cracked concrete.

Bond Strength

Prashant et al. (2020) studied the bond strength between concrete and steel sample. They made composite cylinder specimen of concrete and steel showing monolithic behavior. The concrete and the steel were bound by epoxy on a slant elliptical plane at an angle 30^{o}from the vertical dimension. They used two grades of concrete that is M30 and M40. They tested at what load the composite cylinder failed and bond strength was found. There are two kind of failure adhesive and cohesive failure. In adhesive failure there is a bond failure and in cohesive failure the material fails. Bond strength can be divided into two on the basis of mode of failure. If the failure is on the slant surface it is true bond strength and if the material failed first it is called apparent or minimum bond strength. The type of failure they obtained was cohesive type failure and the bond strength obtained was apparent or minimum bond strength. They recommended in order to get the true bond strength higher grade of concrete (M45 and above) be used.

The bond strength between three different types of concrete and reinforcing bars was measured by VlastimilBilek et al. (2017). Alkali-activated concrete came second, followed by cement-based hybrid concrete (with minor amounts of both), the first type of concrete being primarily based on Portland cement. There are two grades of each type of concrete, one containing less of a specific binder and one containing more. Concrete with high binder concentration was found to have stronger cohesion. Hybrid-cement concrete has significantly lower cohesive strength than the other two. Both Portland cement and alkali activated cement were found to produce concrete with relatively comparable bond strengths.

The bond strength between two concrete samples was determined by Júlio et al. (2004) various techniques for increasing the surface roughness of substrates. A total of 25 peel specimens and 25 inclined shear specimens were cast. The tensile strength of the connections was evaluated by pull-off tests. Bond strength in shear was determined using oblique shear studies. At the time of testing, both the initial concrete age and the additional concrete age were set to 112 and 28 days, respectively. Surface preparation techniques included wire brushing, grit blasting, light pressing with a jackhammer, or pouring the sub-base into a steel formwork. Sandblasting was the process that provided the strongest bond.

A shear strength test for concrete repairs was proposed by Austin et al. Examined. (1999), this is an important step in judging the effectiveness of remedial methods. Using real and theoretical data, the effects of surface treatments (especially in terms of roughness and strength) and modulus discrepancies between restorations and substrates are highlighted. He conducted a number of tests to assess adhesive failure in concrete repairs, including the pull-off test and the Arizona oblique shear test, which measure stresses in both compressive and purely tensile phases. The resulting peak FE analysis is typically used to determine the fracture stress mechanism. After extracting the pure stress values from the oblique shear test results to provide a cut-off relationship, a 2nd order polynomial curve was found to be the most appropriate. He started using the Mole Coulomb strategy. The Griffith fracture criterion is a traditional surrogate criterion for live traffic and was applied to brittle materials. Adding shear to his conception for both normal loads and loading situations results in a parabolic relationship. Interfacially bonded samples are preferred, as opposed to the Mohr-Coulomb relationship, which is influenced by the stress state within the material. He concluded that bond failure studies that require specimen tearing at the bond interface are likely to be naturally sensitive to the basic criterion of fracture failure. It can be concluded that the purpose of this study was to find cases of empirical compound fractures and to establish a relationship between these two common types of fractures.

Wu et al. focused on the effect of grooved surface roughness on interfacial shear strength. (2022) investigated the interfacial shear behavior between freshly mixed concrete and freshly mixed concrete in composite concrete elements. The purpose of this study was to better understand the intrinsic interfacial shear behavior that occurs between freshly mixed concrete in composite concrete structures. He tested 24 composite concrete samples with different surface roughness. The samples were tested under direct shear loading to measure the interfacial shear strength and deformation behavior. The results showed that there was a strong correlation between the surface roughness of precast concrete and its interfacial shear strength, with the grooved surface showing the highest interfacial shear strength. Furthermore, we also found that the failure mechanism of specimens shifts from cohesive failure to interfacial failure as the surface roughness increases. They also observed that the deformation behavior of specimens was affected by surface roughness, with grooved surfaces being more ductile than smooth surfaces.

A study was performed by Santos et al. carried out. (2011) investigated how differences in shrinkage and stiffness affect the bond strength of new and old concrete surfaces. He claims that in the literature he studies two types of failure: cohesive failure and cohesive failure. He also notes that as the surface roughness increases, the failure rate increases under cohesion conditions. Furthermore, he concluded that as the stiffness difference increased, the collapse of the cohesive state increased. Different shrinkage states were studied using different curing conditions and different ages between the additional concrete layer and the subfloor. This characteristic determines the nature of the failure, he added.

Repair Material

Rashmi R Pattnaik (2015) examined how the compressive strength of substrate mortar and repair material affects the failure pattern of the composite cylinders. It was discovered that the bond strength and failure pattern of repair materials are influenced by the compressive strength of the repair material. The bonding and testing of substrate mortar and repair mortar with varying strengths. It was found that substrate mortar would fail if the repair material's compressive strength was higher. A repair material that showed compressive strength comparable to that of collapsed subsoil mortar. In addition, when the compressive strength of the repair material was lower than the compressive strength of the underlying mortar, damage occurred on the inclined surface. If the compressive strength ratio of the repair material and the underlying mortar is less than about 1.0, the repair material is comparable or inferior to the underlying mortar, indicating damage to the repair material or the inclined surface. In order to achieve a strong bond between the repair material and base grout, it has been found that failure occurs at the repair material or base grout rather than at the interface.

Issa and Debs (2007) used 15 concrete cubes to study epoxy repair of concrete cracks. Six of the cubes had unhealed cracks, six had scratches that were healed with gravity-filled epoxy, and three had no cracks at all. The compressive strength was measured and found to drop by up to 40.93% due to global cracking, but when the cracked cubes were fixed with epoxy, the compressive strength recovered and dropped by 8.23%.

According to Dawood and Ganim (2017), hybrid fiber reinforced high-performance mortars perform best. In their tests, they also found that the use of epoxy provided the strongest bond strength, but fibers reinforced with high-performance mortars were more likely to fail. Since he used only two concrete substrates in their experiments, it was hypothesized that epoxy would provide the optimum strength we were looking for.

Hypothesis

The bond between the repaired structure and the epoxy resin has a gradient shear strength much higher than that of the original, unrepaired structure. This is because epoxy resin, which is known for its high adhesion quality, can efficiently transfer stress between the substrate and repair material during adhesion, resulting in stronger adhesion. Moreover, the oblique shear test method has been used effectively in previous studies and is a reliable and accurate means of measuring the bond strength of repaired structures. Therefore, the results of this study are expected to support the hypothesis that epoxy resin bonding can significantly enhance the diagonal shear strength of repaired structures.

Research Objective:

1) To see the bond strength between two specimen bonded by epoxy.
2) To see if the thickness of the binding material (epoxy) has any effect on the bond strength of two old concrete.
3) To see if the grade of concrete has any effect on the bond strength of the material.

CHAPTER 3

MATERIALS AND METHODOLOGY

General

This chapter describes the materials used in the project for casting and testing of the specimen. Casting of the concrete specimen included a series of material and procedure to be done before the actual casting was done. Mix design was done only after the testing of certain properties of the materials. After the mix design cubes were casted and then tested after which mix design was approved. The specimens were casted, cured and bonded by epoxy.

Materials

Cement

Pozzolana Portland Cement (PPC), fly ash based, 43 grade was used in the project without mixing with other grade of cement. The presence of fly ash and volcanic ash as a pozzolanic materials give different character from other types of cements.

Figure 3.1: PPC Cement

Coarse aggregate

Coarse aggregates can be made up of crush rocks. The size of aggregates used will depend upon the work and the strength of concrete required. 20mm coarse aggregates were used in this project. The specific gravity is required to find the quantity of coarse aggregate in the concrete mix. The tests conducted showed that the specific gravity of the coarse aggregate used in this project was 2.76.

Figure3.2: Coarse Aggregate

Fine aggregate

Crusher dust is used as fine aggregate in this project which met Indian Standard Specification IS383-2016. Specific gravity of 2.62 with absorption rate of 1% was used to find the volume of fine aggregate in concrete mix design.

Figure 3.3: Fine Aggregate

Epoxy Resin

The binding agent used in this project is TamRez Bonding Agent from Normet India Private limited. ASTM C881 was used for bonding two specimens with epoxy of different thickness that is of 1mm, 2mm, and 3mm. It has two parts, one being the resin and one being hardener. It is used in the ratio 3:7. The compressive strength test was done after 7 days to check the bond strength. The full bonding time is 7 days. The period where chemical reaction takes place is termed as curing time or cure time. It is also defined as the time taken by epoxy resin for chemical reaction to take place so that it reaches hard state from liquid epoxy.

$$\text{Epoxy resin (liquid state)} \xrightarrow{\text{Curing}} \text{Epoxy resin (solid state)}$$

Different Stages for Curing of Epoxy Resin

i. Stage 1: Liquid state

   Cure time starts as soon as the epoxy container cap is removed. As the resin and hardener are combined together, the chemical reaction also starts.

ii. Stage 2: Semi liquid state

   As the reaction continuous, it will begin to dry out and hence it will reach a stage where it can no longer be workable.

iii. Stage 3: Solid state

   Since it has reached final stage, the structure cannot be reshaped.

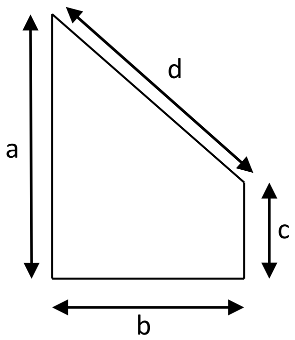
Epoxy and temperature

When chemical reaction takes place in epoxy it also generates the exothermic heat. The combination of surrounding heat (known as ambient temperature) and exothermic heat, it makes the cure time faster. Hence, more heat leads to faster epoxy reaction.

Figure 3.4: Epoxy Resin

Cylindrical Mold

A cylindrical mold with an inclination of 30º from the vertical was used for casting the specimen.



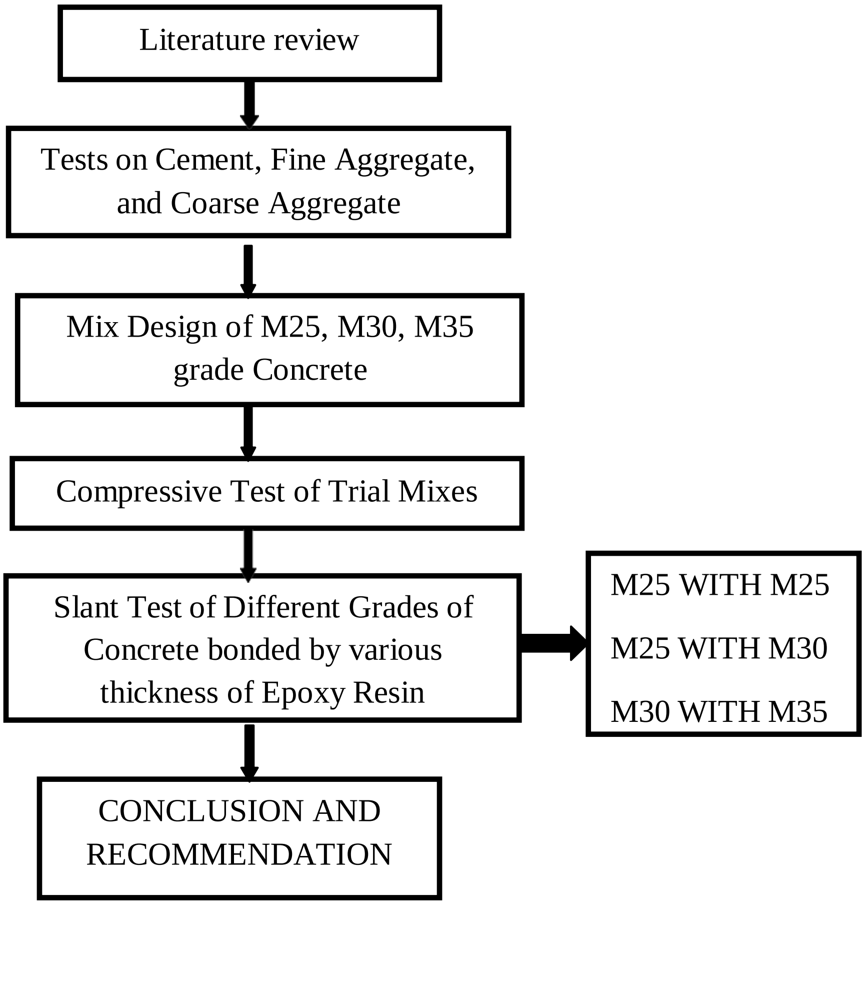
Where, a= 160 mm; b= 75 mm; c= 30mm; d=150 mm

Figure 3.5: Dimensions of the Mold

Figure 3.6: Cylindrical Molds

Methodology

The slant shear of two concrete bonded by epoxy of different thickness is checked. In the experiments, the bond strength between two concrete blocks, bound by a binding material i.e., epoxy resin of varying thickness of 1mm, 2mm and 3mm, is checked. However, to perform the experiments, background research is conducted on various methods of repair and rehabilitation of concrete structures. Further, extensive tests are conducted on cement, fine aggregates, and coarse aggregates to calculate the properties and further formulating mix design of M25, M30, and M35 grades of concrete. The trial mixes are then cast and tested at 7 days, 14 days, and 28 days to validate the mix design. The methodology of this study is detailed in the flow chart below.



Tests done before mix designing

These tests were done before mix design:

- Specific gravity test for PPC, coarse aggregate and fine aggregate.
- Sieve analysis as well as water absorption test for fine aggregate and coarse aggregate.

Specific Gravity of Cement

Specific Gravity of cement was performed based on IS 270-Part 3. Specific Gravity of cement is the ratio of given volume of cement to weight of an equal volume of water at specified temperature.

- ***Purpose of Experiment:*** To find the volume of cement in mix design.
- Type of cement= PPC conforming to IS 1489(Part 1)
- Weight of empty bottle with stopper,W1= 50g
- Weight of bottle + cement, W2= 100g
- Weight of bottle + cement + kerosene,W3= 130g
- Weight of bottle + kerosene, W4= 94 g
- Weight of bottle + water, W5= 105.5g
- Sp.gr of kerosene= $\frac{W4-W1}{W5-W1}$

$= \frac{94-50}{105.5-50}$

=0.79

- Sp. gr of cement= $\frac{W2-W1)XSp.gr\ of\ Kerosene}{(W4-W1)-(W3-W2)}$

$= \frac{(100-50)X0.79}{(94-50)-(130-100)}$

=2.82

Fineness Modulus of Aggregates:

Fineness modulus of an aggregate is performed as per IS 383-1970. The fineness modulus (FM) is an empirical figure calculated by summing the percentages of aggregate samples that were retained on each given set of sieves then divided by 100.

Purpose of Experiment: To find the zone of the aggregates to find their proportions.

Sieve Size(mm)	Wt. Retained (kg)	Cumulative Wt. Retained (kg)	% Cumulative Retained	% Passing
40	0	0	0	100
20	0	0	0	100
10	0.99	0.99	99	1
4.75	0.01	1	100	0
Pan	0	1		
Sum			199	
Fineness Modulus			2.0	

Table 3.1: Fineness Modulus of 20 mm Aggregates

Sieve Size(mm)	Wt. Retained (kg)	Cumulative Wt. Retained (kg)	% Cumulative Retained	% Passing
10	0	0	0	100
4.75	0.006	0.006	0.603	99.397
2.36	0.195	0.201	20.201	79.799
1.18	0.345	0.546	54.847	45.126
0.6	0.144	0.690	69.647	30.653
0.3	0.124	0.814	81.809	18.181
0.15	0.074	0.888	89.246	10.754
0.075	0.068	0.956	96.080	3.920
Pan	0.039	0.995		
Sum			412.16	
Fineness Modulus			4.1	

Table3.2: Fineness Modulus of Fine Aggregates

Result: The Fine Aggregates are in Zone 1

Figure 3.7: Weighing the Aggregates

Figure 3.8: Mechanical Shaker

Specific Gravity of Fine Aggregates:

Specific Gravity of Fine Aggregates is performed based on IS 2386(Part 3):1963. Specific gravity of a fine aggregate sample is obtained by the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water.

- ***Purpose of Experiment:*** To find the volume of fine aggregates in mix design.
- Weight of Pycnometer,W1=0.639 kg
- Weight of Pycnometer + sand,W2= 1.027kg
- Weight of Pycnometer + sand + water,W3=1.765 kg
- Weight of Pycnometer+water,W4= 1.525 kg
- Sp.gr = $\frac{W2-W1}{(W2-W1)-(W3-W4)}$

$$=\frac{1.027-0.639}{(1.027-0.639)-(1.765-1.525)}$$

= 2.62

Specific Gravity of Coarse Aggregate

Specific Gravity of Coarse Aggregates is performed based on IS 2386(Part 3):1963.

- ***Purpose of Experiment:*** We need the specific gravity of coarse aggregates to find their quantity in concrete mix.
- Weight of saturated aggregate suspended in water with basket,W_1= 1.805 kg
- Weight of basket suspended in water, W_2=0.68kg
- Weight of saturated aggregates, (W_s=W_1-W_2)=1.125kg
- Weight of saturated surface dry aggregates in air, W_3=1.75 kg
- Weight of Oven dry aggregates in air, W_4= 1.725 kg
- Sp.gr = $\frac{W4}{W3-Ws}$

$$=\frac{1.725}{1.725-1.125}$$

= 2.76

Water Absorption of Coarse Aggregates

Water Absorption of Coarse Aggregates is performed based on IS 2386(Part 3):1963.

- ***Purpose of Experiment:*** To find the quantity of water that would be added if we had the aggregates in dry condition.

- Water absorption (%), w= $\frac{W3-W4}{W4}$

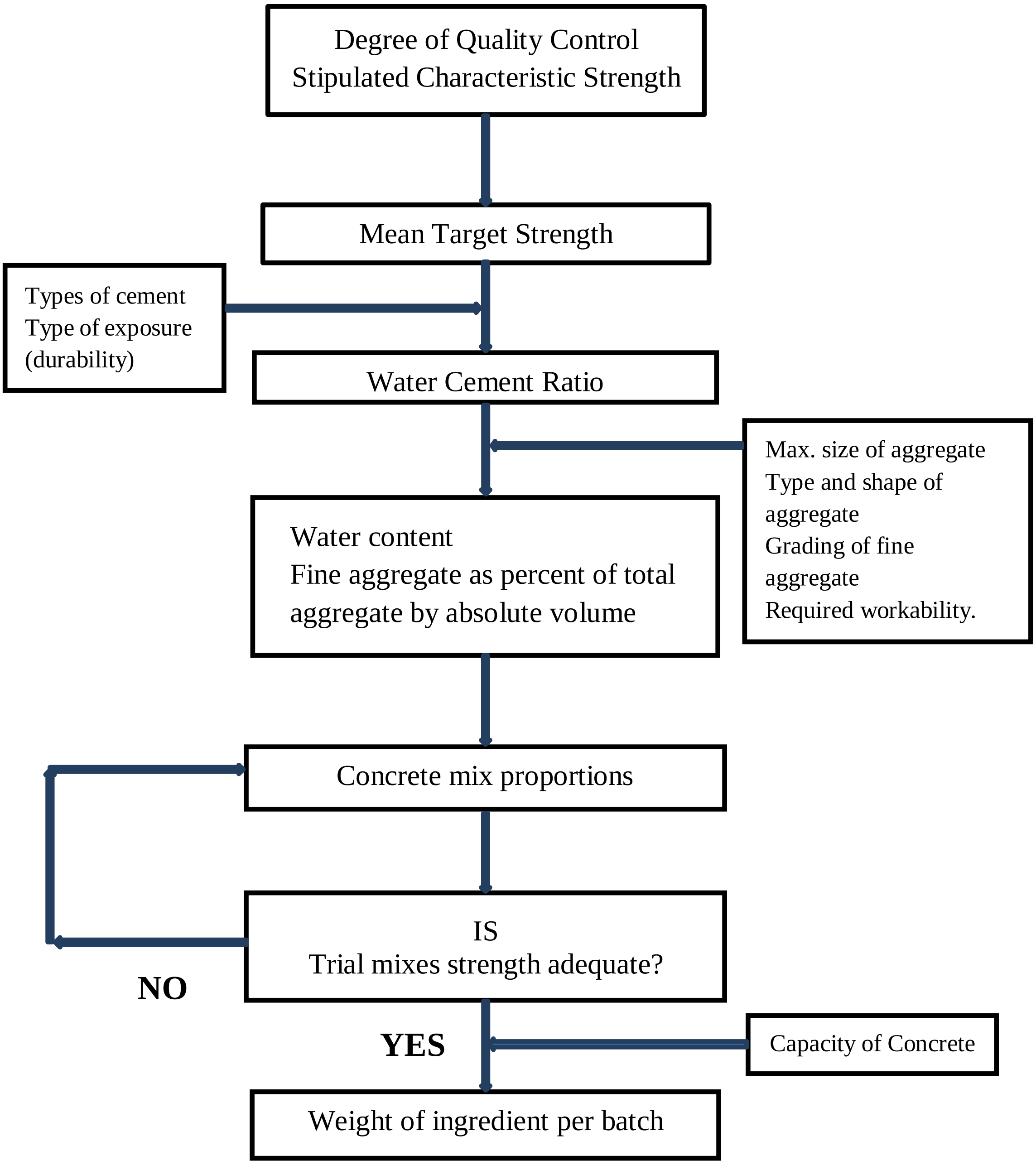
$$=\frac{1.75-1.725}{1.75} X100= 1.4\%$$

Figure 3.9: Coarse Aggregate and Bucket for Specific Gravity and Water Absorption

Mix Designs

After the acquisition of all the necessary data, mix design of concrete of grade M25, M30 and M35 was initiated. Mix Design was proceeded according to IS 10292:2019 and IS 456:2000.

Steps for Mix Design



Stipulations for Proportioning:

a) Grade design= M25
b) Type of Cement = PPC conforming to IS 1489(Part 1)
c) Maximum nominal size of aggregate= 20mm
d) Minimum cement content and maximum water cement ratio to be adopted and/or exposure condition as per table 3 and table 5 of IS 456=severe (for plain concrete)
e) Workability= 75 mm (slump)

Test Data for Materials

1) Cement used = PPC 43
2) Specific gravity of cement = 2.82
3) Specific gravity of coarse aggregate = 2.76
4) Specific gravity of fine aggregate = 2.62
5) Water Absorption=1.4%

Target Strength for mix proportioning

$f'_{ck}=f_{ck}+1.65S$

$=25+1.65\text{x}4$

$=31.6\text{N/mm}^2$

Approximate Air Content

20mm, entrapped air = 1 % (table 3)

Volume of entrapped air=0.01m^3

Selection of water-cement ratio

From Fig.1, for f'ck =31.6N/mm²

w/c ratio =0.43 <0.5 hence its O.K.

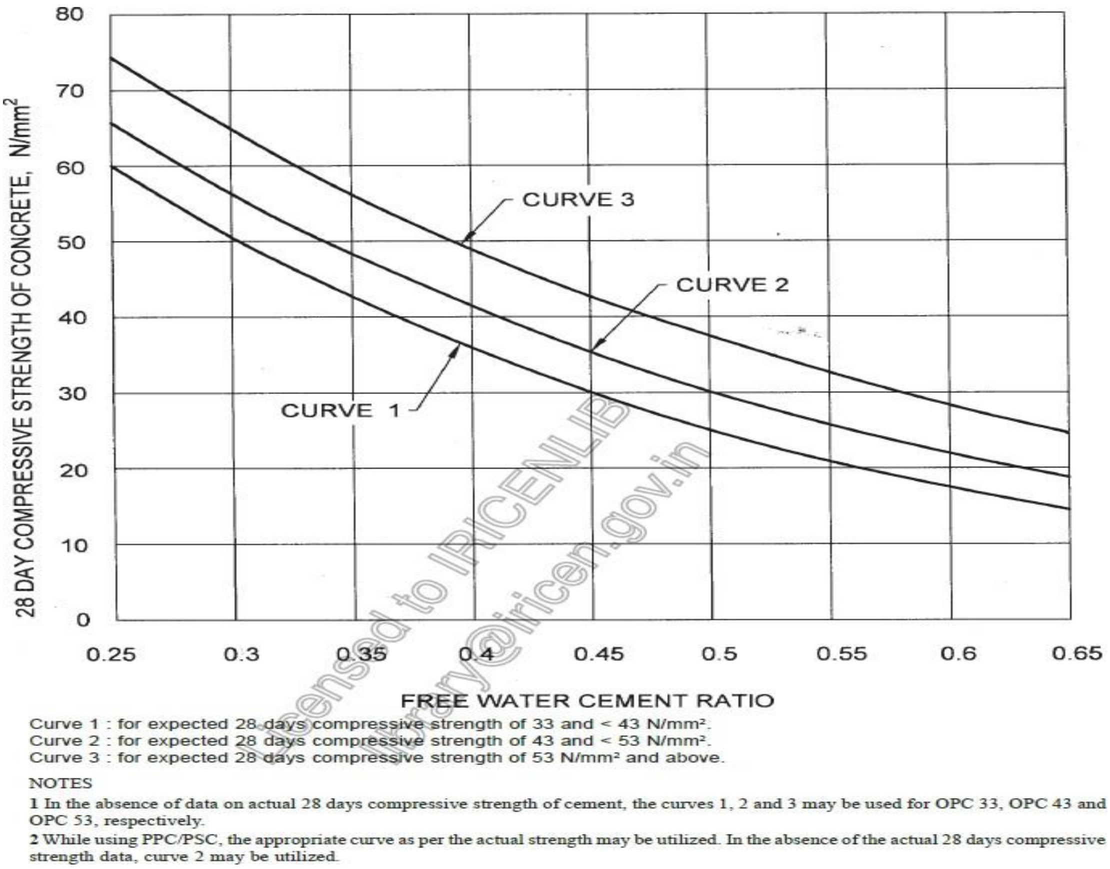


Figure 3.10: Relationship between free water cement ratio and 28 days compressive strengths of concrete for cements of various expected 28 days compressive strength. (IS 10262:2019, Fig.1)

Selection of Water Content

Estimated water content for 75 mm slump

$$= 186 + \frac{3X186}{100}$$

$$=191.58 \text{ kg} \approx 192 \text{ kg}$$

Calculation of Cement Content

Water cement ratio=0.43

Cement content = 192/0.43=446.51kg/m³≈ 447kg/m³>250kg/m³

Hence, OK.

Proportion of Volume of Coarse Aggregate and Fine Aggregate

Using Table 5 to determine the volume of coarse aggregate with W/C 0.5=0.6 corresponding to 20 mm aggregate and fine aggregate in zone 1.

In this case, the coarse aggregate volume increases by 0.014 and the W/C decreases by 0.07 (at a rate of 0.01 for every 0.05 change in W/C). As a result, the corrected volume of coarse aggregate with w/c of 0.43 is 0.6 + 0.014 = 0.614.

1-0.614 = 0.386 is the fine aggregate content.

Mix Calculations

a) Total Volume= 1m³

b) Volume of entrapped air in wet concrete= 0.01m³

c) Volume of cement = $\frac{Mass\ of\ Cement\ X\ (\frac{1}{1000})}{Sp.gr\ of\ Cement}$

=(447/2.82)x(1/1000)

=0.159 m³

d)Volume of water = $\frac{Mass\ of\ Water\ X\ (\frac{1}{1000})}{Sp.gr\ of\ Water}$

=(192/1) x (1/1000)

=0.192 m³

e)Volume of all in aggregate = [(a-b)-(c+d)]

=[(1-0.01)-(0.159+0.192)]

=0.639m³

f)Mass of Coarse Aggregate= e x vol. of CA xSp.gr of CA x1000

=0.639x0.614x2.76x1000

=1083 kg

g)Mass of Fine Aggregate

= e x vol. of FA x Sp.gr of FA X 1000

= 0.639x0.386x2.62x1000

=647 kg

Mix Proportions for 1m³(SSD):

Cement=447 kg

Water= 192 L

Fine Aggregate= 647 kg

Coarse Aggregate = 1083 kg

Water cement ratio= 0.43

Mix Proportions for 1m³(SSD) for M30 and M35

Grade of Concrete	Cement (kg/m³)	Fine Aggregate (kg/m³)	Coarse aggregate (kg/m³)	Water (kg/m³)	w/c ratio
M30	480	626	1075	192	0.4
M35	506	610	1067	192	0.38

Table 3.3: Mix Proportions of Concrete MixM30 and M35

Fig 3.11: Mixing of Concrete

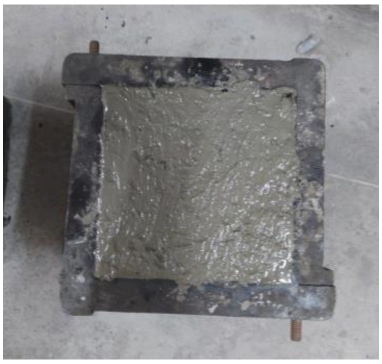


Fig. 3.12: Casting of M25

Fig. 3.13: Vibrating of Concrete

Fig. 3.14: Testing of the cubes

Compressive strength test result(IS.4031 (6)-1988)

Compressive strength is a measure of the ability of a material, such as concrete, to withstand compressive loads without failure or deformation. In the case of concrete, compressive strength is determined by subjecting a sample of the material to a compressive force until it fails. The compressive strength of concrete is usually expressed in units of pounds per square inch (psi) or Megapascals (MPa). The compressive strength of the cubes was checked after 28 days.

$$\text{Compressive Strength} = \frac{CompressiveLoad}{c/s area of the specimen}$$

Grade of Concrete	Target Strength (N/mm²)	Cube No.	Compressive Load(N)	c/s area(mm²)	Compressive strength	Mean Compressive Strength(N/mm²)
M25	31.6	1	634000	22500	28.18	28.67
		2	660000	22500	29.33	
		3	285000	10000	28.5	
M30	38.25	1	771000	22500	34.27	35.21
		2	814000	22500	36.18	
		3	792000	22500	35.2	
M35	43.25	1	936000	22500	41.6	40.23
		2	885000	22500	39.3	
		3	895000	22500	39.78	

Table 3.4: Compressive Strength observed after 28 days of curing

Slant Shear Strength Tests

Casting of specimen of different grades

All the mix design for were approved. Half inclined cylindrical specimen was casted and after 24 hours of setting it was kept for curing. Each specimen was cured for 28 days so that the specimen gained its maximum strength. For joining two specimens with the help of epoxy of differing thickness was casted and kept in curing for 28 days. On the 28th day both the specimen were bound with the help of epoxy resin of thickness 1mm,2mm and 3mm.

Figure 3.15: Preparation of concrete

Figure 3.16: Casting of cylindrical specimen

Figure 3.17: Cylindrical Specimen

Application of Epoxy

Epoxy is applied to the specimen that was cured for 28 days. The specimen is kept for air drying 1 hour prior to application of epoxy. The surface of the specimen is made rough and the applied with epoxy of required thickness. The specimen bonded by epoxy is kept for 1 week curing and then tested using compression testing machine.

Figure 3.18: Mixing of Epoxy with the Hardener

Figure 3.19: Application of Epoxy on the Specimen.

Figure 3.20: Two Specimens bound by Epoxy.

CHAPTER 4
RESULTS AND DISCUSSION

Results

Tests for the thickness of 1mm, 2mm and 3mm are also conducted. The results were obtained as below:

$$\text{Bond Strength} = \frac{\text{Max Load}}{\text{Area of Slant Surface}}$$

Result for M25-M25 bonding with different thickness.

Grade of Concrete	Thickness of Epoxy (mm)	Sample No.	Compressive Load (N)	Area of Slant Surface (mm^2)	Bond Strength (N/mm^2)	Remarks
M25-M25	1	1	70000	8835.72	7.92	Bond Failure
		2	78000	8835.72	8.82	Bond Failure
		3	71000	8835.72	8.03	Bond Failure
	2	1	83000	8835.72	9.39	Bond Failure
		2	82000	8835.72	9.28	Bond Failure
		3	81000	8835.72	9.17	Bond Failure
	3	1	110000	8835.72	12.45	Bond Failure
		2	91000	8835.72	10.29	Bond Failure
		3	98000	8835.72	11.09	Bond Failure

Table 4.1: Result for M25-M25

Observation: The concrete specimens both of grade M25 was bonded together with the help of epoxy of different thickness (1mm, 2mm and 3mm) and tested. It was found that the bond failed and the material sustained.

Result for M25-M30 bonding with different thickness

Grade of Concrete	Thickness of Epoxy (mm)	Sample No.	Compressive Load(N)	C/S Area (mm^2)	Compressive Strength (N/mm^2)	Remarks
M25-M30	1	1	57000	4417.9	12.90	M25 failed
		2	52000	4417.9	11.77	M25 failed
		3	55000	4417.9	12.45	M25 failed
	2	1	76000	4417.9	17.20	M25 failed
		2	75000	4417.9	16.97	M25 failed
		3	74000	4417.9	16.75	M25 failed
	3	1	98000	4417.9	22.18	M25 failed
		2	110000	4417.9	24.89	M25 failed
		3	107000	4417.9	24.21	M25 failed

Table 4.2: Result for M25-M30

Observation: The concrete specimens of grade M25 and M30 was bonded together with the help of epoxy of different thickness (1mm, 2mm and 3mm) and tested. It was found that the material with the lower strength (i.e. M25) failed and the bond sustained.

Result for M25-M35 bonding with different thickness

Grade of Concrete	Thickness of Epoxy (mm)	Sample No.	Compressive Load (N)	C/S Area (mm^2)	Compressive Strength (N/mm^2)	Remarks
M25-M35	1	1	81000	4417.9	18.33	M25 failed
		2	85000	4417.9	19.24	M25 failed
		3	88000	4417.9	19.91	M25 failed
	2	1	102000	4417.9	23.08	M25 failed
		2	93000	4417.9	21.05	M25 failed
		3	112000	4417.9	25.35	M25 failed
	3	1	118000	4417.9	26.70	M25 failed
		2	116000	4417.9	26.25	M25 failed
		3	121000	4417.9	27.38	M25 failed

Table 4.3: Result for M25-M35

Observation: The concrete specimens of grade M25 and M35 was bonded together with the help of epoxy of different thickness (1mm, 2mm and 3mm) and tested. It was found that the material with the lower strength (i.e. M25) failed and the bond sustained.

Result for M30-M30 bonding with different thickness

Grade of Concrete	Thickness of Epoxy (mm)	Sample No.	Compressive Load(N)	Area of Slant Surface (mm²)	Bond Strength (N/mm²)	Remarks
M30-M30	1	1	75000	8835.72	8.48	Bond Failure
		2	85000	8835.72	9.62	Bond Failure
		3	82000	8835.72	9.28	Bond Failure
	2	1	99000	8835.72	11.20	Bond Failure
		2	98000	8835.72	11.09	Bond Failure
		3	103000	8835.72	11.66	Bond Failure
	3	1	126000	8835.72	14.26	Bond Failure
		2	124000	8835.72	14.03	Bond Failure
		3	107000	8835.72	12.10	Bond Failure

Table 4.4: Result for M30-M30

Observation: The concrete specimens both of grade M30 was bonded together with the help of epoxy of different thickness (1mm, 2mm and 3mm) and tested. It was found that the bond failed and the material sustained.

Result for M30-M35 bonding with different thickness

Grade of Concrete	Thickness of Epoxy (mm)	Sample No.	Compressive Load(N)	C/S Area (mm^2)	Compressive Strength (N/mm^2)	Remarks
M30-M35	1	1	109000	4417.9	24.67	M30 failed
		2	128000	4417.9	28.97	M30 failed
		3	127000	4417.9	28.74	M30 failed
	2	1	137000	4417.9	31.01	M30 failed
		2	131000	4417.9	29.65	M30 failed
		3	103000	4417.9	23.31	M30 failed
	3	1	144000	4417.9	32.59	M30 failed
		2	142000	4417.9	32.14	M30 failed
		3	140000	4417.9	31.68	M30 failed

Table 4.5: Result for M30-M35

Observation: The concrete specimens of grade M30 and M35 was bonded together with the help of epoxy of different thickness (1mm, 2mm and 3mm) and tested. It was found that the material with the lower strength (i.e. M30) failed and the bond sustained.

Result for M35-M35 bonding with different thickness

Grade of Concrete	Thickness of Epoxy (mm)	Sample No.	Compressive Load(N)	Area of Slant Surface (mm^2)	Bond Strength (N/mm^2)	Remarks
M35-M35	1	1	94000	8835.72	10.64	Bond Failure
		2	85000	8835.72	9.62	Bond Failure
		3	86000	8835.72	9.73	Bond Failure
	2	1	120300	8835.72	13.61	Bond Failure
		2	104500	8835.72	11.82	Bond Failure
		3	101000	8835.72	11.43	Bond Failure
	3	1	134200	8835.72	15.18	Bond Failure
		2	144600	8835.72	16.36	Bond Failure
		3	137400	8835.72	15.55	Bond Failure

Table 4.6: Result for M35-M35

Observation: The concrete specimens both of grade M35 was bonded together with the help of epoxy of different thickness (1mm, 2mm and 3mm) and tested. It was found that the bond failed and the material sustained.

Figure 4.1: Sample to be tested

Figure 4.2: Failure of the Slant Surface

Figure 4.3: Failure of the Material

Result Analysis and Discussions

Through this experiment the following conclusions were drawn:

1) Bond strength of the repair material is dependent on the thickness of the repair material. Greater the thickness of epoxy resin, greater the bond strength.
2) When the bonding agent was kept for 2 days the bond strength was lower than that of 7 days.
3) In case of composite specimen with different grade of concrete, concrete with lower grade failed first (in case of M25-M30, M25-M35).
4) In case of specimen with same grade (M25-M25), failure was observed in the bond.

Conclusions

In conclusion, numerous elements, including thickness, curing time, and concrete quality, have an impact on the binding strength of epoxy resin. Longer curing times can result in stronger bonds, as using more epoxy resin and layering it on thicker. To get the best bond strength when utilizing a bonding agent, it is crucial to give the curing process enough time. The lower grade of concrete frequently fails first when composite specimens made of multiple grades of concrete are tested. Bond failure is, however, frequently noted when utilizing examples made of the same grade of concrete. These results highlight the need of carefully weighing the many variables that may affect bond strength when dealing with epoxy resin and bonding agents in concrete applications.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

Objective and Result

1) Objective: To see the bond strength between two specimen bonded by epoxy.
   Result: Bond strength of two similar grade of concrete cured for longer days were found to have higher bond strength that of those cured for lesser days.
2) Objective: To see if the thickness of the binding material (epoxy) has any effect on the bond strength of two old concrete.
   Result: Two concrete specimens bonded with epoxy showed higher bond strength when the thickness of the epoxy was higher.
3) Objective: To see if the grade of concrete has any effect on the bond strength of the material.
   Result: When concrete of same grade were bonded together by epoxy, there was a bond failure. When concrete of different grades were bonded together, the concrete having lower grade of strength failed first.

Conclusions

A total of 108 cylindrical specimens were casted and cured for 28 days. On the 28^{th} day the specimens were taken out one hour prior to applying epoxy. The surfaces were roughened by sand blasting. The specimens were bonded together and kept for another 7 days. On the 7^{th} day it was tested. It was found that specimens with similar graded of concrete experienced bond failure (adhesive failure). The bond strength obtained was true bond strength. The specimens with different grade of concrete experienced material failure (cohesive failure) and the bond strength obtained was apparent or minimum bond strength. When different grade of concrete was used the concrete with lower strength failed. The thickness of the epoxy also affects the bond strength. Greater the thickness, greater was the bond strength. Curing duration also affects the bond strength i.e. Bond strength obtained at 7^{th} day was greater than that obtained at 2^{nd} day.

Recommendations

It can be recommended from the project that the bond strength obtained is higher when the thickness of the repair material used is higher. Also the duration of curing period is an important factor. Higher the number of days of curing period, higher is the bond strength. To obtain more bond strength different grade of concrete is to be used. This arrangement results in material failure retaining the bond.

Future Work

In the future, if one wants to go for further studies, it will be recommended for them to analyze the result obtained along with some Finite Element Method (FEM) based software such as Abaqus, Ansys, etc. to further validate the results obtained.

It will be recommended to study or investigate the bond strength of old concrete and new concrete with different thickness of epoxy. Different grades of concrete can also be utilized here and result can be generated.

It will be recommended to do a study on the bond strength obtained with respect to the position of the specimen. It was noticed that there were certain variation in the bond strength obtained with the differing position of the specimen. M25-M35 bonded with epoxy when place under compression testing machine with M25 faced upside showed a varied bond strength than compared to M35 kept upside. There is a scope to see if the bond strength is affected by the position of concrete of different grades.

REFERENCES

[1] Prashant, Pankaj Kumar and AbhilashShukla (2020) 'Performance Assessment of Steel-Concrete Composite Bonded Specimen Under Slant Shear', *International Journal of Current Advanced Research,* 09(05), pp. 22341-22344.

[2] ASTM C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear, ASTM Int, 2013.

[3] Rashmi R.Pattnaik (2015) 'Investigation on ASTM C882 Test Procedure of Slant Shear Bond Strength of Concrete Repair Material', *International Journal of Civil, Structural, Environment and Infrastructure Engineering,*05(02)

[4] Dawood and Ganim (2017) 'Effective Performance Mortar Reinforced with Fibres as Repair Material', Challenge Journal of Concrete Research Letters, 08(02), pp.29-47

[5] Issa, C.A., & Deps, P.(2007). Experimental study of epoxy repairing in cracks in concrete. Construction and Building Materials, 21(1), 157-163.

[6] Bilek, V., Bonczková, S., Hurta, J., Pytlík, D., &Mrovec, M.,(2017). 'Bond Strength between Reinforcing Steel and Different Types of Concrete', *Procedia Engineering, Structural and Physical Aspects of Construction Engineering,* pp 243-247

[7] Júlio, E. N. B., Branco, F. A., & Silva, V. D. (2004). 'Concrete-to-concrete bond strength. Influence of the roughness of the substrate surface', *Construction and Building Materials,* 18(9), pp 675–681

[8] Bilek, V., Bonczková, S., Hurta, J., Pytlík, D., &Mrovec, M.,(2017). 'Bond Strength between Reinforcing Steel and Different Types of Concrete', *Procedia Engineering, Structural and Physical Aspects of Construction Engineering,* pp 243-247

[9] Júlio, E. N. B., Branco, F. A., & Silva, V. D. (2004). 'Concrete-to-concrete bond strength. Influence of the roughness of the substrate surface', *Construction and Building Materials,* 18(9), pp 675–681

[10] Austin, S., Robins, P., & Pan, Y. (1999). 'Shear bond testing of concrete repairs'. *Cement and Concrete Research,* 29(7), pp 1067–1076.

[11] Pedro Miguel Duarte Santos and Eduardo Nuno Brito Santos Júlio (2011). Factors Affecting Bond between New and Old Concrete. ACI MATERIALS JOURNAL, Title no. 108-M48.

[12] KEIVAN NESHVADIAN BAKHSH(2010) "Evaluation of Bond Strength between

Overlay and Substrate in Concrete Repairs”
[13] Is code 383:2016 “Coarse and Fine Aggregate for Concrete-specification” Bureau of Indian Standards. New Delhi, India
[14] ASTM C 109 “Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)”
[15] ASTM C39 “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”
[16] IS code 10262:2019 “concrete mix proportioning-guidelines”
[17] IS code 456:2000 “plain and reinforced concrete (fourth revision)”
[18] ASTM C882 “Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear”
[19] Director general works {DG(W)},”Central Public Works Department (CPWD)”-Government of India, New Delhi
[20] https://theconstructor.org/structural-engg/failure-modes-concrete-beams-flexural-shear/37752/?amp=1

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