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EFFECT OF REPLACEMENT OF CEMENT BY GLASS POWDER ON STRENGTH

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Abstract: Bond strength assumes significant part in the structural performance of Reinforced Concrete (RC) component. Compressive strength and tensile strength of conventional concrete impacts bond strength of RC component. Glass powder with molecule size under 75 microns when utilized as cement substitution material, upgrades compressive strength and tensile of cement. In the examination work it is suggested to explore the impact of glass powder as a cement substitution material on compressive strength and tensile strength of reinforced concrete and bond strength in reinforced concrete. The substitution rate is proposed to be 0% to 30% with increments.

***Index Terms*–Bond Strength, Glass Powder, Compressive Strength, Concrete, Tensile Strength.**

I. Introduction

Glass is characterized as an inorganic result of combination which has been cooled to a rigid condition without crystallization. As per this description, a glass is a non-crystalline material got by melt quenching process. Wastes are delivered by the ventures independent of the type of their items. Glass is a material which has an old history. Glass creation was at that point known in old Egypt since 9000year B.C it was utilized in beautifications and jewels. From old Egypt glass producing technique passed to antiquated Rome in the 1 century B.C. Glass creation was exceptionally restricted till 18 and 19 hundred years because of its soaring cost. These days glass is one of the most well-known materials utilized in regular life in different structures, bottles, containers, windows, and windshields, and so forth. The items have restricted lifetime. Consistently millions of tonnes of waste glass is produced. It is the standard thing practice to discard this loss in landfills. Glass being non-biodegradable material doesn't give sound and healthy environment.

Removal of this waste is a mind-boggling issue for some nations on the planet. Numerous administrative and nongovernmental associations are managing this issue, however regardless of the endeavours, the reusing of glass in numerous nations is deficient. As we know reusing of glass has various roundabout advantages, for example, decrease in landfill cost, energy saving, and safeguarding the climate structure from conceivable pollution impacts.

II. Problem Statement

1. To determine the performance of the glass powder on the behavior of the reinforced concrete and
2. Hence finding the solution to make less polluting concrete

III. Objectives

1. To study effect of glass powder on workability of concrete
2. To investigate the effect of Glass powder on compressive strength of concrete.
3. To investigate the effect of Glass powder on tensile strength of the concrete.
4. To investigate the effect of Glass powder on bond strength of the concrete.
5. Finding a way to make less polluting concrete and to find solution to landfill problem caused by dumping of glass waste

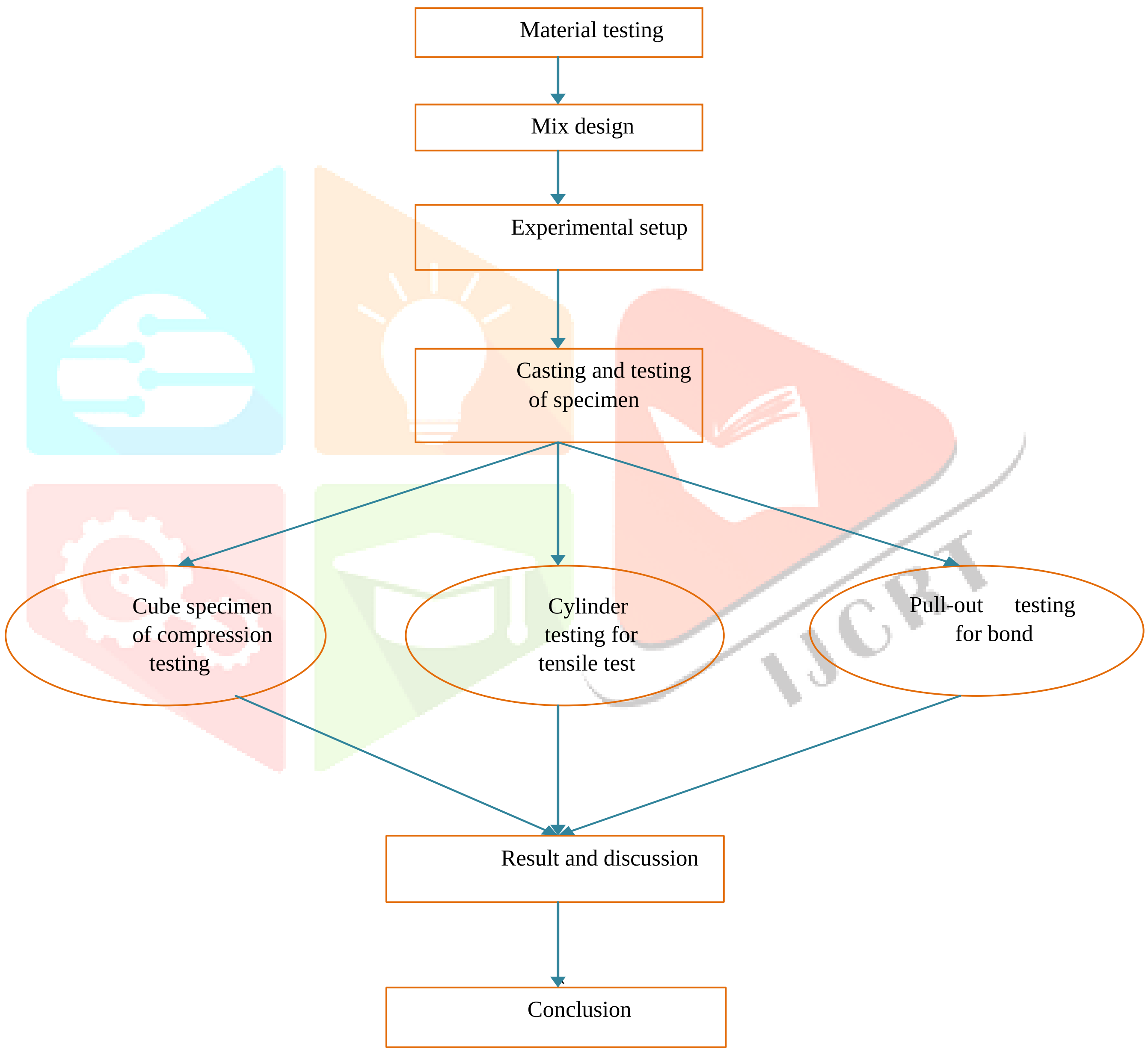
IV. SCOPE of the Project

1. Other values of concrete like M35, M40, M45,M50 etc can be tested
2. Further research can be carried out on bond strength on reinforced concrete
3. Different types of glasses can be studied for replacement
4. Different type of cement can be used
5. Different diameter of steel bar can be used
6. Crushed sand can be used instead of river sand
7. Further research can be carried out for increasing workability after replacement by glass powder.

V. Research Methodology

The purpose of this study is to investigate the performance of waste glass powder-containing concrete by creating concrete cube samples, cylindrical samples, and pullout samples and testing them for engineering qualities such as compressive strength, split tensile strength, and bond strength. The concrete mix design is carried out using a systematic analysis in accordance with IS: 10262-2009, and the proportions of the ingredients used in the concrete mix are chosen to generate an economical concrete with the necessary strength after the cube is hardened.Collecting material

- Collecting material
- Testing material
- Proportional and compatible mixing of material
- Casting
- Testing of compressive, Bond and tensile strength



1. The importance of material testing cannot be overstated. According to Indian standard rules, cement of grade 53, water, reinforcement, coarse aggregate, fine aggregate, and glass powder must all be tested.

2. For subsequent investigation, proportionate and compatible material mixing is also critical. Mix proportionality must be computed according to IS: 10262-2009. M30 has been repaired.

3. The cubes have been cast. 30 cubes and 36 pull-out specimens have been completed. a total of six Each cube, cylinder, and pull-out specimen was casted according to IS codes (150*150*150 mm, 150mm diameter*300mm height, 150*150*150 mm, respectively).

4. Making a cube out of concrete mix M30 and evaluating it for compressive strength after 7 days and 28 days, as well as cylinder specimens out of concrete mix M30 and testing them for tensile strength after 28 days. Pull-out specimens were cast using concrete mix M30 and steel bars of 16mm diameter, and bond strength was tested after 7 and 28 days.

5. Observing the influence of concrete compressive and tensile strength on bond strength and bond slip behaviour based on test findings.

6. Based on the findings, we can determine if glass powder material may be employed as a structural material in construction.

From study of recent literature it is seen that-

The effect of different parameters on the concrete-bar bond by Hasan Sahan Arel & Semsi Yazıcı shows that load required to pull the embedded reinforcement increases with increase in the tensile strength and compressive strength of concrete. The relationship between pull-out load and compressive strength

Bond behaviour and assessment of design ultimate bond stress of normal and high strength concrete by Ahmed M. Diab, Hafez E. Elyamany, Mostafa Felfel and Hazem M. Al Ashy shows that As the compressive strength increases single pull out bond strength increases. The single pull out bond strength increases by 27.8% and 25.3% as the compressive strength increases from 30 to 50 MPa. So, compressive strength has significant effect on bond strength which improves the bearing, cohesion and friction strength

Experimental investigation of waste glass powder as the partial replacement of cement in concrete production byJitendra B. Jangid , Prof.A.C.Saoji shows that Higher strength was obtained when 20% cement was replaced by waste glass powder. Workability decreases as percentage of glass powder increases

Effects of Waste Glass Powder as Pozzolanic Material in Saw Dust Cement by Omoniyi, T.E. Akinyemi B.A, Fowowe A.OThe results indicated that WGP can be used as cement replacement material up to 30% at particle size less than 100μm to prevent alkali silica reaction and this can be utilized in the manufacture of non-load bearing sand Crete block without any unfavorable effect. The trial was conducted was using M40 grade of concrete.

Value-added utilisation of waste glass in concrete by Ahmad Shayan and Aimin Xu From the laboratory experiments, it shows that it can suppress the alkali-reactivity of coarser glass particles, as well as that of natural reactive aggregates. It undergoes beneficial pozzolonic reactions in the concrete and could replace up to 30% of cement in some concrete mixes with satisfactory strength development

Effect of Using Glass Powder in Concrete by Shilpa Raju, Dr. P. R. Kumar it is seen that As the percentage of glass powder increases the workability decreases.Use of super plasticizer was found to be necessary to maintain workability with restricted water cement ratio. Compressive strength and Flexural strength increases with increase in percentage of glass powder upto 20% replacement and beyond 20% strength decreases.

Investigation of Strength and Durability Parameters of Glass Powder Based Concrete by Bhupendra Singh Shekhavat, Dr.Vanita Aggrawal shows that Cement can be replaced by waste glass powder up to 20% by weight showing increase in compressive strength at 28 days beyond which strength decreases 20% replacement of cement by waste glass powder showed 18% increase in compressive strength at 7 days and 19% increase in compressive strength at 28 days.

Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete by Dhanraj Mohan Patil, Dr. Keshav K. Sangle shows that compared to plain concrete, the concrete with cement replaced by glass powder has shown betterresult for for compressive strength when the percentages of glass powder was 20.The addition of recycled green building materials such as glass powder can increase the slump of concrete .

Performance of Using Waste Glass Powder In Concrete As Replacement Of Cement by Gunalaan Vasudevan , Seri Ganis Kanapathy Pillay shows that Concrete using waste glass powder averagely have higher strength at 14 days but once the concrete reached at 28 days the control mix give more higher value compare to mix that contained waste glass powder but still give high value of the grade 30.Concrete using waste glass powder has a very high workability from control sample.

Studies on Glass Powder as Partial Replacement of Cement in Concrete Production by Vijayakumar G., Vishaliny H. and Govindarajulu D shows that Replacement of glass powder in cement by 40% increases the split tensile strength by 4.4% respectively... This increment was Very finely .

Reusing of glass powder and industrial waste material in concrete by Raghavendra K, Virendrakumara. K shows that The Compressive strength, Split tensile strength at 7,14,28 increase initially as percentage of wate glass powder increases.

Combined Effect of Waste Glass Powder And Recycled Steel Fibres On Mechanical behaviour of concrete by Mavoori Hatsh Kumar, Nihar Raju Mohanta, Sandeep Samantaray, Nagarampalli Monaj Kumar shows that The utilization of waste glass powder and recycledsteel fibers in concrete mixes has resulted in the increased compressive, flexural and split tensile strength for both 7 days and 28 days curing.b. Compressive strength showed a gradual increment till 9% replacement of waste glass powder and later decreased with further replacement of 12% and 15% which indicates that 9% mix of waste glass powder exhibited the best overall compressive performance

Experimental analysis of sheet glass powder in partial replacement of fine aggregate in concrete by A. Naveenarasu, V. Dharani Priya, M. Shanthini, A. Vijaykrishnakumar, K. Chandru shows that From the results obtained it is suggested that GPand

Reclamation of GP with a substitution rate upto 25% can be used effectively as a fine aggregatein sensible concrete production while not reducingthe concrete standard. The concrete mixtures of GP and Reclamation ofGP 25% and 35% showed a decrease incompressive strength of just 1.6% and 5.7%,severally, at the age of 28 days when compared tothe CC.

Sustainable use of recycled glass powder as cement replacement in concrete by Nafisa Tamanna, Rabin Tuladhar shows that Compressive strength showed a gradual incrementtill 9% replacement of waste glass powder and later decreased with further replacement of 12% and 15% which indicates that 9% mix of waste glass powder exhibited the best overall compressive performance

Effect of pulverized glass powder on the compressive strength of revibrated concrete by Samuel Mahuta Auta, Abdulrahman Abdullahi Shows that the pulverised glass is a good pozzolana and physical properties of both aggregates and that fresh concrete conformed to BS standards.· The compressive strength of the cubes having 0% replacement with revibration was found to exceed those with non-revibration (0% PGP) by 11% increment and while optimum PGP percentage replacement was at 20%.

Durability of high volume glass powder self compacting concrete by Samia Tariq, Allan N. Scott, James R. Mackechnie, Vineet Shah shows that the amount and particle size of incorporated waste glass has a significant influence on themechanical and durability properties of SCC. Glass powder replacement level of 20–30% showedbetter performance as compared to fly ash and GP mixes. Moreover, the filling effect ofsmall-sized glass particles results in improved particle packing, forming a denser and less

Experimental study on effective utilization of glass powder in concrete by Payal V. Piprade, Dr. P.P. Saklecha, Prof. M S Kitey shows us that the most suitable mix proportion is the 15% to 20% replacement of waste glass powder to cement which gives maximum strength to concrete.2. Used of glass powder in concrete will eradicate the disposal problem of waste glass powder, reduce emission of harmful pollution by cement manufacturer industry into our environment

Partial replacement of fine aggregate by glass powder in concrete by Suraj P Mishra, Kalpana D Thakur, Vicky N Gupta shows us that the chemical compostion of normal glass and colored glass powders are quite similar and the materials could bedeclared as pozzolanic material as per ASTM standard. 2.The optimum glass content is 15% after that strength start reducing. In 28 days the compressive strength was found slightly higher (2%) .

Waste glass powder as partial replacement of cement for sustainable concrete practice by G M Sadiqul Islam, M D Habibur Rahman, Nayem Kazi shows us that the optimum glass content is 20% considering mortarand concrete compressive strength at 90 days. Inthis agethe compressive strength was found slightly higher (2%)than the control concrete specimen. 2.In general, consideringthe similar performance with replaced material, glass addition can reduce cost of cement production up to 14%.

Study of Waste Glass Powder as Pozzolanic Material in Concrete by Mohd Rahman, Prof. Raman Nateriya it is seen that initial strength of concrete is not fully achieved after addition of glass but at the larger age fully strength is obtained.30% replacement of cement give approximately equal srength to the normal concrete mix so that 30% Glass Powder is effectively used in concrete mix as a replacement of cement.

VI. Experimental Investigation

The purpose of this study is to determine the performance of concrete that contains waste glass powder. To do this, concrete samples in the form of cubes, cylinders, and pull-outs will be prepared and then subjected to various tests to determine their engineering properties. These properties will include compressive strength, split tensile strength, and bond strength. To prepare concrete, waste glass powder with a particle size of 40 microns is partially substituted for cement in the mixing process. Zero percent, ten percent, fifteen percent, twenty-five percent, twenty-five percent, and thirty percent of the cement in concrete is replaced by the glass in powdered form. The design of the concrete mix is determined through a methodical analysis in accordance with the standard IS: 10262-2009. This determines the proportion of each ingredient that will be used in the concrete mix in order to produce concrete that is both cost-effective and has the desired level of strength once it has had time to harden.

After the trial mix design has yielded positive results, the project will go on to the control mix design and testing for compressive strength, tensile strength, and bond strength. 30 150mm *150mm * 150mm cubes will be cast for compressive strength. For tensile strength, 15 cylindrical specimens of 150 diameter and 300mm length will be casted, and for bond strength, 36 specimens will be casted for each 16mm of pull-out test, with the results analysed.

Table VI.1 Details of samples

Mixes	% Replacement of glass powder	Size of glass powder (microns)	Cube specimens	Cylindrical specimens	Pull-out specimens
					16 mm
Mix 1	0	40	3	3	3
Mix 2	10	40	3	3	3
Mix 3	15	40	-	-	3
Mix 4	20	40	3	3	3
Mix 5	25	40	3	3	3
Mix 6	30	40	3	3	3

Standard size cube and cylindrical specimens that comply with IS:1199–1959 are used to determine the compressive and tensile strength of concrete. Cylindrical pull out specimens with concentrically positioned reinforcing bars are used to determine bond strength in R.C.C. Table 3.11 shows the dimensions of the individual specimens.

Table VI.2: Specimen Geometry

Sr. No.	Tests Performed	Specimen Shape	Specimen Dimensions
1	Compressive Strength	Cube	150mm x 150mm x 150mm
2	Split tensile strength	Cylinder	150mm Dia. x 300mm Height
3	Pull out strength	Cube	150mm x 150mm x 150mm

For Pull-out specimens, embedment length of bars is kept constant at 8 times the bar diameter i.e. (8Ø=128mm). Epoxy coating is done on the specimens to avoid corrosion of steel bars.

a. Test for compressive strength

The compression test is the type of test that is most frequently carried out on hardened concrete. It is simple to carry out and provides the majority of the desirable qualities and properties of concrete, all of which are directly tied to the material's compressive strength. Cubic specimens are used for the compression test to determine the strength of the material. Following a curing period of 28 days, these cubes are evaluated using a digital CTM at a constant loading rate of 4 kN/min in accordance with Indian Standard 516-1959. The failure load is taken into account. Three cubes from each mix are evaluated, and the average value of those evaluations is recorded.

The compressive strength is calculated as follows:

Compressive strength (MPa) = Failure load / cross sectional area.

$$C = \frac{P}{A}$$

Where, P is the compressive load on cube

A is the cross-section area of cube

b. Test for tensile strength of concrete

The cylindrical specimen is positioned horizontally between the loading surfaces of CTM, and the load is applied along the vertical diameter of the cylinder until it fails. The test specimen and the crack pattern in the cylinder are shown in the diagram. The formula for calculating split tensile strength is:

$$T = \frac{2P}{\pi LD}$$

Where,

P is the compressive load on cylinder

L is the length of cylinder

D is its diameter

T is the split tensile strength of cylinder

c. Test for bond strength of concrete

A pull-out test is commonly used to determine the bond strength of reinforced concrete. The UTM with pull-out attachment is utilised in the pull-out testing. The load cell, linear variable displacement transducer (LVDT), and data acquisition system make up the pull-out attachment (DAQS). The load cell provides accuracy in load measurement, the LVDT measures the slip of reinforcing bar from the surrounding concrete, which corresponds to pulling force, and the DAQS records all of the measurements, including the pulling force and slip, during the testing. The following is a detailed description of the pull out:

Load cell: A load cell is a type of transducer that produces an electrical signal that is proportionate to the force being measured. In the experiments, a load cell with a capacity of 200 KN and a precision of 1N was used.

LVDT: The Linear Variable Displacement Transducer is a high-precision, high-reliability linear displacement measurement tool. In this experiment, an LVDT with a precision of 0.01mm was used.

Data acquisition system: The process of measuring an electrical or physical phenomenon using a computer is known as data acquisition (DAQ), and some examples of these phenomena include voltage, current, temperature, pressure, and sound. Sensors, data acquisition (DAQ) measuring gear, and a computer with programmable software are the components that make up a data acquisition system. The Data Acquisition and Quality Control System (DAQS) that was utilised in the experimental study obtained electrical signals from the load cell and the LVDT, converted those signals into an acceptable form, and then recorded and displayed the results on a display unit.

VII. Results and Discussion

Compressive strength of specimens -

Below shown are test results of compressive strength M30 grade reinforced concrete at 7 and 28 days

Table VII.1 – Compressive Strength of cubes

	0% (N/mm2)	10% (N/mm2)	20% (N/mm2)	25% (N/mm2)	30% (N/mm2)
7 DAYS	21.73	23.05	23.51	23.92	21.10
28 DAYS	30.50	34.66	37.25	39.06	35.07

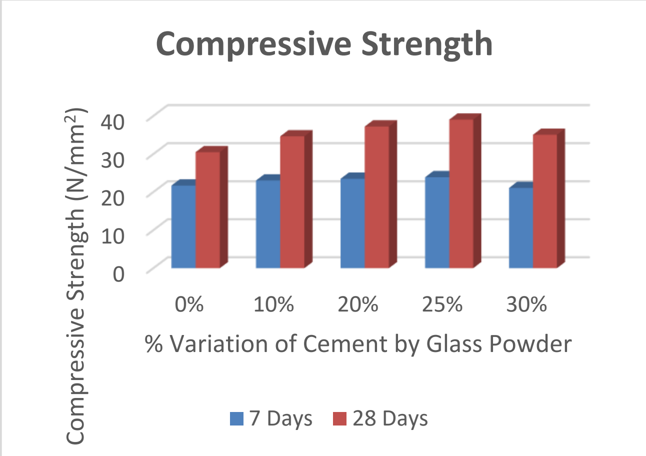


Figure VII.1: Compressive Strength of specimens

Tensile strength of specimens –

Below shown are test results of tensile strength M30 grade reinforced concrete at 28 days

Table VII.2: Tensile Strength of Specimens

	0%	10%	20%	25%	30%
28 DAYS	2.38	3.72	4.98	4.90	4.01

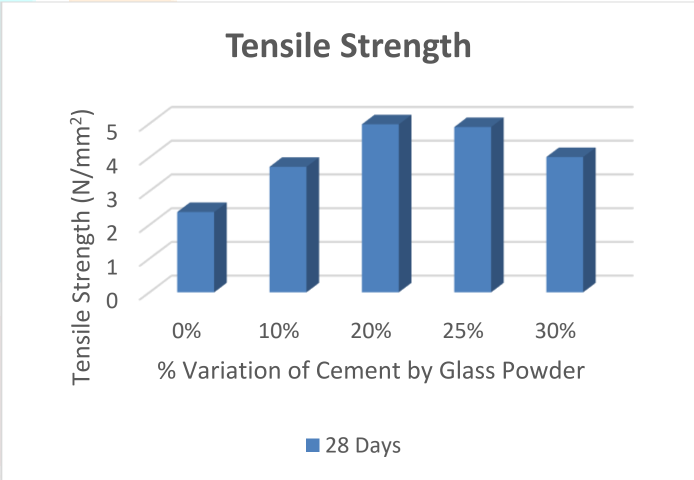


Figure VII.2: Tensile Strength of Specimens

Bond strength of specimens -

Below shown are test results of compressive strength M30 grade reinforced concrete at 7 and 28 days

Table VII.3: Bond Strength of Specimens

	0% (KN)	10% (KN)	15% (KN)	20% (KN)	25% (KN)	30% (KN)
7 DAYS	34.28	35.14	35.9	37.38	38.78	34.74
28 DAYS	50.2	50.6	51.7	53.78	56.06	49.37

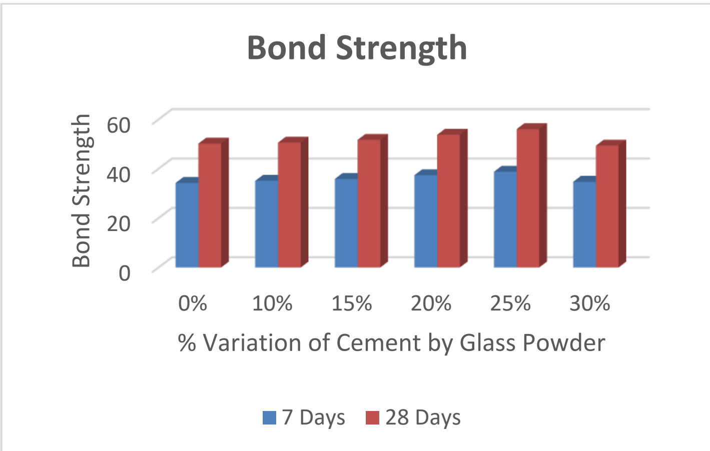


Table VII.2: Bond Strength of Specimens

VIII. Conclusion

• It has been observed that as the percentage of glass powder in reinforced concrete grows, the compressive strength of the concrete drops after the 25% mark.
• It is seen that bond strength increases progressively until it reaches 25%, after which it begins to decline.
• Tensile Strength appears to increase at first, then decline at the 20% point.
• It's also been discovered that employing glass powder as a cement substitute improves its compressive and tensile strength.
• It has the potential to be a solution to the different glass-related landfill issues.
• It can assist to lower CO2 levels in the environment by reducing the usage of cement in concrete.As a result, it may be a partial solution to the greenhouse effect.

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