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Strength and Durability Analysis of Concrete Replacing Cement by Glass Powder

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ABSTRACT
Global warming is induced by the release of greenhouse gasses in the atmosphere, including CO2. Carbon dioxide provides around 65 percent of global warming amongst greenhouse gases. Worldwide cement production generates around 7% of greenhouse gas emissions in the world. As a result, initiatives in concrete production have been undertaken to employ waste materials as partial replacements for coarse or fine aggregates and cement. When crushed to a very fine powder, waste glass exhibits pozzolanic qualities it can be applied as a partial substitute for cement in concrete. The goal of this review is to determine the strength of concrete utilising waste glass powder as a partial substitute for cement in concrete. Cement substitution by glass powder has been tested within ranges of 5% to 40% increments of 5%. It was evaluated for compressive strength and flexural strength at 7 and 28 days of aging, and the data were consistent with those of standard concrete. The findings indicate that replacing 20% of the cement with glass powder resulted in greater strength. An alkalinity analysis was also performed to determine corrosion resistance.
Keywords: Glass powder,M50,Strength and durability.

I. INTRODUCTION

In the present study, an attempt has been made to investigate the strength and durability parameters of concrete made with partial replacement of cement by Glass powder. The effects of curing of concrete on compressive, tensile and flexural strength are investigated when Different percentage replacement of cement by Glass power in weight. Mix design of M30 grade of concrete is prepared by using ordinary Portlandcement (OPC) of 53 grade is adopted. And it has been replaced with Glass powder at different percentageslike Different percentage in weight. The mixed concrete is casted into concrete specimens are cured for 28 daysand are tested for compressive, tensile and flexural strength. The obtained results are compared with the conventional concrete mix .

Solid waste management is a very crucial issue for the society worldwide. Glass wastes form a major component of solid waste and being an inert and nonorganic material, it is non-biodegradable and its disposal into landfills create serious environmental problems. Using waste glass in concrete as fine aggregate provide better solution for its disposal problem and also prevent depletion of natural resources like river sand. Since a very large space and lands are used to stockpile waste glass, it is very essential to find ways to reuse it or recycle it. The advantage of almost 100% recyclability of waste glass makes it as one of the material considered for the concept of waste to wealth, world wide.A variety of new products can be produced using waste glass.There are two main ways of use waste glass in concrete.

Glass wool is one of the important form of glass which is used as an heat insulating material on roofs, walls and floors of buildings.Glass wool insulation is recyclable and reusable, so that it can be recycled for another applicationsafter its original use. Based on the citations, it is found that waste glass can be used in concrete in two ways, one is as fine aggregate as a replacement for natural sand and another one is as aSupplementary Cementing Material in concrete.Many research works have been done on concrete with glass waste as partial replacement for fine aggregate and coarse aggregates. Waste management has become a critical challenge in developing countries like India. Unprecedented levels of waste material are produced due to rise in population and the management of solid wastes havearised as an alarming threat for healthy environment world wide.Since glass wastes are non-biodegradable material. Innovative methodologies of recycling need to be conventional to avoid their disposal in land fills.

The scope of present study includes the Laboratory tests on cement, fine aggregate, coarse aggregate, Glass powder, potable water. Mix design for normal concrete for M50 grades as per IS 10262: 2009 was done by mixing potable water; same mixes were also Glass powder is used as replacement by different percentage weight of cement content. Conducting the trail mixes as per designed work ability and target mean compressive strength of concrete. The specimens were tested at the age of 28 days curing in Potable water. From the test results the following conclusions are drawn regarding compressive strength, Split tensile strength and Flexural strength. As well as Sulphate attack test and Acid attack test is performed.

II. LITERATURE REVIEW

Mageswari et al. [1] investigated the substitution of fine aggregate in concrete using sheet glass at proportions of 10%, 20%, 30%, 40%, and 50%, and carried study to confirm compressive strength, split tensile strength test, and cylinder assessment. As the percentage of glass grows, so does the toughness, up to a 20 percent raise. It was discovered that pulverized recycled glass may substitute 20% of fine aggregate. The water absorption continues to be minimized when the glass content is increased. The strength of the concrete improves as the proportion of glass rises. The substitution of fine aggregate using sheet glass boosted tensile strength up to 20%. Flexural strength shows to be raised by up to 50% when compared to substitution.

TiwariDarshita et.al [2] The substitution of fine aggregate in concrete with crushed brick and crumbled glass powder was researched, and it was discovered that replacing fine aggregate using glass powder by 15% enhances compressive strength while replacing fine aggregate by more than 15% diminishes compressive strength. Although with 20% replacing, a slight loss in strength was discovered.

SadoonAbdallah et.al [3] The researcher of this study tested the properties of concrete with fine aggregate substituted by the crushed glass at concentrations of 0%, 5%, 15%, and 20%. During curing for 28 days, the compressive strength, split tensile strength, and flexure strengths rose by 5.28 percent, 18.38 percent, and 8.92 percent, significantly, with a 20% replacement of fine aggregate.

Iqbal Malik et.al [4] Recycled glass powder was used to substitute fine aggregate in concrete (Range-0 to 1.18 mm) After 7 days, 20 percent replacement for fine aggregate with glass powder resulted in a 15% improvement in compressive strength and a 20% improvement at 28 days. Up to 30% of fine aggregate can all be substituted, resulting in a 9.8% improvement in compressive strength. When differentiated to traditional concrete, water absorption can be minimized. Concrete's performance can be improved.

Tomas et.al [5] In his investigation, he utilized recycled glass instead of fine aggregate and discovered that it meets ASTM specifications and thus can be efficiently employed in mass structures. The substitution of fine aggregate using recycled glass reduced the unit weight of concrete. The water-cement ratio diminishes as fine aggregate substitution with glass increases.

III. MATERIALS AND THEIR PROPERTIES

Coarse Aggregate

The materials whose particles are preserved on an IS sieve of size 4.75mm are referred to as coarse aggregate, and it contains about as much finer material as is authorized for the multiple categories mentioned in IS: 383-1970. Aggregates are the primary constituents of concrete. They account for 70-80% of the entire volume, serve as a stiff skeletal framework for concrete, and serve as cost-effective space fillers. Although aggregate accounts for at least three-quarters of the volume of the concrete, its quality is critical. The qualities of aggregate have a significant impact on the durability and structural performance of concrete.

Aggregate was once regarded as an inert ingredient spread across cement paste, mostly for financial reasons. But, it is feasible to think of aggregate as a building material joined into a cohesive whole using cement paste, in a way comparable to construction. Aggregate is not fully inert, and its physical, thermal, and, in certain cases, chemical qualities all affect on the effectiveness of concrete. Because aggregate is less expensive than cement, it is more cost-effective to use more of the earlier and as little of the former as feasible in the mix. However, the use of aggregate does not only benefit the economics; it also provides significant benefits to concrete, which seems to have higher volume stability and durability over hydrated cement paste alone. Aggregates seem to be of consistent quality in terms of shape and grading. The coarse aggregated size is determined by the content of the task. As indicated in Figure, the coarse aggregate employed in this experiment analysis is 20mm and 10mm in size, crushed, and angular in shape. Until being utilized in concrete, the aggregates are dust-free.

Fig 1 : coarse aggregates

The coarse aggregates were determined by the following tests.
Specific Gravity
Fineness modulus
Bulk density
Sieve analysis
Specific gravity of coarse aggregate

Specific gravity is the mass of a substance divided by the mass with the same volume of liquid at the specified temperature. The investigation was carried out followingaccordance with IS 2386-1963, and the results are shown in Table.

S.NO	property	values
1	Specificgravity	2.60
2	Finenessmodulus	2.32
3	Bulk density LooseCompacted	12KN/m3 15KN/m3
4	Grading	Zone-ii

Table 1 : Specific gravity.

Sieve analysis of coarse aggregate
A sieve assessment is a technique of separating a specimen of aggregates into fractions with the same particle size to determine fineness. The sieve study was performed with sourced locally river sand and the results are shown in Table.

Bulk density

Bulk density is defined as the ratio of material mass to container volume. The investigation was done out, and the results are shown in Table 3.4.

OrdinaryPortlandCement

Ordinary Portland cement is used for general constructions. The raw materials required for manufactureof Portland cement are calcareous materials, such as limestone or chalk and argillaceous materials suchasshale or clay. The manufacture of cementconsistsof grinding the raw materials,mixing themintimately in certain proportions depending upon their purity and composition and burning them in a kilnatatemperatureofabout13000Cto15000Catwhichtemperature,thematerialsintersandpartiallyfuses to form nodular shaped clinker. The clinker is cooled and ground to a fine powder with addition ofabout 2 to 3% of gypsum. The product formed by using the procedure is a "Portland Cement". In thepresentexperimental work KCP 53gradeordinaryPortlandcementwas used.

Cement

The cement is to be tested in the laboratory for its quality requirement limitations as per Indian Standards. The cement used was ordinary Portland cement of OPC 53 grade (KCP 53 grade) as shown in Figure 3.1 confirming to IS: 12269-2013.Various tests are conducted to know the physical properties of cement and the results are tabulated below in Table 3.1. All 16 the tests conducted are as per the norms of standard specifications given in IS 4031 and the results are tabulated.

Fig2 : Glass powder.

Testingof Cement

ThefollowingtestsasperIS:4031-1988isdonetoascertainthephysicalpropertiesofthecement.Theresultsof thetests arecompared to thespecified values ofIS: 4031-1988.

Consistency

The standard consistency of cement paste is defined as consistency, which will permit the Vicatplunger to penetrate to a point 5-7 mm from the bottom of the mould, this test is done to determine thequantity of water required to produce cement paste of standard consistency. For determining the settingtime, compressive strength and soundness, the percentage of water required to produce cement paste ofnormalconsistencyisused.Consistencydependsuponthecompositionofcement,thistestwasconducted as per the procedure given in IS: 4031-1988. The consistency value obtained is shown inTable3.1.

Initial and final setting time

Lower the needle gently and bring it in contact with the surface of the test block and quickly release. Allow it to penetrate into the test block. In the beginning, the needle will completely pierce through the test block. But after some time when the paste starts losing its 17 plasticity, the needle may penetrate only to a depth of 33-35mm from the top. The period elapsing between the times when water is added to the cement at the time of which the needle penetrates the test block to a depth equal to 33- 35mm from the top is taken as initial setting time. Replace the needle of the Vicat apparatus by a circular attachment. The cement shall be considered as finally set when, lowering the attachment gently co the surface of the test block, the center needle makes an impression, while the circular edge of the attachment fails to do so. In other words the paste has attained such hardness that the center needle does not pierce through the paste more than 0.5mm.

S.NO	property	values
1	pH	7.2
2	Taste	Good
3	Appearance	Clear
4	Turbidity	1.67

Table 2 :physicalpropertiesofwater

Potable Water

This is the least expensive but most important ingredient of concrete. The quantity and quality of water is required to be looked in to very carefully. In practice very often great control on the properties of all other ingredients is exercised, but the control on the quality of the water is often neglected. Since quality of the water effects strength, it is necessary for us to go in to the purity and quality of water. The water, which is used for making solution, should be clean and free from harmful impurities such as oil, alkali, acid, etc. in general, the distilled water should be used for making solution in laboratories. Water containing less than 2000 milligrams per litre of total dissolved solids can generally be used satisfactorily for making concrete. Although higher concentration is not always harmful they may affect certain cements adversely and should be avoided where possible. A good thumb rule to follow is, if water is pure enough for drinking it is suitable for mixing concrete and the physical prosperities of the water as shown in Table

S.NO	property	values
1	normal consistency	31%
2	Specificgravity	3.14
3	Initialsettingtime	94 minutes
4	finalsettingtime	197 minutes

Table 3:propertiesof cement

Mix design

The concrete mix without glass powder was adjusted in accordance with Indian Standard Specifications IS 10262- 1982. M50 -grade concrete mix design was created. The sample was mixed with a 0.5 water-to-cement ratio. Thus according to IS 10262-2009, the material mix percentage is 1:2.35:4.47. After that, the natural fine aggregate was employed. In concrete, nine distinct blends (M1, M2, M3, M4, M5, M6, M7, M8, M9) were created with cement replacement amounts of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40%. To improve the mix's workability, a superplasticizer was added at a rate of 2% by mass of cement.

The purpose of testing, i.e. conventional Portland cement, fine aggregate, coarse aggregate, potable water, and Glass powder process of creating concrete, workability of fresh concrete, and concrete testing protocols, are all thoroughly discussed.

Studies of the slump and compaction variables in fresh concrete are made. The compressive strength, split tensile strength, and flexural strength of hardened concrete of M50 grade substitution of cement using Glass powder within quantities mixed at the ages of 7 days, 28 days, and 90 days are given for both exposure circumstances.

Slump Cone Test

All six combinations were subjected to the slump cone test. Table shows slumps for various mixtures.

Sample Name	Percentage replacement of cement by glass powder	Slump in mm	% increment
M1	0	93	0
M2	5	86	-7.5
M3	10	83	-10.7

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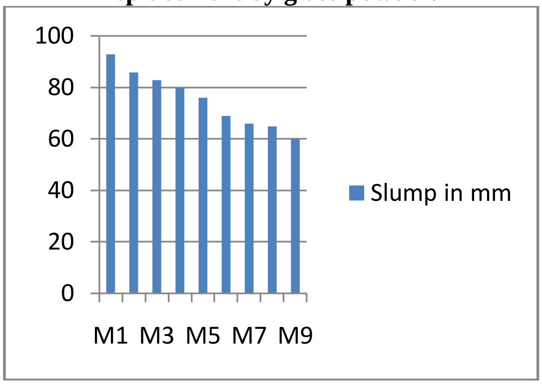
M4	15	80	-13.9
M5	20	76	-18.2
M6	25	69	-25.8
M7	30	66	-29
M8	35	65	-30.1
M9	40	60	-35.4

Table 4: slump of concrete with cement replacement by glass powder.

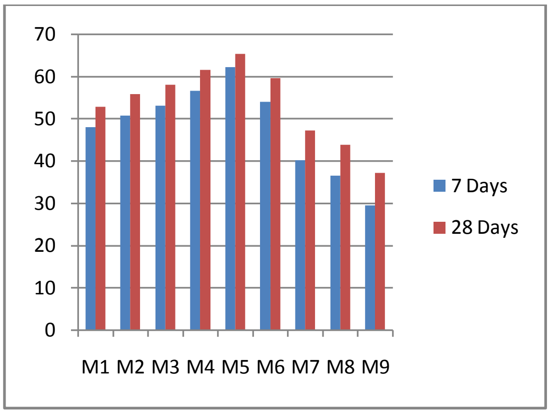


Garph 1: slump of concrete with cement replacement by glass powder.

Compressive Strength

The compressive strength of the concrete was tested on cubes measuring 150 x 150 x 150 mm. For such four combinations, a total of 36 cubes were cast. In other words, 6 cubes were made for each blend. The samples were tested at 7 and 28 days at a rate of three cubes for every combination on that specific day. The strength of that fine specimen is presented as the estimated value of the three specimens.

All of the mixtures were tested for compressive strength, and indeed the results are displayed in the table beneath.

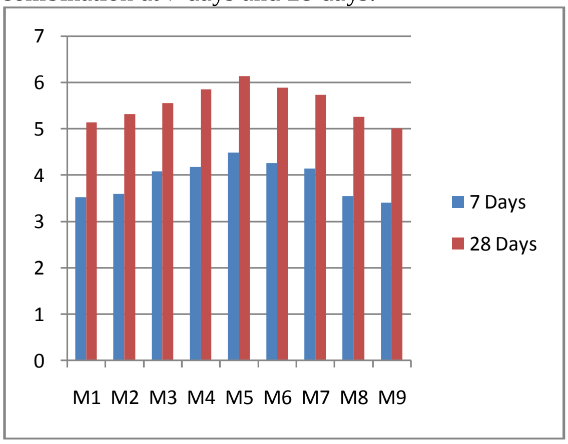


Graph 2:.compressive strength in concrete with age.

The following table is the results of 7 and 28-day tests on hardened concrete with 0-40 percent glass particles. As per the results in the table and figure, the compressive strength improves with rising cure time. The compressive strength achieved for concrete with a 20% replacement by glass powder appears to be 30% more for 7 days and 24% more for 28 days comparing concrete.

Flexuralstrength

The modulus of rupture examination on tested beams of 100 x 100 x 500 mm size was used to measure the flexural strength of the concrete. In this case, a total of 36 specimens were molded, with three samples examined with each combination at 7 days and 28 days.



Graph 3: flexural strength in concrete with age.

The table and figure indicate the fluctuation in flexural strength of concrete with cement substitution by glass powder over 7 and 28 days. Flexural strength of concrete with 20% cement substitution by glass powder appears to be 27% more for 7 days and 20% more for 90 days comparing concrete.

Alkalinity test

After 28 days of curing, the sample is removed from the curing tank to be tested for alkalinity. The samples should next be oven-dried for 24 hours at 105°C. The dried samples are left to cool down the temperature. Upon disintegrating the dry specimen, the mortar was removed from the concrete. The mortar is then pulverized into powder. The powdered mortar is sieved using a 150 mesh sieve. 10 grams of mortar is diluted in 50ml of filtered water and thoroughly mixed. The pH meter is therefore immersed in water, and the ph of the sample is recorded. The overall pH of the solution as well as the amount of generating corrosion in the concrete was observed.

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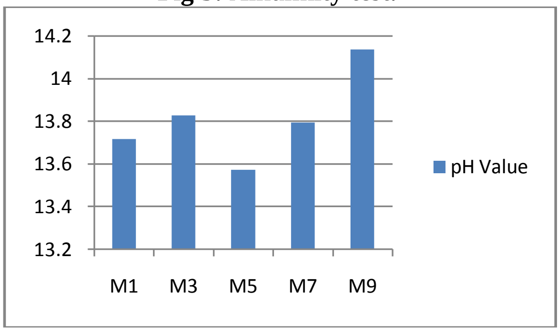
Fig 3: Alkalinity test.



Garph 4: alkalinity test values.

The pH value obtained from the alkalinity test indicated that such specimen examined was more alkaline and therefore more corrosion resistant.

Workability diminishes when the glass content increases (i.e. the cement content drops). As the fineness modulus of cementitious material decreases, the amount of cement paste obtainable for delivering a lubricating effect per unit surface area of aggregate decreases. As a result, there is a restriction on the motion.

As the amount of cement replaced with glass powder improves, strength improves up to 20% and then drops. At a 20% replacement level, the largest percentage improvement in compressive strength was around 30%, while the highest percentage gain in flexural strength was almost 22%. The pozzolanic reaction of glass powder because of its high silica content might account for the improvement in the strength of approximately 20% when replacing cement with glass powder. Thus it efficiently fills cavities and provides a thick concrete microstructure. Therefore, as the concentration reaches 20%, the dilution effect takes hold and the potency begins to decline. As a result, it can be stated that 20% was the ideal quantity for cement substitution with glass powder.

Because of the pore filling action, strength increase was sluggish all across the beginning of curing ages. Later, hydration of waste glass powder relieves a significant amount of lime to initiate the subsequent pozzolanic reaction, resulting in the formation of a greater quantity of C-S-H gel. The workability of new concrete, hardened concrete testing processes and durability tests are all well detailed. The findings from the tests were given and will be utilized to investigate the behavior of fresh and hardened concrete qualities. The results and scope of future study efforts were provided in the next chapter.

IV. CONCLUSIONS

The preceding conclusions are drawn from observed data:

Workability reduces as the proportion of glass powder increases. It was discovered that the application of a super plasticizer was required to preserve workability with a limited water-cement ratio.Compressive strength improves with an increasing proportion of glass powder substitution up to 22% replacement, and then falls.Flexural strength improves with an increasing proportion of glass powder substitution up to 22% replacement, after which strength decreases.Given the strength parameters, replacing cement with glass powder is a viable option. As a result, we may infer that the use of waste glass powder in concrete as a cement replacement is feasible.Very fine powdered glass is good filler and could have adequate pozzolanic characteristics to function as a partial cement replacement; however, the effect of ASR appears to be mitigated with finer glass particles, as the replacement level increases.

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