STUDY OF MECHANICAL PROPERTIES OF CONCRETE PAVEMENT USING GLASS POWDER

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Abstract: waste management is becoming a major issue for communities worldwide. Glass, being non-biodegradable , is not suitable for addition to landfill, and as such recycling opportunities need to be investigated. Waste glass produces big environmental problems, because of inconsistency of waste glass streams. With increasing environmental stress to reduce waste glass and to recycle . it as much as possible, the concrete industry has adopted number of techniques to achieve this goal. My aim is to study the behavior of waste glass powder as partial replacement of cement in concrete. Waste glass powder of particle size less than 90 micron is used in this work. The work was divided in to groups as : group 1 with 0% replacement, group 2 with 10% replacement, group 3 with 20% replacement, group 4 with 30% replacement with milky white glass powder. A constant water/cement 0.40 is used and grade of concrete is M30. A series of tests are conducted to study the effect of glass powder on strength of concrete. Necessary tests to be done are slump test, compression tests on cylinder, flexural tests on beams. Tensile and flexural strength up to different age are to be done and compared with those of conventional concrete.

Keyword: Concrete, Durability, Strength, Admixture, and Super-plasticizers

1. INTRODUCTION: Concrete is an artificial material obtained by mixing cement, coarse aggregate, fine aggregate and water in required proportion. The mixture when placed in forms and allowed to cure becomes like a stone. It is versatile and durable construction material. Concrete is strong, economical and also adopts the shape of the form in which it is placed. From the research and experience it has been observed that concrete is prone to deterioration so, it is necessary to take precautionary measures during the process of design and production. Research is being made all over the world to improve the durability properties of concrete and introduction of admixtures is one of the important ways to overcome this issue. An admixture is as a chemical product which is available in liquid and powdered form. In this research it is used liquid form. It should not be added more than 5% by mass of cement. Liquid state is usually used because it disperses more rapidly than solid state in a uniform manner during mixing of concrete. Admixtures can be added to the concrete at the batching plant during the mixing or directly at the job site during mixing and then concrete is placed in form. In this research we tried to decrease the water cement
ratio and because of this the concrete becomes stiff and difficult to mix. In order to increase the workability we had to use the admixtures so, we decided to use three different types of admixtures and check the effect of these admixtures on concrete. These admixtures replace the quantity of water in the same amount it is reduced. The mix is properly designed with standard Indian codes of practice.

1.1 GLASS: Glass is a non bio-degradable material and is not suitable for landfills. A lot of waste glass comes from the industries which pollutes our environment. To make our environment pollution free concrete industries had used this waste glass in concrete and also as a supplementary cementing material. By using the waste glass as the replacement in concrete reduces the pollution caused by glass waste and also the pollution caused during the production of cement. A glass is an inorganic product of fusion of mixture of silica, calcium carbonate and soda ash which is cooled to a rigid condition without crystallization. The glass being mainly a silica-based material in amorphous form can be used in cement-based applications.

Fig 1.1 Milky white glass powder

The main disadvantage of using crushed glass as a replacement of aggregate in concrete are expansion and cracking. This expansion and cracking is caused due to alkali silica reaction in the concrete. Ground glass is considered as - pozzolanic materials and can exhibit properties similar to other pozzolanic materials. It has been found that using glass in mortar applications caused more expansion compared with mortars without glass particles. This expansion can in some cases cause deterioration to the material.

(ASR) induced expansion could be reduced. In fact data reported shows that if the waste glass is finely ground, under 150 μ, this effect does not occur and mortar durability is guaranteed. It is also well know that typical It was found that if the glass was ground to a particle size of 300 μ or smaller, the alkali-silica reaction pozzolanic materials might features high silica content, an amorphous structure and have a large surface area

The main reason for recycling the waste glass is to create a pollution free environment and also to find a better alternative for concrete mixture that can give higher strength to concrete.

1.2 CEMENT

Cement is one of the main building material. It is a material having adhesive and cohesive properties. The cement used for making concrete is known as hydraulic cement. When water is added to the cement it starts reacting chemically in an exothermic processes known as hydration of cement. In hydration of cement, cement paste is formed which covers the aggregate in concrete and also fill the voids. When the water content in cement is reduced, it starts losing its consistency. The loss of water content may be due to the adsorption, evaporation and subsequently sets transforming the mixture in a solid mass. If the consistency of cement paste is excessively high, there is a danger of segregation. It will decrease the quality of concrete. After adding water to the cement, it starts gaining strength with the time. Ultra tech brand cement of OPC 53 is being used in this research.

1.3 REACTION OF CEMENT AND GLASS POWDER

According to shi et al (2005) glass powder having particle size less than 300 microns and below 100 microns shows the pozzolanic properties. Fineness of the glass powder influences its pozzolanic behavior. Also the pore solution present for reaction greatly influences the pozzolanic behavior of the glass powder. Depending on the fineness of glass powder, glass powder exhibits pozzolanic reaction at a slower rate compared to with the cement hydration. Thus the cement replacement with glass powder might decrease strength an early age but would increase it at later age. Shao et al.(2000) found that concrete with 30% glass powder finer than 38μm,increases compressive strength after 90 days of curing. Due to the dilution of cement the rate of evolving heat and total heat generated is reduced. The low heat of hydration from cracking.

The fineness of glass powder accelerates the hydration processes by the absorption of calcium ions from the liquid phase hence the time for peak hydration is shortened. A glass powder contains high amount of silica . The OH ions present in the pore solution, the silica present starts dissolving in alkaline environment and then reacts with calcium hydroxide to form secondary calcium silicate hydrate, this process is known as pozzolanic reaction. The high content of alkalis act as catalyst in the formation of calcium silica hydrate at an early age.

2. METHODOLOGY

The overall objective of the present study is to study the effect of adding Admixture in concrete on its performance; however the task is divided in to specific objectives to achieve step by step through experimental procedures.

- A standard mould of size (15 x 15 x15) cm is used for cubes, 15 cm x 15 cm x 70 cm for beams and 150 mm diameter and 300 mm height for cylinders batching is done as per the weight of material for casting the cubes.
- The steel mould is properly assembled, cleaned and then lubricated in order to obtain clean surface and easy removal of specimen.
- The concrete mixture is mixed properly till it reached plastic state and then slump test is carried. After obtaining proper slump value the concrete mixture is poured into the moulds.
- After 24 hours the specimen is taken out from the moulds and the moulds are cleaned properly for future use.
- The specimen is then immersed in water for curing. With proper curing concrete gains strength and also absorb heat of hydration till the time it is taken out for testing.
- In our research the cubes are cured for 7 and 28 days while beams and cylinders are cured for 28days.
- The specimens while taken out from the curing tank are surface dried, cleaned and weighed before taken out for testing.

3. EXPERIMENTAL RESULTS:

3.1 TESTS ON FRESH CONCRETE

The test on fresh concrete which I have done in slump test. In this test workability of the concrete is determined.

Table 3.1 Slump test

S.NO	Percentage of glass powder	Slump
1	0%	100 mm
2	10%	96 mm
3	20%	88 mm
4	30%	76 mm

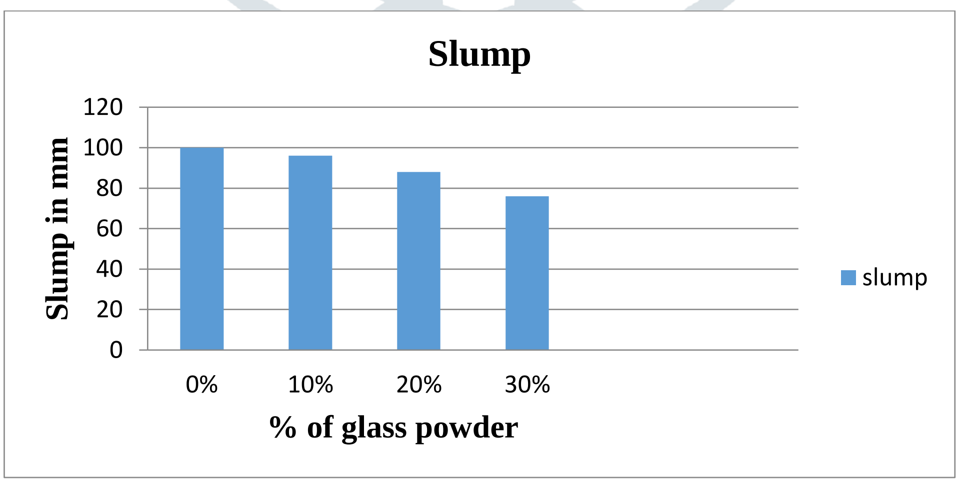

Fig 3.1 slump test on fresh concrete

The maximum slump was recorded at 0% replacement of glass powder with cement in concrete. As from the above fig, the slump of the concrete starts decreasing as the percentage of glass powder increases. The minimum slump was recorded at 30% of replacement of glass powder. Higher the glass powder lower will be the slump of concrete. To maintain the workability of concrete, super-plasticizer is used. The super-plasticizer used in this entire work is commix 777 at the rate of 1% of cement in concrete.

3.2 TESTS ON HARDENED CONCRETE

3.2. Compressive strength test:

The resistance to the failure under the action of compressive forces is known as compressive strength of any material. In this test, the moulds of size 150 x150 x150 mm are used for the preparation of cubes specimens. After the curing age, these cube specimens are tested for compressive strength under the action of compressive loads. Compression testing machine of 2000KN capacity is used in this work for the determination of compressive strength of the cube specimen. The code used for this test is IS 516-1959. After the curing age of 28days the specimen is tested for compressive strength, and the compressive strength is determined by dividing the failure load with the area of the specimen. Load is applied at the rate of 140 kg/min/cm^2 (0.7 KN/sec)

Table 3.2 compressive strength of concrete at 7 days in (N/mm$^{2)}$)

S.NO	Percentage of glass powder	7 Days
1	0%	25.85
2	10%	27.20
3	20%	26.55
4	30%	25.05

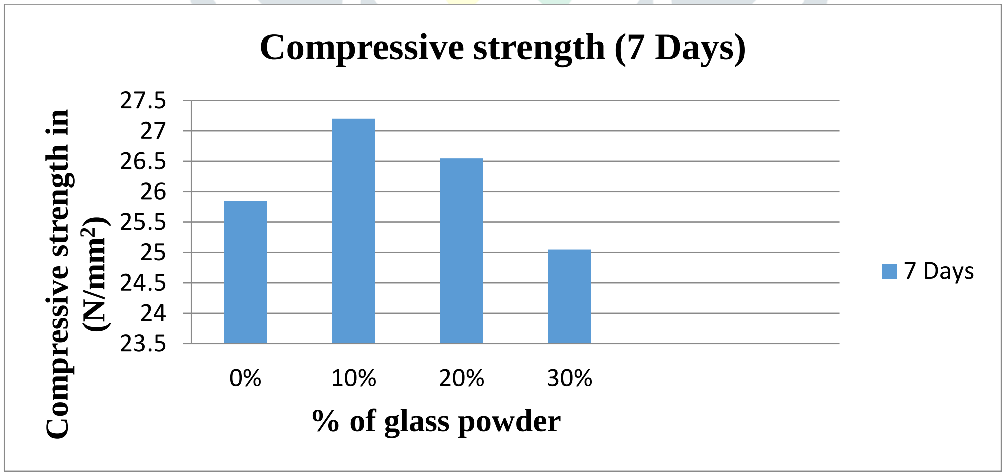

Fig 3.2 Compressive strength of concrete for 7 days in N/mm^2

The work was divided in to 4 groups. For each group three specimens were casted for every replacement. Glass powder is replaced with cement as 0%. 10%, 20%, 30%. In table 3.2 the average results of compressive strength for 7 days are summarized. The above fig 3.2 shows the compressive strength of normal concrete and replaced concrete with glass powder at the age of 7 days. At 0% replacement the strength was 25.85N/mm^2 When the glass powder replacement percentage is increased the strength increases. The strength increases up to 15% and then starts decreasing. The highest strength was recorded at 10% replacement of glass powder with cement when compared to normal concrete.

Table 3.3 Compressive strength of concrete at 28 days(in N/mm^2)

S.NO	Percentage of glass powder	28Days
1	0%	34.99
2	10%	36.73
3	20%	35.62
4	30%	34.18

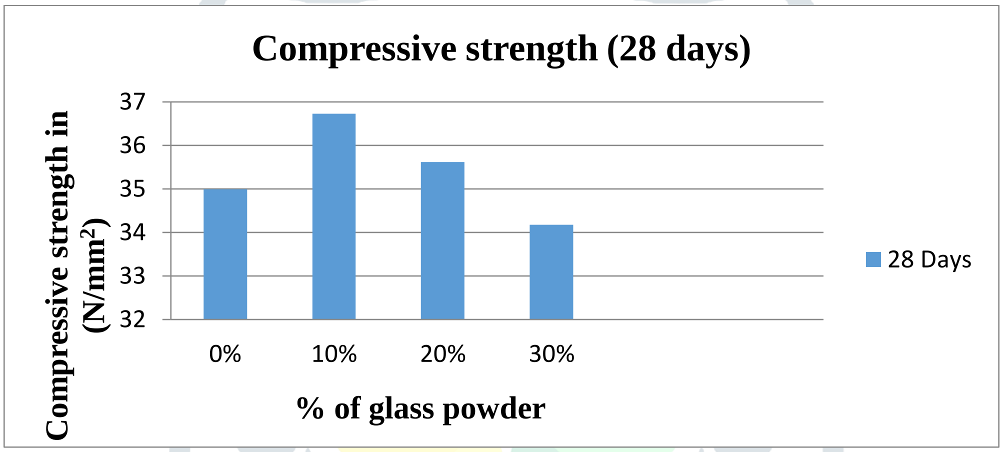

Fig 3.3 Compressive strength of concrete for 28 days (in N/mm^2)

The above fig 3.3 shows the compressive strength of concrete at the age of 28days. The strength recorded for normal concrete at 28 days was 34.99 N/mm^2.On increasing the glass powder up to 20 % the strength starts to decrease on further increment of glass powder. When 10% glass powder is replaced with cement in concrete shows more strength as compared to normal concrete

4. Split tensile strength:

Table 3.4. Split tensile strength of concrete at 7 days in (N/mm^2)

S.NO	Percentage of glass powder	7 Days
1	0%	2.09
2	10%	2.43
3	20%	2.26
4	30%	1.89

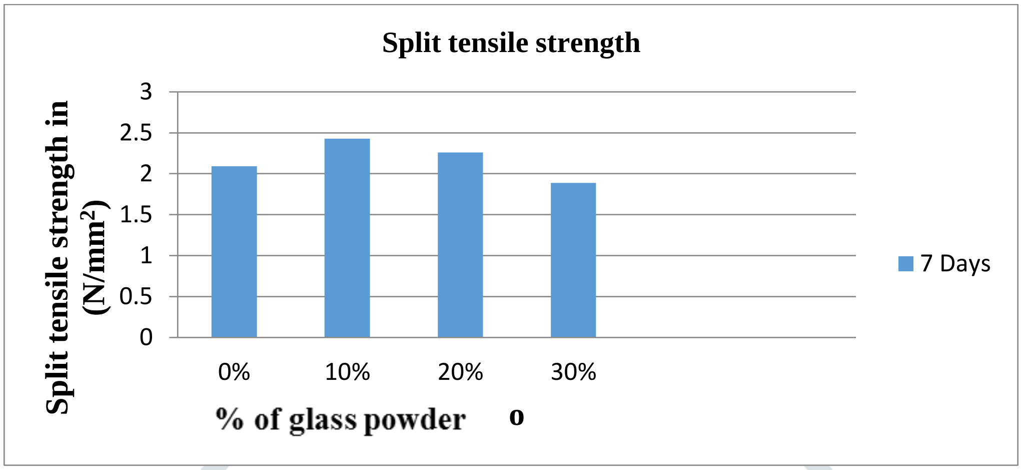

Fig 3.4 Split tensile strength of concrete for 7 days in N/mm^2

The work was divided into 4 groups. For each group three specimens were casted for every replacement. Glass powder is replaced with cement as 0%, 10%, 20%, and 30%. In table 3.4 the average results of split tensile strength for 7 days are summarized. The strength starts increasing as the glass powder replacement increases in the concrete. For the normal concrete, the strength was recorded as 2.09 N/mm^2. Maximum strength was recorded at 10% of replacement level when compared to normal concrete. The maximum strength achieved at 10% replacement of glass powder was 2.43 N/mm^2. On further increment of glass powder the strength decreases but was more as compared to normal concrete.

4.1 Split tensile strength:

Table 3.5 Split tensile strength of concrete at 28 days in(N/mm^2)

S.NO	Percentage of glass powder	28Days
1	0%	3.02
2	10%	3.09
3	20%	3.05
4	30%	2.91

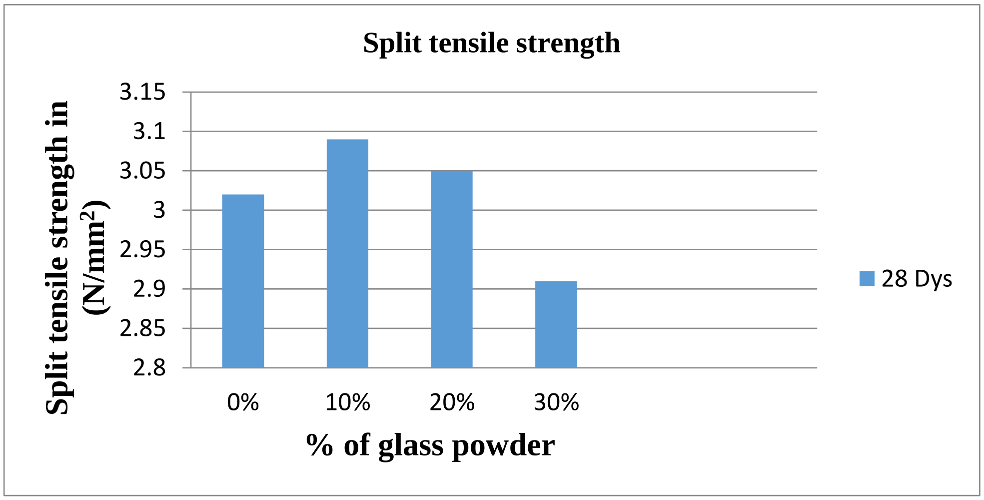

Fig 3.5 Split tensile strength of concrete for` 28 days in N/mm2

The above fig 3.5 shows the split tensile strength of concrete at 28 days. As the glass powder in the concrete increases the strength increases as shown in the fig. The concrete containing 10% to 20% glass powder shows higher strength as compared to normal concrete. The maximum strength was recorded at 10% replacement of glass powder with cement in concrete. At 10% glass replacement levels the strength increased by 2.32%.

5. Flexural strength:

Table 3.6 Flexural strength of concrete at 7 days in (N/mm^2)

S.NO	Percentage of glass powder	7Days
1	0%	5.99
2	10%	6.85
3	20%	5.44
4	30%	4.59

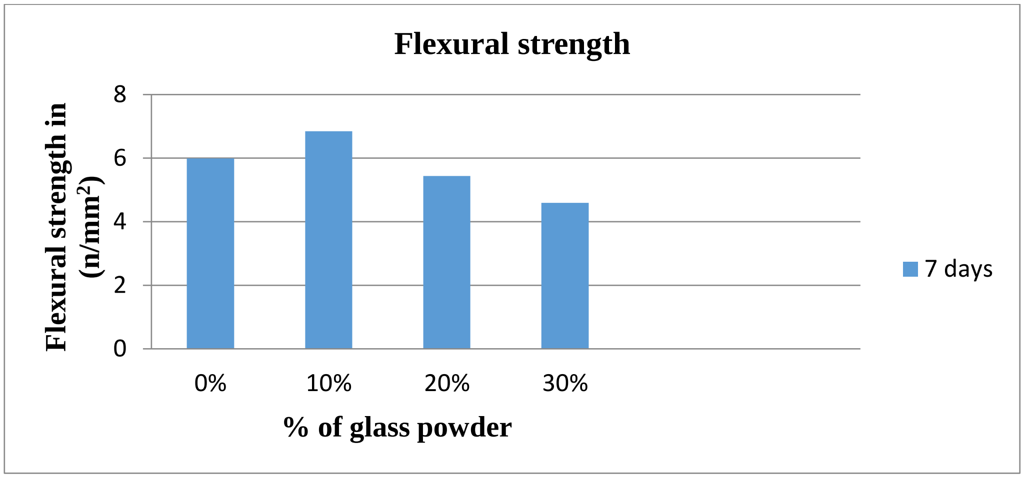

Fig 3.6 Flexural Strength of Concrete for 7 Days In N/mm^2

In table 3.6 the average results of Flexural strength for 7 days are summarized. The above fig 3.6 shows the flexural strength of normal concrete and replaced concrete with glass powder at the age of 7 days . For normal concrete the strength achieved at 7 days is 5.99 N/mm. As the glass powder increases the flexural strength increases. The strength increases up to 20% replacement and then decreases. Lowest strength was noted at 30% replacement level and the maximum strength was recorded at 10% glass replacement levels. When the strength was compared with normal concrete, strength at 10% replacement levels was high.

Table 3.7 Flexural Strength of Concrete at 28 Days In (N/mm^2)

S.NO	Percentage of glass powder	28Days
1	0%	6.69
2	10%	7.45
3	20%	6.30
4	30%	5.52

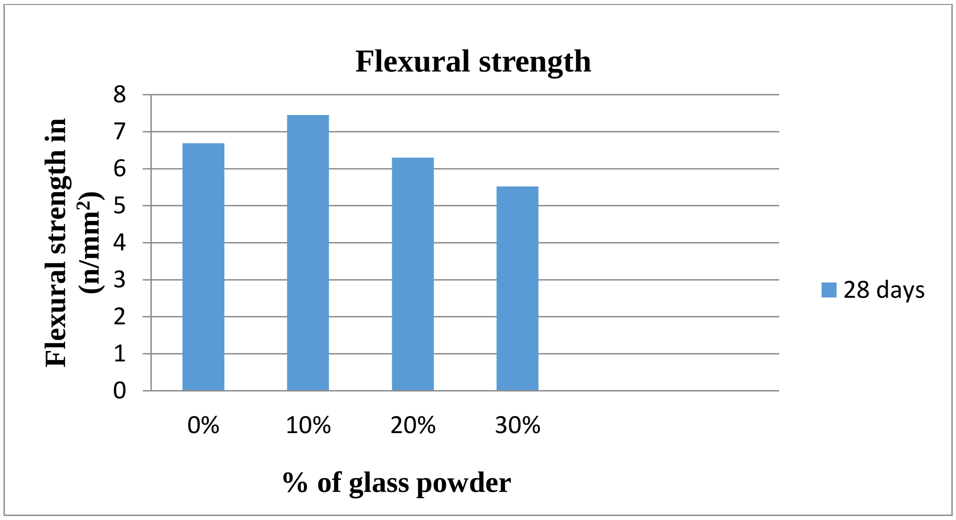

Fig 4.4.1 Flexural Strength of Concrete for 28 Days In (N/mm^2)

In table 3.7 the average results of Flexural strength for 28 days are summarized. The above fig 3.7 shows the Flexural strength of normal concrete and replaced concrete with glass powder at the age of 28 days. Glass powdered concrete shows high strength as compared to normal concrete. Strength of concrete increases as the glass powder replacement increases and also the strength increases as the age of concrete increases. When glass powder concrete is compared to normal concrete, the glass powder concrete at replacement levels 10% shows higher strength. The strength increases up to 20% and the decreases by small amount . When compared to normal concrete

. CONCLUSIONS

The conclusion of the tests done in laboratory for freshly mixed concrete and hardened concrete.

1. Slump of the concrete decreases as the glass powder percentage increases. The workability of concrete decreases as the replacement level of glass powder increases.
2. Compressive strength increases as the glass powder replacement increases and was found maximum at 10% compressive strength increases by 5.97% when compared to control concrete.
3. Split tensile strength increased by 2.30. when compared to control concrete. The strength increases as the glass powder percentage in the concrete increases. High strength was recorded at 10%
4. Also the flexural strength increases as the glass powder replacement increases and the maximum strength was recorded at 10% replacement level.
5. The increase in the strength up to 20% is due to the pozzolonic reaction of the glass powder . it may also due to the filling of voids by glass powder.
6. Beyond 10% the strength starts to drop, this drop of strength may be due to the dilution effect. The pozzolonic reaction requires the hydration component CH. Calcium hydroxide decreases because of the reduction of the cement content and also due to the consumption of CH by glass powder.
7. Beyond 10% glass replacement, the heat of hydration decreases due to the presence of less amount of CH component.As the glass powder can play only the role of inert filler without being activated.

- **Future Scope:**

1. Glass waste management will be recycled and thus not leading to more non-biodegradable solid wastes.
2. It will increase the strength of the concrete.
3. It may help in the cost reduction of concrete replacing the fine quantity of cement as glass powder and it is a product of waste material.
4. It will help us to achieve the greener environment.

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