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Effect of Partial Replacement of Sand By Glass Powder with Calcium Nitrite as Admixtures On the Properties of Concrete

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ABSTRACT- Every year, millions of tonnes of waste glass are produced across the world. Glass is disposed of as garbage in landfills, which is unsustainable since it does not breakdown in the environment. Silica is the main component of glass. The use of milled (ground) waste glass as a partial replacement for cement in concrete might be a significant step toward the creation of environmentally friendly, energy-efficient, and cost-effective infrastructure systems. When waste glass is ground down to micron-sized particles, it is called micro glass. It is believed that it would undergo pozzolanic reactions with cement hydrates, resulting in secondary Calcium Silicate Hydrate (C–S–H). Chemicalcharacteristics of clear and tinted glass were assessed in thisstudy. The X-ray fluorescence (XRF) technique was used to analyse the chemical composition of glass and cement samples, and it revealed slight changes in composition between clear and tinted glasses. Flow and compressive strength experiments on mortar and concrete were conducted by adding 0–25% ground glass, withthe water to binder (cement + glass) ratio being constant for all replacement levels. With the inclusion of glass, mortar flow rose somewhat, with a small influence on Further experiments were undertaken using the same mix parameters and a 1% super plasticizing admixture dosage (by weight of cement) to analyse the packing and pozzolanic effects, and usually observed an improvement in compressive strength of mortars with admixture. Concrete cube samples were made and evaluated for strength in the same way as mortar samples were (until 1 year curing). When compared to control samples, the compressive strength of recycled glass mortar and concrete was found to be higher. The financial and environmental benefits of replacing 20% of cement with waste glass were determined to be compelling.

KEYWORDS- Glass powder with calcium nitrate abbreviations OPC (ordinary Portland cement),PCC (pozalana Portland cement),CTM(compression testing machine),LW(light weight),CSA (cross sectional area),CSS (Compressive strength ofconcrete)

I. INTRODUCTION

Sand is a natural material which is available in rivers and other deposit, sand is one of the main construction materials in modern construction which can be used with cement and coarseaggregates to make concrete or with only cement to makemortar for brick laying and plaster etc. Sand is not a renewable resource which can be produced again and again. Thus we needto think of ways through which other materials can be used instead of sand or can be used as partial replacement of sand. Main focus needs to be made on those resources which are easily and cheaply available in the market. Glass powder is suchan materials which is the residue left after cutting of glass, it canbe broken glass, which can be used in concrete as aggregate. This product obtained from glass is easily and cheaply available. And thus can replace partially sand as aggregate material. This project examines the possibility of using glass powder as areplacement in fine aggregate with calcium nitrite as acceleratingadmixture for a new concrete.

A. Need for This Project Work

To investigate the possible use of GLASS POWDER as partial replacement of SAND with CALCIUM NITRITE as accelerating admixture.

II. OBJECTIVES

The specific objectives were as follows:

- To determine the optimum percentage of glass powder that can be used in concrete mixed with calcium nitrite as accelerator.
- To understand the effectiveness of glass powder in stength enhancement.
- To study and compare the performance of conventional concrete with glass powder concrete with admixture

- To study and compare the performance of conventional concrete with glass powder concrete with admixture.
- To evaluate the utility of glass powder as a partial replacement of fine aggregate in concrete with calcium nitrite as admixture.
- To assess the role of calcium nitrite in helping the rate of gain of early strength in concrete with partial replacement of sand with glass powder.

III. GLASS POWDER SELECTION

Glass is produced from liquid sand and has a high melting point, which means it melts and turns into a liquid when heated to a hightemperature. At a temperature of 1700° C, liquid sand melts. As thedemand for concrete grows, so does the amount of sand required. As a result, natural resources are being exploited. Sand regenerates slowly and cannot keep up with demand in the building industry. As a result, sand is becoming increasingly expensive and scarce. The government has taken note of these issues and imposed several limits and levies on sand mining. Glass is a transparent material which a must in today's construction of homes and high risebuilding, glass is also used for manufacture of bottles, kitchen ware, tables, windows, car windows etc. Thus waste from the glassindustry is also rising as quickly as sand being used in construction. Thus these two materials can complement each other. The broken glass and glass powder can be used in manufacturing of concrete as partial replacement of sand or cement or aggregate. Thus greatly reducing cost of construction and concrete. As these waste glass powder and broken glass is a waste product which can better serve the construction sector then being dumped which is undesirable glass is a non-biodegradable material which makes them less environment friendly. Glass can also be recycled again and again thus giving it another advantages on other materials in the market.

IV. LITRERATURE REVIEW

A. R Sakale [1]

The effects of substituting fine aggregate with waste glass powder by volume of cement in increments of 10- 40% were researched, as well as the effects on C.S., S.T.S., workability, and F.S. The compressive, flexural, and S.T.S. properties of concrete are demonstrated to rise initially as glass powder concentration increases, peaking about 20%, and then dropping. As the replacement percent increases, the workability of concrete diminishes linearly. Up to 20% of cement can be replaced with glass powder without impacting C.S.

B. Subramani and Pugal [2]

According to the study, using plastic waste as a substitute for traditional C.A. increases the physical andmechanical properties of concrete mixes. When compared to control concrete at a 15% replacement level, the concrete tests showed an increase of 8%, 5%, and 3%, respectively. All of the properties of concrete began to degrade when the amount of concrete replacement approached 15%. This was caused to too much water in the concrete mix, as plastic rubbish absorbs water ata far slower pace than typical C.A.

C. G. M. Sadiqul Islam [3]

For sustainable concrete, use waste glasspowder as a partial replacement for cement. Clear and coloured glass powders have relatively similar chemical compositions, and the materials might be classified as pozzolanic materials under ASTM standards. The flow of glass substituted mortar was found to be somewhat enhanced with glass powder content due to its cleaner character. When considering mortar and concrete compressive strength after 90 days, the optimal glass content is 20%. The compressive strength of this age was found to be somewhat greater (2%) than the control concrete specimen. Glass addition can lower cement production costs by up to 14% when compared to the performance of the replacement material.

D. Ana Mafalda Matos [4]

Durability of mortar made using scrap glass powder instead of cement Glass powder is intensively investigated as a partial cement replacement material in mortar, with most papers going much beyond mechanical testing and ASR.For durability evaluation, chloride intrusion, carbonation, sulphateattack, and sorptivity are all taken into account. SEM confirmed the effect of tiny glass particles well enclosed into a thick matrix.

E. AM Rashid [5]

One of the primary environmental concerns is disposing of waste glass originating from container or package glass, flat glass, household or tableware glass, and continuous filament glass fibres. With the growing volume of discarded glassand shrinking disposal capacity, this problem is only becoming worse. As a result, research has been conducted to discover practical techniques to recycle waste glass in construction materialssuch as cement, mortars, concrete, and blocks.

V. MATERIALS AND METHODOLOGY

A. Cement

The materials which were used for obtaining the required M20 mix concrete were cement (binder), sand (fine aggregate) and aggregate (20mm and 10 mm coarse aggregates) and the same were tested for their properties according to the IS codes. OPC 4

B. Aggregates

Aggregates used in the project:

- Fine Aggregate(sand)
- Source: - River sand Ganderbal, J&K.
  Coarse Aggregate (10 mm & 20 mm) Source: - Ganderbal, J&k.

C. Coarse Aggregates

Coarse aggregates are those aggregates which lie between 80mm to 4.75 mm. The shape of aggregates may be flaky or elongated depending upon the source of the aggregates

D. Fine Aggregates

the fine aggregates used in this study were obtained from Ganderbal, J&k which are clean river sand , having maximum sizeof 4.75mm, and conforms to grading zone II.

E. Glass Powder as an Aggregate

Glass powder used in this investigation was obtained from the waste glass from the shops which was then crushed and sieved as shown in figure 1 *I.*

Figure 1: Glass Powder

F. Mix Proportions

- Water cement ratio - 0.5
- Mix ratios - 1 : 1.5: 3
- Grade of concrete - M20

G. Batching

The measurement of materials for making concrete is known as batching. Strictly speaking, weigh batching is the correct method of measuring the materials as compared to volume batching. The weigh batching was adopted in the project so as to facilitateaccuracy, flexibility and simplicity. The concrete mix used in the project is nominal mix M20.The ingredients are therefore mixed inthe ratio of 1: 1.5: 3, with constant water cement ratio of 0.5.

Nominal mix= M-20 (1:1.5:3)
W/c ratio =0.5

Coarse aggregate (10mm =40% & 20mm=60%)

Density of concrete= 2200kg/m3

H. Calculation of Quantities

Volume of concrete moulds:

- Cube (150mm) = (.150x.150x.150) x3= 0.1011 m3
- Cylinder (150mm dia.; 300mm ht.)X1= 0.06 m3
- Prism (500mmx100mmx100mm) x12= 0.0636 m3

Total volume = 0.2247m3

Weight required per casting:

- Total weight required = 0.2247 x 2200 = 495 kg = 500 kg
- Weight of cement required = 495/5.5 = 90kg = 100 kg

Weight of sand required =1.5x495/5.5= 135 kg = 140 kg

- Weight of aggregate required =3x495/5.5= 270kg = 275 kg
  20mm required =0.60x270 = 165 kg =170 kg
  10mm required =0.40x270 = 108 kg =110 kg
- Weight of water required =0.5x90 = 45 kg =50 kg
- Admixture(calcium-nitrite) = 0.025 x100 = 2.5 kg
- Glass Powder = (.10+.25+.50) x140 = 119 kg =120 kg

Nominal mix M20 (1:1.5:3)

(water : cement : fine aggregates : coarse aggregate)
=50kg : 100 kg : 140 kg : 275 kg

I. Mixing

Thorough mixing is essential for the production of uniform concrete. Hand mixing was adopted and 10% more cement was added. . Hand mixing was done on a smooth, clean and water-tight platform consisting of GI sheet in following manner:

- Measured quantity of coarse aggregate is spread evenly.
- The required quantity of sand is dumped on the aggregate and spread evenly.
- The required quantity of cement is dumped on thesand and spread evenly.
- The heap is then mixed intimately with spade, turning the mixture over and over again until it is of even color throughout and free from streaks.
- It should be done in a proper manner.
- The mixing platform is washed at the end of the day
- The mixing of concrete is shown in figure 2.

Figure 2: Mixing of concrete

It should be maintained at no less than 95% The cubes have been cured after removing the molds after 24 hours. Curing has been done by keeping the cubes immersed in water for a period of 5 days for the 7-day test and 26 days for the 28-day test from the 0 date of casting as shown figure 3.

Figure 3: Curing of specimen

J. Sampling Fresh Concrete

Mould dimensions

- The standard size of cube mould used is 150 mm x150mm x 150mm.
- The standard size of beam mould used is 500 mm x100mm x 100mm
- The standard size of cylinder mould used is 300mm height, 150mm diameter

Cubes of 100 mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 20 mm. Cubes of 150 mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 40 mm.The moulds for the specimens must be made of cast iron or cast steel. The inside faces must be machined plane. Each mould has a base, which is a separate metal plate, preferably fastened to the mould by clamps or springs.

Curing The Specimens

Castings must be cured before they are tested. Unless required for a test at 24 hours, they should be placed immediately after demoulding in the curing tank or mist room. The curing temperature of the water in the curing tank should be maintained at 27-30°C. If curing is in a mist room, the relative humidity.

VI. RESULTS AND DISCUSSION

A. Testing of Hardened Concrete

After curing, the concrete wewasested for compressive strength,split tensile strength and flexural strength.

B. Strength Tests

- **Compressive Strength Test**

The concrete specimens were tested for compressive strength after 3, 7 and 28 days of water curing. This test is conducted on cubes (150mm) which are loaded on their opposite faces in a Compression Testing Machine (CTM).six samples werecast in each casting, two of which were tested after 3 days, anothertwo were tested after 7 days and rest two after 28 days. The load at which first crack appears is considered as failure load and the compressive strength is calculated corresponding to this particularvalue of load.cast in each casting, two of which were tested after 3days, another two were tested after 7 days and rest two after 28 days. The load at which first crack appears is considered as failure load and the compressive strength is calculated corresponding to this particular value of load as shown in figure 4.

Figure 4: Compressive strength test

The concrete is taken for compressive test after 3 days and the average compressive strength after 3 days came to be 12.70 MPA for plain concrete, 16.85MPA for concrete with calcium nitrite, 19.45 for concrete with glass powder and calcium nitrite@2.5% , 23.45 for concrete with glass powder and calcium nitrite @2.5, 25.42 for Concrete with glass powder and calcium nitrite @2.5% as shown in Table 1.

Table 1: Result of 3-day Compressive Strength test: Plain concrete

Sample Name	%age	Comp. Strength MPa	Comp. Strength MPa	Avg. Comp. Strength MPa
Plain concrete	0	12.50	12.90	12.70
Concrete with Calcium nitrite	2.5	16.90	16.80	16.85
Concrete with glass powder and calcium nitrite @2.5%	10%	19.40	19.50	19.45
Concrete with glass powder and calcium nitrite @2.5%	25%	23.40	23.50	23.45
Concrete with glass powder and calcium nitrite @2.5%	50%	25.40	25.45	25.42

Figure 5 clearly shows how the CSS varies with different elements of material after 3 days.

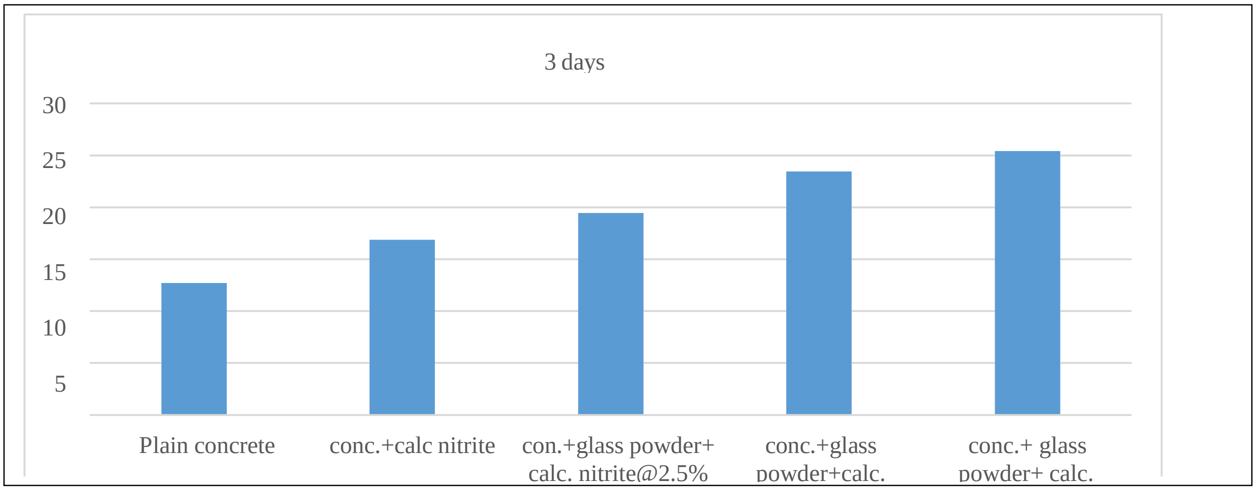

Figure 5: Compressive test trial 1

The concrete is taken for compressive test after 7 days and the average compressive strength after 3 days came to be 14.58 MPA for plain concrete , 19.47MPA for concrete with calcium nitrite, 23.3 for concrete with glass powder and calcium nitrite@2.5% , 23.62 for Concrete with glass powder and calcium nitrite @2.5, 29.49 MPA for Concrete with glass powder and calcium nitrite @2.5% as shown in Table 2

Table 2 : Result of 7-day Compressive Strength test: Plain concrete

Sample Name	%age	Comp. Strength MPa	Comp. Strength MPa	Avg. Comp. Strength MPa
Plain concrete	0	14.52	14.65	14.58
Concrete with calcium nitrite	2.5	19.50	19.45	19.47
Concrete with glass powder and calcium nirtite @2.5%	10%	23.15	23.45	23.3
Concrete with glass powder and calcium nirtite @2.5%	25%	25.60	25.65	25.62
Concrete with glass powder and calcium nirtite @2.5%	50%	29.45	29.53	29.49

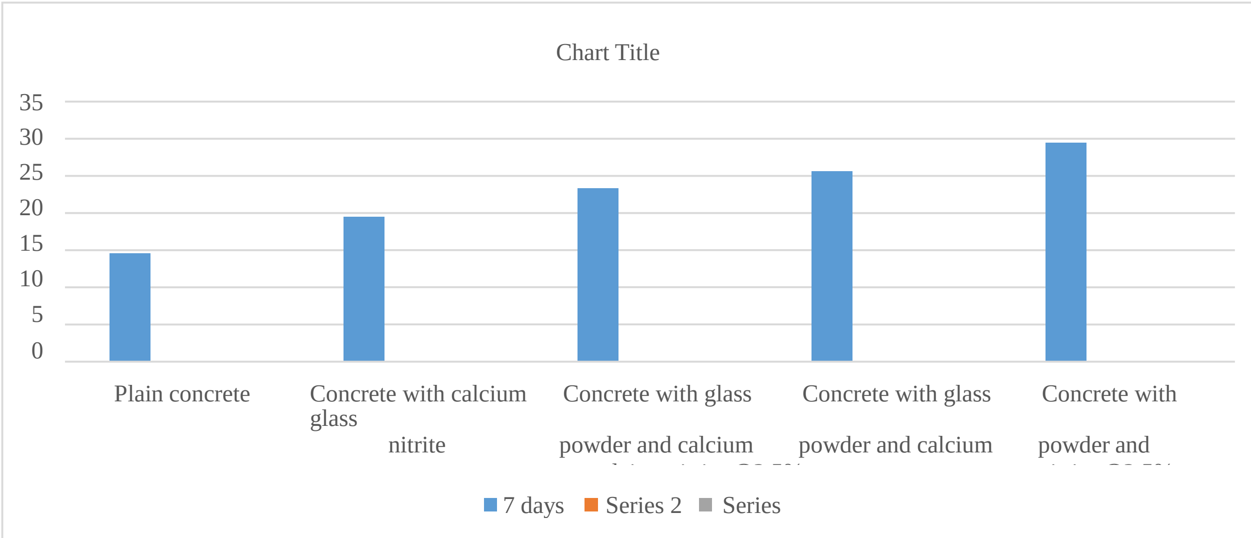

Figure 6: Compressive test trial 2

The concrete is taken for compressive test after 28 days and the average compressive strength after 28 days came to be 22.05MPA for plain concrete , 23.05MPA for concrete with calcium nitrite, 29.56 for concrete with glass powder and calcium nitrite@2.5% 30.2 for Concrete with glass powder and calcium nitrite @2.5, 33.77for Concrete with glass powder and calcium nitrite @2.5% as shown in Table 3.

Table 3: Result of 28-day Compressive Strength test:Plain concrete

Sample Name	**%age**	**Comp. Strength MPa**	**Comp. Strength MPa**	**Avg. Comp. Strength MPa**
Plain concrete	0	21.65	22.45	22.05
Concrete with calcium nitrite	2.5	23.45	22.65	23.05
Concrete with glass powder and calcium nirtite @2.5%	10%	29.50	29.63	29.56
Concrete with glass powder and calcium nirtite @2.5%	25%	30.25	30.15	30.2
Concrete with glass powder and calcium nirtite @2.5%	50%	33.75	33.80	33.77

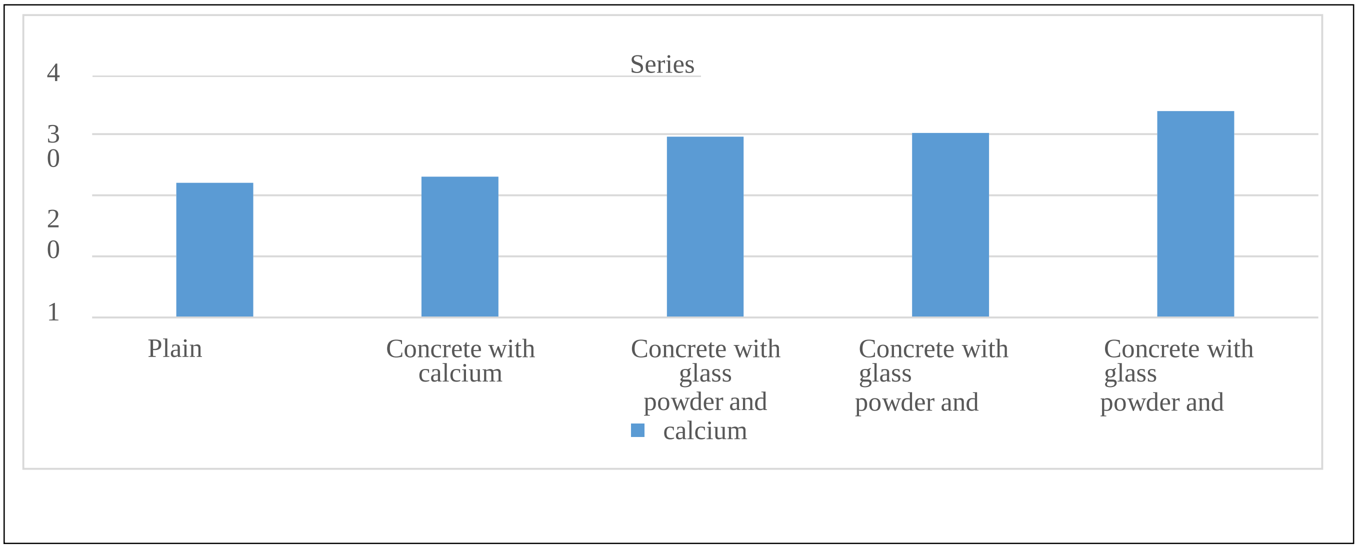

Figure 6: Compressive test trial 2

Figure 6 clearly shows how the CSS varies ver small with different elements of material after 28 day

Flexural Strength Test

Flexural strength test of concrete is performed on beams. The loading applied on the beam is a two point loading in which loads are applied at (1/3) rd points of the beam. . The load is increased until the specimen fails and this load is noted as failure load. Flexural strength is then calculated from the following formula

Flexural strength = $\frac{2Pl}{bd^2}$

Where, P = (Load at failure)/2

Where, P = (Load at failure)/2

l = Length of beam between supports

(400mm)

b = Breadth of beam (100mm)d = Depth of beam (100mm)

The result of flexural strength test after 3 days came to be 1.30MPA as shown in table 4.

Table 4: Result of 3-day flexural Strength test

Glass powder with admixture %	Sample with Admixture (MPa)	Plain (MPa)
10%	2.78	1.30
25%	2.10	
50%	1.28	

The result of flexural strength test after 7 days came to be 2.35 MPA as shown in table 5.

Table 5: Result of 7-day flexural Strength test

Glass powder with admixture %	Sample with Admixture (MPa)	Plain (MPa)
10%	3.68	2.35
25%	3.22	
50%	2.40	

The result of the flexural strength test after 28 days came tobe 3.08MPA as shown in table 6.

Table 6 : Result of 28-day flexural Strength test

Glass powder with Admixture %	Sample with Admixture (MPa)	Plain (MPa)
10%	5.42	3.08
25%	4.65	
50%	4.25	

Split Cylinder Test

The test is carried out by placing a cylindrical specimen, horizontally between the loading surfaces of a Compression Testing Machine and the load is applied until failure of the cylinder, along the vertical diameter.as shown figure 7. It is estimated that the compressive stress is acting for both $(1/6)^{th}$ depth and theremaining $(5/6)^{th}$ depth is subjected to tension. The horizontal tensile stress is given by the Table 7.

Table 7: Result of 3-day split-tensile Strength test

Glass powder with Admixture %	Sample with Admixture (MPa)	Plain (MPa)
10%	3.15	2.24
25%	2.60	
50%	2.38	

following equation:

$$\textbf{Horizontal tensile stress} = \frac{2P}{\pi DL}$$

Where, P = Load at failure
L = Length or height of cylinder (300mm)

The result of split tensile strength test test after 3 days came tobe 2.24MPA as shown in table 7

Figure 7 : Split tensile test

The result of split tensile strength test test after 3 days came to be 1.56MPA as shown in table 8

Table 8: Result of 7-day split-tensile Strength test

Glass powder with Admixtu re %	Sample with Admixt ure (MPa)	Plain (MPa)
10%	2.95	
25%	2.50	1.56
50%	2.25	

The result of split tensile strength test test after 28 dayscame to be 2.32MPA as shown in table 9

Table 9: Result of 28-day split-tensile Strength test

Glass powder with Admixture %	Sample with Admixture (MPa)	Plain (MPa)
10%	3.05	
25%	2.60	
50%	2.18	2.32

VII. COMPARISON AND ANALYSIS RESULTS

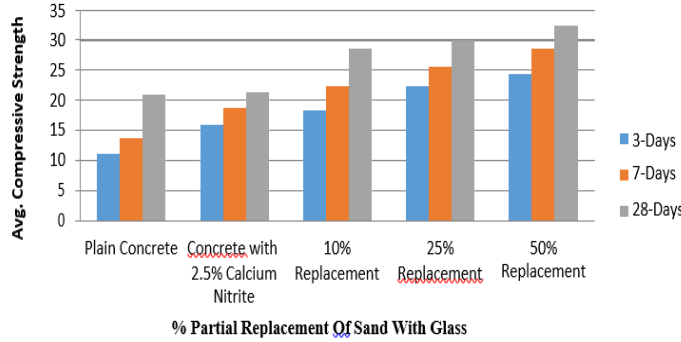

Figure 8: Comparison of Compressive Strength with Glass Powder and Calcium Nitrite % added and corresponding Plain Concrete cube strength

Following is inferred from above comparison: -

- The average 3 Day compressive strength of concrete containing Glass powder as partial replacement up to 50% is more as compared to average 3 Day compressive strength of plain concrete. This indicates an increase in the compressive strength of concrete with addition of Glass Powder up to 50%.
- The difference in the average 3 Day compressive strength between Glass Powder concrete and plain concrete is considerable at the percentage of 50%. This indicates that the highest increase in compressive strength occurs on addition of 50% Glass Powder.

VIII. CONCLUSIONS AND FUTURE SCOPE

- The early compressive strength, flexural strength and split tensile strength of concrete specimens increased with the increase in percentage of Glass Powder upto 50% and Calcium nitrite up to 2.5%
- From trial mixes, a mix with Glass Powder percentage of 50% was found to possess maximum compressive strength.
- There was great effect on the 28 da28-dayressive strengthof concrete at all percentages.
- Use of Calcium nitrite greater than @ 2.5% does not helpin accelerating the gain of early strength and had a negative impact on the gain of strength. However, use of this percentage does not harm 28-day strength. Thus the use of sodium nitrite may be limited to a value of 2.5 %.

Future Scope

- Following are some suggestions for future research.
- The study of effect on strength with partial replacement of sand with glass powder percentage varying from 50% to 70% is suggested.
- And use of other admixture's with conjunction of Glass Powder may be studied.

- Health and Safety Risk assessments should be conducted to

ensure all users are provided with a safe means of use.
- Conduct of study with varying mix proportions is also suggested.

IX. RECOMMENDATIONS

Following parameters are recommended for optimum benefit:
- Mix : M20
- FA/CA : 0.5
- W/C Ratio : 0.5
- Calcium Nitrite % : 2.50% (by wt. of cement)
- Glass Powder % : 50% (by wt. of fine aggregates)

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