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Experimental Study on Concrete Containing Glass Powder as Partial Replacement for Cement and Waste Quarry Dust as Partial Replacement for Fine Aggregate

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Abstract:

This study was conducted to study the effect of using cement by glass powder and sand by quarry dust as the partial replacement materials. Project is conducted to know the performance of concrete by using glass powder and quarry dust as the substitute material for the concrete. By the usage of quarry dust the landfill area required for the disposal purposes can be minimised. The scarcity problem of the natural sand can be also reduced. Quarry dust and glass powder satisfies the reason behind the alternative material as substitute for cement and sand at reasonable price. It is found that the 15% replacement of cement by glass powder and 40% replacement of sand by quarry dust gives maximum strength values when compared to normal concrete mixes.

Keywords— **Cement, Waste glass powder, Fine aggregate, Quarry dust.**

I. Introduction

In today life the concrete is very essential material as it is used for the building activities. Concrete is basically combined mixture of cement, fine aggregate, sand and water of required quantity, made it into the paste and used wherever required. The cement reacts with the water present in the mixture and binds with other materials and forms as a rigid material which is durable and lasts for many years. In order to improve the wet and hardened properties of concrete some additives can be added. So constructional activities are increasing day by day. Concrete is used in the construction of pavement, highway bridges, high rise buildings, drainage pipes. Due to increase in the constructional activities there is a great demand for the concrete. During the manufacture of cement huge amount of carbon-dioxide gas is released, which is very toxic to the environment. By the increase in the construction, the natural resources like natural sand and gravel are becoming scarce. So in order to overcome this crisis many other replacement materials are used in the concrete. The properties of the replacement materials should be properly analysed and then used in the concrete preparation.The strength variation after the replacement of these materials must be properly studied by using certain tests. Later the strength variation of conventional concrete mix and replaced concrete mix has to be analysed. Various replacement materials are used in the concrete like the glass powder, GGBS, flyash, M- sand, vermiculite, copper slag, steel slag. By using these alternate materials the dumping wastes to the landfill area can be minimised.

II. Literature Review

1. Krati Gahoi, R. Kansal(August 2016) The test results showed that by the replacement of cement with glass powder the workability of the concrete mix increases. Durability of the concrete blocks is checked by density and water absorption test. There was an increase in the compression strength, flexural and split tensile values.

2. Harish B A, Hanumesh B M, Siddesh T M, Siddhalingesh B K (Oct 2016) In this project they used the glass powder of size 150µm and 300µm separately. They replaced the cement with waste glass powder by 10%, 20%, 30% and 40%. The compression strength of concrete comprising of glass powder size of below 150µ will be maximum at 30% of cement replacement. Similarly compression values of concrete mix having glass powder of size below 300µ will eventually falls. The tensile strength of concrete mix containing glass powder of downsize 150µ will be optimum at 30% replacement of cement.

3. Mr. G. Raja, Mr. K. M. Ramalingam(May 2016) In this project basically the properties of granite powder such as size, fineness, specific gravity, and moisture content were calculated. The grade of the concrete used here is M20. For experimental purpose the concrete blocks were casted with varied ratios of granite and sand. The substitution of granite fines to fine aggregates are 0%, 10%, 20%, 30%, 40%, 50% and 100%. The concrete blocks are tested after 28 days of curing, for compression value, flexural value and split tensile values. The specimen casted with 40% replacement of sand showed higher strength values when compared to that of conventional blocks.

III. Materials and Methodology

1.CEMENT
2 GLASS POWDER
3 FINE AGGREGATE
4 QUARRY DUST
5 COARSE AGGREGATE
6 WATER

3.1 Mix Design of Concrete

Various trial mixes are prepared and tested to findout the optimum dosage of the replacement materials used. The different properties of cement is directly dependent on the material properties, method implemented for the mixing, compaction method, curing method. The mix used in the project is of M30 grade concrete. Various mix are prepared and tested for control mix and the replaced materials.

Table 3.7 Mix proportion details

DESCRIPTION	DETAIL
Grade of concrete	M30
Type of cement used	OPC 43 grade confirming to IS 8112- 1989
Maximum nominal size of coarse aggregate	20mm
Maximum water cement ratio	0.45
Workability	100mm
Exposure condition	Normal
Optimum cement content	492 kg/m^3

3.2 Experimental Procedure

3.8. PREPARATION OF CONCRETE
1) BATCHING
2) MIXING

Table 3.9 Mix proportion of different concrete mixes

Mix proportions	Types of mixes
M0	Conventional mix
M1	5% glass powder +0% quarry dust
M2	10% glass powder +0% quarry dust

M3	15% glass powder +0% quarry dust
M4	20% glass powder +0% quarry dust
M5	15% glass powder +10% quarry dust
M6	15% glass powder +20% quarry dust
M7	15% glass powder +30% quarry dust
M8	15% glass powder +40% quarry dust

3) CASTING OF CONCRETE

4) CURING

IV. Methodology

3.3.1 Slump Test

Slump test works as the indicator if concrete is not properly mixed. The test is very simple to conduct. It signifies the uniformity for various loads of concrete in the field condition. It also determines the plasticity of the concrete.

3.3.2 Compression Strength Test

Compression strength indicates the resistance of concrete cubes towards the compression stresses. It rely on the aspect such as the water-cement ratio, strength of the cement, quality of the material. After taking the concrete cubes rub the extra water from the exterior part. Cubes are kept in the apparatus in such a way load should be appealed to both sides.. Load at which cube breaks is used to calculate the compression strength. Record the values obtained. Totally 3 specimens are tested for a particular trial mix. Compression value = P/A in N/ mm^2

3.3.3 Split Tensile Strength

Split tensile test is carried out to calculate the tensile strength of concrete. It is poor in tension because of fragile behaviour. The concrete breaks when it is treated with tensile forces. Therefore the tensile test is conducted to estimate the load at which the concrete members breaks. The load at which the cylinder breaks is taken as the split tensile value.

Split tensile strength = $2P/ \pi DL$ in N /mm^2

3.3.4 Flexural Strength Test

Flexural strength test is conducted to evaluate the tensile strength of beams. It is usually conducted on the unreinforced concrete beams and slabs to bear collapse due to deformation. It is conducted on the beams of distance about atleast three times of phase. It is about 10% of compression strength based on kind, dimensions and the volume of coarse aggregate used.

3.3.5 Density Test

To calculate the density value of concrete the average weight of the concrete specimen of each trial mix is taken.

Density = (weight / volume) in kg/m^3

V. Results and Discussions

4.1 Slump Test

This test is made to know the water required by the concrete mix to attain good workability. The nominal mix showed the optimum slump value of 98mm. Slump value goes on decreasing for the trial mixes

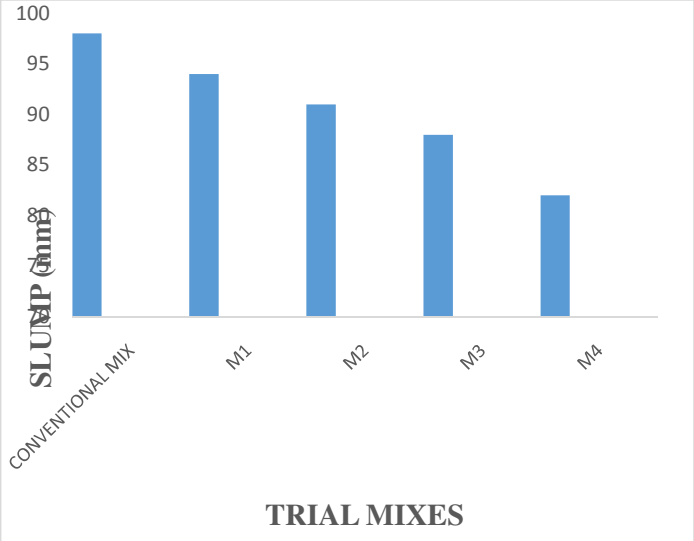

Figure 4.1 Slump test values for trial mixes with partial replacement of cement by glass powder

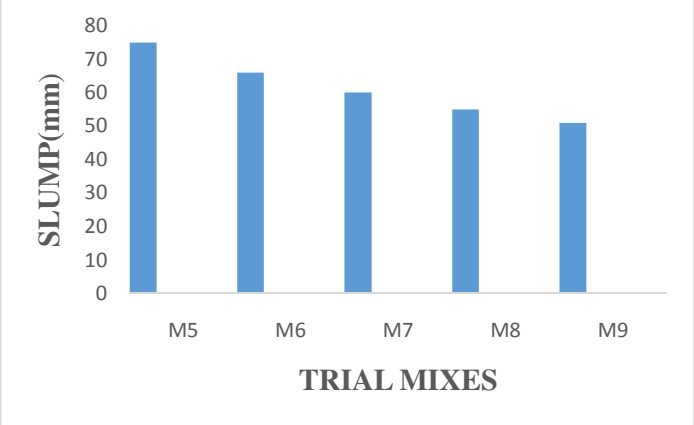

Figure 4.2 Slump test values for trial mix with partial replacement of cement by glass powder and fine aggregate by quarry dust

4.2 COMPRESSION TEST

The compression test is carried out for different trial mixes with partial renewal of cement by glass powder and sand by quarry dust. 3, 7, 14, 28 days tests are conducted for each trialmix.. The test results showed that substitution of cement only by glass powder with 15% replacement showed optimum compression value of 13.27N/mm^2, 21.47N/mm^2, 29.80N/mm^2, 33.06N/mm^2 for 3, 7, 14, 28 days respectively. Here 15% of glass powder replacement is kept constant and trial mixes were made with 10%, 20%, 30%, 40%, 50% replacement of sand by quarry powder.

Table 4.2 Compression values of concrete mixes in N/mm2

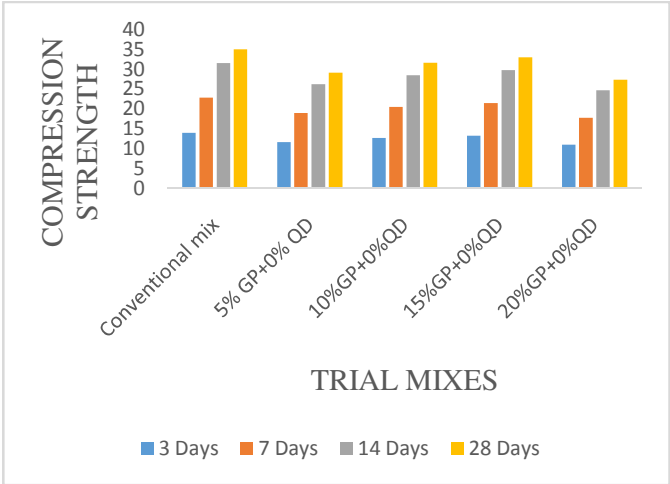

Figure 4.3 Impact of partial replacement of cement by glass powder on compression value of the cube

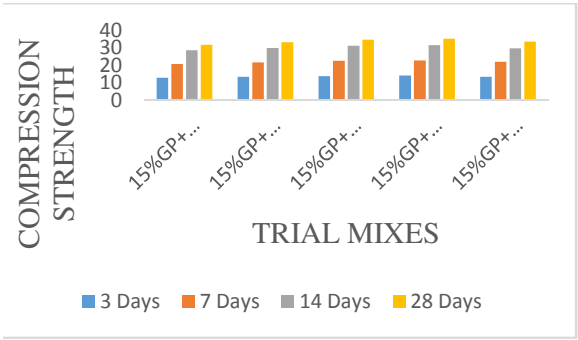

Figure 4.4 Impact of partial replacement of cement by glass powder and fineaggregate by quarrydust on the compression strength of cube.

4.3 SPLIT TENSILE TEST

It is conducted for the different trial mixesto calculate tensile strength of

cylinder. Test is performed on the cylindrical concrete of 100mm diameter and 200mm height kept in the compressive testing machine placed between two horizontal planes. The load is applied to cylinder until it fails. The peak load at which the specimen fails is noted down. Table below shows split tensile values of the various concrete specimens. The test result showed the optimum split tensile value of 1.67N/mm^2, 2.70N/mm^2, 3.75N/mm^2, 4.14N/mm^2 for 3, 7, 14, 28 days at 15% substitution of cement by glass powder and 1.79N/mm^2, 2.90N/mm^2, 3.97N/mm^2, 4.42N/mm^2 for M8 trial mix for same days.

Table 4.3 Split tensile value of various design mix in N/mm^2

MIX CODE	3 Days	7 Days	14 Days	28 Days
M0	1.76	2.89	3.94	4.41
M1	1.46	2.39	3.30	3.66
M2	1.59	2.59	3.60	3.97
M3	1.67	2.70	3.75	4.14
M4	1.38	2.23	3.12	3.45
M5	1.61	2.66	3.55	4.02
M6	1.68	2.74	3.80	4.20
M7	1.78	2.85	3.93	4.38
M8	1.79	2.90	3.97	4.42
M9	1.73	2.77	3.77	4.25

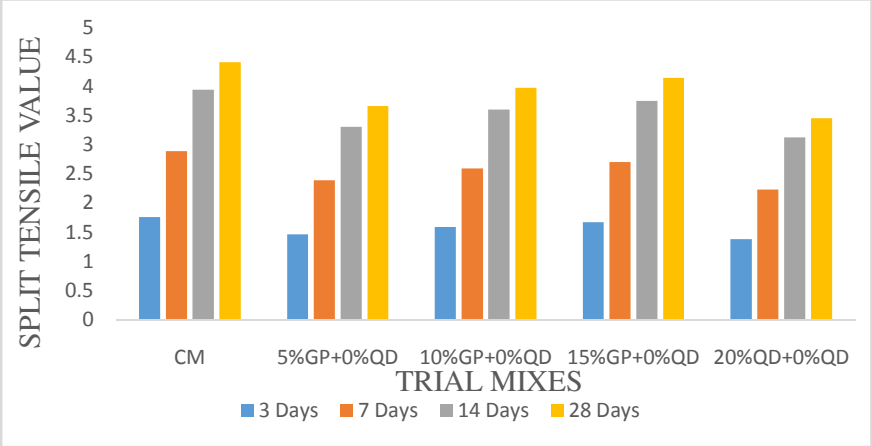

Figure 4.5 Impact of partial replacement of cement by glass powder on split tensile value of cylinder

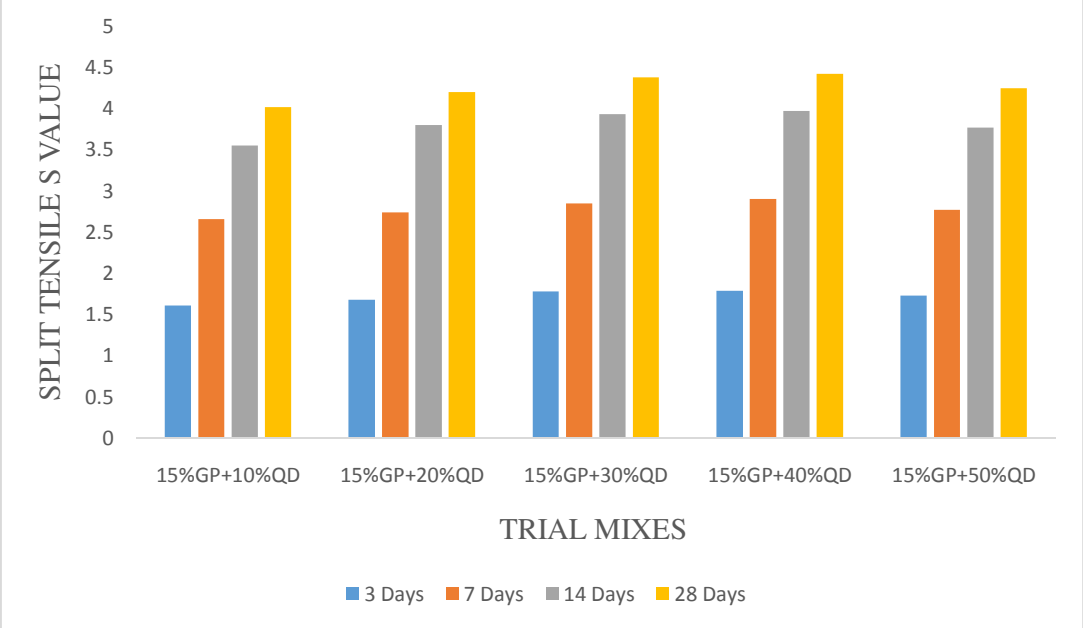

Figure 4.6 Impact of partial replacement of cement by glass powder and fine aggregate by quarry dust on split tensile strength of cylinder

4.4 FLEXURAL STRENGTH

The test was conducted on the concrete beam of dimension 100x100x500mm. The test is conducted to calculate the modulus of rupture. The technique used in the test to calculate the flexural test is three point flexural test. It indicates the elevated strain subjected at its moment of yield. Flexural values obtained by the specimen testing is given in the table below. The test results showed optimum flexural strength of 1.92N/mm^2, 3.10N/mm^2, 4.35N/mm^2, 4.78N/mm^{2}at 15% replacement of cement by glass powder and 2.06N/mm^2, 3.34N/mm^2, 4.57N/mm^2, 5.09N/mm^2 for M8 trial mix for 3, 7, 14, 28 days respectively.

Table 4.4 Flexural strength of various concrete mixes in N/mm^2

MIX CODE	3 Days	7Days	14Days	28Days
M0	2.02	3.33	4.53	5.07
M1	1.69	2.77	3.80	4.23
M2	1.84	2.97	4.15	4.58
M3	1.92	3.10	4.35	4.78
M4	1.59	2.58	3.58	3.97
M5	1.86	3.07	4.08	4.63
M6	1.94	3.15	4.37	4.85
M7	2.05	3.29	4.52	5.07
M8	2.06	3.34	4.57	5.09
M9	1.99	3.17	4.33	4.88

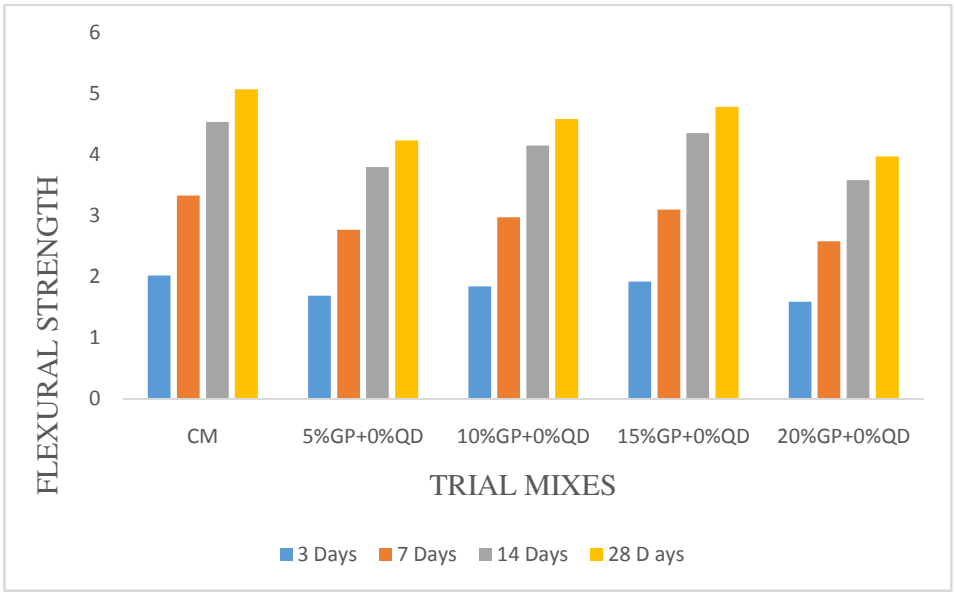

Figure 4.7 Impact of partial substitution of cement by glass powder on flexural strength of beam

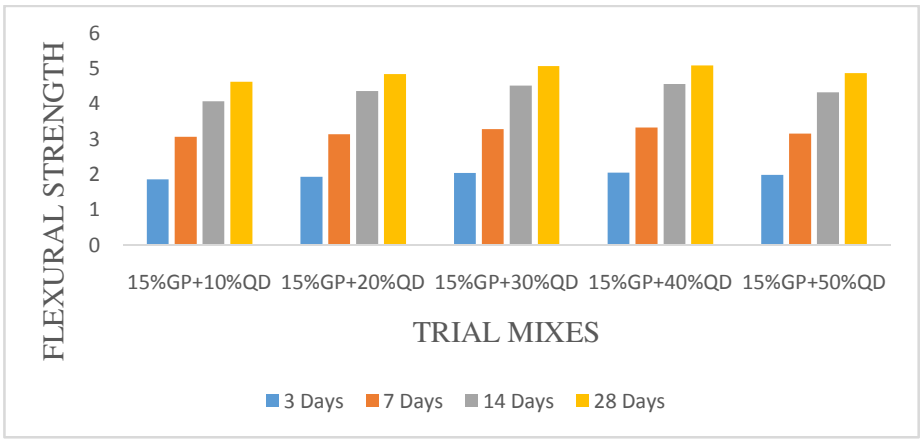

Figure 4.8 Impact of partial replacement of cement by glass powder and fine aggregate by quarry dust on flexural strength of beam

4.5 DENSITY RESULTS

Density of the concrete is the ratio of weight of concrete to its volume. If the concrete is denser then the proper compaction is to be done for the concrete. Therefore as the strength of the concrete is high then density value is also high. The density of concrete depends upon the size of aggregate, method of the compaction, water-cement ratio, time of curing. The density test is conducted for various trial mixes of concrete in the present investigation of study.

Table 4.5 Density values of concrete mixes for 7 and 14 days in kg/m3

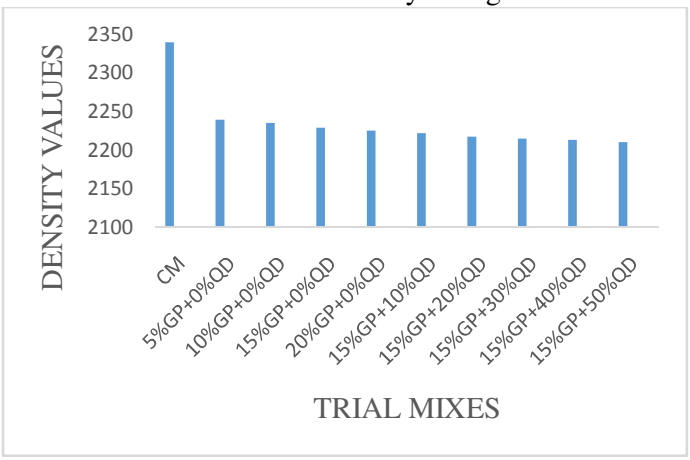

Figure 4.9 Density value of various trial mixes for 7 days

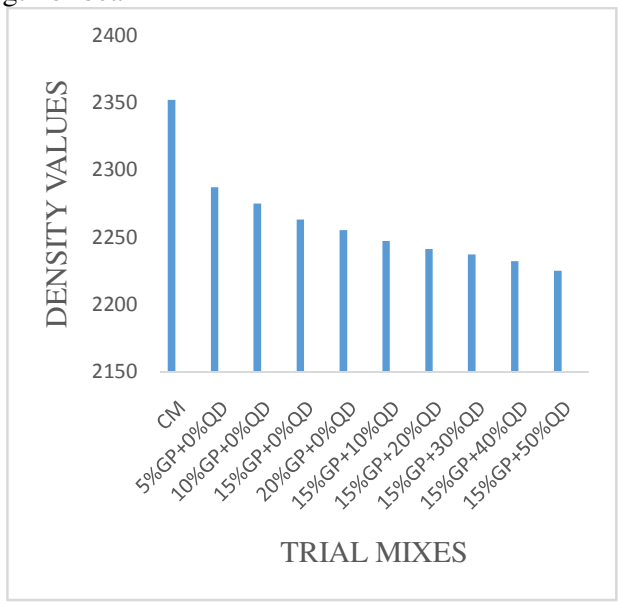

Figure 4.10 Density value of various trial mixes for 28 days

VI. Conclusion

- It is found that 15% replacement of cement by glass powder is the optimum dosage.
- The rise in strength upto 15% substitution of cement by glass powder is due to the pozzolonic reaction of glass powder having high silica content. It effectively

fills the hollow voids and gives a dense concrete structure.

- Beyond 15% replacement the dilution mechanism takes place and the strength drops.
- Workability gradually decreases as the glass content increases.
- Due to reduction in the fineness modulus of the cementatious material, amount of the cement paste available is less to provide the greasy per unit surface area of the aggregate.
- Usage of quarry dust in place of sand reduces the requirement of land fill area and thereby conserving available natural sand and helps in sustainable development.

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