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Experimental Investigation on Preparation of High Performance Concrete

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ABSTRACT: In developing countries where concrete is widely used, the high and steadily increasing cost of the concrete has made construction very expensive. This coupled with deleterious effect of concrete production on the environment and has led to studies on various materials which could be used as partial replacement for cement and coarse aggregate. The only way to reduce and tackle these problems is to reuse and recycle. The material used as partial replacement for cement is glass powder. The entire waste glass collected is crushed into powder. Granite waste was used as a replacement for coarse aggregate. The granite wastes were properly cut down to the size of coarse aggregate and then they were mixed with the concrete. The ideology of the project is to partially replace cement by glass powder in 10%, 20% of weights and to replace blue metal by granite waste in 10%, 20% and 30% of weight and to investigate the behaviour of combination of partial replacement of these two materials.

KEYWORDS: Special concrete, Glass powder, granite waste, high performance.

I. INTRODUCTION

Concrete is a common construction material in India and its production causes the severe environmental concerns. Concrete productions involves usage of large quantities of natural resources such as aggregates and further cement an ingredient of concrete whose production involves release of large quantity of carbon dioxide which is a harmful green house gas which leads to various effects like ozone depletion and global warming. The experimental work presented in this research looks at the use of glass and granite as an eco friendly material to replace cement and aggregate in the production of concrete masonry blocks as well as structural concrete.

Objectives

To create a special concrete which is satisfying in terms of both economical and structural aspects by partial replacement of cement by glass powder and partial replacement of coarse aggregate by granite waste.

Glass powder & Granite

Waste glass available locally was collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it has to be powdered to desired size.

Granite is intrusive igneous rock. Waste was collected nearby roadside damaged during transportation and gets wasted when buildings with granite flooring are demolished.

II. MATERIAL PREPARATION AND PRELIMINARY TESTING OF MATERIALS

This project is experimented to reduce the cost of concrete. The only ways to reduce and tackle these problems is to reuse and recycle. The material used for partial replacement is glass powder. The entire waste glass collected from the roadsides and shops and these collected glasses are crushed into powder by using Los Angeles abrasion test machine. This material is used concrete as partial replacement of cement. The partial replacement of coarse aggregate

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by granite waste. This granite gets damaged during transportation and gets wasted when buildings with granite flooring are demolished. The granite wastes were properly cut down to the size of coarse aggregate and then they were mixed with the concrete.

Basic Test and Results

The following tables give the specific gravity and water absorption values of the various ingredients of concrete

Specific Gravity and Water Absorption of Fine Aggregate (Sand)

Table 1 Specific Gravity and Water Absorption of Fine Aggregate

Description	Trial 1	Trial 2 (g)	Trial 3 (g)
Wt. of Saturated Surface Dry Sample (A)	0.569	0.570	0.570
Wt. of Pycnometer + Sample + Water (B)	1.835	1.836	1.837
Wt. of Pycnometer + Water (C)	1.525	1.525	1.526
Wt. of Oven Dry Sample (D)	0.564	0.554	0.554
Specific Gravity	2.139	2.139	2.139
Water Absorption	2.827	2.827	2.827
Average results	Specific Gravity		2.139
	Water Absorption		2.827

Specific Gravity and Water Absorption of Coarse Aggregate (Blue Metal) - 12.5 mm

Table 2 Specific Gravity and Water Absorption of Coarse Aggregate (Blue Metal) – 12.5 mm

Description	Trial 1 (g)	Trial 2 (g)	Trial 3 (g)
Wt. of Saturated Surface Dry Sample (A)	1.002	1.001	1.001
Wt. of Pycnometer + Sample + Water (B)	4.094	4.093	4.090
Wt. of Pycnometer + Water (C)	3.465	3.464	3.464
Wt. of Oven Dry Sample (D)	1.001	0.996	0.990
Specific Gravity	2.691	2.677	2.642
Water Absorption	0.100	0.502	1.11
Average Results	Specific Gravity		2.670
	Water Absorption		0.570

Specific Gravity and Water Absorption of Coarse Aggregate (Blue Metal) - 20 mm

Table 3 Specific Gravity and Water Absorption of Coarse Aggregate (Blue Metal) - 20 mm

Description	Trial 1	Trial 2	Trial 3
Wt. of Saturated Surface Dry Sample	1.003 g	1.004 g	1.002 g
Wt. of Pycnometer + Sample + Water	4.102 g	4.089 g	4.085 g
Wt. of Pycnometer + Water (C)	3.469 g	3.463 g	3.466 g
Wt. of Oven Dry Sample (D)	1.000 g	1.000 g	1.001 g
Specific Gravity	2.717	2.646	2.614
Water Absorption	0.300	0.400	0.100
Average Results	Specific Gravity		2.659
	Water Absorption		0.266

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Sieve Analysis

The following tables give the grain sizes of the various ingredients of concrete

Table 4 Sieve Analysis

20mm		12.5mm		Sand	
Sieve size	Weight Retained (kg)	Sieve size	Weight Retained (kg)	Sieve size	Weight Retained (kg)
25mm	0.023	16mm	2.080	4.75mm	0.059
20mm	0.537	12.5mm	0.508	2.36mm	0.086
10mm	2.373	10mm	0.339	1.18mm	0.384
4.75mm	0.067	4.75mm	0.071	600u	0.327
Pan	0	Pan	0.002	300u	0.125

Table 5 Sieve Analysis

cement		Glass powder		Granite	
Sieve size	Weight Retained (kg)	Sieve size	Weight Retained (kg)	Sieve size	Weight Retained (kg)
300u	0.001	300u	0.391	25mm	0.039
150u	0.585	150u	0.413	20mm	1.649
Pan	0.415	Pan	0.022	10mm	1.187
				4.75mm	0.115
				Pan	0.010

Los angeles abrasion test

Table 6 Los angeles Abrasion test

The following table gives the weight of sample obtained while conducting the test.

Samples	2.5kg
No of balls	12
Rotation	500
Sample passing 1.70mm sieve	0.692kg
Sample retained 1.70mm sieve	1.808kg
Formula	$(W_2-w_1)/ w_2 \times 100$

Table 7 Slump cone test and flow table test

The following table shows the comparison of slump values between conventional and HP concrete

S.no	Volume of slump	Water content	Slump value		Flow percentage	
			Normal	Special	Normal	Special
1	0.0058m ³	0.97	100	100	60	60

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III. MIX DESIGN AND MIX PROPORTIONING

Mix design for 100mm slump

Stipulations for Proportioning

Grade designation	: M25
Type of Cement	: OPC 53 grade
Maximum nominal size of aggregate	: 20mm
Minimum cement content	: 280 kg/m ³
Maximum water-cement ratio	: 0.45
Workability	: 100 mm (slump)
Type of aggregate	: Crushed angular aggregate
Specific gravity of cement	: 3.15
Specific gravity of:	
• Coarse aggregate (20mm)	: 2.660
• Coarse aggregate (12.5mm)	: 2.663
• Fine aggregate	: 2.139
Water absorption of:	
• Coarse aggregate (20mm)	: 0.233
• Coarse aggregate (12.5mm)	: 0.604
• Fine aggregate	: 2.455
	= 0.647 m³

Mix Proportions

Cement	= 492.5 kg/m ³
Water	= 197 litres
Sand	= 498.216 kg/m ³
Blue metal (12.5mm)	= 434.186 kg/m ³
Blue metal (20mm)	= 650.546 kg/m ³

Mix Ratio

Cement :	Sand :	Blue metal
492.5 kg	498.216 kg	1084.732 kg
1:1.012:2.203		

Water absorption

20mm	= (0.266% x 650.546)	=	1.730
12.5mm	= (0.57% x 434.186)	=	2.475
Sand	= (2.827% x 498.216)	=	<u>14.084</u>
			18.289

Total water to be used in concrete = Water to be used according to design + Water absorbed by materials

Water = 197 + 18.467 = 215.289 lt/m³

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Table 8 Mix proportioning

MIX NO	GLASS POWDER	GRANITE WASTE
C ₀	0	0
C ₁	10%	10%
C ₂	20%	10%
C ₃	10%	20%
C ₄	20%	20%
C ₅	10%	30%
C ₆	20%	30%

IV. SAMPLE PREPARATION & TESTING

The test specimens were cubes, cylinder and prisms. For each ratio 9 cubes were cast and a cylinder and prisms were cast. For 7th day 3cubes were tested and their average values were taken .the same procedure was followed for 14th day and 28th day results. Cylinder and prisms were tested directly for 28th days.

The cubes were of dimension 150mm x150mm x 150mm. The prisms has a nominal dimension of 500mm x 100mm x 100mm and the cylinder has a nominal dimension of 150mm diameter and height 300mm in height .

Table 9 Weighing Materials of Nominal

Materials	For 1m ³ concrete	For 0.045m ³ concrete
Cement	492.5kg	22.1625kg
Sand	498.216kg	22.420kg
Blue metal(12.5mm)	434.186kg	19.538kg
Blue metal (20mm)	650.546kg	29.295kg
Water	197lit	8.865lit

Compressive strength of concrete cube

The cast specimens were tested on their respective schedules of testing cubes were tested for compressions in compression test machine .Cylinders were tested for split tension and prisms were tested for flexure. The following figures show the failure of specimens during compressive, split tension and flexure test.

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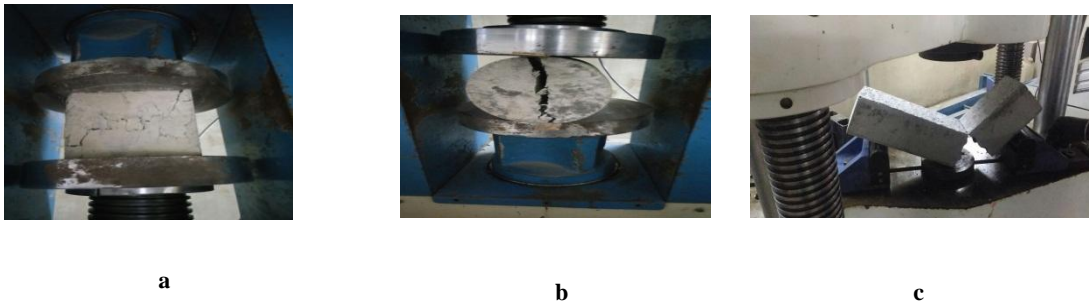


Fig 1 Tests on concrete after 28 days of curing (a) compression test, (b) split tension test, (c) flexural test

The strength values of concrete cubes after 28 days of curing has been given in the table below

Table 10 Compression test results of cubes after 28 days of curing

Mix No	Strength in N/mm ² (28days)			Average
	1	2	3	
C ₀	31.10	32.10	32.00	32.00
C ₁	43.33	43.58	43.79	43.57
C ₂	43.05	42.90	42.95	42.97
C ₃	42.55	41.93	42.30	42.26
C ₄	36.44	37.10	37.01	36.85
C ₅	40.45	40.12	40.56	40.38
C ₆	34.67	34.55	34.20	34.47

Split tension test

Concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. The tensile strength of concrete is one of the basic and important properties. The splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

Table 11 Split tension test results

MIX NO	STRENGTH N/mm ²
C ₀	1.59
C ₁	3.11
C ₂	2.70
C ₃	1.69
C ₄	2.13
C ₅	1.62
C ₆	1.15

Flexural test

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 50 cm x 10 cm x 10 cm concrete prisms with a span

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length at least three times the depth .The flexural strength is expressed as modulus of rupture (MR) IN (N/mm²) and is determine by standard test methods confirming to IS 516:1959.

Table 12 Flexural test results

MIX NO	STRENGTH
C ₀	6.50
C ₁	7.50
C ₂	7.25
C ₃	6.95
C ₄	7.25
C ₅	6.55
C ₆	6.10

V. COST ANALYSIS

Table 13 Cost Analysis

S.No	Description	Nominal	C1	C2	C3	C4	C5	C6
1	Cement	3940	3546	3152	3546	3152	3546	3152
2	Sand	747	747	747	747	747	747	747
3	12.5 mm	378	378	378	378	378	378	378
4	20mm	567	510	510	454	454	370	370
5	Granite	-	-	-	-	-	-	-
6	Glass powder	-	-	-	-	-	-	-
Total weight in kilograms		5632	5181	4787	5125	4721	5041	4647

VI. RESULTS AND DISCUSSION

The compressive strength test on both conventional and glass powder , granite waste added concrete was performed on standard compression test machine. Totally 21 cubes were cast and were tested for the compressive strength at the age of 28 days. The split tensile strength was tested by using split tension test machine, totally 7 cylinders were cast and were tested for the split tension test at the age of 28 days. Totally 7 prism were cast and were tested for flexural strength at the age of 28 days of both conventional and glass powder, granite waste added concrete.

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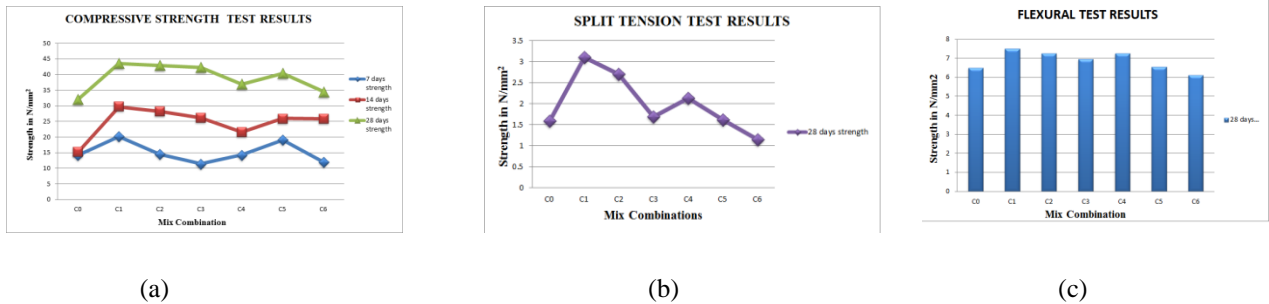


Fig 2 Graphical representation of tests on concrete after 28 days of curing(a) compression test, (b) split tension test, (c) flexural test.

VII. CONCLUSION

Therefore, the various materials have been collected and prepared to be used for concrete specimen casting. The various techniques and replacement to be implemented have also been briefed. Several basic tests were conducted on the materials & fresh concrete and their results have been included in this report. The mix design and proportions have been calculated. The test and results of the casted concrete cubes, prisms and cylinders was tabulated for various percentages. From the above test results it has been found that the blue metal can be successfully replaced with granite chips and cement can be partially replaced by glass powder to produce high strength concrete. The best strength was found in mix combination C1. It was found that further increase in percentage of replacement in concrete mixes reduces the compressive strength of the concrete.

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