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Experimental Study of Waste Glass Powder as Partial Replacement of Cement in Concrete

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Abstract: Glass is used in many forms in day-to-day life. It has limited life span and after use it is either stock piled or sent to landfills. Since glass is non-biodegradable, landfills do not provide an environment friendly solution.
Hence, there is strong need to utilize waste glasses. Many efforts have been made to use waste glass in concrete industry as a replacement of coarse aggregate, fine aggregate and cement. Its performance as a coarse aggregate replacement has been found to be non-satisfactory because of strength regression and expansion due to alkali-silica reaction. The research shows that there is strength loss due to fine aggregate substitution also.
The aim of the present work was to use glass powder as a replacement of cement to assess the pozzolanic activity of fine glass powder in concrete. A series of tests were conducted to study the effect of 15%, 20%, 25%, 30% and 40% replacement of cement by glass powder on compressive strength, Flexure strength, Tensile strength, and workability.
Keywords: Waste glass powder, workability, compressive strength, flexure strength, tensile strength.

I. INTRODUCTION

Concrete is one of the world's most used construction material due to its versatility, durability and economy. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. The main characteristic of concrete is that it can be designed to withstand against environments environmental factor.

Today global warming and environmental devastation have become manifest harms in recent years. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not treated carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required.

The term glass contains several chemical diversities including soda-lime silicate glass, alkali-silicate glass and Boro-silicate glass. To date, these types of glasses glass powder have been widely used in cement and aggregate mixture as pozzolana for civil works. The introduction of waste glass in cement will increase the alkali content in the cement.

It also helps in bricks and ceramic manufacture and it preserves raw materials, decreases energy consumption and volume of waste sent to landfill. Recently, Glasses and its powder have been used as a construction material to decrease environmental problems.

II. LITERATURE REVIEW

The review of a number of literatures shows the importance of this field of research. The findings show that materials like waste glass powder can be incorporated to improve the properties of concrete. This kind of materials is easy to use in concrete because it does not require any extra treatment.

The results show the improved characteristics of the blended concrete in terms of compressive, tensile and flexural strength & durability parameters as well. Many try has been carried out to replace fine aggregate and coarse aggregate but the result does not satisfy the requirement. But for partial replacement in cement ratio it is observed to be satisfying the requirement. The approach is an integrated one in that it links durability index parameters, and performance specifications. The current study is concerned with the incorporation of glass powder in concrete with different percentage and conducts workability test, compressive test, flexural test, and tensile test.

III. OBJECTIVES OF WORK

A. Use the waste glass powder as a partial replacement of cement in concrete.
B. Study the effect on the concrete by changing the proportion of the glass powder in concrete.
C. To determine the most suitable percentage of Glass powder as a replacement of cement in concrete to achieve desired needs.

IV. SCOPE OF WORK

A. The study is to study the effect on the concrete by changing the proportion of the glass powder in concrete.

B. Work flow defined is as under

1) To prepare cubes of M20, M25 and M30 grade of concrete.

2) To prepare cubes by replacing cement by west glass powder (0%, 15%, 20%, 25%, 30% and 40%).

3) Conduct Workability tests

a) Slump Test

4) Conduct strength tests

a) Compressive strength test

b) Flexural strength test

c) Tensile strength test

C. To compare the result.

V. MATERIALS

Concrete is mixture of cement, fine aggregate, coarse aggregate, water and admixtures (if required). Here in this study glass powder is used as pozzolanic material as replacement of cement in different percentages (0%, 15%, 20%, 25%, 30%, 40%). So, for this study cement, fine aggregate, coarse aggregate and glass powder (pozzolanic material) materials are used for better strength and carries out the tests for its strength.

VI. METHODOLOGY

A. Mix Design

As per IS 10262 prepare a mix design of M60 and M65 grade of concrete. In this MIX design fibres, Nano silica are added in different percentage. Table no. I and II show the mix design of M60 and M65 grade of concrete.

TABLE I MIX DESIGN OF M20 GRADE OF CONCRETE

Cement	Water	Sand	Coarse aggregate	Density
358.47 Kg/m^3	197 Kg/m^3	672.19 Kg/m^3	1269.96 Kg/m^3	2497.6 Kg/m^3
1	0.54	1.87	2.83	-

TABLE III MIX DESIGN OF M25 GRADE OF CONCRETE

Cement	Water	Sand	Coarse aggregate	Density
394 Kg/m^3	197 Kg/m^3	661.45 Kg/m^3	1249.69 Kg/m^3	2502.14 Kg/m^3
1	0.5	1.68	3.17	-

TABLE IIIII MIX DESIGN OF M30 GRADE OF CONCRETE

Cement	Water	Sand	Coarse aggregate	Density
438 Kg/m^3	197 Kg/m^3	646.82 Kg/m^3	1222.04 Kg/m^3	2503.86 Kg/m^3
1	0.44	1.47	2.78	-

B. Mixing And Casting

Hand mixing is adopted for mixing and preparation of concrete and mixed concrete is moulded into cube, cylinders and beam for different tests.

C. Curing

When the casting work is over moulded specimens are kept at room temperature for 24 hours. After this specimens are taken out from mould carefully without any damage to the surface and immersed in water for 28 days.

D. Testing

The specimens cured are tested according to IS 516: 1959 code standards and ASTM C1202, ASTM C 1585 – 04. The entire strength tests were done according to IS 516: 1959. The results mentioned were average of the values obtained from three specimens.

VII. RESULTS AND DISCUSSION

A. Slump Test

TABLE IVV RESULTS OF SLUMP TEST (M20 GRADE OF CONCRETE)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Slump value (mm)
1	C-G0	0%	M20	98
2	C-G15	15%	M20	93
3	C-G20	20%	M20	89
4	C-G25	25%	M20	85
5	C-G30	30%	M20	80
6	C-G40	40%	M20	76

TABLE V RESULTS OF SLUMP TEST (M25 GRADE OF CONCRETE)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Slump value (mm)
1	C-G0	0%	M25	96
2	C-G15	15%	M25	94
3	C-G20	20%	M25	90
4	C-G25	25%	M25	85
5	C-G30	30%	M25	82
6	C-G40	40%	M25	77

TABLE VI RESULTS OF SLUMP TEST (M30 GRADE OF CONCRETE)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Slump value (mm)
1	C-G0	0%	M30	99
2	C-G15	15%	M30	97
3	C-G20	20%	M30	91
4	C-G25	25%	M30	87
5	C-G30	30%	M30	81
6	C-G40	40%	M30	83

VIII. COMPRESSIVE STRENGTH

TABLE VII Results of Compressive strength of concrete at 7 days of curing (M20 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M20	17.65
2	C-G15	15%	M20	18.46
3	C-G20	20%	M20	20.82
4	C-G25	25%	M20	23.52
5	C-G30	30%	M20	22.43
6	C-G40	40%	M20	21.97

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TABLE VIII Results of Compressive strength of concrete at 7 days of curing (M25 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M25	20.84
2	C-G15	15%	M25	22.13
3	C-G20	20%	M25	23.77
4	C-G25	25%	M25	26.9
5	C-G30	30%	M25	26.32
6	C-G40	40%	M25	25.7

TABLE VX Results of Compressive strength of concrete at 7 days of curing (M30 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M30	25.1
2	C-G15	15%	M30	28.2
3	C-G20	20%	M30	28.97
4	C-G25	25%	M30	30.67
5	C-G30	30%	M30	29.78
6	C-G40	40%	M30	27.4

TABLE X Results of Compressive strength of concrete at 28 days of curing (M20 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M20	27.89
2	C-G15	15%	M20	28.32
3	C-G20	20%	M20	31.2
4	C-G25	25%	M20	33.72
5	C-G30	30%	M20	33.6
6	C-G40	40%	M20	31.3

TABLE XI Results of Compressive strength of concrete at 28 days of curing (M25 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M25	33.4
2	C-G15	15%	M25	35.53
3	C-G20	20%	M25	35.9
4	C-G25	25%	M25	37.68
5	C-G30	30%	M25	36.2
6	C-G40	40%	M25	34.96

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TABLE XII Results of Compressive strength of concrete at 28 days of curing (M30 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M30	38.76
2	C-G15	15%	M30	40.27
3	C-G20	20%	M30	41.83
4	C-G25	25%	M30	44.40
5	C-G30	30%	M30	43.72
6	C-G40	40%	M30	42.11

IX. FLEXURAL STRENGTH

TABLE XIII Results of Flexural strength of concrete at 7 days of curing (M20 Grade of concrete)

Sr. No.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M20	2.52
2	C-G15	15%	M20	2.71
3	C-G20	20%	M20	2.87
4	C-G25	25%	M20	3.05
5	C-G30	30%	M20	2.92
6	C-G40	40%	M20	2.79

TABLE XIV Results of Flexural strength of concrete at 7 days of curing (M25 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M25	3.23
2	C-G15	15%	M25	3.41
3	C-G20	20%	M25	3.58
4	C-G25	25%	M25	3.86
5	C-G30	30%	M25	3.72
6	C-G40	40%	M25	3.59

TABLE XV Results of Flexural strength of concrete at 7 days of curing (M30 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M30	4.07
2	C-G15	15%	M30	4.19
3	C-G20	20%	M30	4.37
4	C-G25	25%	M30	4.52
5	C-G30	30%	M30	4.47
6	C-G40	40%	M30	4.41

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TABLE XVI Results of Flexural strength of concrete at 28 days of curing (M20 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M20	3.65
2	C-G15	15%	M20	3.83
3	C-G20	20%	M20	3.96
4	C-G25	25%	M20	4.23
5	C-G30	30%	M20	4.1
6	C-G40	40%	M20	3.85

TABLE XVII Results of Flexural strength of concrete at 28 days of curing (M25 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M25	4.58
2	C-G15	15%	M25	4.65
3	C-G20	20%	M25	4.79
4	C-G25	25%	M25	4.92
5	C-G30	30%	M25	4.76
6	C-G40	40%	M25	4.67

TABLE XVIII Results of Flexural strength of concrete at 28 days of curing (M30 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M30	5.78
2	C-G15	15%	M30	5.88
3	C-G20	20%	M30	6.03
4	C-G25	25%	M30	6.11
5	C-G30	30%	M30	5.99
6	C-G40	40%	M30	5.91

X. SPLIT TENSILE STRENGTH

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M20	2.18
2	C-G15	15%	M20	2.31
3	C-G20	20%	M20	2.49
4	C-G25	25%	M20	2.72
5	C-G30	30%	M20	2.61
6	C-G40	40%	M20	2.5

TABLE XX Results of split tensile strength of concrete at 7 days of curing (M25 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M25	2.46
2	C-G15	15%	M25	2.72
3	C-G20	20%	M25	3.02
4	C-G25	25%	M25	3.24
5	C-G30	30%	M25	3.13
6	C-G40	40%	M25	2.96

TABLE XXI Results of split tensile strength of concrete at 7 days of curing (M30 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M30	2.93
2	C-G15	15%	M30	3.12
3	C-G20	20%	M30	3.43
4	C-G25	25%	M30	3.69
5	C-G30	30%	M30	3.56
6	C-G40	40%	M30	3.39

TABLE XXII Results of split tensile strength of concrete at 28 days of curing **(**M20 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M20	2.9
2	C-G15	15%	M20	3.16
3	C-G20	20%	M20	3.43
4	C-G25	25%	M20	3.62
5	C-G30	30%	M20	3.51
6	C-G40	40%	M20	3.52

TABLE XXIII Results of split tensile strength of concrete at 28 days of curing (M25 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M25	3.32
2	C-G15	15%	M25	3.59
3	C-G20	20%	M25	3.92
4	C-G25	25%	M25	4.16
5	C-G30	30%	M25	3.96
6	C-G40	40%	M25	3.73

TABLE XXIV Results of split tensile strength of concrete at 28 days of curing (M30 Grade of concrete)

Sr. no.	Name of Sample	% of Glass Powder	Grade of Concrete	Strength N/mm^2
1	C-G0	0%	M30	3.76
2	C-G15	15%	M30	3.97
3	C-G20	20%	M30	4.11
4	C-G25	25%	M30	4.43
5	C-G30	30%	M30	4.28
6	C-G40	40%	M30	4.02

XI. CONCLUSIONS

A. Waste Glass powder can be used as partial replacement of cement in concrete.
B. Using waste glass powder the workability of a concrete is decreased for M20, M25 and M30 grade of concrete.
C. Using waste glass powder the compressive strength of concrete increases up to some extent (25% waste glass powder) then decreases for M20, M25 and M30 grade of concrete.
D. Using waste glass powder the flexural strength of concrete increases up to some extent (25% waste glass powder) then decreases for M20, M25 and M30 grade of concrete.
E. Using waste glass powder the split tensile strength of concrete increases up to some extent (25% waste glass powder) then decreases for M20, M25 and M30 grade of concrete.

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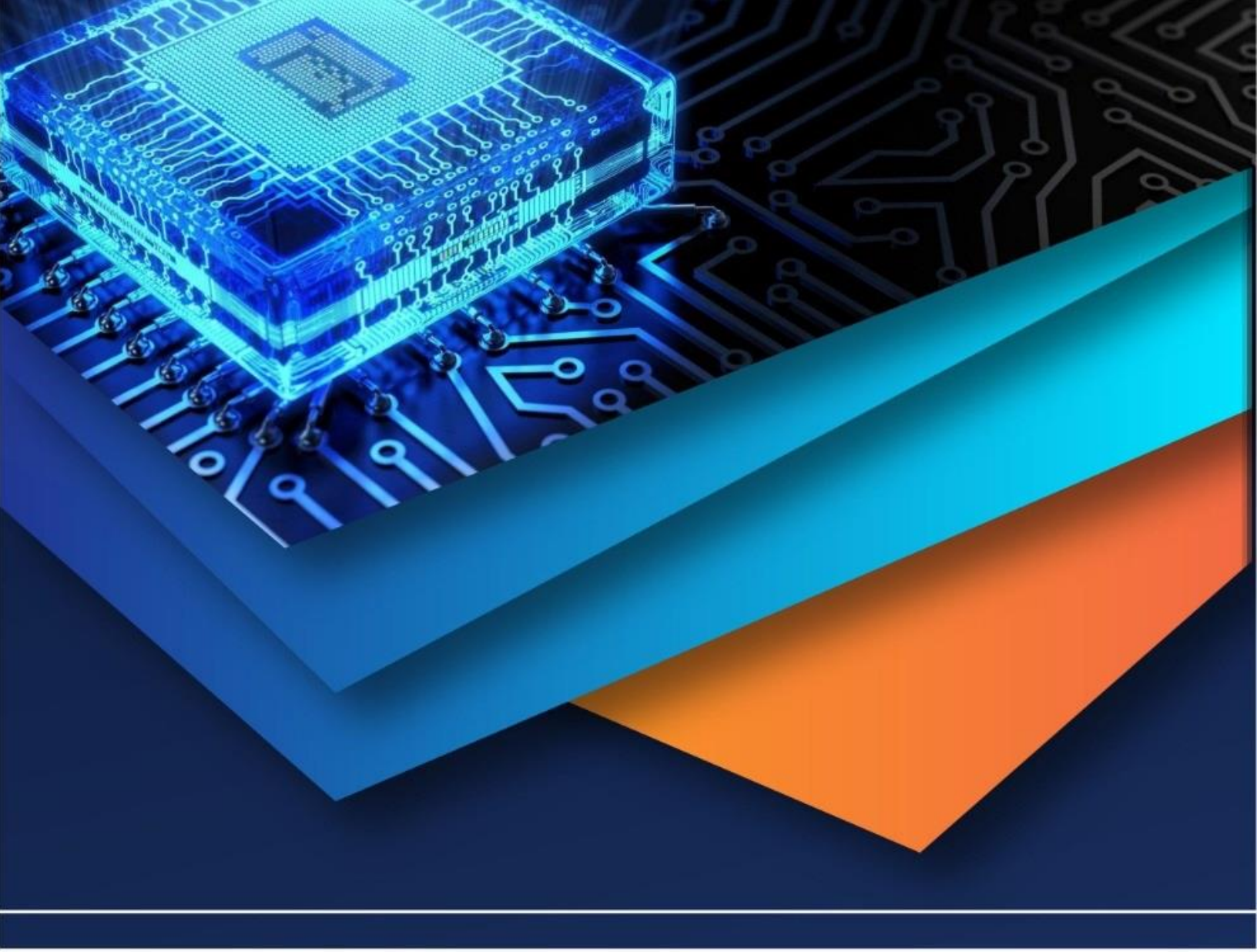

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