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An Experimental Study on Strength and Durability Characteristics of Concrete Made of Glass Powder

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Abstract - *In a growing country like India a huge amount of industrial waste are polluting the Environment. With a view to the above, this study aims at utilization of such industrial by product for value added application. In addition the waste can improve the properties of construction materials. The recycled glass has been used in the form of powder. The waste glass powder was tested with concrete. Cement was replaced by the waste glass powder in the proportion of 0%, 5%, 10%, 15%, 20%, 25% and 30% for concrete with suitable water cement ratio. The compressive strength, split tensile strength, flexural strength and durability characteristics were conducted for the above replacements. The result showed glass powder improves the mechanical properties. The advantages of this project are that the replacement of waste glass powder is economically cheap as well as a superior concrete can be made.*

Key Words: **Industrial Waste1, Environment Pollution2, Recycled Glass3, Concrete Strength4, Superior Concrete5**

1. INTRODUCTION

Concrete the most imperative substantial in present day development. It has adaptable properties like simple mouldability, high compressive quality, and enduring solidness. These properties of cement have made it most mainstream development material for a wide range of structural designing works. The most recent improvements in solid innovation have made it conceivable to utilize it in mind boggling and structurally complex structures, requiring high level of execution, and tasteful appearance. It is gotten by blending bond, water, and totals in required extent. The solidifying is caused by concoction activity amongst water and bond, it proceeds for quite a while and thusly the solid becomes more grounded with age.

1.1 Supplementary Cementitious Materials

Following are the important supplementary cementitious materials used in concrete.

- Glass Powder
- Micro Silica
- Ground Granulated Blast Furnace Slag (GGBS)
- Fly Ash Powder
- Rice Shell Ash

1.2 Glass Powder as Partial Replacement for Cement

Waste lessening and reusing are basic segments in waste organization outline since they benefit to direct regular assets, diminish enthusiasm for essential landfill space, reduce need of rough resources to make new thing, decrease air and water effluence, diminish imperativeness and make novel occupations. It is worth saying that in Eastern zero waste platform it is assessed that advantage efficacy perfections here and there the chains can decrease resource wellsprings of data requirements by 18– 25% by 2028 and a better usage of benefits can talk than a general saving capacity of €680 billion per year for Eastern European industry.

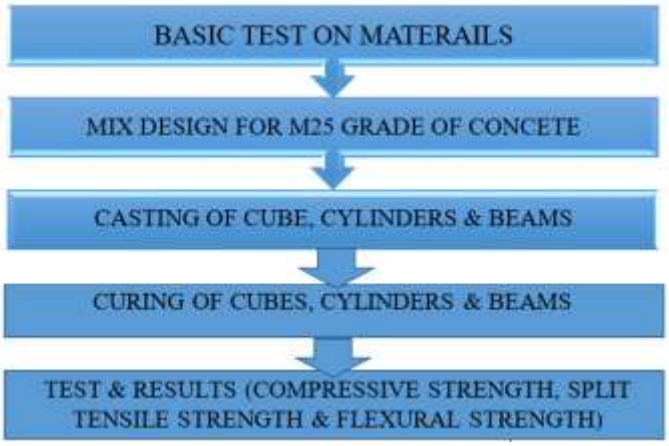
Additionally, more than 190,000 through livelihoods in the European provinces by 2028, despite the assessed 500,000 occupations that resolve be made by execution of waste authorization in drive. They determination provoke sufficient in the region of 12% and 42% of the rough substantial demand in the European regions, although adding to attaining the European center to diminish ozone hurting substance transmissions by 30% – 68 Mt of CO_2 per year would be kept up a key separation from in 2028. Anyhow, the usage of reused cut-glass in the collecting of novel glass diminishes imperativeness use, unrefined resource use, and wearing and tearing on equipment. Nevertheless, not all waste glasses can be reused into novel glass since contaminating impacts, price, or varied shades.

2. OBJECTIVES

- To investigate the effect of variable percentage of powdered glass content on workability of M25 grade concrete.
- To investigate the effect of varying percentage of powdered glass content on compressive strength of M25 grade concrete.
- To investigate the effect of variable proportion of powdered glass on split tensile forte of M25 grade concrete.
- To examine the effect of variable percentage of powdered glass content on flexural tensile strength of M25 grade concrete.

- To investigate the durability possessions of concrete in standings of compressible, split tensile and flexural strength when immersed in 5% NaCl solution.
- To examine the durability possessions of concrete in standings of compressible, split tensile and flexural strength when immersed in 5% $MgSO_4$ solution.

3. METHODOLOGY



3.1 Raw Materials

- Cement (OPC 43 Grade)
- Coarse Aggregate (20mm Downsize)
- Fine Aggregate (M-sand)
- Glass Powder
- Chemical admixture
- Water

3.2 Mix Proportions for M25 Grade Concrete

Table-1: Mix design proportion for M25 grade concrete

Cement	Fine aggregate	Coarse aggregate	w/c ratio
355Kg/m³	819 Kg/m³	1030 Kg/m³	0.5
1	2.30	2.9	-

4. RESULTS AND DISCUSSION

In this chapter, results obtained from the experiments conducted on cement, glass powder, fine aggregate, coarse aggregate, fresh concrete and mix design proportions of M25 grade concrete are discussed. Influence of replacement of cement by glass powder on compressive strength, flexural and split tensile strength of hardened concrete and also durability parameters results are discussed.

4.1 Test Results of Raw Materials

Table-2: Test Results of Cement

Sl. No.	Property		Value	Standard values [IS 8112 (2013)]
1	Fineness by dry sieve analysis		5.73	-
2	Soundness (Le–Chatelier method) (mm)		0.5	10 (maximum)
3	Standard consistency (%)		33.0	Not specified
4	Initial setting time (minutes)		240	30 (minimum)
5	Final setting time (minutes)		430	600 (maximum)
6	Compressive strength (MPa)			
	a)	72 ± 1 h (3 days)	28	23 (minimum)
	b)	168 ± 2 h (7 days)	37	33 (minimum)
	c)	672 ± 4 h (28 days)	45	43 (minimum)
7	Density (g/cc)		3.11	Not specified

Table-3: Test Results of Fine Aggregate

Sl. No.	Property	Value		Remarks
1	Sieve analysis	IS sieve designation	Percentage passing	Conforms to grading zone I of IS 383 (2016)
		10 mm	100	
		4.75 mm	94	
		2.36 mm	77	
		1.18 mm	60	
		600 micron	44	
		300 micron	22	
		150 micron	6	
2	Specific gravity	2.52		–
3	Water absorption (%)	1.0		–

Table-4: Test Results of Coarse Aggregate

Sl. No.	Property	Value		Remarks
1	Sieve analysis	IS sieve designation	Percentage passing	Conforms to Table 7 of IS 383 (2016)
		20mm	84.5	
		16mm	45.3	
		12.5 mm	14.68	
		10 mm	1.62	
		4.75 mm	0.06	
		Pan	0	
2	Specific gravity	2.70		–
3	Water absorption (%)	0.61		–

Table-5: Test Results of Glass Powder

Sl. No.	Property	value
1	Fineness by dry sieve analysis	5.6%
2	Specific gravity	3.04

4.2 Test Results of Fresh Concrete

Table-6: Test Results of Fresh Concrete

% glass powder	Slump (mm)
0.0 (Normal concrete)	110
5	100
10	94
15	90
20	88
25	86
30	83

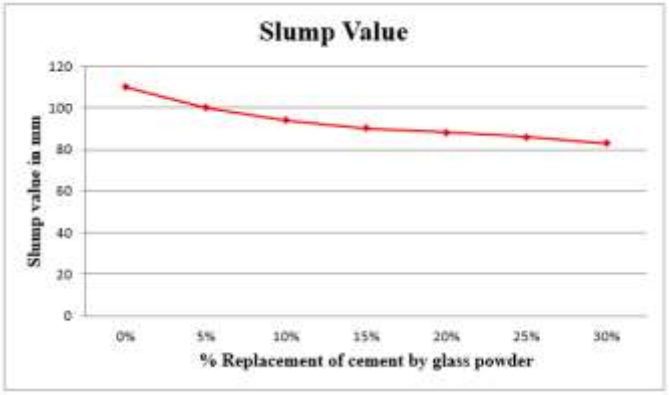


Chart-1: Slump value for % replacement of cement by glass powder

4.3 Test Results of Hardened Concrete

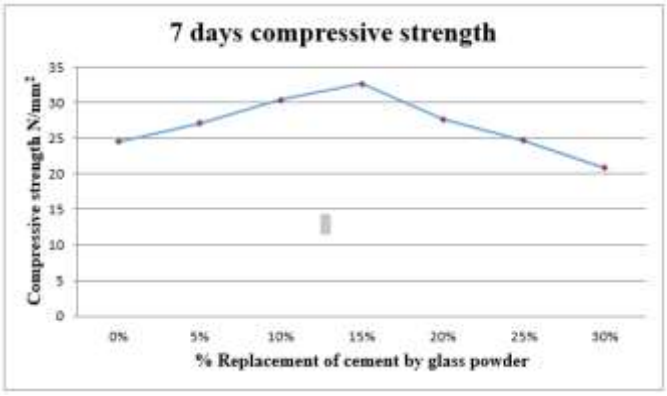


Chart-2: 7 days compressive strength

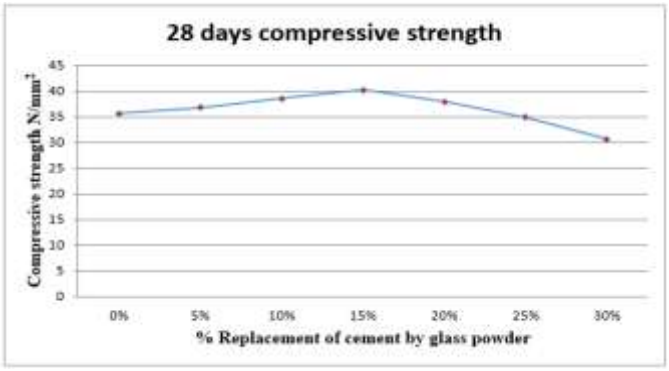


Chart-3: 28 days compressive strength

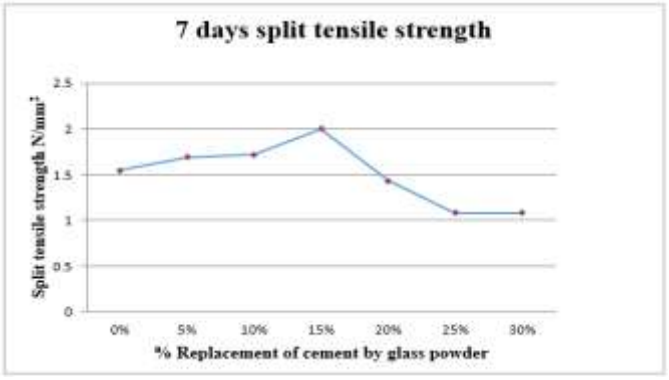


Chart-4: 7 days split tensile strength

Chart-5: 28 days split tensile strength

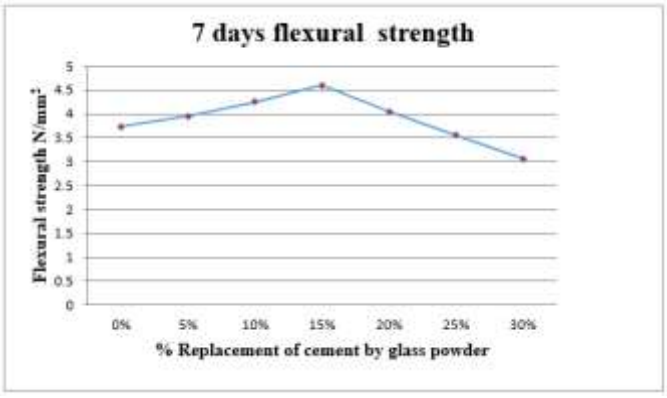


Chart-6: 7 days flexural strength

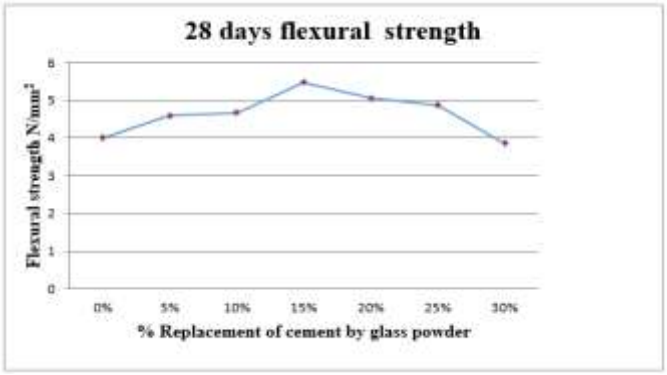


Chart-7: 28 days flexural strength

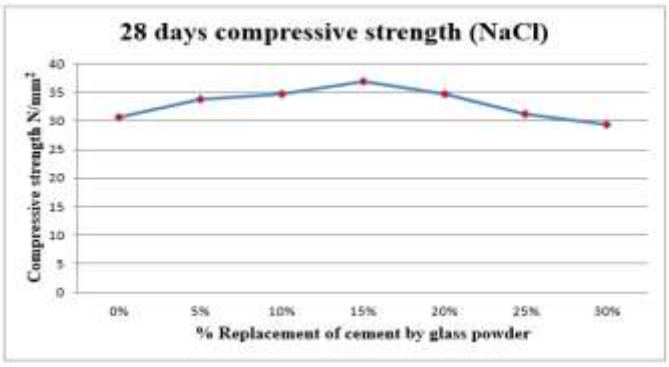


Chart-8: 28 days compressive strength of concrete when immersed in 5% NaCl solution

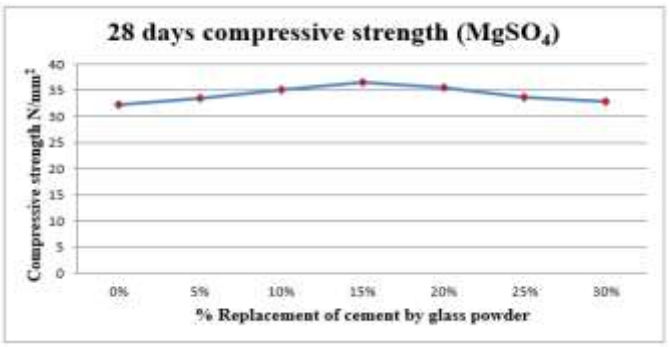


Chart-9: 28 days compressive strength of concrete when immersed in 5% $MgSO_4$ solution

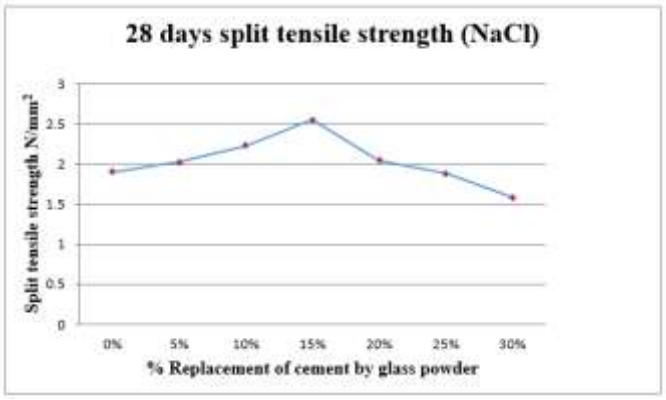


Chart-10: 28 days split tensile strength of concrete when immersed in 5% NaCl solution

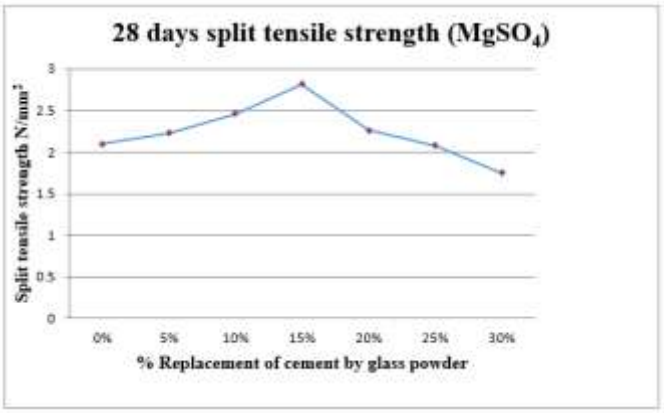


Chart-11: 28 days split tensile strength of concrete when immersed in 5% $MgSO_4$ solution

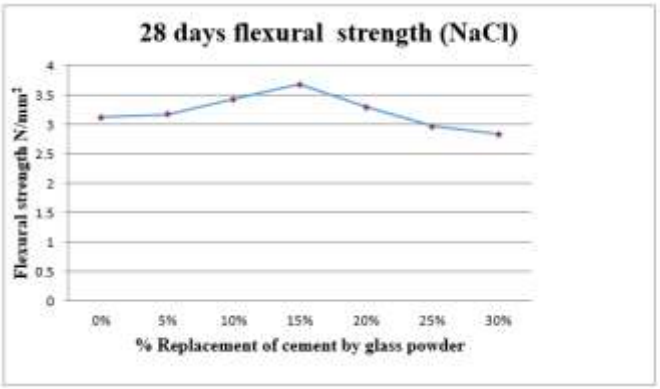


Chart-12: 28 days flexural strength of concrete when immersed in 5% NaCl solution

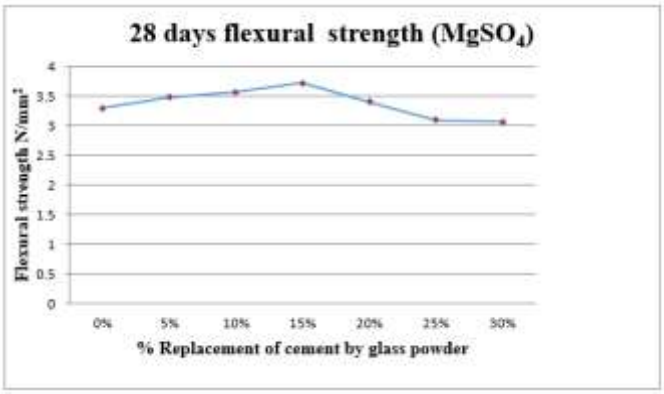


Chart-13: 28 days flexural strength of concrete when immersed in 5% $MgSO_4$ solution

5. CONCLUSIONS

In the present study on "An Experimental Study on Strength and Durability Characteristics of Concrete Made of Glass Powder", the following important conclusions are drawn.

1. It can be observed that workability measured in terms of slump reduces with increase in percentage of replacement of cement by glass powder.
2. For both 7 and 28 days, compressive strength of concrete increases with increase in replacement of cement by glass powder content up to 15%, with further increase in glass powder content decrease, in compressive strength is observed.
3. For both 7 and 28 days, split tensile strength of concrete increases with increase in replacement of cement by glass powder content up to 15%, with further increase in glass powder content decrease, in split tensile strength is observed.
4. For both 7 and 28 days, flexural strength of concrete increases with increase in replacement of cement by glass powder content up to 15%, with further increase in glass powder content decrease, in flexural strength is observed.
5. It can be observed that when 5% NaCl solution, 28 days compressive strength of concrete reduces, as compared to normal curing with portable water. Further 28 days compressive strength of concrete cured in 5% NaCl solution increase with increase in percentage of cement replacement by glass powder up to 15% and then compressive strength is found to be decrease with further increase in glass powder content.
6. It can be observed that when 5% $MgSO_4$ solution, 28 days compressive strength of concrete reduces, as compared to normal curing with portable water. Further 28 days compressive strength of concrete cured in 5% $MgSO_4$ solution increase with increase in percentage of cement replacement by glass powder up to 15% and then compressive strength is found to be decrease with further increase in glass powder content.
7. It can be observed that when 5% NaCl solution, 28 days split tensile strength of concrete reduces, as compared to normal curing with portable water. Further 28 days split tensile strength of concrete cured in 5% NaCl solution increase with increase in percentage of cement replacement by glass powder up to 15% and then split tensile strength is found to be decrease with further increase in glass powder content.
8. It can be observed that when 5% $MgSO_4$ solution, 28 days split tensile strength of concrete reduces, as compared to normal curing with portable water. Further 28 days compressive strength of concrete cured in 5% $MgSO_4$ solution increase with increase in percentage of cement replacement by glass powder up to 15% and then split tensile strength is found to be decrease with further increase in glass powder content.
9. It can be observed that when 5% NaCl solution, 28 days flexural strength of concrete reduces, as compared to normal curing with portable water. Further 28 days flexural strength of concrete cured in 5% NaCl solution increase with increase in percentage of cement replacement by glass powder up to 15% and then flexural strength is found to be decrease with further increase in glass powder content.
10. It can be observed that when 5% $MgSO_4$ solution, 28 days flexural strength of concrete reduces, as compared to normal curing with portable water. Further 28 days flexural strength of concrete cured in 5% $MgSO_4$ solution increase with increase in percentage of cement replacement by glass powder up to 15% and then flexural strength is found to be decrease with further increase in glass powder content.

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