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Strength Characteristics of M40 Grade Concrete with Partial Replacement of Cement by Nano Silica, Granite Powder and Glass Powder

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Abstract : The main aim of this investigation is to compare the influence of nano silica on the strength properties of cement concrete. The concrete was made by using Ordinary Portland Cement[2,11]. Glass is used in many forms in day-to-day life. Today many researches are going into the use of Portland cement replacements, using many waste materials like pulverized fly ash, ground granulated blast furnace slag (GGBS) etc . Like ways a waste glass powder (GLP) is also used as a binder with partial replacement of cement which take some part of reaction at the time of hydration, also acts as a filler material Here the nano silica is replaced with cement at constant percentage (5%).And along with this Granite powder and Glass powder are replaced with cement by 10% , 20% , 30%, 40% ,50%,60%.. In this study, mechanical properties like compressive strength and split tensile strength at 7 days, 28 days are measured for various combinations of Granite powder, Glass powder with Nano silica.
Keywords : Nano silica, Granite powder, Glass powder, compressive strength, and partial replacement.

1.0 Introduction

The use of large quantities of cement produces increasing co_2 emission and as consequences of greenhouse effect method to reduce the cement content in concrete mixes is the use of silica fines .one of the silica fines high potential as cement replacement and as concrete additive is nano silica [1,3]

Nano silica produced in method is a very fine powder consisting of spherical particles or microsphere with main diameter 150nm with high specific surface area[5] Atmosphere level of co_2 have risen by 30% over past 200 years .the use of recycled waste glass in Portland cement &concrete has attracted a lot of interest worldwide due the increase disposal cost &environment concerns.

The glass being mainly silica based material in amphorous form can b use in cement based application. Being non-biodegradable in nature, glass disposal as landfill has environmental impacts and also could be expensive[3]. Sustainable construction practice means creation and responsible management of a healthy built environment considering resource efficiency and ecology being versatile and economical, concrete became prime construction material over the world, however, it has impacts on the environment

This research examined the potential of waste glass powder to produce sustainable concrete. Experimental work was carried out on the performance of glass in mortar and concrete. Normally 150 million tons of GP had been produced in India[4]. These wastes have been dumped in large vast areas. This GP has the particle size 10^{-6} and these wastes have a capability to mix in air, it may cause air pollution.

Due to this many environmental benefits can be achieved, this aims at significant financial, physical, social benefits too, by saving the land area, cost for maintenance of waste dumping in the industries.

This required the use of special devices for accumulation of fine materials. The issue remaining was what to do with the material collected. In an effort to find a solution to this problem, studies were initiated to find a suitable use for the silica fume. After some investigation, it was found that the SF could be used as a very reactive pozzolanic material in concrete.

The glass being mainly a silica-based material in amorphous form can be used in cement-based applications. The main concerns for the use of crushed glasses as aggregates for Portland cement concrete are the expansion and cracking caused by the glass aggregates due to alkali silica reaction[7,9] .Due its silica content, ground glass is considered a pozzolanic material and as such can exhibit properties similar to other pozzolanic materials such as fly ash, metakaolin, slag

2.0 Materials used

2.1 Nano silica

Fig. 1 Nano silica

Nano silica is produced as a byproduct of the manufacture of silica metal and ferro silicon alloys. Nano silica improve the micro structure and reduce water permeability of harden concrete. Nano silica particles fill the voids of the CSH –gel structure act as nucleus to tightly bond with CSH gel particles .This means that NS application reduces calcium will leaching the rate of cement pastes.

2.2 Glass powder

Using ground glass powder can reduce the use of cement and the associated energy demand and impact on air pollution and CO emission. The slump of concrete seems to increase with the increase in glass powder in the concrete mix. At 10% glass powder content the compressive strength of concrete is higher than that of the control concrete. Above 20% glass powder the strength substantially decreased.

Fig. 2 Glass powder

2.3 Granite powder

In order to solve the environmental problem the Research and Development centers in Karnataka, have decided to use the waste in building and as ceramic products, since the silica content is more[10]. Due to this many environmental benefits can be achieved, this aims at significant financial, physical, social benefits too, by saving the land area, cost for maintenance of waste dumping in the industries.

Fig. 3 Granite powder

2.4 Fine Aggregate

Sand confirmed to grading zone-III as per IS: 383-1970, having specific gravity of 2.6 has been used as fine aggregate for this study.

2.5 Coarse Aggregate

Coarse aggregate obtained from local quarry units has been used for this study. Maximum size of aggregate used is 12.5mm with specific gravity of 2.82.

2.6 Cement

Portland pozzolana cement conforming to IS: 269:1976 and IS: 4031-1967 was used in this study.

2.6 Water

Potable tap water available in laboratory was used for mixing and curing of concrete.

3.0 Mix Design

In present study M40 grade concrete were designed as per IS: 10262- 2009. The weight ratios of mix proportions are tabulated in Table. No. 1

Mix Proportions for Various % Replacement of Admixtures

% = Percentage, C = Cement, CA = Coarse Aggregate, FA = Fine Aggregate

GRADE	%			C (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	WC (kg/m^3)
	GP	5					
	GP	2.5	10	444	640	1100	197
	NS	2.5					
	GP	10					
	GP	5	20	395	640	1100	197
	NS	5					
	GP	15					
	GP	7.5	30	345	640	1100	197
	NS	7.5					
	GP	20					
	GP	10	40	295	640	1100	197

	NS	10					
	GP	25	50	247	640	1100	197
	GP	12.5					
	NS	12.5					
	GP	30	60	198	640	1100	197
	GP	15					
	NS	15					

4.0 Experimental Test Setup:

Concrete cubes confirming to IS: 516:1964 [5] of size 150x150x150mm were cast. After 24 hours the moulds were de-moulded and subjected to water curing. Before testing, the cubes were air dried for 2 hours. Crushing loads were noted and average compressive strength of 3 specimens is determined at 7 days and 28 days. Casting and testing of specimen

4.1 Strength of Conventional Concrete

Table:1 strength of cube specimen at 7 and 28 days

Specimen	**7 days strength (N/mm^2)**		**28 days strength (N/mm^2)**	
S1	23.01	23.04	47.63	44.85
S2	22..81		41.91	
S3	23.31		45.02	

For Replacement of 10%

Table:2 strength of cube specimen at 7 and 28 days

Specimen	**7 days strength (N/mm^2)**		**28 days strength (N/mm^2)**	
S1	23.94	25.37	46.70	46.85
S2	25.76		47.04	
S3	26.43		46.83	

For Replacement of 20%

Table:3 Strength of cube specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	28.32	27.98	49.31	47.56
S2	26.19		48.72	
S3	29.43		44.64	

For Replacement of 30%

Table:4 strength of cube specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	23.56	24.15	42.59	42.09
S2	25.69		40.68	
S3	24.02		43.02	

For Replacement of 40%

Table:5 strength of cube specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	22.09	21.70	39.87	40.29
S2	20.59		40.62	
S3	21.63		40.38	

For Replacement of 50%

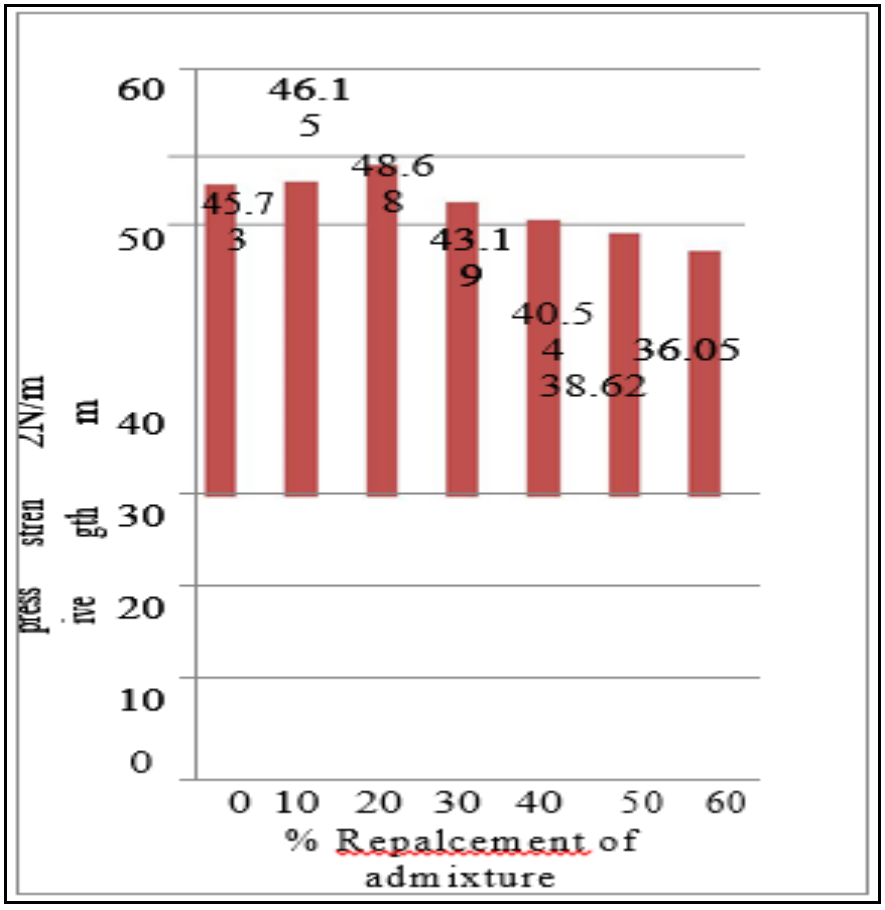
Table:6 strength of cube specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	19.43	20.01	37.54	37.57
S2	20.16		36.13	
S3	21.05		39.04	

For Replacement of 10%

Table:7 strength of cube specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	17.65	18.89	36.56	35.51
S2	19.15		34.74	
S3	19.87		35.24	



Conventional mixing for cylinder

Table:8 strength of cylinder specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	2.15		2.65	
S2	2.43	2.24	2.88	2.66
S3	2.16		2.45	

For Replacement of 10%

Table:9 strength of cylinder specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	2.05		2.89	
S2	2.72	2.38	3.15	2.80
S3	2.38		2.38	

For Replacement of 20%

Table:10 strength of cylinder specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	2.36		2.95	
S2	2.13	2.23	3.30	3.11
S3	2.20		3.18	

For Replacement of 30%

Table:11 strength of cylinder specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	2.36		2.75	
S2	2.13	2.23	2.38	2.57
S3	2.20		2.59	

For Replacement of 40%

Table:12 strength of cylinder specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	2.15		2.20	
S2	2.43	2.19	1.98	2.21
S3	2.01		2.45	

For Replacement of 50%

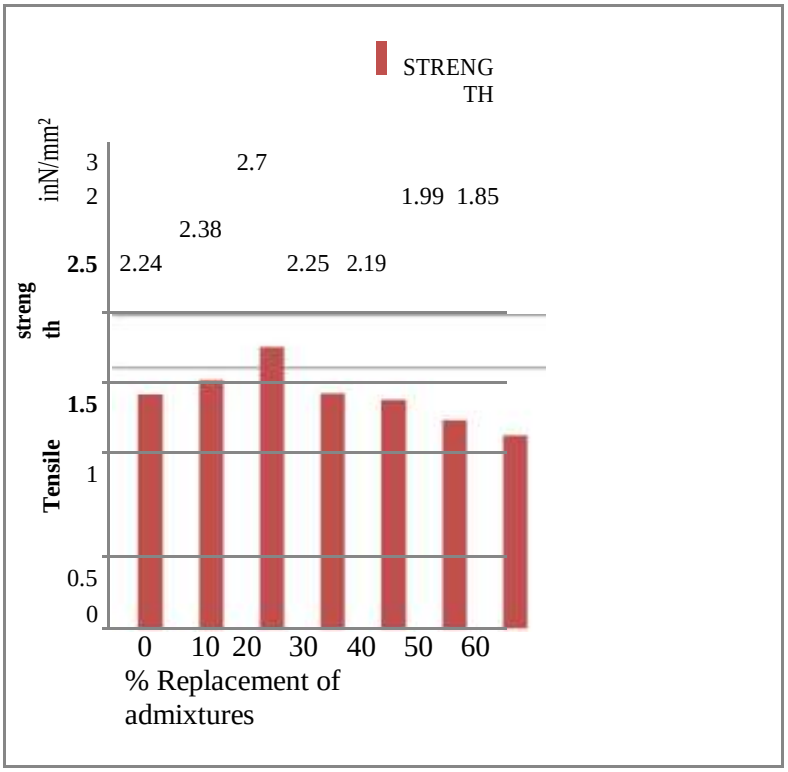
Table:13 Strength of cylinder specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	2.28		1.89	
S2	2.32	2.16	2.38	2.35
S3	1.9		2.78	

For Replacement of 60%

Table: 14 Strength of cylinder specimen at 7 and 28 days

Specimen	7 days strength (N/mm^2)		28 days strength (N/mm^2)	
S1	1.79	1.90	1.65	2.02
S2	2.05		2.73	
S3	1.88		1.68	



5.0 Conclusion

Based on the experimental investigation, the following results have been found,

- The optimum percentage of cement replacement by Nano silica, glass powder, granite powder of M40 grade, the target mean compressive of the cubes have been studied .
- Using Nano silica, Glass powder, Granite powder can reduce the use of cement and the associated energy demand and impact on Construction and Building air pollution and CO_2 emission.
- At 10%, 20%, replacement of admixture (Nano silica, Granite powder and Glass powder) compressive strength of concrete is higher than that of the control concrete. It has been noted that the strength achievement decreases as % replacement of granite powder, Nano silica, glass powder increases. So it is possible to replace the cement content in concrete by lesser amount (20%) with granite powder, Nano silica, glass powder to withstand the strength requirements.
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6.0 Refernces:

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4. IS: 383-1970 "specification for coarse and fine aggregate from natural sources for concrete", (2^{nd} revision), BIS, New Delhi.
5. IS: 516-1959 "method of test for strength of concrete", BIS, New delhi
6. IS 456-2000''Indian standard plain And reinforced concrete code of practice" (fourth revision).
7. T. Felixkala (et al.2010)[1]had obtained the test results that granite powder of marginal quantity as partial sand replacement.
8. Kanmalaiwilliams (et al 2008 [2]**)** reported the results of an experimental study on the high performance concrete made with granite powder as fine aggregate.
9. Ahamed et al (2004) have investigated that waste glass can be used by grinding it into a fine glass powder (GLP) for incorporation into concrete material.
10. Yixin et al (2000) reported about the studies on concrete containingground waste glass and assessment of the pozzolanic activity of the glass.
11. Dr. G.Vijayakumar et.al., [8] had found that use of glass powder as partial replacement to cement was effective.The overall test performance revealed that glass powder can be utilized as a partial replacement of natural sand in high performance concrete.

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