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RESEARCH ARTICLE OPEN ACCESS

Glass Powder and Flyash replacing cement for Sustainable Concrete

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ABSTRACT
In the present era, sustainable materials and its innovations are in great demand due to continual accumulation of different local wastes, which are creating environmental hazards. In the construction industry, cement contributes to about 7% of the green house gas emissions, in the form of CO_2, into the atmosphere. In this perspective, partial substitution of cement by a material containing pozzolanic properties may enhance the mechanical properties of concrete. Flyash already proved itself as a supplementary cementitious material and the disposal problem of huge quantity of flyash from thermal power stations is minimized by replacing cement with some percentage of flyash. On the other side, glass is used in many forms in our everyday life. Its lifetime is limited. The storage or safe disposal of waste glass is an environmental issue and so there is a strong need to utilize waste glass. Hence, this research is planned to examine the potential of waste glass powder as a partial replacement of cement in concrete. Cement replacement by glass powder is done in the range 10% to 40% with an increment of 10%. Also cement is partially replaced with equal percentages of glass powder and flyash from 10% to 40%. It was tested by slump test and hardened properties by compressive strength test at 7, 14 and 28 days. Results show that 20% replacement of glass powder has highest compressive strength but the combination of glass powder and flyash 10% each is confirmed to be the optimum of all cases considered.
Keywords – Compressive strength, Flyash, Glass powder, GP+FA, Sustainable

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I. INTRODUCTION

The environmental and economic obligations in the construction industry have thrown a challenge to reduce the production of cement. Hence, a revision of the methods and materials used in construction is now of prime importance. In this context, the production of cement used in concrete is the crucial problem targeted to protect the environment from CO_2 released into the atmosphere. The cement substitute should also improve its properties to better meet the quality and performance criteria. The search for any such alternate or supplementary material for cement should show the way to global sustainable development as well as lowest possible environmental impact.

At the same time, the quantity of waste glass has slowly increased over the years as glass has limited span, which will be sent to landfills after use. Since glass is non-biodegradable, landfills do not offer an environment-friendly solution. Finely grinded waste glass powder can become material having suitable properties because glass is principally composed of silica and hence enhances the pozzolanic activity. Replacing cement with flyash, produced in power stations, is a smart use of waste material produced which counter balances the environmental damage caused by cement as well as disposal issue of flyash. Moreover, flyash is a versatile material with pozzolanic properties.

Experimental work was carried out to analyze the performance of glass powder replacing cement by conducting compressive strength tests for 10%, 20%, 30% and 40% upto 28 days of age. The compressive strength is also tested by replacing cement content by variant proportions of flyash (FA) and glass powder (GP). These results are tabulated and compared with the results of M30 grade conventional concrete.

II. MATERIALS

1. Cement – OPC 53 Grade
2. Fine Aggregate – Zone 2 Sand
3. Coarse Aggregate – Nominal size 20mm
4. Glass Powder – Less than 90 micron
5. Flyash – Class F
6. Water – Potable water from Gandipet

Table 1- Specific Gravities of ingredients of concrete

Ingredients of Concrete	Specific Gravity
Cement	3.01
Fine Aggregate	2.64
Coarse Aggregate	2.60
Glass powder	2.48
Flyash	2.53

III. METHODOLOGY

3.1 MIX DESIGN

Concrete of grade M30 has been designed confirming IS 10262-2009 as conventional concrete specimen and the same procedure was adopted for other mixes mentioned below

Table 2- Percentage of Cement Replaced

Mix Designation	Cement Replacement Percentages		
	Total replacement %	GP replacement %	FA replacement %
M1	0	0	0
M2	0	10	0
M3	0	20	0
M4	0	30	0
M5	0	40	0
M6	0	5	5
M7	0	10	10
M8	0	15	15
M9	0	20	20

IV. RESULTS AND DISCUSSIONS

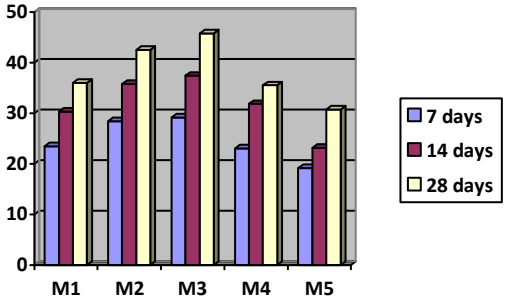
4.1 COMPRESSIVE STRENGTH

Three cubes of size 150mm x 150mm x150mm were casted for each mix and the average of the three samples is taken as the compressive strength of concrete. Compressive test is performed at the age of 7,14 and 28 days for all the specimens. Specimens are placed in the CTM and loading is applied in accordance to the provisions of Indian Standard code, IS:516-1959.

Table 3 – Compressive Strength of different mixes

Mix ID	**Cement Replacement %**	**Compressive Strength (in MPa) at age of**		
		7 days	14 days	28 days
M1	-	23.45	30.28	36.02
M2	10% GP	28.45	35.78	42.56
M3	20% GP	29.12	38.42	45.89
M4	30% GP	23.02	31.84	35.53
M5	40% GP	19.17	23.12	30.70
M6	5% GP + 5% FA	31.03	35.16	43.98
M7	10% GP + 10% FA	28.71	36.42	47.26
M8	15% GP + 15% FA	24.26	28.12	36.69
M9	20% GP + 20% FA	19.47	25.88	31.94

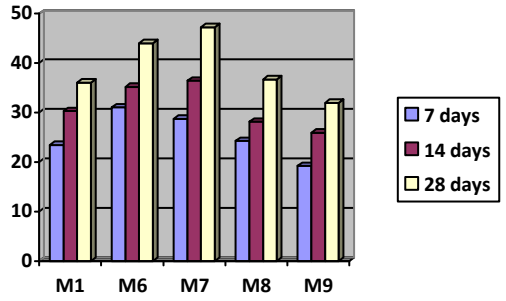
Graph-1 is plotted to depict the Compressive strength (MPa) of GP replacements in Y-axis and Mix designation in X-axis



Graph1- Comparison of glass powder replacement percentages with conventional concrete

With the increase in the percentage of glass powder replacing cement, the compressive strength also increased up to 20% and beyond that the compressive strength decreased. This increase in compressive strength up to 20% replacement may be because of the high silica content in class powder, which improves the pozzolanic reaction of glass concrete. But, after 20%, there is a decline in compressive strength may be because of clinker dilution effect. Hence, 20% glass powder replacement may be concluded as the optimum percentage for replacing cement

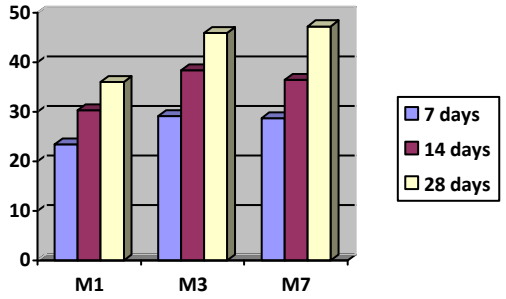
Graph-2 is plotted to depict the Compressive strength (MPa) of GP+FA replacements in Y-axis and Mix designation in X-axis



Graph2- Comparison of glass powder and flyash replacement percentages with conventional concrete

Flyash is known to be a pozzolanic material, which also contains good amount of Silica in it. This may lead to the better formation of C-S-H gel and there by improvement in strength in GP+FA combination when compared to conventional concrete or GP alone. 10%GP + 10% FA proved to be the optimum one of all the mixes considered in the research.

The optimum percentage of GP content alone, GP+FA combination is finalized and compared with conventional concrete as follows



Graph 3- Optimum percentage of GP alone and GP+FA combination

V. CONCLUSIONS

1. The properties of concrete with different percentages of glass powder and glass powder + flyash combination are changing for each mix
2. There is an increase in compressive strength up to 20% replacement of GP, beyond which it decreases
3. 10%GP+10%FA is concluded to be the most favorable mix of all the nine cases considered
4. In view of compressive strength criteria, the replacement of GP alone or GP+FA is feasible and so it is concluded that utilization of glass powder as cement replacement in concrete may be accepted to produce sustainable and economical concrete.

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