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Strength of Concrete using Combination of Glass Powder and Fly ash as a Partial Replacement of Cement

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Abstract: Using glass in concrete is an interesting possibility for economy on wastage disposals. Glass is an inert material which could be recycled and used many times without changing its chemical property. Glass is an amorphous material with high silica content thus making it potentially pozzolanic when particle size is less than 75 µm. A major concern regarding the use of glass in concrete is the chemical reaction that take place between the silica rich glass particle and the alkali in pore solution of concrete, which is called Alkali-Silicate reaction can be very detrimental to the stability of concrete, unless appropriate precautions are taken to minimize its effects. The inclusion of fly ash in glass concrete reduces the alkali silica reaction and improves the workability and durability properties of concrete waste glass powder used in concrete making leads to green environment.

The objective of present work is to find out effectiveness on durability of waste glass powder and fly ash based concrete. In this investigation it was proposed that the use of glass powder with fly ash as cement replacement material partially in concrete. Cement was partially replaced (5%, 10%, 15%,) with combination of fly ash and glass powder. Compressive strength of cubes at 7 days 14 days and 28 days of duration were studied and compared with the conventional concrete. The results showed that the possibility of using glass powder with fly ash as a partial replacement of cement in concrete has a considerable amount of increase in durability with increase in percentage.

Index Terms **– Fly Ash,Glass Powder**

I. INTRODUCTION

Irrespective of the nature of their product, almost all industries produce waste. Effective disposal of waste is challenging task. In olden days solid wastes were used as landfills in low laying areas. Industrial waste like fly ash, silica fumes, blast furnace slag etc. and other wastes of plastics, glass, tiles causing environmental pollution . recycling of waste is therefore emerging as an important component of technology for making contribution towards sustainability. While the pozzolanic reaction adds to strength of concrete and utilization of these materials brings about economy in concrete manufacture.

It has been estimated that several millions of waste glasses are generated annually worldwide. The key source of waste glasses are waste containers, window glasses, Window screen, medicinal bottles, tube lights, bulbs, etc. Fly ash is a coal combustion product and it is pozzolanic in nature. The burning of harder, older anthracites and bituminous coal typically produces class F fly ash. Burning of younger lignite produces class C fly ash. It is well known that Portland cement production is an energy intensive industry, being responsible for about 5% of the global anthropogenic carbon dioxide emission worldwide. The use of waste or by products in concrete production has advantages for improving some or all of the concrete properties. The economic incentives and environmental benefits in term reduces carbon foot prints.The inclusion of fly ash in glass concrete reduces alkali silica reaction and improves the workability and durability properties of concrete waste glass powder used in concrete making leads to green environment. Change in compressive strength of concrete depend on the aggregate cement interaction and interface bonding mechanism. It is well known that silica in the glass highly react with alkalis in cement paste. As the result of pozzolonic reaction fly ash fills the pores in the material.

II. PROBLEM FORMULATION

2.1General

Glass is principally composed of silica. Use of milled (ground) waste glass in concrete as partial replacement of cement could be an important step toward development of sustainable (environmentally friendly, energy-efficient and economical) infrastructure systems. When waste glass is milled down to micro size particles, it is expected to undergo pozzolanic reactions with cement hydrates, forming secondary Calcium Silicate Hydrate (C–S–H). In this research chemical properties of both clear and colored glass were evaluated. Chemical analysis of glass and cement samples was determined using X- ray fluorescence (XRF) technique and found minor differences in composition between clear and colored glasses. Flow and compressive

strength tests on mortar and concrete were carried out by adding 0–25% ground glass in which water to binder (cement + glass) ratio is kept the same for all replacement levels. With increase in glass addition mortar flow was slightly increased while a minor effect on concrete workability was noted. To evaluate the packing and pozzolanic effects, further tests were also conducted with same mix details and 1% super plasticizing admixture dose (by weight of cement) and generally found an increase in compressive strength of mortars with admixture. As with mortar, concrete cube samples were prepared and tested for strength (until 1 year curing). The compressive strength test results indicated that recycled glass mortar and concrete gave better strength compared to control samples. A 20% replacement of cement with waste glass was found convincing considering cost and the environment.

2.2 Properties of materials as replacement of cement

Physical properties of concrete is driven by ingredients. The partially replacement of either of ingredient change the properties of concrete. Replacement of two ingredients at a time leads the problem at different complexity level. Considering the aspects of the problem replacement of two ingredients at a time is studied in the current project. In the current project, cement is replaced by different materials which are compatible to the concrete. Fly ash is traditional fine aggregates used in concrete. Use of Cement is now has some limitations. In order to fulfill the demand of construction industries and considering the restrictions on use of cement , Fly ash and Glass Powder is used for replacement. Due to coherent properties Fly ash and Glass Powder is one of familiar choice for the replacement of cement. Apart from Fly ash and Glass Powder are also used in concrete to improve the workability of concrete. In the present study both replacements of cement are taken into account. Partial replacement of cement by FA & GP considered in this dissertation. Effect of replacement of Fly Ash and Glass Powder together by different compatible material on physical properties of concrete is focused in the current project. In order to find best suited combination Glass powder and Fly ash along with cement various ranges of percentage are decided which are highlighted in the chapter.

2.2.1 Fly ash

It is generally spherical in shape and size up to 0.5 micro-meter to 300 micro-meter. Class F type of Fly ash generated with burning of harder and older anthracite coal. Class F type Fly ash contain high silica and low calcium content. Fly ash For this project brought from Parali thermal power plant.

2.2.2 Glass Powder

Glass is an amorphous material with high silica content thus making it potentially Pozzolanic when particle size less than 90 micro-meter. The major concern regarding the use of glass in concrete is a chemical reaction take place between silica rich glass particle and the alkali in the pore solution of concrete which takes alkali-silica reaction. Glass powder used in Project brought from Bombay glass center osmanabad.

Table 2.1 Comparison of Physical and Chemical Properties Cement, GP & FA

Composition (% by Mass)	Cement	Glass Powder	Fly ash
Silica (Sio2)	20.2	72.5	55.9
Alumina(AL2o3)	4.7	0.4	27.8
Iron Oxide(Fe2o3)	3.0	0.2	7.09
Calcium Oxide (Cao)	61.9	9.7	3.95
Magnesium Oxide (Mgo)	2.6	3.3	0.17
Sodium Oxide (Na2O)	0.19	13.7	0.31
Potassium Oxide (K2O)	0.82	0.1	1.55
Sulphur Trioxide (So3)	3.9	-	0.27
Loss of ignition	1.9	0.36	1.45
Fineness % passing (Sieve Size)	97.4	95	91

2.3 Methodology of flow work

From exclusive literature survey it is noted that cement is successfully replaced by various researchers. Considering the combination of different replacement are un touched or touched.In this dissertation cement is replaced by Fly ash and Glass Powder. This replacements are studied for various grades of concrete .And effects of this replacement is studied for various properties of concrete such as compressive strength, workability etc.The laboratories results are obtained and observed and comparison between various combinations is worked out and finally concluding remarks are drawn in Fig.1.

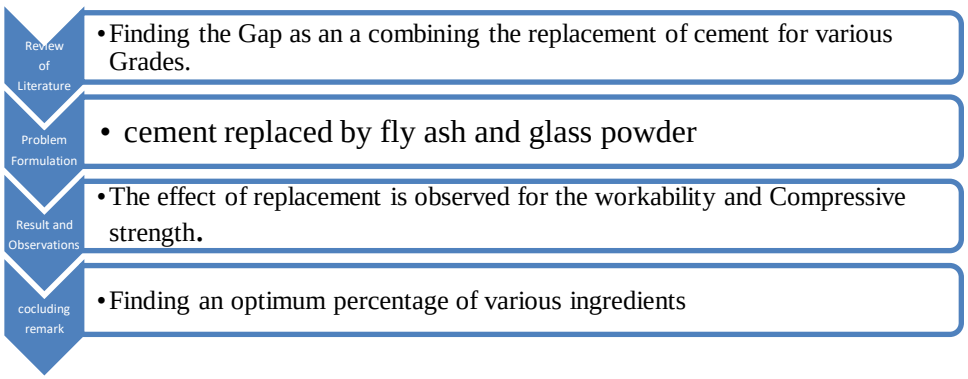


Fig.1 Flow Work

III. PARAMETRIC INVESTIGATION

3.1 Replacement of Glass Powder / Fly Ash

Parametric investigation allows nominating parameters for evaluation, defining the parameter range, specifying the design constraints, and analyzing the results of each parameter variation. Along with ingredient the materials which used as replacement are also tested .The properties are mentioned in the previous chapter. Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75µm(Federio.L.M and Chidiac S.E,2001 and Baxter.S,2000). Studies have shown that finely ground glass does not contribute to alkali – silica reaction. In the recent, various attempts and research have been made to use ground glass as a replacement in conventional ingredients in concrete production as a part of green house management. A major concern regarding the use of glass in concrete is the chemical reaction that takes place between the silca – rich glass particle and the alkali in pore solution of concrete, which is called Alkali – Silicate reaction can be very detrimental to the stability of concrete. Class F Fly ash obtained from Parali thermal power plant used in the present study. Chemical analysis of fly ash is given in above table. The fly ash had a relatively low specific gravity and fineness modulus of 1.975 and 1.195 respectively.

3.2 Various Parameters Considered for Study

Mix design was prepared for M20, M25 Grade of Concrete according to IS 10262-2009. Test samples were prepared containing different proportions of Glass Powder and Fly ash and tested to get optimum strength by partial replacement of cement. The following methodology will be adopted for project work,

- Glass is Clear in colour generated by cutting of window glass and Fly ash used in Project is Class F fly ash.
- Cement used in project is 53 grade OPC
- On Aggregate test can be taken includes Flakiness, Water absorption , Impact test test and on Sand test can be taken Silt content and Sieve analysis in lab.
- Material properties testing as per Indian standards code (IS 383–1996) procedures.
- Mix designing for concrete proportion as per IS 10262 Casting and curing the concrete
- specimens as per Indian Standards procedure
- Curing is done for 7, 14, 28 days at normal temperature water.
- Testing of characteristic strength of hardened concrete specimen as per IS 456 – 2000

Table 3.1 Design mix proportion of concrete grades

Grade of concrete	Cement By weight (kg)	Fine aggregateBy weight (kg)	Coarse aggregate Byweight (kg)	W/c Ratio By weight (kg)
M20	372	845.22	1089	-
	1	**2.27**	**2.92**	**0.5**
M25	414	811	1090	-
	1	**1.95**	**2.63**	**0.45**

IV RESULTS AND DISCUSSION

4.1 General

Various contributions done by researchers are studying a gap is found to have combined study of replacement of ingredients of cement. With reference section of previous chapter various cases are identified and performance of concrete of various grades is observed. The workability, Compressive Strength is studied and observation of cases mentioned is tabulated as given in sub-sequent section from the results. Various observations are drawn to findout visible combinations of considered a replacement.

4.2 Variations of workability for Glass Powder and Fly Ash Combinations for Various Grades.

Workability is one of key property of concrete, which indirectly leads to the strength of concrete.Two grades of concrete are considered with different percentages of Fly ash and Glass powder replacement of cement . The Workability using slump cone obtain the results of replacement for two grades is given in table.Graph gives workability test result of M20 grade concrete and Fig.4.2 Graph gives workability test result of M25 grade of concrete .The observation graph 1&2 are sub-sequentially given along with

Table 4.1 Workability test on concrete cubes for M20 and M25 grade by Slump cone test.

%GP	5	5	5	10	10	10	15	15	15
%FA	5	10	15	5	10	15	5	10	15
Slump(mm) M20 Grade	125	110	95	100	90	70	95	65	45
Slump(mm) M25 Grade	120	105	90	85	80	70	65	55	40

4.2.1 Workability test on concrete cubes for M20 grade by Slump cone test.

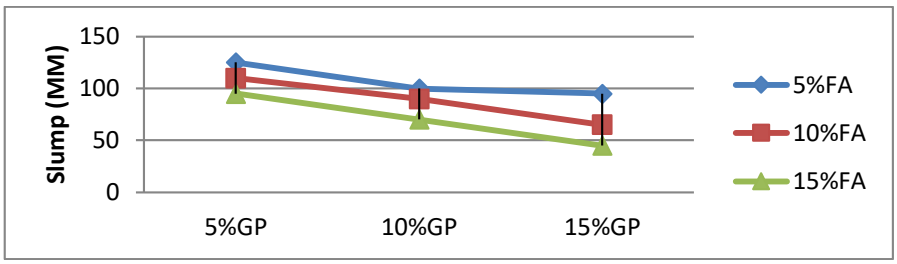


Fig.4.1 Variation of slump for M20 grade of concrete

Observations for Graph

1) For 5% FA and 5% GP replacement percentage, workability of concrete increases.

2) For 5% FA and 10% GP replacement percentage, workability of concrete rapidly decreases and at 5% FA and 15% GP replacement workability Slightly decreases.

3) For 10% FA replacement Workability rapidly Decreases with percentage of Glass powder increases

4) For 15% FA Replacement Workability Rapidly Decreases with percentage of Glass powder increases

4.2.2Workability test on concrete cubes for M25 grade by Slump cone test

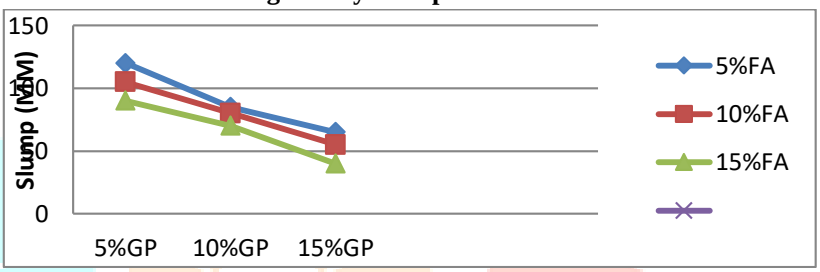


Fig.4.2 Variation of slump for M25 grade of concrete

Observations for Graph

1) For 5% FA and 5% GP replacement percentage , Workability of concrete increases.

2) For 5% FA replacement on increasing percentage of Glass powder workability decreases.

3) For 10% FA replacement Workability rapidly Decreases with percentage of Glass powder increases.

4) For 15% FA Replacement Workability Rapidly Decreases with percentage of Glass powder increases.

4.2.3 Comparison of Various Grades of Concrete for Replacement of Cement by Glass Powder and Fly Ash.

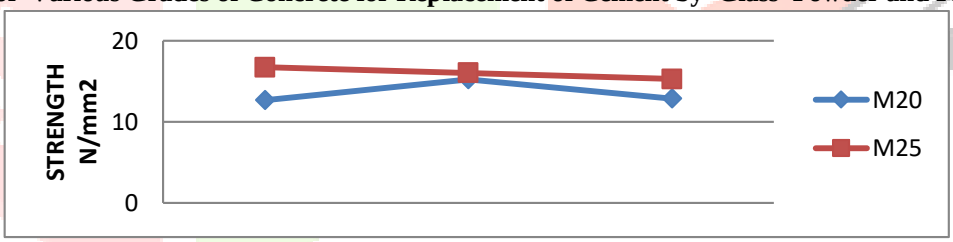


Fig.4.3Comparision of M25 and M20 Grade of Concrete for variation of 5%GP and 5,10,15% FA replacement vs compressive strength for 7 Days

Observations for Graph

1) For M25 Grade of Concrete there is a Slightly Decreases in Strength at all Combinations of Replacement.
2) For M20 Grade of Concrete Compressive Strength increases at 5% Glass Powder and 10% Fly Ash Replacement and Decreases at percentage replacement Increases.

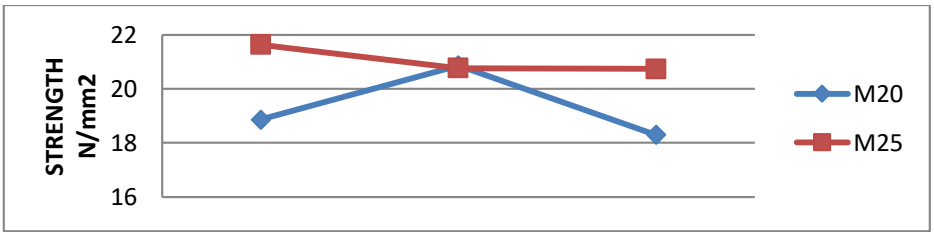


Fig.4.4 Comparision of M25 and M20 Grade of Concrete for variation of 5%GP and 5,10,15% FA replacement vs compressive strength for 14 Days

Observations for Graph

1) For M25 Grade of Concrete there is a Decreases in Strength at 5% GP and 10% FA and no change in Strength at 5% GP and 15% FA Replacement.
2) For M20 Grade of Concrete Compressive Strength rapidly increases at 5% Glass Powder and 10% Fly Ash Replacement and Rapidly Decreases at 5% GP and 15% FA replacement.

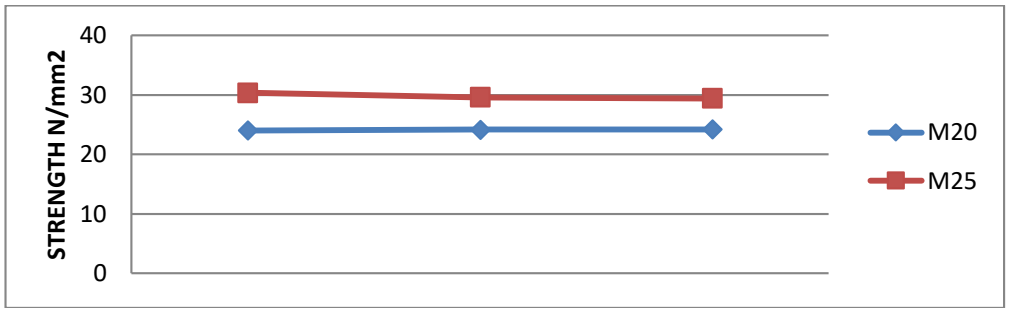


Fig.4.5 Comparision of M25 and M20 Grade of Concrete for variation of 5%GP and 5,10,15% FA replacement vs compressive strength for 28 Days

Observations for Graph

1) For M25 Grade of Concrete there is a Slightly Difference in Strength at all Combinations of Replacement.
2) For M20 Grade of Concrete Compressive Strength is same for all Combination Replacement.

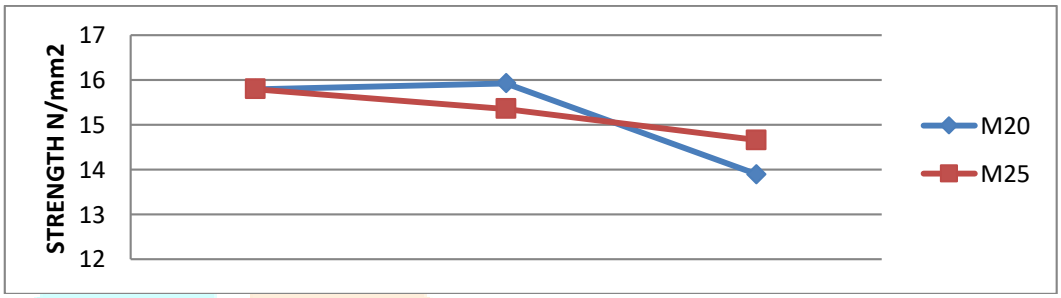
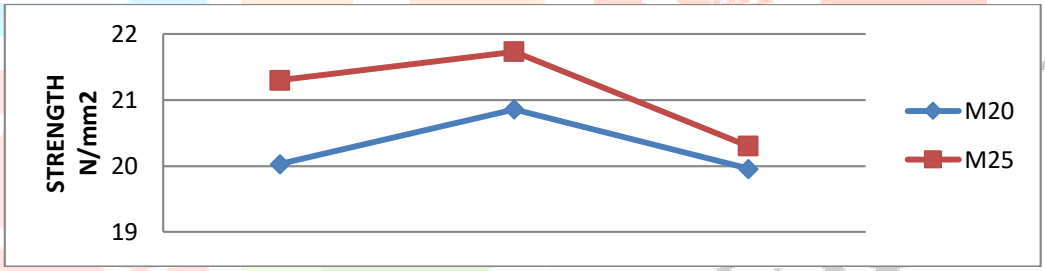


Fig.4.6 Comparision of M25 and M20 Grade of Concrete for variation of 10%GP and 5,10,15% FA replacement vs compressive strength for 7 Days

Observations for Graph

1) For M25 Grade of Concrete there is a Slightly Decreases in Strength at all Combinations of Replacement.
2) For M20 Grade of Concrete Compressive Strength increases at 10% Glass Powder and 10% Fly Ash Replacement and Rapidly Decreases at 10% GP and 15%FA replacement.



Graph 13.Comparision of M25 and M20 Grade of Concrete for variation of 10%GP and 5,10,15% FA replacement vs compressive strength for 14 Days

Observations for Graph

1) For M25 Grade of Concrete at 10% GP and 10% FA Replacement, Compressive Strength Increases and at 10%GP and 15% FA replacement Compressive Strength rapidly Decreases.
2) For M20 Grade of Concrete at 10% GP and 10% FA Replacement, Compressive Strength Increases and at 10%GP and 15% FA replacement Compressive Strength rapidly Decreases.

CONCLUSION

5.1 Conclusion

Cement is binding material for coarse and fine aggregate in concrete. The cost of concrete is varying with cement content. Various research can be carried out to replace cement content by various different materials, has a byproduct of various mechanical and construction industries without hampering properties and integrity of concrete.

In this current dissertation the replacement of cement studied by ingredients i.e. Glass powder and Fly Ash. Different percentage of combination are tried and its effect on properties of concrete. Specially compressive strength of concrete and workability is studied results are mentioned in previous chapter. Following are conclusions drawn from observations.

1) Observations regarding workability

a) As percentage of Glass powder increases workability of concrete decreases it depend on present of Fly Ash percentage.
b) As Fly Ash percentage increases workability decreases varying with percentage of Glass Powder. This observes for lower as well as higher grade of concrete.
c) For lowest percentage of Glass Powder and lowest percentage of Fly Ash highest workability is observed in grading of concrete considered for current project.

2) Observations regarding Compressive strength

a) As percentage of Glass Powder increases the compressive strength of concrete is go on increasing with varying percentage of Fly Ash. The Fly Ash effect is more fruit full along with Glass Powder with lower percentage.

b) For lower percentage of Glass Powder with increasing Fly Ash percentage Compressive strength is found to be increase. It is Observe that for up to 10% Fly Ash there is a gain in Compressive strength of concrete for different grades considered.

c) The above facts are true up to 10% and above 10% the reduction in compressive strength is observed with increasing Fly Ash for a constant Glass Powder percentage. In above mention cases up to 24% gain is observed with 10% Fly Ash.

d) For 5% Glass Powder compressive strength at 28 days remains practically same. For 7 days it is found to increase up to 10% of Fly Ash and then decreases. For lower grade of concrete.

e) For 10% Glass Powder the earliest strength is found to be increased up to 10% and constant but surprisingly found to be reduction for 15% Fly Ash. Similar variations are observed for 15% Glass Powder for lower grade of concrete.

f) For higher grade of concrete the percentage of increasing compressive strength is observed with varying percentage of Fly Ash and Glass powder.

g) For 5% Glass Powder compressive strength at 28 days remains practically same for various percentage of Fly Ash.

h) For higher grade of concrete the compressive strength do not differ much in early days with increasing percentage of Fly Ash but reduction of Compressive strength is observed at 28 days maturity of concrete in increasing Fly Ash percentage.

i) For 15% of Glass Powder and higher grade of concrete values are not varying with change in Fly Ash Percentage.

j) For lowest combination of Fly Ash and Glass Powder 20% gain in compressive strength is observed in lower as well as higher grade of concrete.

k) For higher percentage of combinations after replacement of cement required grade of concrete is also can be achieved.

5.2 Future Scope of Study

Hence, Following Point should be considered for better performance of Glass Powder and Fly ash in concrete.

a) It has been noted that at 20% and above 20% the test results are likely to fall at high dosages, particle packing is complete for the most part and excess silica fume is adding more surface area, and thus increases the water demand.

b) Combination of fly ash and Glass powder with different proportion can be utilized for plain concrete or reinforced cement concrete.

c) Higher grades of concrete more than M25 can be also checked for compressive stress after 28days.

5.3 Recommendations

Class C fly ash with variations % and Glass Powder as can be checked on variations of Grades of Concrete.

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