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Experimental study on Self Compacting Concrete Using Fly ash with Glass Powder

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Abstract— Self compacting concrete is a type of concrete that get's under its self weight. It is commonly abbreviated as the concrete. Which can placed and compacted in to every corner of a formwork; purely means of its self weight by eliminating the need of either external energy input from vibrators or any type of compacting effort. There is a current trend in all over the world to utilize the treated and untreated industrial by- products, domestic wastes etc. as raw materials in concrete. These not only help in the reuse of the waste materials but also create a cleaner and greener environment. This study aims to focus on the possibility of using waste material in a preparation of innovative concrete. One kind of waste was identified: Glass Powder (GP) and fly ash (FA). The use of this waste (GP) was proposed in different percentage (0, 5, 10 &15) and Fly ash at constant percentage (i.e. 20) as an instead of cement for production of self compacting concrete. The paper deals with the ingredient of these mixtures (Glass powder, fly ash, super plasticizer, cement) by examining the specific role in self compacting concrete.
Keywords— Glass Powder (GP), Self Compacting Concrete (SCC), Compressive strength, fly ash (FA)

I. INTRODUCTION

The placing of fresh concrete, the transport equipment and the vibration tools were the same for the last decades. The development in concrete admixtures led to a better control of fresh and hardened properties control of the concrete, also the majority of limitations regarding architectural design of concrete structures disappeared. The 21 st century has a big problem to solve: that is to reduce the environmental problems that appeared during the big industrial development in the past century. This leads to important problems regarding the design and preparation of the building products and materials, so that finally to obtain an economic cost of the product and also a "friendly with the environment" during its fabrication process Self Compacting Concrete represents a new building material which has an endless potential of utilization and application and it is considered be the greatest breakthrough in concrete technology for many decades, due to the improved performance and working environment.

The development of Self Compacting Concrete can be assumed to be the most important one into the building material's domain. This is due to the benefits that this concrete offers:

A. The technology of producing Self Compacting Concrete can be considered as an energy conservation process, since the electricity consumption for vibration it is eliminated; - use of Self Compacting Concretes increase the lifetime of the construction moulds, reduces the necessity of skilled workers;
B. SCC can be used for all types of structures due to the fact that it can be pumped at long distances without any of its segregation;
C. From the contractors point of view, costly labour operations are avoided improving the efficiency of the building site;
D. The concrete workers avoid poker vibration which is a huge benefit for their working environment;
E. When vibration is omitted from casting operations the workers experience a less strenuous work with significant less noise and vibration exposure;
F. Faster placement with less labour;
G. Very good finishing surfaces of the elements made with Self Compacting Concrete, which is a cut in remedial costs;
H. SCC is believed to increase the durability relatively to vibrated concrete (this is due to the lack of damage to the internal structure, which is normally associated with vibration).Construction practice and performance, combined with the health and safety benefits, make SCC a very attractive solution for both precast concrete and civil engineering construction. SCC mainly used in highly congested reinforced concrete structure in seismic region and to overcome the problem of storage of skilled labours for the efficient compaction of concrete. Review of literature indicates that durability of SCC largely depends on the type of mineral admixtures.

The following three important features of SCC over and above the usual factors, which influence the design of normal concrete.

A. Increases the powder content, ensures cohesiveness or viscosity of the mixture and reduces coarse aggregate
B. A substitutional part of cement that is fly ash is used for achieving economy.

C. Micro silica is used for the better packing of powder particles.
D. The required flow ability is achieved with the help of superplasticizers which is able to retain its dispersing effect for at list two hours.
E. Stabilizing agent (viscosity modifying agent) is usually needed through that small changes in water concrete of mixes, which arise due to site variables, do not adversely affect the cohesiveness of SCC.

SCC has proved beneficial because of number of factors including
1) Faster construction
2) Reduction in site man power
3) Better surface finishing
4) Improve durability
5) Easier placing
6) Greater freedom in design
7) Reduce noise levels, absence of vibration

II. OBJECTIVE

A. Principally, to find test which identify the three key properties of SCC, for mix design purposes in the lab, and for compliance purposes on site.
B. To recommended a range of results, for the chosen tests, which will enable non- specialists to identify suitable SCC, and be considered for compliance in specifications.
C. To confirm the scientific basis of these tests by fundamental rheological measurements of the concrete.
D. To encourage the use of self-compacting concrete in general construction and to realize the potential economical and environmental benefits of this technology.
E. To study the effect of glass powder on the durability parameters of SCC using fly ash.

III.REQUREMENTS FOR CONSTITUENT MATERIALS

A. Cement

Selection of the type of cement will depend on the overall requirements for the concrete, such as strength, durability, etc.C_3 content higher than 10% may cause problems of poor workability retention.
The typical content of cement is 350-450 Kg / m^3.
More than 500 Kg/ m^3 cement can be dangerous and increase the shrinkage.
Less than 350 Kg/ m^3 May only is suitable with the inclusion of other fine filler, such as fly ash pozzolana etc.

B. Aggregates

1) *Sand:* All normal concreting sands are suitable for SCC, both crushed or rounded sands can be used. Siliceous or calcareous sands can be used. The amount of fines less than 0.125 mm is to be considered as powder and is very important for the rheology of the SCC. A minimum amount of fines (arising from the binders and the sand) must be achieved to avoid segregation.
2) *Coarse Aggregate:* All types of aggregates are suitable. The normal maximum size is generally 16-20 mm; however particle sizes up to 40 mm or more have been used in SCC. Consistency of grading is of vital importance. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of the interlocking of the angular particles, whilst rounded aggregates improve the flow because of lower internal friction.

C. Admixture

The most important admixtures are the Super plasticizers (high range water reducers), used with a water reduction greater than 20%. The use of a Viscosity modifying Admixture (VMA) gives more possible of controlling segregation when the amount of powder is limited. This admixture helps to provide very good homogeneity and reduces the tendency to segregation.

D. Addition

Additions are commonly used in SCC due to the need for substantial contents of fine particles. All additions conforming to the EN standards are suitable.

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E. Glass Powder

The chemical composition of soda lime glass which is most commonly used. The chemical composition of glass Sio_2 and (Na_2O+K_2O) of glass and much higher than fly ash and cement total reactive component ($Sio_2+Al_2O_3+Fe_2O_3$) of glass and fly ash is about the same. Other main constituent are in similar range to those of fly ash and cement. Glass has a potential to be used as a powder in SCC. The preferred fineness of addition for SCC is more than 70% of particle passing 0.063mm fine glass powder was reported to contribute to Micro Structural Properties due to its filler effect pozzolanic reactivity the sulphate resistance/ penetration resistance and freez/thaw of concrete was all improvement after incorporating 20-30% glass powder compare to those of fly ash.

F. Fly Ash

The flow ability of self compacting concrete depends on the powder and paste cement. Hence, in order to increase the flow ability, mineral admixtures such as fly ash has been used was obtained from thermal Power station, Paras Akola (M.S.) India. The Normal Consistency of Fly Ash was found to be 43%.

IV. EXPERIMENTAL WORK

A. Material Properties

1) Cement : Ultra-tech (53 Grade)

a) Properties of cement are as follows:

Fineness = 5%
Normal consistency = 29.5%
Soundness = 2 mm
Initial Setting Time = 53 min.
Final Setting Time = 493 min.
Specific gravity = 3.1

2) Coarse Aggregate

Aggregate crushing value = 16.15%
Bulk density = 1896.29 kg/m^3
Specific gravity = 2.85

3) Fine Aggregate

Bulking of sand = 17% of 10% water
Fineness modulus = 3.18
Specific gravity = 2.65
Bulk density = 1428 kg/m^3

4) Super plasticizer

Chloride content Nil
Specific Gravity 1.26 at 30^ C
Solid content 40 %
Nature Liquid

5) Fly Ash

Sr. no.	Physical properties	Test value	Specification limit as per 3812-1981
1	Specific gravity	2.55	
2	Specific surface (cm^{2}gm)	3850	3200
3	Limit reactivity (Kg/ cm^2)	52.5	40
4	Fineness by sieving % passing 300 µ % passing 150µ % passing 75 µ % passing 53 µ	 97.5 93.0 84.5 80.1	

Table 1. Physical Properties of fly ash

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Sr. No.	Chemical Constituents	Percentage
1	Silica	62.12
2	Iron oxide	6.48
3	Calcium oxide	1.23
4	Titanium oxide	1.80
5	Potassium oxide	128
6	Magnesium oxide	0.49
7	Phosphorous Pentaoxide	0.40
8	Sulphur	0.36
9	Disodium oxide	0.28

Table 2. Chemical Properties of fly ash

6) Glass Powder

Sr. No.	Chemical Constituents	Percentage
1	SiO_2	70.22
2	CaO	11.33
3	MgO	___
4	Al_2O_3	1.64
5	Fe_2O_3	0.52
6	SO_3	___
7	SO_3	15.29
8	K_2O	___
9	Density	2.42
10	Specific Surface area (m^2/Kg)	133

Table 3. Properties of glass powder

V. EXPERIMENTAL WORK

A. Design of mix

The design mix is carried out by the specified method by NAN-SU Scientist in Japan.

B. Batching of ingredients

The various ingredients required for SCC mix were taken by weight batching.

C. Mixing of ingredients

All the ingredients taken by weigh batching are separately sorted out. First of all coarse aggregate is spread up in the large tray. In separate tray fine aggregate, cement and fly ash are mixed in dry condition. This mixed material is then spread up over coarse aggregate and then complete ingredient is mixed in dry conditions. After that make a hole at center of the mixed material then 70% of the required quantity of water as per adopted water cement ratio is added and material is mixed and remaining 30% water is added. Mixing is continued till the concrete mix attained uniform colour and consistency.

D. Preparation of cubes

At a time 3 cubes are casted in the laboratory of size 15 cm x 15 cm x 15 cm. The casting of cubes is done as follows

First of all the moulds used for casting purpose are oiled from inside so that the concrete does not stick to the surface. Then nuts and bolts of mould are checked, whether they are well tightened or not. Immediately after mixing, the concrete is filled in mould. Like this moulds cubes are filled. The temperature of water and test room as specified i.e. 27^0 C $\pm$ 2^0C during the above operations

E. Curing of cubes

The prepared cubes are kept as such as a temperature of 27^0C $\pm$ 20C in an atmosphere of at least 90% relative humidity for 24 hrs. From the time of addition of water to dry ingredients. At the end of this period concrete cubes are taken out of mould for curing

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purpose. The method of curing by pounding. In this method after taking out cubes from the moulds they are immediately submerged in clean and fresh water for curing and kept for specific period till they are taken out for testing purpose.

F. Testing of cubes

These cubes were removed turn by turn and the compressive strength was tested after 7 & 28 days of curing of each set of cubes the compressive strength of cubes was tested in compressive testing machine.

1) *Preparation of beams:* At a time 2 beams are casted in the laboratory of size 10 cm x 10 cm x 50 cm. The casting of beams is done as follows. First of all the moulds used for casting purpose are oiled from inside so that the concrete does not stick to the surface. Then nuts and bolts of beams mould are checked, whether they are well tightened or not. Immediately after mixing, the concrete is filled in mould. Like this mould beams are filled. The temperature of water and test room as specified i.e. 2^{70} C $\pm$ ^{20}C during the above operations.
2) *Curing of beams:* The prepared beams are kept as such as a temperature of 27^0C $\pm$ 20C in an atmosphere of at least 90% relative humidity for 24 hrs. From the time of addition of water to dry ingredients. At the end of this period concrete beams are taken out of mould for curing purpose the method of curing by pounding. In this method after taking out beams from the moulds they are immediately submerged in clean and fresh water for curing and kept for specific period till they are taken out for testing purpose.
3) *Testing of beams:* These beams were removed turn by turn and the flexural strength was tested after 7 & 28 days of curing of each set of beams the flexural strength of beams was tested in universal testing machine.

V. TEST RESULTS AND DISCUSSION

MIX	FLY ASH IN (%)	GLASS POWDER IN (%)	STRENGHT IN Mpa	
			7 DAYS	28 DAYS
M20	0	0	18.70	26.70
	20	5	17.50	24.50
	20	10	16.67	22.60
	20	15	14.00	20.00
M25	0	0	21.96	26.78
	20	5	20.60	25.88
	20	10	19.50	23.76
	20	15	18.00	22.00
M30	0	0	26.44	36.88
	20	5	25.00	34.45
	20	10	23.85	31.77
	20	15	21.12	30.34

Table 4. Test Results

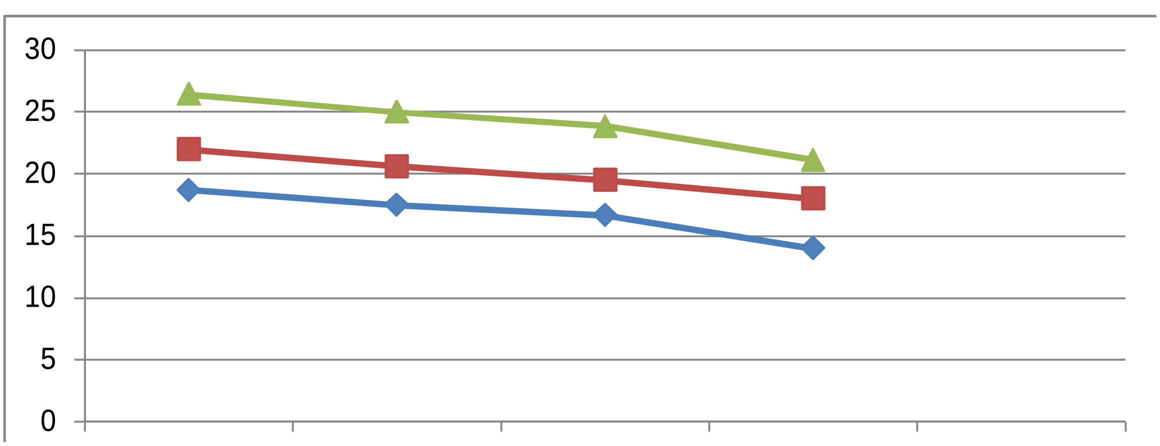

Fig 1. 7 Days Strength

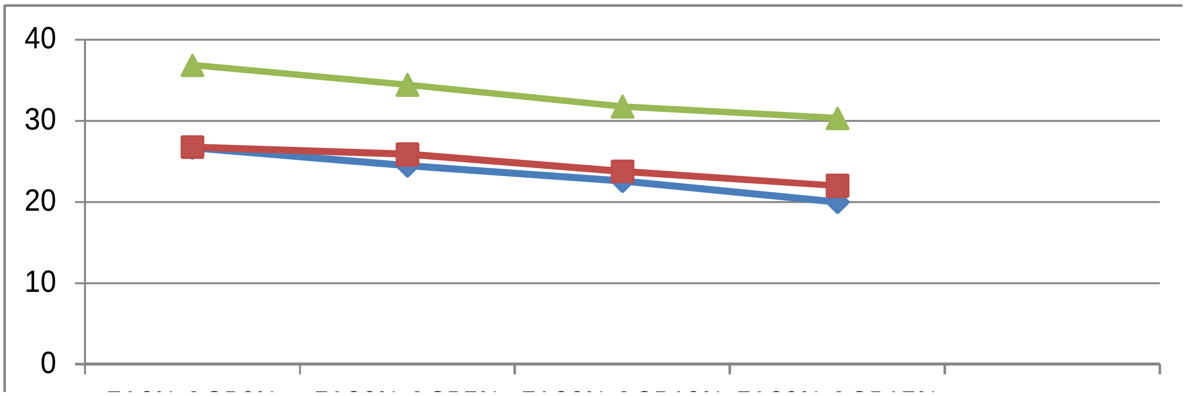

Fig 2. 28 Days Strength

Glass powder was used to replace the cement content by three various percentages (5, 10 and 15%).According to the results, a decrease on compressive strength had been observed for glass powder added SCC composite compared to conventional SCC. It was observed that the glass powder distribution within the composite was uniform, but the compressive strength varied inversely with the percentage of glass powder content.

VI. CONCLUSION

From the above mentioned work of various researchers and our present experimental work, it is clear that glass can be used as a replacement of cement in concrete because of its increased workability, strength parameters like compressive strength. As disposal of waste by-products problem is a major problem in today's world due to limited landfill space as well as its escalating prices for disposal, utilization of waste glass in concrete will not only provide economy, it will also help in reducing disposal problems. The results obtained from the present study shows that there is great potential for the utilization of best glass powder in concrete as replacement of cement. The fine glass powder can be used as a replacement for expensive materials like silica fume and fly ash. Considering the strength criteria, the replacement of cement by glass powder is feasible. Therefore we can conclude that the utilization of waste glass powder in concrete as cement replacement is possible.

VII. ACKNOWLEDGMENT

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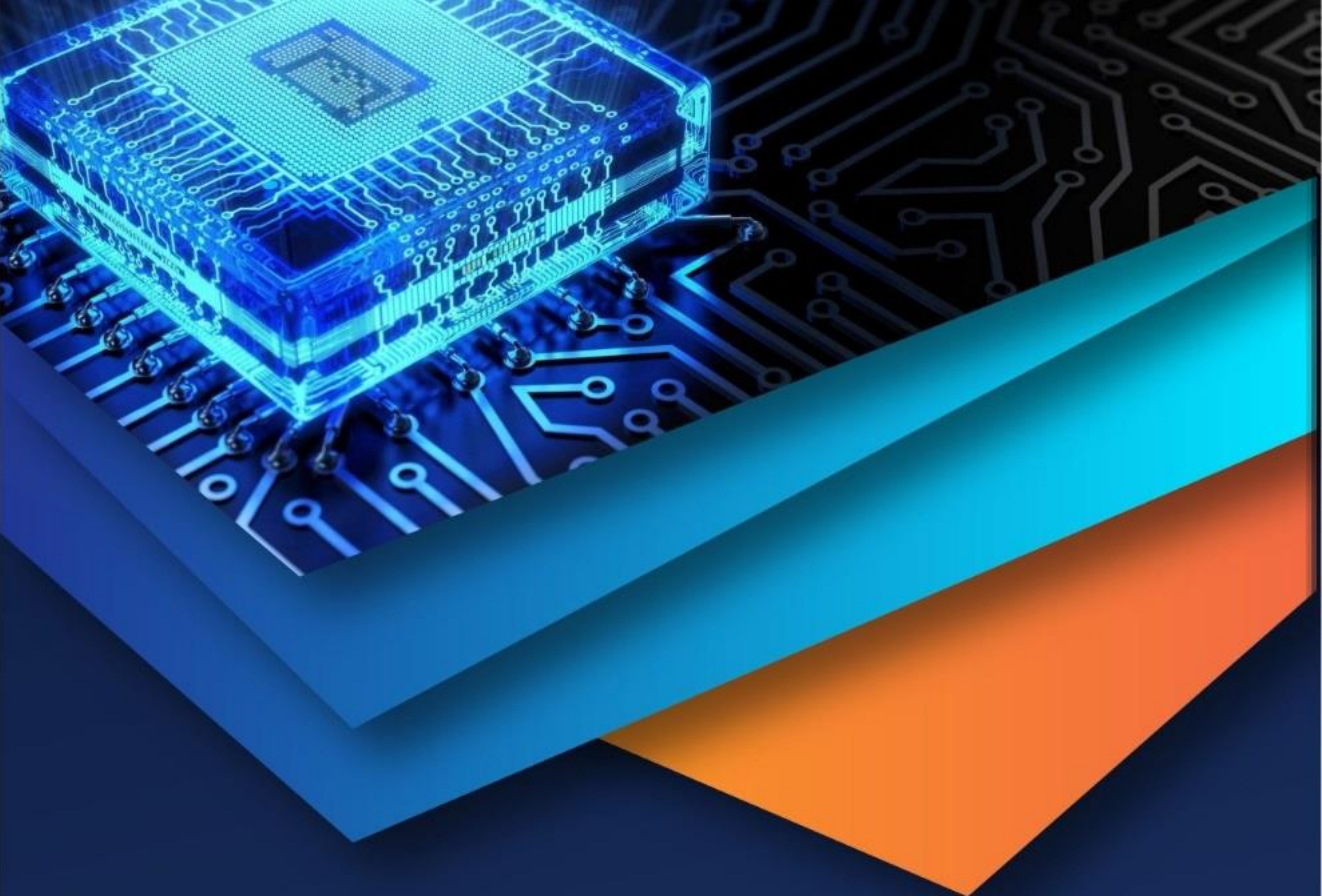

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