Analyzing Self-consolidating Concrete with Glass Powder

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Abstract —*This paper presents the experimental study of glass powder in the Self consolidating concrete with different mix proportions to find their behaviors. Self-Compacting Concrete is also referred to as "Self consolidating concrete" and "High performance concrete". It is one of the biggest modern innovations in the construction field worldwide. It has recently been one of the most important developments in the building industry. 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 materials but also create a greener and cleaner environment. This study aims to focus on the possibility of using waste material in a preparation of innovative concrete .The one kind of waste identified is 'Glass Powder' (GP). The use of this waste (GP) was proposed in different percentage as an instead of cement for production of Self compacting concrete.*

- **Keywords —** *Glass Powder (GP), Self-Consolidating Concrete (SCC), Self-compacting, Compressive strength, Mix proportion.*

I. INTRODUCTION

Concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advancement. Generally the three major characteristics of concrete are workability, strength, and durability. It is believed that strength and durability are related to the hardened concrete and workability is related to the fresh concrete, however hardened properties may be directly attributed to the mix design and fresh properties. In other words, mix design and the fresh properties of concrete are the most critical points to control in relation to the mechanical characteristics of hardened concrete. Many types of concrete have been developed to enhance the different properties of concrete. So far, this development can be divided into four stages. The earliest is the traditional normal strength concrete which is composed of only four constituent materials, which are cement, water, fine and coarse aggregates. With a fast population growth and a higher demand for housing and infrastructure, accompanied by recent developments in Civil Engineering, such as high-rise buildings and long-span bridges, higher compressive strength concrete was needed. At the beginning, reducing the water-cement ratio was the easiest way to achieve the high compressive strength. Thereafter, the fifth ingredient, a water reducing agent or super plasticizer, was indispensable. The chemical admixture is said to be any material that is added in a small quantity (i.e., less than 5%) to the concrete mixture which enhances the properties of concrete in both the fresh and hardened state.

In recent years, the usage of self-compacting concrete in ready mix concrete plants have tremendously increased due to its advantages in consolidation, uniformity and reliability. Self-compacting Concrete is an innovative concrete that does not require any vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The slump of concrete in which cement is replaced by glass powder, decreased with an increase in glass content because of its angular shape. Strength of concrete with glass powder, which depends on the size and content of glass, was comparable to the concrete without glass. The drying shrinkage of concrete with glass powder was higher and decreased with an increase in the fineness of the glass. In addition, the color of glass does not have remarkable effect on fluidity and strength of the concrete. Ground glass is an unconventional material for SCC but it is certainly promising considering its recognized feasibility in concrete and potential environmental benefits.

II. OBJECTIVE

The main objective of the project is –

- To derive an appropriate mix design for self-compacting concrete and analyse its rheological properties.
- To investigate the effect of dosages of blended admixture on compressive strength of self-compacting concrete.
- To determine the compressive strength of both conventional and self-compacting concrete and compare their results.

III. MATERIAL USED

A. CEMENT

In this experiment, Ordinary Cement conforming to IS: 8112-1989 was used. The physical and mechanical properties of the cement used are shown in Table 1.

B. AGGREGATE

Locally available natural sand with 4.5 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given in Table 2 and crushed stone with 16 mm maximum size having specific gravity, fineness modulus and unit weight as given in Table 2 was used as coarse aggregate. Table 2 gives the physical properties of the coarse and fine aggregates.

C. GLASS POWDER

Waste glass available locally in Rohtak shops is been collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it has to be powdered to desired size. In this studies glass powder ground in ball/ pulverizer for a period of 40 to 60 min resulted in particle sizes less than size 150 µm and sieved in 75 µm.

TABLE I

Properties of Cement

Physical Property	Result
Fineness (retained on 90-um sieve)	8%
Normal Consistency	29%
Vicat initial setting time (min)	74.5
Vicat final setting time (min)	214
Specific gravity	3.17
Compressive strength at 7-days	20.2 MPa
Compressive strength at 28-days	51 MPa

TABLE II

Properties of Aggregate

Property	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.6	2.6
Fineness Modulus	7.7	3.2
Surface Texture	-	Smooth
Particle Shape	Angular	Rounded
Crushing Value	16.50	-
Impact Value	11.52	-

TABLE III

Properties of Glass Powder

S.No.	Physical Properties of Glass	
1.	Specific gravity	2.2
2.	Colour	white

D. ADMIXTURE

The admixture used was a super plasticizer based on modified poly carboxylates. With a relatively low dosage they allow a water reduction up to 40%, due to their chemical structure which enables good particle dispersion. It was used to provide necessary workability. Superplasticizers (high-range water-reducers) are low molecular-weight, water-soluble polymers designed to achieve high amounts of water reduction (15-30%) in concrete mixtures in order to attain a desired slump. These admixtures are used frequently to produce high-strength concrete (>50 MPa), since workable mixes with water-cement ratios well below 0.50 are possible.

IV. MIX PROPORTIONS

The mix proportion was done based on the method proposed by Nan. *Et.al.* The mix designs were carried out for concrete grade 25. This method was preferred as it has the advantage of considering the strength of the SCC mix. Unlike other proportioning methods like the Okamura and EFNARC methods, it gives an indication of the target strength that will be obtained after 28 days of curing. The water to powder ratio was varied so as to obtain SCC mixes of various strengths. All the ingredients were first mixed in dry condition. Then 70% of the calculated amount of water was to be added to the dry mix and mixed thoroughly. Then, 30% of water was mixed with the super-plasticizer and included in the mix. Then, the mix was checked for self-compact ability by flow test, V-funnel test and L-Box test.

A standard has been laid down with a recommended procedure for designing concrete mixes for general types of construction using the concrete materials. The design is carried out for a desired compressive strength and workability of concrete, using continuously graded aggregates. Out of all the physical characteristics of concrete, compressive strength is often taken as an index of its quality in terms of durability, impermeability and water tightness and is easily measurable.

Table 4: Mixture Proportion for 1 cm^3 of SCC

Mix Grade	mix	w/p	Water (kg/m^3)	Cement (kg/m^3)	Gp (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	SP (%)
M25	Scc1	0.5	193	385	0	1024	793	1
	Scc2			366	20.25	1024	793	1
	Scc3			347.5	39	893	793	1
	Scc4			326.2	57	893	825	1

V. TESTS ON SCC MIXES

Various tests were conducted on the trial mixes to check for their acceptance and self compatibility properties. The tests included Flow test and V-funnel tests for checking the filling ability and L-box test for the passing ability.

A. Slump Test

Table 5: Slump Flow Test Results

Trial Mix	Slump Flow	Requirement	T_{50cm} Slump flow	Requirements
Units	Mm	Mm	Sec	Sec
Scc1	785	650-800	3.2	2-5
Scc2	700	650-800	3.8	2-5
Scc3	650	650-800	4.4	2-5
Scc4	605	650-800	5.0	2-5

B. V- Funnel Test

Table 6: V- Funnel Test Results

Trial Mix	Slump Flow	Requirement	T_5 min	Requirements
Units	Sec	Sec	Sec	Sec
Scc1	8.2	8-12	1.5	0-3
Scc2	9.4	8-12	2.4	0-3
Scc3	10.6	8-12	2.6	0-3
Scc4	11.2	8-12	3	0-3

C. **L- Box Test**

T ıble 7: L Box Test Results

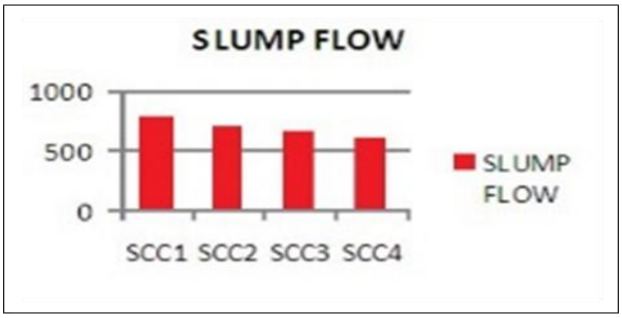
Trial Mix	**L - Box Test**			**Requirements**
	H1	**H2**	**H2/H1**	**H2/H1**
Units	mm	mm	-	-
Scc1	10	7	0.95	0.8 – 1
Scc2	9	7	0.94	0.8 – 1
Scc3	9	8	0.86	0.8 – 1
Scc4	10	6	0.82	0.8 – 1

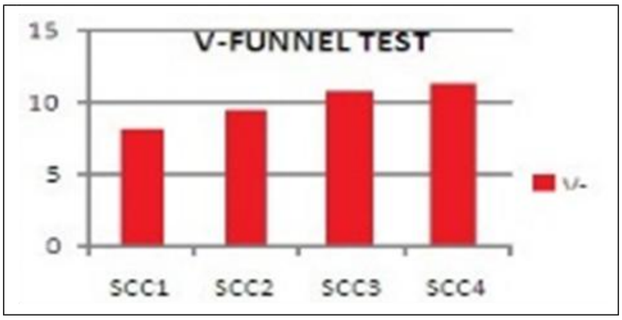
D. **Compressive Test**

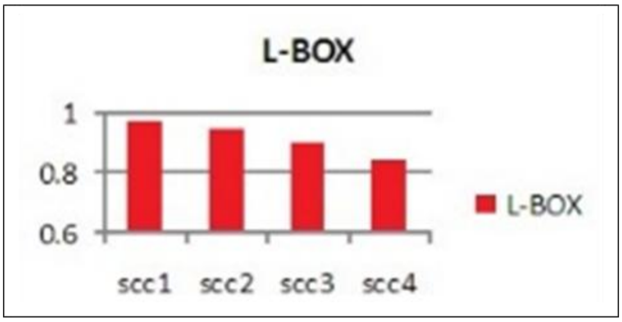
Table 8: Compressive Test Results

Admixture Dosage	**Curing days**	**Compressive Strength (MPa)**			Average compressive Strength
		Batch-1	**Batch-2**	**Batch-3**	
SCC-15%	7 days	19.26	19.1	18.95	19.10
	14 days	25.4	25.4	25.15	25.31
	28 days	32.2	31.1	31	31.16
SCC-210%	7 days	19	18.8	18.5	18.75
	14 days	24.6	24.42	24.12	24.34
	28 days	29.9	30.1	30	29.9
SCC-315%	7 days	18.8	17.93	17.67	18.15
	14 days	20.1	19.45	20.5	20.03
	28 days	28.8	27.9	27.45	28.03

Graphs for the Tests







VI. CONCLUSIONS

The latest researches are concentrating on ways to create new concrete by using various industrial wastes. The addition of glass powder into concrete was a step that was taken to utilize glass powder obtained from the waste glass factory in an effective manner. Various properties of the glass powder integrated SCC mixes such as self compatibility, compressive strength, and flexural strength were evaluated and compared with those of conventional SCC. From the experimental investigations, the following conclusions were arrived at:

i. The addition of glass powder in SCC mixes reduces the self compatibility characteristics like filling ability, passing ability and segregation resistance.

ii. The flow value decreases by an average of1.35%, 2.0% and 4.35% for glass powder replacements of 5%, 10% and 15%, respectively.

iii. The V-funnel time was observed to increase by an average of 6.2%, 15% and 22.5% for glass powder contents of 5%, 10% and 15% respectively. This increase in the V funnel time indicates decreased values of relative flow time and thereby the higher viscosity (resistance to flow) for the mixes.

iv. The L-box value was also observed to follow a decreasing trend with an average variation of 1.5%, 3.4% and 5% for glass powder contents of 5%, 10% and 15%, respectively.

The compressive strength decreases with even increase in glass powder contents. The average reduction in compressive strength for the grade was around 6%, 15% and 20% for glass powder contents of 5%, 10% and 15%, respectively.

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