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Effect of Fly Ash on Fresh and Hardened Properties of Self Compacting Concrete

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Abstract

Self-compacting concrete (SCC) is one of the High Performance Concrète with excellent strength and durability properties. However, its mix proportioning and testing methods for flow characteristics are different from those of the ordinary concrete. SCC has high powder content and a super plasticizer for enabling flow while keeping coarse aggregate in a viscous suspension. The powder is usually cement and a filler material. In this paper an attempt has been made to study fresh and hardened properties of self compacting concrete using Fly ash as partial replacement of cément in different percentages in addition to filler.Modified Nan-su method has been used for design mix as the study was carried out for medium strength of concrete.

Keywords: Fly ash, Self Compacting Concrete, Strength, Durability, Modified Nan-su Method.

Introduction

Self-compacting concrete (SCC) is an innovative concrete that does not requires 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 hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete. Popularity of using self-compacting concrete (SCC) in concrete construction is increased in many countries, since SCC is effectively applied for improving durability of structures while reducing the need of skilled workers at the construction site.

Self-compacting concrete (SCC) offers various advantages in the construction process due to its improved quality, and productivity. SCC has higher powder content and a lower coarse aggregate volume ratio as compared to normally vibrated concrete (NVC) in order to ensure SCC's filling ability, passing ability and segregation resistance. If only cement is used in SCC, then it become costly, susceptible to be attacked and produces much thermal crack. It is therefore necessary to replace some of the cement by addition of filler to achieve an economical and durable concrete.

Nowadays, the ecological trend aims at limiting the use of natural raw materials in the Field of building materials and hence there is an increased interest in the use of alternative materials (waste) from various industrial activities, which presents significant advantages in economic, energetic and environmental terms. In this paper Fly ash is used as a mineral admixture and Fly ash is one of the numerous substances that cause air, water and soil pollution, disrupt ecological cycles and set off environmental hazards. The combustion of powdered coal in thermal power plants produces fly ash. The high temperature of burning coal turns the clay minerals present in the coal powder into fused fine particles mainly comprising aluminium silicate. Fly ash possesses both ceramic and pozzolanic properties.

Figure 1. Fly ash

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Literature Review

Naveen Kr. C.kiran, et.al.[1] Presented a experimental results on different mineral admixtures used in SCC as filler. The results showed that SCC can be produced with cement content, as low as 200kg/m^3 of concrete together with rest of the powder coming from fly ash.

Vilas V. Kirjinni & Shrishail B. Anadinn.[2] They emphasized on the mixture proportion which is one of the important parameter in the self compacting concrete. They have used modified Nan-su method and obtained mix design in normal grades with different mineral admixtures & the compressive strength and flow properties of SCC were also studied.

Vilas V. Karjinni, Shrishail B.Anadinni, Dada S. Patil.[3] Presented a comparative evaluations of fresh and hardened properties of SCC using different mineral admixture with Nan-su and Modified Nan-su mix design method.

On the basis of above studies, the objective of this investigation was to study the behavior of SCC with different percentages of Fly ash in addition to filler, to understand effect of mineral admixture on fresh and hardened properties of SCC. The modified Nan-su method was used for mix design of SCC and also investigated the compatibility of Fly ash in SCC along with chemical admixture such as superplasticizer and to study the durability aspect of SCC.

Research Significance

Self-compacting concrete (SCC) has recently been one of the most important developments in the concrete technology. For a newly developing material like Self compacting concrete, studies on durability is of paramount importance for instilling confidence among the engineers and builders.

The literature indicates that some studies are available on the SCC with different mineral admixture as powder content (filler) but comprehensive studies are not available on fresh and hardened properties of self compacting concrete with different percentages of fly ash in addition to filler which involves compressive strength, flexural strength, split tensile strength and water absorption test.

Hence, considering the gap in the existing literature, an attempt has been made to study the effect of mineral admixture (Fly ash) on the fresh and hardened properties of self compacting concrete.

Materials

Cement

In this experimental study, Ordinary Portland Cement conforming to IS: 8112-1989 [4] was used. The physical and mechanical properties of the cement used are shown in Table 1.

TABLE 1. Properties of cement

Physical property	Results
Fineness (retained on 90-µm) sieve)	8%
Normal Consistency	28%
Vicat initial setting time(minutes)	75
Vicat final setting time (minutes)	215
Specific gravity	3.15
Compressive strength at 7-days	20.6 MPa
Compressive strength at 28-days	51.2 MPa

Aggregates

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given in Table 3 and crushed stone with 16mm maximum size having specific gravity, fineness modulus and unit weight as given in Table 2 was used as coarse aggregate.

TABLE 2. Physical properties of coarse and fine aggregates

Property	Fine Aggregate	Coarse Aggregate
Specific Gravity	2.66	2.95
Fineness Modulus	3.1	7.69
Surface Texture	Smooth	--
Particle Shape	Rounded	Angular
Crushing Value	---	17.40
Impact Value	---	12.50

Fly Ash

The combustion of powdered coal in thermal power plants produces fly ash. For this work Fly ash was obtained from Thermal Power Station, PARAS, Akola (M.S) India.

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TABLE 3. Chemical composition of Fly ash

SiO_2	58.55
Fe_2O_3	3.44
Al_2O_3	28.20
CaO	2.23
MgO	0.32
SO_3	0.07
Na_2O	0.9
K_2O	0.6

TABLE 4. Physical properties of Fly ash

Physical Properties	Results
Fineness (retained on 90-µm)	12%
Specific Gravity	2.10
Colour	Greenish

Super Plasticizer (SP)

The admixture CONPLAST SP 430 G8 was used a superplasticizer with a density of 1.2 kg/l. It was used to provide necessary workability.

TABLE 5. Physical Properties of Super plasticizer

Physical Properties	Results
Colour	White
Specific Gravity	2.11

Mix Proportioning

The mix proportion was done based on the Modified Nan-Su method. The mix design was carried out for M30 normal grade of self compacting concrete with Fly ash as partial replacement of cement with a fraction of 0%, 10%, 20% & 30%

TABLE 6. Quantities of Materials for 1m^{3}of SCC mixes.

Mix	Mix-0 (kg/m^3)	Mix-1 (kg/m^3)	Mix-2 (kg/m^3)	Mix-3 (kg/m^3)
Cement	382	343.8	305.6	267.2
Fly ash (Filler)	260	260	260	260
Fly ash as Cement Replacement	0.00	38.2	76.4	114.8
Total Powder Content	642	642	642	642
Fine Aggregate	710	710	710	710
Coarse Aggregate	612	612	612	612
W/P (0.38)	258	258	258	258
SP (0.8 %)	5.136	5.136	5.136	5.136

Mix-0:- 0% Replacement of Cement with Fly ash.
Mix-1:- 10% Replacement of Cement with Fly ash.
Mix-2:- 20% Replacement of Cement with Fly ash.
Mix-3:- 30% Replacement of Cement with Fly ash.

Self Compactability Tests On Scc Mixes

Various tests were conducted on the trial mixes to check the quality control test for SCC are performed to ensure that the requirement of Filling ability, Passing ability and flow ability are as required.

Table 7: Requirement of Fresh SCC

Method	Properties	Range of values
Flow value	Filling ability	650-800mm
V-funnel	Viscosity	6-12 sec
L-box	Passing ability	0.8 - 1.0

Result And Discussion

Fresh Properties SCC

Fly ash was used to replace the cement content by three various percentages (10, 20 and 30%). The partial replacement with Fly ash was carried out for M30 grades of concrete. To fulfill the requirement of SCC in fresh state and evaluate flow characteristic using slump cone, V-funnel, & L-box tests and to fix dosage of superplasticizer (HRWRA) as per EFNARC guidelines and fix the dosage of water /powder ratio was needed. The test results are presented in the table 8.

Table 8: Fresh properties of SCC.

Mixes	Mix-0	Mix-1	Mix-2	Mix-3
Slump	760mm	700mm	690mm	670mm
V-Funnel	8.7 Sec	8.5 Sec	8.1 Sec	6.47
L-Box	1	0.922	0.889	0.850

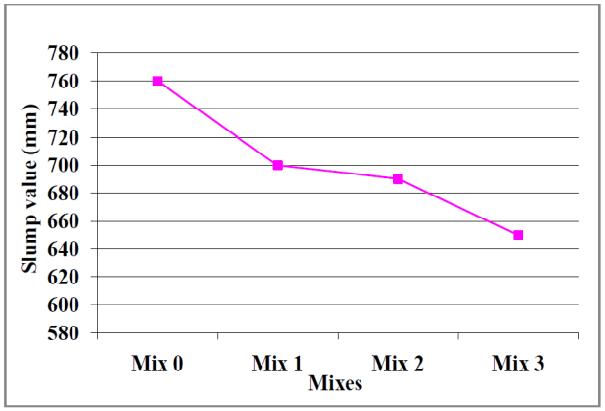

Figure 2. Slump flow value with Fly ash

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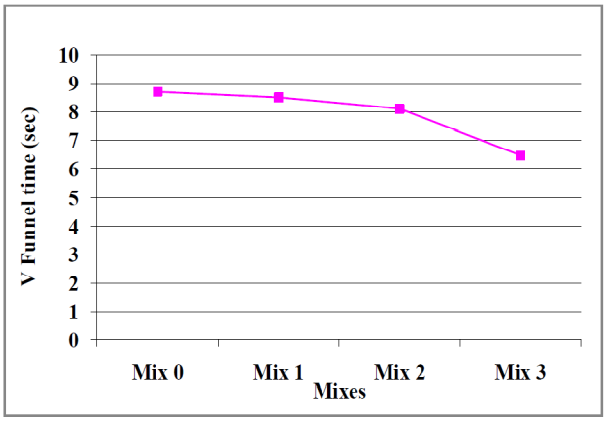

Figure 3. V-Funnel value with Fly ash

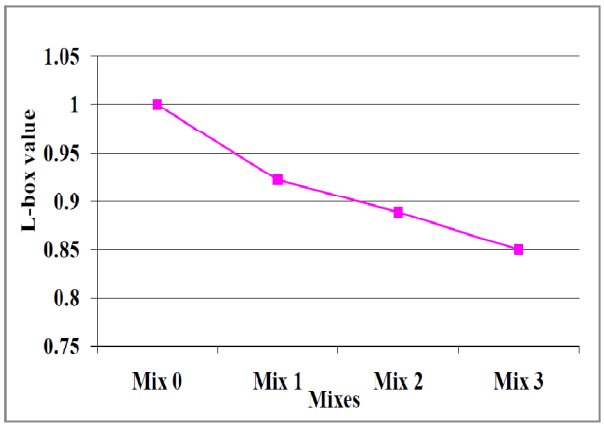

Figure 4. L-Box value with Fly ash

Hardened Properties of SCC

All the mixes were tested for various hardened properties like compressive strength, flexural strength & Split Tensile Strength and water absorption test as per Indian Standards.

Up to 20% addition of *Fly ash* (**Mix-2**), the compressive strength, flexural strength & Split Tensile Strength were obtained nearly same. After addition of 20% Fly ash the above results were found in decreasing order.

Figure 5 to Figure 7 shows the variation in compressive strength, flexural strength & Split Tensile Strength obtained for SCC.

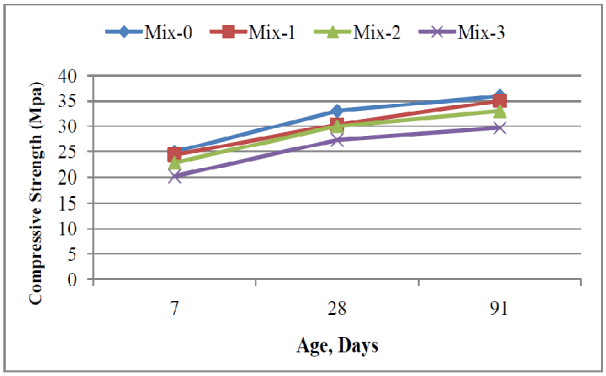

Figure 5. Variation of compressive strength with age

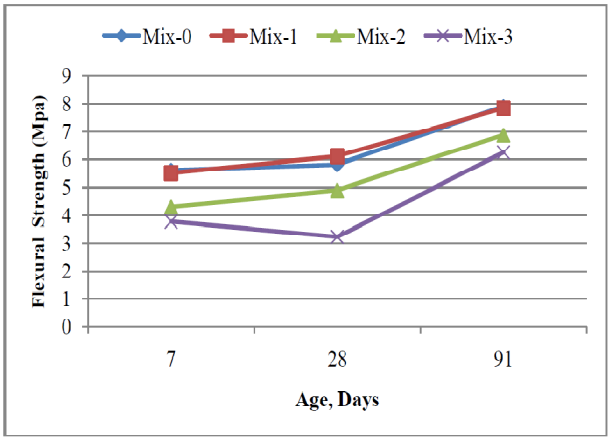

Figure 6. Variation of flexural strength with age

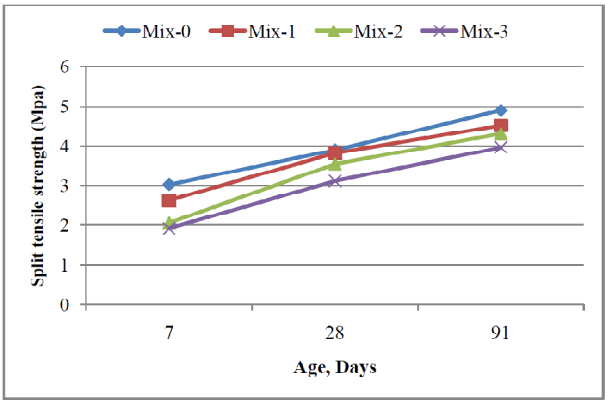

Figure 7. Variation of split tensile strength with age

Conclusions

On the basis of experimental investigations carried out, it is concluded that,

i. The brief literature review of SCC mixes made with Fly ash as a filler and addition of Fly ash as a partial replacement of cement used in SCC whenever economic, environmental and easy availability considerations predominate, without much apprehension.

ii. The slump flow value was obtained within the acceptable value up to 30% of Fly ash.
iii. The V-funnel & L-box Test showed acceptable value up to 30% of Fly ash.
iv. It is observed that Fly ash can be used in large quantity in SCC and cement content can be reduced to as low 305.6 kg/m^3 without losing the requisite characteristic of SCC. However this result in obtaining lower grades of concrete in terms of 28-days compressive strength. This may be acceptable for many applications where high 28-days compressive strengths are not necessary.
v. The SCC mixes with the addition of 20% Fly ash gave an optimum strength for M30 grade.
vi. The compressive strength of M30 grade of concrete monitored up to 91 days and showed an increased 1 to 2% over its 28 day strength. Similarly the split tensile strength and flexural strength increased by 2 to 3% compared to the 28 day strength.
vii. It was observed that the water absorption capacity is very less for design mix-2 as compared to other mixes. Hence the concrete is less permeable.

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