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DEVELOPMENT OF HIGH STRENGTH SELF-COMPACTING CONCRETE CONTAINING FLY ASH GGBS AND CEMENT

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Abstract:
Self-consolidating concrete (SCC) is being used in wide ranged buildings pavements and industrial applications which may be subjected to high temperatures to support fire resistance. The proper meaning of the effects of standard temperatures on the properties of SCC is necessary. It can flow and compact under its own weight into a uniform void free mass even in areas of congested reinforcement. The mix design for SCC was arrived as per the Guidelines of European Federation of National Associations Representing for Concrete (EFNARC-2005). In this investigation, SCC was made by usual ingredients such as cement, fine aggregate, coarse aggregate, water, fly ash and GGBS at various replacement levels. The super plasticizer used was conplast SP 430. Workability of the fresh concrete is determined by using tests such as: slump flow, L-Box and U-box tests. The mixes were then tested for other mechanical properties like, cube compressive strength at 7th day, 28th day, split tensile strength, and flexural strength at 28th day. For all levels of cement replacement with admixtures concrete achieved superior performance in the fresh and mechanical tests. In the experiment fly ash was varied by 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40%. GGBS was kept constant at 20% for all mixes. Cement was proportioned as 75%, 70%, 65%, 60%, 55%, 50%, 45%, and 40% respectively. The mechanical properties like Compressive strength, Split Tensile Strength, and Flexural properties were examined by replacing VMA with conplast SP 430.

Key words - Keywords: SCC, Fly ash, GGBS, compressive strength, split tensile strength, Flexural strength

1.0 INTRODUCTION

The cement industry is India's second highest payer of Central Excise and a major contributor to GDP. With infrastructure development growing and the housing sector booming, the demand for cement is also bound to increase. However, the cement industry is extremely energy intensive. After aluminum and steel, the manufacturing of Portland cement is the most energy-intensive process as it consumes 4GJ per tonne of energy. After thermal power plants and the iron and steel sector, the Indian cement industry is the third largest user of coal in the country. In 2003-04, 11,400 million kwh of power was consumed by the Indian cement industry. The cement industry comprises 130 large cement plants and more than 300 mini cement plants. The industry's capacity at the beginning of the year 2008-09 was about 198 million tonnes. The cement demand in India is expected to grow at 10% annually in the medium term buoyed by the housing, infrastructure, and corporate capital expenditures. Considering an expected production and consumption growth of 9 to 10 percent, the demand-supply position of the cement industry had improved from 2008-09 onwards. Coal-based thermal power installations in India contribute about 65% of the total installed capacity for electricity generation.

In order to meet the growing energy demand of the country, coal-based thermal power generation is expected to play a dominant role in the future as well, since coal reserves in India are expected to last for more than 100 years.

Self-Compacting Concrete

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in the section with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced.

Self–compacting concrete (SCC) is a fluid mixture, which is suitable for placing in difficult conditions and also in congested reinforcement, without vibration. In principle, a self-compacting concrete must:

- Have a fluidity that allows self-compaction without external energy.
- Remain homogeneous in a form during and after the placing process.
- Flow easily through reinforcement.

GGBS:

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

Applications of GGBS:

GGBS is used to make durable concrete structures in combination with ordinary portland cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete

2.0 LITERATURE REVIEW

Aijaz Ahmad Zende1, B. Khadirnaikar [1] In this study Particularly in India, the use of Self-compacting concrete for routine construction is not much because of the lack of awareness while in countries like Canada apart from Japan, SCC is used for the routine construction and with research data available, an awareness can be spread in order to utilize the various benefits of this material. It is not fully clear whether existing design codes for structural concrete can be practical in case of self-compacting concrete.

Balaraju Yugandhar [2] The present research includes investigation of mechanical properties of self-compacting concrete with fly ash, GGBS and broken tiles as partial replacement for cement, fine aggregate and coarse aggregate respectively. The mechanical properties of self-compacting concrete are evaluated by determining compressive strength, tensile strength and flexural strength for each of the mixes.

Objectives:

To obtain the Mix Design for High Strength Self-Compacting Concrete of M 40 grade incorporating fly ash fillers as per Nan Su mix design procedure and satisfying with EFNARC guide lines for different combinations of mineral admixtures, chemical admixtures, and complete replacement of fine aggregate fly ash and GGBS.

- To study the Fresh Properties of HSSCC.
- To study the Hardened Properties of HSSCC.
- To analyze the flexural behavior and crack pattern for HSSCC.
- With the above objectives in mind the experimental program is categorized into four phases as detailed below.

3.0 MATERIALS AND MIX PROPORTION

The materials generally required for producing self-compacting concrete differs from the ordinary normal concrete as SCC uses more powder content and less coarse aggregate in addition to high range water reducers (HRWR, super plasticisers) in a larger quantity. The factors which dominates the selection of materials are-

i. Amount of aggregates used which are deviating from ideal shapes and sizes.
ii. Type of super plastizer used.
iii. Types of powder used (fly ash and GGBS).
iv. Compatibility between cement, super plastizer, fly ash and GGBS.

Cement

In the present work ordinary Portland cement of 53 Grade ultra tech super conforming to IS 12269:1987

Table: Properties of cement

Physical Properties	Results
Fineness by dry sieve % (90 micron)	5 %
Specific Gravity	3.12
Initial setting time (min)	204

Final setting time (min)	315
Normal Consistency	30 %
Compressive strength at 3- days (N/mm2)	35.10
Compressive strength at 7- days (N/mm2)	47.30
Compressive strength at 28- days (N/mm2)	56

Aggregates: The shape and gradation of aggregates play an important role in producing a SCC. Much research has been conducted in this area to produce SCC by using locally available aggregates. Rounded aggregates are much preferred as they play an important role to achieve workability with lower cement content as compared to angular aggregates.

Table: Properties of Coarse Aggregates

Property	Value
Size	20mm
Shape	Irregular
Specific gravity	2.70
Abrrasion	27.18%
Water Absorption	0.50%
Crushing value	14.18%

Poor gradation of aggregates is also one of the causes which may affect the flowability of SCC and using fillers, both inert and reactive may solve this problem. Because of unavailability of sand in present days due to the environmental impact of mining river sand in India, alternative to fine aggregates or artificial sand is being used much as a filler to produce SCC, but not much research has been carried out on the effects of artificial sand on SCC till date.

Superplasticizers- High range water reducing admixture plays an important role in the desirable flow at low water contents. In this experiment we have used conplast sp 430 as superplasticizer.

Fly ash-

Fly ash is residue attained after combustion of coal. Fly ash used in the study from ASTM Class F and it is sourced from RDC CC plant near Bachupally in Hyderabad. The specific gravity of fly ash used was 1.72 Class F fly ashes are produced from bituminous and sub bituminous coals and contain alumina and silicate as active components. In this experimental work fly ash is taken as binder.

Ground Granulated Blast Furnace Slag (GGBS)

Blast furnace slag is a by-product obtained in the manufacture of iron. It is a product formed by the combination of the earthy constituents of iron-ore with the limestone flux at high temperature in

the blast furnace (about 1500 0c). The molten slag is rapidly quenched by a hose of water to yield a glassy granular non-metallic material consisting essentially of silicates and aluminates of calcium and other bases product called granulated blast furnace slag.
The specific gravity of GGBS is 2.56. In this experimental work GGBS was assumed as binder.

TABLE 3 Properties of Fly Ash and GGBS

Property	Fly-ash	GGBS
Specific gravity	1.72	2.56
Bulk density (Kg/m^3)	500-800	1100
Appearance	Grey	White
Particle size	30 microns	25 microns
Fineness (m^2/kg)	345	375

Super Plasticiser (conplast sp 430)

Conplast sp 430 is an admixture of a new generation based on modified polycarboxlic ether. The Product has been primarily developed for application in High performance concrete where highest Durability and performance is required. Conplast 430 is free of chlorine and low alkali. It is Compatible with all types of cements. The product compile with ASTM C494 Type F.

Table 4: Properties of conplast 430

Aspect	Brownish flowing liquid
Relative Density	1.09, 0.01 at 25°C
PH 7	± 1
Chlorine iron content	< 0.23%

Water

Potable water was used for mixing and curing.

4.0 EXPERIMENTAL PROGRAM

This experiment studies the strength characteristic of self-compacting concrete that contains quartz sand and coarse aggregates. The studies were carried out using different mix proportions for self-compacting, self-compacting cubes, beams and cylinders with different strength Compressive strength, flexural strength, split tensile strength were conducted for 7 days and 28 days.

Mix Designation	cement (kg/m^3)	GGBS (kg/m3)	flyash (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate (kg/m^3)	SP % of powder content	Extra water
MIX A	410	20%	5%	1020	1210	1.2	22%
MIX B	360	20%	15%	1020	1210	1.2	22%

MIX C	300	20%	25%	1020	1210	1.2	22%
MIX D	250	20%	35%	1020	1210	1.2	22%

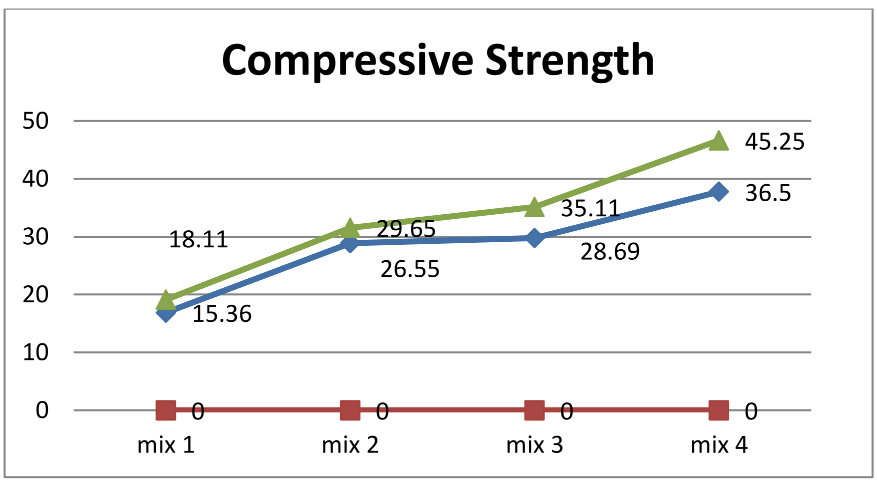
TEST RESULTS

Rheological properties

Rheological properties such as flow table test, V-funnel test and L- box test are performed according to EFNRC guidelines.

Mix	Flow Table		V Funnel	L- box
	T_{50} (sec)	Diameter (mm)	T_f (sec)	
SCC A	5	650	10	0.80
SCC B	3	680	8	0.89
SCC C	4	630	7	0.80
SCC D	3	690	12	0.96

Compressive Strength: units (N/mm^2): It is the tendency of structure to resist loads, tending to reduce size, as counter to tensile strength, which supports loads tending to expand. In present trends, compressive strength resists compression. Cubes of size 150mm X 150mm X150 mm are casted and tested.



Split Tensile Strength: units (N/mm^2):

The spilt tensile strength of self-compacting concrete is also an important property. Self-compacting concrete casted cylinders are used to determine the tensile strength of self-compacting concrete. The self-compacting concrete is slightly weak in tension due to its brittleness nature and is not dreamt to resist the tension directly.

Cylinders of 150mm diameter and 300mm length are casted and tested.

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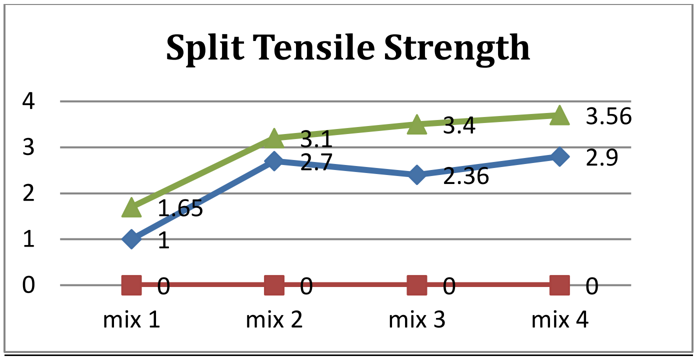
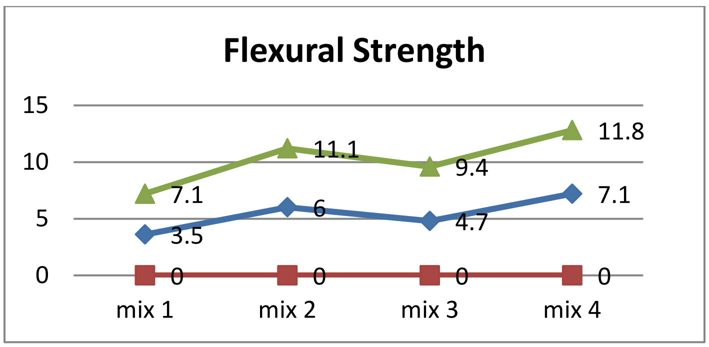


It is one measure of the bending strength of self-compacting concrete. It is a measure of an unreinforced concrete beam or slab to resist rupture in bending. It is measured by loading (**100x100x500mm**) concrete beams with a span length of at least three times the depth.



Conclusion

- It is absorbed that Increase of 40% in 28 days compressive strength when compared with 7 days compressive strength of nominal mix (mix 1).
- It is observed that increase of 25% in 28 days compressive strength when compared with 7 days compressive strength of optimum mix (mix 4).
- It is observed that increase of 15% is observed in 28 days compressive strength when compared with 7 days split tensile strength of optimum mix (mix 4).
- It is observed that increase of 20% in 28 days compressive strength when compared with 7 days flexural strength of optimum mix (mix 4).
- Mix 4 is considered as optimum mix with maximum mechanical properties and maximum increase of their parameters.
- Optimum mix is also satisfying all rheological properties under EFNRC guidelines.

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