EXPERIMENTAL INVESTIGATIONS ONDURABILITY PROPERTIES OF SELF COMPACTED CONCRETE BY PARTIAL REPLACEMENT OF FLYASH AND GGBS

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ABSTRACT: A self-compacting concrete (SCC) is the one that can be placed in the form and can go through obstructions by its own weight and without the need of vibration. Since its first development in Japan in 1988, SCC has gained wider acceptance in Japan, Europe and USA due to its inherent distinct advantages. Although there are visible signs of its gradual acceptance in the Middle East through its limited use in construction. The contributing factors to this reluctance appear to be lack of any supportive evidence of its suitability with local marginal aggregates and the harsh environmental conditions. The primary aim of this study is to explore the feasibility of using SCC made with local marginal aggregates of Andhra Pradesh by examining its basic properties and durability characteristics. This research consists of : (i) development of a suitable mix for SCC that would satisfy the requirements of the plastic state; (ii) casting of concrete samples and testing them for compressive strength, drying shrinkage, water permeability, and chloride permeability; and (iii) cyclic exposure tests involving wet-dry and heat-cool cycles to observe the degradation of the prepared SCC samples. Local aggregates, cement, admixtures and additives produced by the local suppliers were used by in this work. The significance of this work lies in its attempt to provide some performance data of SCC made in the Andhra Pradesh so as to draw attention to the possible use of SCC.

1. INTRODUCTION

In India, the manufacturing of Portland cement was commenced around the year 1912. The start was not exceptionally encouraging and development of bond industry was moderate. At the season of autonomy in 1947, the introduced limit of bond plants in India was roughly 4.5 million tons and genuine creation around 3.2 million tons for each year. The extensive development movement embraced amid the different 5 years designs for the most part amid the required the development of concrete industry. In any case, the five year designs conceived for multipurpose undertakings and furthermore for fast modern development remained stinted because of the total control practiced by the Government over the bond business. As the infra-structure division was creating amid 1980s provoked the different mechanical associations were intrigued for setup new bond plants in the nation. The full progression on concrete industry in 1988 further gave quick development to the development. One of the fundamental infrastructural offices that man requirements for good living is protect. The improvement of innovation in materials and development has made it conceivable to assemble even high rises. Notwithstanding, the expanding expense of regular development materials has made it hard to meet the haven prerequisites of the overflowing populace of creating nations. Quick extension in the development business delivered with it related issues. Because of its adaptability and simple form capacity, overall cement is perceived as a chief development material. It is the material of decision for an assortment of utilizations, for example, lodging, spans, roadway installments, mechanical structures, water conveying and holding structures, and so forth the credit for this accomplishment goes to surely understood points of interest of cement, for example, simple accessibility of fixings, satisfactory designing properties for an assortment of basic applications, flexibility, adaptability, relative ease, and so forth.

1.1. SELF COMPACTING CONCRETE

Self-compacting concrete is a type of solid that is fit for streaming in to the congested inside of frame work going through the fortification and filling it in a characteristic way, combining under the activity of its own weight without isolation and dying. It is produced using practically an indistinguishable fixings from that of the ordinarily vibrated concrete aside from that the relative extents of these fixings are to be deliberately chosen to bestow self-compacting property to newconcrete.

The idea of self-compacting was proposed in 1986 by Professor Hajime Okamura. In any case, the main model was produced in Japan by Professor Ozawa in the year 1988 at the University of Tokyo. Because of the improvement of the model of SCC, the utilization of SCC in real structures has been slowly expanded everywhere throughout the world. The primary explanations behind the work of SCC are to be abbreviated the development time frame, to guarantee uniform compaction in the structure, and to keep away from clamor because of vibration. SCC is consequently called "the very upheaval in solid development' (The Concrete Society and BRE 2005).

1.2.GROUND GRANULATED BLAST FURNACES (GGBS)

Ground-granulated impact heater slag (GGBS or GGBFS) is gotten by extinguishing liquid iron slag (a result of iron and steel-production) from a shoot heater in water or steam, to create a lustrous, granular item that is then dried and ground into a fine powder. These work at a temperature of around 1500 degrees centigrade and are bolstered with a deliberately controlled blend of iron metal, coke and limestone. The iron mineral is decreased to press and the rest of the materials from a slag that buoys over the iron. This slag is intermittently tapped off as a liquid fluid and in the event that it is to be utilized for the make of GGBS it must be quickly extinguished in expansive volumes of water. The extinguishing streamlines the cementious properties and produces granules like coarse sand. This „granulated" slag is then dried and ground to a fine powder. Albeit ordinarily assigned as "GGBS" in the UK, it can likewise be alluded to as "GGBS" or "Slag bond" Concrete is essentially a blend of fine total, coarse total and bond. The principle issue is the first customary materials are exhausting and we are in chase for substitute building materials which lands us here on the motivation behind GGBS. Being a result and waste utilizing it viably up to some degree fills in as a stage for a greener domain and in the meantime remembering that the quality of the solid doesn't corrupt by the use GGBS.

2. MATERIALS AND METHODOLOGY

2.1.1. Cement

A concrete is a cover, a substance utilized as a part of development that sets, solidifies and holds fast to different materials, restricting them together. Bond is at times utilized exclusively, yet is utilized to tie sand and rock (total) together. Bond is utilized with fine total to create mortar for stone work, or with sand and rock totals to deliver concrete. Cement is the most normally utilized establishing fixing in show day concrete contains stage that comprise of mixes of calcium silicon, aluminum, iron and oxygen. In this venture we contracted Commercially accessible 53grade customary Portland bond fabricated by Ultra Tech Cement with Specific Gravity of 3.2 and Fineness Modulus of 225m2/kg utilized as a part of all solid blends.

2.1.2 Aggregates

'Total' is a term for any particulate material. It incorporates rock, smashed stone, sand, slag, and reused cement and Geosynthetics totals. Total might be common, produced or reused. Totals make up somewhere in the range of 60 - 80% of the solid blend. They give compressive quality and mass to concrete. Totals in a specific blend of cement are chosen for their solidness, quality, workability and capacity to get wraps up. For a decent solid blend, totals should be spotless, hard, solid particles free of consumed chemicals or coatings of earth and other fine materials that could cause the weakening of cement. Depending upon the size the aggregates are classified into two types

- Coarse Aggregate
- Fine Aggregate

2.1.3 Fly Ash

Fly ash is classified into two types

1) Class F
2) Class C

2.1.3.1 Class F

It is normally low in lime, more often than not under 15%, and contains a greater combination of silica, alumina and iron (greater than 70%) than Class C fly ash

2.1.3.2 Class C

Class C fly slag ordinarily originate from coals which may fabricate a fiery remains with higher lime content by and large over 15% regularly as high as 30%.

Fly fiery remains complying with the prerequisites of IS 3812 assembling from Rayalaseema Thermal Power Project (RTPP) in dharmal town close to Proddtur Kadapa region. The particular gravity of fly cinder is 2.2 and particular surface region of fly fiery remains 280m2/kg was utilized as supplementary cementitious material in solid blends. 85% of particles are gone through 45um sifter. In this examination Class F fly fiery remains is utilized as a part of Self Compacting Concrete.

2.1.4 Ground Granulated Blast Furnace Slag (GGBS)

Ground Granulated Blast Furnace Slag (GGBS) is a result of Iron industry and which is gotten from amid the make of iron. The liquid slag is an optional result of sintering of the crude materials and this is extinguished under high weight of water planes, which comes about as pulverizes. The GGBS is acquired when the granulated slag is ground to a fine powder with a particular surface zone of 400-600m^2/kg .The concoction structure of a slag differ fundamentally relies upon the organization of the crude materials in the iron generation process. Silicate and aluminates contamination from the mineral and coke be commonly in the shoot heater with a motion which brings down the thickness of the slag. On account of pig press fabricate the motion comprises basically of a blend of limestone and forsterite or inside a few cases dolomite. In the impact heater the slag skim over best of the iron and is tap for partition. Moderate cool of slag dissolves brings about an uncreative crystalline material comprising of a gathering of Ca-Al-Mg silicates. Towards get a decent slag reactivity or hydraulicity, the slag melt wants to be quickly cooled or extinguish beneath 800 °C to stay away from the crystallization of merwinite and melilite. To cool and part the slag a granulation procedure can be connected in which liquid slag is subjected to fly stream of water or air underweight. Then again, in the pelletization procedure the fluid slag is somewhat cooled with water and therefore anticipated into the air by a turn drum. So as to acquire a fitting reactivity, the got pieces are ground to achieve an indistinguishable fineness from Portland concrete.

2.1.5 Super Plasticizer Admixture

For self-compacting concrete, the best Super plasticizer is an admixtures situated in Polycarboxilates, don't manage by the brand of the admixtures in light of the fact that every maker have the individual name, the sythesis must be situated in ethers of Polycarboxilates, the last age of substance superplastizicer admixtures. Materials which grant high workability with an expansive decrease in water content for a predetermined workability. Super plasticizer is likewise called as High range water lessening admixture (HRWA) in light of polycarboxylate ethers are commonly used to plasticize the blend. Because of low water-bond proportion, SCC is extremely vulnerable to dampness variances in the assembling procedure; hence, stabilizers such in the meantime as polysaccharides are included.

2.2 MIX DESIGN PROCEDURE FOR SELF COMPACTING CONCRETE

The design procedure adopted for preparation of self-compacting concrete with the application of fly ash and GGBS. Self-compacting concrete mix design for M30 grade as per **"EUROPEAN GUIDE LINES"**

In designing the mix it is most useful to consider the relative proportions of the keycomponents by volume rather than by mass.

- ✓ Water / Powder ratio by volume of 0.80 to 1.10
- ✓ Total powder content – 160 to 240 liters (400 – 600 Kg) per cubic meter.
- ✓ Coarse aggregate content normally 28 to 35 percent by volume of the mix.
- ✓ Water cement ratio is selected based on requirements in EN 206. Typically water content does not exceed 200 liter/m^3.
- ✓ The sand content balances the volume of the other constituents.
- ✓ Generally, it is advisable to design conservatively to ensure that the concrete is capable of maintaining its specific fresh properties despite anticipated variations in raw material quality. Some variation in aggregate moisture content should also be expected and allowed for at mix design stage.

2.3 Selection of Mix Proportions

In designing the SCC mix, it is most useful to consider the relative proportions of the key components by volume rather than by mass. The following key proportions for the mixes listed below:

1. Air content (by volume)
2. Coarse aggregate content (by volume)
3. Paste content (by volume)
4. Binder (cementitious) content (by weight)
5. Replacement of mineral admixture by percentage binderweight
6. Water/ binder ratio (by weight)
7. Volume of fine aggregate/ volume of mortar SP dosage by percentage cementitious (binder) weight.

2.4 Final Proportions

Water = 199.67 lit/m^3

Adjusted C.A =771.84 kg/ m^3

Adjusted sand = 850.805 kg/ m^3

Super plasticizer = 4.8 lit/ m^3

Binder (cement + fly ash+ GGBS) – 533 kg/ m^3

Cement – 453.2 kg/ m^3

Fly ash – 53.3 kg/ m^3

GGBS – 26.65 kg/ m^3

Super plasticizer – 4.8 lit/ m^3

Water content – 199.677 lit/ m^3

Coarse aggregate – 771.84 kg/ m^3

Fine aggregate – 850.805 kg/ m^3

In the present study from the above mix design we have chosen the following cases for casting

3. EXPERIMENTAL INVESTIGATION

3.1.Workability Tests for SCC

In this investigation workability tests are followed by

3.1.1. Slump Flow Test with T500

3.1.2. L-Box Test

3.1.3. V-funnel and T5

3.1.4. J-Ring Test

3.2. COMPRESSIVE STRENGTH TEST

1.	NORMAL CONCRETE,	A1
2.	10% FLY ASH AND 0% GGBS,	A2
3.	10% FLY ASH AND 5% GGBS,	A3
4.	10% FLY ASH AND 10% GGBS,	A4

3.2.1. ACID RESISTANCE TEST

3.2.2. SULPHATE ATTACK TEST

3.2.3. ALKALINITY TEST

3.2.4. RCPT (RAPID CHLORIDE PERMEABILITY TEST)

4. EXPERIMENTAL RESULTS AND DISCUSSION

This chapter explains the mechanical strength properties like compressive strength, and durability properties where specimens were cured in acid and in chemical where concrete mixture with fly ash and ground granulated blast furnace slag and discussion are presented.

The results completed in the present investigation are reported in the form of Tables and Graphs for various fresh properties and hardened properties of Self-compacting concrete for various percentage of fly ash and GGBS as a partial replacement to cement in SCC by fly ash taken constant of 10% and GGBS taken as percentages like 0%, 5%, 10%&15%, are worked out and tabulated in the table below.

4.1.Fresh properties of SCC

Table 4.1: Fresh properties of self-compacting concrete

PERCENTAGE REPLACEMENT OF FLY ASH AND GGBS	SLUMP FLOW IN Mm	SLUMP FLOW IN sec (T_{50cm})	V-FUNNEL in sec	L-BOX (H_2/H_1)
10% & 0%	670	5	10	0.9
10% & 5%	650	7	9	0.83
10% & 10%	630	7	12	0.8
10% & 15%	625	7	8	0.79

4.2.Hardened properties of SCC

The following are the tables give the test results of Self compacting concrete, when cement is partially replaced by FLY ASH and GGBS, for Compressive strength and Split tensile strength, flexure strength, rebound hammer test and Young's modulus test.

Table 4.2.: Mix proportions

Mix Designation	Proportions of Binding Materials
A1	100% cement
A2	90% cement + 10% fly ash
A3	85% cement + 10% fly ash + 5% GGBS
A4	80% cement + 10% fly ash + 10% GGBS
A5	75% cement + 10% fly ash + 15% GGBS

4.3.COMPRESSIVE STRENGTH RESULTS

The Compressive strength results for various replacement levels of fly ash and GGBS by Cement such as 0%, 5%, 10% & 15% are tabulated below in table.

❖ Compressive strength of the cubes when they are tested under the following parameters are given below

1. Acid Resistance Test
2. Sulphate Attack Test
3. Alkalinity Test

4. RCPT(Rapid Chloride Permeability Test)

4.3.1 TEST RESULTS IN NORMAL CURING

Table 4.3.: COMPRESSION TEST RESULT @NORMAL CURING

Mix Designation	Compressive strength N/mm^2 28 days
A1	43.4
A2	33.86
A3	35.3
A4	30.63
A5	29.89

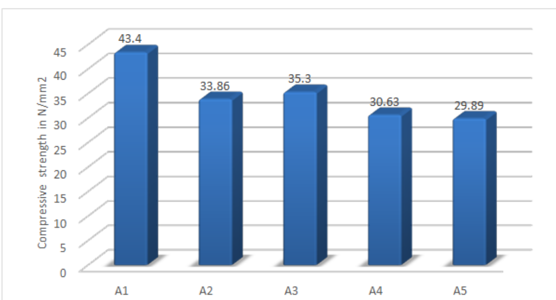

Fig.4.1: Compressive Strength test results (normal curing)

4.3.2. TEST RESULTS IN ACID ATTACK at 60days curing

As we observed the compressive strength is 28 days strength of SCC at acid attackfor (30days normal curing + 30days acid curing) i.e. Total 60 days as 10%FA & 0%GGBS, from the graph we can clearly make a forward step towards the increase in compressive strength when the replacement of 10% flyash and 10% GGBS is done at acid curing in 60 days compared to all the remaining mixes.

Table 4.4.: COMPRESSION TEST RESULT @ ACID ATTACK

Mix Designation	Compressive strength N/mm^2 60 days
A1	33.0
A2	33.8
A3	36.3
A4	41.6
A5	32.4

4.3.3. TEST RESULTS IN ACID ATTACK at 90 days curing

TEST RESULTS IN SULPHATE ATTACK at 60 days curing

Table 4.5.: COMPRESSION TEST RESULT @ ACID ATTACK

Mix Designation	Compressive strength N/mm^2 90 days
A1	40.26
A2	28.0
A3	41.73
A4	48.8
A5	30.2

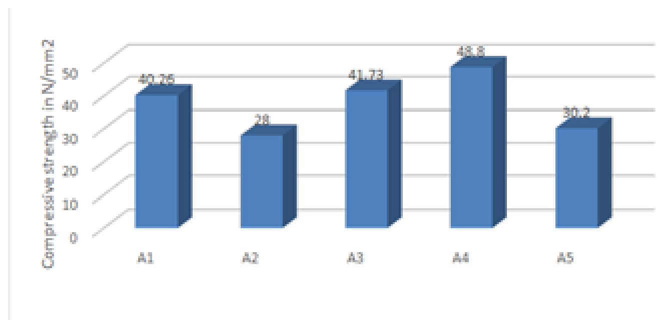

Fig.4.3: Compressive Strength test results (Acid Attack @90 DAYS)

4.3.4. TEST RESULTS IN SULPHATE ATTACK at 60 days curing

Table 4.6.: COMPRESSION TEST RESULT @ SULPHATE ATTACK

Mix Designation	Compressive strength N/mm^2 60 days
A1	37.4
A2	38.26
A3	31.56
A4	43.73
A5	32.50

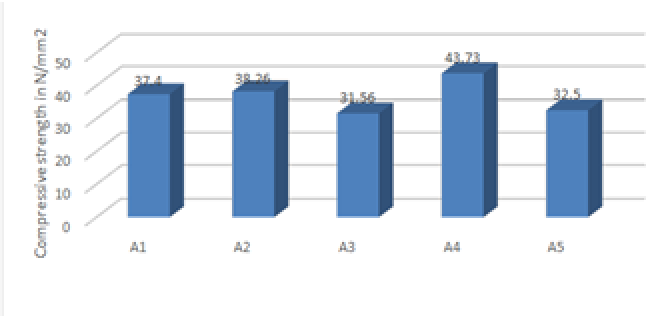

Fig.4.4: Compressive Strength test results (Sulphate attack @60 DAYS)

4.3.5. TEST RESULTS IN SULPHATE ATTACK at 90 days curing

Table 4.7.: COMPRESSION TEST RESULT @ SULPHATE ATTACK

Mix Designation	Compressive strength N/mm² 90 days
A1	35.53
A2	37.4
A3	40.2
A4	41.36
A5	30.5

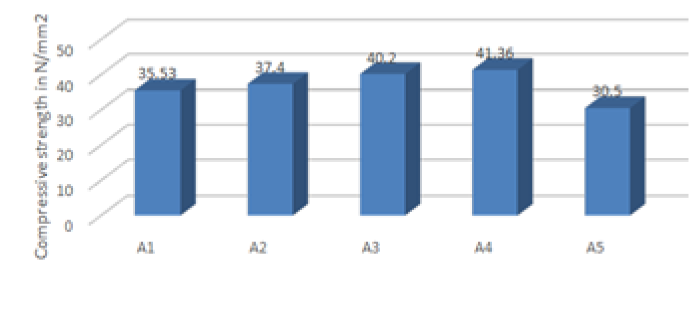

Fig.4.5: Compressive Strength test results (Sulphate Attack)

4.3.6. TEST RESULTS IN ALKALINITY TEST at 60 days curing

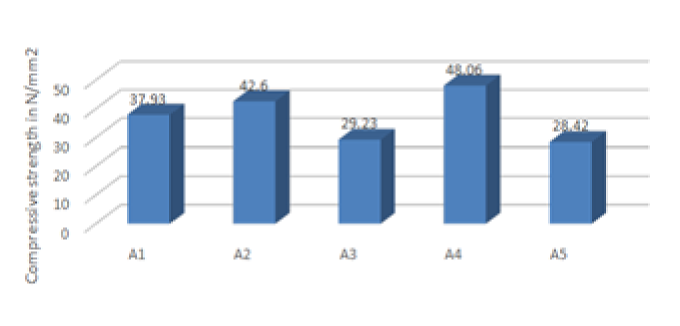

Fig.4.6: Compressive Strength test results (ALKALINITY TEST)

4.3.7. TEST RESULTS IN ALKALINITY ATTACK at 90 days curing

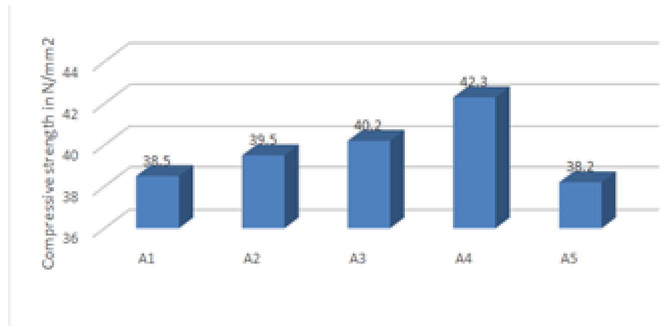

Fig.4.7: Compressive Strength test results (ALKALINITY TEST)

4.3.8. RCPT VALUES @28 DAYS & 60 DAYS

Table 4.10.: RCPT VALUES @28 DAYS & 60 DAYS

MIX PROPORTIONS	CHARGE PASSED (COULOMBS)	
	28DAYS	60 DAYS
A1	1672.5	1296.7
A2	1485.4	1078.5
A3	1183.6	963.55
A4	1088.7	785.89
A5	1185.6	995.3

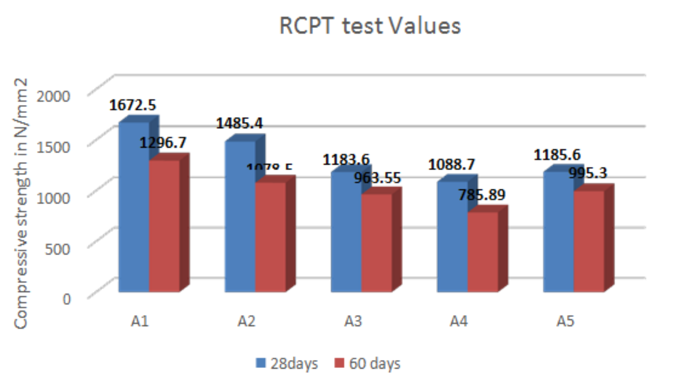

Fig.4.8: RCPT Values

5. CONCLUSIONS

Based on the investigation conducted for the durability study on behavior of self- compacting concrete the following conclusions are arrived.

- As no specific mix design procedures for SCC are available mix design can be done with conventional BIS method and suitable adjustments can be done as per the guidelines provided by different agencies.

- So, we should made trail mixes for maintaining filling ability, flowing ability, passing ability, self-compatibility and obstruction clearance.

- By making the replacement of cement with GGBS increases consistency.
- With the use of super plasticizer it possible to get a mix with low water to cement ratio to get the desired strength.
- In this project we done compressive strength of the cubes in the acid, sulphate and alkalinity attack
- The compressive strength of normal concrete is almost equal to the strength of 10% fly ash and 10% GGBS.
- From this project we can conclude that the mix proportion 10% fly ash & 10% GGBS withstands all the strengths and we got optimum results for the above mix.
- Mechanical and Durability properties of concrete of the following mix was taken as optimum i.e. 10% Fly ash and 10% GGBS, if we increase the percentage again the strength decreases.

6. SCOPE OF FUTURE WORK

- Fly ash can replace a significant part of the necessary filler when used into a self-compacting concrete composition.
- The elimination of vibrating equipment improves the environment protection near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration.
- SCC is favourably suitable especially in highly reinforced concrete members like bridge decks or abutments, tunnel linings or tubing segments, where it is difficult to vibrate the concrete, or even for normal engineering structures.
- The improved 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. Based on these facts it can be concluded that SCC will have a bright future.

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