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Effect on Mechanical Properties of M25 SCC with Variation of Class - F Fly Ash & GGBS

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Abstract : The present investigation aims to study the workability and mechanical properties of Self compacting concrete (SCC)double blended with Class-F Fly ash and Ground granulated blast furnace slag (GGBS).The reference control mix considered in the present study is M25 grade concrete and the mix design adopted is as per Nan-Su et.al (2001) mix design. Apart from cement, the different proportions of admixtures considered in the present study are GF1, GF2, GF3, GF4, GF5 and GF6 mix proportions. As per the mix design proposed by Nan-su,W/P ratio of 0.425 is considered at the age of 3,7,28,91 days. Properties of fresh concrete for workability are done as perguidelines of European Federation of National Association Representing for Concrete (EFNARC) in terms of J-Ring test, L-Box test, Slump flow test, T50 test and V-Funnel test are done to evaluate workability properties of fresh concrete. Mechanical properties of concrete in terms of compressive strength and Split tensile strength are determined for 3,7,28 and 91 days of curing period.
Keywords: EFNARC, Class-F fly ash, Ground granulated blast furnace slag (GGBS), J-Ring test, L-Box test, Slump Flow test, T50 test, V-Funnel test.

1. Introduction

We all live in such a world where concrete is extensively used in construction applications. Now-a-days, many structures are being constructed with a very good architectural and aesthetic view. Extensive research is done to design a concrete which ensures good passing and filling ability and it named as Self compacting concrete. SCC has the ability of passing and filling even in congestedreinforcement.SCC is a high performance concrete. It doesn't require any means to vibrate so as to have good compaction in order to avoid voids in the concrete. In order to overcome the problem of defective workman ship; SCC was first acknowledged in Japan which overcome the problems of passing and filling ability in congested and complex reinforcement and defective workman ship.

Material composition of SCC is same as that of the conventional concrete but in case of SCC, a high amount of Ultra high materials are required in addition to chemical admixtures especially high range water reducers and viscosity enhancing admixtures.SCC offers speedy placement in congested environment of

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reinforcement due to its fluidic nature and segregation resistance make high level of homogeneity which made the concrete placement free of voids.

2. Literature Review:

Nan su*et al*. [16]projected a new mix design methodology onSCC.At first the quantity of aggregates required was determined, and also the paste of binders was then filled into the voids of aggregates to confirm that the concrete thus obtained has flow ability, self-compacting ability and alternative desired SCC properties. Slump flow, V-funnel, L-box, U-box and compressive strength tests are meted out to examine the performance of SCC, and also the results indicated that the proposed methodology might be used to produce successfully SCC of top quality. Compared to the strategy developed by the Japanese Ready-Mixed Concrete Association (JRMCA), this methodology is less complicated, easier for implementation and less time-consuming, needs a little amount of binders and saves price.

Hajime Okamura and Masahiro Ouchi[9] demonstrated on rational mix design methodology and self-compactability testing strategies that have been carried out from the point of view of making self-compacting concrete a standard concrete. When SCC becomes widely used, it's seen as normal concrete instead of special concrete.

Mayur B. Vanjare and Shriram H. Mahure[15]investigated Glass Powder(GP) was made for 5%,10% and 15% proportion as the replacement of cement for the production of SCC for M20, M25 and M30 grade concrete. Nan-su mix design is established for this investigation. The addition of glass powder in SCC mixes reduces the self-compatibility characteristics like flowing ability, passing ability and segregation resistance. Compressive strength and flexural strength decreases with the increase of GP ratios. The flow value reduces by a mean of 1.3%, 2.5% and 5.36% for GP replacements of 5%, 10% and 15%.The V-funnel value was increased by an average of 6.21%, 15% and 22.54% for glass powder contents of 5%, 10% and 15% and L-box value was also decreases with variation of 1.5%, 3.2% and 5% for glass powder contents of 5%, 10% and 15% correspondingly.

The objectives of the present study is to investigate systematically the effect of various proportions of class-F fly ash and GGBS as powder content excluding cement on the properties of concrete like workability and mechanical properties.

3. Scope of the Present Study

SCC has recently been one of the most important developments in the concrete technology. In this study an attempt was made to study the effect of mineral admixture i.e.,GGBS & class-F fly ash on the fresh properties and mechanical properties of SCC using Nan-su et.al mix design. Green and environment friendly form of construction can be developed by SCC.

4. Materials and Mixture Proportions

4.1 Cement:

Ordinary Portland cement of 53 grade (Priya cement)was used and tested for chemical and physical properties with specific gravity of 3.16 as per IS: 4031 – 1988 and found to be conforming to different specifications as per IS: 12269-1987 as shown in Table 1.

Table-1 Test Results on Cement (IS 12269-1987)

<table>
<tr><th colspan="2">Properties</th><th>Results obtained</th></tr>
<tr><td rowspan="2">Setting time</td><td>Initial</td><td>129 min</td></tr>
<tr><td>Final</td><td>225 min</td></tr>
<tr><td colspan="2">Specific Gravity</td><td>3.16</td></tr>
<tr><td colspan="2">Soundness of Cement(mm)</td><td>0.5 mm</td></tr>
<tr><td colspan="2">Fineness</td><td>2%</td></tr>
<tr><td colspan="2">Standard Consistency</td><td>31%</td></tr>
</table>

4.2 Fine aggregate:

Locally available sand having specific gravity of 2.64 having fineness modulus of 2.46conforming to IS: 383-1970 is used in the present study.

Table-2 Test Results on Fine aggregate0

Properties	Results obtained
Specific Gravity	2.64
Fineness Modulus Test	2.46
Bulking Of sand	21%

4.3 Coarse Aggregate :

Coarse Aggregate of nominal size 12.5-20mm was used in the present study having specific gravity 2.73 as per IS: 383-1970.

Table-3 Test Results on Coarse aggregate

Properties		Results obtained	Range
Shape Tests	Flakiness Index	21.52%	< 35% (BS 882-1992)
	Elongation Index	26.32%	< 40% (BS 882-1992)
Aggregate Impact Test		16.66%	< 35%
Los Angeles Abrasion Test		10.34%	< 40%
Specific Gravity Test		2.73	2.6-2.8
Aggregate Crushing Value		18.32%	< 45%

4.4 Chemical admixture:

All mixtures contains different percentages of "Conplast SP430", it's a chloride free superplasticising admixture based on selected sulponated naphthalene polymers compiles with BS 5075 part 3 and with ASTM C494 as type A and type F .

4.5 Mineral admixture:

Mineral admixtures used in the present study are class-F fly ash and GGBS.Within the chemical properties of fly ash caO content is less than 20% thus it's said to Class-F fly ash, confined as per IS 3812-1:2003 as shown in Table 4and the standard of blast furnace slag is governed by IS 12089-1987 and BS 9966 as shown in Table 5.

Table - 4Chemical composition and colour of Fly ash

Chemicals	Fly ash
Moisture	0.20%
Loss on ignition	4.00%
Sio_2+Al_2o_3+Fe_2o_3	89.82%
Silicon dioxide(Sio_2)	60.70%
Reactive silica	52.35%
Magnesium Oxide(Mgo)	0.64%
Calcium Oxide(CaO)	9.02%
Total Sulphuras	0.18%

Sulphur Trioxide(So_3)	
Available Alkalis as Sodium Oxide(Na_2o)	0.34%
Total Chlorides	< 0.01%
Specific gravity	2.2
Colour	Dark grey

Table - 5Chemical composition and colour of GGBS

Chemicals	**GGBS**
Moisture	0.15 %
Loss on ignition	1.56 %
Cao+MgO+SiO_2	78.56 %
Silicon dioxide(sio_2)	34.28 %
Calcium oxide(Cao)	37.08 %
Magnesium Oxide(Mgo)	7.20 %
Glass content	92.60 %
Aluminum oxide(Al_2O_3)	18.02 %
Chloride content	0.007 %
Specific gravity	2.89
Colour	White

5. Specimen Preparation:

At 3,7,28 and 91 days of age, cube specimens of size 150×150×150mm/were tested for compressive strength with CTM machine in accordance with ASTM C109/C109M. For the cylinder specimens, 300mmin height and 150mmin diameter were tested for compressive strength with an CTM machine in accordance with ASTM C 39/C 39M for 28 and 91 days . In the present study, Nan-su*et.al* (2001) mix design is designed with packing factor 1.14. Details of mixture proportions are shown in Table 6.

Table – 6 Mix proportions w.r.t to Nan su et.al mix design

Mix	**Coarse aggregate (Kg/m^3)**	**Fine aggregate (Kg/m^3)**	**% of cement in total cementitious material**	**W/P ratio**	**Cement (kg/m^3)**	**SP dosage% of powder**	**SP Content (kg/m^3)**	**Fly ash (kg/m^3)**	**GGBS (kg/m^3)**	**Water (lt/m^3)**
GF1	787	865	35.8%	0.425	230	1.0	2.3	-	411.46	270.3
GF2	787	865	37.4%	0.425	230	0.98	2.254	76.81	307.25	258.7
GF3	787	865	38.8%	0.425	230	0.96	2.208	145.02	217.53	249.6
GF4	787	865	40.2%	0.425	230	0.94	2.162	204.82	136.54	240.6
GF5	787	865	41.4%	0.425	230	0.92	2.116	260.21	65.052	234.8
GF6	787	865	42.6%	0.425	230	0.9	2.07	309.38	-	227.1

6. Experimental Results and Discussions

6.1 Tests on Fresh concrete:

It is important note that the test methods for SCC areyet to be standardized. One principal issue in production such tests is that they need to assess three distinct, although related, properties of fresh SCC i.e., its filling ability(flow ability),its passing ability(free from blocking at reinforcement),and its resistance to segregation(stability).The standard flow tests like slump flow test, L-Box test, V-funnel test, T50 slump flow and J-Ring test were conducted for the six mix proportions and the results were compared with the values as per EFNARC guidelines. All mix proportions satisfy all the properties of SCC.Fresh properties results are shown in Table 7.

Table 7 Workability properties of SCC

Description	Results obtained					
W/P Ratio	0.425	0.425	0.425	0.425	0.425	0.425
SP dosage %of powder	1.0	0.98	0.96	0.94	0.92	0.9
Mix	GF1	GF2	GF3	GF4	GF5	GF6
% of cement in total cementitious material	35.8%	37.4%	38.8%	40.25%	41.4%	42.6%
Slump Flow (mm)	656	668	671	667	669	668
J-ring Test (mm)	1.460	1.180	1.152	1.200	1.151	1.147
L-box Test(mm)	1.0	0.971	0.947	0.95	0.984	0.994
V-funnel Test(sec)	11.7	9.4	9.0	9.2	8.9	9.0
T50 Slump Flow (sec)	3.9	4.2	4.3	4.3	4.1	4.0

With the addition of Fly ash to the concrete, it increases the workability of fresh concrete properties. Conplast SP430 has a substantial influence on fresh properties of SCC. SCC mix which incorporates GGBS requires more dosage of super plasticizer to produce satisfactory workability. Slump flow value states that with the increase of proportions, flow value increases but at GF4 mix, flow value slightly decreases.Slump flow decreases and V-funnel flow time, J-Ring, T50 flow time and L-Box increases with the increase of slag cement for the GF4 mix proportion. Rheological tests results indicate that presence of fly ash is necessary to achieve and improve SCC properties in the GGBS concrete.

6.2 Test on Hardened Concrete

6.2.1 Compressive strength:

The concrete is tested for the hardened properties like compressive strength for 3,7,28 and 91 days with both Compressive Testing Machine (CTM) and also by Schmidt Rebound hammer and split tensile strength for 28 and 91 days. All tests were performed in accordance with the provision of IS: 516-1959 and IS: 5816-1999. The test results are shown in Fig 1 and Fig2.

Fig 1 and Fig 2indicate thatcompressive strength(both CTM & Rebound hammer) linearly decreases from GF1 proportion to GF6 mix proportion for all ages of concrete. Also compressive strength at 3 days with CTM decreases by 42.03% from GF1 proportion to GF2 and for Rebound compressive strength decreases by 41.67% from GF1 to GF2,compressive strength at 7 dayswith CTM decreases by 38.01% from GF1 proportion to GF2 and for Rebound compressive strength decreases by 37.52% from GF1 toGF2,compressive strength at 28 dayswith CTM decreases by 20.57% from GF1mix proportion to GF2 and for Rebound compressive strength decreases by 20.569% from GF1 to GF2. At 91 days compressive strength using CTM decreases by 20.74% from GF1 proportion to GF2 and for Rebound compressive strength decreases by 21.17% from GF1 toGF2.

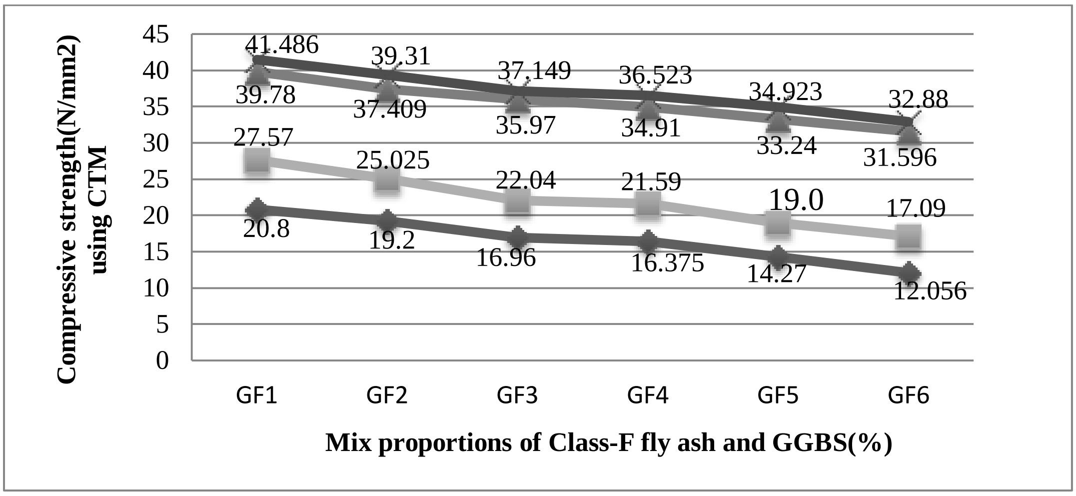

Fig 1Compressive strength (N/mm^2) using CTM at 3,7,28 and 91 days

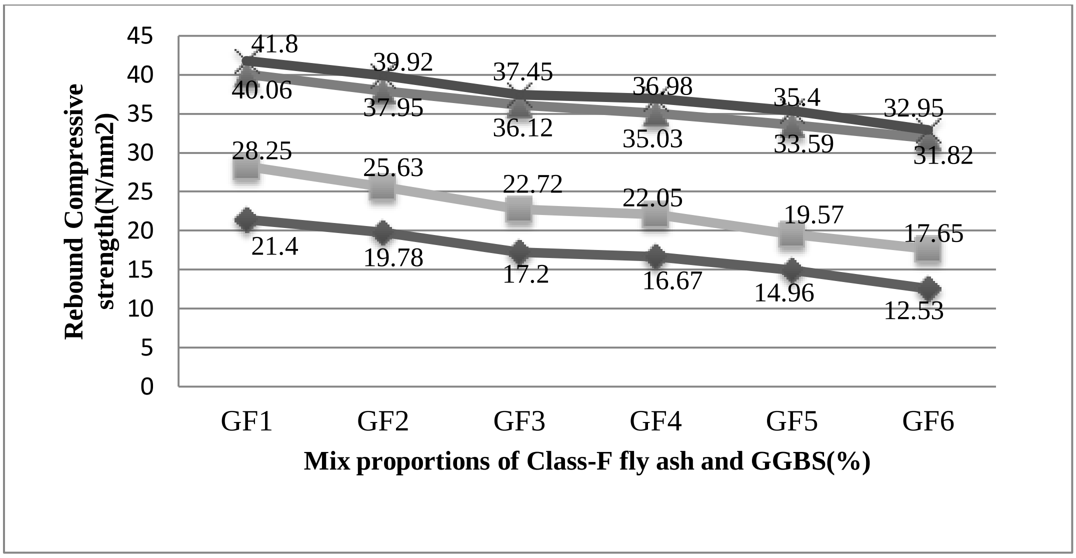

Fig 2 : Rebound compressive strength (N/mm^2) at 3,7,28 and 91 days

6.2.2 Split tensile Strength:

Fig 3indicate that at 28 days split tensile strength decreases by 29.74% from GF1mix proportion to GF2 and at 91 days strength decreases by 28.04% from GF1 to GF2 mix proportion.

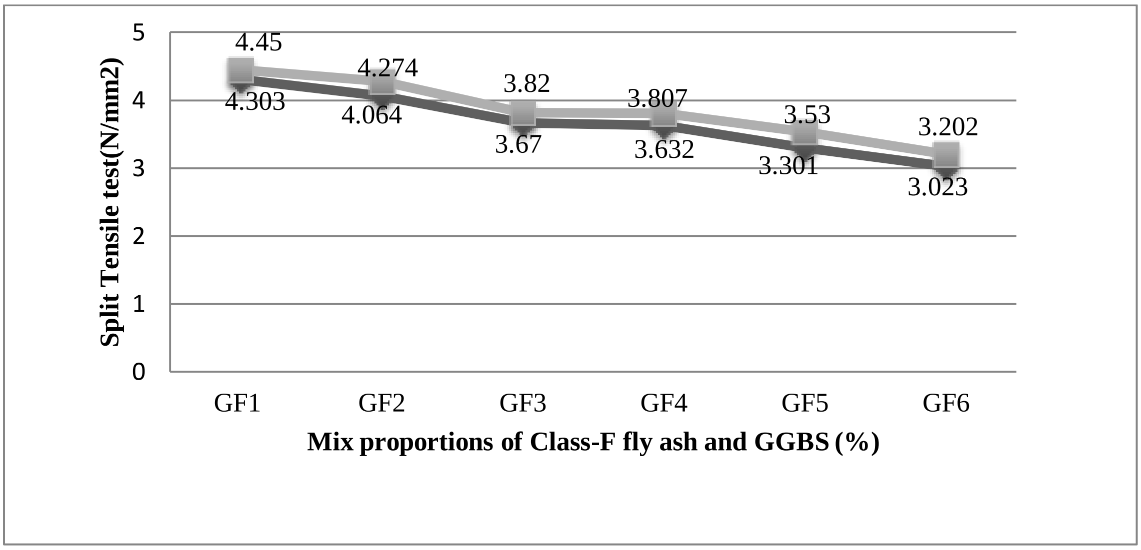

Fig 3 Split tensile strength (N/mm^2) at 28 and 91 days

7. Conclusions

1. Fresh properties such as Slump flow, J-ring test, V-Funnel, L-Box, T50 slump flow test values of SCC were fulfilled as per EFNARC guidelines.
2. With the supplement of Fly ash to the concrete, it improves the workability of fresh concrete properties. Conplast SP430 has a significant influence on fresh properties of SCC. SCC mix which incorporates GGBS requires more dosage of super plasticizer to produce satisfactory workability when compared to fly ash.
3. At 7 days compressive strength using CTM decreases by 38.01% from GF1 proportion to GF6 and for Rebound compressive strength decreases by 37.52% from GF1 to GF6.
4. At 28 days compressive strength using CTM decreases by 20.57% from GF1 proportion to GF6 and for Rebound compressive strength decreases by 20.569% from GF1 to GF6.
5. At 91 days compressive strength using CTM decreases by 20.74% from GF1 proportion to GF6 and for Rebound compressive strength decreases by 21.17% from GF1 to GF6.
6. Split tensile strength at 28 days decreases by 29.74% from GF1 proportion to GF6 and for 91 days strength decreases by 28.04% from GF1 to GF6 proportion.
7. Comparing Fig 1 and Fig 2 of compressive strength using CTM and Rebound compressive strength there is no much variation in strength so it is better to use Rebound compressive strength to measure the strength for the purpose of cost reduction.
8. Compressive strength (both CTM & Rebound hammer) and split tensile strength linearly decreases from GF1 mix proportion to GF6 mix proportion for all ages of concrete.

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