



A Study On Strength Properties Of Concrete Using Admixtures And Glass Fiber

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ABSTRACT

The compaction of concrete is one of the prominent factors to be considered to obtain the desired strength of the concrete. The mechanical vibrators are mostly used in the site for compaction of the concrete. But, compactions are not done properly in sites and this affects the strength and durability properties of the concrete. The concrete that flows by its own weight is named as Self-Compacting Concrete (SCC). The flow ability of conventional concrete can be improved by developing or introducing self-compacting concrete. But the cost of SCC is very high due to the high cementitious content and super plasticizer. This high cost can be brought down by using the Supplementary cementitious materials (SCMs). Very fine particle size of these SCMs enables pore refinement in the concrete and subsequently improves both the mechanical and durability properties of the concrete. The results indicated that the fresh characteristics of ternary blended self-compacting concrete were gradually decreased when SCMs (fly ash and silica fume) replacement increases. The mechanical characteristics of ternary blended SCC were greater than that of the normal SCC mix up to a certain limit of replacement. The durability properties of SCC were enhanced when replaced with SCMs. Ternary blended SCC mix containing 70% of Ordinary Portland Cement, 20% of fly ash, and 10% of silica fume has enhanced the mechanical and durability properties of SCC. Therefore TBC7 mix was considered as the optimized mix. The alkali-resistant glass fibers were added with the optimized mix.

Key words: Self-Compacting Concrete; fly ash, silica fume.

1.0 INTRODUCTION

The concrete that flows by its own weight is named as Self- Compacting Concrete (SCC). The flow ability of conventional concrete can be improved by developing or introducing self-compacting concrete. The SCC has high flow ability and it leads the concrete to flow in any architectural structures and through congested reinforcement elements. The SCC was first developed in Japan to overcome the defects in concrete due to insufficient compaction and lack of skilled laborer's. In 1990's, many researches in Japan and Europe countries focused on the field of SCC. The placing of SCC was comparatively easier than that of the conventional concrete. The main difference in the design of SCC is, the content of coarse aggregate is comparatively less than that of the fine aggregate. This reduces the blockage of concrete in the congested reinforcement.

2.0 LITRATURE REVIEW

Burak *et al.* (2007) in their research work, the SCC was studied with the supplementary cementitious material such as lime stone powder. The design mixes were prepared with different water to cementitious material ratio and determined the flow ability of concrete by conducted V-funnel, L-box and slump flow test. The optimum mix proportions were found by conducting hardened concrete tests such as compressive strength, splitting tensile strength and modulus of elasticity. They reported that the lower water to powder ratio of self-compacting concrete attained the highest compressive strength of the concrete. From the research they concluded that, the compressive and split tensile strength of SCC attained higher values than that of the normal concrete. Ali *et al.* (2012) investigated the strength and durability properties of the ternary concrete mixes containing silica fume and blast furnace slag. They inferred that the silica fume contributed mainly to attain early strength of ternary blended concrete mixes. The durability properties also got significantly improved the in ternary blended concrete when compared with that of the normal and binary blended concrete. The water demand got significantly reduced in ternary blended concrete without increasing the super plasticizer dosage. The concurrent use of silica fume increased the strength with slow rate of furnace slag concrete. In durability aspect, the ternary blended (low reactive slag & silica fume) concrete gave surpassed result than that of the control concrete mix and binary blended mixes. Kannan & Ganesan (2012) studied the effects of metakaolin and fly ash as an admixture in Self-Compacting Concrete (SCC). The ternary blended mix with 70% of Ordinary Portland Cement + 15% of metakaolin + 15% of fly ash showed better fresh concrete (slump flow test and V-funnel test) and strength properties (compressive strength test and flexural strength test). They concluded that the combination fly ash and metakaolin blended concrete mixes significantly improved the mechanical and durability properties of SCC. Gencel *et al.* (2011) examined the influences of polypropylene fiber on fresh and hardened properties of self-compacting concrete. The polypropylene fiber reinforced SCC reduced the flow ability and passing ability. The polypropylene fiber reinforced SCC decreased the pulse velocity. However, by the addition of polypropylene fiber in self-compacting concrete showed better results in the compressive strength, splitting tensile strength and flexural strength when compared with that of the normal SCC mix.

3.0 MATERIALS AND METHODOLOGY

This paper furnishes the properties of cement, supplementary cementitious materials (fly ash and silica fume), fine aggregate, coarse aggregate and water. In addition, the mix design is made for the ternary blended SCC mix proportions as per the guidelines of IS: 10262-2019.

Table 3.1 Physical properties of OPC 53-grade

Physical properties	Obtained values	IS: 12269-2013 requirement
Specific gravity	3.12	-
Consistency	31%	-
Initial setting time	42 minutes	Not less than 30 minutes
final setting time	220 minutes	Not more than 600 minutes

Table 3.2 Chemical compositions of OPC 53-grade

Chemical compositions	Values (%)
SiO ₂	20.56
Al ₂ O ₃	5.05
Fe ₂ O ₃	3.15
CaO	62.54
MgO	2.72
K ₂ O	0.34
Na ₂ O	0.38

Table 3.3 Physical properties of silica fume

Physical properties	Obtained values
Specific gravity	2.26
Fineness	20000 m ² /kg
Bulk density	656 kg/m ³
Physical form	Powder
Colour	Light gray

Table 3.4 Chemical compositions of silica fume

Chemical compositions	Values (%)
SiO ₂	94.4
Al ₂ O ₃	0.62
Fe ₂ O ₃	0.15
CaO	1.12
MgO	0.72
K ₂ O	1.15
Na ₂ O	0.22

GLASS FIBER:

Alkali-resistant glass fiber with the aspect ratio of 857.14 was used in this investigation. The sample of glass fiber.



Figure 3.1 Alkali-resistant glass fiber

4.0 RESULTS AND DISCUSSION

This paper deals with the fresh properties of ternary blended self-compacting concrete. A normal workability test was not suitable to study the fresh properties of the Self-Compacting Concrete (SCC). The foremost fresh characteristics of SCC such as passing ability, flow ability and segregation resistance were assessed by using slump flow test, T500 mm slump flow time test, L-box test, V-funnel test and V-funnel T5 minutes test as per the guidelines of EFNARC-2005.

4.1 Slump flow slump flow time tests results of TBCmixes

Mix	F (%)	SF (%)	Slump flow values (mm)
NM	-	-	750
TBC1	10	5	762
TBC2	10	7.5	767
TBC3	10	10	780
TBC4	15	5	781
TBC5	15	7.5	748
TBC6	15	10	722
TBC7	20	5	722
TBC8	20	7.5	701
TBC9	20	10	700
TBC10	25	5	682
TBC11	25	7.5	671
TBC12	25	10	664

TBC13	30	5	642
TBC14	30	7.5	621
TBC15	30	10	609

4.2 Compressive Strength Test

As per the guidelines of IS: 516–1959, concrete cube specimens of size 150 x 150 x 150 mm were cast and immersed in water for four different curing ages (7, 14, 28 and 56 days). The cubes were tested in compression testing machine (2 tons capacity) under the loading rate of 140 kN/mm²/min. The load was applied gradually and recorded the cube failure load. Then, the compressive strength of the cube was obtained from the Equation and the experimental setup of compressive strength test. The test results are obtained by the average value from three specimens in each mix proportion and curing period.

Compressive Strength Test Results

Compressive strength test values of ternary blended self- compacting concrete mixes at 7, 14, 28 and 56 days was presented in Table 5.1. The compressive strength values of ternary blended SCC mixes at 7 and 14 days are shown in Figure 5.6 and 5.7. The compressive strength value of normal mix (NM) at 7 and 14 days were attained 45 and 65% of target mean strength value respectively. A marginal increase in the compressive strength from 18.13 to 20.98 N/mm² was observed at early ages up to a maximum level of 20% fly ash replacement. At higher replacement level of fly ash (say >20%), the desired strength at early ages (7 and 14 days) was not attained.

Table 4.1 Compressive strength test results of ternary blended SCC mixes

Mix	F (%)	SF (%)	Compressive strength (N/mm ²)			
			7 th day	14 th day	28 th day	56 th day
NM	-	-	17.18	24.50	38.11	42.22
TBC1	10	5	18.33	25.11	40.19	42.51
TBC2	10	7.5	17.58	26.11	41.40	45.67
TBC3	10	10	18.64	26.47	41.56	47.19
TBC4	15	5	19.10	27.28	40.59	46.63
TBC5	15	7.5	19.20	27.53	41.26	48.29
TBC6	15	10	19.11	28.14	42.27	46.73
TBC7	20	5	19.21	28.24	42.47	47.69
TBC8	20	7.5	20.17	28.70	43.48	48.10
TBC9	20	10	20.88	29.31	44.49	49.28
TBC10	25	5	16.42	25.46	41.65	44.14
TBC11	25	7.5	16.42	21.13	40.33	44.34
TBC12	25	10	14.29	20.27	38.11	39.01
TBC13	30	5	13.58	19.60	35.10	36.17
TBC14	30	7.5	12.16	18.44	31.22	34.20
TBC15	30	10	11.32	17.12	30.34	31.71

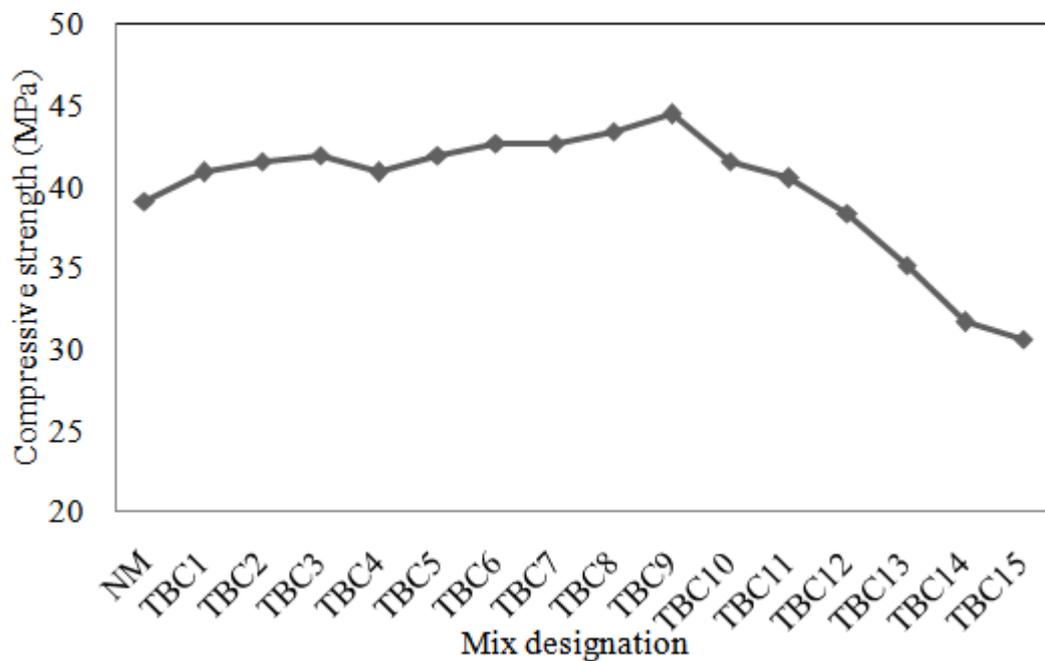


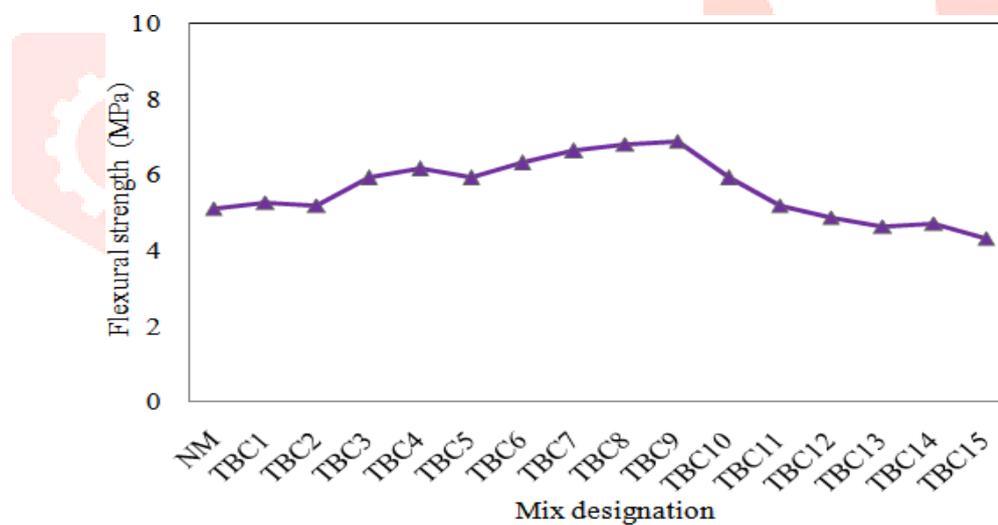
Figure 4.1 Compressive strength test results at 28 days

4.3 Splitting Tensile Strength Test Results

A marginal increase in splitting tensile strength from 2.49 to 3.40 N/mm² was observed at the early ages (7 days) up to the mix TBC10. Beyond that from TBC11 to TBC15, the strength showed a decreasing trend and was reported to have 1.36 N/mm² for TBC15. At 28 days, the splitting tensile strength values of TBC9 and TBC10 were observed to be higher than that of other TBC mixes. TBC10 and TBC9 give 31.25 and 28.13% higher strength than that of the NM. The splitting tensile strength values of all TBC mixes are greater than NM mix at 56 days, excluding two mixes, TBC14 and TBC15. In TBC15, the reduction in strength up to 31 and 15% were achieved at 28 and 56 days, respectively when compared with NM mix. The better performance of TBC15 mix at 56 days could be attributed to the improvement in pozzolanic reactions. These observations are consistent with the compressive strength results also as compression and splitting tensile strength are closely interrelated. The obtained splitting tensile strength values of TBC mixes are in the range of 9 to 12% of compressive strength values. The bond between the cementitious paste and aggregate plays an important role in the development of splitting tensile strength but it is not effective in the cube compressive strength, because its depth to breadth ratio is very less.

Table 5.3 Splitting tensile strength test results of ternary blended SCC mixes

Mix	F (%)	SF (%)	Splitting tensile strength (N/mm ²)		
			7 th day	28 th day	56 th day
NM	-	-	2.18	3.32	3.45
TBC1	10	5	2.39	3.74	3.55
TBC2	10	7.5	2.20	3.74	3.89
TBC3	10	10	2.10	3.96	4.07
TBC4	15	5	2.28	3.85	4.56
TBC5	15	7.5	2.50	3.91	4.58
TBC6	15	10	2.32	4.05	4.94
TBC7	20	5	2.54	4.11	5.23
TBC8	20	7.5	3.58	4.31	5.39
TBC9	20	10	3.50	4.63	5.55
TBC10	25	5	3.40	4.73	5.68
TBC11	25	7.5	2.33	3.86	4.55
TBC12	25	10	2.29	3.77	4.55
TBC13	30	5	1.71	3.25	3.73
TBC14	30	7.5	1.33	2.95	3.57
TBC15	30	10	1.31	2.33	3.11

**Figure 5.14 Flexural strength test results of ternary blended SCC mixes at 28 days**

CONCLUSIONS

- A marginal increase in the compressive strength was observed at early ages (7 and 14 days) up to a maximum level of 20% fly ash replacement. At higher replacement level of fly ash (say >20%), the desired strength at early ages was not attained.
- The highest percentage of increase in compressive strength at 28 days test was attained in TBC9 mix as 13.64%.
- The enhancement in the compressive strength (at all ages) of concretes with fly ash replacement level is up to 20%. Conversely, there is a reduction in the compressive strength when the fly ash substitution levels are 25 and 30%. Among the sixteen mixes, the worst-case scenario was observed in TBC15. The reduction in strength at these later ages (21% at 28 days and 20% at 56 days) is less than that of reduction in strength reported at early ages (say, 7 and 14 days). This could be attributed to the enhancement in the pozzolanic reaction of fly ash at the later ages. Inclusion of glass fiber in the SCC reduces the compressive strength values and the maximum reduction in strength was found in GFTBC4 mix. Small pores on the fracture surface of the concrete may reduce the compressive strength of SCC.

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