Use of fly ash and broken tiles as partial replacement for cement and coarse aggregate in self-compacting concrete

Byna. Arun [1], Manthena. Srilakshmi [2], CH. Surya teja[3]

P.G. Student, Department of Civil Engineering, Gitam, Visakhapatnam, Andhra Pradesh, India[1]

Research scholar, JNTU Kakinada, Visakhapatnam, Andhra Pradesh, India[2]

Assistant Professor, Department of Civil Engineering, Gitam, Visakhapatnam, Andhra Pradesh, India[3]

ABSTRACT

In this study, broken tiles are used as partial replacement for coarse aggregates and fly ash is used as partial replacement for cement in concrete. This study includes designing a self-compacting concrete mix which is standardized using its fresh properties with respect to EFNARC (European Federation of National Associations Representing for Concrete) standards. The mix design for M30 grade self-compacting concrete is done as per EFNARC standards. Then various properties of different mixes of M30 grade with 0%, 10%, 20%, 30%, 40% & 50% partial replacements of cement and coarse aggregate with fly ash and broken tiles are compared, and the optimum percentage replacement is obtained at 30% replacement (SCC 30).

Keywords **-** *Self-compacting concrete, Compressive strength, Split tensile strength, Flexure strength, EFNARC standards*

I. INTRODUCTION

Self-compacted concrete has high workability, flowability, lack of skilled labour and over compaction compared to normal compacted concrete. The main characteristics of self-compacting concrete are the different properties in fresh state. Self-compacting concrete can be classified as if it has following characteristics are filling ability, passing ability and segregation resistance. The study aims at designing a self-compacting concrete mix which is standardized using its fresh properties with respect to EFNARC (European Federation of National Associations Representing for Concrete) standards. To study the properties of fresh and hardened self-compacting concrete with partial replacements of fly ash and broken tiles as partial replacements for cement and coarse aggregate respectively. Material cost of self-compacted concrete will be about 16 to 17% higher than conventional concrete.

Fly ash is a waste product generated by thermal power stations. It is usually much cheaper than cement in india. On using fly ash and broken tiles as partial replacement for cement and coarse aggregate, it can reduce the environmental hazards and also we can partially overcome the waste disposal crisis. Cost of fly ash as compared to the cement will be very less. Broken tiles are procured from construction and demolition waste. Hence the overall cost of concrete with fly ash and broken tiles as partial replacement for cement and coarse aggregates will be very much less compared to normal SCC. Partial replacement of coarse aggregate by waste ceramic tile increases the strength and durability where as partial replacement of cement by fly ash increases the strength of concrete, we are aiming at achieving increasing strength and durability properties.

This study aims at designing a self-compacted concrete mix which standardized using its fresh properties with respect to EFNARC standards. Then various properties different mixes of mix design with 0%, 10%, 20%, 30%, 40% and 50% of partial replacements of cement and coarse aggregate with fly ash and broken tiles respectively are compared and the ideal percentage replacement is determined.

II. LITERATURE REVIEWS

Nipat puthipad et.al [1] conducted experimental study on the enhancement of self-compacting ability in fresh concrete with high volume fly ash and the stability in terms of volume of entrained air bubbles was analysed. In this paper, the authors considered the lower water retention, ball-bearing effect of fly ash and entrained air bubbles which affect the self-compact ability of fresh concrete.

Vageesh H.P et.al [2] The scope of the authors work is limited to the development of a suitable mix design to satisfy the requirements of Self Compacting Concrete

with Fly ash as partial replacement in plastic stage using local aggregates and then to determine the Compressive, Split tensile and Flexural strengths. Tests were conducted and the fresh properties obtained were checked against the specifications given by EFNARC guidelines.
Mongi Ben Ouezdou et.al [3] investigated the behaviour of self-compacting concrete (SCC) by incorporating wastes from marbles and tile factories as mineral additives to it.

P.R da silva et.al [4] studied the porosity and microstructure of Self-compacting concrete. These properties were studied by incorporating Fly ash (FA) and Lime stone filler (LF) in binary and ternary mixes of SCC by producing a total of 11 SCC mixes.

By observing all the investigations the combination of fly ash and ceramic tiles as a partial replacement of cement and coarse aggregate respectively have been investigated separately. Hence the current study aims at studying fresh and hardened properties of SCC with fly ash and broken tiles as partial replacement for cement and coarse aggregate respectively.

III METHODOLOGY

Self-compacting of concrete of mix design is calculated as follows, the assumed cement content is 480kg/m^3 and water powder ratio assumed is 0.9. 1) Water content is 0.9*480kg/m^3 = 432kg/m^3 as super plasticizer used 30% water content is reduced. 2) Hence reduced water content = 432-432*0.3 = 302.5kg/m^3. Coarse aggregate assumed as 38% of concrete volume 10mm aggregate size 3) hence quantity of coarse aggregate = 1600*0.38 = 608kg/m^3. Fine aggregate assumed as 47% of mortar volume and since mortar volume consist of cement, fine aggregate and water and therefore volume of water can be taken as 52% of mortar volume. 4) hence quantity of fine aggregate = 0.47 $\frac{480+302.5}{0.52}$ = 707.25kg/m^3 .

Table1: EFNARC ranges for SCC

Constituent	Typical range
Water	150-210 kg/m^3
Coarse aggregate	<50%
Water powder ratio	0.8-1.0
Sand content	>40% of mortar (volume)
Sand content	>50% by weight of total aggregate
Paste volume	>40% of the volume of the mix
Cement	350-500kg/m^3

Table2 final mix proportions

Cement	480 kg/m^3
Fine aggregate	707.25 kg/m^3
Coarse aggregate	608 kg/m^3
Water content	216 kg/m^3

Table3 fresh properties results for SCC

Property	Test method	Measured value	Results	Limits
Viscosity/ Flowability	T_{500}	Flow time	4 sec	2sec-5sec
	V funnel	Flow time	11 sec	8sec-12sec
	Slump flow	Flow distance	680 mm	650mm-800mm
Passing ability	L box	Passing ratio	0.9	0.8-1.0

IV. RESULTS

Following results obtained for 7days, 28days and 90days of compressive strength, split tensile strength and flexure strength. In this study, compressive strength of 150 mm x 150 mm x 150 mm cubes is determined by using compressive testing machine. Compressive strengths of self-compacting concrete are presented as follows.

COMPRESSIVE STRENGTH

Fig1 shows the compressive strength of concrete using fly ash and broken tiles as partial replacement for cement and coarse aggregate at 7, 28 and 90 days respectively. Optimum replacement is achieved at SCC 30. For SCC 30, compressive strengths of 24.7 MPa, 45.6 MPa and 46.22 MPa has been observed at 7, 28 and 90 days respectively. The compressive strength obtained is 5.6%, 31.6% and 18.17% more than SCC 0 for 7, 28 and 90 days respectively as shown in table 4. The compressive strength of mixes SCC10, SCC 20, SCC 30 have increased compared to SCC 0. The variation in strength may be due to shape, size and surface texture of fly ash and broken tiles, which provide better bonding between the aggregates and cement paste.

SPLIT TENSILE STRENGTH

Fig2 shows the split tensile strength of concrete using fly ash and broken tiles as partial replacement for cement and coarse aggregate at 7, 28 and 90 days. Optimum replacement is achieved at SCC 30. For SCC 30, tensile strength of 2.83 MPa, 3.25 MPa and 7.23 MPa has been observed at 7, 28 and 90 days respectively. The tensile

Table4 Compressive strength of SCC with different partial replacements

S.No	Mix Designation	% partial replacement	Compressive strength (MPa)					
			7 days	% variation	28 days	% variation	90 days	% variation
1.	SSC 0	0	23.40	+0	34.66	+0	39.11	+0
2.	SSC 10	10	24.00	+2.56	37.33	+7.69	39.7	+1.50
3.	SSC 20	20	24.14	+3.14	40.29	+16.2	41.77	+6.80
4.	**SSC 30**	**30**	**24.70**	**+5.6**	**45.60**	**+31.6**	**46.22**	**+18.17**
5.	SSC 40	40	17.03	-27.2	26.3	-23.9	37.18	-4.9
6.	SSC 50	50	14.1	-39.87	22.6	-34.6	36.14	-7.57

Strength obtained is 26.31%, 9.52% and 7.23% more than SCC 0 for 7, 28 and 90 days respectively. The tensile strength of mixes SCC 10, SCC 20, SCC 30 have increased compared to SCC 0. The variation in strength may be due to shape, size and surface texture of fly ash and broken tiles, which provide better bonding between the aggregates and cement paste.

FLEXURAL STRENGTH

Fig3 shows the flexure strength of concrete using fly ash and broken tiles as partial replacement for cement and coarse aggregate at 7, 28 and 90 days. Optimum replacement is achieved at SCC 30. The maximum flexure strength of 6.25 MPa, 7.32 MPa and 7.48 MPa has been observed at 7, 28 and 90 days respectively as shown in table 6. The flexure strength obtained is 25.74%, 14.35% and 15.45% more than SCC 0 for 7, 28 and 90days respectively as shown in table 6. The flexure strength of mixes SCC10, SCC 20, SCC 30 have increased compared to SCC 0. The variation in strength may be due to shape, size and surface texture of fly ash and broken tiles, which provide better bonding between the aggregates and cement paste.

From the above three results, the optimum replacement is obtained at SCC 30 as the compressive, split tensile and flexural strength have increased upto SCC 30 and decreased for further replacements.

Table5 split tensile strength of SCC with different partial replacements

S.NO	Mix Designation	% partial replacement	Tensile strength (MPa)					
			7 days	% variation	28 days	% variation	90 days	% variation
1	SCC 0	0	2.24	+ 0	2.97	+ 0	3.20	+0
2	SCC 10	10	2.28	+ 6.52	3.16	+ 6.34	3.30	+2.84
3	SCC 20	20	2.5	+ 11.57	3.20	+ 7.93	3.34	+4.39
4	**SCC 30**	**30**	**2.83**	**+ 26.31**	**3.25**	**+ 9.52**	**3.44**	**+7.23**
5	SCC 40	40	2.47	- 10.52	2.40	- 19.4	2.83	-11.78
6	SCC 50	50	2.07	- 5.26	2.38	- 19.84	2.73	-14.71

Table6 flexure strength of SCC with partial replacements

S.NO	Mix Designation	% partial replacement	Flexure strength (MPa)					
			7 days	% variation	28 days	% variation	90 days	% variation
1	SCC 0	0	4.97	+ 0	6.40	+0	6.48	+0
2	SCC 10	10	5.3	+6.6	6.72	+5.02	6.74	+4.05
3	SCC 20	20	5.76	+15.84	6.91	+7.94	7.00	+8.11
4	**SCC 30**	**30**	**6.25**	**+25.74**	**7.32**	**+14.35**	**7.48**	**+15.45**
5	SCC 40	40	4.66	-6.27	5.46	-14.61	6.05	-6.57
6	SCC 50	50	3.98	-19.80	4.85	-24.1	5.97	-7.83

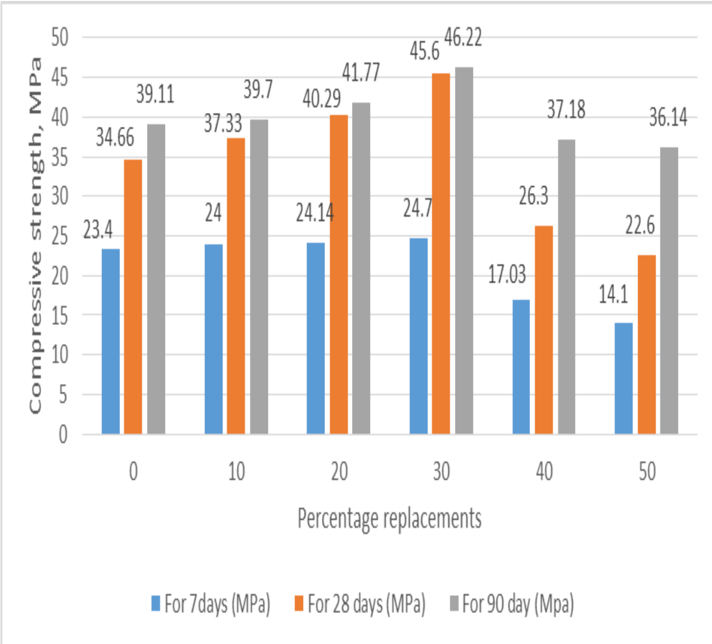

Fig1- Variation of 7, 28 and 90days compressive strength at various percentage replacements

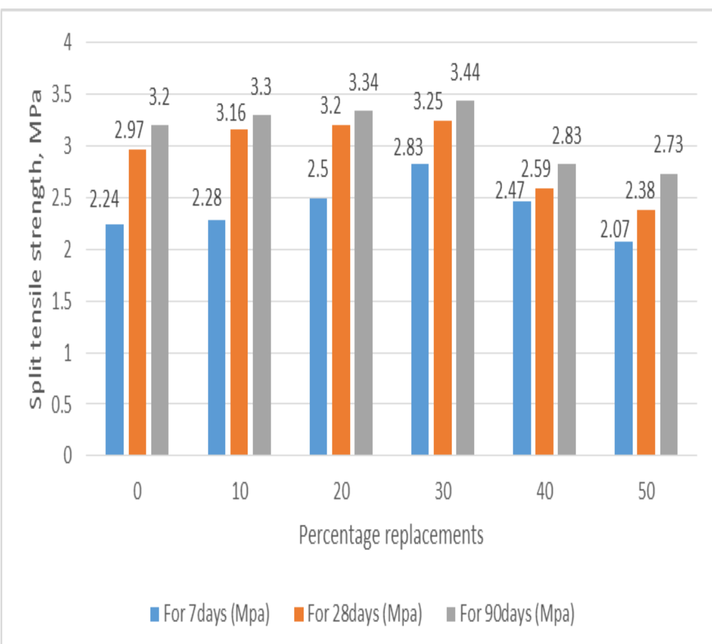

Fig2- Variation of 7, 28 and 90days split tensile strength at various percentage replacements

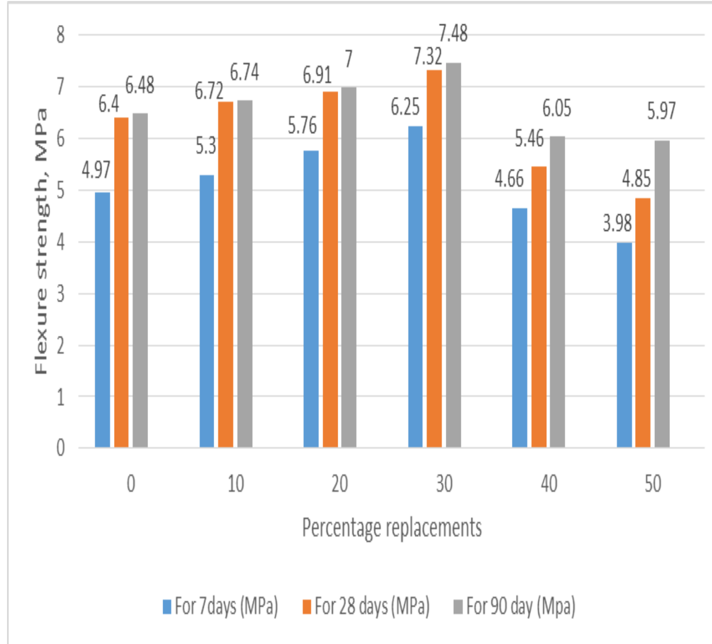

Fig 3- Variation of 7, 28 and 90days flexure strength at various percentage replacements

V. CONCLUSIONS

In this study, the optimum % replacements cement with fly ash and coarse aggregates with broken tiles in self-compacting concrete is determined based on compressive, split tensile and flexure strength.

- For compressive strength, the optimum percentage replacement of SCC is obtained at optimum at SCC30.
- For split tensile strength, the optimum percentage replacement of SCC is obtained at optimum at SCC30.
- For Flexure strength, the optimum percentage replacement of SCC is obtained at optimum at SCC30.
- The use of fly ash and broken tiles are economical.
- The experimental has proved to be better way to produce fly ash and broken tiles.
- The optimum mix was found to be optimum SCC30.

REFERENCES

[1] Nipat Puthipad, Masahiro Ouchi, Sovannsathya Rath, Anuwat Attachaiyawut., "Enhancement in self-compactability and stability in volume of entrained air in self-compacting concrete with high

volume fly ash", Construction and Building Materials, 128, 2016 pp. 349-360.

[2] Vageesh H.P1, Reena K.2., "fly ash as partial replacement for cement in self-compacting concrete a study on compressive, tensile and flexural strength", International Journal of Advanced Technology in Engineering and Science, 11, 2014, pp. 2348-7550.

[3] Mongi Ben Ouezdou, Mohsen Tennich, Abdrrazek Kallel., "Incorporation of fillers for marbles and tile wastes in the composition of self-compacting concrete", Construction and Building Materials, 2015, pp. 50–59.

[4] P.R. da Silva, J. de Brito., "Experimental study of the porosity and microstructure of self-compacting concrete (SCC) with binary and ternary mixes of fly ash and limestone filler", Construction and Building Materials, 2015, pp. 86:101-112.

[5] IS: 12269 -1987 reaffirmed 1989. Indian Standard Specification for 53 Grade ordinary portland cement.

[6] IS 2386-1963., Indian Standard methods of test for aggregates for concrete, Bureau of Indian Standards, New Delhi.

[7] IS: 516-1959, Indian standard Methods of Tests for Strength of concrete, Bureau of Indian Standards, New Delhi, India.

[8] IS: 383-1970., Indian Standard Specification for coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi, India.

[9] The European guidelines for self-compacting concrete. formed in 2004 by EFNARC, available at www.efnarc.org..