An Experimental Study on Performance of Roof Tile Powder in Self Compacting Concrete

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Abstract- Concrete is the most important engineering material and the addition of some other materials may change the properties of concrete. With increase in trend towards the wider use of concrete for prestressed concrete and high rise buildings there is a growing demand of concrete with increase in the workability and strength of self compacting concrete. Mineral additions which are also known as mineral admixtures have been used with cements for many years. Traditional roof tile powder in self compacting concrete is an effort to recycle waste and new development in environmental friendly concrete material technology. The main objective of this work is to study the effect of roof tail powder on properties of self compacting concrete of M25 with percentage replacement is varied as 0%,5%,10%,15%,20%,&25%.

Key words: Roof tail powder, self compacting concrete, Slum flow-funnel test, strengthening.

I. INTRODUCTION

Self–compacting concrete (SCC) is a fluid mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibration. Recently, development on concrete technology grows to satisfy the needs to make higher performance concrete. Self-compacting concrete (SCC) is well known as an innovation on concrete technology.SCC capability to flow with high flow-ability makes the fresh concrete is not need compaction and then suitable to use in structure elements which have dense reinforcement. This characteristic also generates easier workability, reduce the need of large number workmanships, and reduce duration of concrete construction stage.Okamura introduce self-compacting concrete (SCC) in Japan and makes the SCC popular, fast developed, and widely applicable especially on pre-cast concrete due to its cost reduction (Okamura and Ozawa 1994). Self compacting concrete could be defined as concrete which could compact by its self-weight without vibrator help, Proportion of coarse aggregate on self compacting concrete is less than normal concrete. On self compacting concrete, cement content is replaced with powder, which conventionally consists of Portland cement, silica fume and fly ash. Proportions of water and sand on both types of concrete are relatively same.

Materials used :

Self-compacting concrete was made of cement, sand, water, fly ash and mineral admixture.

- Cement: Ordinary Portland cement, 43 Grade conforming to IS: 12269 – 1987.
- Fine aggregate: Locally available natural sand with 4.75 mm maximum size is used as a fine aggregate. According to IS 383-1970 sand conforming zone for the given fine aggregate is zone-2.
- Coarse aggregate: The crushed coarse aggregate tested according to IS : 2386.
- Roof Tile Powder: Powder has particle dimension of 0.125 mm and potentially has capabilities to be a binder and filler.

The physical and chemical properties of Roof tile powder are given in table

Physical property	Results
Fineness (retained on 90-μm) sieve)	2%
Specific gravity	2

Ingredient	Oxides	% in OPC	% in Roof Tiled Powder
Lime	CaO	62	4
Silica	SiO2	22	20
Aluminium	Al2O3	5	25
Iron oxide	Fe2O3	3	38.5
Sodium Oxide	Na2O	-	2.5
Titanium	TiO2	-	5
Alkalies	-	1	-
LOI	-	-	5

GGBFS (Ground Granular Blast Furnace Slag): Ground granular blast furnace slag confirming to BS 12089-1987 is used. The following are the properties of GGBFS.

Physical property	Results
Fineness (retained on 90-	2%
Specific gravity	2.9

Super plasticizer (SP): The admixture CONPLAST SP 430 G8 was used a super plasticizer with a density of 1.2 kg/lt was used to provide necessary workability.

Preliminary Analysis :
In designing the mix it is most useful to consider the relative proportions of the key components by volume rather than by mass.

- Water / Powder ratio by volume of 0.80 to 1.10
- Total powder content – 160 to 240 litters (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 litter/m3.
- The sand content balances the volume of the other constituents.

Mix Design :
Mix design for m25 grade concrete according to BIS method is carried out design stipulations are as follows

Test data of materials

- Specific gravity of cement : 3.06
- Compressive strength of cement at 7-days : Satisfies the requirements of IS269-1989(37N/m2)
- Specific gravity of Coarse aggregate : 2.70
- Specific gravity of Fine aggregate : 2.65
- Water absorption of Coarse aggregate : 0.5%
- Water absorption of Fine aggregate : 1.0%
- Fineness modulus of Coarse aggregate : 6.15
- Fineness Modulus of Fine aggregate : 4.0

According to BIS design the proportions of the mix is take as shown in the below table

Cement	Sand	Coarse Aggregate	Water
524.31Kg	928.08Kg	672.36Kg	199.24
1	1.77	1.28	0.38

Further in modified proportion cement is replaced with 5% of ***GGBFS and Tile powder*** is varied in order of 0%, 5%, 10%, 15%, 20% and 25%. Dosage of Super plasticizer is 2% of cementations material. Water/cement ratio is 0.38

Workability Test on Fresh SCC:
Following table gives the results of test conducted on fresh SCC such as Slump flow and T50cm slump flow, V-Funnel and V-funnel T5min, L-box and U-Box test for various replacement of Roof Tile powder for cement in SCC.

Percentage replacement of Tile Powder	Slump Flow in mm	T50 cm Slump Flow in Sec	V-Funnel in Sec	V-Funnel in T5min in Sec	L-Box (H2/H1)	U-Box in mm
0%	710	2	6	6	0.8	30
5%	710	2	6	6	0.8	30
10%	700	3	7	7	0.8	30
15%	700	3	7	8	0.8	30
20%	680	3	9	10	0.9	30
25%	650	3	10	11	0.9	30

Hardened Properties of SCC:
The following are the tables give the test results of Self compacting concrete, when cement is partially replaced by Roof Tile powder, for Compressive strength, Split tensile strength and Beam flexure strength.

Compressive strength results:
The Compressive strength results for various replacement levels of Roof Tile Powder by Cement (0-25%) at an increment of 5% for 7-days, 28-days and 56-days are tabulated below in tables.

Grade	% Roof Tile Powder variation	Load in kN	Area in Sq.mm	Compressive Strength in Mpa	Average Compressive Strength (Mpa)
M25	0%	500	150x150	22.22	22.22
		490	150x150	21.77	
		510	150x150	22.67	
	5%	530	150x150	23.55	23.55
		520	150x150	23.11	
		540	150x150	24	
	10%	550	150x150	24.44	24.59
		550	150x150	24.44	
		560	150x150	24.89	
	15%	520	150x150	23.11	23.7
		540	150x150	24	
		540	150x150	24	
	20%	530	150x150	23.55	22.81
		510	150x150	22.67	
		500	150x150	22.22	
	25%	470	150x150	20.89	21.63
		500	150x150	22.22	
		490	150x150	21.77	

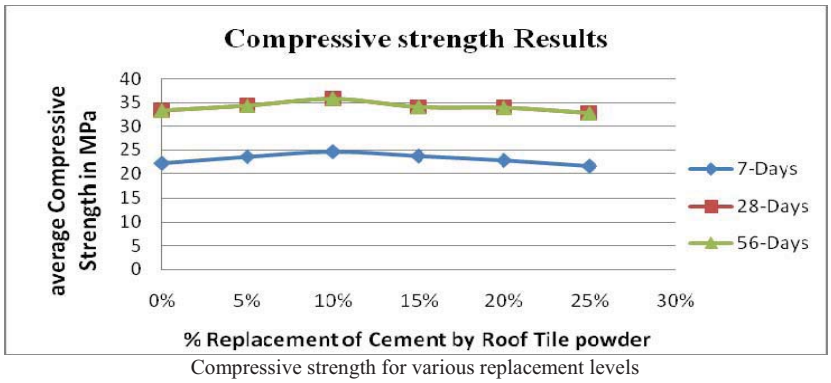
Compressive strength for various replacement levels at 7days

Grade	% Roof Tile Powder variation	Load in kN	Area in Sq.mm	Compressive Strength in Mpa	Average Compressive Strength (Mpa)
M25	0%	750	150x150	33.33	33.32
		740	150x150	32.88	
		760	150x150	33.77	
	5%	780	150x150	34.67	34.37
		750	150x150	33.33	
		790	150x150	35.11	
	10%	800	150x150	35.55	35.84
		800	150x150	35.55	
		820	150x150	36.44	
	15%	750	150x150	33.33	34.07
		750	150x150	33.33	
		800	150x150	35.55	
	20%	780	150x150	34.67	33.92
		760	150x150	33.77	
		750	150x150	33.33	
	25%	720	150x150	32	32.74
		750	150x150	33.33	
		740	150x150	32.88	

Compressive strength for various replacement levels at 28days

Grade	% Roof Tile Powder variation	Load in kN	Area in Sq.mm	Compressive Strength in Mpa	Average Compressive Strength (Mpa)
M25	0%	770	150x150	34.22	33.32
		760	150x150	33.77	
		760	150x150	33.77	
	5%	780	150x150	34.67	34.37
		770	150x150	34.22	
		790	150x150	35.11	
	10%	790	150x150	35.11	35.84
		800	150x150	35.55	
		790	150x150	35.11	
	15%	750	150x150	33.33	34.07
		770	150x150	34.22	
		750	150x150	33.33	
	20%	740	150x150	32.88	33.92
		740	150x150	32.88	
		750	150x150	33.33	
	25%	720	150x150	32	32.74
		720	150x150	32	
		740	150x150	32.88	

Compressive strength for various replacement levels at 56days



Compressive strength for various replacement levels

It has been observed that 56-days Compressive strength for various replacement of cement by roof tile powder the optimum compressive strength is at 10% replacement. After that the strength goes on decreasing. Roof tile powder can be effectively used as replacement up to 20% by weight of cement, without decreasing the strength compared to controlled concrete, thereby reducing the consumption of cement, with turn reduces the cost.

Split-Tensile strength results:

The Split-Tensile strength results for various replacement levels of Roof Tile Powder by Cement (0-25%) at an increment of 5% for 7-days, 28-days and 56-days are tabulated below in tables.

Grade	% Roof Tile powder variation	Load P (kN)	Tensile Strength (2P/∏DL) Mpa	Average tensile Strength (Mpa)
M25	0%	30	0.95	1.05
		40	1.27	
		30	0.95	
	5%	40	1.27	1.48
		50	1.59	
		50	1.59	
	10%	50	1.59	1.69
		50	1.59	
		60	1.9	
	15%	40	1.27	1.59
		60	1.9	
		50	1.59	
	20%	50	1.59	1.37
		40	1.27	
		40	1.27	
	25%	30	0.95	0.85
		20	0.64	
		30	0.95	

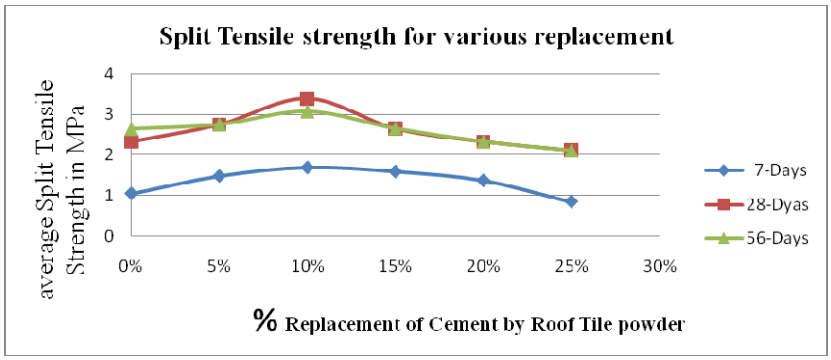
Split-Tensile strength for various replacement levels at 7days

Grade	% Roof Tile powder variation	Load P (kN)	Tensile Strength (2P/∏DL) Mpa	Average tensile Strength (Mpa)
M25	0%	70	2.22	2.33
		80	2.55	
		70	2.22	
	5%	80	2.55	2.75
		90	2.86	
		90	2.86	
	10%	100	3.18	3.39
		120	3.82	
		100	3.18	
	15%	80	2.55	2.65
		80	2.55	
		90	2.86	
	20%	70	2.22	2.33
		70	2.22	
		80	2.55	
	25%	70	2.22	2.11
		60	1.9	
		70	2.22	

Split-Tensile strength for various replacement levels at 28days

Grade	% Roof Tile powder variation	Load P (kN)	Tensile Strength (2P/∏DL) Mpa	Average tensile Strength (Mpa)
M25	0%	90	2.86	2.64
		90	2.86	
		70	2.22	
	5%	80	2.55	2.75
		90	2.86	
		90	2.86	
	10%	90	2.86	3.07
		100	3.18	
		100	3.18	
	15%	80	2.55	2.65
		80	2.55	
		90	2.86	
	20%	70	2.22	2.33
		70	2.22	
		80	2.55	
	25%	70	2.22	2.11
		60	1.9	
		70	2.22	

Split-Tensile strength for various replacement levels at 56 days



It has been observed that 56-days Split-tensile strength for various replacement of cement by roof tile powder the optimum compressive strength is at 10% replacement. After that the strength goes on decreasing. Roof tile powder can be effectively used as replacement up to 20% by weight of cement, without decreasing the strength compared to controlled concrete, thereby reducing the consumption of cement, with turn reduces the cost.

Beam-Flexure strength results: The Beam-Flexure strength results for various replacement levels of Roof Tile Powder by Cement (0-25%) at an increment of 5% for 7-days, 28-days and 56-days are tabulated below in tables.

Grade	% Roof Tile Powder Variation	Load P (kN)	Flexural Strength PL/bd2 (Mpa)	Average Flexural Strength (Mpa)
M25	0%	17.40	6.96	6.90
		17.00	6.80	
		17.40	6.96	
	5%	18.00	7.20	7.22
		18.00	7.20	
		18.15	7.26	
	10%	20.40	8.16	8.10
		20.35	8.14	
		20.00	8.00	
	15%	18.25	7.30	7.25
		18.00	7.20	
		18.15	7.26	
	20%	17.50	7.00	6.88
		17.00	6.80	
		17.10	6.84	
	25%	16.50	6.60	6.63
		16.25	6.50	
		17.00	6.80	

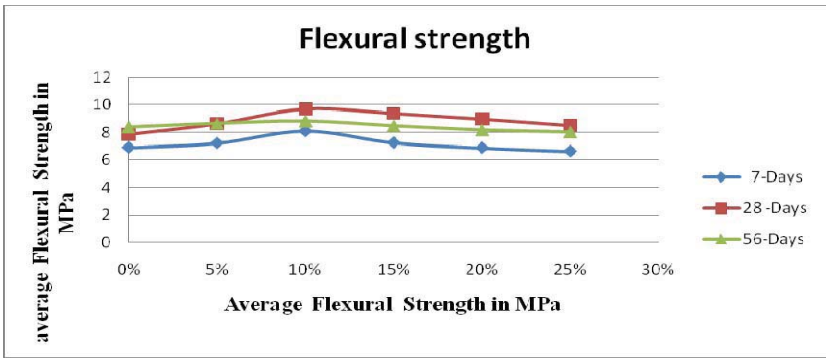
Beam-Flexure strength for various replacement levels at 7days

Grade	% Roof Tile Powder Variation	Load P (kN)	Flexural Strength PL/bd^2 (Mpa)	Average Flexural Strength (Mpa)
M25	0%	19.40	7.76	7.83
		19.35	7.74	
		20.00	8.00	
	5%	21.85	8.74	8.61
		21.50	8.60	
		21.25	8.50	
	10%	24.30	9.72	9.70
		24.00	9.60	
		24.50	9.80	
	15%	23.45	9.38	9.37
		23.25	9.30	
		23.55	9.42	
	20%	22.75	9.10	8.96
		22.45	8.98	
		22.00	8.80	
	25%	21.10	8.44	8.48
		21.00	8.40	
		21.50	8.60	

Beam-Flexure strength for various replacement levels at 28 days

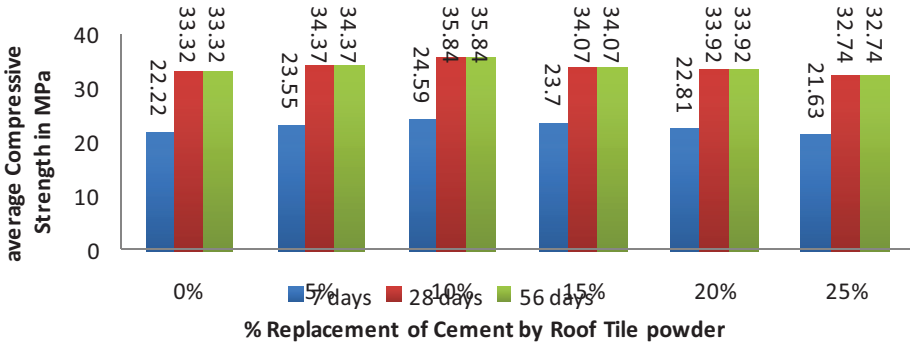
Grade	% Roof Tile Powder Variation	Load P (kN)	Flexural Strength PL/bd^2 (Mpa)	Average Flexural Strength (Mpa)
M25	0%	21.00	8.40	8.41
		21.10	8.44	
		21.00	8.40	
	5%	21.70	8.68	8.68
		21.65	8.66	
		21.75	8.70	
	10%	22.10	8.84	8.85
		22.00	8.80	
		22.25	8.90	
	15%	21.50	8.60	8.50
		21.00	8.40	
		21.25	8.50	
	20%	20.80	8.32	8.19
		20.45	8.18	
		20.20	8.08	
	25%	20.35	8.14	8.04
		20.00	8.00	
		19.95	7.98	

Beam-Flexure strength for various replacement levels at 56 days

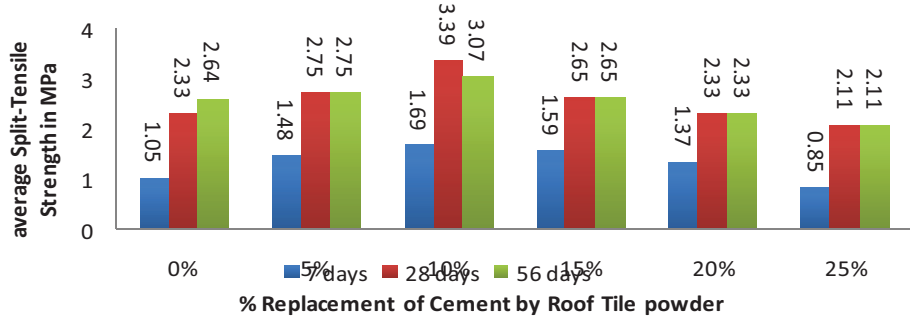


It has been observed that 56-days Beam-Flexure strength for various replacement of cement by roof tile powder the optimum compressive strength is at 10% replacement. After that the strength goes on decreasing.

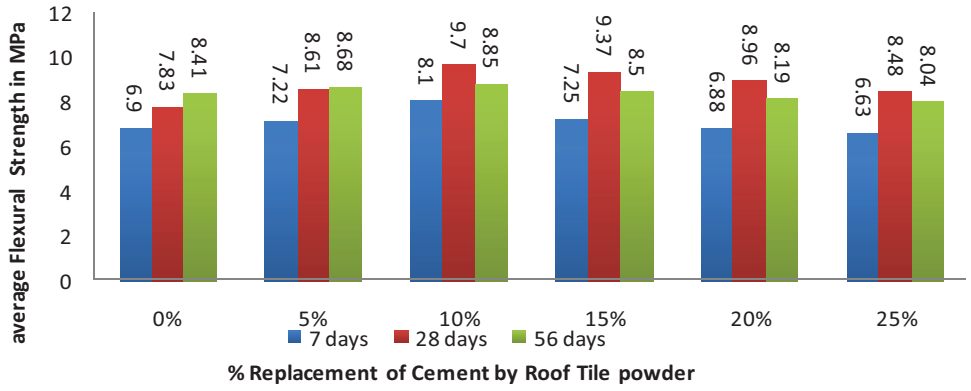
Overall results: Following chart gives the variation of Compressive strength, Tensile Strength and Flexural strength for different % replacement of Roof tile powder in SCC.
The following charts gives the comparison of Compressive strength, split-tensile strength and beam flexure strength for 7-days, 28-days and 56-days for replacement to cement by Roof tile powder in SCC. Optimum strength is achieved at 10% replacement and Roof tile powder can be effectively used as replacement up to 20% by weight of cement, without decreasing the strength compared to controlled concrete, thereby reducing the consumption of cement, with turn reduces the cost. And 28 days and 56 days strengths are almost same.



Comparison of Compressive strength for various replacement levels at 7-days, 28-days and 56-days



Comparison of Split Tensile strength for various replacement levels at 7-days, 28-days and 56-days



Comparison of Flexural strength for various replacement levels at
7-days, 28-days and 56-days

IV.CONCLUSION

Based on the investigation conducted for the study of behaviour 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.
- Trail mixes have to be made for maintaining flow ability, self compatibility and obstruction clearance.
- Self compacting concrete mixes can make, with Roof tile powder, without sacrificing the strength.
- Self compacting concrete mix requires high powder content and all most equal quantity of coarse and fine aggregate.
- Super plasticizers are necessary to full fill the fresh property of SCC.
- Roof tile powder can be effectively used as replacement up to 20% by weight of cement, without decreasing the strength compared to controlled concrete, thereby reducing the consumption of cement, with turn reduces the cost.
- Increase the percentage of Roof tile powder (0%, 5%, 10%, 10%, 15%, 20% and 25%) reduces the flow of concrete.
- Self compacting concrete with 10% replacement of cement with Roof tile powder showed good results.
- It can be seen from fresh properties results of SCC with Roof tile powder improves the filling ability and segregation resistance compare to controlled concrete.

REFERENCES

[1] ASTM C127-07, “Standard test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate”.
[2] Baskar .I et al (1999), “Influence of silicafume on properties of self compacting concrete SCC” Journal of Research of NIST, Vol. 104, No. 5,pp.461-478.
[3] Bernardinus Herbudiman and Adhi Mulyawan Saptaji (March 2013),”Self-Compacting Concrete with Recycled Traditional Roof Tile Powder”, The 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering, vol. 54, pp. 805 – 816.
[4] Brain poulson (Feb 2002), EFNARC, Secretary general, “Specifications and guide lines for self compacting concrete”. pp. 1-32
[5] Brouwers, Radix (2005), Cement and Concrete Research [Online]. Available: http://digilib.petra.ac.id.
[6] Hajime Okamura and Masahiro Ochi (April 2003), “Self-Compacting Concrete” journal of advanced concrete technology, Vol.1, No 1.5-15..
[7] Manu Santhanam (June 2004), “Current development in self compacting concrete” The Indian concrete journal (11) –Volume 78, number 6, pp. 1-34.
[8] Nan Su, Kung-Chung Hsu (2001) “A Simple Mix Design Method for Self- compactingbConcrete”, Cement and Concrete Research Vol.31, 2001- pp, 1799–1807.
[9] Navaneethakrishnan and V. M. Shanthi (2012) , “Experimental study of self compacting concrete (SCC) using silicafume” EngOpt 2012 – 3rd International conference on Engineering Optimization Rio Janeiro,Brazil, July, pp.475-482.
[10] Nugraha, P., dan Antoni (2007), Teknologi Beton dari Material, Pembuatan, ke Beton Kinerja Tinggi, Andi, Jakarta.
[11] Okamura, H., and Ozawa, K (1994), “Self-Compactable High Performance Concrete”, American Concrete Institute, Detroit.

[12] Prof. Shriram H. Mahure, Dr. V. M. Mohitkar (Oct 2013),"Effect of Mineral Admixture on Fresh and Hardened Properties of Self Compacting Concrete", Head of Civil Engineering Department, Babasaheb Naik College of Engineering Pusad, District-avatmal, (Maharashtra), India.
[13] Salem Al-Sanusi et al (2012), "Influence of Silicafume on the Properties of Self- Compacting Concretes" International journal of emerging trends in engineering and developments, Issue 2, Vol 4, pp. 1-7.
[14] Vengala, et al,(Aug 2003)" Experimental study for obtaining self compacting concrete", The Indian concrete journal, Vol.77, No.8, pp.1261-1264.