SELF-COMPACTING CONCRETE WITH RECYCLED TRADITIONAL ROOF TILE POWDER

Anupama.B.S[1] & Dr. H. Eramma[2]

[1]PG Student, [2]Associate Professor, CAD structures, University B D T College of Engineering, Constituent College of Visvesvaraya Technological University, Davangere-577000, Karnataka, India

ABSTRACT

Concrete occupies unique position among the modern construction materials, Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate (usually made for different types of sand and gravel), that is bond by cement and water. Bad reinforcement concrete works could generate building failures after earthquake. Concrete pouring and compacting on structural element with dense reinforcement and beam column joint are difficult. Suitable solution on this problem is the use of self-compacting concrete that has flow ability, filling-ability, and passing-ability. Traditional roof tile waste is available in Indian villages. The use of traditional roof tile powder in self-compacting concrete is an effort to recycle waste and new development in environmental friendly concrete material technology. This research tends to understanding contribution of traditional roof tile powder in development of workability and strength of Self-Compacting Concrete. The Roof tile powder percentage for replacement of SCC is varied as 0%, 5%, 10%, 15%, 20%, & 25%. The Mix Design for concrete M_{25} grade is being done as per the Indian Standard Code IS: 10262-1982.

Keywords - M_{25}, Roof Tile Powder, SCC, SP, Strength

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 has small volume of pore in concrete then could minimize amount of captured air in concrete. Refer to its name; Self-Compacting Concrete could be defined as concrete which could compact by its self-weight without vibrator help. Self-compacting concrete has several direct advantages, such as: reach difficult place in building, prevent bleeding and segregation, minimize amount of infiltrate water on concrete which could generate corrosion on reinforcement, give protection against external factors.

1.1. SCC

The introduction of Self-Compacting Concrete (SCC) technology has significantly changed the way the concrete operation is executed. It enables improvements in the concrete construction techniques for increased and efficient results. Elimination of discontinuous mechanical vibration makes concrete structures more consistent having reliable properties. General enhancement of the working environment is paid off by improvement in health and safety of workers, which also adds to the increase of productivity. SCC is new and improved way of executing the concreting operations, while maintaining homogeneity without the need for external vibration.

1.2 Requirements For SCC

SCC exhibits following properties in its plastic state.

- **Filling Ability**

It is the ability of SCC to flow into and fill completely all spaces in the formwork and encapsulate reinforcement while maintaining homogeneity.

- **Passing Ability**

It is the ability of concrete mix to pass through obstacles like narrow sections in form work, closely spaced reinforcement bars without getting blocked by interlocking of aggregate particles.

- **Resistance To Segregation**

Segregation resistance of self-compacting concrete is its capability to retain homogeneity in the distribution of ingredient in fresh state during both static and moving condition i.e., during mixing, transportation and placing. It is dependent on viscosity of mix in fresh state.

1.3 Materials

Materials were used in this study like Cement, Fine aggregate, Coarse aggregate, Roof Tile Powder, GGBFS, and Super Plasticizer (SP) for preparation of SCC.

1.4 Testing Methods for SCC

Cement

Chettinad (43 grade) cement

Tests on cement

- Normal consistency = 34%
- Initial setting time = 45 min
- Final setting time = 290 min
- Soundness of cement = 2 mm
- Fineness of cement = 2%

1.5 Design mix for SCC by IS: 10262-1982

To produce SCC, the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. In practice, SCC in its fresh state shows high fluidity, self-compacting ability and segregation resistance, all of which contribute to reducing the risk of honey combing of concrete. With these good properties, the SCC produced can greatly improve the reliability and durability of the reinforced concrete structures. In addition SCC shows good performance in compressive strength test and can fulfil other construction needs because its proportion has taken into consideration the requirements in the structural design.

Data's obtained from Experimental Program

- Characteristic compressive strength required in the field at 28-days: 25Mpa
- Maximum size of aggregate: 12.5 mm (rounded)
- Degree of workability: 0.9(compaction factor)
- Specific gravity of cement :3.06
- Specific gravity of Coarse aggregate : 2.70
- Specific gravity of Fine aggregate : 2.65

Mix Proportions

Cement: Fine Aggregate: Coarse Aggregate: Water: SP

524.31: 928.08: 672.36: 199.24: 10.50

1:1.77 :1.28:0.38:0.02

In total Cement GGBFS is replaced by 5% and Roof tile Powder is varied in 0%,5%, 10%, 15%, 20% and 25%.

1.6 Tests Conducted On SCC

1. Slump flow test
2. V- Funnel flow test
3. L-box test
4. U-box test

1.6.1 Slump Flow Test

Slump test is one of the most popular method of measuring workability throughout the world. The slump flow is used to assess the horizontal free flow of SCC in the absences of obstructions. The slump cone, filled with concrete, if lifted off and concrete will flow – the horizontal diameter of the flowed material is measured. The average diameter of the concrete circle is measure for filling ability of the concrete. The T50 time is a secondary indication of flow, it measures the time taken in secs from the instant the cone is lifted to the instant when horizontal flow diameter reaches 500 mm as shown in Fig 1.1 According to **Nagataki** and **Fujiwara**, a slump flow ranging from 500 to 700 mm is considered to be self-compacted. At more than 700 mm the concrete might segregate and at less than 500 mm the concrete may have insufficient flow to pass through highly congested reinforcement. Slump flow value ranges from 650-800mm and T_{50cm} slump flow 2-5 secs.

1.6.2 V-Funnel Flow Test

The flowability of the fresh concrete can be tested with the V- funnel test, where by the flow time is measured. The funnel is filled with about 12 liters of concrete and the time taken for it to flow through the narrow end of the apparatus is measured. Further, another parameter T5 min, is also measured with V- funnel. This is to indicate the tendency for segregation. For this, the funnel is refilled with concrete and left for 5 min to settle. If the concrete has exhibited segregation the flow time will increase significantly, compared to the measurement as shown in Fig 1.2.V-finnel test should be between 8-12 secs ad v-Funnel at T_{5mins} is 6-15 secs.

1.6.3 L – Box Test

Passing ability of SCC is determined using the L-box test. The vertical section of the L-box is filled with concrete, and then the gate lifted to let the concrete flow in to the horizontal section. The height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2 / H1) as shown in Fig 1.3.Value of L-Box test should be 0.8-1.0.

1.6.4 U-Box Test

The test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometimes the apparatus is called a "box – shaped "test. The test is used to measure the filling ability of self – compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments as shown in Fig 1.4.Value of U-Box test should not exceed 30mm.

1.6.5 Chemical Admixtures

Super plasticizers are an essential component of SCC to provide necessary workability. The new generation super plasticizers termed poly-carboxylated ethers (PCE) are particularly useful for SCC. Dosage of SP is determined by Marsh Cone test.

1.6.6 Roof Tile Powder

Roof tile powder is added to cement in various replacement to improve the quality and durability of SCC.

1.6.7 Ground Granulated Blast Furnace Slag (GGBFS)

GGBFS which is both cementitious and pozzolanic material may be added to improve rheological properties.

II. EXPERIMENTAL PROGRAM

Mixing of concrete was carried out by machine. Machine mixing is not only efficient but also economical. Then tests for SCC are carried out after satisfying those tests concrete is casted in to cube moulds of size 150mm×150mm,beam moulds of size 100×100×500mm and cylindrical moulds of 200 mm height ×100 mm dia. After 24 hours the specimens were removed from the moulds and immediately submerged in clean fresh water and kept there until taken out just prior to testing. Then 7days, 28days and 56days Compressive strength, Split-tensile strength and Beam-Flexure Strength are determined.

1.1 Slump Flow Test

1.2 V-Funnel Test

1.3 L-Box Test

1.4 U-Box Test

III. RESULTS AND DISSCUSSIONS

The results completed in the present investigation are reported in the form of Tables and Graphs for various fresh properties and harden properties of SCC for various percentage of Roof Tile powder as a partial replacement to cement in SCC by 0%, 5%, 10%, 15%, 20% and 25% are worked out and tabulated in the table below.

3.1 Fresh Properties of SCC:

Percentage Replacement of Tile Powder	Slump Flow in mm	T_{50cm} Slump Flow in Sec	V-Funnel in Sec	V-Funnel T_{5min} in sec	L-Box H_2/H_1	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

3.2 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.

Table 1: Compressive Strength For Various Replacement Levels At 7, 28 And 56days

Grade	% of Roof Tile Powder Variation	Compressive strength in Mpa		
		7-days	28-days	56-days
	0%	22.22	33.32	33.32
	5%	23.55	34.37	34.37
M_{25}	10%	24.59	35.84	35.84

	15%	23.70	34.07	34.07
	20%	22.81	33.92	33.92
	25%	21.63	32.74	32.74

Table 2: Split-Tensile Strength For Various Replacement Levels At 7, 28 And 56days

Grade	% of Roof Tile Powder Variation	Split-tensile strength in Mpa		
		7-days	28-days	56-days
M_{25}	0%	1.05	2.33	2.64
	5%	1.48	2.75	2.75
	10%	1.69	3.39	3.07
	15%	1.59	2.65	2.65
	20%	1.37	2.33	2.33
	25%	0.85	2.11	2.11

Table 3: Beam-Flexure Strength For Various Replacement Levels At 7, 28 And 56days

Grade	% of Roof Tile Powder Variation	Beam-Flexure strength in Mpa		
		7-days	28-days	56-days
M_{25}	0%	6.90	7.83	8.41
	5%	7.22	8.61	8.68
	10%	8.10	9.70	8.85
	15%	7.25	9.37	8.50
	20%	6.88	8.96	8.19
	25%	6.63	8.48	8.04

3.3 Charts

The following Figures 3.1 to 3.3 shows the variation of Compressive strength, Split tensile strength and Beam flexure strength for different % replacement of Roof Tile Powder in SCC.

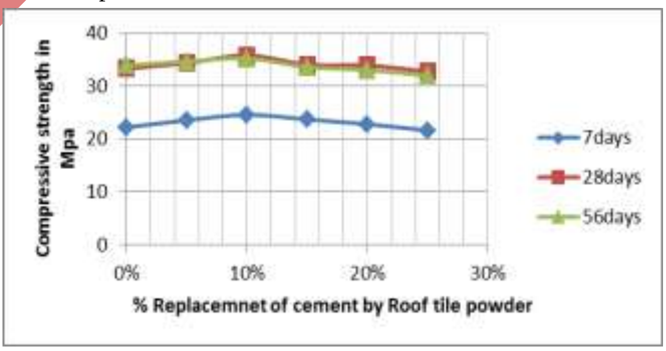

Fig 3.1 Comparison Of Compressive Strength For Various Replacementlevels At 7-Days,28-Days And 56-Days

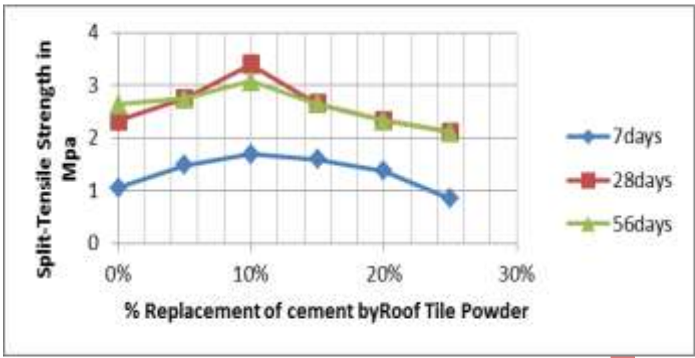

Fig 3.2 Comparison Of Split-Tensile Strength For Various Replacementlevels At 7-Days, 28-Days And 56-Days

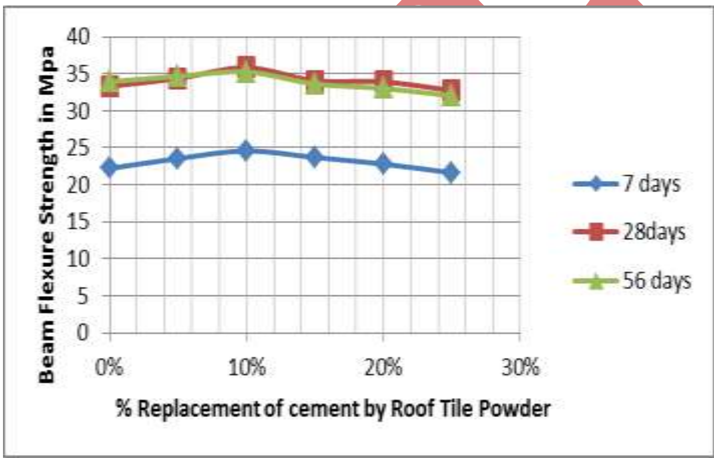

Fig 3.3 Comparison Of Beam-Flexure Strength For Various Replacementlevels At 7-Days,28-Days And 56-Days

IV. CONCLUSIONS

1. 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.
2. Trail mixes have to be made for maintaining flow ability, self-compatibility and obstruction clearance.
3. Self-compacting concrete mixes can make, with Roof tile powder, without sacrificing the strength.
4. Self-compacting concrete mix requires high powder content and all most equal quantity of coarse and fine aggregate.
5. Super plasticizers are necessary to full fill the fresh property of SCC.
6. 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.
7. Increase the percentage of Roof tile powder (0%, 5%, 10%, 10%, 15%, 20% and 25%) reduces the flow of concrete.

8. Self-compacting concrete with 10% replacement of cement with Roof tile powder showed good results.
9. 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.

V. ACKNOWLEDGMENT

The authors wish to thank the authorities of University BDT College of Engineering for giving us an opportunity to conduct the experimental work in the Concrete and Highway Laboratory in Civil Engineering Department. Davangere.

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 silica fume 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.

REFERENCE CODE OF PRACTICE

[1] IS: 456-2000 Plain and reinforced concrete code of practice.

[2] IS: 10262-1982 recommended guidelines for concrete mix design.

[3] IS: 10262-2009 recommended guidelines for concrete.

[4] IS: 383-1970 Indian Standard Specification for Coarse and Fine aggregates from natural sources for concrete.

[5] IS: 2386-1963 (All parts), Methods of tests for aggregate of concrete.

[6] IS: 516-1059 Methods of test for Strength of Concrete.