Mechanical Characteristics and Durability of Self-Compacting Concretes Produced with Roof Tile Powder

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Abstract— 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. Compaction and pouring of concrete on element of structure with dense reinforcement and structural joint like beam column joint are difficult. Many types of concrete have been developed to enhance the different properties of concrete. When huge amount of concrete of very high steel is to be placed in a reinforced concrete member, it is very hard or difficult to ensure that the form work completely filled with concrete that is, fully compacted without voids or honeycombs. On this research using of roof tile powder in self-compacted concrete give better workability and also strength of self-compacted concrete. The roof tile powder is easily available in Indian villages. The possibility of using roof tile powder (RTP) with fly ash for partial replacement of ordinary Portland cement (OPC) will explore in this research. An experimental study is made by preparing specimens by utilizing roof tile powder (RTP) as partial replacement of ordinary Portland cement in Self compacted concrete with a percentage replacement from 0% to 40% i.e. (0%, 10%, 25%, 30% and 40%). The super plasticizer and viscosity modifying agent are added in Self compacted concrete. Test on fresh concrete is slump spread for all trial mixes. The mix that has the largest slump spread is tested with V-funnel, L-shaped box and U-shaped box Conventional specimens are also prepared for M30 and M35 grade Concrete without using RTP and fly ash. By conducting tests for both the specimens the properties of concrete will be investigate. This study ensures that using of roof tile powder (RTP) as partial replacement of ordinary Portland cement substitutes in concrete gives a good approach to reduce cost of materials and will accomplish the better properties of self-compacted concrete at all ages.

Key words: Self-Compacted Concrete, Roof Tile Powder (RTP), VMA – Viscosity Modified Agent, M30, M35, Super Plasticizer, Slump Flow, Durability

I. INTRODUCTION

The delegated concrete works could promote structure failure after earthquake. Compaction and pouring of concrete on element of structure with dense reinforcement and structural joint like beam column joint are difficult. So the self-compacted concrete is a better solution for this problem. Use of self-compacted concrete that has flow ability, filling ability and passing ability is better than the normal concrete. It increase in difficulty of construction and lack of skilled labours. In congested designed of steel fair as applied to concreting in congested area, and it decrease the strength of concrete. Concrete is a widely used construction material around the world. Many types of concrete have been developed to enhance the different properties of concrete. When huge amount of concrete of very high steel is to be placed in a reinforced concrete member, it is very hard or difficult to ensure that the form work completely filled with concrete that is, fully compacted without voids or honeycombs. Compaction by manually or mechanically vibrators is very hard in this condition. The methods of compaction, vibrations produces delay and it increase the cost of the overall project. In case of underwater concreting, the vibration or compaction are not possible, in that case self-compacting concrete (SCC) are adopted.

Its tendency to flow under their own weight and completely filling formwork and achieving full compaction even in congested steel designed. The hardened concrete has same properties and durability as tradition vibrated concrete. To get SCC of high fluidity without segregation or bleeding during the transportation or placing, the use of high powder content, super plasticizer and viscosity modifying agent seems a good results. The cost of this type of concrete is very high than normal concrete.

The use of mineral admixture such as silica fumes, fly ash and ground granulated blast-furnace slag can be decrease the material cost and increase the flowing ability.

To make the durable concrete, the compaction is compulsory by the trained labours. The reduction in the trained labour is affect the whole construction concrete quality. For that problem, the self-compacting concrete (SCC) used, which is compacted by itself by its own weight and without any type of vibrations.

II. SCOPE

Efforts have been made in construction industry to use roof tile powder (RTP) as a partial replacement of the cement.

The successful use of other industrial by products of wastes such as fly ash and silica fume in concrete set as good example for waste to be used in a different way.

Trials are also suggesting utilizing roof tile powder (RTP) usage in concrete as a partial replacement of the cement.

III. NEED OF STUDY

- The natural resources can be protected by the use of roof tile powder.
- Roof tile powder is used in building construction as a cement which protects natural resources.
- By resulting natural materials use in high range, Main purpose is to save the natural material at certain level.
- Only recycled roof tile are reuse.
- With the comparison of OPC cement, roof tile powder is more economical for use as construction material in construction.
- If at the site, there is no possibility of compaction, the Self Compacting Concrete (SCC) is very best option.

IV. OBJECTIVE

To evaluate the fresh properties (Slump test, L-box, V-funnel and J-ring) of Self Compacting Concrete (SCC) with use of roof tile powder (RTP) up to 40% Replacement with the increment of 10%.

To achieve the harden properties (Compressive strength, Split tensile Strength and Flexural tensile Strength) of Self Compacting Concrete (SCC) with use of roof tile powder (RTP) up to 40% Replacement with the increment of 10%.

To check the durability Properties, Acid attack (HCL) and sulphate attack (MgSO4) of Self Compacting Concrete (SCC) with use of roof tile powder (RTP) up to 40% Replacement with the increment of 10%.

V. MATERIAL USED IN SELF-COMPACTING CONCRETE (SCC)

A. Cement

The "Ordinary Portland Cement 53 grade was used for all concrete mixes. The properties of cement is fine, greenish, and grey powder. Cement is mixing with water, sand, super plasticizer and aggregate to make self-compacted" concrete (SCC).

B. Water

Water used for mixing and curing shall be clean and free from injurious amount of oils, acids, alkalis, salts, organic materials or other deleterious materials.

C. Fly ash

The cement and water form a paste that binds the other materials together as the concrete harden state. In this experimental study, Class F fly ash is used.

D. Fine Aggregate

The fine aggregate, which is used in the investigation is clean river sand and conforming to zone II as per IS: 383-1970. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm.

Sr. No.	Fine Aggregate	
1	Specific gravity	2.77
2	Water Absorption	1.0
3	Moisture content	Nil

Table 1: Basic Result of Fine Aggregate

E. Coarse Aggregate

The"coarse aggregate use as the crushed stone aggregate passing through 10 mm sieve. The aggregate occupy 70%-80% of the total volume of normal concrete. But Self Compacting Concrete (SCC) have only 50% of total volume of concrete. Coarse aggregate shall comply with the requirement of IS 383".

F. Super plasticizer

Admixture is most important constitute of self-compacting concrete (SCC) to achieving flow ability and passing ability. In this experimental study, Glenium sky 8784 is used. This admixture of older name is Glenium sky 8784.

G. VMA – viscosity modifying agent

VMA is most important constitute of self-compacting concrete (SCC) to achieving viscosity & strength. In this experimental study, Master matrix -2 is used.

H. Roof tile powder (RTP)

Roof tile collected from Khirasara Palace Located at the Rajkot. After collecting, Roof tile are finely ground in ball mill and tube mill. The size of the used powder is retained in 90 micron sieve. This roof tile powder replaced by cement by the increment of 10% interval respectively.

Sr.No.	TEST	UNIT	OBTAIN RESULT
1	Loss of ignition	%	2.2
2	MgO	%	0.84
3	CaO	%	7.71
4	SiO_2	%	65.00
5	Al_2O_3	%	4.62
6	Fe_2O_3	%	8.45

Roof tile powder
Table 2: Chemical Composition of RTP

VI. EXPERIMENTAL PLAN

A. Test procedure

1) Assessment of mix design methods
2) Selection of mixing procedures and test methods.
3) Selection of the target properties of self-compacting concrete for the subsequent tests
4) Selection of constituent materials

B. Mix proportions

OPC was replaced by RTP varying from 10% to 40% at the equal interval of 10% with incultion of constant 25% fly ash replacing equal amount of OPC. Test was carried out for M30 and M35 grade concrete.

Concrete mixes with the target fresh properties at each RTP with constant 25% fly ash replacement level up to 50% will produce, and all level tested for hardened properties. The hardened properties of each of the concrete mixes will then measure, including compressive strength, splitting tensile strength and flexural strength. Then the relationships between compressive strength and splitting strength will compare to those of NVC. This can be used to compare the material properties of SCC and NVC and will give indirect information about SCC in situ.

VII. RESULTS AND DISCUSSIONS

A. Fresh Concrete Results

Sr No.	Test Method	Unit	Criteria	Maximum value	Property
1	Slump flow	mm	500 - 800	670	Filling ability
2	L-Box	h2/h1	0.8 - 1	0.9	Passing ability
3	J-Ring	sec	0 - 10	6	Passing Ability
4	V-funnel	sec	8 - 12	9	Filling ability

Table 3: Fresh Properties Test as per EFNARC (European Guidelines)

Sr no.	Type of Mix	Slump (mm)	V-Funnel (sec)	U-Box (h2/h1)	L-Box (h2/h1)
		650-800 mm	6-12 sec	0.9-1	0.8-1
1	0% RTP+25% FA+75%OPC	660	11.3	0.97	0.82
2	10% RTP+25% FA+65%OPC	677	10.9	0.96	0.84
3	20% RTP+25% FA+55%OPC	680	10.2	0.94	0.87
4	30% RTP+25% FA+45%OPC	693	9.5	0.91	0.89
5	40% RTP+25% FA+35%OPC	709	8.4	0.75	0.92

Table 4: Results of Fresh Properties Test for M-30 Grade Concrete

Sr no.	Type of Mix	Slump (mm)	V-Funnel (sec)	U-Box (h2/h1)	L-Box (h2/h1)
		650-800 mm	6-12 sec	0.9-1	0.8-1
1	0% RTP+25% FA+75%OPC	680	11	0.94	0.81
2	10% RTP+25% FA+65%OPC	688	10.7	0.96	0.85
3	20% RTP+25% FA+55%OPC	692	9.8	0.97	0.88
4	30% RTP+25% FA+45%OPC	702	8.3	0.93	0.91
5	40% RTP+25% FA+35%OPC	712	7.5	0.9	0.94

Table 5: Results of Fresh Properties Test for M-35 Grade Concrete

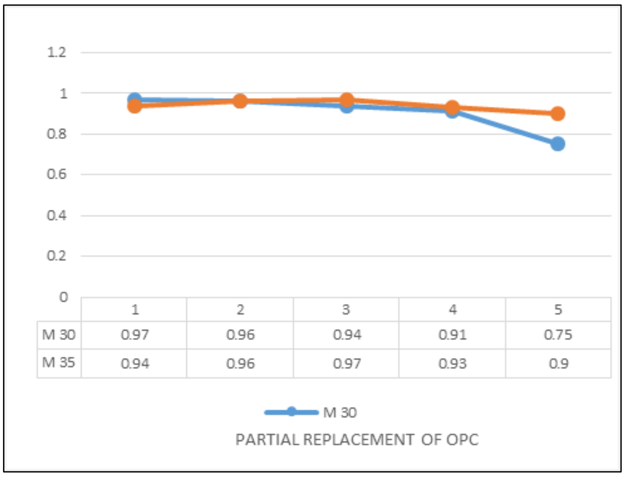

Chart 1: U-BOX Chart

In M-30 grade concrete with the increment of RTP with fly ash up to total replacement of 50% with increment of 10% with constant 25% fly ash the value of level difference varies in the rate of 0.97, 0.96, 0.94, 0.91 and 0.75 respectively.

In M-35 grade concrete with the increment of RTP with fly ash up to total replacement of 50% with increment of 10% with constant 25% fly ash the value of level difference varies in the rate of 0.94, 0.96, 0.97, 0.93 and 0.9 respectively.

B. Hardended concrete results:

1) Compressive strength result (without using VMA):

In M-30 grade concrete the value of 30% RTP replacement with constant 25% fly ash without using VMA gives maximum 43.92MPA compressive strength.

In M-35 grade concrete the value of 30% RTP replacement with constant 25% fly ash without using VMA gives maximum 47.22MPA compressive strength.

Compressive Strength for M-30 Grade in Mpa				
Target mean strength-38.75				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	27.73	33.27	41.25
2	10% RTP+25% FA+65%OPC	28.12	33.78	41.55
3	20% RTP+25% FA+55%OPC	28.25	34.88	42.33
4	30% RTP+25% FA+45%OPC	29.36	36.52	43.92
5	40% RTP+25% FA+35%OPC	27.67	33.41	42.15

Table 6: Compressive Strength of Cubes for M-30 (WTHOUT using VMA)

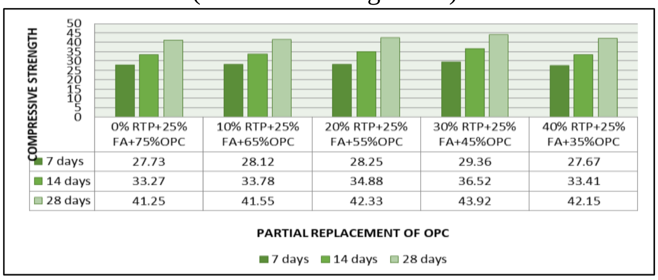

Chart 2: Compressive Strength of M-30 (WTHOUT using VMA)

Compressive Strength for M-30 Grade in Mpa				
Target mean strength-38.75				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	28.45	33.86	44.65
2	10% RTP+25% FA+65%OPC	28.96	35.62	45.48
3	20% RTP+25% FA+55%OPC	29.84	36.41	45.87
4	30% RTP+25% FA+45%OPC	30.76	35.97	47.22
5	40% RTP+25% FA+35%OPC	29.58	33.37	44.83

Table 7: Compressive Strength for M-35 (WTHOUT using VMA)

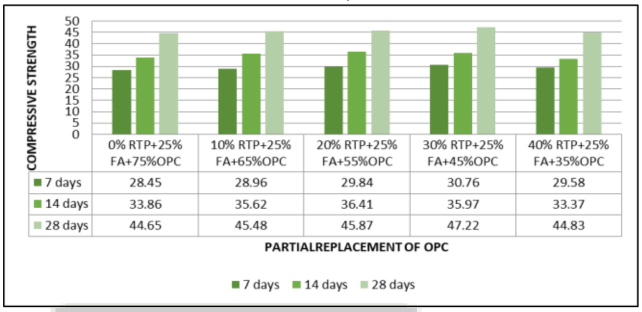

Chart 3: Compressive Strength of M-35 (WTHOUT using VMA)

2) *Compressive strength result (using VMA):*

In M-30 grade concrete the value of 30% RTP replacement with constant 25% fly ash using with VMA gives maximum 45.58 MPA compressive strength.

In M-35 grade concrete the value of 30% RTP replacement with constant 25% fly ash using with VMA gives maximum 46.92 MPA compressive strength.

Compressive Strength for M-30 Grade in Mpa				
Target mean strength-38.75				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	28.55	34.23	42.52
2	10% RTP+25% FA+65%OPC	28.99	34.83	42.89
3	20% RTP+25% FA+55%OPC	29.69	36.66	44.62
4	30% RTP+25% FA+45%OPC	30.42	37.84	45.58
5	40% RTP+25% FA+35%OPC	29.92	36.13	48.9

Table 8: Compressive Strength of Cubes for M-30 (using VMA)

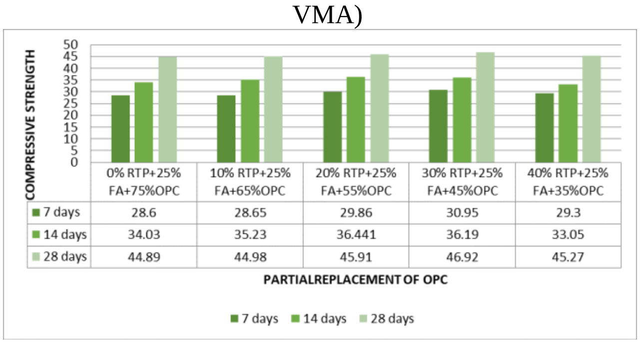

Chart 4: Compressive Strength of M-30 (using VMA)

Compressive Strength for M-30 Grade in Mpa				
Target mean strength-38.75				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	28.6	34.03	44.89
2	10% RTP+25% FA+65%OPC	28.65	35.23	44.98
3	20% RTP+25% FA+55%OPC	29.86	36.441	45.91
4	30% RTP+25% FA+45%OPC	30.95	36.19	46.92
5	40% RTP+25% FA+35%OPC	29.3	33.05	45.27

Table 9: Compressive Strength for M-35 (using VMA)

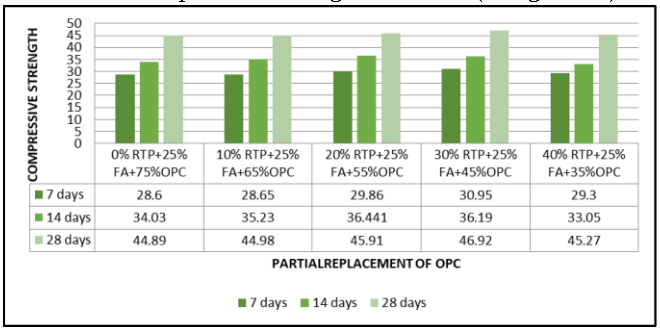

Chart 5: Compressive Strength of M-35 (using VMA)

C. *Durability tests results*

In durability, Due to the acid attack and sulphate attack the strength of concrete reduce with the increment of percentage of FCA replace with OPC.

Sr No.	Type of mix	Comp. Strength (28 days)	HCL		MgSO4	
			Reduced Strength	% loss in Strength	Reduced Strength	% loss in Strength
1	0% RTP+25% FA+75% OPC	41.25	38.45	5.47	37.14	9.96
2	10% RTP+25% FA+65% OPC	41.55	39.1	5.90	38.23	7.99
3	20% RTP+25% FA+55% OPC	42.33	39.75	6.09	38.76	8.43
4	30% RTP+25% FA+45% OPC	43.92	40.12	8.65	39.35	10.41
5	40% RTP+25% FA+35% OPC	42.15	39.23	6.93	38.69	8.21

Table 10: Durability Results for M-30

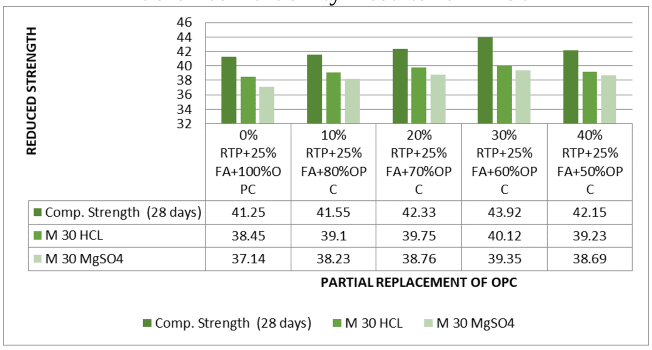

Chart 6: Durability Results for M-30

Sr No.	Type of mix	Comp. Strength (28 days)	HCL		MgSO4	
			Reduced Strength	% loss in Strength	Reduced Strength	% loss in Strength
1	0% RTP+25% FA+75% OPC	44.65	40.16	10.06	39.15	12.32
2	10% RTP+25% FA+65% OPC	45.48	40.54	10.86	39.48	13.19
3	20% RTP+25% FA+55% OPC	45.87	41.19	10.20	39.77	13.30
4	30% RTP+25% FA+45% OPC	47.22	42.74	9.49	40.21	14.85
5	40% RTP+25% FA+35% OPC	44.83	40.29	10.13	39.2	12.56

Table 11: Durability Results for M-35

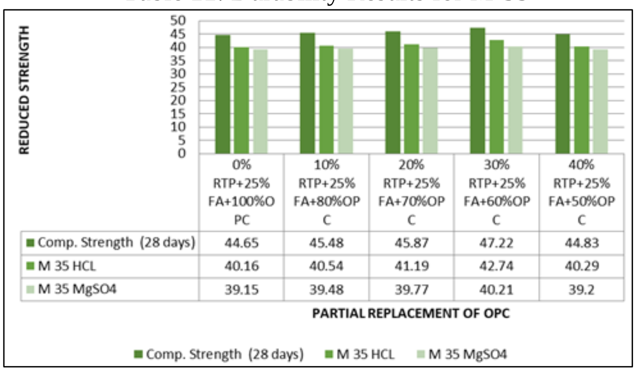

Chart 7: Durability Results for M-35

VIII. CONCLUSIONS

Based on experimental investigation, following observations are made on the fresh property, hardened properties and durability of SCC:

- The Compressive, flexural and tensile strength of concrete containing RTP and Fly ash, replacing OPC up to 40% improved significantly at all age.
- Sorptivity of concrete mixes containing RTP and Fly ash found less than control mix at all ages.
- Results of compressive strength, flexural strength, tensile strength and sorptivity study conformed each other.
- Maximum increase in strength observed in concrete mix containing 30% RTP and 25 % lime.
- It can be broadly concluded from the present study that RTP along with Fly ash is a useful raw material for partial replacement of OPC up to 40% in SCC.
- Water demand increases, setting time decreases and soundness remains consistent on inclusion of 25% Fly Ash and up to 40% RTP as partial replacement of OPC
- The use of powder additions helps make SCC a green alternative. Also the practice of use of powder additions to self-compacting concrete mix will helps to reduce the cement consumption, which reduce the greenhouse gas emissions during cement manufactures.
- In Durability test using HCL Solution and MgSO4 Solution in M-30 and M-35 grade of concrete, Results for 28 Days shows that there is minimum average loss of compressive strength in percentage of decreasing at Mix 2(10 % Roof Tile Powder and 25% fly ash) in self-compacting concrete. Than significantly increase in the average loss of compressive strength percentage at 15%, 20%, 25%, and 30% Roof Tile Powder and 25% fly ash.

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