Performance of Roof Tile Powder as Partial Replacement of Cement in Self Compacted Concrete

Mitul K. Chovatiya[1] Yogesh V. Akbari[2] Shradhha R. Vaniya[3]
[1]PG Student [2,3]Assistant Professor
[1]Department of Structure Engineering and Management [2,3]Department of Civil Engineering
[1,2]DIET-Rajkot, Gujarat, India [3]GEC-Rajkot, Gujarat, India

Abstract— 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. 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 50% i.e. (0%, 10%, 25%, 30%, 40% and 50%) . The super plasticizer is 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 and L-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), M30, M35, Super Plasticizer, Slump

I. Introduction

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. 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.

SCC was developed in 1988 in japan. It is developed by Professor Okamura intended to improve the durability properties of concrete structures. Due to shortage of trained labours, this type of concrete demandable. In 1988, first prototype introduced and it is done by K. Ozawa and Melawi from Tokyo University. By the year 2000, it has become popular in Japan for precast product and ready mixed concrete.

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. 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 50% 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 50% Replacement with the increment of 10%.

To check the durability Properties, Acid attack (HCL, H2SO4) and sulphate attack (MgSO4) of Self Compacting Concrete (SCC) with use of roof tile powder (RTP) up to 50% Replacement with the increment of 10%.

III. 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). The cement and water form a paste that binds the other materials together as the concrete harden state. A material having adhesive and cohesive properties which make it capable of bonding material fragment into a compact mass. Cement is very important ingredient in concrete.

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.

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.

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) has 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. 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.

H. Roof tile powder

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

Table 1: Chemical Composition of RTP

IV. 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.

V. Results and Discussions

A. Fresh Concrete Results

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 2: 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 3: Results of Fresh Properties Test for M-35 Grade Concrete

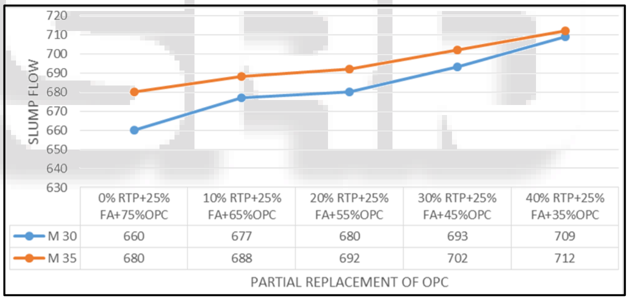

Chart 1: Slump Flow Chart

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 slump increases in the rate of percentage 2.58, 3.03, 5.00, and 7.42 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 10% fly ash the value of slump increases in the rate of percentage 1.18, 1.16, 3.24, and 4.71 respectively.

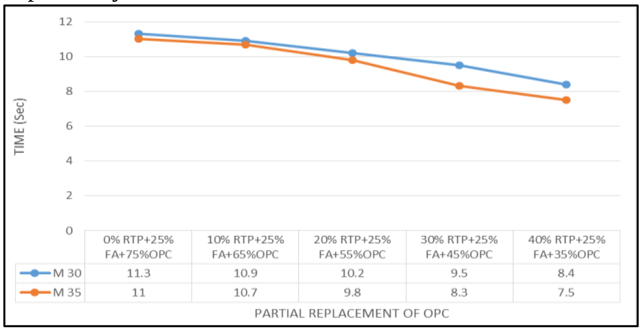

Chart 2: V-Funnel Chart

In M-30 grade concrete with the increment of RTP with lime up to total replacement of 50% with increment of 10% with constant 10% fly ash the value of slump decreases in the rate of percentage 3.54, 9.73, 15.93 and 25.66 respectively.

In M-35 grade concrete with the increment of RTP with lime up to total replacement of 50% with increment of 10% with constant 10% fly ash the value of slump decreases in the rate of percentage 2.73, 10.91, 24.55 and 31.52 respectively.

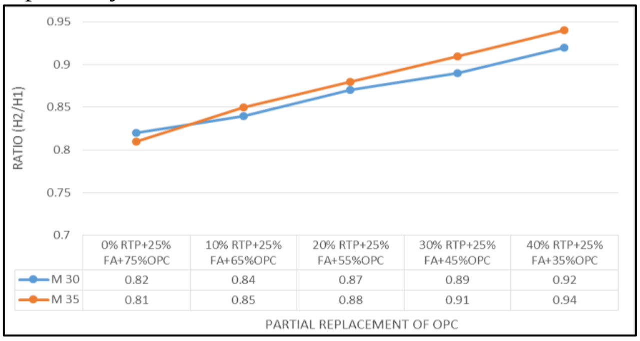

Chart 3: L-Box Chart

In M-30 grade concrete with the increment of RTP with lime up to total replacement of 50% with increment of 10% with constant 10% fly ash the value of L-Box increases in the rate of percentage 2.44, 6.10, 8.54, and 12.20 respectively.

In M-35 grade concrete with the increment of RTP with lime up to total replacement of 50% with increment of 10% with constant 10% fly ash the value of slump increases in the rate of percentage 4.94, 8.64, 12.35, and 16.05 respectively.

B. *Hardended Concrete Results*

1) *Compressive Strength Result:*

In M-30 grade concrete the value of 30% RTP replacement with constant 25% fly ash gives maximum 43.92MPA compressive strength.

In M-35 grade concrete the value of 30% RTP replacement with constant 25% fly ash 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 4: Compressive Strength of Cubes for M-30

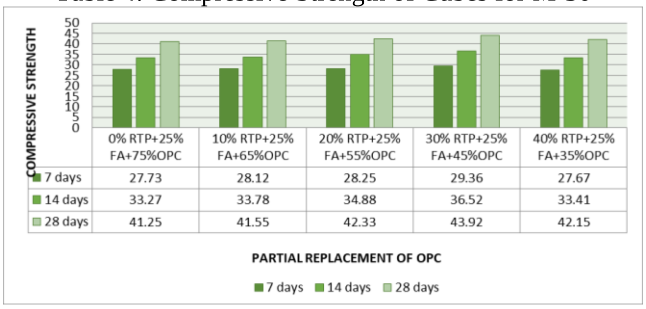

Chart 4: Compressive Strength of M-30

Compressive Strength for M-35 Grade in Mpa				
Target mean strength-43.25				
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 5: Compressive Strength for M-35

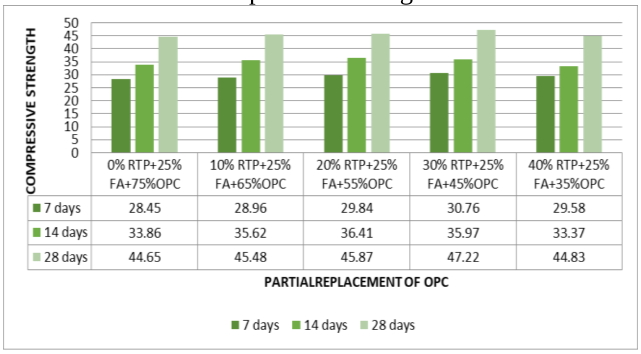

Chart 5: Compressive Strength of M-35

C. *Flexural Strength Results:*

In M-30 grade concrete the value of 30% RTP replacement with constant 10% fly ash gives maximum 4.41MPA Flexural strength

In M-35 grade concrete the value of 30% RTP replacement with constant 10% fly ash gives maximum 4.86MPA Flexural strength.

Flexural Strength for M-30 Grade in Mpa				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	2.65	3.14	3.95
2	10% RTP+25% FA+65%OPC	2.71	3.24	4.26
3	20% RTP+25% FA+55%OPC	2.78	3.36	4.36
4	30% RTP+25% FA+45%OPC	2.85	3.45	4.41
5	40% RTP+25% FA+35%OPC	2.72	3.31	3.11

Table 6: Flexural Strength of M-30

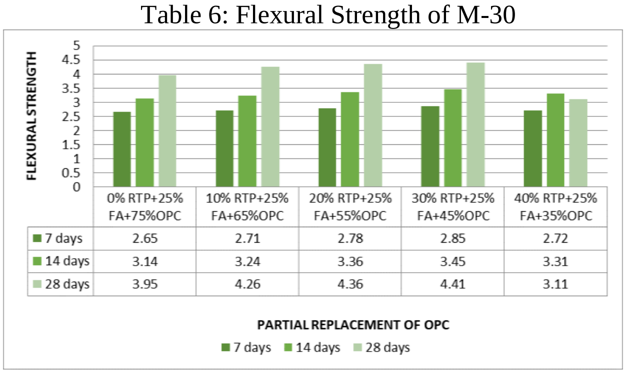

Chart 6: Flexural Strength of M-30

Flexural Strength for M-35 Grade in Mpa				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	2.76	3.12	4.06
2	10% RTP+25% FA+65%OPC	2.81	3.23	4.31
3	20% RTP+25% FA+55%OPC	2.84	3.32	4.46
4	30% RTP+25% FA+45%OPC	2.94	3.75	4.86
5	40% RTP+25% FA+35%OPC	2.96	3.71	4.65

Table 7: Flexural Strength M-35

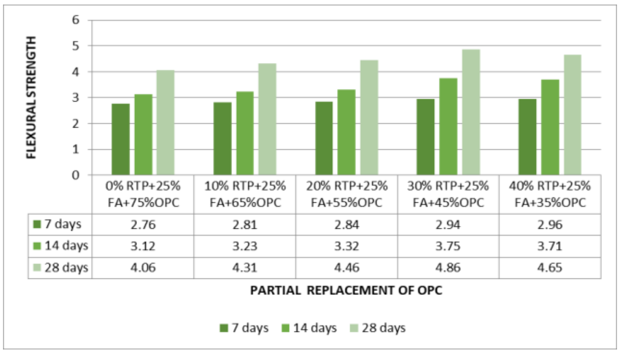

Chart 7: Flexural Strength of M-35

1) *Split Tensile Strength Results:*

In M-30 grade concrete the value of 30% RTP replacement with constant 10% fly ash gives maximum 4.18MPA Split tensile strength.

In M-35 grade concrete the value of 30% RTP replacement with constant 10% fly ash gives maximum 4.35MPA Split tensile strength.

Split Tensile Strength for M-30 Grade in Mpa				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	2.32	2.75	3.24
2	10% RTP+25% FA+65%OPC	2.36	2.85	3.36
3	20% RTP+25% FA+55%OPC	2.45	3.04	3.58
4	30% RTP+25% FA+45%OPC	2.58	3.34	4.18
5	40% RTP+25% FA+35%OPC	2.54	3.26	3.96

Table 8: Split Tensile Strength for M-30

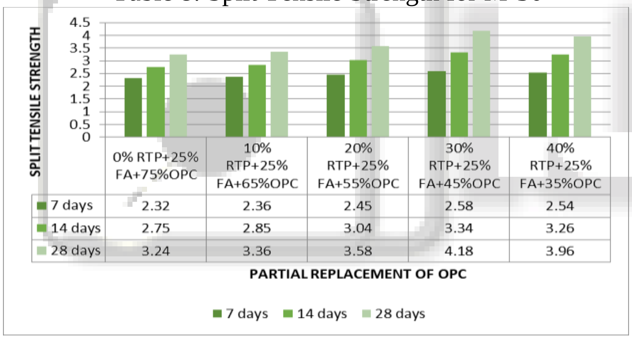

Chart 8: Split Tensile Strength of M-30

Split Tensile Strength for M-35 Grade in Mpa				
Sr. No.	Type of Mix	7 days	14 days	28 days
1	0% RTP+25% FA+75%OPC	2.41	2.78	3.49
2	10% RTP+25% FA+65%OPC	2.52	2.89	3.66
3	20% RTP+25% FA+55%OPC	2.62	3.09	3.87
4	30% RTP+25% FA+45%OPC	2.78	3.48	4.35
5	40% RTP+25% FA+35%OPC	2.49	3.3	4.12

Table 9: Split Tensile Strength for M-35

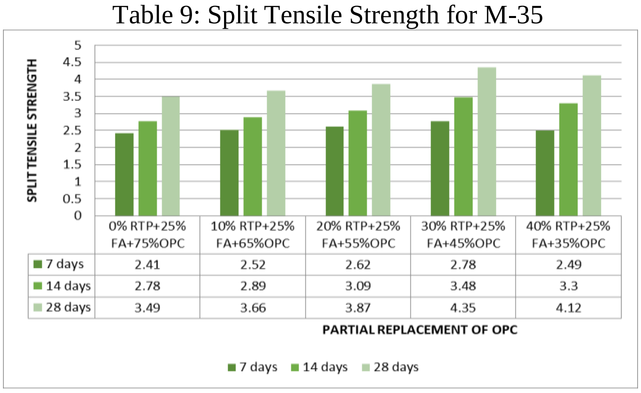

Chart 9: Split Tensile Strength of M-30

2) *Durability Tests Results:*

a) Sorptivity Test Results:

The sorptivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid. The cylinders after casting were immersed in water for 60 days of curing. The specimen size 100mm dia x 50 mm height after drying in oven at temperature of 100 + 10 °C were drowned as shown in figure 4with water level not more than 5 mm above the base of specimen and the flow from the peripheral surface is prevented by sealing it properly with non-absorbent coating:

Sorptivity Test

Sr. no.	Concrete type	Cement Replace ment (%)	Dry wt. in gram	Wet wt. in gram	Sorptivity value in 10^(-5)mm/ mm^(0.5)
1	0% RTP+25% FA+75%OPC	0%	992.5	993.5	1.16
2	10% RTP+25% FA+65%OPC	20%	980.3	981.05	1.74
3	20% RTP+25% FA+55%OPC	30%	943	944.25	2.9
4	30% RTP+25% FA+45%OPC	40%	931.25	933	4.07
5	40% RTP+25% FA+35%OPC	50%	948	950	4.65

Table 10: Sorptivity Test for M-30

Sorptivity Results for M35					
Sr. no.	Concrete type	Cement Replace ment (%)	Dry wt. in gram	Wet wt. in gram	Sorptivity value in 10^(-5)mm/ mm^(0.5)
1	0% RTP+25% FA+75%OPC	0%	997.25	998.25	2.32
2	10% RTP+25% FA+65%OPC	20%	968.5	970	3.48
3	20% RTP+25% FA+55%OPC	30%	938.3	939.55	2.9
4	30% RTP+25% FA+45%OPC	40%	946	947.75	4.07
5	40% RTP+25% FA+35%OPC	50%	951.45	953.7	5.23

Table 11: Sorptivity Test for M-35

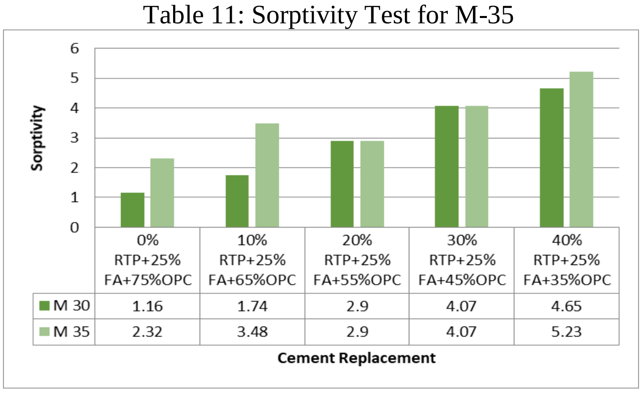

Chart 10: Sorptivity Test for M-30 & M -35

VI. CONCLUSIONS

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

REFERENCES

[1] A.S.E Belaidi, L. Azzouz, E. Kadri, S. Kenai "Effect of Natural Pozzolana and Marble Powder on the Properties of Self-compacting Concrete" Construction And Building Materials, Elsevier- 2011.
[2] B.H.V. Pai1, M. Nandy, A. Krishnamoorthy, P.K. Sarkar, Philip George "Comparative Study of Self Compacting Concrete Mixes Containing Fly Ash and Rice Husk Ash" AJER-2014.
[3] Hardik Patel, Dr. N.K. Arora, Asst. Prof. Shraddha R. Vaniya "The Study of Ceramic Waste Materials as Partial Replacement of Cement: Review" IJSRD- 2015.
[4] Ilker Bekir Topçu, Turhan Bilir, Tayfun Uygunog "Effect of Waste Marble Dust Content as Filler on Properties of Self-compacting Concrete" Construction and Building Materials, Elsevier- 2008.
[5] Krishna Murthy , Narasimha Rao , Ramma Reddy, Vijay Sekhar "Mix Design Procedure for Self Compacting" IOSR Journal Of Engineering-2012
[6] Khalid Najim, Ibrahim Al-Jumaily, Abdukhaliq Atea "Characterization of Sustainable High Performance/ Self-Compacting Concrete Produced Using CKD as a Cement Replacement Materials" - Elsevier- 2015.
[7] N R Gaywala, D B Raijiwala "Self- Compacting Concrete: A Concrete of Next Decade" JERS- 2011.
[8] Concrete technology by M.S. Shetty.
[9] IS : 4031 (Part-1) – 1998 (determination of fineness by dry sieving)
[10] IS : 4031 (Part-3) – 1998 (determination of soundness test)
[11] IS : 4031 (Part-4) – 1998 (determination of consistency of std cement paste)
[12] IS : 4031 (Part-5) – 1998 (determination of initial and final setting time)
[13] IS 12269 : 2013 (OPC -53 grade specification)
[14] IS 3812 (PART-1) : 2013 (for use as pozzolana in cement , cement mortar & concrete)