STM JOURNALS

Recent Trends in Civil Engineering & Technology
ISSN: 2249-8753(online), ISSN: 2321-6476(print)
Volume 6, Issue 1
www.stmjournals.com

Feasibility Study of Reetha Powder (*Sapindus trifoliatus*) as a Plasticizer Admixture in Concrete

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Abstract

With on-going research and development activities in the field of concrete admixtures, emphasis is laid on use of naturally available organic material to enhance properties of concrete. Reetha (Sapindus trifoliatus), is popularly used in ayurvedic medicines such as shampoo and other products because of its excellent foaming and cleansing properties. This study emphasizes on the effect of natural admixtures such as reetha powder concrete (RPC) in comparison with super plasticizers (SPC) and air entraining admixtures (AEC) on various engineering and microscopic properties. The dosages of admixtures were taken as 0.5, 0.8 and 1% by weight of cement for RPC, SPC and AEC concrete. It was observed that RPC gives excellent flow ability and slump however, compressive strength of RPC is reduced by 50% in comparison to SPC and AEC concrete. Hence, study was further extended by reducing dosage of reetha from 0.5 to 0.3% with 0.5% of superplasticizer (R-SP) and compared the results with SPC. It was found that R-SP has 100 mm slump and strength was 31 MPa in comparison to SPC which had 70 mm slump and 36 MPa strength. It is also found in improvement of microscopic properties of concrete over SPC and AEC concrete.

Keywords: *Sapindus trifoliatus (Reetha), air entraining admixture, air content, compressive strength*

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INTRODUCTION

With the advancements in concrete technology, there are many new chemical admixtures which are added in concrete to modify the properties of ordinary concrete, so as to make it more suitable for different environmental conditions. Chemical admixtures are designed to enhance the properties of concrete in the plastic and hardened states, increase efficiency of cementitious material, and improve the economy of the concrete mixture (ACI).

The use of an admixture or combination of admixtures may be the only viable strategy to achieve the desired results. The commonly used super plasticizers are sulfonated melamine formaldehyde (SMF), sulfonated naphthalene formaldehyde (SNF), modified lignosulfonates (MLS), and carboxylated acrylic ester co-polymers. The superplasticizers (SPs) are used mainly for two main purposes:

(1) To produce high-strength concrete at a w/c ratio in a range of 0.23–0.3; and
(2) To create flowing concrete with high slump flow in the range of 500 to 600 mm, the self-compacting concrete.

Another benefit is that a lower w/c ratio would lead to better durability and lower creep and shrinkage. The main drawbacks of superplasticizers are; that they retard setting (especially in large amounts), and cause more bleeding and entrain too much air [1].

In order to develop new type of admixture which is having flowing properties as that of super plasticizers is reetha seeds also called as Sapindus trifoliatus which is widely used in shampoos, bath soaps etc. because of its foaming properties without any side effect to human beings. The research on reetha indicates that it has good emulsifying, separating, dispersing, cleaning and good foam capacity [2]. As far as organic materials are concerned, some research has been done on natural organic materials such as black gram in concrete. Chandra *et al*. used black gram seeds in concrete and it was seen that it worked like

air entraining agent; it improved the adhesiveness and hydrophobicity of cement mortar and concrete [3]. Giridhar *et al*. used olive oil in concrete as an admixture and found improvement of workability of fresh concrete [4]. Though not much research has done with the use of reetha as an admixture, to check the feasibility of reetha in concrete, a comparative study was carried out between reetha powder, super plasticizer and air entraining admixture as per IS 9103-1999, used as guideline for admixtures for concrete in India [5].

DETAILS OF EXPERIMENTAL WORKS

Material Usage

Cement

OPC 43 grade Birla gold cement was procured for this investigation. The specific gravity of the cement was 3.15. The initial and final setting times were found as 60 and 400 min respectively.

Aggregates

Locally available river sand passing through 4.75 mm sieve was used; the specific gravity of the sand was found to be 2.62, confirming to zone II of IS 383-1970 [6]. Crushed ballast coarse aggregate available from local sources had been used. The size of coarse aggregate was 10 and 20 mm and the specific gravity was 2.85.

Admixtures

- *Reetha Powder (Sapindus trifoliatus):* Sapindus seeds which are generally used in formation of shampoos in ayurvedic medicines were taken and they were grounded in pulveriser and then sieved to 150 micron sieve. The view of seeds and grounded particles is given in Figures 1 and 2.
- *Super Plasticizer (Rheo Build 916):* Naphthalene sulphonate based set retarding high range water reducing/superplasticizer admixture from BASF.
- *Air Entraining Admixture (AC-PLAST-AEA-C):* An air entraining admixture of Apple chemic was used for comparison purpose for reetha powder as it was found from the literature that the reetha powder had air entrainment properties.

Table 1: *Physical Properties of All Three Admixtures.*

Properties	Reetha	Super Plasticizer	Air Entraining Admixture
Colour	Light brown powder	Dark brown liquid	Pale yellow/brown liquid
Ph	5.8	>6	5.5–5.6

Fig. 1: *Reetha Seeds.*

Fig. 2: *Powder Form Sieved through 150 micron Sieve.*

Methodology

Trials were performed on the materials which were used for concrete production. Mix design was done as per the methodology given by IS 10262-2009 for M25 grade and its proportion was found as 1:0.5:2.36:3.26 (C:W:FA:CA) by weight [7]. In this present work, comparative study was carried on concrete with individual

dosages of 0.5, 0.8 and 1% of reetha, super plasticizer and air entraining admixture called the concrete as reetha powdered concrete RPC, super plasticizer concrete SPC and air entraining concrete AEC. Reetha was also partially replaced with super plasticizer and compared to air entraining admixture which was mixed with super plasticizer and a total of 78 cubes of size 100*100*100 mm were casted. These cubes were tested to estimate the compressive strength, Workability, flow ability, air content and density of concrete as per IS 9103 [5]. For each admixture dosage, same numbers of specimens were casted and kept at room temperature for evaluating their properties (Figure 3 and 4).

Fig. 3: *Slump Test of Reetha Powder Concrete.*

Fig. 4: *Air Content Test.*

Fig. 5: *Flow Table Test of Reetha Powder Concrete.*

Table 2: *Individual Mix Dosage.*

Ingredients	Unit	Reetha (RPC)			Super Plasticizer (SPC)			Air Entraining Admixture (AEC)		
		M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9
Admixture %		**0.5%**	**0.8%**	**1%**	**0.5%**	**0.8%**	**1%**	**0.5%**	**0.8%**	**1%**
Admixture dosage	Kg/m3	1.82	2.92	3.65	1.82	2.92	3.65	1.82	2.92	3.65
Cement(43 Grade)	Kg/m3	365	365	365	365	365	365	365	365	365
20 mm aggregate	Kg/m3	739	739	739	739	739	739	739	739	739
10 mm aggregate	Kg/m3	452	452	452	452	452	452	452	452	452
Sand	Kg/m3	832	832	832	832	832	832	832	832	832
Water cement ratio		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Water	Kg/m3	182	182	182	182	182	182	182	182	182
Water absorption	Lit/m3	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1

Table 3: *Combined Dosage of Mixes.*

Ingredients	Unit	Reetha + Super Plasticizer (R-SP)		Air Entraining Admixture + Super Plasticizer (AE-SP)	
		M-10	M-11	M-12	M-13
Admixture %		**0.3% R-SP**	**0.5% R-SP**	**0.3% AE-SP**	**0.5% AE-SP**
Admixture dosage	Kg/m3	1.095+1.825	1.825+1.825	1.095+1.825	1.825+1.825
Cement (43 Grade)	Kg/m3	365	365	365	365
20 mm aggregate	Kg/m3	739	739	739	739
10 mm aggregate	Kg/m3	452	452	452	452
Sand	Kg/m3	862	862	862	862
Water cement ratio		0.5	0.5	0.5	0.5
Water	Kg/m3	182	182	182	182
Water absorption	Kg/m3	17.1	17.1	17.1	17.1

RESULTS AND DISCUSSIONS

Effect of Reetha Powder Concrete on Properties of Fresh Concrete and Hard Concrete

Workability and Flow of Concrete

The slump and flow tests were carried out for workability of reetha powder (RPC), super plasticizer (SPC) and air entraining mix concrete (AEC). The slump of RPC was found as comparatively higher than slump of SPC and AEC at the equal dosage in the mix as shown in Figure 6. Generally reetha is used as foaming agent in soap and shampoo and has ayurvedic properties and because of its foaming characteristic, it could produce higher slump in concrete. The slump of SPC and AEC was quite similar whereas around 60–70% higher slump was observed with RPC. At 0.5% increase of plasticizer in concrete showed 40 mm increase of slump in case of SPC and AEC however it was increased by 70 mm in case of RPC. Similarly, improvement of flow in concrete was observed in case of RPC as compared with SPC and AEC as given in Table 4.

Air Content and Density of Concrete

As there was improvement of workability of RPC, as seen previously in the paper, it could have the possibility of higher air content as well as lower density of RPC in comparison with SPC and AEC. So, air content as well as density of each mix was measured in fresh state as shown in Figure 4. They were observed and tabulated in Figures 7 and 8 for air content and density respectively. The percentage of air content observed at 0.5% dosage of RPC as 4.1%, SPC as 3.7% and AEC as 4.7%. As in case of 1% dosage in mix, percentage of air content of RPC observed as 4.8%, SPC as 2.5% and AEC as 5.2%. Hence the air content is increasing in case of RPC and AEC whereas it is decreasing with SPC. The increase of air content could be due to foaming agent properties of RPC and AEC concrete. It was also observed from the

Figure 8, that there was 20% reduction in density of RPC as compared with SPC and AEC. So, RPC may have large no. of air bubble formation in the concrete and hence microstructure study needs to be carried out and investigate reason of reduction of density in RPC which is explained later in the paper.

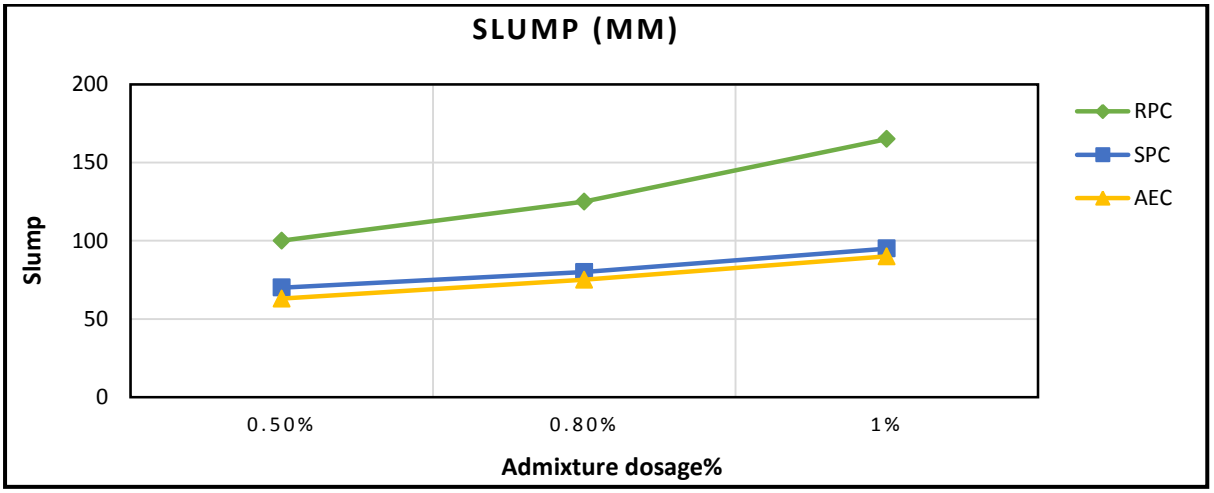


Fig. 6: *Slump for Different % Dosage of Admixtures.*

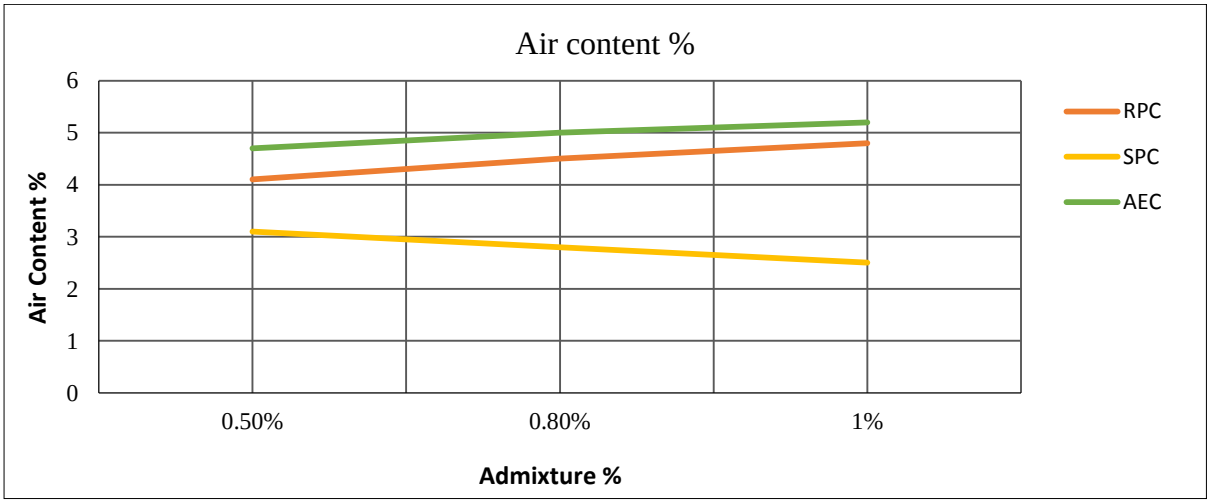


Fig. 7: *Air Content for Different % Dosage of Admixtures.*

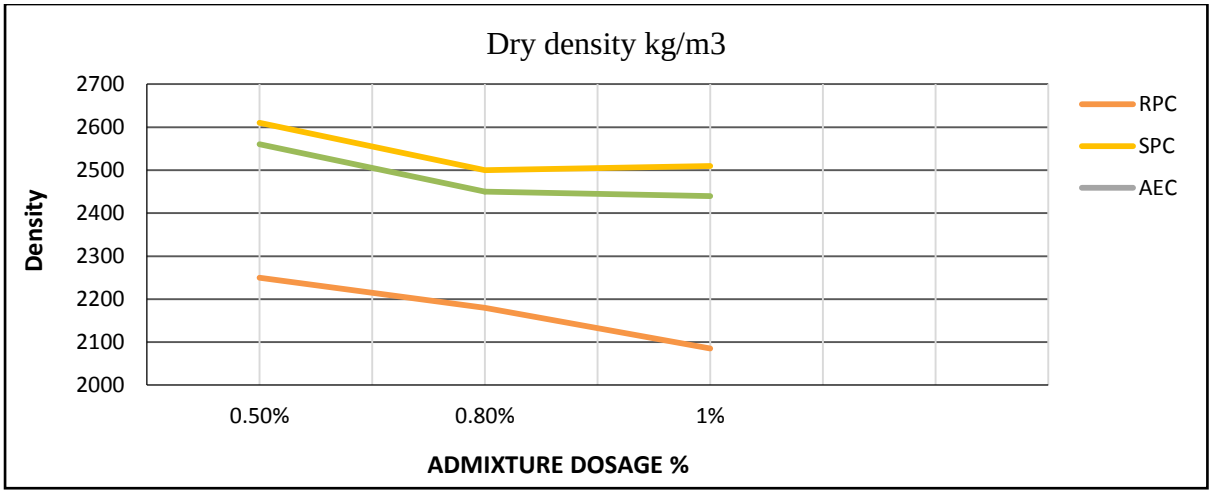


Fig. 8: *Dry Density of Concrete with % Variation of Dosage Admixtures.*

Compressive Strength of Concrete

Compressive strengths of concrete samples were tested at 7 and 28 days as shown in Figure 10. The graph was prepared between compressive strength vs. percentage of admixture dosage by weight of cement as shown in Figure 9. The average compressive strength at 28 days with 0.5% dosage of SPC was 36.7 MPa, AEC was 32.8 MPa and RPC was 14.1 MPa. Furthermore at 1% dosage, the compressive strength in SPC observed as 34.1 MPa, AEC as 31.4 MPa and RPC as 8.2 MPa. Hence there is reduction of 20–30% strength with increase of admixture dosage from 0.5 to 1% of cement with all types of admixture used in concrete. Also, there was significant reduction of strength in RPC as compared to SPC and AEC concrete. The strength of RPC was found to be half of the compressive strength of SPC and AEC whereas there was slight reduction in compressive strength of AEC in comparison with SPC. At this point it could be concluded that RPC is not suitable as concrete admixture even though it has very good flow properties.

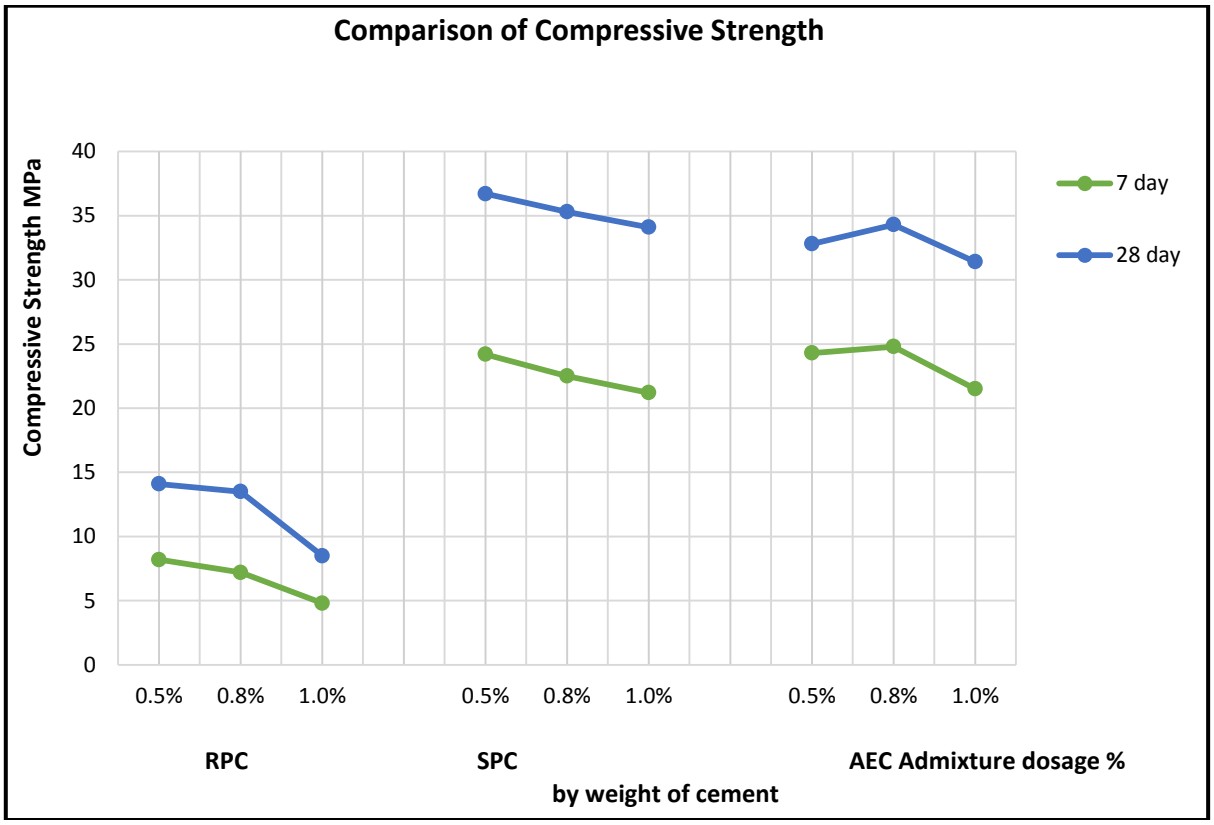


Fig. 10: *Comparison of Compressive strength for 7 and 28 Days for Different % Dosage of Admixtures.*

Microstructure Study of Concrete

Engineering properties such as slump, flow, density and air content were excellent for RPC concrete but its compressive strength was very low. In order to identify the reason of reduction of strength, micro structural study was carried out between AEC and RPC. Microstructure study was conducted on 0.8% admixture dosage in RPC which was compared to 0.8% admixture dosage of AEC. As shown in Figures 11(a) and 11(b), in RPC at 50x scale, large amount of small diameter bubbles were observed which were uniformly distributed on the concrete surface. In AEC, concrete showed few numbers of large diameter air bubbles on the concrete surface.

At 5000x scale, it was also observed in RPC that amount of C-S-H was very less, high amount of CH crystals (white colour) and un-reacted cement was seen on the surface which might cause low compressive strength of RPC Figure 11 (c) and 11 (d). Whereas,

microstructure view of AEC found that long micro cracks existed in the internal structure of concrete, however, it had densely packed C-S-H and less amount of CH crystals.

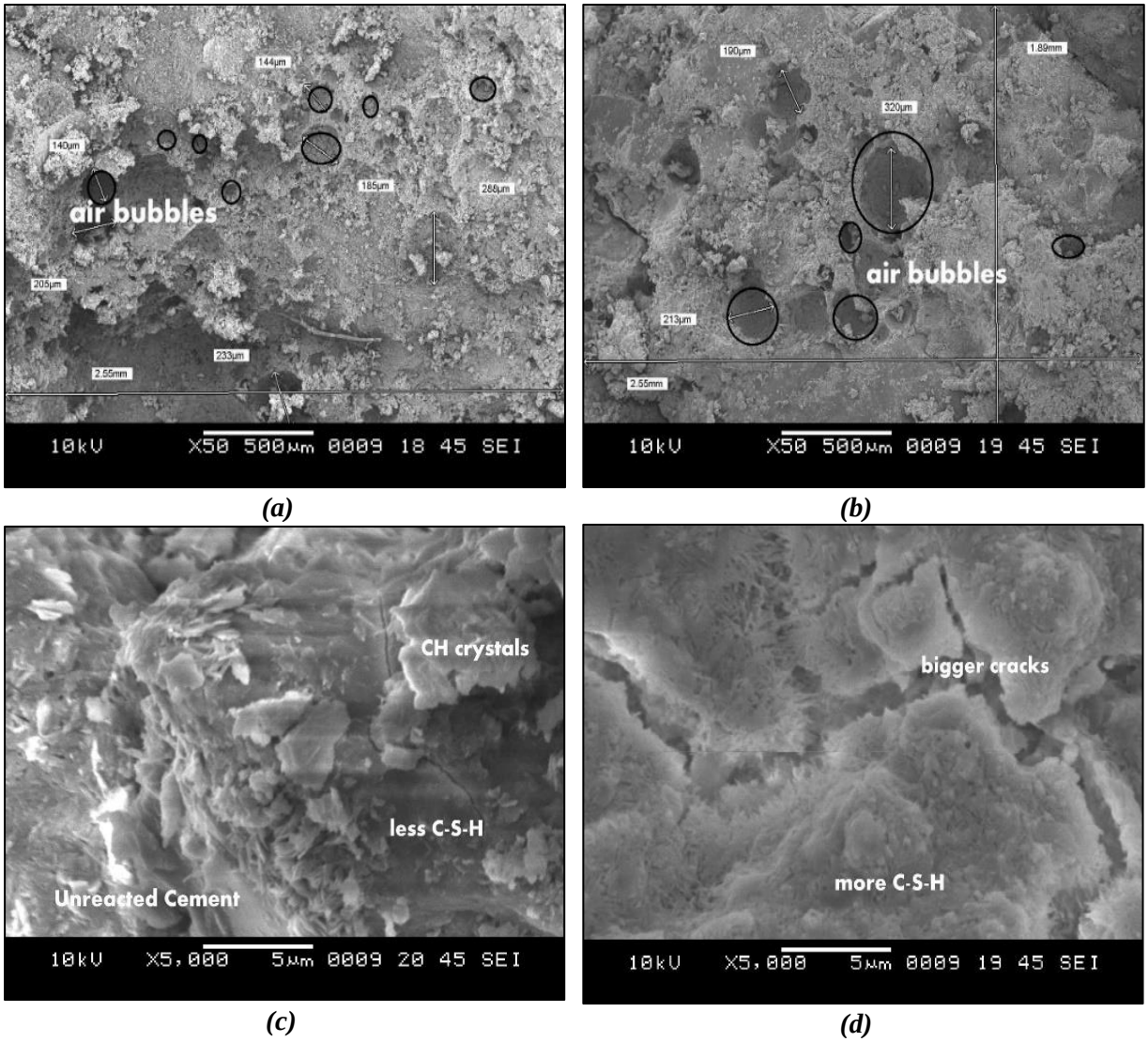


Fig. 11: *Microstructure Study on RPC and AEC at 0.8% Dosage.* ***(a)*** *RPC at X50.* ***(b)*** *AEC at X50.* ***(c)*** *RPC at X5000.* ***(d)*** *AEC at X5000.*

Table 4: *Results of Individual Dosages.*

		Reetha Powder (RPC)			Super Plasticizer (SPC)			Air Entraining Admixture (AEC)			Remarks
		M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9	
Dosages		0.5%	0.8%	1%	0.5%	0.8%	1%	0.5%	0.8%	1%	
Slump (mm)		100	125	165	70	80	95	63	75	90	Slump was found more for reetha
Flow (mm)				520			450			430	Flow was more for reetha
Air content (%)		4.1	4.5	4.8	3.1	2.8	2.5	4.7	5	5.4	Air content was comparatively more for AEA when compared with reetha
Dry density (kg/m3)		2250	2180	2085	2610	2500	2510	2560	2450	2440	Reetha has low dry density when compared to other concrete
Avg. Compressive strength (MPa)	(7 days)	8.2	7.2	4.8	24.2	22.5	21.2	24.3	24.8	21.5	Reetha has very low compressive strength
	(28 days)	14.1	13.5	8.5	36.7	35.3	34.1	32.8	34.3	31.4	

Based on results and discussions on RPC, SPC and AEC, it is recommended that RPC concrete is not suitable for individual dosage. So feasibility of reetha power with partially replaced dosage with super plasticizer has been discussed in following part of the paper.

Combined Effect of Reetha Powder and Super Plasticizer on Fresh and Hardened Concrete

Workability of Concrete

Comparative study was carried on workability of concrete with reetha and super plasticizer (R-SP) and air entraining admixture with super plasticizer (AE-SP) as shown in Figure 12. The slump of SPC (0.5% dosage) was observed as 70 mm. For a constant 0.5% dosage of super plasticizer and varying dosage of reetha such as 0.3 and 0.5% in R-SP concrete, the slump was 100 and 110 mm respectively. Similarly for a constant 0.5% dosage of super plasticizer and varying dosage of air entraining admixture such as 0.3 and 0.5% in AE-SP concrete the slump was 35 and 55 mm respectively.

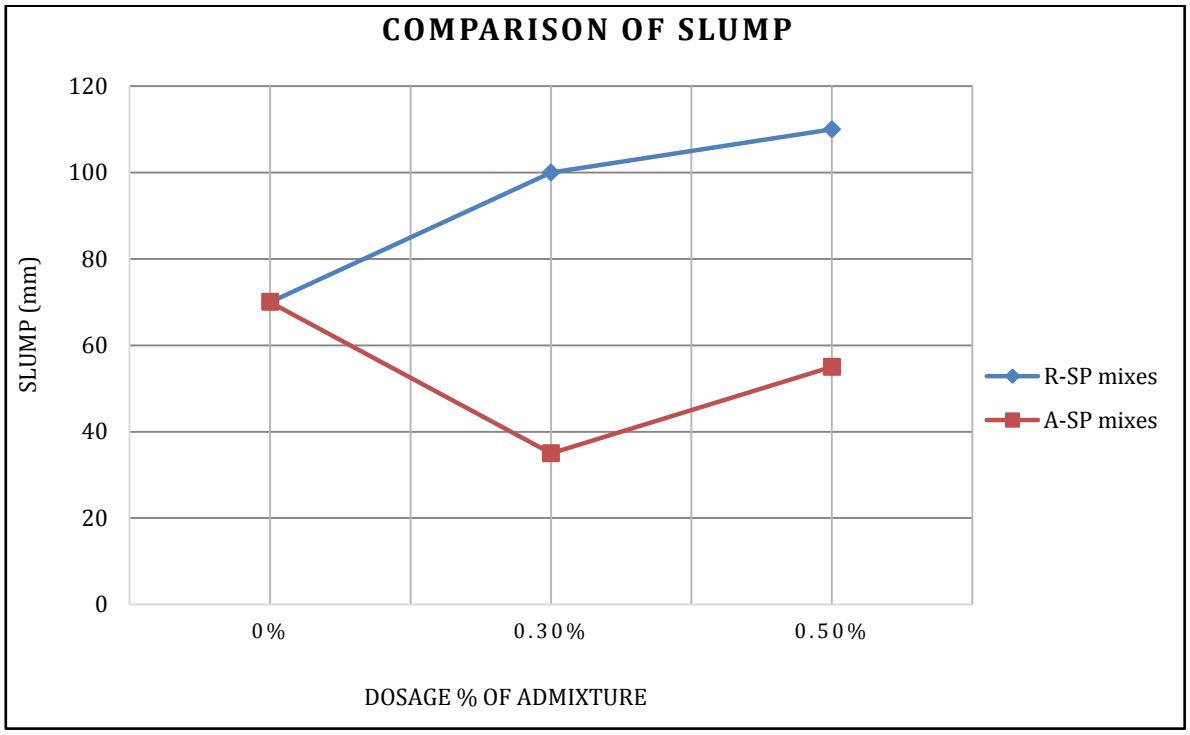


Fig. 12: *Slump for Combined Admixture Dosage.*

Hence, there was 43 and 57% increase in slump at 0.3 and 0.5% dosage of R-SP concrete which was higher than AE-SP. This increase of slump could be due to the foaming properties of reetha.

Air Content and Density of Concrete

Air content test was conducted to determine the amount of air entrainment due to R-SP and AE-SP concrete which was compared with SPC. It was observed that air content at 0.5% dosage of admixture in SPC was 3.1%. For 0.5% dosage of super plasticizer and varying dosage of 0.3 and 0.5% reetha in R-SP concrete, air content was 3.8 and 4.1% respectively. Similarly air content for 0.5% dosage of super plasticizer and varying dosage of air entraining admixture such as 0.3 and 0.5% in AE-SP concrete was 4.1 and 4.8% respectively. It was also observed that R-SP concrete mixes had slightly less density (around 10%) when compared to A-SP concrete mixes. Figure 13 shows the air content with different admixture dosages.

Compressive Strength of Concrete

Seven days and 28 days compressive strength of 0.3% AE-SP was 26.3 and 33.1 MPa, and 0.5% AE-SP was 24.5 and 31.7 MPa. So, it is observed that the strength was decreasing with increasing dosage of either reetha or air entraining admixture. Hence, minimum dosage is suggested in order to achieve strength as well as workability. While comparing between

strength of R-SP, SPC and RPC, the 28 days R-SP strength was 31.1 MPa, SPC strength was 36.7 MPa and RPC strength was 14.7 MPa. Hence, R-SP strength is 15–20% lower than SPC strength whereas increasing in slump is over the 50% from the SPC concrete.

On the other hand, addition of air entrained admixture has nearly same strength of 33.1 MPa in comparison with R-SP at 0.3% dosage but it loses extensive slump of 50% from the SPC concrete as shown in Figure 14.

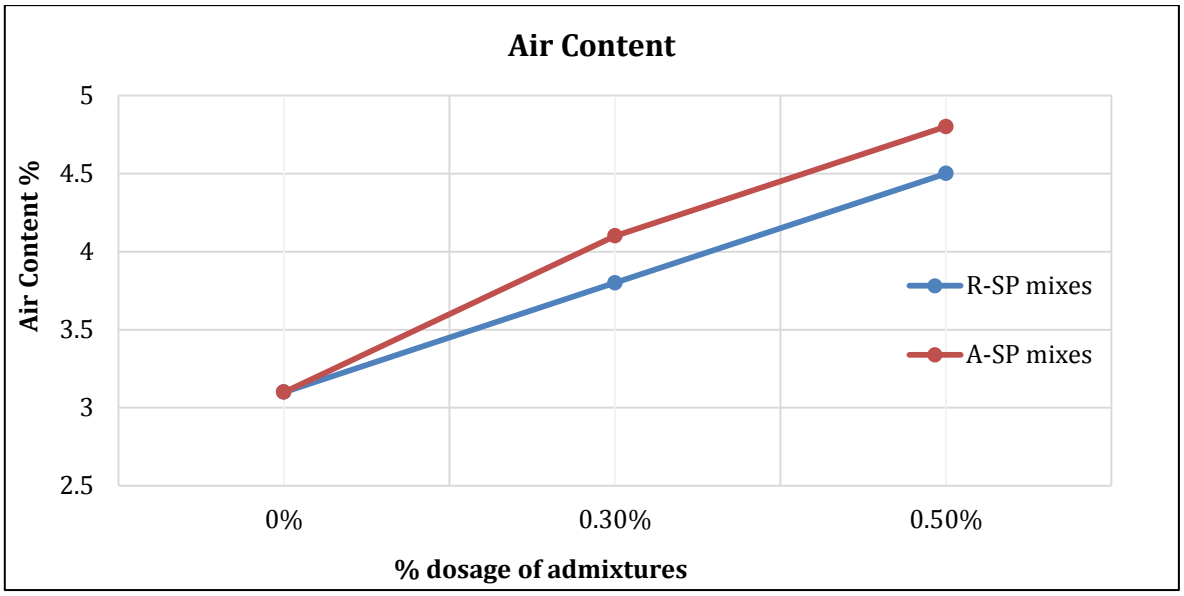


Fig. 13: *Air Content for Different Dosage of Admixtures.*

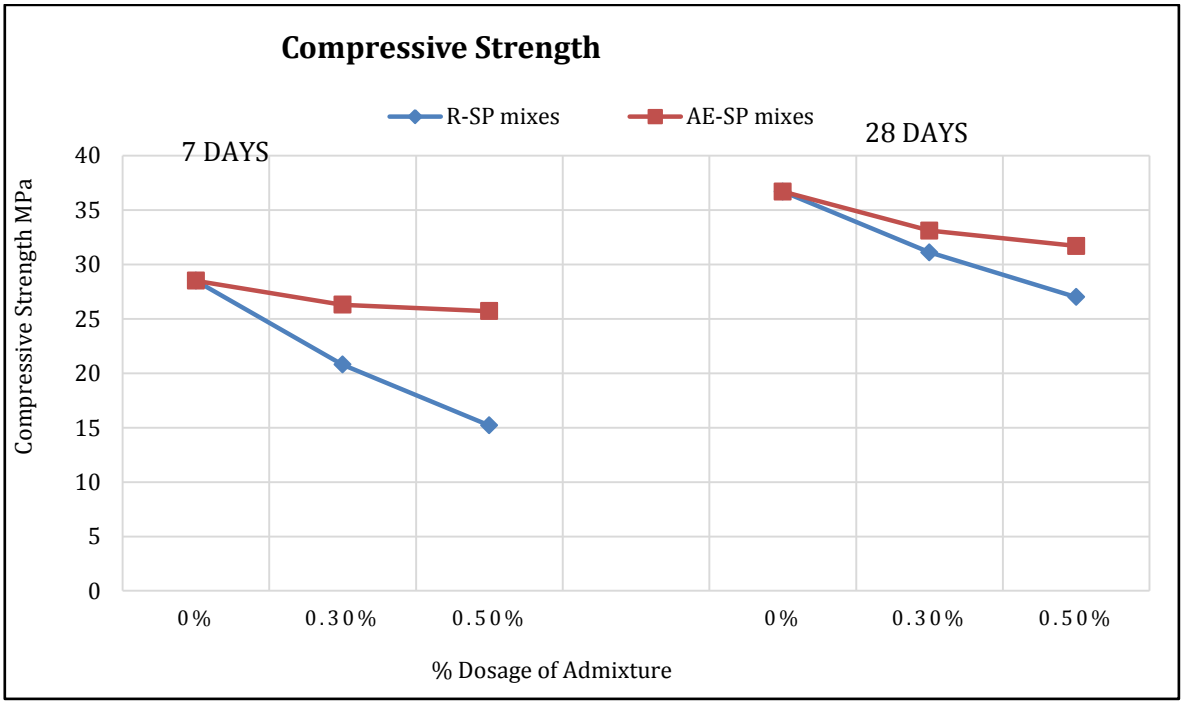
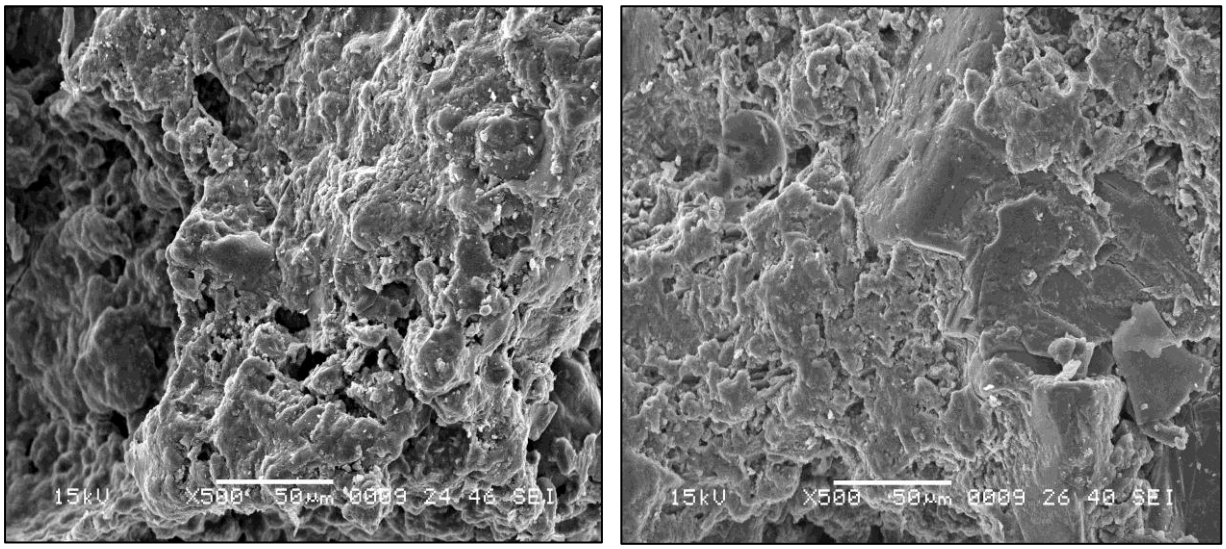


Fig. 14: *Compressive Strength for 7 and 28 Days for Mixed Dosage of Admixture.*

Microstructure of the Concrete

Microstructure study was also performed on 0.3% of R-SP as shown in Figure 15(a) and it was compared to microstructure of SPC Figure 15(b). It is observed that SPC and 0.3% R-SP had almost similar microstructure. Both the microstructure indicated pores and sufficient amount of dense C-S-H formation.



(a) ***(b)***

Fig. 15: *Microstructure of Concrete with Mixed Admixture Dosages.* ***(a)*** *0.3%R-SP at X500.* ***(b)*** *SPC at X500.*

Table 5: *Combined Dosage of Admixtures.*

		0.5%SP	**0.5%SP+ 0.3%R**	**0.5%SP+ 0.5%R**	**0.5%SP+ 0.3%AIR**	**0.5%SP+ 0.5%AIR**	**Remarks**
Mixes		**M-4**	**M-10**	**M-11**	**M-12**	**M-13**	
Slump (mm)		70	100	110	35	55	Slump increased by adding reetha as seen in M-10, M-11.
Air content		3.1	3.8	4.5	4.1	4.8	M-10, M-11 showed more air content than M4.
Dry density (kg/m3)		2610	2570	2550	2580	2640	M-10 had better density as per IS code.
Avg. Compressive Strength (MPa)	7 days	28.5	20.8	15.2	26.3	24.5	Compressive strength increased for M-10 than individual dosage.
	28 days	36.7	31.1	27.0	33.1	31.7	

CONCLUSIONS

Based on the results obtained in this experimental study, and within the limitations of the test parameters, the following conclusions can be drawn:

1. Use of reetha powder in concrete reduced significant strength over super plasticizer concrete and air entrainment concrete. However, it has excellent flow ability and other workability properties in comparison with SPC and AEC concrete. But on the basis of compressive strength and micro structural feature of RPC, addition of reetha must be avoided in concrete.
2. Since reetha powder provides excellent flow ability to concrete and it is medically proved that reetha is a good ayurvedic hair tonic as compared with other chemicals used as shampoo. In order to use flow properties of reetha, it is partially mixed with super plasticizer and compared with branded air entraining admixture which is also partially mixed with super plasticizer. It was found that (0.5% SP+0.3% R) has not only excellent flow properties and slump but also good compressive strength and micro structural properties. Hence it could be recommended to carry further study in the area of additive of reetha powder in the concrete admixtures.
3. Reetha powder could be used as an additive for admixture where flow of concrete is required such as pumpable concrete, self-compacting concrete and long retention concrete.

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Cite this Article
Wanjari Swapnil P., Rajshekhar M.Y.V.N., Rajesh Rajankar. Feasibility Study of Reetha Powder (*Sapindus trifoliatus*) as a Plasticizer Admixture in Concrete. *Recent Trends in Civil Engineering & Technology*. 2016; 6(1): 76–86p.