EFFECT OF SUPERPLASTICIZERS COMPATIBILITY ON THE WORKABILITY, EARLY AGE STRENGTH AND STIFFENING CHARACTERISTICS OF OPC, PPC, AND PSC PASTES AND MORTAR

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Abstract

Super Plasticizers have become indispensable constituents of any designed concrete mix today. Property of fresh and hardened concrete is strongly influenced by the interaction of Superplasticizers and cement. A careful selection of SP is essential. In this paper, an attempt has been made to understand the effect of 2 types Superplasticizers i.e. PCE/Polycarboxylic ethers based and SNF/sulphonated naphthalene based formaldehyde with 3 types of cements OPC, PPC and PSC cement by investigating effect of SP on the properties of cement pastes and mortars. The fresh properties of paste and mortar such as saturation dosages, slump retention, flow retention, setting time, early age strength, effect of SP, and effect of sand have been investigated using Mini-Slump cone, Marsh cone, Flow table and V-Funnel apparatus. The strength properties of mortars are also determined for different proportions of cement and sand for various w/c ratios. From the studies, it can be observed that among PCE and SNF based SP's PCE exhibits better compatibility with all types of cements in terms of workability and also strength and SP dosage required for mortar was found to be 0.8-1% more than dosage required for cement paste due to incorporation of sand.

Keywords: *Superplasticizers; Cements; Compatibility; Saturation dosage*

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1. INTRODUCTION

The term cement-SP compatibility is used to represent the ability to achieve a desired result from a cement-SP combination in a concrete mix viz., improved workability for a given w/c or reduction in free water for a target workability. Any failure in this respect is called incompatibility. The problem is faced on most construction sites and is one of the burning issues of the construction industry. The problem has been accentuated in recent years by the increasing adoption of blended and insitu cement- Pozzolana blends and the very high variability of such products compared to OPC. In the absence of proper quality control measures, the batch to batch variations in SPs can also add to the problems. Problems arising out of compatibility issues are often mistaken for problems with concrete mixture design, because of the lack of awareness amongst practicing engineers. Admixture manufacturers try to overcome the problem by formulating project-specific chemicals. Obviously, this is only a short term solution. For a more comprehensive approach, a thorough understanding of the causes and remedies of incompatibility is necessary. Since the problem is often region specific and project specific, it is necessary to identify possible source of variability and address the problem of incompatibility that can arise.

1.1 Objective and Scope

1.1.1 Objective

- To investigate the compatibility of 3 types of cement manufactured locally with selected brand and 2 types of SP's.
- To investigate the changes in the saturation dosage with various w/c ratios for cement paste and mortar of different proportions due to incorporation of sand.
- To study fresh properties of cement paste, fresh and hardened properties of mortar.

1.1.2 Scope

The main purpose of the study is to select the SP type and dosage required from compatibility studies based on experimental programs and to study early age strength, workability and stiffening characteristics.
Experimental programs used for this purpose are:

- Mini slump cone test and Marsh cone test for finding saturation dosage for cement pastes.
- Flow table test and V-funnel test for finding saturation dosage for mortar (Sand used 4.75mm-75μ)

- Using saturation dosage for the studies on setting time, strength properties of mortar.

2.RESULTS AND DISCUSSIONS

2.1 Paste Studies

2.1.1 Saturation Dosage

Marsh cone and Mini-slump cone tests were carried out on each type of cement with different w/c ratio. The SP dosages were determined for flow time/spread. The plot of flow time / spread versus SP dosage shows a distinct change of slope at SP dosage beyond which there is no distinct difference in flow time or spread. This is recognized as saturation dosage.

Saturation dosages are found for different cement pastes with PCE and SNF based SP's for w/c ratio of 0.30, 0.35, 0.4, and 0.45 with Mini-Slump cone and Marsh cone. Fig.1 and Fig.2 presents the plot of saturation dosage obtained for PCE based SP for w/c ratio 0.35 with respect to spread and flow time respectively. Fig.3 shows saturation dosages obtained for different Cement-SP combinations with respect to different w/c ratios.

Table 1 – Mini-slump cone spread and Marsh cone flow time with PCE based SP for w/c ratio of 0.35

S.P, %	OPC		PPC		PSC	
	Spread, mm	Flow time, sec	Spread, mm	Flow time, sec	Spread, mm	Flow time, sec
0.1	238	9.88	184	-	-	-
0.2	263	6.06	209	20.31	-	-
0.3	278	4.08	231	11.74	188	39.64
0.4	278	4.08	252	6.83	205	24.31
0.5	278	4.08	265	5.07	225	14.53
0.6	-	-	265	5.07	240	9.22
0.7	-	-	265	5.07	249	6.06
0.8	-	-	-	-	249	6.06
0.9	-	-	-	-	249	6.06

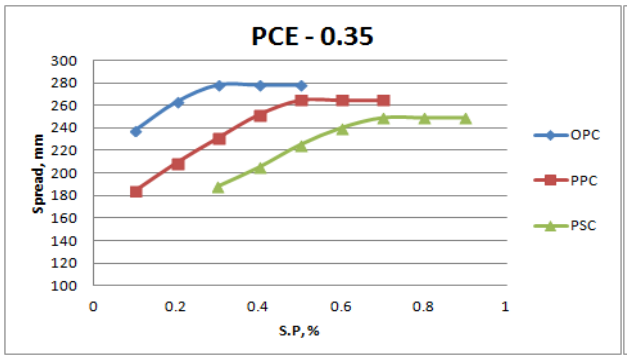

Fig.1

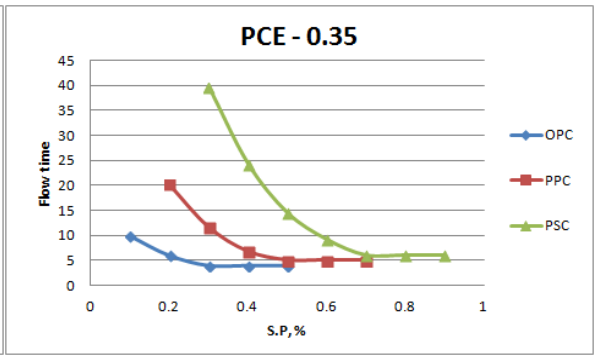

Fig.2

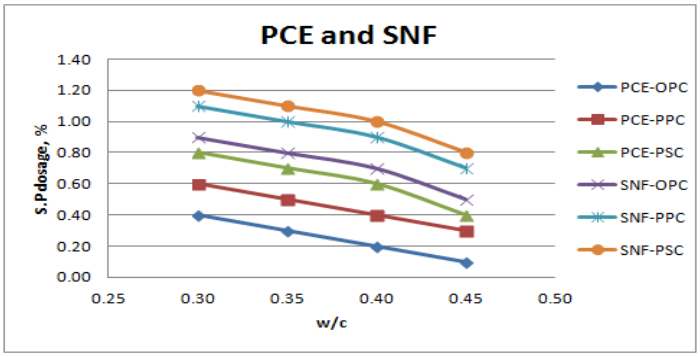

Fig.3

Discussions:

1. From table 1, Fig.1 and Fig.2 shows typical plot of spread and flow time and also it can be seen that saturation dosage point getting increased i.e. the dosage required for OPC is comparatively lower than the PPC and PSC.
2. From Fig.3 it can be observed that a saturation dosage decreases with increase in w/c ratio.
3. Also, it is distinct that saturation dosages required for SNF based SP is higher than PCE based SP since SNF works on electrostatic repulsion and PCE works on both electrostatic repulsion and Steric hindrance mechanism and also presence of fly ash and slag in PPC and PSC increases water demand.

2.1.2 Setting Time

Setting time are estimated for different cement pastes without using SP and also with using SP according to IS 4031 - (Part 5):1988 i.e. for saturation dosages obtained from different Cement-SP combinations for various w/c ratios.Fig.4 shows variations in initial and final setting time of different cements for various w/c ratios. Fig.5 and Fig.6 represents initial and final setting time of different cements for various w/c ratios using saturation dosages of SNF and PCE based SP respectively. Fig.7 shows comparison graphs of initial and final setting time with and without SP's for w/c ratio of 0.35.

SNF

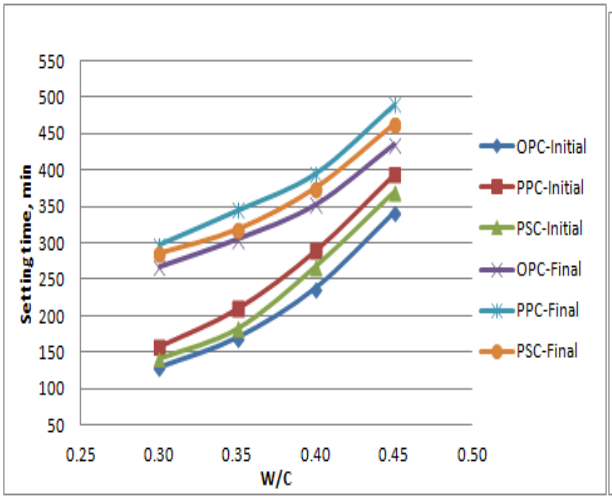

Fig.4

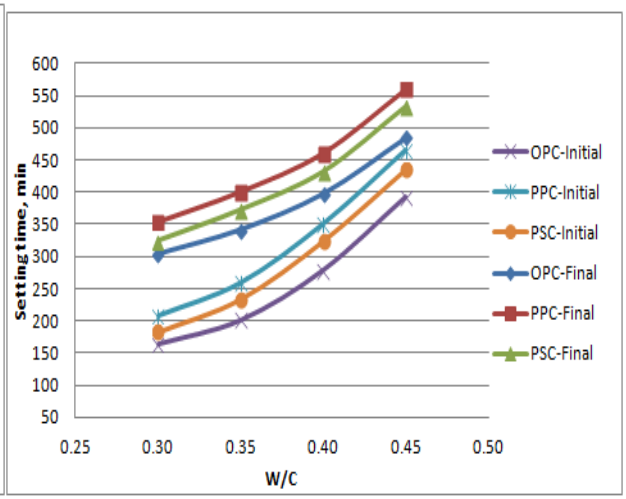

Fig.5

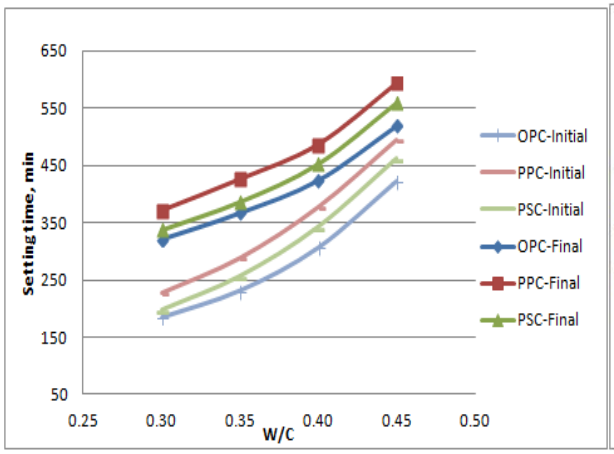

Fig 6 PCE

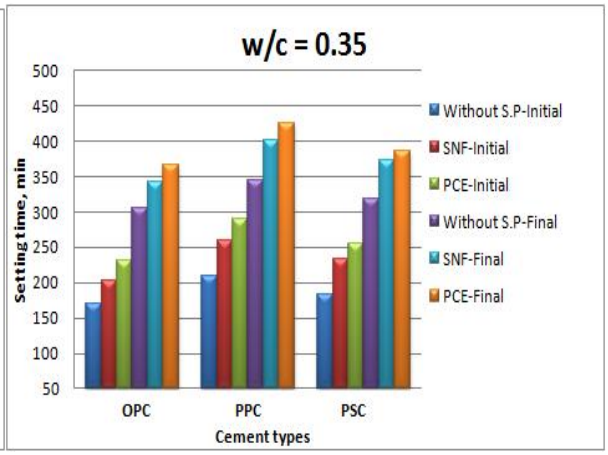

Fig.7

Discussions:

1. From Fig.4 it can be observed that initial and final setting time PPC and PSC is higher than OPC which are within the limits of codes.
2. By comparing Fig.5 and Fig.6 it can be seen that setting times obtained is higher in case of PCE based SP than SNF based SP.
3. The comparison plot Fig.7 it is clear that setting times is higher for PPC than PSC and OPC.

2.1.3 Retention Test

Slump retention and flow retention tests are done with various w/c ratios for different cements with saturation dosages obtained. Retention test includes observing spread and flow time of cement pastes for 0, 15, 30, 45 minutes which is done using Mini-slump and Marsh cone apparatus. Fig.8 and Fig.9 shows flow retention of various cements for different w/c ratios with 2 SP's. Fig.10 and Fig.11 shows spread retention of various cements for different w/c ratios with 2 SP's.

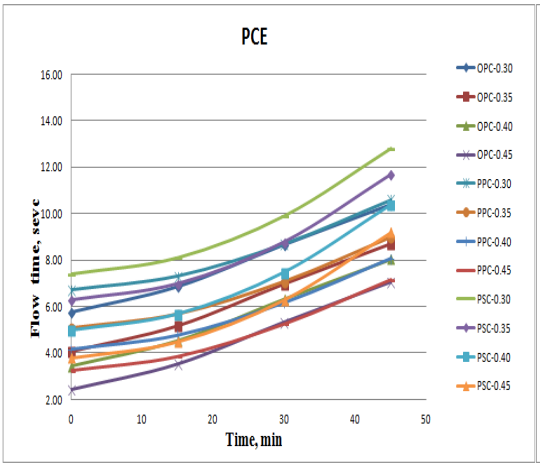

Fig.8

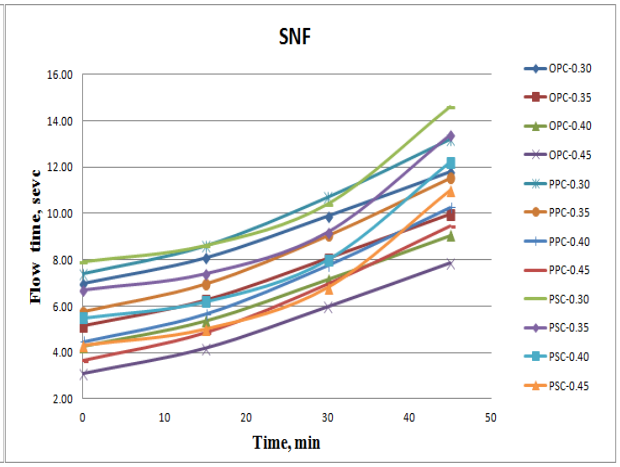

Fig.9

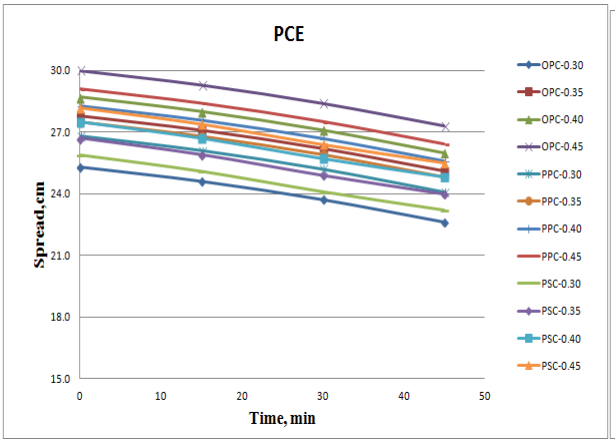

Fig.10

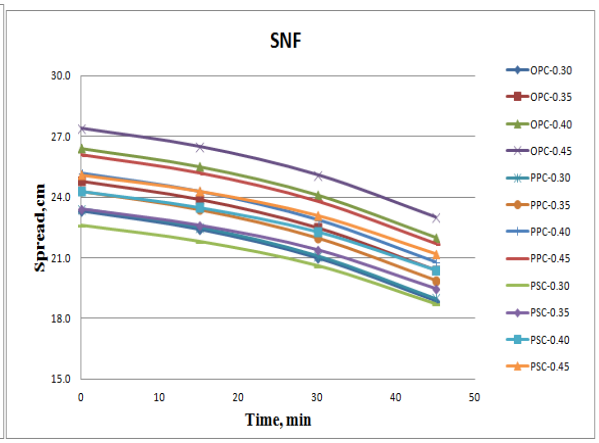

Fig.11

Discussions

1. Comparing Fig.10 and Fig.11 it can be observed that retention of spread in case of PCE based SP is better than SNF with all types of cements.
2. This proves that PCE based SP can be used in lower w/c ratio which is more effective than SNF based SP.

2.2 Mortar Studies

2.2.1 Saturation Dosage

Saturation dosages are found for mortars using M-sand (4.75mm-75µ) with two different proportions for 2 SP's with various w/c ratios and cements the results are tabulated in Table 2.

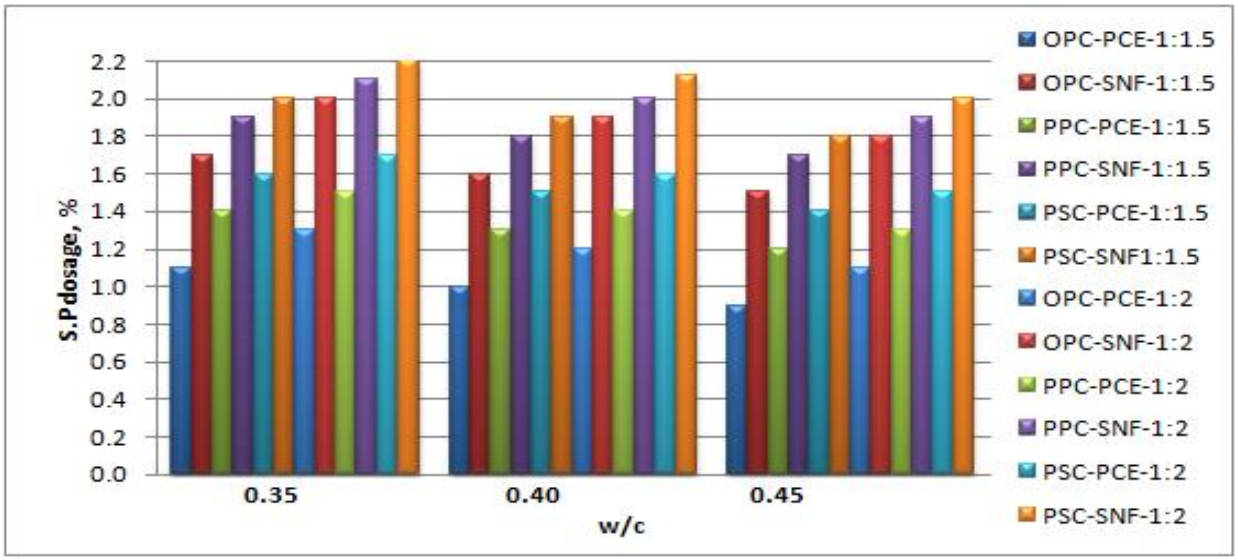

Fig.12 Variation of Saturation dosages w.r.t w/c ratios

Discussions

1. From Fig.12 it can be seen OPC requires less dosage compared PPC and PSC.
2. It can be observed that OPC requires 0.2% more in case of 1:2 cement mortar, whereas PPC and PSC require 0.1%.
3. Comparing fig.3 and fig.12 it can be observed that SP dosage required mortar ranges from 0.8-1% more which is due to water absorption by sand.

2.2.2 Initial Setting time of Mortar (Penetrometer Test)

This test method covers the determination of the time of setting of concrete, with slump greater than zero, by means of penetration resistance measurements on prepared mortar and grouts. This test method is suitable for use only when tests of the mortar fraction will provide the information required.Fig.13 shows initial setting time of mortar proportion 1:1.5 with different cements and saturation dosages of SP obtained for mortars.

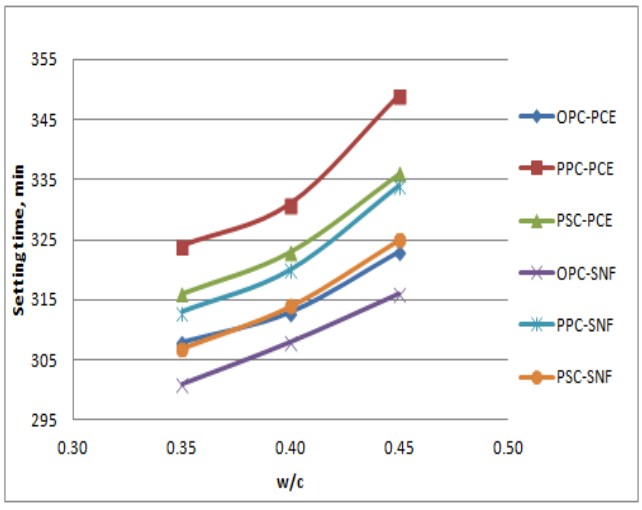

Fig.13 Variation of Initial setting time w.r.t w/c ratios

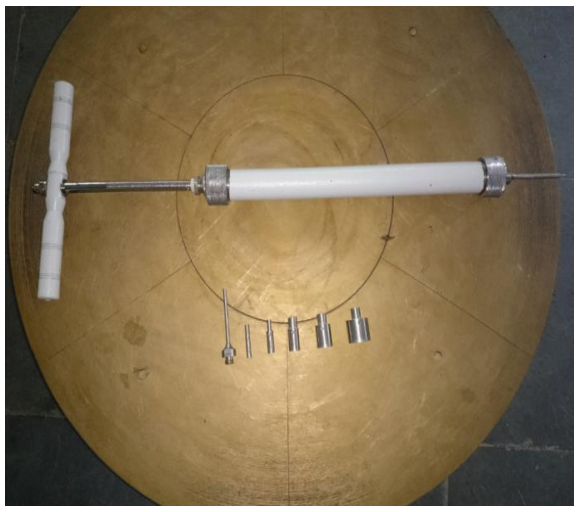

Fig.14 Penetrometer Apparatus

Discussions

1. From Fig.13 we can see that PPC-PCE combination is taking higher initial setting time of mortar.
2. Also it can be observe that initial setting time of PSC-SNF and OPC-PCE are almost similar.
3. Mortar takes time for setting compared to cement paste for any given w/c ratio and mortar proportion due to volume of fraction of cement.

2.2.3 Compressive Strength

Compressive strength is one of the important properties of cement mortar. Studies have been carried out for w/c ratio 0.35-0.45 and for different mortar proportions.

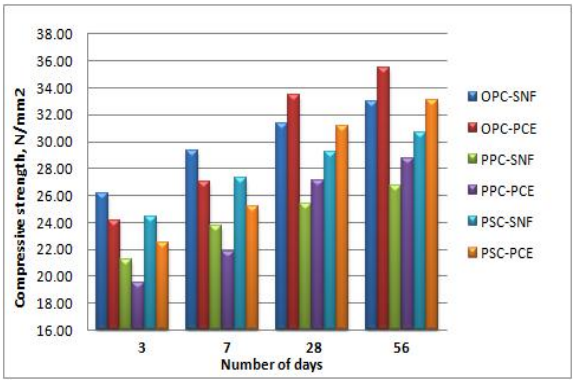

Fig 15 Compressive strength of mortar for w/c of 0.35

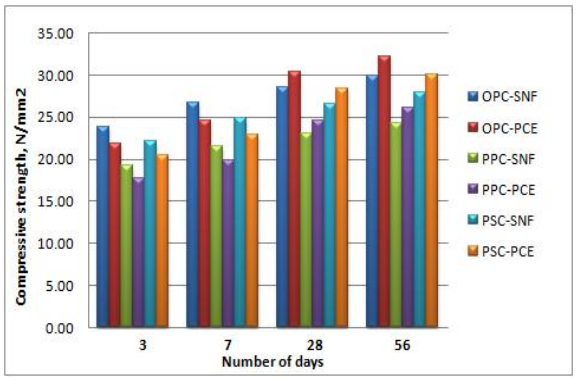

Fig 16 Compressive strength of mortar for w/c of 0.4

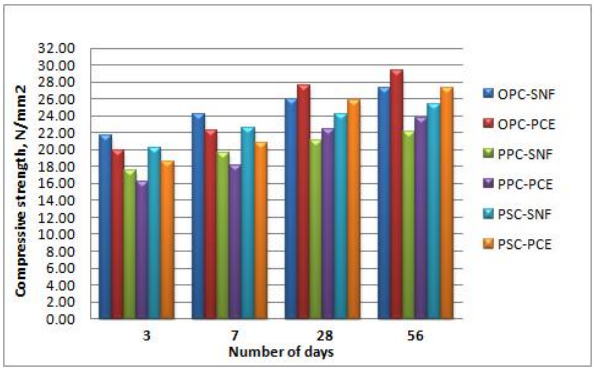

Fig.17 Compressive strength of mortar for w/c of 0.45

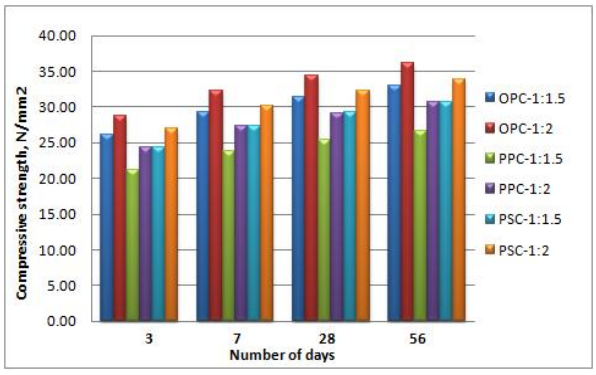

Fig.18 Strength of mortar for different proportions

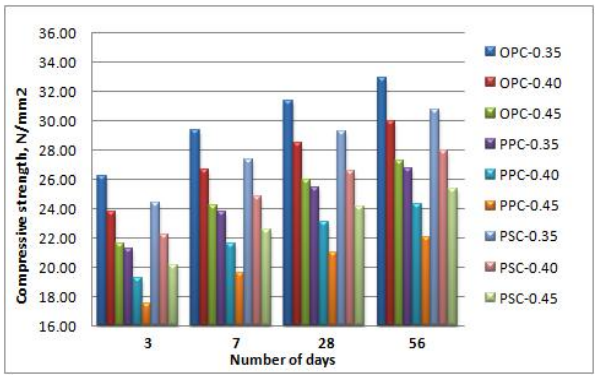

Fig.19 Variation of mortar with different w/c

Discussions

It is observed that there is delayed gain in strength in case of PCE based SP's compared to SNF based SP which also results in delayed strength. However, at the end of 28 days PCE based mortars have higher strength.

3. CONCLUSIONS

- PCE based SP exhibits better compatibility withal types of cements.
- SP requirements for blended cements are more than OPC.
- SP dosage requirements of cement mortar increase is found to be higher and therefore Marsh cone and Mini-slump cone on pastes will not give satisfactory estimations to consider SP dosage requirements for concrete mixes.
- The flow/spread retention was found to be higher for PCE based SP compared to SNF based SP.
- There is delay in setting and strength development for cement mortars compared to SNF based SP.

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