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Super Plasticizer effects on Workability and Mechanical Properties of Concrete

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Abstract

Superplasticizer which is also known as high range water reducers are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation and to improve the flow characteristics of concrete. Flocculation of cement particles occur in a concrete mix without superplasticizer which reduces the workability of concrete, however for the same water-cement ratio there is a uniform distribution of cement particles for a concrete mix with superplasticizer. The super plasticizers added in small amounts, affect many properties of concrete, from the time the water comes into contact with dry ingredients of concrete to long-term behaviour. Super plasticizers advantages are high water reduction up to 40percentage, increased mechanical strength, increased impermeability and increased durability. In order to obtain high strength fluid concrete.This paper is a study of the effect of three different types of superplasticizer namely: Sulphonated Naphthalene Formaldehyde (SNF), Poly Carboxylate Ether (PCE) and Modified Poly Carboxylate Ether (MPCE) on the workability and mechanical properties of self-compacting concrete (SCC) mixtures.

Keywords:

Admixture
Modified Poly Carboxylate EtherSelf-compacting concrete
Sulphonated Naphthalene Formaldehyde
Superplasticizer.

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1. Introduction

Concrete is a composite material obtained by mixing cement mixture, aggregates and water. Besides these basic components, concrete contains additions and/or additives. The concrete performances depend on the quality of component materials, their proportions, the place and the exposure conditions. The quality of raw materials used in clinker manufacture, conditions of calcinations fineness and particle size of cement, the relative proportions of cement and the water amount, all influence the physicochemical behaviour of cement grout. Furthermore, the type of cement, aggregates nature, water, mixing temperature, additives and the environment will determine the physical, chemical behavior and durability of concrete. Super plasticizer is the fourth generation of super plasticizer for concrete. It meets the requirements for high range water reducing super plasticizers. It is also called as ConfluxGuard. Super plasticizer admixture has special chemicals which helps in water reduction of concrete and also gives the better workability. It aids in making a cohesive concrete mix.They are chemically different from normal plasticizers. The use of plasticizers permits reduction of water to an extent up to 30% without reducing the workability in contrast to the possible reduction up to 15% in case of plasticizers. There are a number of superplasticizers available in the market, out of which three superplasticizerswill be used in this research to study their effect on workability and mechanical properties of concrete mixture in both fresh

and hardened state. Superplasticizers produce a homogeneous, cohesive concrete generally without any tendency for segregation and bleeding. [1] experimentally observed the effects of concrete workability on addition of superplasticizer. [2] Studied the application of powder superplasticizers in japan and Southeast Asian countries to increase the strength of concrete. [3] Performed the experiment to know the dosage limit for determination of superplasticizing admixture and their effects evaluation on properties of concrete. [4] Observed that concrete is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. [5] Observed that to achieve full compaction particularly where reinforcement congestion and shortage of skilled workers by adding mineral and chemical admixtures like fly ashAlsadey 2015 explained the effects of superplasticizer on fresh and hardened properties of concrete.Sulphonated Naphthalene Formaldehyde (SNF) is a polymer produced by condensed polymerisation of naphthalene, sulphonic acid and formaldehyde. The dispersion of cement particles caused as a result of negative charge left on the admixture adsorbed cement particle, which will repel the other cement particles. This phenomenon is called electrostatic repulsion.

Superplasticizers constitute of a relatively new category and improved version of plasticizer, the use of which was developed in japan and germany during 1960 and 1970, respectively. They are chemically different from normal plasticizers. The use of plasticizers permits reduction of water to an extent up to 30percentage without reducing the workability in contrast to the possible reduction up to 15percentage in case of plasticizers. There are a number of superplasticizers available in the market, out of which three superplasticizers will be used in this research to study their effect on workability and mechanical properties of concrete mixture in both fresh and hardened state. Superplasticizers produce a homogeneous, cohesive concrete generally without any tendency for segregation and bleeding. Sulphonated naphthalene formaldehyde (SNF) is a polymer produced by condensed polymerisation of naphthalene, sulphonic acid and formaldehyde. The dispersion of cement particles caused as a result of negative charge left on the admixture adsorbed cement particle, which will repel the other cement particles. This phenomenon is called electrostatic repulsion. Poly carboxylate ether (PCE) is composed of a methoxy-polyethylene glycol copolymer (side chain) grafted with methacrylic acid copolymer. The dispersion of cement particles occur due to steric hindrance. Steric hindrance depends on the length of main chain, length and number of side chain. However, they are more sensitive to overdosing, and can lead to problems such as retardation and excessive air entrainment. Modified carboxylate ether (MPCE) is the modified version of PCE with better water retaining properties.

2. Research Method

TABLE 1 PROPERTIES OF SUPERPLASTICIZERS USED

A study on the behaviour of a specific concrete mix with different superplasticizer can show the comparative view on the behaviour of the different superplasticizer used. Table 1 gives the properties of the superplasticizers used in this research.

Sl.No	Name of the admixture	Relative density	Colour	Dosage*
1.	SNF	1.24 at 25ºC	Dark Brown	0.5-2%
2.	PCE	1.08 at 25ºC	Honey Brown	0.4-1.2%
3.	MPCE	1.08 at 25ºC	Golden Brown	0.6-1.2%

* as recommended by the manufacturer

2.1 Slump flow test

The slump flow test is done to access the horizontal flow of concrete in the absence of obstruction. It is most commonly used test and gives good assessment of filling ability. The test also indicates resistance of self-compacting concrete mixture to segregation. About 15 kilograms of concrete mix is needed for this test. Place the base plate on level ground. Keep the slump cone centrally on the base plate. Fill the cone with the scoop. Do not tamp. Simply strike off the concrete level with the trowel. Remove the surplus concrete lying on the base plate. Raise the cone vertically and allow the concrete to flow freely. Measure the final diameter of the concrete in two perpendicular directions and calculate the average of the two. Test values for slump flow with different superplasticizers are given in Table 3 and Fig.1.

TABLE 2 TEST VALUES FOR SLUMP FLOW TEST

Sl.No	Types of admixture used	Slump flow value
1.	SNF	560mm
2.	PCE	650mm
3.	MPCE	800mm

2.2Additional material for proposed concrete: Sulphonated Naphthalene Formaldehyde (SNF)

Sulphated Naphthalene Polymers and supplied as a brown liquid instantly dispersible in water. Conplast SP430 G8 has been specially formulated to give high water reductions upto 25 percentage without loss of workability or to produce high quality concrete of reduced permeability. Sulphonated naphthalene formaldehyde polymer is a major ingredient of super-plasticizers. it takes a role neutralizing the surface charges on the cement particles and enhancing water tied up in the cement concrete agglomerations and thereafter reducing the viscosity of the paste and concrete. It promotes dispersing the cement particles and reduces water requirements without affecting the workability thus resulting high-strength concrete and lower permeability

2.3 T_{500mm} slump flow test

Flow table test at T_{500mm} indicates the rate of flow within a defined flow distance. This test shows the filling ability of the the procedure for this test is same as for slump flow test. When the slump cone is lifted, start the stop watch and find the time taken for the concrete to reach 500mm mark. This time is called T_{500mm} time. This is an indication of rate of flow of concrete. A lower time indicates greater flowability of concrete mixture. It is suggested that T_{50cm} time may be 2 to 5 seconds. Table 4 and Fig. 2 give the time taken to spread 500mm for the three types of superplasticizer mixed

TABLE 3 TEST VALUES FOR T_{500mm} SLUMP FLOW TEST

Sl.No	Types of admixture used	T_{500mm} Slump flow value
1.	SNF	4.3 seconds
2.	PCE	3.6 seconds
3.	MPCE	3.0 seconds

2.4 Workability Retention Test

Workability of concrete is one of the most important criteria that should be always be kept in check for long duration depending upon the retention time which is calculated keeping the distance between the site and the Ready Mixed Concrete (RMC) plant. When concrete is to be designed for more than M40, naturally, admixture(s) of preferred choice is to be used. The main types of admixtures that must be used are water reducing agents and superplasticizer. When water reducing agents are used, the total quantity free water used will be kept under control as increasing free water affects the strength of concrete. For a retention time of about 2 hours, either a PCE or an MPCE is can be used. Any admixture which is a superplasticizer cum- water reducing agent if chosen will reduce the cost of the concrete. Theoretically, initially at the RMC plant,

immediately after the mixing of concrete, a certain amount of bleeding is allowed such that the bleeding is arrested within 20 – 25 minutes from the mixing time of concrete.

Sl.NO	Time (Minutes)	Slump (mm)		Average slump (mm)
1.	15	640	640	640
2.	30	547	548	547.5
3.	45	454	456	455
4.	60	375	375	375
5.	75	324	326	325
6.	90	275	275	275
7.	105	250	250	250
8.	120	250	250	250

3. Results and Analysis

3.1 Slump Test

Slump test is the most commonly used method of workability of concrete which can be employed either in laboratory or at site of work.

The apparatus for conducting the slump test is essentially consists of

3.2 Metallic mould in the form of a frustum of a cone having the internal dimensions as

- Bottom diameter : 20 cm
- Top diameter : 10 cm
- Height : 30 cm

3.3 A steel tamping rod

- Diameter :16 mm
- Length : 0.6 m with a bullet end.

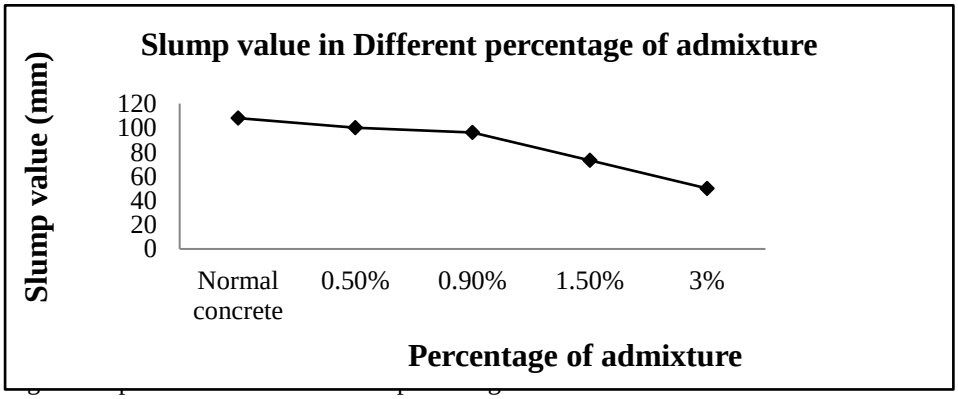
3.4 Procedure

- The internal surface of the mould is thoroughly cleaned and freed from superfluous moisture and adherence of any oldest concrete before commencing the test.
- The mould is placed on a smooth, horizontal, rigid and non-absorbent surface.
- The mould is then filled in four layers, each approximately ¼ of the height of the mould.
- Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section.
- After the top layer has been rodded, the concrete is stuck off level with a trowel and tamping rod.
- The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. The subsidence is referred to as SLUMP of concrete.
- The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height is noted in mm and is taken as Slump of concrete.
- Higher the slump value, higher is the workability.
  The mix we prepared for testing was of M40

For same water content, at different replacement percentage:

Table 5 slump value for fresh concrete with different percentage of admixture

PERCENTAGE of ADMIXTURE	WATER CEMENT RATIO	SLUMP (mm)	DEGREE OF WORKABILITY
0	0.40	108	High
0.5	0.40	100	High
0.9	0.40	96	Medium
1.5	0.40	73	Low
3.0	0.40	82	Medium



In the above graph we have seen that for a normal concrete slump value is higher and as we increase the dosage of super plasticizer with a constant w/c ratio it decrease the slump value.

3.5 Compression Test:

The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concrete is employed primarily to resist compressive stresses. The concrete making properties of various ingredients of mix are usually measured in terms of the compressive strength. Compressive strength is also used as a qualitative measure for other properties of hardened concrete.

Procedure

For the preparation of the specimens the following procedure is adopted and this module includes the curing of the Cubes and is illustrated as follows.

- Weight the quantities of cement, fine Aggregates, Coarse Aggregates and water for one batch of concrete to an accuracy of 0.1percentage of the total weight of batch.
- Mix the concrete by hand (or) preferably in a laboratory batch mixer.
- For mixing the Concrete we have adopted the mix ratio 1:2.11:3.5.
- First of all mix the equal amounts of Cement and sand with hand followed by the trowel.
- Now add the coarse aggregates to the cement and sand and mix it thoroughly. Mixing should be in such a way that all the constituents in the concrete should mix uniformly so that we can obtain a uniform mix.
- Now add require amount of water by the weight of cement to the Mix. Care should be taken water should not go out of the mixing plate or batch mixer.
- Mix the concrete after adding the water thoroughly.
- Now take the moulds of size 15 × 15 × 15 cm, apply grease or oil to the sides of the mould. Make sure that the screws are fixed tightly so that bleeding does not take place.
- Now transfer the required quantity of the concrete into the moulds. Transfer of concrete should be in such a way that we should lay nearly u3 layers and compacting each layer for 25 times.
- After filling the mould level it on the top side of the cube and leave it aside for 24 Hours.
- After 24 hours unfasten the screws and take out the cube and proceed for curing.
- We have adopted the method of Immersion for curing. The cubes are to be placed in the water for 7 days, 21 days, 28 days and compression test is to be done with respect to the age.
- Care should be taken that the specimens are deeply immersed in the water and the water should be free from the organic matter, salinity, and alkalinity of higher order as it affect the durability of the concrete.

  Factors affecting Strength of concrete:-
  a) Ratio of cement to water mixing
  b) Ratio of cement to aggregate
  c) Grading, surface texture, shape, strength and stiffness of aggregate particles
  d) Maximum size of aggregate

Fig. 2 Compression test on cube

3.6 Compressive Strength of Concrete at different percentage of admixture

Table 6 compressive strength of concrete

percentage of admixture	7 days N/mm2	21 days N/mm2	28 days N/mm2
No admixture	25.33	28.88	42.44
0.5 percentage	9.78	22.22	26.22
0.9 percentage	25.55	35.55	44.44
1.5 percentage	26.66	33.55	44.44
3 percentage	21	33.33	36.44

The concrete develops strength with continued hydration. The rate of gain of strength is faster to start with and the rate gets reduced with age. It is customary to assume the 28th day strength as the full strength of concrete. Although concrete develops strength beyond 28 days. Earlier codes have not been permitting to consider that this strength in the design. The increase in strength beyond 28 days is used to get immersed with the factor of safety and make the structure more economical. The first step to mix design calculation is the target strength, which according to IS 10262:2009 is given by:

$$f'_{ck} = f_{ck} + 1.65s$$

The design is then carried out using the value of f'_{ck}, which in this case gives a value of 48.25 MPa. TABLE 12 COMPRESSIVE STRENGTH VALUE FOR SNF

Sl.No	Days	Weight (kg)	Ultimate Load (kN)	Strength (MPa)	Average strength (MPa)
1.	3	8.360	641.7	28.52	28.2
		8.320	649.1	28.85	
		8.396	610.2	27.12	
2.	7	8.360	815.0	36.22	36.2
		8.325	825.8	36.70	
		8.412	805.5	35.80	
3.	28	8.385	1189.4	52.86	53.5
		8.405	1206.9	53.64	
		8.365	1217.7	54.12	

TABLE 13 COMPRESSIVE STRENGTH OF PCE

Sl.No	Days	Weight (kg)	Ultimate Load (kN)	Strength (MPa)	Average strength (MPa)
1.	3	8.455	700.7	31.14	31.8
		8.340	740.0	32.89	
		8.460	705.6	31.36	
2.	7	8.675	868.5	38.60	38.1
		8.560	844.7	37.54	
		8.475	857.9	38.13	
3.	28	8.455	1241.1	55.16	55.7
		8.400	1258.2	55.92	
		8.445	1262.7	56.12	

TABLE 14 COMPRESSIVE STRENGTH OF MPCE

S.No	Days	Weight (kg)	Ultimate Load	Strength (MPa)	Average strength

			(kN)		(MPa)
1.	3	8.560	840.9	37.50	37.9
		8.480	857.4	38.50	
		8.450	849.2	37.70	
2.	7	8.630	951.0	42.50	43.0
		8.580	979.8	43.50	
		8.600	965.0	42.90	
3.	28	8.575	1328.0	59.02	59.2
		8.695	1139.8	59.50	
		8.650	1330.0	59.11	

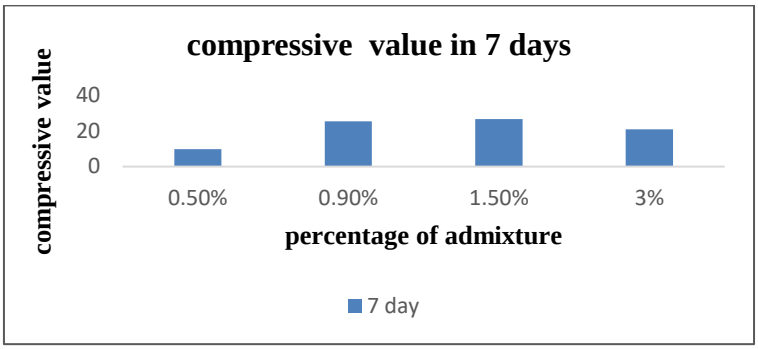


Fig.3 Compressive strength of concrete after 21 days of curing with different percentage of admixture.

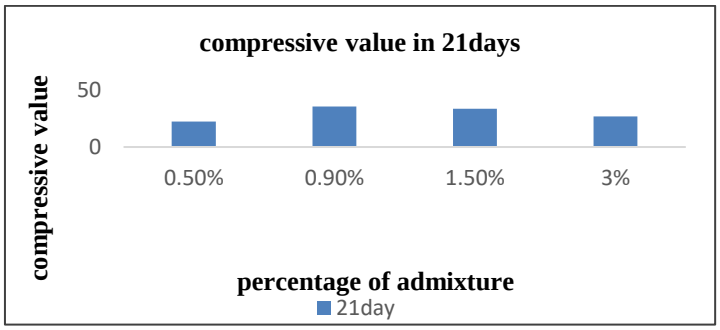


Fig.4 Compressive strength of concrete after 28 days of curing with different percentage of admixture.

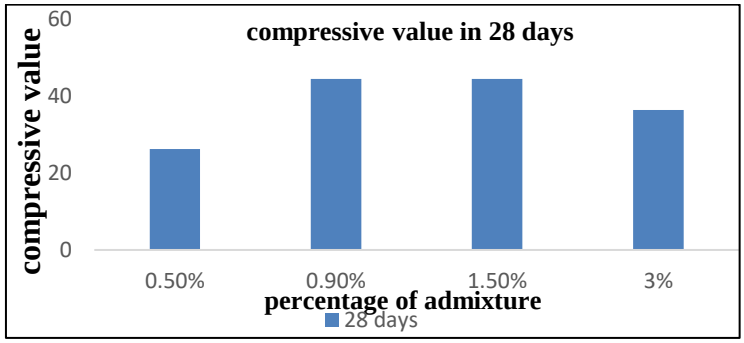
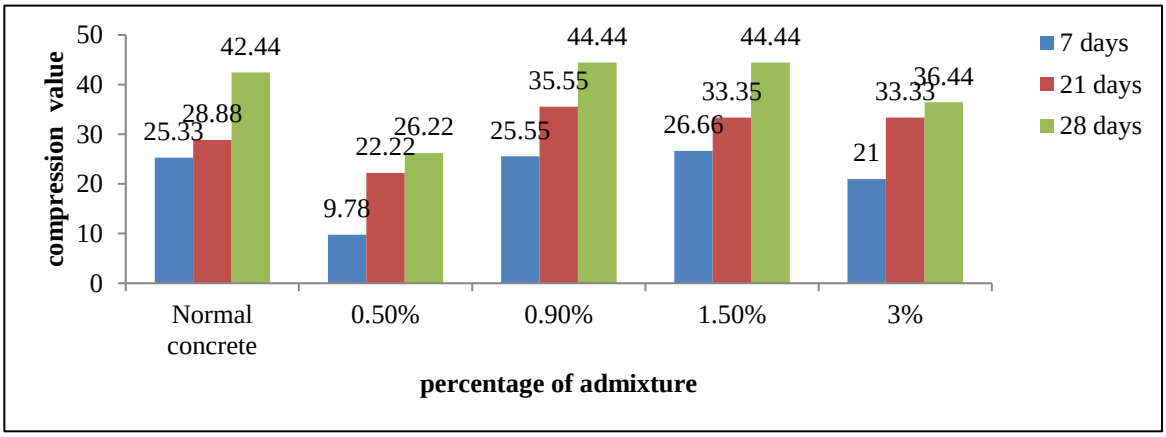


Fig.5 Combined graphical representation of compressive strength of concrete with different percentage of admixture

3.7 Discussion

- Water Reduction – Reduces water requirement for getting high slump in concrete thus gives high strength concrete with reduced permeability.
- Workability – Improves workability of freshly mixed cement concrete. Allows easier compaction leading to denser concrete and superior finish
- Durability – Increases durability by improving cohesiveness of concrete
- Superior plasticising effect, resulting in improved flow, placing and compaction
- Chloride free – does not attack reinforcement



4. Conclusion

- In this project we have added super plasticizer as per code IS 10262-2009 up to the maximum i.e 0.5 percentage to 3 percentage without changing the water cement ratio.
- The compressive strength for normal concrete gives good strength but when we increase the dosages or percentage of super plasticizer from 0.5 percentages to 3 percentages the compressive strength increased from the normal concrete which gives a very good result in compared with normal concrete.
- But the increase in strength by adding super plasticizer is limited for certain percentage. There is a limit to add super plasticizer if we increase the dosage it affect the strength of concrete.
- so in this project in 0.9 percentage of admixture it give good compressive strength but in 3 percentage it decrease the compressive strength.

The mix was becoming harsh with increase in percentage beyond 3 percentages and it favorable at 0.9 percentages only to increase the mechanical strength

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