IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

AN EXPERIMENTAL STUDY ON COMPRESSIVE AND SPLIT TENSILE STRENGTH OF CONCRETE BY ADDING THE STEEL SLAG AS THE COARSE AGGREGATE REPLACEMENT

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ABSTRACT:
Concrete assumes an essential part in the outline and development of the country's foundation. Right around seventy five percent of the volume of cement is made out of totals. These are acquired from common rocks and waterway beds, in this way debasing them gradually. This issue of ecological debasement, and requirement for totals requests for the utilization of whatever other option source. In this manner the idea of supplanting of coarse total with steel slag is by all accounts promising. In this study an endeavor is made to utilize steel slag, a by-item from steel industry as swap for coarse total in cement and locate the ideal substitution level of steel slag as coarse total and add steel filaments to the ideal blend at various volume portions. M25 review of cement was utilized. Conceivable ideal substitution of slag material was observed to be 50%. Tests on Compressive quality, Flexural quality, Split rigidity, Young's modulus and extreme load conveying limit were led on examples. It was presumed that supplanting some rate of coarse total with steel slag improves the quality. The outcomes demonstrated that supplanting around 50 percent of steel slag totals for coarse total and expansion of steel strands at volume division of 1.5% builds the quality of the solid when contrasted with the control solid blend.

I. INTRODUCTION

Concrete

Concrete is a composite material composed of fine and coarse aggregate bonded with a fluid cement that hardens over time.. Concrete is the most consumed material on the earth after water. When aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The cement reacts chemically with water and the other ingredients to form a hard matrix that binds the materials together into a durable stone like material called concrete, which has many uses.

Over the time there were situations were high strength was required, early strength was required and in some cases light weight concrete was required, so due to all these constraints there were many concretes developed. Some of them were:

1. High strength concrete
2. High performance concrete
3. Ultra high performance concrete
4. Self compacting concrete
5. Shortcrete
6. Limecrete etc

These are few types of concretes which are extensively in use recently. Producing different types of concretes is not possible by using regular materials like water, cement, Aggregates. Apart from these there should be some extra ingredient which imparts the desired property to the concrete. This extra ingredient which is used in concrete for obtaining the desired property is called "Admixture". In order to produce any concrete other than conventional concrete, admixture is necessary.

Admixtures

An admixture basically is an ingredient used to give special properties to fresh or hardened concrete. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete, to ensure the quality of concrete during mixing, transporting, placing and curing and to overcome certain emergencies during concrete operations. Successful use of admixtures depends on the use of appropriate methods of batching and concreting. Most of the admixtures re supplied in ready to use liquid form and are added to the concrete at the plant or at the jobsite.

OBJECTIVES

This study aims at evaluating the performance of various super plasticizers with different types of cements. The objectives of this project are listed below

(1) To study the behavior and check for compatibility of various super plasticizers with different types of cements.
(2) To consider various methods for studying the compatibility, like delayed addition and durability tests.
(3) Preparing concrete mixes with different super plasticizers, namely Sulphonated-naphthalene based, Polycarboxylic ether based and polymeric ether based with OPC and PPC cements
(4) Studying the slump and slump retention properties of various super plasticized concrete mixes.
(5) To determine the optimum dosage of various super plasticizers for different types of cements.
(6) To evaluate compressive and flexural strength of the super plasticized concretes with different kinds of cements.
(7) To determine the affect of delayed addition of super plasticizer on the concretes prepared from different types of cements.
(8) To evaluate water absorption property of super plasticized concretes.
(9) To find out the sorptivity of various mixes prepared using different super plasticizers and cements.

SCOPE OF STUDY

This project mainly focuses on studying the incompatibility between cement and super plasticizer. For this various methods were adopted and different tests were performed. M40 concrete was prepared with 0.42 water cement ratio using different super plasticizers and different types of cements. A much more extensive study on this performance evaluation can be made.

II. LITERATURE REVIEW

Some of the studies were represented below.

BaoujiLio et al (2018) investigated the effect of curing conditions on the permeability of concrete with high volume mineral admixtures. The influence of mineral admixtures and curing conditions on the permeability of concrete with high volume mineral admixtures is investigated. The test results show that the water absorption, capillary water absorption, sorptivity coefficient, electric flux and carbonation depth of concrete decrease with the longer standard curing time, higher curing humidity and appropriate curing temperature, and decrease with the increasing of GGBFS content.

WojciechKubissa et al (2013) carried out a research on Measuring and Time Variability of The Sorptivity of Concrete. The article presents measurements of sorptivity. They were performed not only, as usual, after 28 days, but also after longer periods of time (2, 3, 6, 9, 12, 24 months) on samples made of the same concrete. However, in subsequent measurement periods, the results of sorptivity measurements do not significantly differ from the initial one. In general, on the basis of the research findings, it can be concluded that the sorptivity measured in case of young concrete is its representative later on as well.

III. EXPERIMENTAL INVESTIGATION

MATERIALS

The aggregate used was procured locally. Sand was used as fine aggregate and crushed stone was used as coarse aggregate. Tests were done to determine the physical properties of the aggregates. These tests included Specific gravity, sieve analysis and water absorption.

Fine aggregate

Sand was used as fine aggregate. It was procured locally. It had the following properties.

Table: Physical properties of Fine aggregate

Property	Sand	Test method
Specific gravity	2.65	IS 2386 (Part III) 1963
Absorption (%)	0.98	IS 2386 (Part III) 1963
Sieve analysis	Zone – III	IS 383-1970

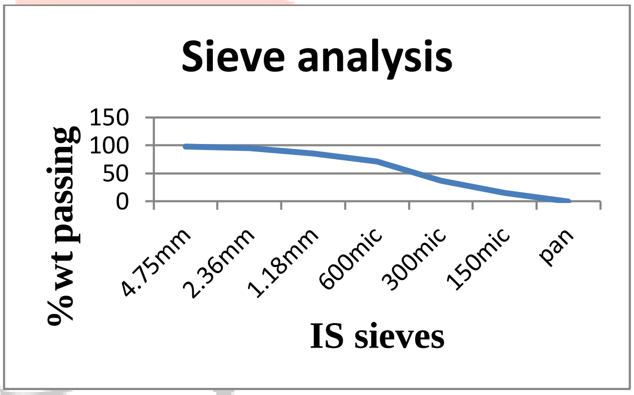

Fig Sieve analysis of fine aggregate

Coarse aggregate

Crushed stone was used as the coarse aggregate. Coarse aggregate was mostly angular in shape. Water absorption test was done for this aggregate. Pycnometer was used for testing the specific gravity.

Table: Physical properties of Coarse aggregate

Property	Coarse aggregate		Test method
	20mm	10mm	
Water absorption	0.43%	0.43%	IS 2386 Part 3-1963
Specific gravity	2.65	2.65	IS 2386 Part 3-1963

Table: Sieve analysis of coarse aggregate

S.No	I.S Sieve NO	Weight Retained (gms)	Percentage weight retained	Cumulative percentage retained	Percentage passing
1	20	1257.2	41.86	41.86	58.14
2	10	1665.6	55.46	97.32	2.68
3	4.75	76.8	2.55	99.87	0.13
4	Pan	31	0.10	99.97	0.03
		3002.8			

Cement

PPC and OPC cements of the same brand were used throughout. Tests were done to determine the physical properties of cements. These tests included Specific gravity, fineness, initial and final setting. The specific gravity of cement was tested using a specific gravity bottle. The Initial setting time was tested using vicats apparatus. Initial setting time of PPC was slightly more than OPC.

Table: Physical properties of cements

Properties		Values		Standards
		PPC	OPC	
Consistency (%)		38	32	IS 4031 part 4-1988
Setting Time(min)	Initial	55	35	IS 4031 part 5-1988
	Final	310	180	
Specific gravity		2.95	3.15	IS 1727-1967
Fineness (%)		7	8	IS 4031 part 1-1996

Super plasticizers

Super plasticizers, these are also known as high range water reducers. These polymers are used as dispersants to avoid particle segregation and to improve the flow characteristics of concrete. Super plasticizers enable reduction in water to cement ratio without affecting the workability of concrete.

Water

Water used was potable water which is fit for drinking. This water must be free from dissolved salts and other impurities. Water must be free from organic impurities.

Concrete mix design

IS 10262-2009 was used for the mix design (M40). A water cement ratio of 0.42 has been adopted for all the concrete mixes. Quantities of coarse and fine aggregates have been calculated from the above mentioned code. A no. of trail mixes have been done to determine the optimum dosage of every super-plasticizer. From the trail mixes the optimum dosage of all the three super-plasticizers was determined. These specimens were tested for the three days compressive strength. Based on this result we proceeded to the main mixes. A total of 6 mixes were casted with three different super-plasticizers and 2 cements. 3 mixes each were casted for OPC and PPC. Each mix had a different mix design and different ratio depending upon the dosage of super plasticizer.

Table: Properties of Super plasticizers

Type of Super plasticizer	Specific gravity	Dosage	pH	Chloride ion content	Properties	Uses
Sulphonated Naphthalene	1.26	0.8%-1.8%	≥6	<0.2%	This SP will neither initiate nor promote corrosion.	Precast concrete, Long distance transportation, etc
Polycarboxylic ether	1.08	0.6%-1.2%	≥6	<0.2%	Chloride free and low alkali.	HPC for durability, Resistance of segregation even at high workability, Extended setting.
Polymeric ether	1.1	0.5%-1.5%	≥6	<0.2%		Cohesive and flowable concrete, High early and ultimate strength, HPC for durability, etc

Table: Concrete mix design

Mix	Type of cement +Super plasticizer	w/c ratio	Water (Kg)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg) (20mm)	Coarse Aggregate (Kg) (10mm)	Super Plasticizer (grams)
1	PPC + SN	0.42	186	442.85	852.34	412.352	618.528	6.19
2	PPC + PCE	0.42	186	442.85	720.58	411.364	617.046	3.54
3	PPC + PME	0.42	186	442.85	721.89	412.112	618.168	3.099
4	OPC + SN	0.42	168	400	766.44	439.192	658.788	4.8
5	OPC + PCE	0.42	168	400	807.11	426.32	639.48	3.2
6	OPC + PME	0.42	168	400	807.22	426.416	639.624	3.2

Preparation of concrete mixes

Firstly batching of raw materials was done. From the mix design required quantities of raw materials were weighed. Before feeding them into the mixer, the mixer must be cleaned and oiled properly so that the wastage of material would be less. After the proper cleaning of mixer the raw materials were added in the proper order…that is coarse aggregate, fine aggregate, cement and water with super plasticizer. The mixer was operated for at least 10min to ensure the proper mixing of the ingredients. After the mixing the fresh concrete was collected in a tray and moulds were filled. Moulds were filled in three layers ensuring proper compaction. After filling the moulds they were placed on a table vibrator. 12 cubes of size 100*100*100 mm and 6 beams of 500*100*100 mm were casted in each mix. These moulds were kept undisturbed for 24 hours to facilitate proper setting. After 24 hours then these are unmolded and placed in the curing tank for curing.

Testing of concrete

Hardened concrete was tested for strength and durability. Table 3.2.3.1 enlists the various tests which have been conducted.

Table: Tests on concrete

S. no	Name of the test	Standards and codes
1	Compressive strength	IS 516 – 1959
2	Flexural strength	IS 516 – 1959
3	Water absorption	ASTM C642-06
4	Water sorptivity	ASTM C 1585-13
5	Water permeability	IS 3085-1964

IV. RESULTS AND DISCUSSION

Slump values

Table : Slump Values

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Mix (cement + SP)	Slump (mm)	
	Initial	Final
PPC+SN	170	50
PPC+PCE	200	55
PPC+PME	200	40
OPC+SN	150	20
OPC+PCE	160	35
OPC+PME	160	35

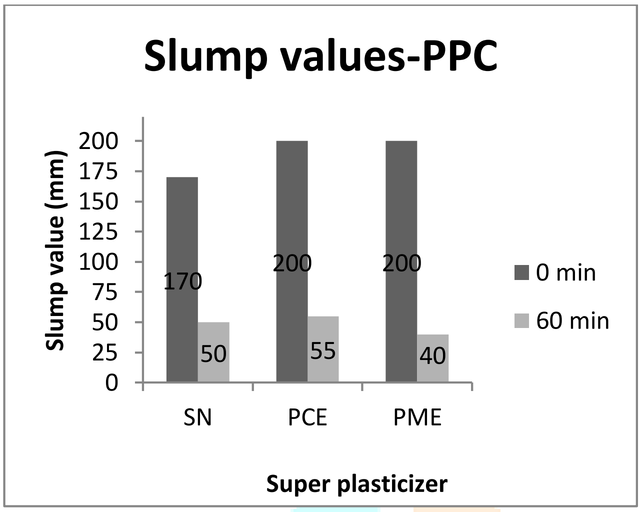

Fig. Slump value- PPC

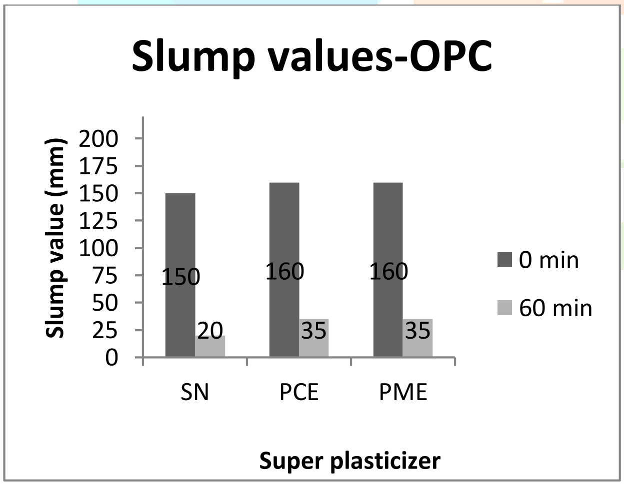

Fig. Slump values-OPC

Table. Compressive strength

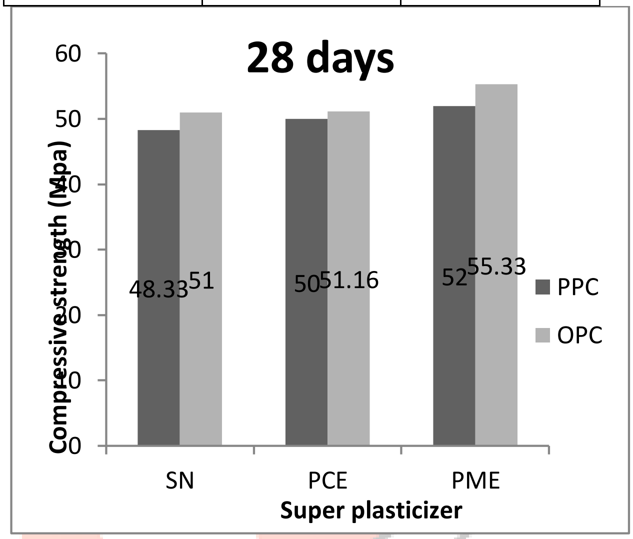

Fig . Compressive strength 28 days

Flexural Strength

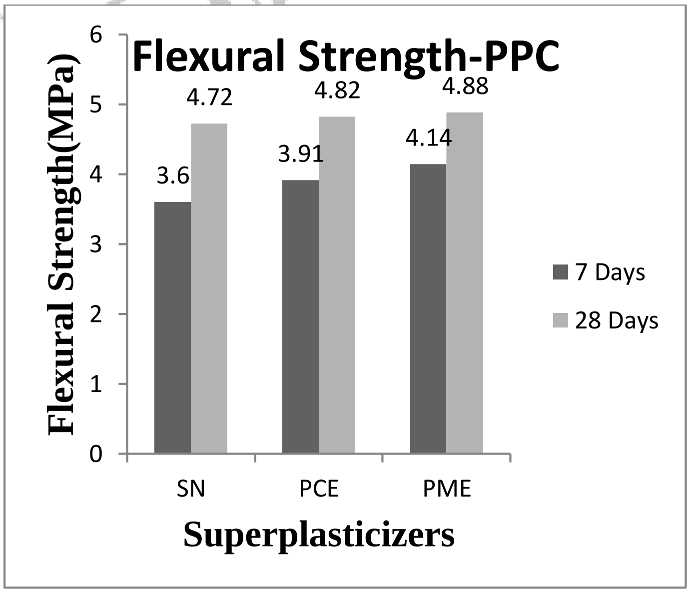

Fig. Flexural strength PPC

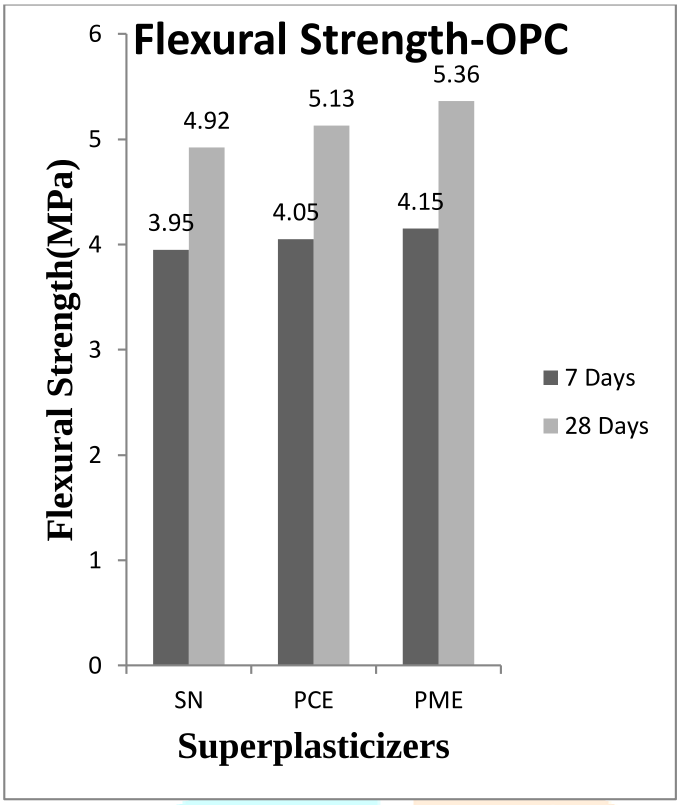

Fig. Flexural strength OPC

Durability tests

Water absorption

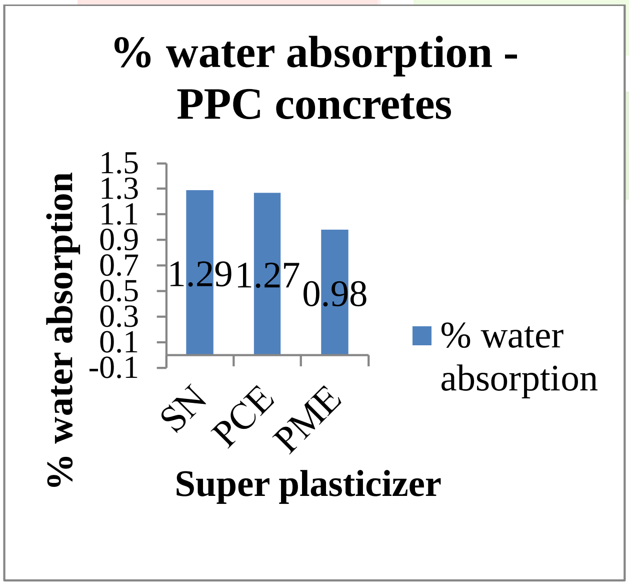

Fig. % of water absorption-PPC

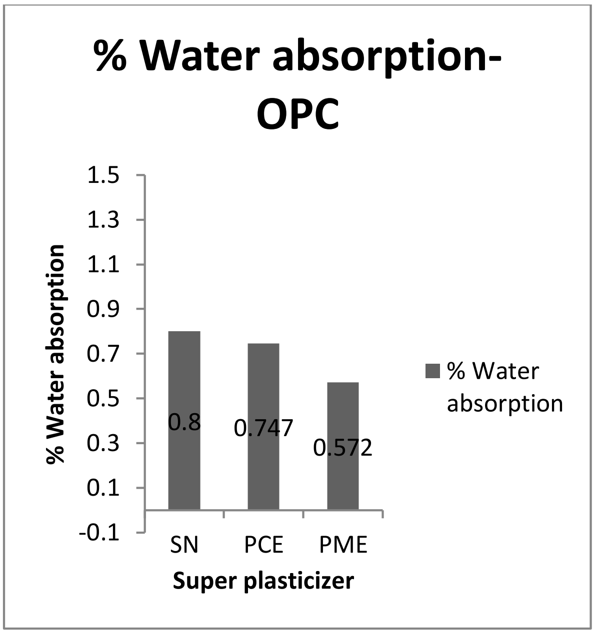

Fig. % of water absorption OPC

V. CONCLUSIONS

(1) (a) From the above results we can determine the optimum dosage of super plasticizers. For a water-cement ratio of 0.42 the optimum dosage of SN based super plasticizer would be 1-1.2% for PPC cement. This would be the optimum dosage for obtaining excellent workability in both the cases, that is initial and retention.

(b) For the same water-cement ratio, the optimum dose of Polycarboxylic ether SP would be 0.6% for PPC and was 0.8% for OPC. This super plasticizer is a modification of SN SP, so it gives more workability and higher strengths. So slightly less dose of this SP would be sufficient. Based on our experimental results we can suggest an optimum dose of 0.6% for PPC and 0 .8% for OPC. Even the slight increase in this dose would result in segregation, which is not at all desirable. A rapid decrease in compressive strength will be observed if super plasticizer is added beyond optimum dose irrespective of cements.

(c) 0.6-0.7% was the optimum dose for PME based super plasticizer for PPC which almost behaves in the same way as that of PCE based SP. 0.7-0.8% was found to be the optimum dose for OPC. The reason for OPC requiring higher dose was more the same as in previous points.

So from our results we specified the appropriate dosages of different SP'S both for OPC and PPC. For any change in water cement ratio, the optimum doses of super plasticizers must be determined through trail mixes only.

(2) Every mix achieved the target strength at the end of 28 days. Compressive strength continuously increased for all the ages starting from 3 to 28 days. There was a clear increase in compressive strength compared to conventional concrete. This is because addition of Super plasticizer provides more water for concrete mixing, so that the hydration process is not disturbed but it is accelerated by the additional water from defloculation of cement particles. Hence increasing in dose of Super plasticizer will increase the entrapped air and promotes hydration. This increases the compressive strength. But there would always be an

optimum dose beyond which strength reduces. That optimum dose for every super plasticizer is clearly mentioned above.

Flexural strength also shows the same trend like compressive strength for every super plasticizer, but the values would be much less.

(3) Sorptivity values for OPC are higher with all the super plasticizers when compared to PPC. This is because of faster hydration process of OPC. Due to faster hydration more cracks will be formed which automatically increases the sorptivity coefficient. Due to the same reason sorptivity of OPC was higher with all the super plasticizers [11]. Very convincing results were obtained for both the Cements. In every case PCE base SP with PPC showed the least value of sorptivity indicating its higher durability. PME and SN SP'S showed almost similar sorptivity values for PPC cement. Unlike in PPC, PCE SP in OPC showed higher sorptivity values at all the time intervals. This indicates that PCE SP is less compatible with OPC in terms of durability.

(4) Water absorption values were slightly higher for PPC when compared to OPC. But the values of both the cements are well within the limits. It can also be concluded that any kind of super plasticizer didn't show considerable effect, either positive or negative in terms of water absorption. PPC was expected to have less water absorption because of its higher fineness, but in this case OPC has slightly less water absorption values. Super plasticizer. There was no much influence of super plasticizer on the water absorption.

(5) Increase in the dose of Super plasticizer decreases the permeability as super plasticizer ensures extended and complete hydration, which fills the voids. But if optimum dose is crossed then permeability would increase because of the segregation and bleeding [15]. The optimum dosages determined in this project holds good in permeability case also. So usage of SN, PCE, PME SP'S produced concretes with very low permeability with both cements.

(6) On a whole we can clearly conclude that, when used in specified dosages Sulphonated naphthalene, polycarboxylic ether, polymeric ether were compatible with both OPC and PPC as no adverse effects were observed in any case.

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