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Comparison of strength between normal concrete & admixture concrete

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Abstract

Materials scientists, chemists, engineers, and manufacturers' technical representatives have helped the concrete industry to improve our ability to control work times, workability, strength, and durability of Portland cement concrete by adding some supplementary substances named admixtures.

The function of each admixture focuses on a specific need, and each has been developed independently of the others. Some admixtures already have chemistry that affects more than one property of concrete, and some have simply been combined for ease of addition during the batching process. To better understand recommended usage for various application of these chemicals admixture in concrete, the present study is planned to be obtained more specific information in this direction.

In this investigation on performance of concrete with GGBS and different PCE based water reducing admixture the tests on compressive strength and Workability of the concrete with Ordinary Portland cement and Portland pozzolana cement with GGBS and admixture are carried out at different curing periods for M45 grade of concrete to conclude its behavior.

1. INTODUCTION

1.1. General

Concrete is a composite construction material, composed of cement (commonly Portland cement) and other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water, and admixtures. Materials scientists, chemists, engineers, and manufacturers' technical representatives have helped the concrete industry to improve our ability to control work times, workability, strength, and durability of Portland cement concrete by adding some supplementary substances named admixtures.

The function of each admixture focuses on a specific need, and each has been developed independently of the others. Some admixtures already have chemistry that affects more than one property of concrete, and some have simply been combined for ease of addition during the batching process.

Admixture is an essential component of any modern concrete mix, providing a compromise for the conflict between water and workability and performance of hardened concrete. The advancement in admixture technology has played a significant role in the development of concrete technologies. The advanced PCE based admixtures have demonstrated various performance benefits and technical advantages over conventional super plasticizers in meeting the diversified challenging technical requirements of various high performance concrete technologies for construction.

In this investigation on performance of concrete with GGBS and different PCE based water reducing admixture the tests on compressive strength and Workability of the concrete with Ordinary Portland cement and Portland pozzolana cement with GGBS and admixture are carried out at different curing periods for M45 grade of concrete to conclude its behavior.

1.2. Admixtures:

General:

ACI 116R-00 defines the term admixture as "a material other than water, aggregates, hydraulic cement, and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing." In ACI 212.3R it is stated that "chemical admixtures are used to enhance the properties of concrete and

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mortar in the plastic and hardened state. Admixtures have long been recognized as important components of concrete used to improve its performance.

Function:

In ACI 212-3R, the reasons for the use of admixtures is outlined by the following functions that they perform:

- Increase workability without increasing water content or decrease the water content at the same workability;
- Retard or accelerate time of initial setting;
- Modify the rate or capacity for bleeding;
- Reduce segregation;
- Reduce rate of slump loss;
- Retard or reduce heat evolution during early hardening;
- Accelerate the rate of strength development at early ages;
- Increase strength (compressive, tensile, or flexural);
- Decrease permeability of concrete;
- Increase bond of concrete to steel reinforcement;
- Increase bond between existing and new concrete;
- Improve impact and abrasion resistance;
- Produce colored concrete or mortar

1.3. Chemical admixtures:

Plasticizers or dispersants are additives that increase the plasticity or fluidity of the material to which they are added; these include plastics, cement, concrete, wallboard, and clay. Although the same compounds are often used for both plastics and concretes the desired effects and results are different. Plasticizers or water reducers, and super plasticizer or high range water reducers, are chemical admixtures that can be added to concrete mixtures to improve workability. Unless the mix is "starved" of water, the strength of concrete is inversely proportional to the amount of water added or water-cement (w/c) ratio. In order to produce stronger concrete, less water is added (without "starving" the mix), which makes the concrete mixture less workable and difficult to mix, necessitating the use of plasticizers, water reducers, super plasticizers or dispersants.

1.3.1. Polycarboxylate ether:

Polycarboxylate ether super plasticizer (PCE) or just polycarboxylate (PC), work differently from sulfonate-based super plasticizers, giving cement dispersion by steric stabilization, instead of electrostatic repulsion. This form of dispersion is more powerful in its effect and gives improved workability retention to the cementitious mix.

Polycarboxylate ether (a free flowing, spray-dried powder) high-range water reducer is the third generation super plasticizer and high performance polycarboxylate (purity 100%),specifically developed a high range water reducing agent for concrete .It has several aspects such as, comprehensive property indexes , an environmental protection product with high property, good dispersing property, high water reducing rate ,good compatibility with various cements and good powder fluidity, it is especially suitable to be used in dry-mixed mortar to improve its property.

Uses:

Polycarboxylate ether is mainly used as a major ingredient to produce a high-performance water reducers or plasticizers for the following applications:

- High performance concrete
- Self-compacting concrete
- Pump able or flow able concrete
- Concrete containing silica fume, fly ash or blast furnace slag
- Specially shaped concrete elements
- Architectural concrete
- Lightweight concrete

Notes:

- It can't be used it with additives containing naphthalene sulfonate. Unreliable rheological behaviors may be experienced
- It should be stored at temperature 5-40 (40-104F). When it freezes; full strength can be restored after complete thawing and thorough agitation. Keep container closed when it is not in use. Do not store the product directly under sunlight.

The shelf life is twelve (12) months.

LITERATURE REVIEW

Admixtures-enhancing concrete performance: Mario Collepardi, *Enco, Engineering Concrete, Ponzano Veneto (Italy)****;*** Studied that super plasticizers are the most important admixtures enhancing concrete performance. The development of new superplasticizers during the last decades has determined the most important progress in the field of concrete structures in terms of higher strength, longer durability, lower shrinkage and safer placement particularly in elements with very congested reinforcement. The progress from sulphonated polymer to polycarboxylate has resulted in higher water reduction at a given workability and lower slump loss. More recently poly-functional super plasticizers have been developed which are able to completely keep the initial slump for at least 1 hr. without any retarding effect on the early strength. Moreover, multi-purpose and poly-functional super plasticizers have been invented which are able to reduce drying shrinkage. The recent progress of super plasticizers was examined in this paper.

Compatibility Issues of Nsf-Pce Super plasticizers with Several Lots of Different Cement Types (Long-Term Results) by Luigi Coppola, Sergio Lorenzi and Alessandra Buoso: This paper focuses on the compatibility issue between cement and chemical admixtures. Different kind of chemical admixtures were considered belonging to naphthalene (NSF) and polycarboxylate-based families. Five lots of six different cements widely spread in Italy were considered. Mortars and concretes were manufactured by varying super plasticizer dosage to achieve fixed workability at the end of mixing. Flow retention up to sixty minutes and tendency to entrap air in the mortars and concrete were measured to evaluate performances in terms of water reduction and workability loss of each chemical admixture. Compressive strength at 1, 7 and 28 days was also considered. The rheological and mechanical behavior of manufactured concretes showed good agreement with results collected on mortars.

Advanced admixture applications in high performance concrete infrastructure construction Jiang Jiabiao –PhD W. R. Grace (Singapore) Pte. Ltd., Singapore: This paper discusses new generation poly-carboxylate (PC) based admixture technologies and its application in high performance concrete for infrastructure building. With the powerful dispersion capability and flexibility in molecular design, PC admixtures enable the production of concrete at low water cementitious ratio with high workability, use of more blending materials, and to cater to different challenging requirements, such as high strength, high durability, high workability and long workability retention, etc. Some cases of advanced admixture application in high performance concrete infrastructural construction, such as marine bridges, high-rise buildings, water treatment plants in Asia, are presented as well.

New trends in the development of chemical admixtures in japan by Etsuo Sakai, Atsumu Ishida and Akira Ohta: This paper describes the history and new trends in the development of chemical admixtures in Japan. PC (polycarboxylic acid)-based agents are the main products in the super plasticizer market. A low-stickiness type PC-based super plasticizer has been developed based on the conventional PC-based super plasticizer. The flowing speed of concrete with low stickiness type PC-based super plasticizer is faster than that with the conventional PC-based super plasticizer. By addition of a new viscosity agent consisting of a mix of anionic and cationic surface active agents, the three- dimensional reticulation structures are formed in fresh cement paste and the viscosity of the cement paste can be increased and segregation can be prevented. The hydration of cement in sludge water is controlled by addition of a set-retarder, and the specific surface area of cement does not increase while a large amount of unreacted alite remains in the sludge water. Recycling of concrete at ready mixed concrete plants is possible without adversely influencing the properties of concrete when sludge water with the set-retarder containing gluconate salt is used. The slurry type and powder type calcium aluminate based accelerator (CA) and calciumsulfoaluminate based accelerator (CSA) for shotcrete have been developed. In the case of CA, the final setting time of the mortar is accelerated by increasing the dosage. By adding of CSA, both the initial and final setting times of mortar are shortened with increased dosages.

Effect of superplasticizer and shrinkage-reducing admixtures on alkali-activated slag

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pastes and mortars by M. Palacios, F. Puertas: This paper shows how several superplasticizers (polycarboxylates, vinyl copolymers, melamine and naphthalene-based) and shrinkage reducing (polypropylenglycol derivatives) admixtures affect the mechanical and rheological properties and setting times of alkali-activated slag pastes and mortars. Two activator solutions, waterglass and NaOH, were used, along with two concentrations—4% and 5% of Na2O by mass of slag. All admixtures, with the exception of the naphthalene-based product, lost their fluidifying properties in mortars activated with NaOH as a result of the changes in their chemical structures in high alkaline media. The difference in the behavior of these admixtures when ordinary Portland cement is used as a binder is also discussed in this paper.

Effect of w/cm and high-range water-reducing admixture on formwork pressure and thixotropy of self-consolidating concrete by Kamal H. Khayat and Joseph J. Assaad: An experimental program was undertaken to evaluate the effect of water- cementitious material ratio (w/cm) and type of high- range water-reducing admixture (HRWRA) on the development of formwork pressure that can be exerted when using self-consolidating concrete (SCC). Test results show that the variations in lateral pressure and thixotropy of SCC are significantly affected by the w/cm. Irrespective of the HRWRA type, mixtures proportioned with 0.46 w/cm exhibited greater initial pressure and lower thixotropy compared with mixtures made with a w/cm of 0.40 and 0.36. This is related to the higher water content and lower coarse aggregate volume in concrete proportioned with the higher w/cm, which can lead to a reduction in shear strength properties of the plastic concrete. The rate of pressure drop and increase in thixotropy with time, however, were greater in mixtures made with a higher w/cm. This is attributed to the lower HRWRA demand that can lead to sharper fluidity loss with time. For any given w/cm, the type of HRWRA appears to have a limited effect on initial lateral pressure. Compared with naphthaleneand melamine-based HRWRA, the use of polycarboxylate-based. HRWRA in SCC resulted in lower rate of pressure drop with time. This is reflected by the greater fluidity retention of the mixtures containing the polycarboxylate-based HRWRA. The incorporation of a water-reducing agent in mixtures made with polynaphthalene sulphonate- based HRWRA is shown to increase lateral pressure development of the plastic concrete over time.

1. MATERIALS

1.1. Cement:

Two types of cements were used during the experimental investigation:

1. Ordinary Portland Cement 53 grade (Brand: Ultra Tech) confirming to IS: 12269-1987 in case of control mix. The physical properties of the cement obtained on conducting appropriate tests as per IS:269/4831 and the requirements as per IS:12269-1987
2. Portland Pozzolana Cement 53 grade (Brand: Ultra Tech) confirming to IS 1489: 1991 (Part 1) in case of control mix is used

1.2. GGBS:

GGBS was brought from Ultra TECH Ready Mix Concrete plant. Properties of GGBS are as per specification.

1.3. Fine Aggregate:

Locally available clean river sand was sieve analyzed and tests for specific gravity were carried out. The fine aggregate used belongs to Grade II.

1.4. Coarse Aggregate:

Crushed granite of 20 mm maximum size and retained on IS: 480 sieves have been used as coarse aggregate; approximately 36.45% (390 kg/m^3) of coarse aggregate passing 20 mm sieve size and 63.55% (680 kg/m^3) of coarse aggregate passing 10 mm sieve size were combined to obtain coarse aggregate in the investigation. The sieve analysis of aggregate conforms to the specifications of IS 383:1970 for graded aggregates. Test results are given in Table below.

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Table- 1 properties of M-Sand and Course Aggregate

Properties	River Sand	Course Aggregate
Specific Gravity (SSD)	2.6	3.28
Water Absorption (%)	18.75 %	0.5 %
Fineness Modulus	2.71	7.56

1.1. Water:

Clean potable water was used for mixing and curing of concrete. Bore water from college campus good for drinking.

1.2. Admixture:

In this investigation three admixtures are used separately for each type of cement:

1. **Brand: GLENIUM™B233 Manufacturer: BASF**

   High-performance super plasticizer based on PCE for concrete

2. **Brand: K2 SELFPLAST PCE Manufacturer: Jay Chemicals**

   PCE based high strength super plasticizer

3. **Brand: Pidicrete CF HYPER (R) Manufacturer: Dr. Fixit**

Dosage for each admixture is taken as 0.9% by weight of the cementitious material.

4. CONCRETE MIX DESIGN

For the present work, concrete of M45 grade is adopted and the mix proportions of control mix concrete (without admixture) was obtained as per IS method out lined in IS 10262. Same mix proportions were also adopted for concrete with different PCE based water reducing admixture.

Calculations have been carried out and finally a mix proportion that gives required 28 days compressive strength with minimum cement content and required workability of 100 mm is selected.

Table- 2 OPTIMIZED MIX PROPORTION

(As per IS 10262-2009 Annex B)

Material		Quantities (kg/m^3)	Proportion
Cement		421	1
GGBS		66	0.157
Fine Aggregate		710	1.6865
Coarse Aggregate	20 mm	390	0.9264
	10 mm	680	1.6152
Water		166	0.34

4. TEST ON CONCRETE

4.1. Slump Test

The workability is measured using slump test. Unsupported concrete when it is fresh will flow to the sides and a sinking in height will takes place. This vertical settlement is known as slump. Slump is a measure indicating the consistency or workability of cement concrete it gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed and easily placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Segregation is said to occur when coarse aggregate tries to separate out from the finer material and contraction of coarse aggregate at one place occurs. This result in large voids, less durability and less strength. Bleeding of concrete occurs when the excess waters comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable. Slump increases with increase in W/ C ratio

Test is performed as per IS specifications and the values of slump with constant water/binder ratio for GGBS replaced concretes and GGBS replaced concretes by adding different admixtures are given in Table 3 & 4 The graph between slump value and time of concrete (GRCO & GRCP) and normal concretes are shown below. (Fig. 1)

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Table- 3 Slump value of concrete (OPC) with different water reducing admixture

Slump		At 0min	At 45min
Normal Concrete	NCO	0	0
	GRCO-B	180 mm	140 mm
Concrete (GRCO) with admixture	GRCO-J	178 mm	99.7 mm
	GRCO-D	165 mm	90.8 mm

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Over a period of 45 minutes, reduction in slump has taken place. Concrete with type 'B' admixture have lesser reduction in slump that is around 22.22%. Type 'B' admixture with OPC concrete imparts good initial slump value of 180 mm and the loss of slump is 40 mm after a period of 45minutes.

Whereas the loss of slump is high in case of type 'J' admixture & type 'D' admixture. The initial slump value by use of type 'J' admixture is 178mm and reduces to 99.7mm after 45minutes of retention. The loss of slump by type 'J' admixture is 44%. The initial slump value by use of type 'D' admixture is 165mm and reduces to 99.80mm after a period of 45minutes.The loss of slump by type 'D' admixture is 45%.

Concrete with type 'B' admixture have lesser reduction in slump that is around 23.27%. Type 'B' admixture with PPC concrete imparts good initial slump value of 202mm but the loss of slump is 47mm after a period of 45minutes.

Whereas the loss of slump is high in case of type 'J' admixture & type 'D' admixture with PPC concrete.

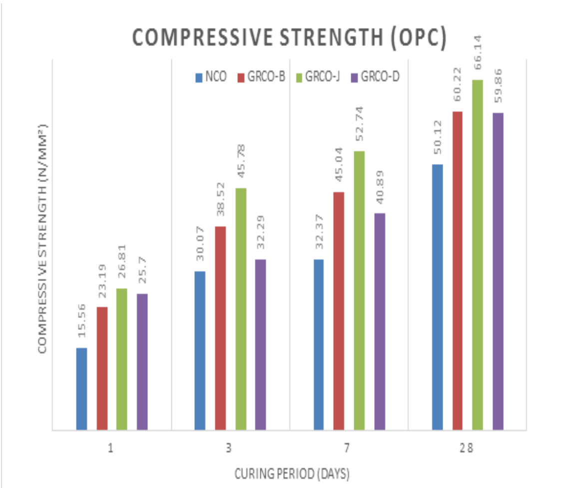
The initial slump value by use of type 'J' admixture is 200mm and reduces 110.4mm after 45minutes of retention. The loss of slump by type 'J' admixture is 44.8%.

The initial slump value by use of type 'D' admixture is 185mm and reduces to 100.3mm after a period of 45minutes.The loss of slump by type 'D' admixture is 45.78%.

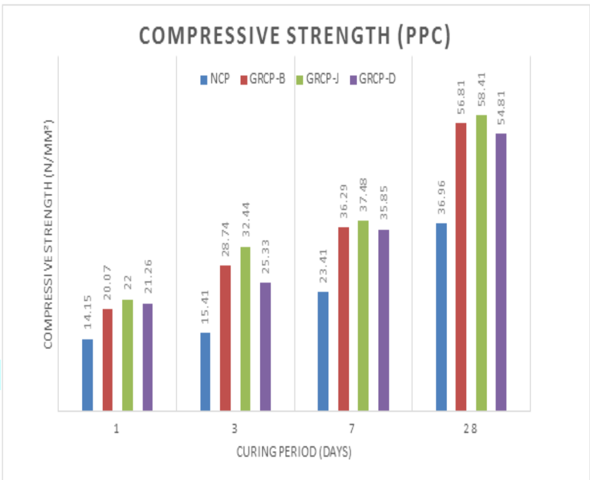
The slump retention after a period of 45minutes for PPC concrete is slightly higher than OPC concrete. By observing, there would be some variation of slump. Type of admixture also influences the workability of concrete after a period of time. One can also check the dosage of admixture to attain same workability and slump retention.

4.1. Compressive Strength Test

The compressive strength of concrete i.e. ultimate strength of concrete is defined as the load which causes failure of the specimen divided by the area of the cross section in uniaxial compression, under a given rate of loading. To avoid large variation in the results of compression test, a great care is taken during the casting of the test specimens and loading as well. It is however realized that in an actual structure, the concrete at any point is in a complex stress condition and not in uniaxial compression. However, it is customary to conduct the test in uniaxial compression only. Concrete under triaxial state can offer more resistance and will fail only after considerably large deformations. The use of 150mm cubes have been made as per IS code of practice IS 456. Compression testing machine is used to test the concrete cubes. Compressive strength of concrete is determined as per IS: 516-1959.



(a)



(b)

Fig. 2 Comparisons of strength 1, 3, 7 and 28 days of concrete with admixtures and normal concrete.

5. **Table 5 & 6 report the strength at different ages i.e. 1, 3, 7 and 28 days of concrete with three different types of admixture and normal concrete.**

Table- 5 Compressive strength of optimized Mix Concrete (OPC)

Sl. No.	Designation	1 Day	3 Days	7 Days	28 Days
1	NCO	15.56	30.07	36.37	50.12
2	GRCO-B	23.19	38.52	45.04	60.22
3	GRCO-J	26.81	45.78	52.74	66.14
4	GRCO-D	25.70	32.296	40.89	59.86

Table- 6 Compressive strength of optimized Mix Concrete (PPC)

Sl. No.	Designation	1 Day	3 Days	7 Days	28 Days
1	NCO	14.15	15.41	23.41	36.96
2	GRCO-B	20.07	28.74	36.296	56.81
3	GRCO-J	22.00	32.44	37.48	58.41
4	GRCO-D	21.26	25.33	35.85	54.81

(a)

The compression strength is calculated using the formula,

Compression strength= Load/Area (N/mm^2)
Comparisons of strength 1, 3, 7 and 28 days of concrete (OPC & PPC) added with PCE based admixture and normal concrete are shown in the **fig.2**

(a) & (b).

6. CONCLUSION

The present experimental investigation analyzed different super plasticizers (PCE) in combination with different cement types. Chemical admixture (PCE) performances were evaluated on M45 concrete, the following conclusions were drawn.

- Type B admixture gives good workability even after slump retention of 45min and can be used in places where very less loss of slump is required.
- Places where concrete with slightly less initial workability but good 1 day strength is required, type J admixture can be used.
- Loss of slump is slightly higher in PPC concrete than OPC concrete due to high surface area and more fineness.
- Type D admixture can be used in places where good 1 day strength is required.
- Loss of slump using type J and type D is high but the desired workability is achieved.

The concrete added with PCE based super plasticizers generally showed higher constancy in terms of performances and efficiency in terms of water reduction to attain the same initial workability in normal concrete without PCEs.

Compressive strength at 1 day, 3 days, 7 days and 28 days of PCE based concrete is higher than these collected in the case of normal concrete, independent of the cement type and admixture. Good correspondences between data collected on concrete can be evidenced.

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