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Experimental Study on Super Plasticizer and Water Based Curing Compound

P.Guruswamygoud[1], M.Rajasekhar[2], V.Madhukrishna[3], N.Vijayakumar[4], P.Anil[5]
Assistant Professor
Department of Civil Engineering
St.Martin's Engineering College, Dhulapally, Secunderabad.500100
Corresponding Author's E-mail:guruswamygoud@gmail.com

Abstract

This paper presents the results of an experimental research on the workability and compressive strength of ordinary and standard concrete. Superplasticizers are commonly known as High Range Water Reducers (HRWRs) because it permits low water cement ratio as well as the workability also affected. In this paper the properties of concrete mixtures with three different dosages of superplasticizers SNF have been investigated. In this experimental programme superplasticizerfosracconplast 430wp of basically modified naphthalene/melamine formaldehyde sulphonate dispersion and having brown liquid confirming to IS: 9103- 1999 & IS: 2645, ASTM C 494/C494M, Type F has been used. The properties investigated are workability on the fresh state and compressive strength on the hardened state of concrete by using three mixes with three superplasticizer dosages (0.8%, 1% ,1.5%and 2%) is used. concrete mix M-20 by IS 10262: 2009, Concrete Mix Proportioning - Guidelines. Compressive strength at 7, 14 and 28 days was also determined. The graphs between different percentage of superplasticizers with W/C ratio and compressive strength are plotted. Overall 16 specimens (concrete cube) with the dimension of 150 mm x 150 mm x 150 mm were fabricated at laboratory.

The effectiveness of water-based curing compound (WBCC) applied to concrete surface at different elapsed time from casting on the various properties of OPC, silica fume (SF) and fly ash (FA) concrete. It also signifies *the importance of utilizing moist curing prior to applying WBCC. A series of OPC cylindrical concrete specimens made with a constant water-binder ratio of 0.50 were prepared. For the first series, the casting surfaces were sprayed with WBCC after various elapsed periods from casting, 1, 2, 3, 4,24 hrs, while, for the second series, the casting surfaces were pre-cured with water for 1, 3 and 7days prior to the application of WBCC. The third and fourth series of samples were exposed to air and water curing regimes, respectively, until the age of testing (28 days). Various test techniques, namely strength, hardness, capillary absorption and porosity, were applied on the series of samples to assess their mechanical and durability related properties. It was found that the efficiency of WBCC is significantly dependent on the time of its application, used blending material, period of pre- water curing specified prior to its application and considered property of concrete. Increasing the time of application of WBCC from casting can lead to diminishing the possible positive effect of using such regime of curing*

Keywords: *Curing Compounds, Silica Fume, Sorpivity, Fly Ash, Microstructure of Concrete, Admixture Modified Poly Carboxylate Concrete, Compressive Strength, Superplasticizer, Water Cement ratio and Workability etc.*

INTRODUCTION

Concrete curing is defined as the process of maintaining satisfactory moisture in concrete during hydration and or pozzolanic reaction, so that the mechanical, microstructure and durability properties of the concrete are developed. Various in situ-curing methods are widely used and mainly divided into two groups, namely, water-adding techniques (e.g. ponding, spraying) and water-retaining techniques (e.g. plastic sheeting, membrane-forming curing compounds).

Water curing is undoubtedly the much preferred for most concrete construction projects. However, owing to restrictions encountered in situ and for certain concrete applications such as construction of highway pavements, canal lining, shell structures and high-rise buildings circumstances, curing compounds are judged to be more practical and economical. Also, in undeveloped areas, water taps are rarely available and trucking water in is expensive and difficult to supervise.

Various types of curing compounds are used nowadays in concrete industry; mainly include water-based, resin-solvent based, chlorinated rubber, wax-based, etc. Generally, water-based curing compound (WBCC) is considered as one of the most common-used curing compounds worldwide. Curing compounds are applied to the exposed surfaces of the fresh or hardened concrete as a liquid by either spraying or brushing or with roller, leaving a thin layer of coating that nearly seals the concrete surface against the evaporation of mixing water. This means that the early application of curing compounds can reduce the amount of moisture evaporated from concrete, and hence reducing the probability of occurrence of plastic shrinkage at concrete surface and in turn diminishing the amount of fine cracks.

Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregate those are added to the mix immediately before or during mixing. 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 admixtures are supplied in ready-to-use liquid form and are added to the concrete at the plant or at the jobsite. Certain admixtures, such as pigments, expansive agents, and pumping aids are used only in extremely small amounts and are usually batched by hand from premeasured containers.

The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and temperatures of the concrete and air. Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture-reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation.

TYPES OF CONCRETE ADMIXTURES

- Air-entraining admixtures

- Water-reducing admixtures
- Plasticizers
- Accelerating admixtures
- Retarding admixtures
- Hydration-control admixtures
- Corrosion inhibitors
- Shrinkage reducers
- Alkali-silica reactivity inhibitors
- Colouring admixtures
- Miscellaneous admixtures such as workability, bonding, damp proofing, permeability reducing, grouting, gas-forming, anti washout, foaming, and pumping admixtures

LITERATURE REVIEW

1. A review of cement–superplasticizer interactions and their models

Authors: M. Y. A. Mollah, W. J. Adams, R. Schennach, and D. L. Cocke

This paper presents a focused review of cement–superplasticizer interactions. It has been concluded from the survey of the literature that cement–superplasticizer interactions are generally preceded by the adsorption of superplasticizers on the hydrating cement particles. However, the mechanisms of such adsorptive interactions have not been adequately addressed experimentally or discussed in the literature. The reason for this appears to be the lack of a conceptual model that can delineate the results to date and project needed experiments. Phase growth in the hydrating cement is discussed in terms of the proposed model.

2. Effect of chemical structure of polycarboxylate-based superplasticizers on workability retention of self-compacting concrete

Author links open overlay panel Burak Felekoğlu, aHasan Sarıkahyab

In self-compacting concrete (SCC) mixture design, polycarboxylate-based superplasticizers (PC-based SPs) usually guarantee the initial workability. However, the time dependent workability of mixtures principally depends on the chemical structure of PC-based SPs and its compatibility with cement. PC-based SPs are the copolymers of chemical structures, which have the potential to be modified to improve their performances. In this study, three synthetic PC-based SPs were synthesized by using radical polymerisation techniques. The effect of these admixtures on setting time of cement pastes and time dependent workability and strength development of SCCs were investigated, respectively.

Test results showed that, from the viewpoint of chemical structure, workability retention performance of PC-based SPs could be manipulated by modifying the bond structure between main backbone and side- chain of copolymer. PC-based SPs with ester bonding was not effective in maintaining fresh concrete workability due to the alkali attack vulnerability of this bond structure.

3. Analysis of cement superplasticizers and grinding aids a literature survey

Ervanne, H.; Hakanen, M. Helsinki Univ.(Finland).Lab. of Radiochemistry) Posiva Oy, Helsinki (Finland)

This literature survey reviews the methods for analysis of cement plasticizers and organic grounding aids in cement solutions in preparation of grouts/concrete and methods for determination of plasticizers and grinding aids in groundwater conditions.

The survey focuses on three different types of superplasticizers: sulphonated naphthalene condensates, sulphonated melamine condensates and polycarboxylates. There are various organic grinding aids, such as alkanolamines, glycols or phenolic compounds, used in the cement industry. (orig.)

1) Increased Durability of Concrete Made with Fine Recycled Concrete Aggregates Using Superplasticizers

Francisco Cartuxo, Jorge De Brito,Luis Evangelista,José Ramón Jiménez 3, and Enrique F. Ledesma

This paper evaluates the influence of two superplasticizers (SP) on the durability properties of concrete made with fine recycled concrete aggregate (FRCA). For this purpose, three families of concrete were tested: concrete without SP, concrete made with a regular superplasticizer and concrete made with a high- performance superplasticizer. Five volumetric replacement ratios of natural sand by FRCA were tested: 0%, 10%, 30%, 50% and 100%. Two natural gravels were used as coarse aggregates. All mixes had the same particle size distribution, cement content and amount of superplasticizer. The w/c ratio was calibrated to obtain similar slump. The results showed that the incorporation of FRCA increased the water absorption by immersion, the water absorption by capillary action, Rheological behaviour of concrete made with fine recycled concrete aggregates.

– Influence of the superplasticizer

Author: F.CartuxoaJ., de BritoaL. Evangelistab, J.R.Jiménezc,, m E.F.Ledesmac

This paper evaluates the influence of two superplasticizers (SP) on the rheological behaviour of concrete made with fine recycled concrete aggregates (FRCA). Three families of concrete were tested: family C0 made without SP, family C1 made with a regular superplasticizer and family C2 made with a high- performance superplasticizer. Five replacement ratios of natural sand by FRCA were tested: 0%, 10%, 30%, 50% and 100%. The coarse aggregates were natural gravels. Three criteria were established to design the concrete mixes' composition: keep the same particle size distribution curves, adjust the water/cement ratio to obtain a similar slump and no pre-saturation of the FRCA. All mixes had the same cement and SP content. The results show that the incorporation of FRCA significantly increased the shrinkage and creep.

MATERIALS REQUIRED

1. **Cement:** 53 Grade ordinary Portland cement of coromandel king make conforming to IS: 12269 were used. The Specific gravity of the cement was 3.05. The initial and final setting times were found as 45 minutes and 10 hours respectively.

2. **Fine Aggregate:** Locally available river (Godavari river Karimnagar) sand passing through IS 4.75mm was used. The specific gravity of the sand is found to be 2.62

3. **Coarse Aggregate:** Crushed granite aggregate available from local sources has been used. The size of coarse aggregate is 20mm.

4. **Admixtures:**

1) FosrocConplast SP430 (Super Plasticizer):

Conplast SP430 is a chloride free, super plasticising admixture based on selected sulphonated napthalene polymers. It is supplied as a brown solution which instantly disperses in water. Conplast SP430 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained.

- Dosages outside the typical ranges quoted above may be used if necessary and suitable to meet particular mix requirements, provided that adequate supervision is available. Compliance with requirements must be accessed through trial mixes.

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Properties:

- Appearance: Brown liquid
- Specific gravity: Typically 1.20 at 20°C
- Chloride content: Nil to BS 5075
- Air entrainment: Typically less than 2% additional air is entrained at normal dosages.
- Alkali content: Typically less than 72.0 g. Na2 O equivalent/litre of admixture. A fact sheet on this subject is available.

2) FosracConcure WB (water based curing compound):

Concure WB is a white, low viscosity wax emulsion which incorporates a special alkali reactive emulsion breaking system. This system ensures that the emulsion breaks down to form a nonpenetrating continuous film immediately upon contact with a cementitious surface. This impervious film prevents excessive water evaporation which in turn permits more efficient cement hydration, thus reducing shrinkage and increasing durability.

Once formed, the membrane will remain on the concrete surface until eventually broken down and eroded by natural weathering. Where it is required to apply a further treatment to such concrete surface, it may be necessary to remove the membrane remaining after curing by wire brushing or other mechanical means. The use of curing membranes on internal floor slabs is generally to be avoided where additional surface finishes are to be applied. Concure WB is however ideal where the concrete surface of a floor slabs is to be left as 'finished'.

Properties

- Specific gravity: 1 to 1.01 g/cc.
- Colour: Bulk liquid White.
- Minimum application temperature: 10ºC.

CONCRETE MIX PROPORTION

For the performance analysis, three design mixes of M20 concrete grade with same water cement ratio 0.55 and superplasticizer dose of 0.8, 1.0,1.5 and 2 percentage of cement content required for mix of normal concrete are prepared. These mixes are casted in standard cement concrete cubes and tested in the college lab (i.e compressive strength test). These three mixes of SCC are abbreviated as A1, A2, A3 and A4 for further discussion and interpretation with respect to normal concrete (compacted artificially without addition of superplasticizer) being designated as A. The design proportion obtained for normal concrete mix using IS code practice for concrete mix design and are re-adjusted the same proportion for various Self-Compacting Concrete.

Concrete cubes are tested on 7th, 14th day and 28th day by Compressive strength test.

- A (normal concrete cubes of M20).
- A1 (concrete cubes of M20 with super plasticizer 0.8%).
- A2 (concrete cubes of M20 with super plasticizer 1%).
- A3 (concrete cubes of M20 with super plasticizer 1.5%).
- A4 (concrete cubes of M20 with super plasticizer 2%).

Total 16 cubes are tested in this project, so that we can suggest one of the preferable Percentages of super plasticizer in which workability and strength will be more.

Some of this Cubes are painted with water based curing compound (no curing is required for it and it attains same strength when compared to cubes that are cured). Super Plasticizer used is fosracconplast 430 DIS; we have calculated the quantities as per the proportions that we have mentioned.

This Water Based Curing Compound (WBCC) for concrete Cubes should be done at the periods of 1, 2,6,24 etc., So that hydration doesn't takes place and strength of cubes will become maximum i.e as per mix design and percentages as specified above.

Table 1 Concrete Mix Proportions

Trialmix	Water		Cement		Fine aggregate		Coarse aggregate		Superplasticizer	
	Proportion	Quantity (Liters)	Proportion	Quantity (Kg)	Proportion	Quantity (Kg)	Proportion	Quantity(Kg)	Proportion	Quantity (Liters)
A	0.45	2.6	1	5.52	1.5	9.2	3	16.67	0	0
A_1	0.43	2.5	1	5.52	1.5	9.2	3	16.67	0.8	45
A_2	0.42	2.4	1	5.52	1.5	9.2	3	16.67	1	55
A_3	0.4	2.3	1	5.52	1.5	9.2	3	16.76	1.5	65
A_4	0.38	2.2	1	5.52	1.5	9.2	3	16.76	2	85

PROPERTIES

Properties of Concrete Curing Compound

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There are 5 properties to deicide the quality of concrete curing compound namely

- Water retention
- Reflectance
- Drying period
- Long term setting
- Non-volatile matter Properties of materials are as follows:

Table 2 Properties of Cement

Teston Cement	Values
Specific Gravity	3.05
Fineness	3.34%
Consistency	33%
Initial Setting Time	45 min

Table 3 Properties of Fine Aggregate

Teston Fine aggregate	Values
Specific Gravity	2.63
Water absorption	1%
Gradation	ZoneI

Table 4 Properties of Coarse Aggregate

Teston Coarse aggregate	Values
Specific Gravity	2.63
Aggregate Impact Value	25.805%
Aggregate Crushing Values	29.54%
Aggregate Abrasion Value(Los Angeles)	5%

ADVANTAGES

- Major increases in strength at early ages without increased cement contents are of particular benefit in precast concrete, allowing earlier stripping times.

- Makes possible major reductions in water: cement ratio which allow the production of high strength concrete without excessive cement contents.

- Use in production of flowing concrete permits easier construction with quicker placing and compaction and reduced labour costs without increasing water content.

- Increased workability levels are maintained for longer than with ordinary sulphonated melamine admixtures.

- Improved cohesion and particle dispersion minimises segregation and bleeding and improves pumpability.

- Chloride free, safe for use in prestressed and reinforced concrete.

- In screed material, the lower water content leads to quicker drying times.

- Single application: Forms moisture barrier for whole of the curing period.

- No other curing necessary: Eliminates use of water, hessian or sand, completely.

- Reliable: No risk of erratic or poor curing and ensures that cement hydrates efficiently.

- Ensures hard-wearing surface: Minimises risk of drying shrinkage, cracks and dusty surfaces.

- Easy and safe spray application: Non-toxic and non-flammable.

- When properly applied, provides a premium-grade film, which optimizes water retention.

- Protects by reflecting the sun's rays to keep the concrete surface cooler and prevent excessive heat buildup, which can cause thermal cracking.

- Furnished as a ready-to-use, true water-based compound. Produces hard, dense concrete.

- Minimizes hair checking, thermal cracking, dusting and other defects.

Offers a compressive strength significantly greater than improperly or uncured concrete.

Improves resistance to the abrasion and corrosive actions of salts and chemicals minimizes shrinkage. at 1.5% of superplasticizer.

Table 5 Compressive Strength at 28th Day

SL.NO.	PERCENTAGE OF SUPERPLASTICIZER ADDED INTO THE NORMAL CONCRETE	COMPRESSIVE STRENGTH (N/mm^2)
1.	0% of superplasticizer	19.962
2.	0.8% of superplasticizer	28.177
3.	1% of superplasticizer	30.897
4.	1.5% of superplasticizer	35.040
5.	2% of superplasticizer	35.316

It was observed that the compressive strength of the concrete is increased by increasing the percentage of the superplasticizer within the recommended dosage i.e, 0.5 to 3.0 percentage of superplasticizer by weight of the cement beyond this dosage it cause decrease in strength. The 28 days compressive strength is maximum at 2% of superplasticizer. But there is not much variation of strength between 1.5%and 2%.

Slump Cone Test:

Table 6 Slump Cone Test

SL.NO	PERCENTAGE OF SUPERPLASTICIZER ADDED INTO THE NORMAL CONCRETE	SLUMP(mm)
1	0	95
2	0.8	125
3	1	130
4	1.5	140
5	2	170

It is observed that the slump value increases with increase in percentage of superplasticizer. Value of slump of superplasticized concrete varies from 95mm to 170mm, occurrence of segregation of concrete when we goes beyond the recommended dosage of superplasticizer (0.5 to 3.5%) hence 1.5% of superplasticizer where we got the optimum value of slump without any segregation

COMPACTION FACTOR TEST:

Table 7 Compaction Factor Test

SL.NO.	PERCENTAGEOFSUPERPLASTICIZERADDEDINTO THENORMALCONCRETE	COMPACTION FACTOR
1.	0%ofsuperplasticizer	0.880
2.	0.8%ofsuperplasticizer	0.898
3.	1%ofsuperplasticizer	0.903
4.	1.5%ofsuperplasticizer	0.913
5.	2%ofsuperplasticizer	0.922

It is observed that the compaction factor value increases with increase in percentage of superplasticizer. Value of compaction factor of super plasticized concrete varies from 0.898 to 0.960, occurrence of segregation of concrete when we goes beyond the recommended dosage of superplasticizer (0.5 to 3.5%)hence 1.5% of superplasticizer where we got the optimum value of compaction factor without any segregation.Vee – Bee is a good laboratory test. This is contrast to Compacting factor test where error may be introduced by tendancy of some dry mixes to stick in the hopper. This test determined workability of fresh concrete by using vee- bee consistometer apparatus.

Table 8 Vee – Bee Consistometer test

SL.NO.	PERCENTAGEOF SUPERPLASTICIZER ADDEDINTOTHENORMALCONCRETE	REQUIRED (INSEC.)
1.	0%ofsuperplasticizer	7.09
2.	0.8%ofsuperplasticizer	5.02
3.	1%ofsuperplasticizer	5.00
4.	1.5%ofsuperplasticizer	6.23
5.	2%ofsuperplasticizer	7

The results obtained from this test is the time required to level the concrete surface of a standard slump cone, so the time required for the different samples varies but for 1.5% of superplasticizer the time required is very less as compared with other samples.

CONCLUSIONS

- The workability of the concrete such as slump, compaction factor and vee-be degree increases with increase in percentage of superplasticizer (at 1.5%). The use of super plasticizer can significantly reduce the water requirement for workability in concrete. The amount of water reduction increase with the dosage of super plasticizer. However, slump loss with elapsed time is more rapid when the dosage of super plasticizer is higher and compaction factor and vee-bee values of super plasticized concrete are not significantly different from those of conventional concrete of the same consistency. This indicates that the tendency for segregation of fresh concrete is not affected by super plasticizers.

- The compressive strength of the concrete increases by 56.95% that to conventional concrete at 2.5% of superplasticizer added.

- At most of the construction sites, wet curing is often applied only intermittently so in practice curing compound may lead to better results.

- Where water curing is inconvenient or potable water for curing is not available, sealing fresh concrete surfaces with curing compound is the best way of curing.

- The higher the adsorption of the cement the greater is its initial slump.

- Conventional water curing is the most efficient method of curing as compared to Membrane curing, Self-curing, Wrapped curing and Dry air curing methods.

- Using Membrane curing and Self-Curing methods one can achieve 90% of efficiency as compared to Conventional Curing method. Self Curing method is most suitable for high-rise buildings especially in columns and inaccessible areas. Membrane curing compounds are most practical and widely used method it is most suitable in water scarce area.

- Wrapped curing is less efficient than Membrane curing and Self-Curing it can be applied to simple as well as complex shapes.

- Dry-Air curing should be avoided at the construction sites because designed design strength is not achieved by this method.

- The average efficiency of the curing compound increases with curing age initially by reduces at later age.

- Application of the curing compound is significantly dependent on the time of application of the compound. Curing of concrete is mostly governed by two parameters Temperature and Period

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