INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 01, January 2024, pp : 1-8

e-ISSN : 2583-1062

Impact Factor : 5.725

DEVELOPMENT IN THE PHYSICAL PROPERTIES OF CONCRETE BY USING DIFFERENT PERCENTAGE OF SUPERPLASTICIZER IN PREPARED MIXTURE

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ABSTRACT

In last few years, considerable attention has been given to the use of superplasticizer as a chemical admixture in cement concrete mixture. However, the use of chemical admixtures in cement concrete is a very common solution to achieve high performance concrete. The past researchers have been underlined the use of chemical admixtures imparts the desirable properties to the cement concrete in both fresh and hardened state. The Strength of cement concrete is a very important characteristic. This thesis investigated prior studies on the compressive strength and flexural strength of cement concrete as it relates to water-cement ratio, aggregate-cement ratio, aggregate size, quantity of admixture and compaction and compares those results with results obtained in laboratory experiments conducted on samples of cement concrete cube casted for this purpose. This thesis work has been made an attempt to study the influence of the superplasticizer dose of 0.5, 1, 1.5, 2 and 2.5 percentage on the performance of the cement concrete, by using superplasticizer we can reduce the water demand of concrete mix. This study utilizes the Conplast sp430 which is a superplasticizer; it is used in the concrete mix with variable quantity i.e. 500 ml – 2,500 ml per 100 kg of cement. The use of superplasticizer helps in reducing the utilization of water and it also increases the strength of the concrete. The use of superplasticizer also helps in preservation of the environment by saving the water. The main objective of this research is to determine that what percentage the superplasticizer can be used in the concrete mix to achieve its target mean strength. The experimental tests for fresh and hardened properties of concrete for M25 grade are studied and the results are compared with normal concrete. In this ongoing research work it is concentrated on the use of superplasticizer for reducing the water demand in the mix. A series of tests were carried out to determine the slump value, compressive strength and flexural strength with and without addition of superplasticizer, the result shows that the increase of superplasticizer dose in the cement concrete mixture leads to gain of good ability in addition to slump. Additionally, there is also slightly increase in the compressive strength as well as flexural strength than that of normal concrete. During the development of new generation product like concrete made with superplasticizer, it is essential to investigate the properties of fresh and hardened concrete to encourage and escalate its application in the civil engineering construction industry. This research investigates the properties of fresh and hardened concrete made with different quantity utilized of superplasticizer in concrete mix.

1. INTRODUCTION

1.1 General

Construction developments are on their peak level in the 21st century round the globe. There are number of skyscrapers, roads, dams, bridges, underground tunnels and under water structures all over the world. The old days when it was very difficult to talk about the advantages of using admixtures have passed. It is now fairly clear that admixtures can both solve technical problems and save substantial cost also by increasing the strength of concrete and reducing the water demand. However, they also have the potential to generate technical problems if not correctly selected or used. According to (Neville A.M., 1994), several benefits are obtainable through the use of admixtures, such as improved quality, retardation or acceleration of setting time, coloring, improved concrete strength, increased flowability for the same water/cement ratio, better frost and sulfate resistance, improved fire resistance, improved workability, cracking control and superior finishability. The specific effects of an admixture usually vary with the type of cement, mix proportion, special conditions (particularly temperature) and dosage (Irving Kett).

In the construction industry a lot of admixtures are used for different purposes to improve different desirable properties of cement concrete. Generally, admixtures are classified in to two groups:-

- Mineral
- Chemical admixtures.

Water reducing admixture is one type of chemical admixture which provide a wide range of benefits for concrete in the fresh and hardened sates. Different water reducing admixtures can be easily available in the market; from those admixtures high range water reducing admixture also known as superplasticizer, type F is the main type of admixture which provide a lot of improvement in the properties of the for concrete properties. This admixture is produced in our country as the name mega flow SP1 and SP4, which has a capacity to improve the workability, compressive strength and permeability of concrete. Though, in our country researches and investigation are not yet done on admixtures. Consequently, this research has investigated some benefits which are obtained by the use of superplasticizing admixture as an additional construction material. In order to show the effects of superplasticizing admixture on the concrete properties, such as: workability, strength and permeability, laboratory experimentations were performed by adding dosages of 0%, 0.5%, 1% and 1.5% superplasticizing admixture in the concrete mixes prepared by used and virgin aggregate with four stages and results are determined. Then, based on the experimental results the conclusions are drawn and recommendations have been forwarded.

Cement concrete has low tensile strength, and hence, this is the main reason why it is used with steel bar (reinforcement) to resist any tensile forces in the Reinforced Cement Concrete (RCC). On the other hand, cement concrete is usually used in building construction for foundation work, columns, beams and slabs construction, in shell structures, bridges, sewerage treatment plants (STP), roads, electric polls, cooling towers, railway sleepers and so on. In precast concrete industry, cement concrete is broadly used as concrete blocks, shell panels, pipes, piles and electric lamp posts (Jackson, N.; and Dhir R.K. (Eds.). 1996).

At the present time, more than 70 percent of in-situ cement concrete in the world is produced by the ready mixed concrete (RMC) industry. The ready mixed concrete (RMC) producers are using a superplasticizer (SP) admixture which is easily available from various manufacturers. Superplasticizer (SP) is used to increase the workability without changing the water/cement (W/C) ratio. Or, it can be used to increase the ultimate strength of the cement concrete by reducing the water content while maintaining the sufficient workability.

Superplasticizer is a type of water reducing admixture; however, the difference between the superplasticizer and water reducer is that superplasticizer will significantly reduce the water required for cement concrete mixing (Neville A.M, 2005).

Usage of superplasticizer becomes very popular these days since it possesses advantages for both fresh state concrete and hardened state concrete. The utilization of superplasticizer will have positive effects on the properties of cement concrete, both in the fresh and hardened states (Yamakawa C., Kishitani K., Fukushi I. and Kuroha K., 1990). In the fresh state concrete, utilization of the superplasticizer will in general reduces the tendency to the bleeding due to the reduction in water/cement ratio or water content of the cement concrete mix. On the other hand, if W/C ratio is maintained, there is tendency that superplasticizer will extend the time of set of concrete mix as more water is available to lubricate the mixture. In case of the hardened concrete the use of superplasticizer will increase the compressive strength by enhancing the effectiveness of the compaction of the mix to produce denser concrete. Risk of drying shrinkage will be reduced by maintaining the cement concrete in liquid state for longer period of time. In addition, the rate of carbonation becomes the slower when water/cement ratio is decreased with the presence of superplasticizer in the mix (Yamakawa C., Kishitani K., Fukushi I. and Kuroha K., 1990).

Effects of superplasticizer are very obvious, i.e. to produce cement concrete with a very high workability or cement concrete with a very high strength. Mechanism of superplasticizer is all the way through giving the cement particles highly negative charge so that they can repel each other due to the same electrostatic charge. By deflocculating the cement particles, more water is provided for cement concrete mixing (Neville A.M, 2005). For common usage, dosage of superplasticizer is used in the range between 1 to 3 l/m3. Though, the dosage can be increased to as high as 5 to 20 l/m3. Since concentration of superplasticizer is different, any comparison of performance should be made on the basis of the amount of solids, and not on the total mass of the mix. Usefulness of a given dosage of superplasticizer depends on the W / C ratio. Effectiveness increases when water/cement ratio decreases. Compatibility with actual binding material i.e. cement is one of the most significant parameters that required to be into consideration, and it’s not recommended that the cement and superplasticizer conform the standard independently (Neville A.M, 2005).

1.2 Objective Of This Thesis

The foremost objective of this thesis is to develop a sustainable and eco friendly solution for producing ready mix concrete by using superplasticizer i.e. conplast sp430. This study is targeted to produce a durable concrete that is acceptable in its all fresh and hardened properties. This research work is conducted to achieve the following objectives:

1- Comparative study of the fresh and hardened properties of the cement concrete with different percentage of superplasticizer i.e. conplast sp430 in the cement concrete mix.

2- Investigate the potential of superplasticizer i.e. a water reducing admixture in the cement concrete mix.

3- Investigate the various properties of new concrete mix like workability, compressive strength and flexural strength.

4- Determination of the best suitable mix for the higher desirable properties.

1.3 Superplasticizer

Superplasticizing admixture is a type of high range water reducing chemical admixture, which have a capacity of reducing the mixing water up to 35%. This type of admixture will provide high quality development or improvement for concrete in both fresh and hardened states. Generally, superplasticizing admixtures improve the workability, compressive strength, flexural strength and permeability of the concrete (28) (Steven Kosmatka H., 2003).

Therefore, the main discussion of this chapter focus on reviewing the admixtures, particularly on superplasticizing admixture used to produce a quality concrete.

Several chemical admixtures can be applied to pervious concrete to obtain special properties, including retarders, hydration-stabilizing admixture, water-reducing admixture and air-entraining admixture. These admixtures are also used for the same reasons in conventional concrete. For example, retarders are used to stabilise and control cement hydration, and an air-entraining admixture is used for freeze–thaw durability. ACI recommended that accelerators should be used for cold weather, and a retarding admixture should be used for hot weather.

2. LITERATURE REVIEW

In this chapter, we discussed previous researches regarding Cement concrete prepared with superplasticizer (water reducing admixture) characteristics and the influences of these materials on properties of fresh as well as hardened concrete.

Concrete admixtures perform specific properties on fresh and hardened concrete; admixtures are natural minerals and chemical additives to enhancethe consistency and performance of hardened concrete.The paper investigated the performance of super-plasticisersmixed with combine supplementary cementitious materials (SCM) partly replaced cement in concrete production. The research works used the chemical admixture conplast SP430 and mineral admixtures of ground granulated blast furnace slag (GGBFS), metakaolin (MK) and partly cement to produce concretes at 0, 30, 40, 50, 60% and addition of 1.5% conplast SP430 respectively by weight of cement. Concrete mix ratio of 1: 1: 2, water/ cement ratio 0.4 added to the mix. The study produced 48 numbers of 150 x 150 x 150 mm cubes and 36 numbers of beam size 100 x 100 x 450 mm tested at 7, 14, 28 and 60 days curing period to determine the workability, density, compressive and flexural strength of the concrete.The slump test carried out on the freshly mixed concrete due to the addition of conplast SP430showed plastic consistency ofMB, MC, MD,and MEresultedin slump ranges between 50- 85 mm of medium workability while the control MA was a stiff concrete and low in workability of 30 mm slump. The compressive strength performed on the hardened concrete mixed with 1.5% conplast SP430 at 28 days, MB 22.9%, MC and MD proportioned with supplementary cementitious materials resulted in 45.9 and 33.3% increase over MA the control without conplast SP430. The flexural strength tested on the beam samples MB, MC and MD resulted in 5.5, 17.1 and 10.5% increase over the control MA without conplast SP430 at 28 days. The study revealed that conplast SP430 enhanced the fluidity, improved the consistency and workability of the concrete and enhance the proportioned combine supplementary cemetitious materials in attainment of high strength of the concrete products Olaleye, 2Olaleye, 2021.

Different types of cement and super plasticizer are available in the market, even though the cements and super plasticizers complied with the respective code of practice, their performance are not the same in concrete, even if quality and source of other ingredients are kept constant. This has created a lot of problem among the users about what type of super plasticizers to be used with what type of cement and what optimum dosage of super –plasticizer should be added. Consequently, this study involves the application of Conplast SP 430 Superplasticizer on three different cement brands in northern part of Nigeria. The same Grade 42.5N of the three cements were selected and coded as NB, ND, and NS respectively. American concrete Institute (ACI) method of mix design was used to obtain the required proportion of the constituent materials for 30N/mm2produced for the study. The study was limited to fresh properties (unit weight and slump test) and hardened properties (density, water absorption and compressive strength test). All the three cements indicated an improvement for the performances studied Nasir Kabir, Aminu Sallau and Adamu Umar Chinade, 2019. The purpose of this study is in the consideration of using CONPLAST SP430 superplasticizer upon attainment of desirable strength of concrete and optimizing same for highway pavement using four different new types of cement produced in Nigeria. In the facet, one normal cement type tagged 42.5Np and three rapid cement types tagged 42.5Rd, 32.5Rs and 32.5Rt were individually mixed with granites, sand and water plus CONPLAST SP430 superplasticizer for the production highway cement concrete pavement. Individual mixture was at a very low water-cementitious material ratio (w/cm) of 0.32 and concrete mix ratio of 1:1.5:3. Cement tests included specific gravity, fineness, consistency, setting time, chemical and metallic compositions. Tests carried out on the fine and coarse aggregates used included particle size distribution, specific gravity, chemical and metallic compositions. Laboratory tests that were also carried out on the coarse aggregate included crushing, impact and abrasion. Tests carried out on fresh concrete included slump and compaction factor while those on hardened concrete were compressive, tensile splitting and flexural strengths. At 28 days curing age, each of the compressive strength value for the concrete specimens produced based upon the four cements used are respectively 26.67 N/mm2 , 25.63 N/mm2 , 25.56 N/mm2 and 25.11 N/mm2 . The concrete specimens' tensile splitting strength values are respectively 2.78 N/mm2 , 2.48 N/mm2 , 2.10 N/mm2 and 1.89 N/mm2 while that of the flexural strength amounts are respectively 5.274 N/mm2 , 4.208 N/mm2 , 4.208 N/mm2 and 3.496 N/mm2 for the cements used. The significance of this study is that although the required compressive and tensile splitting strength values are not satisfied, the flexural strength value is satisfactory for highway pavement only by cement tagged 42.5Np. The justification for this research is in identifying the newly Nigerian made cement among the readily available ones to produce enhanced concrete at a cheaper economy and satisfying the required standard strength specification for highway pavement design and its construction Isaac Akiije, 2017.

Cement concrete prepared with admixture has in recent times become very attractive to the civil engineers and material scientists. As it demonstrates higher workability, better mechanical properties and improved durability, these concrete mixes has been gradually more applied in the civil engineering constructions such as tall building, off-shore structures and bridges (Aitcin, P. C. and B. Miao, 1992). One most important chemical admixture in preparing the High Performance Concrete is superplasticizer. The most significant improvement in the concrete technology during the past 30 years has been the use of superplasticizers. However, the reason that superplasticizers are much more important than any other chemical admixture is the number of improvements, which can be achieve by its use. However, the reason for widespread usage of admixtures is that admixtures are able to impart considerable physical and economic benefits with respect to concrete. However, usage of admixture is not remedy for poor quality of concrete due to the use of incorrect mix proportion, poor workmanship in concrete mixing and the problems caused by low quality raw materials selection. According to (Fukuda K., Mizunuma T., Izumi T., Iizuka M., Hisaka M.M., 1990, Tanaka M., Matsuo S., Ohta A. and Veda M., 1996), advances in superplasticizers, containing alternative water soluble synthetic products, have been proposed in the been proposed in the last decade to reduce the slump-loss drawback which can partly or completely cancel the initial technical advantage associated with the use of superplasticizers (low w/c ratio or high slump level).

An admixture, according to the ASTM C-125-97a standards, is a material other than water, aggregates or hydraulic cement that is used as an ingredient of concrete or mortar, and is added to the batch immediately before or during mixing. A material such as a grinding aid added to cement during its manufacture is termed an additive (Ramachandran, C. K., Hignite, C. E., Gray, S. L. & Melnykovych, 1981).

According to Yamakawa, the utilization of superplasticizer will have positive effects on properties of concrete, both in the fresh and hardened states.

However, if water/ cement ratio is maintained, there is tendency that superplasticizer will prolong the time of set of concrete as more water is available to lubricate the mix. In the case of hardened concrete, (Yamakawa C., Kishitani K., Fukushi I. and Kuroha K., 1990) highlighted that the use of superplasticizer will increase compressive strength by enhancing the effectiveness of compaction to produce denser concrete. Risk of drying shrinkage will be reduced by retaining the concrete in liquid state for longer period of time. In addition, rate of carbonation become slower when water/ cement ratio is decreased with the presence of superplasticizer.

3. MATERIALS USED

3.0 Introduction

This Chapter provides detailed information about the materials and test procedures used to achieve the objectives of this thesis research work. The mixtures of cement concrete require careful analysis of aggregate size distribution and properties for a road paving material to be capable of bearing the expected loads. This research approach examined with multiple mixes prepared by different aggregate sizes, water/cement ratios and varying quantity of admixtures.

The main objective of this study is to perform the experimental study to investigate the properties of concretes produced with superplasticizer i.e. Conplast sp430 and varying W/C ratios and comparison of them with conventional concrete prepared without superplasticizer i.e. Conplast sp430. During the experimental work, different concrete samples with variable percentages of superplasticizer i.e. Conplast sp430 and varying W/C ratios in mix designs were investigated by different ages (7 days and 28 days).

3.1 Preparation

Various test specimens were prepared to determine the slump value, compressive strength, split tensile strength and other properties of the concrete mix. The data is the reference of the study experiment that has to be done. Experiments needed to be done to achieve the objectives given are sieve analysis, specific gravity, water absorption, Aggregate Impact Value and crushing strength of aggregate.

3.2 Material Used

1- Ordinary Portland Cement (OPC)
2- Fine Aggregate
3- Coarse Aggregate
4- Superplasticizer
5- Potable Water

4. ANALYSIS OF RESULTS

Series of the tests were carried out on the prepared samples with various mixes i.e. variable percentage (0.5%, 1.0% and 1.5%)of superplasticizer i. e. Conplast SP430 in the cement concrete mixtures. The tests conducted were compressive strength, split tensile strength and flexural strength of concrete mixes. The obtain results are given in the Table below.

4.1 Compressive Strength Test Results

The laboratory test results are presented below in the tabular form for different mixes with variable percentage of superplasticizer in the mixtures.

Table-1 Test Results of Compressive Strength of Mix-I

S. No.	Quantity of Superplasticizer in the mix (%)	Compressive strength at 7 days (Kg/cm^2)	Compressive strength at 28 days (Kg/cm^2)
1	0	21.08	31.80
2		21.39	30.55
3		21.70	30.75

Table-2 Test Results of Compressive Strength of Mix-II

S. No.	Quantity of Superplasticizer in the mix (%)	Compressive strength at 7 days (Kg/cm^2)	Compressive strength at 28 days (Kg/cm^2)
1	0.5	21.95	32.25
2		22.25	31.25
3		22.30	31.15

Table-3 Test Results of Compressive Strength of Mix-III

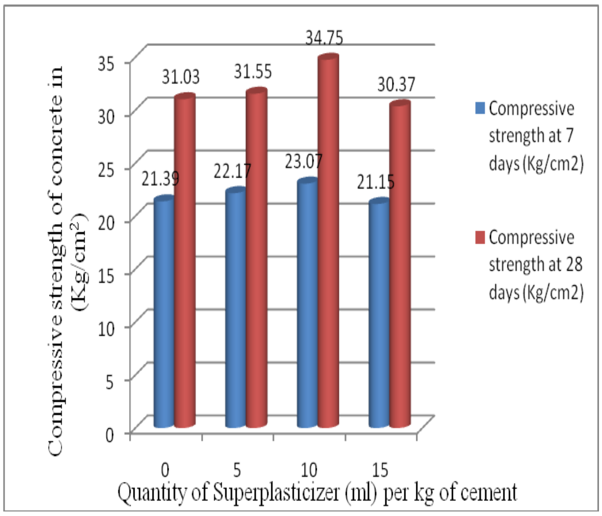
S. No.	Quantity of Superplasticizer in the mix (%)	Compressive strength at 7 days (Kg/cm^2)	Compressive strength at 28 days (Kg/cm^2)
1	1.0	22.80	34.95
2		23.15	34.75
3		23.25	34.55

Table-4 Test Results of Compressive Strength of Mix-IV

S. No.	Quantity of Superplasticizer in the mix (%)	Compressive strength at 7 days (Kg/cm^2)	Compressive strength at 28 days (Kg/cm^2)
1	1.5	20.95	30.65
2		21.65	30.05
3		20.85	30.40

Table-5 Test Results of Compressive Strength of All The Mixes (Prepared With Superplasticizer)

S. No.	Quantity of Superplasticizer in the mix (%)	Compressive strength at 7 days (Kg/cm^2)	Compressive strength at 28 days (Kg/cm^2)
1	0	21.39	31.03
2	5	22.17	31.55
3	10	23.07	34.75
4	15	21.15	30.37



Graph-1 Test Results of Compressive Strength of All The Mixes Prepared With Variable Quantity of Superplasticizer

After comparing all these test results we found that when we add 1.0 % Superplasticizer in the mix the results of compressive strength at 7 days shows approximately 8 % increment in compressive strength and at 28 days shows 12 % increment in compressive strength.

4.2 Flexural Strength Test Results

The laboratory test results are presented below in the tabular form for different mixes with variable percentage of Superplasticizer i.e. Conplast SP430.

Table-6 Test Results of Flexural Strength of Mix-I

S. No.	Quantity of Superplasticizer in the mix (%)	Flexural strength after 7 days (Kg/cm^2)	Flexural strength after 28 days (Kg/cm^2)
1	0	3.90	4.88
2		3.91	5.22
3		4.10	5.78

Table-7 Test Results of Flexural Strength of Mix-II

S. No.	Quantity of Superplasticizer in the mix (%)	Flexural strength after 7 days (Kg/cm^2)	Flexural strength after 28 days (Kg/cm^2)
1	0.5	3.95	5.90
2		4.05	5.96
3		4.15	5.88

Table-8 Test Results of Flexural Strength of Mix-III

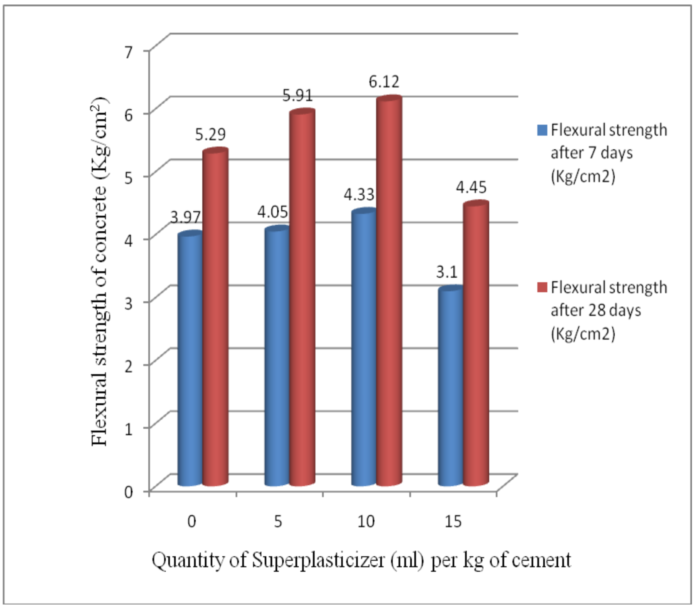
S. No.	Quantity of Superplasticizer in the mix (%)	Flexural strength after 7 days (Kg/cm^2)	Flexural strength after 28 days (Kg/cm^2)
1	1.0	4.25	5.95
2		4.35	6.25
3		4.40	6.15

Table-9 Test Results of Flexural Strength of Mix-IV

S. No.	Quantity of Superplasticizer in the mix (%)	Flexural strength after 7 days (Kg/cm^2)	Flexural strength after 28 days (Kg/cm^2)
1	1.5	3.15	4.75
2		2.95	4.25
3		3.20	4.35

Table-10 Test Results of Flexural Strength of All The Mixes (Prepared With Superplasticizer)

S. No.	Quantity of Superplasticizer in the mix (%)	Flexural strength after 7 days (Kg/cm^2)	Flexural strength after 28 days (Kg/cm^2)
1	0	3.97	5.29
2	0.5	4.05	5.91
3	1.0	4.33	6.12
4	1.5	3.10	4.45



Graph-2 Test Results of Flexural Strength of All The Mixes Prepared With Variable Percentage of Superplasticizer.

After comparing all these results we can say that lime Conplast SP430 increases the Flexural Strength of a concrete mix up to 9.06 % at 7 days and 15.68 % 28 days respectively till certain limit but after that range it starts reducing its strength.

5. DISCUSSION AND CONCLUSION

The prime objective of this thesis research work was to understand the effect of addition of Superplasticizer (Conplast SP430) in the cement concrete mixtures. In this experimental study we determine the best composition of the cement concrete mix prepared with appropriate quantity of Superplasticizer (Conplast SP430). For determination of compressive strength, split tensile strength and flexural strength of the various mix prepared with variable percentage of Superplasticizer (Conplast SP430). These are the following conclusions of this research.

1- By this experimental research we found that the compressive strength of cement concrete can be increase up to 8 % at 7 days curing and 12 % at 28 days curing with use of 1.0 % Superplasticizer (Conplast SP430) in the concrete mixture.

2- By these test results we can say that addition of Superplasticizer i.e. Conplast SP430 in the cement concrete mixture can be a useful material in civil engineering construction work.

3- By this research we can save lots of water and it will be great for environment.

4- The results for flexural strength test are 16.23 % and 16.86 % increment respectively for 7 days and 28 days curing by adding 1.0 % Superplasticizer (Conplast SP430) in the concrete mixture.

Vol. 04, Issue 01, January 2024, pp : 1-8

e-ISSN : 2583-1062

Impact Factor : 5.725

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