EXPERIMENTAL INVESTIGATION ON HIGH PERFORMANCE CONCRETE WITH SASplast SP60

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Abstract - *Super plasticizers are generally used as high water reducing admixture in concrete production. In this project, we are going to carry out test on concrete strength by using this super plasticizer in order to get high performance concrete. According to various research papers, it has been found that Super plasticizer give the maximum strength than the use of silica fume and improving materials. Now a days there exists many techniques for improving the strength of concrete materials which produce more load carrying capacity and durability. High performance concrete has been successfully used in slabs on grade, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications. The usefulness of high performance concrete in various Civil Engineering applications is thus indisputable. This review study is a trial of giving some highlights for production of high performance concrete.*

Key Words: Super plasticizer, High Performance, Durability, Seismic regions, Barriers.

1. INTRODUCTION

One of the important widely used artificial engineering materials is concrete. Concrete is a building material made from mixture of broken stone or gravel, sand cement and water which can be spread or poured in to molds and forms a mass resembling stone on hardening. Concrete has been since long a major material for providing a stable and reliable infrastructure. Concrete with compressive strengths of 20 -40N/mm^2 has been traditionally used in construction projects. With the higher requirement for more sophisticated structural forms along with deterioration , long term poor performance of conventional concrete demanded accelerated research for development of concrete which would score on all the aspects that a new construction material is evaluated upon : strength, workability, durability, affordability and will thus enable the construction of sustainable and economic buildings with an extraordinary architectural design besides providing a material that will have long term better performance and reduced maintenance.

The development of high performance concrete in this regard has been a great land mark in concrete technology. ACI defines High Performance Concrete as ―Concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing and curing practices‖. Important governing factors for High Performance Concretes are strength, long term durability, serviceability as determined by crack and deflection control, as well as response to long term environmental effects.

Typical classifications of concrete are the following:-

- Normal strength concrete:- 20-50Mpa
- High strength concrete:- 50-100Mpa
- Ultra high strength concrete:-100-150Mpa
- Especial concrete >150Mpa

Admixtures are defined as additions made as the concrete mix. There are both chemical and mineral admixtures. Some of the examples of mineral admixtures are fly ash and silica fumes.as for the chemical admixtures such as super plasticizer increase concrete strength by reducing the mixing water requirement for constant slump and by dispersing cement particles with or without a change in mixing water content. As for our project the type of plasticizer used is SASplast SP60.Objective of this study is to obtain high performance concrete, to reduce the overall cost of the project and to reduce environmental impacts of concrete.

2. LITERATURE REVIEW

High-Performance-Concrete (HPC) has been defined as concrete that possesses high workability, high strength and high durability. ACI (American Concrete Institute) has defined HPC as a concrete in which certain characteristics are developed for a particular application and environment. Under the ACI definition durability is optional and this has led to a number of HPC structures, which should theoretically have had very long services lives, exhibiting durability associated distress early in their lives. ACI also defines a high-strength concrete as concrete that has a specified compressive strength for design of 6,000 psi (41 MPa) or greater. The American Concrete Committee on HPC includes the following six criteria for material selections, mixing, placing, and curing procedures for concrete.

- Ease of placement
- Long term mechanical properties
- Early-age strength
- Toughness
- Life in severe environments
- Volumetric stability

A mix of high performance concrete was described by Ozawa et al. (1990), which is defined as a concrete with high filling capacity. It can be filled into all the corners of formwork without using any vibrators.

(1)Mehta and Aitcin (1990) suggested the term High-Performance-Concrete (HPC) for concrete mixtures that possess the following three properties: high-workability, high-strength, and high durability. Durability rather than high strength appears to be the principal characteristic for high-performance concrete mixtures being developed for use in hostile environments such as seafloor tunnels, offshore and coastal marine structures, and confinement for solid and liquid wastes containing hazardous materials. Strength, dimensional stability, impermeability, and high workability are usually the principal characteristics required of high-performance concrete.

The meaning of HPC, (2) Aitcin and Neville (1993) stated that "in practical application of this type of concrete, the emphasis has in many cases gradually shifted from the compressive strength to other properties of the material, such as a high modulus of elasticity, high density, low permeability, and resistance to some forms of attack.

HPC was defined by (3) Forster (1994) as "a concrete made with appropriate materials combined according to a selected mix design and properly mixed, transported, placed, consolidated, and cured so that the resulting concrete will give excellent performance in the structure in which it will be exposed, and with the loads to which it will be subjected for its design life.

The Federal Highway Administration (FHWA) has proposed criteria for four different performance grades of HPC (Good speed et al., 1996). The criteria are expressed in terms of eight performance characteristics including strength, elasticity, freezing/thawing durability, chloride permeability, abrasion resistance, scaling resistance, shrinkage, and creep. Depending on a specific application, a given HPC may require different grade of performance for each performance characteristics.

(4) Nima Farzadni et al. (2011) say that with a fast population growth and a higher demand for housing and infrastructure, accompanied by recent developments in civil engineering, such as high-rise buildings and long-span bridges, higher compressive strength concrete is needed. Currently, high-performance concrete is used in massive volumes due to its technical and economic advantages. Such materials are characterized by improved mechanical and durability properties resulting from the use of chemical and mineral admixtures as well as specialized production processes.

R .N. Swamy a High Performance concrete element is that which is designed to give optimized performance characteristics for a given set of load, usage and exposure conditions, consistent with requirement of cost, service life and durability. High Performance concrete has (a) Very low porosity through a tight and refined pore structure of the cement paste. (b) Very low permeability of the concrete (c) High resistance to chemical attack. (d) Low heat of hydration (e) High early strength and continued strength development (f) High workability and control of slump (g) Low water binder ratio (h) Low bleeding and plastic shrinkage.

3. MATERIALS AND PROPERTIES

The main ingredients of HPC are almost the same as that of conventional concrete. They are

i. Cement
ii. Coarse aggregate
iii. Fine aggregate
iv. Chemical admixtures (plasticizers, super plasticizers, retarders, air-entraining agents)
v. Mineral admixtures (fine filler and/or pozzolonic supplementary cementations materials)
vi. Water

3.1 Cement

The two important requirements for any cement are strength development with time and facilitating appropriate rheological characteristics when fresh. Studies made by Perenchio (1973) and Hanna et al. (1989) have led to the following observations.

a. High C3A content in cement generally leads to a rapid loss of flow in fresh concrete. Therefore, high C3A content should be avoided in cements used for HPC.
b. The total amount of soluble sulphate present in cement is a fundamental consideration for the suitability of cement for HPC.
c. The fineness of cement is the critical parameter. Increasing fineness increases early strength development, but may lead to rheological deficiency
d. The super plasticizer used in HPC should have long molecular chain in which the sulphonate group occupies the beta position in the poly condensate of formaldehyde and melamine sulphonate or that of naphthalene sulphonate.
e. The compatibility of cement with retarders, if used, is an important requirement.

Aggregates

The properties of the aggregate are decisive for the compressive strength and modulus of elasticity of HSC. In normal strength concrete (NSC); the aggregate has a higher strength and stiffness than the cement paste. Failures in NSC are characterized by fractures in the cement paste and in the transition zone between paste and aggregate. Reduced water-cement ratio, therefore, causes a great improvement in compressive strength of cement paste and hence of concrete.

3.2 Coarse Aggregate

In HSC the capacity of the aggregate can be the limiting factor. This may be either the result of the aggregate being weaker than the low water-cement matrix, or alternatively it is not sufficiently strong and rigid to provide the strengthening effect. This is mainly related to the coarse aggregate (CA).For optimum compressive strength with high cement content and low water-cement ratios the maximum size of CA should be kept to a minimum, at ½ in. or 3/8 in. The strength increases were caused by the reduction in average bond stress due to the increased surface area of the individual aggregate. Smaller aggregate sizes are also considered to produce higher concrete strengths because of less severe concentrations of stress around the particles, which are caused by differences between the elastic moduli of the paste and the aggregate.

3.3 Fine Aggregate

Fine aggregates (FA) with a rounded particle shape and smooth texture have been found to require less mixing water in concrete and for this reason are preferable in HSC. HSC typically contain such high contents of fine cementations materials that the grading of the FA used is relatively unimportant. However, it is sometimes helpful to increase the fineness modulus (FM) as the lower FM of FA can give the concrete a sticky consistency (i.e. making concrete difficult to compact) and less workable fresh concrete with a greater water demand. Therefore, sand with a FM of about 3.0 is usually preferred for HSC (ACI 363R, 1992).

Table -1: Specific Gravity of Fine Aggregate

Description	Sample 1(Grams)	Sample 2(Grams)
Weight of pycnometer (w1)	106	140.76
Weight of pycnometer + Sample (w2)	231	263.76
Weight of pycnometer+ Sample+ Water (w3)	676	715
Weight of pycnometer + Water (w4)	602	638
Weight of sample (w2-w1)	125	125
(w3-w4)	74	77
Specific Gravity	2.451 g/cm^3	2.604 g/cm^3
Average Specific Gravity	2.527 g/cm^3	

Admixtures

Admixtures are widely used in the production of HSC. These materials include air-entraining agents and chemical and mineral admixtures. Significant increases in compressive strength, control of rate of hardening, accelerated strength gain, improved workability, and durability are contributions that can be expected from the admixture or admixtures chosen. Reliable performance on previous work should be considered during the selection process.

3.4 Chemical admixtures

Chemical admixtures such as super plasticizers (high–range water reducer) increase concrete strength by reducing the mixing water requirement for a constant slump, and by dispersing cement particles, with or without a change in mixing water content, permitting more efficient hydration. The main consideration when using super plasticizers in concrete are the high fines requirements for cohesiveness of the mix and rapid slump loss. Neither is harmful for the production of HSC. HSC mixes generally have more than sufficient fines due to high cement contents. The use of retarders, together with high doses and redoes of super plasticizers at the plant or at the job site can improve strength while restoring slump to its initial amount. Even a super plasticized mix that appears stiff and difficult to consolidate is very responsive to applied vibration (Peterman and Carrasquillo, 1986).

3.5 Mineral admixtures

Mineral admixtures form an essential part of the high-performance concrete mix. These are used for various purposes, depending upon their properties. More than the chemical composition, mineralogical and granulometric characteristics determine the influence of mineral admixture's role in enhancing properties of concrete. The fly ash (FA), the ground granulated blast furnace slag (GGBS) and the silica fume (SF) has been used widely as supplementary cementations materials in high performance concrete. These mineral admixtures, typically fly ash and silica fume (also called condensed silica or micro silica), reduce the permeability of concrete to carbon dioxide (CO_2) and chloride-ion penetration without much change in the total porosity.

Studies on Super plasticizers

Super plasticizers are widely used in concrete processing to increase the rheological properties of hardened pastes. Super plasticizers are chemical admixtures which can maintain an adequate workability of fresh concrete at low water/cement ratio for a reasonable period of time, without affecting the setting and hardening behavior of the cementations system. Super plasticizers are introduced in concrete like many other admixtures to perform a particular function; consequently they are frequently described according to their functional properties. Super plasticizers have been classified as high range water reducers (HRWR) to distinguish them from other categories of less effective water reducers.

Franklin (1976) stated that, super plasticizers are organic polyelectrolytes, which belong to the category of polymeric dispersants. The performance of super plasticizers in cementations system is known to depend on cement fineness, cement composition mode of introduction to the mixture etc., as well as chemical composition of super plasticizer. For many years, it was not possible to reduce water/cement ratio of concrete below 0.40 till the advent of super plasticizers.

The super plasticizers were first used in concrete in 1960s and their introduction occurred simultaneously in Germany and Japan (Meyer and Hottori, 1981). At first, the super plasticizers were used as fluidizers than water reducing agents. By using large enough super plasticizer, it was found possible to lower the water/binder ratio of concrete down to 0.30 and still get an initial slump of 200mm. Reducing the water/binder ratio below 0.30 was a taboo until Bache reported that using a very high dosage of super plasticizers and silica fume, water binder ratio can be reduced to 0.16 to reach a compressive strength of 280MPa (Bache, 1981). Aitcin et al. (1991) reported, that by choosing carefully, the combination of Portland cement and super plasticizer, it was possible to make a 0.17 water/binder ratio concrete with 230mm slump after an hour of mixing which gave a compressive strength of 73.1MPa at 24 hours but failed to increase more than 125MPa after long term wet curing. During 1980s, by increasing the dosage of super plasticizers little by little over the range specified by the manufacturers, it is realized that super plasticizers can be used as high range water reducers (Ronneberg and Sandvik, 1990).

Many authors have pointed out that one of the problems related to the use of super-plasticizers is the increasing slump loss related to other factors such as temperature, type of cement, chemical constituents of cement and cement content: Malhotra (1981), Maillvaganem (1978), Pernchio (1978), Hattori (1978).

In order to overcome this problem set retarders are used in combination with super-plasticizers with consequent retardation of the hardening process in early stages. It is clear, whether the addition of water on neither the job site nor the hardening retardation due to the addition of retarders are desired either from the consultant's or contractor's point of view.

3.6 Water

Sea water has a total salinity of about 3.5% (78% of the dissolved solids being NaCl and 15% MgCl2 and MgSO4) , and produces a slightly higher early strength but a lower long term strength; the loss of strength is usually not more than 15% (Abrams (1924)) and can therefore often be tolerated. However, in practice it is generally considered not advisable to use sea water for mixing unless this is unavoidable (Lea (1956)).When reinforced concrete is permanently under water, either sea or fresh, the use of sea water in mixing seems to have no defects (Shalon and Raphael (1959)). Brackish water contains chlorides and sulphates. When chloride does not exceed 500 ppm, or SO3 does not exceed 1000 ppm, the water is harmless, but water with even higher salt contents has been used satisfactorily (Building research station London (1956). The appendix to BS 3148-1980 recommends limits on chloride and on SO3 as above, and also recommends that alkali carbonates and bicarbonates should not exceed 1000 ppm. Somewhat less severe limitations are recommended in American literature Mc Coy (1956).Water containing large quantities of chlorides (e.g.: sea water) tends to cause persistent dampness and surface efflorescence. Such water should, therefore not be used where appearance of the concrete is important, or where a plaster-finish is to be applied (Lea (1956) & Anderson et.al (1985)).

4. MATERIAL PROPORTION AND TEST RESULTS

Table -2: Material Proportion

Ingredients of Concrete	Weight of ingredient per 0.003375 m^3
Coarse aggregate	4.70
Fine aggregate	2.88
Cement	2.17
Water	0.93
Water used with the admixture	0.54
SAS S60 super plasticizer	0.022491

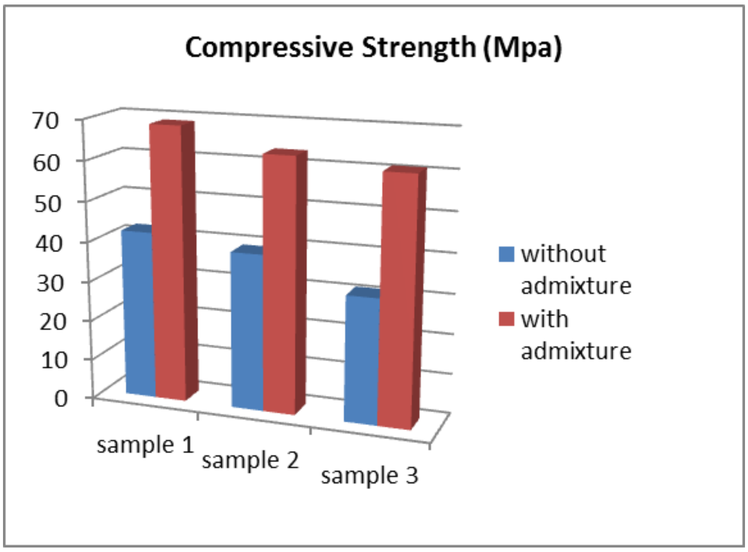

Chart -1: 7 Days test result for cubes

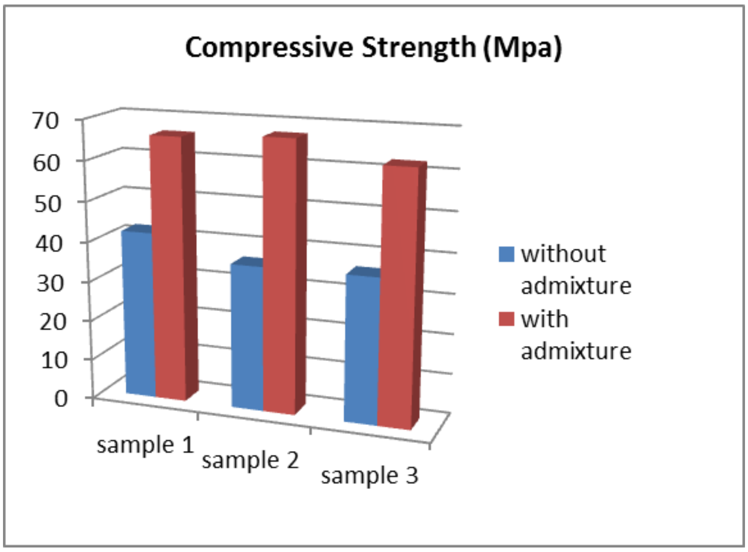

Chart -2: 14 Days test result for cubes

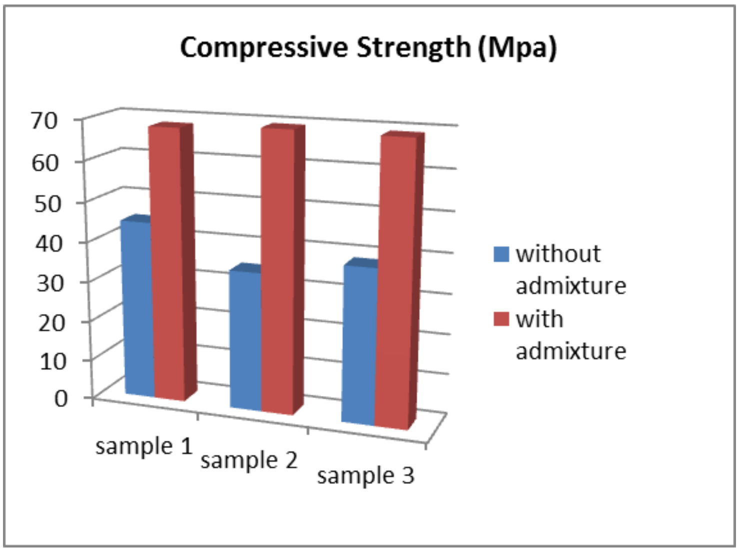

Chart -3: 28 Days test result for cubes

5. CONCLUSION & RECOMMENDATION

HPC that consistently meets requirements for workability and strength development places more stringent requirements on material selection than that for lower strength concrete. Therefore, the production of HPC may or may not require the special materials, but it definitely requires materials of highest quality and their optimum proportions. In the production of HPC, use of strong, sound and clean aggregates is essential. HPC can be accomplished by using high water reducing admixture or SASplast we can reduce water-cement ratio and the required amount of cement which significantly improve strength, cost and environmental impact of concrete .According to the above result by usage of the high water reducing admixture has resulted in obtaining a HPC above 60 Mpa within short period of time .

High water reducing admixture can be used in the construction industry to produce a concrete that has strength, durability, workability, cost effective and also which has less environmental impact.. In addition we recommend future researchers on this area of study to include the following points.

- Effect of high water reducing admixture on strength and durability of concrete.
- Standardization of experimental environment in order to produce ultra-performance concrete.
- The effect of high performance concrete related with tensile strength.
- Exercise of admixtures in the common working environment.

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