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IMPACT OF SUPERPLASTICIZER ON CONCRETE COMPRESSIVE AND TENSILE STRENGTH WITH DIFFERENT DOSAGE

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ABSTRACT

Impact Of Superplasticizer on Concrete Compressive and Tensile Strength With Different Dosage

Concrete structures are the most common type of construction as compared to other materials and they are always developing and improving to meet the global and environmental necessaries. Concrete is the most effective material, yet with modern civilization comes a lot of challenges. Concrete prepared with admixture has recently become very attractive to material scientists and the engineers for producing High Performance Concrete (HPC), when it has higher workability, greater mechanical properties and improved durability more than normal concrete that is using in complex construction structures, such as large skyscrapers, bridges, and offshore structures. This type of concrete admixture is produced with special ingredient such as plasticizers, optimal aggregate size, and fiber steel reinforcing. Superplasticizer (SP) is an essential chemical admixture in the preparation of HPC. SP is a type of chemical admixture that is used in this experimental study to determine impacts of SP on concrete properties. Improper dosage of SP might cause to deteriorate properties of concrete, thus the aim of investigation is to determine optimum dosage of SP and effects of over dosages on fresh properties of concrete (workability) and hardened properties of concrete (compressive strength and tensile strength) by concrete mixes with characteristic strength of 30 (N/mm2) and using W/C ratio (0.46) for concrete mix (1:1.5:3) with different SP dosages of (250ml, 500ml, 750ml, 1000ml, and 1250ml /100 kg of cement) and a control mix. At the results strengths increased with increment in dosages of SP with a limit. The optimum dosage for compressive and tensile strength that is obtained is at dosage (500ml /100 kg of cement) at (C2) for the (POLYCARBOXLATE) SP. But workability is increased with increasing SP for all dosages linearly.

Keywords: Superplasticizer, Workability, Compressive Strength and Tensile Strength of Concrete.

CHAPTER ONE

INTRODUCTION

1.1 Background

Concrete structures are the most frequent form of construction. In the whole world, approximately 90 to 95 % of the construction materials for the structural and non-structural applications are made of cement concrete when compared to other materials used for similar properties and functions. They are always evolving and improving to satisfy global and environmental standards. Cement, aggregate, and water are three fundamentals' ingredients of concrete. Then, very small quantities of chemical products were added into the mix in order to improve some of the properties of concrete. These chemical products are often known admixtures [1] [2] [3].

Concrete buildings should be able to perform the functions for which they were designed throughout the duration of their service life. The long-term endurance of structures is heavily influenced by variables such as safety, economy, and the environment Therefore; achieving durability in concrete should be a major consideration in the design and construction of new structures. During the service life of a structure, the capacity of concrete to withstand chemical assault, abrasion, weathering action and other degradation impacts is critical. Design, materials utilized, and skillfulness are all key aspects in achieving high-quality construction that will increase the life of concrete [4] [5] [6].

Increased understanding of material characteristics is critical in considering the longevity of concrete buildings. The importance of material quality in concrete durability cannot be overstated. Mechanical and durability properties of high-performance concretes containing supplementary cementitious materials were investigated, and it was concluded that the combination of different cementitious materials, as well as the precise choice combinations, should be based on the physical properties relevant to the durability and performance expected from the concrete, as well as the exposure conditions [7, 8].

The presence globe is testified of very challenging civil work in constructions and substructures. Concrete is the most effective material in civil engineering, yet with modern civilization comes gher workability, greater mechanical properties and improved durability more than conventional concrete, these a lot of new challenges. Cement concrete prepared with admixture has recently become very attractive to material scientists and the civil engineers, when it demonstrates hiconcrete mixtures are increasingly being used complex construction structure such as tall buildings, bridges and off-shore structures. High Performance Concrete (HPC) is introduced [9, 10].

HPC has higher workability, higher strength, higher density, higher dimensional stability, low permeability and resistance to chemical attack. This type of concrete admixture is made with special ingredient such as plasticizers, optimal aggregate size, and fiber steel reinforcing. Superplasticizer is an essential chemical admixture in the preparation of HPC of proper mix design and mixed sufficiently HPC is a concrete that meeting special combination of performance and uniform characteristics which can’t be obtained by using conventional ingredients, normal mixing, and curing practices [10] [11] [12].

A lot of admixtures are used in the construction industry for different purposes for improving different desirable properties of cement concrete. In general, admixtures are divided into two groups thus (Mineral and Chemical admixtures). Chemical admixtures are being used more widely for concrete, they are used as a routine ingredient of mixes for many applications, and their technology is well known and applied. Admixtures are substances instituted into a batch of concrete, during or immediately before its mixing, in order to alter or improve fresh and hardened properties of concrete [13, 14] .

Admixtures are the essential materials for manufacturing modern concrete and key elements in the development of concrete in high-tech fields. Using admixtures will provide avoiding of some problems that are related for mixing of concrete, transferring, placing, compaction, and finishing. And it overcome problems of poor concrete mixing or workmanship. Some admixtures in concrete mix can help to maintain the W/C ratio, slump, and workability [15, 16].

High-range water reducers (HRWRs) are also known as superplasticizers, super fluidizers, and super water reducers, they are chemical admixtures that are water reducing but significantly and distinctly more than the water-reducing admixtures, Superplasticizers are also often very distinguishable in their nature, they make possible the production of concrete in its fresh and hardened state. The quality of hardened concrete is strongly affected by the amount of water that used in concrete. The water content affects compressive and tensile strength, flexural strength, permeability, resistance to weathering, bond between concrete and reinforcement. The reason that caused superplasticizers are much more important than any other chemical admixture is the number of improvements that will be achieved by its use. However, the reason for widely using of admixtures is that admixtures can impart considerable physical and economic benefits with respect to concrete [17, 18].

Historically, using superplasticizers in concrete began in the 1960s in japan and Germany. Kenichi Hattori introduced the first superplasticizer in 1964 in Japan that was constituted of beta-naphthalene sulfonates. In Germany the second superplasticizer (Melment) that was contained of sulphonated melamine formaldehyde condensate and introduced in the same year. After a decade, using of SPs was arrived to the American continent in 1970. New admixtures were improved based on polycarboxylate ethers in the late twentieth century, with structural characteristics which gave for more fluidity of concrete that resist segregation and exudation more than any prepared with the previously SPs. For these causes in these days admixtures with polycarboxylate have been initiated into the cement systems replacing melamine and naphthalene admixture [19] [20] [21].

Super plasticizers are composed of chemical and mineral constituents. SPs are utilized when workability with high degree and its retention are required, when delaying in transportation or placing is required, or when high ambient temperatures be a reason for quick slump loss. It eases provide concrete with high-quality. They allow quicker placing and compaction of concrete, also minimizing the risk of segregation and bleeding [22].

Nowadays, the ready mixed concrete industry produces more than 70% of the world's in-situ concrete; producers are using a SP admixture that is readily available from various manufacturers. Ready-mixed concrete can be mixed by using one of three methods: central-mixed concrete, shrink-mixed concrete, or truck mixed concrete. Contractors can save time by using ready-mixed concrete, and higher quality concrete can be produced as well. According to the wide using of ready-mixed concrete, it was very important to use admixtures for improving the concrete quality, improve workability, and to produce concrete which can sustain the severe environmental conditions [23, 24].

There are many advantages that can be achieved with using superplasticizers in concrete including increase workability without changing the mixture composition, reduce water-cement ratio by reducing water to increase strength and/or improve durability, and to reduce both water and cement in order to reduce cost in addition to reducing creep, shrinkage and thermal strains caused by heat of cement hydration. There exist four main categories of superplasticizers: sulfonated melamine-formaldehyde condensates; sulfonated naphthalene-formaldehyde condensates; modified lignosulfonates; and polycarboxylate derivatives. Different types of SP will normally have different impacts on performance and properties of concrete [25, 26].

Hydroxyl, sulphonate or carboxylate groups attached to the main organic unit of the SP that is usually anionic, provides the water solubility to these admixtures. Workability enhancement by the SP in the concrete is mainly by increasing the surface potential force, the solid-liquid affinity, and the steric hindrance mainly in PCE based SP [26].

Using of SPs in concrete preparation was a milestone in the history of concrete and this played a main role in the improving of high strength and performance concrete. They are chemical admixtures that are added to concrete with small dosages. Their performance depends on the ingredients of the concrete mixture, types of the superplasticizer, the time of adding, and conditions of temperature during mixing and concreting [27].

Superplasticizer is an admixture that is used in this study with different specific dosages and the effects on concrete compressive strength and tensile strength is considered. The main objective in this study is finding the optimum dosage of the superplasticizer and determining impacts of over and low dosages on concrete strength.

1.2 Objectives of the Study

This study aims to:

- Determine the effect of superplasticizers on properties of hardened concrete, by testing the compressive and tensile strength of concrete at different dosages.
- Determine the optimum dosage of the superplasticizer that can achieve the best compressive and tensile strength of normal concrete with good workability.
- Determine the effect of superplasticizers on the workability of the concrete that is one of the most important properties of fresh concrete.

1.3 Outline of the Thesis

1. Introduction

Important and benefits of the superplasticizer in concrete mix were presented.

2. Literature review

Previous researches about impact of SP on compressive strength, and preparing self-compacting concrete and HPC has been studied,

3. Methodology Materials physical tests and tests of fresh and hardened state of concrete of the study are clarified.
4. Result and discussion

Results of the testes is presented and analyzed.

5. Conclusion Summary of the results of the tests is indicated in this chapter

Chapter two

LITERATUEE REVIEW

2 General

The most used construction material is concrete in the world because of its versatility, durability, sustainability, and economy. Hence the most common type of structure is concrete structure, and it is always developing and improving to meet the global and environmental necessaries [28, 29].

According to ASTM C-125-97a standards, an admixture is a material other than water, aggregates, or hydraulic cement which is utilized as a constituent of concrete or mortar, and it is added to the batch immediately before or during mixing for providing improved concrete properties and economical solution [30, 31].

There is a various type of admixture for using in concrete mixtures to modify fresh and hardened concrete properties, Air-entraining, Normal; Mid-range; and High-range water-reducing, set accelerating, set retarding, Hydration-control, Rheology modifying, Corrosion inhibitors, Shrinkage reducers, Permeability reducing admixtures, Alkali-silica reactivity inhibitors, Coloring admixture, Miscellaneous admixtures. All of these admixtures have been refined to provide concrete designers and builders more option and better flexibility to a wider range of applications and ambient conditions [32, 33].

An admixture's efficacy depends upon some factors such as its the chemical nature and molecular weight of the polymer, particle size distribution and composition of the binder, dosage of admixture, amount of cementing materials, aggregate shape, gradation, and proportions, water content, mixing time, slump and temperature of the concrete. Thus, it is very significant to have a principle for choosing the appropriate admixture for the given concrete and application [34, 35].

Superplasticizer (high water reducer) is one type of additives that will use in this study. The aim of this study is to discuss about effects of superplasticizers on strengths of concrete, to investigate optimum dosages for the chemical admixture, and to determine impacts of lower and over dosages of the admixture on concrete. So, there is need to discuss about the properties of concrete in fresh and hardened state that superplasticizers have effects on it.

2.1 Mechanism of Superplasticizers

Superplasticizers are consisted of long molecules of high molecular mass which produce by a complex polymerization process of o Water-soluble organic polymers, and they are therefore relatively expensive. The main action of the long molecules is to enclose themselves around the particles of cement and give them a highly negative charge so that they revise each other or act by steric repulsion. These results in deflocculating and dissipation of cement particles. The resulting improvement in workability can be advertised in two ways: concrete with a very high strength or by producing concrete with a very high workability [36].

2.2 Impact of Superplasticizers on Compressive Strength

Superplasticizers are used in concrete mix to improve fresh and hardened concrete properties. Workability and fundamental rheological properties, reversible and non-reversible evolution, thixotropy, slump loss, setting time, bleeding, segregation and practical issues related to formwork filling and pressure, are addressed among the properties of fresh concretecompressive strength and other mechanical and physical properties of hardened concrete, such as tensile strength, elastic properties, shrinkage, creep, cracking resistance, electrical, thermal, transport and other properties are covered hardened concrete properties [37].

Workability is one of the main properties of fresh concrete, and compressive strength is one important property of physical properties that are considered in many researches. Also, in this research effect of different dosages of the SP on tensile strength of concrete is considered.

The effects of different dosages of (400 ml/100 kg, 600 ml/100 kg, 800 ml/100 kg, 1000 ml/100 kg and 1200 ml of SP per 100 kg of cement) on compressive strength and workability of concrete is presented. The study was based on normal strength concrete with characteristic strength of 35 N/mm2 at 28 days. Slump test was conducted to assess the workability, and it was observed that Increasing amount of SP was increased the slump hence increase workability. Also, it was observed that addition of SP will increase compressive strength but, Continuous addition of superplasticizer agent may not be able to raise the compressive strength of concrete indefinitely because excessive addition of SP (over dose) disrupts the hydration process by providing additional water to mix the concrete. Overdosing causes the deflocculation of cement particles to speed up. Furthermore, as the dosage is increased, the entrapped water increases, causing hydration of the cement [38].

The effects of SP on workability by different tests of slump test, flow table, and compressive strength test at 1th, 3th, 7th and 28th days is studied with dose of (400ml, 600ml, 800ml, 1000ml and 1200ml/100 kg of cement). From the results of the study the workability of concrete improved with addition of superplasticizer with constant W/C ratio, and compressive strength was observed that it is increasing with the increasing of superplasticizer dosage, when it was cured with water for all ages and superplasticizers has a locontinuous strength gain for chemical admixture concrete which is observed by the increase in compressive strength with age. At early age (1- 7 days from casting), the rate of getting strength was high hence the reaction between the cement particles and water was active but When time goes by the rate of strength was decrease [39].

Impacts of different dosages (1%, 2%, 3%, 4%, and 5% of SP by weight of cement) at 7 days and 28 days on fresh and hardened state is investigated, the experimental program included test on workability and compressive strength. Ratio (1:2:4) by mass proportions was used as mix design with water cement ratio of 0.5 for all mixes. At the results It was observed that compressive strength with value 385.4 Kg/cm² at dosage of 3% was the maximum achieved value at 28 days, and at dosage of 1% was maximum achieved value 281.7 Kg/cm² at 7 days, and the highest compressive strength at 28 days was achieved at dosage of 3% when the main concern is the ultimate compressive strength, while the highest compressive strength at 7days achieved at dosage of 1% when the main concern is the early compressive strength [40].

Experimental study with SP dosage (0.5%, 0.7%, 0.9%, 1.1% and 1.2%) by weight of cement on the performance of the concrete is investigated. The research has been established to determine the optimum amount of the chemical admixture to add the concrete and effects on compressive strength and workability of concrete. Six trial mixes with a control mix were prepared, with a specific w/c of 0.43 for 7- and 28-days strength test. Slump test and compaction factor were conducted to determine workability. The result showed that increasing of superplasticizer to the concrete will increase in the slump from (20mm) to (180mm) with respect to the normal mix, and when the dosages of SP increased the compaction factor approaches to the 1.0. That is obvious that increase SP increase workability. And the results of the compressive strength test were showed that the optimum ratio of SP is (0.7%) for 28 days with strength value of (46.25 N /m2), but the optimum ratio of SP is (1.1%) for 7 days with value of (27.77 N /m2) [41].

The influences of SP on compressive strength and workability of concrete is Studied with dosages of (0.8%, 1% and 1.2%) by weight of cement. Normal-strength concrete with a characteristic strength of 30 Mpa at 28-day age with water/cement ratio of 0.55 was used. (OPC, type1) as a binder, sea sand as fine aggregate, crashed stone with a maximum size of 20 mm as coarse aggregate, and Sikament®-520 as were used. 12 specimens with different dosages and one control mix with dimensions of 150 mm x 150 mm x 150 m were prepared, each dosage with three specimens. It was noted that higher amount of SP in concrete produced higher workability. And compressive strength was improved by Sikament ®-520, hence ultimate strength (33MPA) was higher than the desired characteristic strength, even over dosage was deteriorate properties of the concrete [42].

2.3 High Performance Concrete

Additives have achieved wide using in the last few years, especially those required to manufacture high-strength concrete (HSC). It has higher workability, High durability, High strength, High early strength etc. it has been widely applied in the constructions such as tall building, bridges and off-shore structures [43, 44].

HSC is designed to give optimized performance characteristics for the given set of materials, usage and exposure conditions, consistent with requirements of cost, service life and durability. It exceeds the properties and constructability of normal concrete. Normal and special materials are utilized to produce these specially designed concretes which must meet a combination of performance requirements. One important chemical admixture in preparing HSC is superplasticizer. The most important improvement in concrete technology has been the use of superplasticizers during the 30 last year’s [45] [46] [47].

The effects of SP with different dosages of (600, 800, 1000 and 1200 ml) per each 100kg of cement on properties of concrete is studied, and the optimum dosages of the admixture on compressive and workability of concrete were determined. The study was focused on normal strength concrete with characteristic strength of 30 N/mm^2m, and Sikament® R2002 as SP was used. The results that were obtained showed that the workability of concrete can be increased by increasing SP, it’s going to help to retain the concrete in liquid state for a longer time then reduce the slump loss during the transportation of concrete to the site, but over dosages tend to impair the cohesiveness of concrete and will lead to high slump that will not give true slump, and less dosage leads to less fluidity and less workable. And the optimum dosage was (%1) that obtained after 28 days of curing with maximum compressive strength [48].

Impacts of (Duraplast SP-400) with different dosages (0.5 %, 1.0%, 1.5 %, 2.0% and 2.5%) are investigated on the properties of concrete at early age. Workability, setting time and concrete compressive strength at 1, 3, 7 and 28 days were determined. The slump value was improved by increasing the percentage of SP dosages from dosage 0% to 2% (50mm to 225mm), but it was declined increasing at the dosage 2.5 %. At a result it was noted that Workability and flow-ability of concrete increased with the increase of SP dosages with optimum limit of 2 %. It was observed that the maximum value at dosage 2.5 % reached to 26.9 MPa at 7 days, and the maximum value of 38.44 MPa were achieved at dosage 2.5 % at 28 days compressive strength. Hence it was observed that with increasing in SP dosage concrete compressive strength at early age reduced however its strength at 28 days increased by adding SP dosage up-to 2% [49].

The influence of two different types of SPs (ViscoCrete-5930) and (KUT PLAST PCE600) with different dosages (0.5, 1, 1.5, and 2%) on the properties of reactive powder concrete is studied. Workability, compressive strength, and saturated surface dry density of reactive powder concrete were conducted. The results showed that the flow ability of the concrete mix containing ViscoCrete-5930 is more than the concrete that contained KUT PLAST PCE600. It was noted that Using ViscoCrete-5930 in comparison with KUT PLAST PCE600 with dosage 2% by weight of cement led to increase the flow ability of the concrete mix. Also, using of two different dosages of (ViscoCrete-5930 and KUT PLAST PCE600) at the same mixture with dosage 1.5% of (ViscoCrete-5930) with dosage 0.5% of (KUT PLAST PCE600) led to increase the workability of the concrete mix more in comparison with mixes containing of other different ranges. The results showed that the influence of dosage 2% for both types (ViscoCrete-5930 and KUT PLAST PCE600) on the compressive strength at 3 days was same approximately, but at 7 and 28 days using of 2% ViscoCrete-5930 lead to increasing the strength more than of using 2% KUT PLAST PCE600, and using both types of the admixture with dosages 1.5% ViscoCrete-5930 with 0.5% KUT PLAST PCE600 leads to reach the strength to the optimum value in compressive strength [50].

2.4 Self-Compacting Concrete

Self-compacting concrete (SCC) is an important and significant advance within concrete technology that is having an important impact on concrete practice. SCC is a new variety of high-performance concrete which has more favourable fluid properties such as increased workability, and good segregation resistance. It can settle by its own weight completely and achieving full compaction, even in the presence of congested reinforcement [51] [52] [53].

SCC is can be achieved by reducing the aggregate to cementitious volume ratio, increasing the paste volume and using various enhancing admixtures and Super plasticizers. It is a complex system which is usually proportioned with one or more additions or chemical admixtures. The high flowablity of SCC mixtures is can be achieved by using superplasticizer which impacts fresh and hardened properties of SCC mixtures [54].

The effects of SP and retarder on fresh and hardened properties on concrete is presented with dosages of (600, 1200, 1800, and 2500 ml/100 kg of cement) and control mix with specific water/cement ratio (0.50). Slump test utilized to estimate the workability of the concrete mixes and compressive strength was conducted as properties of hardened state of concrete at 7, 14 and 28 days. At the experimental program the results showed that the workability was paired by addition of SP and retarder with a specific limit, because high dosages of both admixtures led to impair the cohesiveness of concrete, and it was noted that Slump loss can be reduced by using the chemical admixtures but effectiveness is higher for superplasticized concrete. And when the retarder was compared with the SP, the setting time for retarded concrete is longer than that of superplasticized concrete. Also, it was approved that addition of retarders couldn't increase the compressive strength of concrete at early age; instead of it reduced the strength significantly. Both SP and retarder were increasing the compressive strength with increasing dosages for all ages, but still there is a specific limit [55].

The effect of SPs on workability and properties of self-compacting concrete (SCC) is studied. Three types of SPs (Conplast SP 561), (Conplast SP 430) and (Conplast SP 264) at dosages (0, 10, 20 and 30%) with specific w/c ratio 0.3 for M30 grade of concrete were used. Slump, v-funnel and l-box test was conducted to determine workability, and Compressive strength test to determine hardened concrete properties. Samples were prepared with percentages of 10, 20, 30%

self-compacting mixes and control without SP content (NCC). It was noted that all mixtures improved the workability compared to the control mix, and the concrete mixture with conplast SP 430 had a good effect on slump flow with increasing percentage, but slump flow decreased in the concrete mixture with conplast SP 561. Also compressive strength increased with increasing in percentage of conplast SP 264 and conplast SP 430 at all, compared to the conplast SP 561 had a decrease in the compressive strength with increasing dosages at all dosages. It was observed that conplast SP 430 has a better effect on the fresh and hardened states more than the rest of the SPs selected [56].

2.5 Impact of Curing on Concrete Strength

The quality and durability of concrete not only rely on the properties and quality of the ingredients but also on the methods of preparation, placing curing and environmental conditions to which it is exposed over its service life. Curing is a procedure that occurs in the order of operations for the manufacturing of concrete, usually after the finishing processes. It should usually begin start after the final set of the cement in order to avoid drying shrinkage and consequently, the development of cracks [57, 58].

It is a cause of controlling the rate and range of moisture loss from concrete during cement hydration which it ensures that concrete experience continued hydration, leading to its continued gaining strength and maintaining proper moisture content and temperature within the concrete for a sufficient period of time results in continued hydration. So, it has an important effect on the properties of hardened concrete, such as strength, permeability, abrasion resistance, and volume stability, resistance to freezing and thawing, and deicing chemical [58, 59]

The impacts of different SPs with different dosages (0%, 0.5%, 1%, 1.5%, and 2%) by weight of cement with W/C ratio 0.48 under 4 different curing regimes (28 days immersed in water (C1), 14 days immersed in water and 14 days in atmosphere at ambient temperature (C2), 3 days immersed in water and 25 days in atmosphere at ambient temperature (C3), 28 days in atmosphere with daily curing with sprinkling (C4)) is investigated. It was noted that the water curing up to testing is showing maximum compressive strength in all cases at 28 days. The maximum value was achieved at 0.5%, and the lowest value of compressive strength was achieved in dosage 1% which exposed to ambient environment for 28 days without initial wet curing. In the C2 the strength obtained is lower than even that of the specimens without SP. it was noted that in all the batches compressive strength was decreased gradually as the curing duration was reduced, and it also specifies the effect of temperature on the compressive strength. Tensile strength also conducted, the water curing up to testing is showed maximum tensile strength in all cases. In B-4 batch with dosage 1.5% and in C1 the highest value of tensile strength was obtained, and the lowest value of tensile strength 0.68 MPa was observed in C4.[60]

CHAPTER THREE

3 METHEDOLOGY

Concrete is a composite mix that consists of cement, (fine and coarse) aggregate and water. Sometimes, admixtures are added in order to change the properties of concrete for certain applications. Hence the materials are important in determining the properties of produced concrete that should be properly selected and chosen before the beginning of the experiment [61].

The aim of this study is to investigate the effects of SP on compressive and tensile strength of concrete with different dosages and determining optimum limit for the usage of the SP, and the effect of over dosage of the SP on the concrete. It's obvious that increasing w/c will decrease strength of concrete, using SP helps in reducing the utilization of water while maintaining the sufficient workability hence it also increases the strength of the concrete.

3.1 Material for Experimental Work in this Study:

3.1.1 Cement

Cement is the chemically active ingredient which its reactivity is only brought into effect upon mixing with water. The most commonly used cement in any cement concrete mixing purpose is called Ordinary Portland Cement (OPC) [62]. Tasluja cement based on OPC is used in this study that complies with Iraqi Standard IQ.S 5:1984 Type I and EN 197-1:2011.

There are over ten different types of cements that are used in construction purposes, and they differ by their composition and are manufactured for different uses. These are rapid-hardening cement (RHC), quick-setting cement (QSC), low-heat cement (LHC), sulphate-resisting cement (SRC), blast furnace slag cement (BFSC), high-alumina cement (HAC), white cement (WC), coloured cement (CC), pozzolanic cement (PzC), air-entraining cement (AEC), and hydro-phobic cement (HpC). RHC has increased the lime content compared to the Portland cement (PC).

The cement is recommended for concrete applications which require high performance and endurance, typically reinforced concrete structures. There are some properties of the cement such as high initial strength development, High performance and wide compatibility with chemical and cement additives, Moderate sulfate resistance, High durability concrete, the preferred choice for harsh environments, improved productivity for block makers with limited storage space.

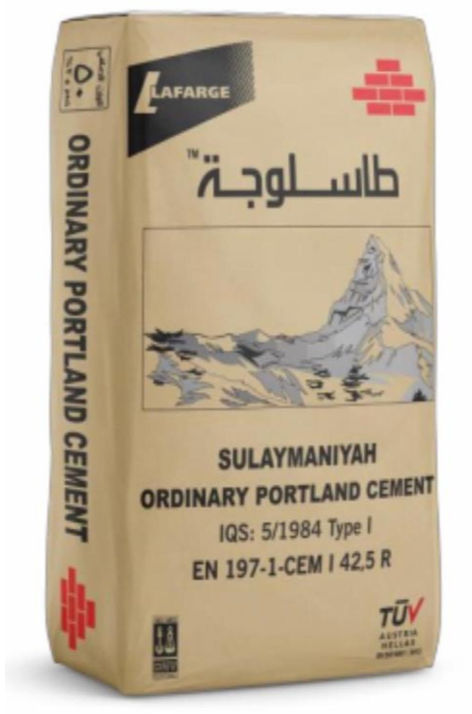

Figure 3-1: Tasluja Cement (OPC).

3.1.2 Aggregate

Aggregate is a major ingredient in concrete because it occupies about three quarters of the volume of concrete. Generally, aggregates composed of fine and coarse aggregates. Two aggregate sizes are used in concrete according to size, Fine aggregates generally consist of natural sand or crushed stone with particle sizes that smaller than 4.76 mm, Coarse aggregates which are consist of one type of particles or a combination of particles generally having size between 4.76mm and 20mm [63, 64].

The aggregate participates not significant roles in the chemical reaction but its effectiveness arises because that is an economical filler material or hard composite material with fine resistance to the changing of volume that take place with-in the concrete after mixing, further improving the durability of concrete [65].

There are many parameters needed to be considered in selection of aggregate, types of aggregate, size and shape of the particle, and the strength of the aggregate. Aggregates must be free from dust because may the dust influence the bonding between the aggregate and particles of cement [66]. The coarse aggregate that is used in this study is natural gravel with density of 1800kg/m^3, and the fine aggregate is river sand with density of 1600kg/m^3 that is used. (Figure 3-2) and (Figure 3-3) shows the coarse aggregate and fine aggregate that is used in this study respectively.

Figure 3-2: Natural Gravel.

Figure 3-3: River Sand.

3.1.3 Water

In concrete technology, water is used for mixing, curing, and cleaning aggregates. Although the amount of mixing water in a fresh concrete mix is the most important factor in determining the qualities and performance of hardened concrete, the quality of that water is also significant [67]. As mixing water for concrete, almost any natural water that is drinkable and has no discernible flavor or odor can be utilized. Excessive impurities in mixing water can cause efflorescence, staining, corrosion of reinforcement, volume instability, and reduced durability, in addition to affecting setting time and concrete strength [68]. Drinkable water is used in this study as mixing and for curing.

3.1.4 Superplasticizer

Superplasticizer (SP) is a type of the admixtures, which is used in this study with different proportions of (250ml, 500ml, 750ml, 1000ml, 1250ml per 100kg cement) with a specific water/cement ratio (0.46), and with same specific amount of material for all mixes. The SP was used in this study is (POLYCARBOXLATE) based on type (Polycarboxylic) with a brand name (idea), this liquid SP is a high- range water reducing concrete admixture that it can improve workability hence improve strength. (Table 3-1) shows the properties of the SP and (Figure 3-4) shows the SP that is used in this study.

Table 3-1: Properties of the Superplasticizer.

POLYCARBOXLATE	
Super Plasticizer Retarder High Water Reducer	
Density	1.085 kg/m^3
Ph	6
Color	Waxy
T. Chlorine	Max 0.1%
Solid. C%	36

Figure 3-4: Superplasticizer (POLYCARBOXLATE).

3.2 Conducted Tests in this Study

3.2.1 Materials Physical Tests

3.2.1.1 Sieve Analysis Test

Sieving is the most popular method for determining an aggregate's grading, or particle size distribution according. The proportion of material passing each sieve is frequently used to describe grading and grading limitations. There are causes for determining grading limits and nominal maximum aggregate size such as aggregate proportions, workability, pumpability, economy, porosity, shrinkage, and durability of concrete [69, 70].

Coarse and fine aggregates are often sieved individually. Fine aggregate (sand) is defined as that portion of an aggregate that passes the 4.75 mm (No. 4) sieve and is retained on the 75 m (No. 200) sieve and larger aggregate is called (coarse aggregate) according to ASTM C 136. Coarse aggregate comes in a variety of sizes, including 19 to 4.75 mm (3/4 in. to No. 4) and 37.5 to 19 mm [71]. (Figure 3-5) indicates the sieve analysis machine that is used in this study.

Figure 3-5: Sieve Analysis Machine.

3.2.1.2 Normal Consistency of Cement with Vicat's Apparatus

The relative mobility of a freshly mixed cement paste or mortar, or its ability to flow, is referred to as consistency. Cement paste specimens were prepared by mixing the hydraulic cement with enough water to make a paste with a normal consistency. Pastes are mixed defined by penetration of 10 ± 1 mm by Vicat plunger. The test conforms to the ASTM C 187 or AASHTO T 129 [72, 73]. (Figure 3-6) indicates the normal consistency of cement apparatus.

Figure 3-6: Normal Consistency of Cement with Vicat's Apparatus.

3.2.1.3 Initial Setting Time and final Setting Time of Cement with Vicat's Apparatus

The onset of rigidity in fresh concrete is defined as setting of concrete. Setting precedes hardening, but it need be emphasized that both are gradual changes, which are controlled by the continuing hydration of the cement. A transitional period between states of the true fluidity and true rigidity is called setting [74].

The goal of the setting time test is to ascertain the time that elapses from the time which elapses from the moment water is added until the paste ceases to be fluid and plastic that it called initial set, as well as the time required for the paste to reach a specified hardness level called final set. This test method conforms to the ASTM standard requirements of specification C191 Vicat's Apparatus or AASHTO T 131 [75, 76]. (Figure 3-7) indicates the setting time of cement apparatus.

Figure 3-7: Initial and Final Setting Time of Cement with Vicat's Apparatus.

3.2.2 Tests on Fresh Concrete

3.2.2.1 Slump test

Workability, consistency, and plasticity are all requirements for concrete. Workability refers to how easily concrete can be mixed, placed, consolidated, and finished, with filling ability, passing ability and stability. The method and duration of transportation; the quantity and characteristics of cementitious materials; concrete consistency (slump); grading, shape, and surface texture of fine and coarse aggregates; entrained air; water content; concrete and ambient air temperatures; and admixtures are some of the factors that affect the workability of concrete [77, 78].

Slump test is the most common method for determining the consistency or flow ability of concrete paste. According to ASTM C 143, the ASTM standard cone is used for the test with the dimensions (height, 300mm: top width, 100mm: bottom width, 200mm [79, 80]. Slump test is used in this study for testing consistency of the concrete pastes for all concrete mixes (C0, C1, C2, C3, C4, C5) with the standard cone with the dimensions (height, 300mm: top width, 100mm: bottom width, 200mm). (Figure 3-8) shows the slump apparatus.

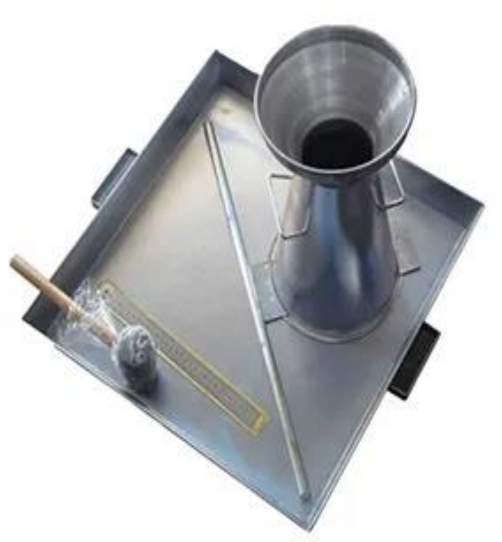

Figure 3-8: Slump Apparatus.

3.2.3 Mechanical property tests

3.2.3.1 Compressive strength test:

The compressive strength of concrete (fc') is defined as the ability of a concrete specimen to resist an axial load per unit area. The resistance varies depending on the age of the concrete. Seven-day strengths are typically estimated to be around 75% of 28-day strengths, while 56-day and 90-day strengths are roughly 10% to 15% more than 28-day strengths [81, 82].

Generally, it is indicated in megapascals (MPa) or pounds per square inch (psi) at 28 days of the age. Several factors influence the compressive strength of concrete cement paste, including water cementitious materials ratio, supplementary cementitious materials, use of admixture, curing, cement type, etc. [83, 84].

A concrete specimen can be broken in a compression testing machine to perform the compressive strength test. A standard cube specimen of 150 x 150 x 150 mm3 in Britain and Europe or a standard cylindrical specimen of 150 mm x 300 mm or 100mm*200mm according to ASTM C 39 in United State can be used [85].

Compressive strength test is considered in this study for concrete mixes (C0, C1, C2, C3, C4, C5) with different dosages (0 ml/100 Kg of cement, 250 ml/100 Kg of cement, 500 ml/100 Kg of cement, 750 ml/100 Kg of cement, 1000 ml/100 Kg of cement, 1250 ml/100 Kg of cement). Thirty six (36) cube specimens with standard dimension 150*150*150 mm^3 into different six mixes are prepared, and the specimens is broken in a compression testing machine at 28 days of the ages. The cube that is used in this study is shown in (Figure 3-9) and (Table 3-2) shows the concrete mixes that are used for preparing compressive specimens. The machine that is used for testing the cubes is shown in (Figure 3-10).

Figure 3-9: Standard Cube of 150mm x 150mm x 150 mm.

Table 3-2: Concrete Mixes for Compressive Test.

Concrete Mix	Superplasticizer Proportion	No. of Cubes for Compressive test (28 days)
C0	0 ml/100 Kg of cement	6
C1	250 ml/100 Kg of cement	6
C2	500 ml/100 Kg of cement	6
C3	750 ml/100 Kg of cement	6
C4	1000 ml/100 Kg of cement	6
C5	1250 ml/100 Kg of cement	6

Figure 3-10: Compressive Strength Machine.

3.2.3.2 Split tensile strength test

Generally, concrete it is used with steel bar to withstand any tensile forces in the reinforced concrete, because Concrete is an inherently brittle material with a relatively low tensile strength compared to compressive strength. Split tensile strength (fspt) is a type of tensile strength of concrete that is considered in this study [86] [87] [88].

According to ASTM C 496, the split tensile strength test determines the strength of cylindrical concrete specimens with standard dimension 150mm*300mm while the splitting tensile strength of 100 mm x 200 cylinders was determined in accordance with BS 1881-117. The testing machine needs to have sufficient capacity which will provide the rate of loading. In this research effects of different dosages of the SP on tensile strength of concrete is considered [89, 90].

Split tensile strength test is considered in this study for concrete mixes (C0, C1, C2, C3, C4, C5), eighteen (18) cylindrical concrete specimens with standard dimension 100mm*200mm into different six mixes are prepared with different dosages (250ml, 500ml, 750ml, 1000ml, 1250ml per 100kg cement) of the SP and one control mix, and the specimens is broken in a compression testing machine at 28 days of the ages. (Figure 3-11) shows the cylinder that is used in this study and (Table 3-3) shows the concrete mixes that are used for preparing specimens. From (Figure 3-12) shows the machine that is used for testing split tensile strength.

Figure 3-11: Standard Cylinder of 100 mm x 200mm.

Table 3-3: Concrete Mixes for Tensile Test.

Concrete Mix	Superplasticizer Proportion	No. of Cylinders for Compressive test (28 days)
C0	0 ml/100 Kg of cement	3
C1	250 ml/100 Kg of cement	3
C2	500 ml/100 Kg of cement	3
C3	750 ml/100 Kg of cement	3
C4	1000 ml/100 Kg of cement	3
C5	1250 ml/100 Kg of cement	3

Figure 3-12: Tensile Strength Machine.

3.3 Mix design

The concrete mix design is the process of selecting suitable constituents of concrete and determining their relative amounts with the aim of producing a concrete of the required strength, workability and durability economically as possible [91].

The mix design of concrete required for meeting the performance requirements of the fresh and hardened concrete, a fresh concrete should be workable, cohesive, and have a retarded initial setting. Concrete should be strong, impervious, and durable at hardened state. The relative proportions of the concrete constituents are determined in order to get a desired strength and workability in a most economical way [92].

There are various proportions were rated by weight but were concreted to equivalent proportions by volume (1:4:8, 1:3:6, 1:2.5:5, 1:2:4, 1:1.5:3, 1:1.5:2, 1:1:1) which were chosen based on project requirements [93].Ratio of 1:1.5:3 for reinforced concrete with characteristic strength of 30 (N/mm2) is chosen for this study.

CHAPTER FOUR

4 RESULT AND DISCUSSION

In this chapter the results of concrete samples that are prepared with different SP dosages and specific amount of others materials are conducted. The mix design (1:1.5:3) with characteristic strength of 30 (N/mm2) and W/C ratio of (0.46) was used for preparing cubes and cylinders, and mixing amount of each type of materials for preparing each mix is shown in (Table 4-1). Sieve analysis, Normal Consistency of Cement, Initial Setting Time and final Setting Time of Cement, slump test, Compressive strength test and split tensile strength test are discussed in this study.

Table 4-1: Materials Amount per Each Mix.

Concrete Mix	Superplasticizer proportion	Cement (kg)	Sand (kg)	Gravel (kg)	W/C Ratio	Superplasticizer (ML)
C0	0 ml/100 Kg of cement	6	11.5	22.65	0.46	0
C1	250 ml/100 Kg of cement	6	11.5	22.65	0.46	15
C2	500 ml/100 Kg of cement	6	11.5	22.65	0.46	30
C3	750 ml/100 Kg of cement	6	11.5	22.65	0.46	45
C4	1000 ml/100 Kg of cement	6	11.5	22.65	0.46	60
C5	1250 ml/100 Kg of cement	6	11.5	22.65	0.46	75

4.1 Sieve Analysis

4.1.1 Coarse aggregate

The coarse aggregate which is used in this study is natural gravel. The ranges are between (4mm-22.4mm) hence the maximum aggregate size was 22.4 mm. (Table 4-2) shows the results of the coarse aggregate and the limits thus the results are in the limits, and (Figure 4-1) shows the results of the sieve analysis of the aggregate.

Table 4-2: Limit of Percent Passing by Mass and Coarse Aggregate Sieve Results.

Gravel	Lower Limit	Results	Upper Limit
4	0	0	0
5.6	0	1.64	5
8	0	7.38	10
11.2	10	27.87	40
16	40	58.2	80
22.4	90	96.92	100
31.5	100	100	100

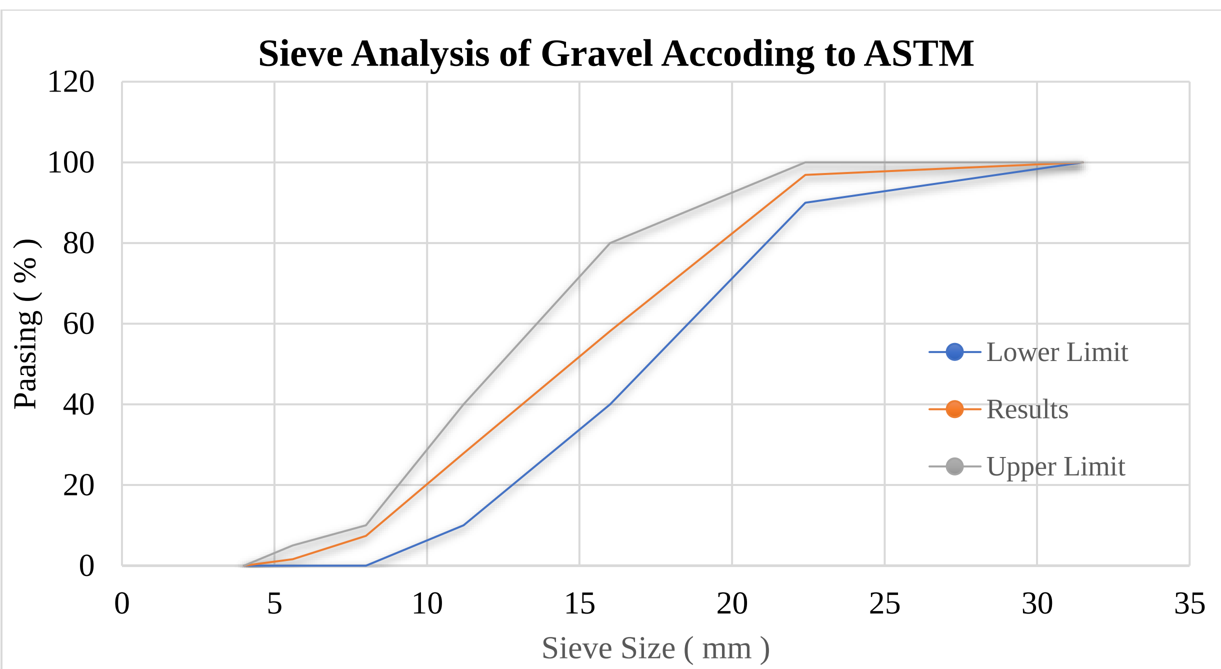

Figure 4-1: Coarse Aggregate Sieve Analysis.

4.1.2 Fine aggregate

The fine aggregate is river sand that is used in this study. The ranges are between (0.125mm-5.6mm). The data of size gradation of the fine aggregate is shown in (Table 4-5) and (Figure 4-2) shows the results of the sieve analysis of the fine aggregate. According to results and the limits at (Table 4-6) the fine aggregate is in the limits.

Table 4-3: Limit of Percent Passing by Mass and Fine Aggregate Sieve Results.

Sand	Lower Limit	Results	Upper Limit
0.125	0	5.97	5
0.25	2	11.94	10
0.5	10	28.36	30
1	25	42.29	60
2	50	71.14	85
4	80	85.52	100
5.6	95	99	100

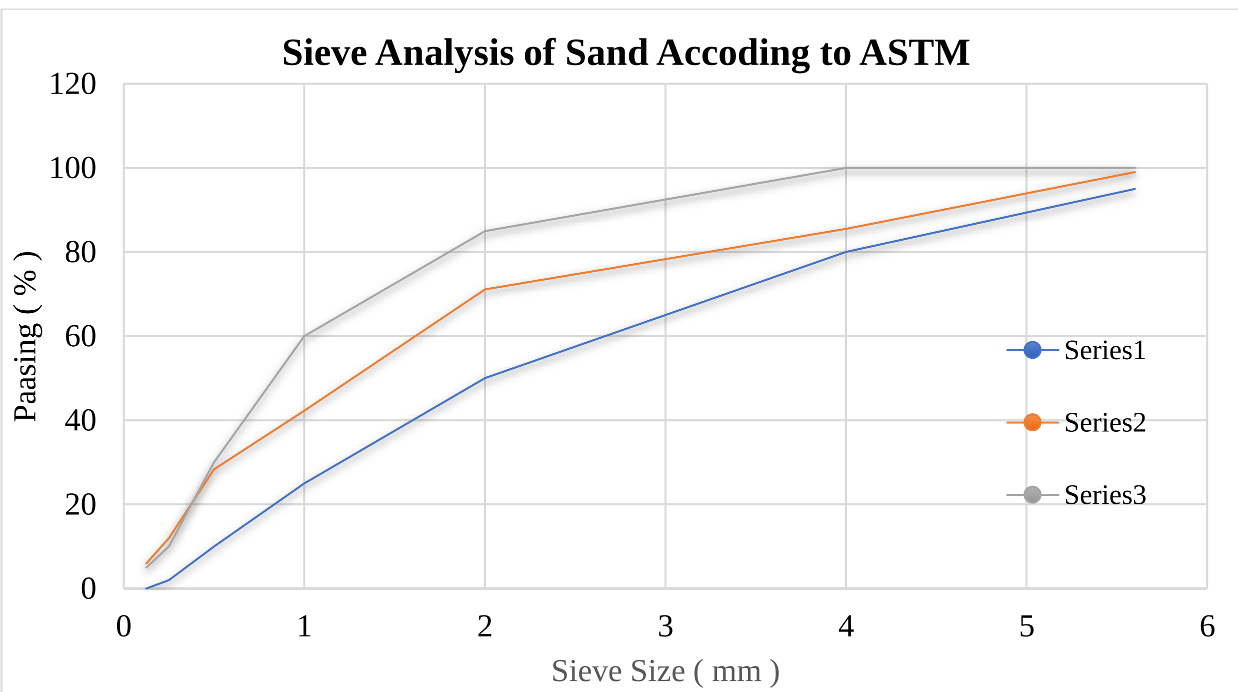

Figure 4-2: Fine Aggregate Sieve Analysis.

4.2 Normal Consistency of Cement:

For the consistency test five (5) samples is gotten but two of out five failed, and the penetration of 10 mm is taken according to the standard for finding W/C, thus at the penetration of 10 mm the W/C was about 0.26 w/c ratio. (Figure 4-3) indicates normal consistency of (Tasluja) cement.

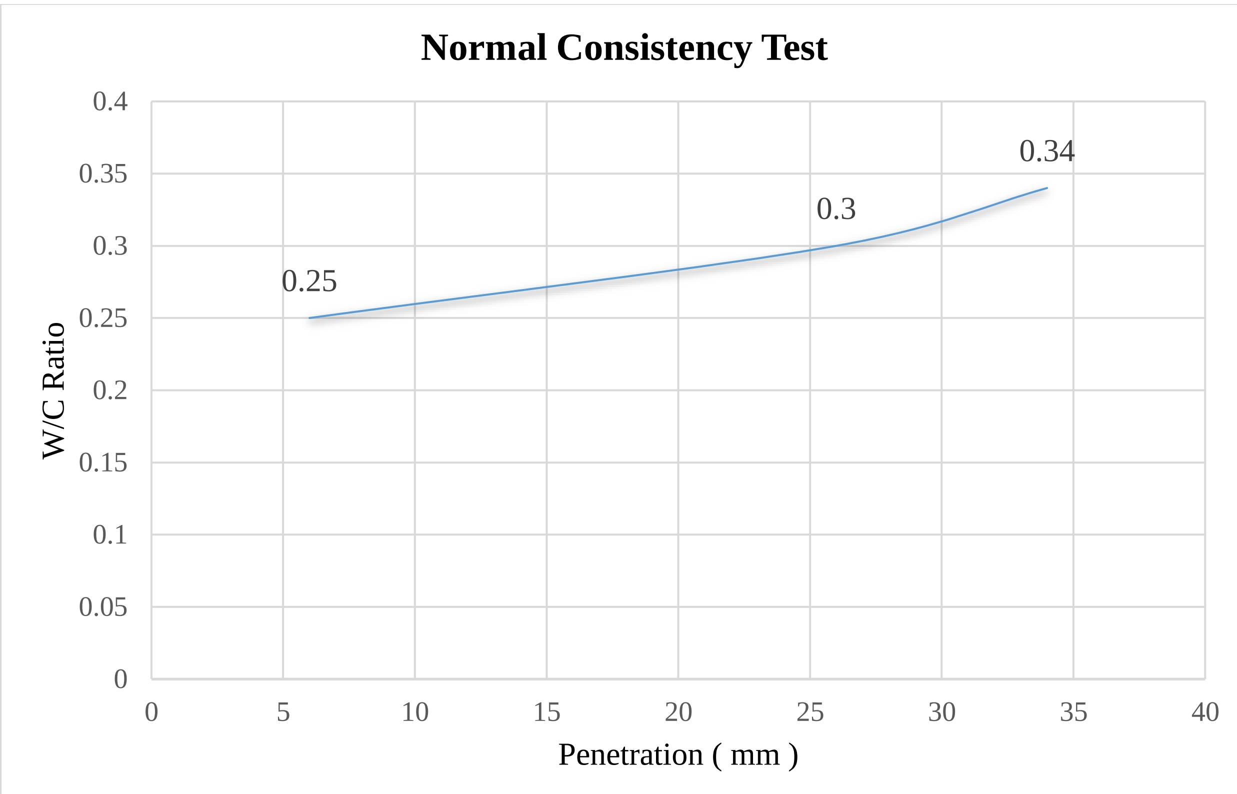

Figure 4-3: Normal Consistency of Cement.

4.3 Initial Setting Time and final Setting Time of Cement

Penetration of 10mm and 0.26 w/c ratio is chosen for samples for testing setting times of the cement. in the (Figure 4-4) it is shown that after 120 minutes there isn’t any change in the penetration but 5 minutes later it makes some different in penetration , at 150 minutes the needle is reached 22 mm penetration. For determining the initial setting time when the needle penetrate 25 mm but there isn’t 25 mm penetration directly but at 145 minutes it reach 26 and for 150 minutes it reach 22 mm hence by interpolation the time was 146.25 minutes for 25 mm penetration. There is a formula for finding final setting (90+1.2*t) when (t) is equal the time of the initial setting , by this formula final setting equal 265.5 minutes and it is proper with standard. (Figure 4-4) indicates penetration of the cement with different time.

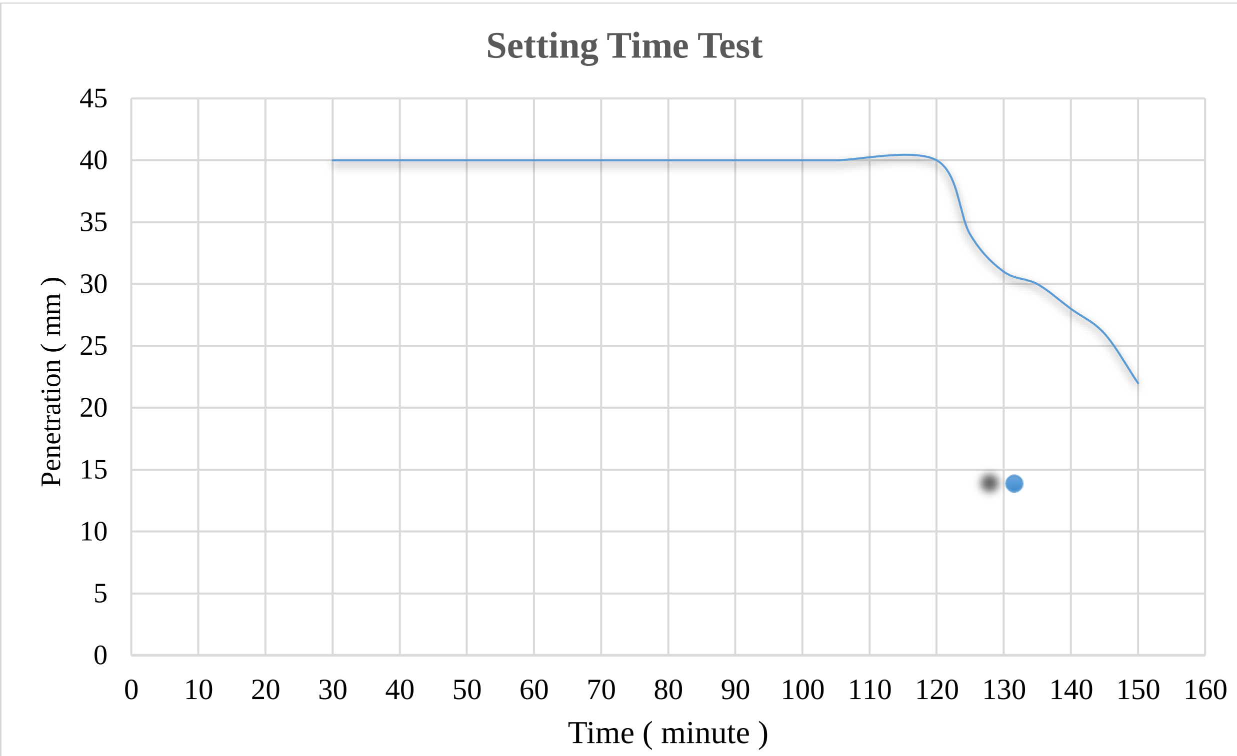

Figure 4-4: Setting Time of Cement.

4.4 Effects of Superplasticizer on workability

Slump test is conducted for determining workability for all mixes in this study. (Table 4-4) shows the results of slumps for superplasticizer and relationship between dosages of superplasticizer and slumps. From (Figure 4-5), it's obvious that increase of dosages of superplasticizer will increase slump linearly that it describes the increase of concrete workability.

Table 4-4: Slump Data.

Concrete Mix	Superplasticizer proportion	Slump (cm)
C0	0 ml/100 Kg of cement	1
C1	250 ml/100 Kg of cement	3
C2	500 ml/100 Kg of cement	14
C3	750 ml/100 Kg of cement	17
C4	1000 ml/100 Kg of cement	19
C5	1250 ml/100 Kg of cement	23

From (Figure 4-6), (Figure 4-7), (Figure 4-8), (Figure 4-9), (Figure 4-10) and (Figure 4-11) show the slumps of mixes of (C0, C1, C2, C3, C4, C5) respectively. The slump that is achieved at mix control with (0 ml/100 Kg of cement) is (1cm) hence it isn't a workable concrete. At C1 (250 ml/100 Kg of cement) the mix is low workable with slump value (3cm) but by adding more SP at dosages (500 ml/100 Kg of cement, 750 ml/100 Kg of cement, 1000 ml/100 Kg of cement, 1250 ml/100 Kg of cement) slump value is increased to (14cm, 17cm, 19cm, 23cm) that mean the mixes are high workable at these mixes.

Comparing to control mix (C0) by adding SP with dosages of (250 ml/100 Kg of cement, 500 ml/100 Kg of cement, 750 ml/100 Kg of cement, 1000 ml/100 Kg of cement, 1250 ml/100 Kg of cement) slump increased to (3cm, 14cm, 17cm, 19cm, 23cm) respectively with same W/C ratio for all mixes, thus slump increased with increasing SP dosages linearly. The minimum value is (1cm) and the maximum value is (23cm) from C0 (0 ml/100 Kg of cement) and C5 (1250 ml/100 Kg of cement) respectively.

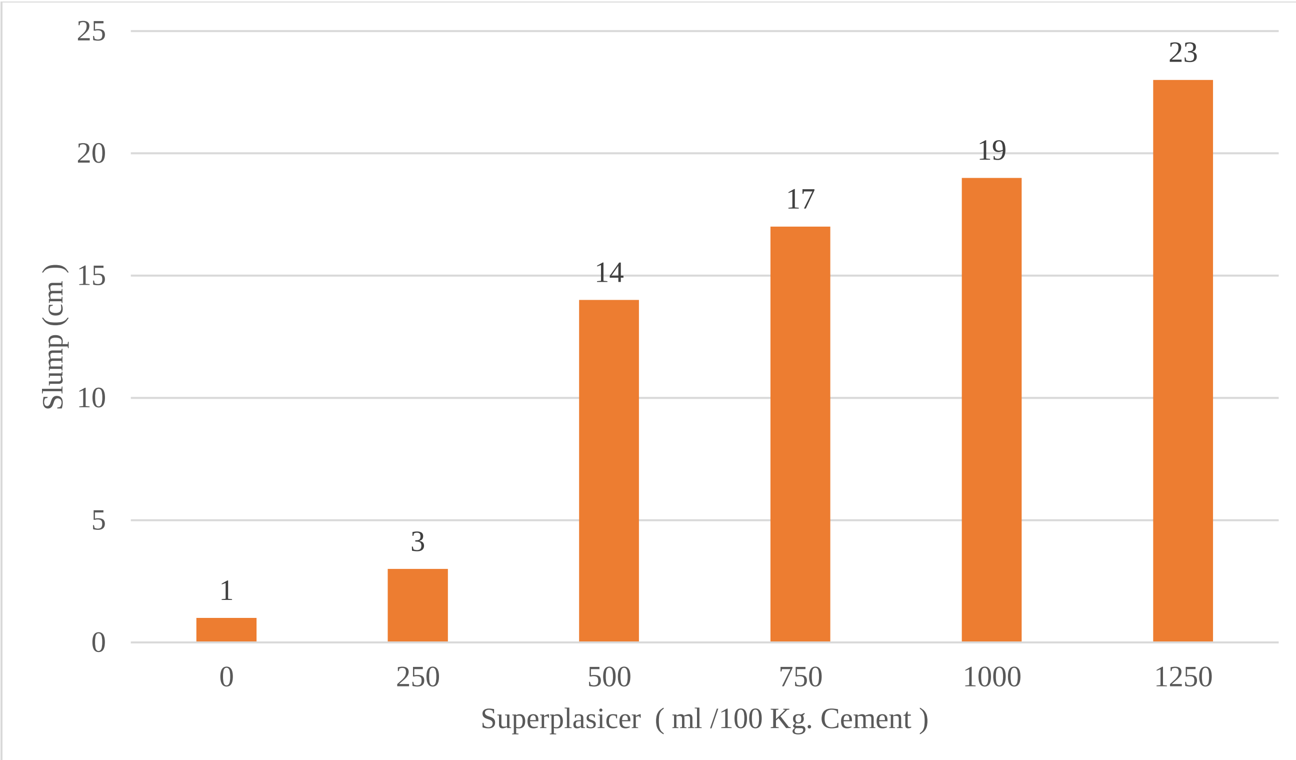

Figure 4-5: Effect of SP dosage on slump loss.

Figure 4-6: Slump Test at (C0)

Figure 4-7: Slump Test at (C1).

Figure 4-8: Slump Test at (C2).

Figure 4-9: Slump Test at (C3).

Figure 4-10: Slump Test at (C4).

Figure 4-11: Slump Test at (C5).

4.5 Effects of Superplasticizer on Compressive Strength

Compressive strength is determined by using standard cubes (150mm*150mm*150mm) for 28 days of curing that performed by compressive machine. Six specimens are tested for each mix and their averages are taken. (Table 4-5) indicates the results of compressive strength of control mix (C0) and mixes of (C1, C2, C3, C4, C5) with different dosages of super-plasticizer (250ml, 500ml, 750ml, 1000ml, 1250ml /100 kg of cement) and the relationship between them. The results are (22.67Mpa, 22.86Mpa, 22.93Mpa, 22.72Mpa, 22.02Mpa, and 21.28Mpa) for (C0, C1, C2, C3, C4, C5) respectively.

Table 4-5: Compressive Strength of Concrete with Different Dosages of Superplasticizer.

Concrete Mix	Superplasticizer proportion	Compressive Strength (28 days)
C0	0 ml/100 Kg of cement	22.67Mpa
C1	250 ml/100 Kg of cement	22.86Mpa
C2	500 ml/100 Kg of cement	22.93Mpa
C3	750 ml/100 Kg of cement	22.72Mpa
C4	1000 ml/100 Kg of cement	22.02Mpa
C5	1250 ml/100 Kg of cement	21.28Mpa

At figure (4-12), it' obvious that increment in dosage of the admixture will enhance the compressive strength, but there is an limit for admixture usage, when the dosages go beyond this limit increasing in dosage will reduce the compressive strength. This phenomenon occur since over dosage of super-plasticizer will cause bleeding and segregation, which will affect the cohesiveness and uniformity of the concrete. As a result, compressive strength will reduce if the used dosage is beyond the optimum dosage.

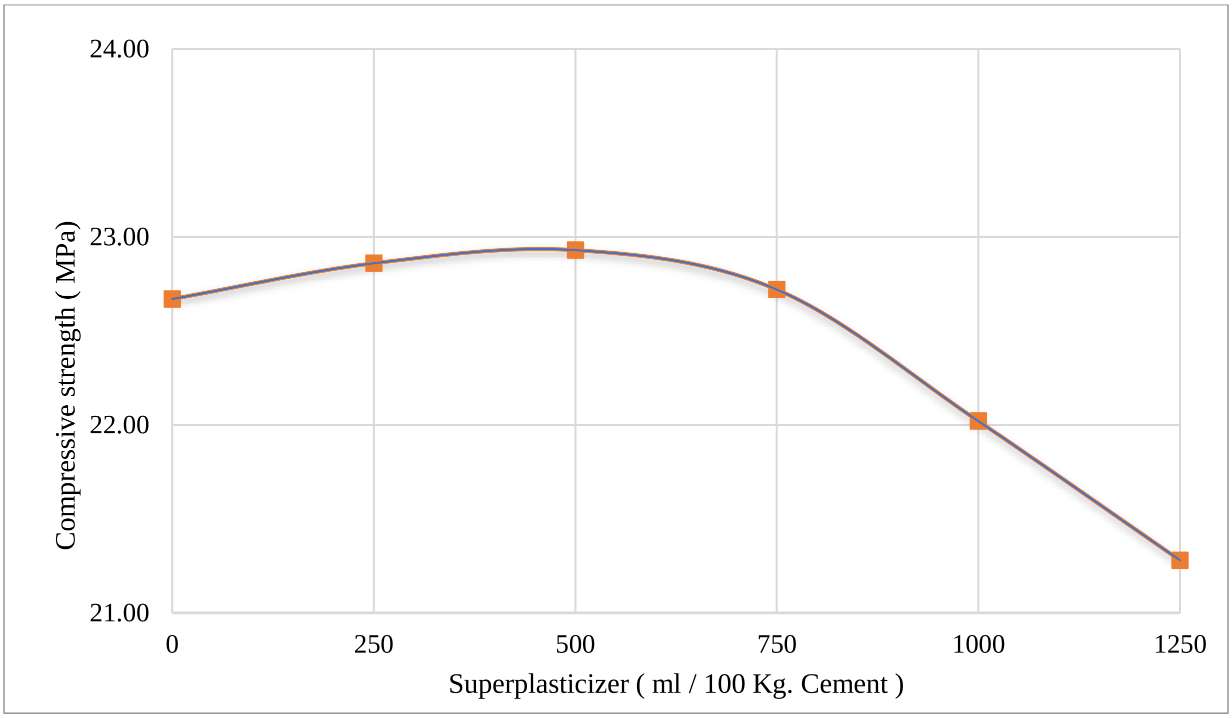

Figure 4-12: Compressive Strength of Concrete with Different Dosages of Superplasticizer.

From (Figure 4-13), (Figure 4-14), (Figure 4-15), (Figure 4-16), (Figure 4-17) and (Figure 4-18) show the compressive strength specimens of (C0, C1, C2, C3, C4, C5) respectively. The value of compressive strength at control mix (C0) is recorded as 22.67Mpa, the strength increased to 22.86Mpa by rate %0.84 at dosage 250ml/100kg of cement (C1), still with continuous increasing in the amount of SP the strength are increased to 22.93Mpa at dosage 500ml/100kg of cement (C2) by rate %1.15 according to control mix.

However at dosage 750ml/100kg of cement (C3) the value of strength is reduced to 22.72Mpa by rate %0.92 while comparing with (C2), but still increased by rate %0.22 while comparing with

(C0). The decreasing of the strength is continued, it is reduced 22.02Mpa at dosage 1000ml/100kg of cement (C4) by rate %2.95 and %3.18 while comparing with each (C0) and (C3) respectively. The strength shows same trend at dosage 1250ml/100kg of cement (C5) its value decreased to 21.28Mpa by %6.53 and %3.48 according (C0) and (C4) respectively.

The compressive strength is increased until dosage 500ml/100kg of cement at mix (C2), after this dosage the strength is dropped down, although the strengths are more than control mix until dosage 1000ml/100kg of cement (C4), hence the optimum value of 22.93Mpa is achieved at dosage 500ml/100kg of cement (C2) that shown at (Figure 4-15).

Figure 4-13: The Compressive Specimens (C0**).**

Figure 4-14: The Compressive Specimens (C1).

Figure 4-15: The Compressive Specimens (C2).

Figure 4-16: The Compressive Specimens (C3).

Figure 4-17: The Compressive Specimens (C4**).**

Figure 4-18: The Compressive Specimens (C5).

4.6 Effects of Superplasticizer on Tensile Strength

Tensile strength is determined by using standard cylinders (100mm*200mm) for 28 days of curing that performed by compressive machine. Three specimens are tested for each mix and their averages are taken. Table (4-6) indicates the results of tensile strength of control mix (C0) and mixes of (C1, C2, C3, C4, C5) with different dosages of super-plasticizer (250ml, 500ml, 750ml, 1000ml, 1250ml /100 kg of cement) and the relationship between them.

The results are (2.38Mpa, 2.45Mpa, 2.51Mpa, 2.35Mpa, 2.30Mpa, and 2.05Mpa) for (C0, C1, C2, C3, C4, C5) respectively. Because Concrete is an inherently brittle material with a relatively low tensile strength compared to compressive strength the tensile strength that achieved is so small while comparing with compressive strength. Split tensile strength (fspt) is the type of tensile strength of concrete that is considered in this study.

Table 4-6: Tensile Strength of Concrete with Different Dosages of Superplasticizer.

Concrete Mix	Superplasticizer proportion	Tensile Strength (28 days)
C0	0 ml/100 Kg of cement	2.38Mpa
C1	250 ml/100 Kg of cement	2.45Mpa
C2	500 ml/100 Kg of cement	2.51Mpa
C3	750 ml/100 Kg of cement	2.35Mpa
C4	1000 ml/100 Kg of cement	2.30Mpa
C5	1250 ml/100 Kg of cement	2.05Mpa

As well as the compressive strength, tensile strength is increased with increasing dosages of superplasticizer with a limit, hence go beyond this limit increasing in dosage will reduce the tensile strength that is obvious at (Figure 4-19). So there is an optimum dosage for using superplasticizer.

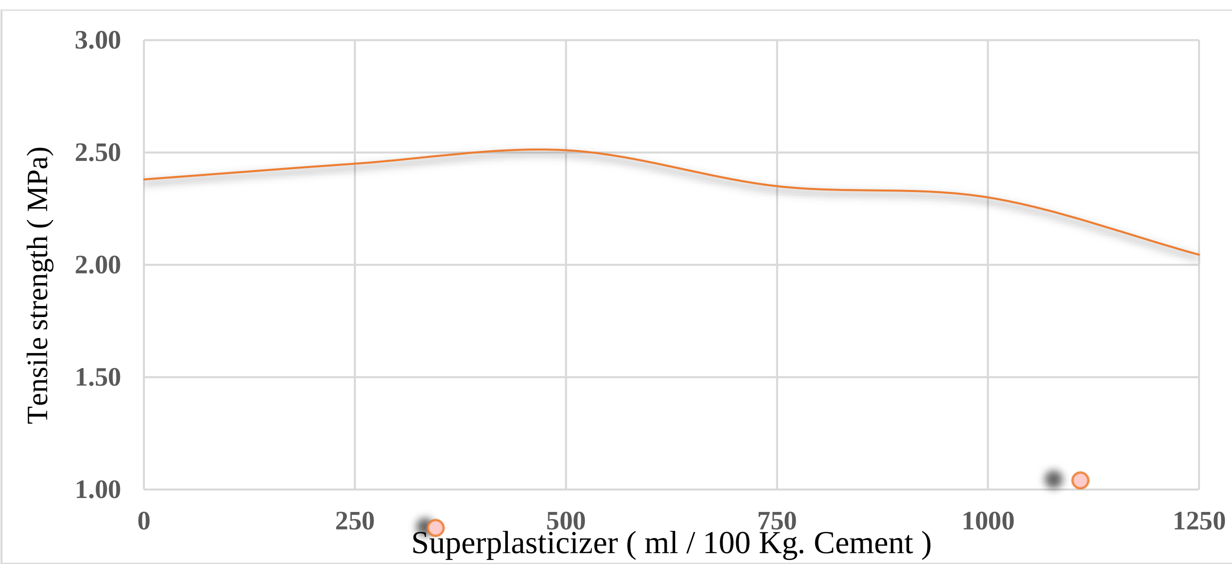

Figure 4-19: Tensile strength of concrete with different dosages of superplasticizer.

From (Figure 4-20), (Figure 4-21), (Figure 4-22), (Figure 4-23), (Figure 4-24) and (Figure 4-25) show the tensile strength specimens of (C0, C1, C2, C3, C4, C5) respectively. The tensile strength value is 2.38Mpa that is achieved at control mix (C0), this value increased to 2.45Mpa by rate %2.94 at dosage 250 ml/100 Kg of cement (C1), increasing continued in the strength for 2.51Mpa with increasing dosages for 500 ml/100 Kg of cement (C2) by rate %5.46.

The strength is dropped down at dosage 750 ml/100 Kg of cement (C3), the value reduced to 2.35Mpa by rate %1.28 and %6.81 according to control mix (C0) and (C2) respectively. Same phenomenon is occurred at dosages 1000 ml/100 Kg of cement (C4) and 1250 ml/100 Kg of cement (C5). At dosage 1000 ml/100 Kg of cement the strength reduced to 2.30Mpa by rate %3.48 and %2.17 while comparing with (C0) and (C3) respectively. Also, at dosage 1250 ml/100 Kg of cement (C5) strength reduced to 2.05Mpa by rate %16.1 and %12.2 according to (C0) and (C4) respectively.

The tensile strength is increased until dosage 500ml/100kg of cement (C2), after this dosage the strength is dropped down according to (C0) and it's before. Hence the optimum value of 2.51Mpa is obtained at dosage 500ml/100kg of cement (C2) which, shown at (Figure 1-4). So there is same optimum limit is achieved for both compressive and tensile strength that is 500ml per 100kg of cement. At compressive it's true that after that limit strength is reduced but still is more than control mix until dosage 1000 ml/100 Kg of cement, but at tensile strength after dosage 500ml/100kg of cement strength is less than both control mix and it's before mix.

Figure 4-20: The Tensile Specimens (C0).

Figure 4-21: The Tensile Specimens (C1).

Figure 4-22: The Tensile Specimens (C2).

Figure 4-23: The Tensile Specimens (C3).

Figure 4-24: The Tensile Specimens (C4).

Figure 4-25: The Tensile Specimens (C5).

4.7 Relationship between Effects of SP on Slump, Compressive strength and Tensile Strength

The relationship between slump, compressive strength and tensile strength is shown at (Figure 4-26). The results show that slump is increased linearly with increasing dosages of SP it means that slump is increased by adding SP for all dosages. But both compressive strength and tensile strength increased with increment in dosages of SP with a limit, after these limit strengths are reduced.

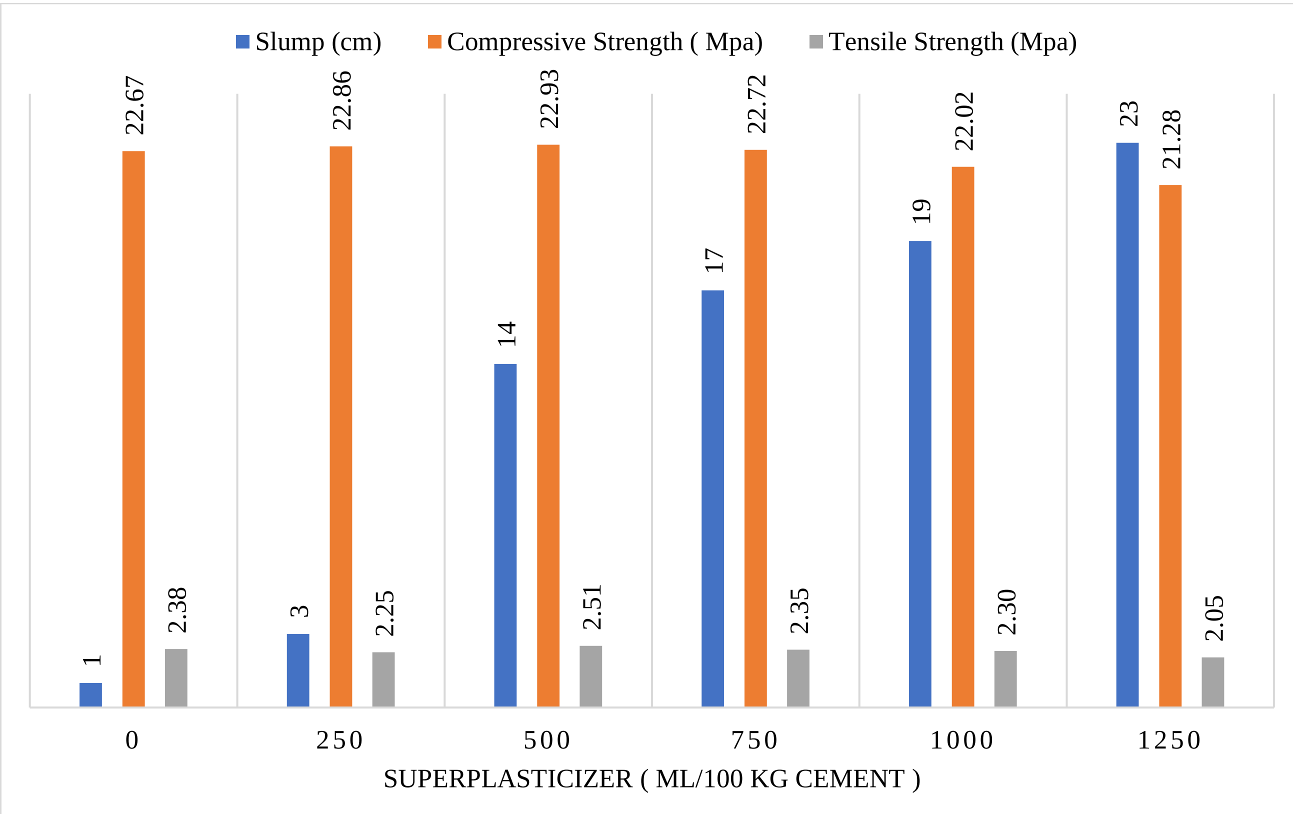

Figure 4-26: Effect of SP on Slump, Compressive strength and Tensile Strength.

The compressive strength and tensile strength value are 22.67Mpa and 2.38Mpa that is achieved at (C0) respectively. These strengths are increased to 22.86Mpa and 2.45Mpa at (C1) for compressive and tensile strength respectively. Still there are increasing in strength for both compressive and tensile strength at (C2) for 22.93Mpa and 2.51Mpa respectively.

But by adding more SP the strengths are reduced to 22.72Mpa and 2.35Mpa for compressive and tensile strength respectively. This phenomenon is continued for (C4) and (C5), at C4 the compressive strength and tensile strength value are 22.02Mpa and 2.30Mpa that is achieved and at C5 the compressive strength and tensile strength value are 21.28Mpa and 2.05Mpa that is achieved respectively.

The optimum value is (22.93Mpa) and (2.51Mpa) achieved at C2 (500ml/100kg of cement) for both compressive strength and tensile strength respectively. Tensile strength after this dosage is dropped down according to (C0) and it’s before. But at compressive it’s true that after that limit strength is reduced but still is more than control mix until dosage 1000 ml/100 Kg of cement.

Mix control with (0 ml/100 Kg of cement) isn’t a workable mix with slump value (1cm) and C1 with (250 ml/100 Kg of cement) is low workable mix with slump value (3cm). but at dosages (500 ml/100 Kg of cement, 750 ml/100 Kg of cement, 1000 ml/100 Kg of cement, 1250 ml/100 Kg of cement) with adding more SP slump value is increased to (14cm, 17cm, 19cm, 23cm) hence the mixes are high workable at these mixes. Thus C2 with (500ml/100kg of cement) is the optimum dosage for both compressive and tensile strength and has a good workability with slump value (14cm) this is more suitable mix than other mixes.

CHAPTER FIVE

CONCLUSION

This study is conducted to investigate the effects of SP on compressive strength and tensile strength of concrete with different dosages and determining optimum limit for the usage of SP, six mixes is taken (C0, C1, C2, C3, C4, C5) with different dosages (0ml, 250ml, 500ml, 750ml, 1000ml, 1250ml /100 kg of cement) with W/C ratio (0.46) and concrete mix (1:1.5:3) with characteristic strength of 30 (N/mm2).

Thirty six (36) cube specimens with different SP dosages are prepared for compressive strength test, for each mixes six (6) specimens out of 36 specimens and their averages are taken. Eighteen (18) cylinder specimens with different SP dosages are prepared for tensile strength test, for each mixes three (3) specimens out of 18 specimens and their averages are taken.

At the results strength increased with increment in dosages of SP with a limit beyond this limit strength is reduced linearly. The compressive strength value is 22.67Mpa that is achieved at (C0), the strength increased by rate %0.84 at dosage 250ml/100kg of cement (C1), still with continuous increasing in the amount of SP the strength are increased by rate %1.15 at dosage 500ml/100kg of cement (C2) according to control mix.

However at dosage 750ml/100kg of cement (C3) the value of strength is reduced by rate %0.92 while comparing with (C2), but still increased by rate %0.22 while comparing with (C0). The decreasing of the strength is continued, it is reduced at dosage 1000ml/100kg of cement (C4) by rate %2.95 and %3.18 while comparing with each (C0) and (C3) respectively. The strength shows same trend at dosage 1250ml/100kg of cement (C5) its value decreased by %6.53 and %3.48 according (C0) and (C4) respectively.

Also, tensile strength increased with increment in dosages of SP with a limit beyond this limit strength is reduced linearly. The tensile strength value is 2.38Mpa that is achieved at control mix (C0), this value increased to by rate %2.94 at dosage 250 ml/100 Kg of cement (C1), increasing continued in the strength by rate %5.46 with increasing dosages for 500 ml/100 Kg of cement (C2) according to (C0).

The strength is dropped down at dosage 750 ml/100 Kg of cement (C3) by rate %1.28 and %6.81 according to control mix (C0) and (C2) respectively. Same phenomenon is occurred at dosages 1000 ml/100 Kg of cement (C4) and 1250 ml/100 Kg of cement (C5). At dosage 1000 ml/100 Kg of cement the strength reduced by rate %3.48 and %2.17 while comparing with (C0) and (C3) respectively. Also, at dosage 1250 ml/100 Kg of cement (C5) strength reduced by rate %16.1 and %12.2 according to (C0) and (C4) respectively.

Hence the optimum dosage of the compressive strength and tensile strength at dosage (500ml /100 kg of cement) at (C2) for that SP which is used in this study (POLYCARBOXLATE) after this dosage both compressive and tensile strength is reduced linearly.

The slump that is achieved at mix control with (0 ml/100 Kg of cement) is (1cm) hence it isn’t a workable concrete. At C1 (250 ml/100 Kg of cement) the mix is low workable with slump value (3cm) but by adding more SP at dosages (500 ml/100 Kg of cement, 750 ml/100 Kg of cement, 1000 ml/100 Kg of cement, 1250 ml/100 Kg of cement) slump value is increased to (14cm, 17cm, 19cm, 23cm) that concrete mixes are high workable at these mixes. The minimum value is (1cm) at C0 (0 ml/100 Kg of cement) and the maximum value is (23cm) at and C5 (1250 ml/100 Kg of cement). Hence, workability is increased with increasing SP for all dosages linearly.

Thus concrete mix at (C2) with dosage (500 ml/100 Kg of cement) has the optimum compressive and tensile strength with value (22.93Mpa) and (2.51Mpa) respectively and a possible workability with slump (14cm) that is appropriate with standard slump with range (3cm-15cm).

According to the results that is obtained the SP (POLYCARBOXLATE) is impacted workability more than compressive and tensile strength hence the SP is using for improving workability but still the SP is impacted compressive and tensile strength and increased them with a limit. According this, SP can lead less use of water with the specific ratio and improving workability with reducing W/C ratio without deteriorate of strengths of concrete and it has effect on developing and improving the global and environmental necessaries by saving water.

From the results of the study these achievements have been obtained:

1. Workability of concrete mixes can be improved by Increment in dosages of SP linearly.
2. Compressive strength optimum value is obtained at (C2) with dosage (500ml /100 kg of cement) after this dosage the strength is dropped down, although the strengths are more than control mix until dosage 1000ml/100kg of cement (C4).
3. Tensile strength optimum value is obtained at (C2) with dosage 500ml/100kg of cement, after this dosage the strength is dropped down according to (C0) and it’s before.
4. Concrete mix at (C2) with dosage (500 ml/100 Kg of cement) has the optimum compressive and tensile strength with value (22.93Mpa) and (2.51Mpa) respectively and a possible workability with slump (14cm) that is appropriate with standard slump with range (3cm-15cm) thus the most appropriate mix is (C2) .

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