The Effect Of Admixtures On Properties Of Concrete

BY

Raed Abu Dawood   Ahmad Khalaf

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

BACHELOR OF ENGINEERING

IN

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

SUPERVISED BY

Dr. Nafez Nasereddin

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COLLEGE OF ENGINEERING AND TECHNOLOGY

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CERTIFICATION

Palestine Polytechnic University

(PPU)

Hebron- Palestine

The Senior Project Entitled:

The Effect Of Admixtures On Properties Of Concrete

Prepared By:

Raed Abu Dawod   Ahmad Khalaf

In accordance with the recommendations of the project supervisor, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of the department for the degree of Bachelor of Science in Engineering.

Project Supervisor   **Department Chairman**

Jan. 2010

Dedication

We dedicate this simple labor:

To our parents

To our brothers

To our friends

To our nation

To any person works hard

ACKNOWLEDGEMENT

We would like to thank and gratitude to Allah, who gives us, the most Merciful who granted us the ability and willing to start project. We authentic and appeal to Allah who give us blessed and power to continue our project to the benefits of our country.

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ABSTRACT

This project investigates the effects of admixtures on the properties of concrete; which may be affected by water cement ratios and admixtures quantity on concrete mix. Because the use of admixtures for many purposes in concrete and the importance of concrete as a construction material this project will be made.

An experimental approach took place for studying the effect of the varying water cement ratios and the effect of the admixtures. This was done by making a number of concrete mixes each with either a different water cement ratio or amount of admixture added to the mix. The properties of these concrete mixes assessed by measuring both the fresh and hardened state properties of the concrete mix.

There are some of literature review which talk about admixtures or concrete in general or specified in admixtures, these will be discussed in chapter two, but non of these researches study the effect of the used admixtures on properties of concrete in its details.

The results of the tests showed that the properties of concrete will be affected by the percentage of admixtures and water cement ratio, and the optimum percent is 1% witout reducing wlc ratio and 1.5% with reduction of water, slag cement used this project is bad , and it requires chemical treatment.

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1: Introduction:-

1:1: General Back Ground:

Concrete considered essential in construction materials, it is widely used in buildings and any other type of constructions.

1.1.1 History of Concrete

Concrete has been known for many centuries; the first known use of a material resembling concrete was by the Minoan civilization around 2000 BC. During the early stages of the Roman Empire around 300 BC the Romans discovered that mixing a sandy volcanic ash with lime mortar created a hard water resistance substance which we now know as concrete. The predominant type of cement used in modem concrete is Portland cement, other types of cement available include; Blended cement, which is similar to Portland cement but may contain materials such as fly ash slag or silica fume; High early strength cements, which as the name suggests gains strength a lot quicker then Portland or blended cements; Low heat cements, used when limits are placed on the heat of hydration of the concrete; Shrinkage limited cements; Sulphate resisting cements; Coloured cements; Masonry cement.

Portland cement is made by mixing calcium carbonate commonly found in limestone or chalk and silica, alumina and iron oxide found in clay or shale. The two ingredients are ground and mixed together in either a dry or wet state depending on the characteristics of the rocks being used. The mix is then placed in a kiln at temperatures as high as 1400 degrees Celsius, at this temperature the two rocks fuse together to form clinker. The clinker is allowed to cool and gypsum is added at around 1 - 5 percent. The mix is then ground to the required fineness and distributed to concrete batch plants. Portland cement derives its name from the Portland limestone because of the close resemblance of the finished concrete to the Portland Limestone.

Concrete is one of the most popular materials for constructing any structural member which owing to the fact that it can be cast into just about any shape, it has good compressive strengths, is readily available just about anywhere and is relatively cheap in comparison to other materials available for construction, such as steel or fiber composites. Concrete is made from a mixture of cement powder coarse and fine aggregates, normally sand and crushed rock and water. It can be either mixed in a hand mixer or by a large batch plant.

1.1.2 Aggregates

Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However it is now known that the type of Aggregate used for concrete can have considerable effects on the plastic and hardened state properties of concrete. Aggregates can form up to 80% of the concrete mix so their properties are crucial to the properties of the concrete. Aggregates can be broadly classified into four different categories, they are heavy weight, normal weight, light weight and ultra-light weight aggregates. However in most concrete practices only normal weight and light weight aggregates are used. The other types of aggregates are for special uses, such as nuclear radiation shielding for heavy weight concrete and thermal insulation for light weight concrete.

Types of aggregates commonly used include natural sands and gravels, crushed rocks and manufactured aggregates. Natural sands and gravels are normally sourced from stream beds, dunes, alluvial deposits or marine deposits. Crushed rocks have an advantage over other aggregates in that their size may be specified by using different size screens when the rocks are crushed. Rock types used for crushed aggregates include igneous rocks such as basalt, diorite and granite; Sedimentary rocks normally used as aggregates are lime stone but occasionally some sandstone is used; and metamorphic rocks are rarely used due to the highly variable nature of the mineral composition of these rocks.

1:2: Objectives:

This project will be done for many purposes, Most of civil engineers will be interested by the results, also the admixtures are new materials added to concrete mix, but few of these engineers know what are the effects of these admixtures on the properties of concrete.

The objectives of this project are:

1- Studying the effect of used admixtures on the properties of concrete.
2- Correlating between the percentage of admixture used and the properties of concrete and to decide the optimum percentage for the used admixture.
3- Making a mixing between two or more types of admixtures, and note there effect.
4- Varying water cement ratio with the percentage of admixture, and see the effect on the properties of concrete.
5- If time submits, seeing the effect of used admixtures on compressive strength not only after 28 days; but also take longer time intervals.

1:3: Importance:

Because admixtures are widely used now by the most of concrete manufacturers, It is important for engineers to know the effect of the admixtures on specific properties of concrete, and to insure which type of admixture have a negative results or which the concrete mix have a negative behavior when this type of admixtures used.

Another important point that civil engineer should know all types of admixtures, there properties and there effect on concrete so when the engineer make a request from the manufactory or make mix in the site; He will be able to specify the type and the percentage of the admixture will be used.

The importance of this project is to specify the optimum percentage for the used admixtures so the engineer deals with one percentage not with range.

1:4: Scope of Project:

This project will depend on the experimental works which results will be reached. Three experiments will be done: initial time set test, slump test for workability and the compressive strength test for measuring the compressive strength of concrete.

These tests will be discussed in chapter 3.

2: Literature review:

2:1: Admixtures:

Admixtures are substances which are added to the concrete mix to give it more desirable properties. Admixtures can be classified into a number of different categories. They are

* Air entraining Agents
* Accelerating Agents
* Retarders
* Water Reducing or Plasticizers
* Superplasticizer
* Bonding Admixtures
* Water Repelling Agents
* Pigments
* Profilers
* Pozzolans

Each of these different admixtures has a different effect on the properties of fresh and hardened concrete. A superplasticizer will be used in this project because of its ability to dramatically increase the workability of fresh concrete with minimal effect on the overall strength of the concrete.

Water reducing plasticizer has a detergent property which is referred to as a surface active agent. These substances carry an unbalanced charge of electricity and when put into water will migrate towards the surface of the water with the electrically charged end sticking into the water whilst the tale is out of the water.

The Cement and Admixtures Association, (1977) reported that two things will happen when a surface active agent is placed into a suspension of cement particles.

1. The surface active agents 'tail' is absorbed on the surface of the cement particle with the negative charge protruding into the water. As a result the cement particles do not collect together and therefore more surface area is available for reaction with the water. At the same time water that may be trapped inside a cement particle floc is released. The combined effects improve the workability of the cement mix; this can be seen graphically in figure 2.1

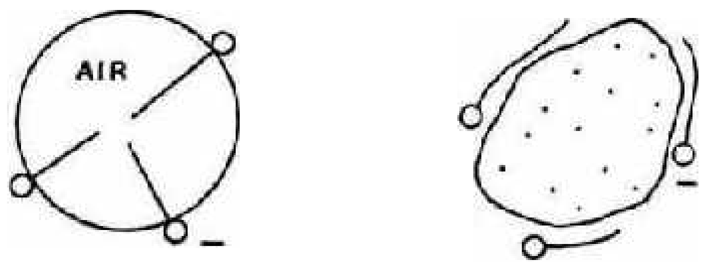

Figure 2.1: Effect of surface active agent on cement particles floc, Source: Cement Admixtures Association

2. Entrapped air is also more readily removed since orientation of the surface active agents prevents the air bubble from attaching to cement particles, seen in figure 2.2.

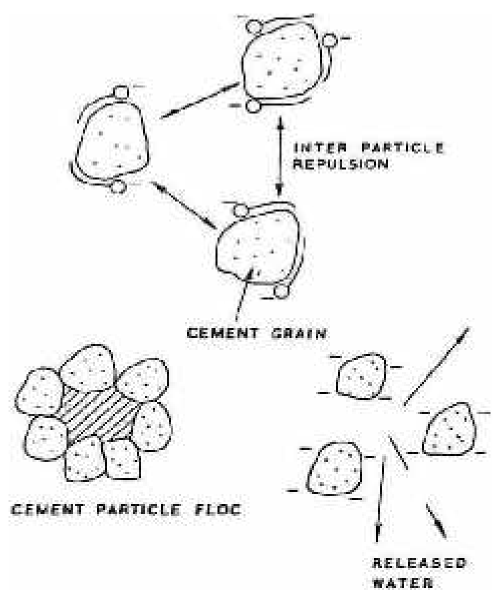

Figure 2.2: Repulsion of air bubble by surface Active Agent, Source: Cement Admixtures Association

Another research done by Uwe Herterich, Gerhard Volland, Gunter Krause, Dagmar Hansen, it’s about: Determination of concrete admixtures by NMR spectroscopy.

This literature say that “Based on investigations of typical components - active components and impurities - of common concrete admixtures like water reducers, retarders, plasticizers, mobile components and mobile decomposition products of active components resulting from reactions of concrete admixtures with concentrated alkaline solutions in porous water were determined. Cement mortar and concrete samples with admixtures (admixture concentration 0.5 and 2 % of cement content) were extracted/leached with different organic solvents and aqueous solutions at higher temperatures. The identification and quantification of relevant compounds in initial products and extracts were carried out by nuclear magnetic resonance spectroscopy *CH* NMR) as well as by gas chromatography/ mass spectrometry. The obtained data prove on one hand, that concrete admixtures are detectable in concrete with the methods chosen. On the other hand the data proves, that even under "worst-case" -conditions (grounded cement bound building material and extraction/leaching at higher temperatures for more than 5 d) only minor portions of active components and impurities are mobile in water. More than 70 % of the added admixture is irreversible bound to the concrete matrix. Besides small portions of active components mainly formiate and acetate can be detected in aqueous solutions. Of the listed dangerous substances only phosphoric acid tributyl ester can be detected in aqueous extracts of concrete and cement mortar in minor traces.

3: Materials and experimental works:

3:1 Concrete:

<u>Concrete</u>: is a word of Latin derivation (con - together) (Crete - to grow) and its history can be charted from 5000 BC.

It is a composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregate. In hydraulic cement concrete the binder is formed from a mixture of hydraulic cement and water.

Concrete composites of:-

1- Cement.
2- Aggregates
3-sand
4- Water
5- Admixtures (if used) .

In this project two mixes were made with different portions of the main component, one mix expected strength (after 28 days) is 300 kg/cm²; the other is 200 kg/cm².
Two reference mixes made without any admixture, these mixes made for comparing.
Other mixes made with different dosage of admixtures(sp561) .

3:1:1 Cement:

Cement: is inorganic material or a mixture of inorganic materials that sets and develops strength by chemical reaction with water by formation of hydrates and is capable of doing so under water.

Portland cement concrete is composed of three basic components: portland cement, aggregates, and water. In addition, there are a host of other materials, called additives that may be added to obtain special properties. These include air entraining agents, accelerators, decelerators, carbon black, fly ash, pozzolans, silica fume, water-reducing agents, super plasticizers, among others. The use of these admixtures is a specialized subject for experienced professionals.

CEMENTING MATERIALS

Any material which can be made plastic and which gradually hardens to form an artificial stone-like material is referred to as a cementitious material. Hydraulic cements, namely Portland and natural, along with limes are the principal cementing materials used in structures. They become plastic by the addition of water and then the mix hardens.

The earliest cement known was pozzolan cement which was first used by the Romans more than 2000 years ago. It was produced by mixing lime with a volcanic ash called pozzolana which is found near the town of Pozzuoli, Italy. Natural cement in more recent times was produced by burning a limestone high in clay and magnesia to drive off the carbonic acid and then grinding the clinker to a fine powder. In comparison to Portland cement, natural cement possesses lower tensile strength, gains strength more slowly, and is less uniform.

Portland cement comes in five basic types and a number of specialty varieties to fulfill different physical and chemical requirements. The most frequently used cements are Types I, II, and III with an A after the number signifies that the cement contains an air-entraining agent. There also is a white portland cement for special purposes in Types I and III. This does not exhaust the list of hydraulic cements that are available but it will suffice for the purpose here.

3:1:2 Aggregate:

Aggregates: Granular materials, such as sand, gravel, crushed stone, or iron blast-furnace slag, used with cementing medium to form concrete or mortar. Aggregates act as relatively inexpensive inert filler, providing stability against volume changes and influencing strength and stiffness.

Aggregates are the inert particles that are bound together by the cementing agent (such as Portland cement) to form a mortar or a concrete. Mortar is a mixture of fine aggregate, a cementing material, and water. A mixture of only cement and water is referred to as "neat cement." Concrete is composed of the ingredients of mortar plus coarse aggregates. The boundary size definition of fine aggregates is one that passes a 5 mm (#4) sieve. Coarse aggregate particle sizes are those that are retained on a 5 mm (#4) sieve opening. There is no real maximum size aggregate, but in most concretes for pavements and structures the upper limit is usually 5 cm (2 in.), but may be larger.

Coarse aggregates are obtained from gravel or crushed stone, blast furnace slag, or recycled concrete. Trap rocks, granite, limestones, and sandstones are satisfactory for crushed stone. Fine aggregates are derived from the same sources except that in the place of gravel, naturally occurring sand is used. All aggregates should be composed of hard particles and free of injurious amounts of clay, loam, and vegetable matter. The principal characteristics of aggregates that affect the strength, durability, and workability of a concrete are cleanness, grading, hardness, and shape. Usually the aggregates are stronger than the concrete from which they are made. A coating of dirt or dust on the aggregate will reduce the strength of concrete because it prevents the particles from properly bonding to the mortar. A well-graded aggregate mix is essential to obtaining an economical concrete of good quality. If poorly graded, even clean, sound aggregates will require excessive water for workability, resulting in lower strength, or the mix will require an excessive amount of cement to develop a given strength.

The ASTM specification for the grading and quality of aggregates for normal weight concrete is defined by ASTM Designation: C 33. There are seven standard sieve openings for fine aggregate and up to 13 sieve sizes for coarse aggregates. The grading requirements are shown in Table 3.1

Table 3.1 Grading Requirement for Fine Aggregates from ASTM Designation: C 33

Sieve Size (Specification E 11)	Percent Passing
9.5 mm (3/8 in.)	100
4.75 mm (No.4)	95-100
2.36 mm (No.8)	80-100
1.16 mm (No.16)	50-85
600 m (No.30)	25-60
300 m (No.50)	10-30
150 m (No.l00)	2-10

3:1:3 Sand

Sand, along with gravel, silt and clay are collectively known as sediment, and are produced by the mechanical and chemical breakdown of rocks. Once disaggregated from the original source rock, this material is then eroded and transported by either wind, water or ice, often ending up at the deposits of rivers or lakes, as sand dunes, or ultimately as sediment in the sea. Eventually this material may be buried to sufficient depth within the earth to harden and form sedimentary rock.

The composition of sand is largely dependent on the source material. For example, the sand around volcanic islands is often composed of volcanic rock fragments, volcanic glass, and other minerals associated with volcanic rocks. In contrast, sediment found on the beaches of southern California are largely composed of quartz (the most durable common mineral), possibly some feldspar (also durable, but more easily chemically weathered to clay), and other minerals associated with the plutonic igneous rocks which form the bulk of the mountain ranges nearby. In areas where there is no good source of sedimentary material from mountains or volcanoes, sand is often entirely composed of organic material i.e. shell fragments, coral, and the tests (skeletons) of small plank tonic organisms.

The texture of sediment is largely determined by the transportation process. The three important parameters used to assess the texture of sediment are size, rounding and sorting.

Grain Size - There terms gravel, sand, silt and clay carry with them a size connotation. Gravel is any material greater than 2 millimeters in its largest dimensions. This includes boulders, cobbles, pebbles and granules (in decreasing size order). Sand is any material between 2mm and 0.06 mm in size. We usually sub-divide this category into very coarse, coarse, medium, fine etc... In practical terms, very fine sand is about the smallest grain size you can still see with the naked eye. Silt is material which is finer than sand, but still feels gritty when rubbed on your teeth. Clay is the finest material of all, and pure clay will feel smooth on your teeth, and will form a sticky ball when wet. As a general rule, material gets smaller the more it has been transported. Therefore very coarse material usually indicates a short distance of transport and vice versa.

Rounding - As material is transported, it is subject to abrasion and impact with other particles which tends to "round-off" the sharp edges or corners. Therefore a well rounded sand grain has probably travelled a great distance from its original source area, while an angular grain has probably only been transported locally. Be careful not to confuse rounding with sphericity. A well-rounded grain may or may not resemble a sphere. Rounding is also related to the size of the grains, i.e. boulders tend to round much more quickly than sand grains because they strike each other with much greater force.

Sorting - The sorting of a sediment is simply how well the sedimentary material is separated out by size. For example, if all the grains in a sediment sample are very nearly the same size, then we say the sample is "well-sorted." If a sediment sample were to contain pieces of gravel, as well as sand and silt, it would be a "poorly sorted" sample. Sorting is somewhat dependant on the distance of transport, but it is primarily affected by the medium of transport. Water is an excellent medium for sorting of particles by size (and density). Wind is probably the best sorting mechanism of all, but only on the finer grain sized (not much gravel is moved by wind transport). Ice is the poorest sorting mechanism, transporting and depositing all sizes of sediment with equal ease.

We can learn a lot by looking closely at sand. By carefully examining the composition, size, rounding and sorting of sand, along with other clues such as the surface texture of the grains and the kind of organic material present, we can make an interpretation as to depositional environment of the sand, how far it has traveled, and its ultimate source

3:1:4: Water

Water: It reacts with the cement and also lubricates the fresh concrete enabling it to be placed into position and compacted.

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and allows it to flow more easily.

Less water in the cement paste will yield a stronger, more durable concrete; more water will give an easier-flowing concrete with a higher.

Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles, and other components of the concrete, to form a solid mass.

Reaction:

Cement chemist notation: $C_3S + H_2O \rightarrow CSH(gel) + CH$

Standard notation: $Ca_3SiO_5 + H_2O \rightarrow (CaO)\bullet(SiO_2)\bullet(H_2O)(gel) + Ca(OH)_2$

Balanced: $2Ca_3SiO_5 + 7H_2O \rightarrow 3(CaO)\bullet2(SiO_2)\bullet4(H_2O)(gel) + 3Ca(OH)_2$

Water used for concrete should be clean and free from dirt or organic matter. Water containing even small quantities of acid can have a serious deleterious effect upon concrete. The presence of oil will result in slowing the set and reducing the strength. Generally speaking, if water is potable, it is satisfactory for the production of a good concrete

3:2: Admixtures:

Admixtures: They are chemicals that can be added to the concrete immediately before or during mixing and significantly change its fresh, early age or hardened state to economic or physical advantage.

Chemical admixtures: are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement, and are added to the concrete at the time of batching/mixing. The most common types of admixtures are:

- Accelerators speed up the hydration (hardening) of the concrete. Typical materials used are $CaCl_2$ and NaCl.
- Retarders slow the hydration of concrete, and are used in large or difficult pours where partial setting before the pour is complete is undesirable. A typical retarder is table sugar, or sucrose ($C_{12}H_{22}O_{11}$).
- Air entrainments add and distribute tiny air bubbles in the concrete, which will reduce damage during freeze-thaw cycles thereby increasing the concrete's durability. However, entrained air is a trade-off with strength, as each 1% of air may result in 5% decrease in compressive strength.
- Plasticizers (water-reducing admixtures) increase the workability of plastic or "fresh" concrete, allowing it be placed more easily, with less consolidating effort.

Superplasticizer (high-range water-reducing admixtures) is a class of plasticizers which have fewer deleterious effects when used to significantly increase workability. Alternatively, plasticizers can be used to reduce the water content of a concrete (and have been called *water reducers* due to this application) while maintaining workability. This improves its strength and durability characteristics.

- Pigments can be used to change the color of concrete, for aesthetics.
- Corrosion inhibitors are used to minimize the corrosion of steel and steel bars in concrete.
- Bonding agents are used to create a bond between old and new concrete.
- Pumping aids improve pump ability, thicken the paste, and reduce dewatering – the tendency for the water to separate out of the paste

In this project super plasticizer " sp561" and slag admixtures used with different dosage.

3.2.1 High performance super plasticizing for slump retention and high strength concrete (Uniplast SP561)

Uses

• To provide excellent slump retention properties in tropical conditions even at low water cement ration.

• Particularly suitable for high strength concrete.

• To significantly improve the workability of site mixed without increasing in water demand.

• To provide improved durability by increasing ultimate strengths and reducing concrete permeability.

Advantages

• Makes possible major reduction in water cement ratio which allows the production of high strength concrete without excessive cement contents.
• Use in production of flowing concrete permits easier construction with quicker placing and compacting and reduced labor costs without increasing in water content.
• Increase workability levels are maintained for longer than ordinary sulphonated melamine admixtures.
• Improved cohesion and particle dispersion minimize segregation and bleeding and improves pump ability.
• Chloride free, safe for use in prestressed and reinforced concrete.

Standards compliance:

Uniplast SP561 complies with ASTM C494 Type B,D and G, depending on dosage used. Complies with BS 5075 Part 3 and with BSEN 934-2-1998.

Dosage:

The optimum dosage of Uniplast SP561 to meet specific requirements should always be determined by trial mixes using the materials and conditions that will be experienced in use.
For high strength, water reduced concrete the normal dosage range is from 0.70 to 1.50 liters/ 100 kg of cementitious material.

Use at other dosages:

Dosages outside the typical ranges for use telled above can be used for to meet particular mix requirements. Contact (UMC) for advice.

Effects of overdosing:

An overdose of double the amount of Uniplast SP561 will result in an increase in retardation as compared to that normally obtained. Provided that adequate curing is maintained, the ultimate strength of the concrete will not be impaired by increased retardation and will generally be increased. The effects of overdosing will be further increased if sulphate resisting cement or cement replacement materials are used.

Instructions for use:

Mix design:

Where the main requirement is to improve strengths, initial trials should be made with normal concrete mix designs. The addition of the admixture will allow the removal of water from the mix whilst maintaining workability. After initial trials, minor modifications to the overall mix design may be made to optimize performance.

Where the main requirement is to provide high workability concrete, the mix design should be one suitable for use as a pump mix. Advice on mix design or flowing concrete is available from Universal for Modem Construction (UMC).

Compatibility:

Uniplast SP561 is compatible with other Universal for Modem Construction (UMC) admixtures used in the same concrete mix. All admixtures should be added to the concrete separately and must not be premixed together prior to addition. The resultant properties of concrete containing more than one admixture should be assessed by trial mixes.

Uniplast SP561 is suitable for use with all types of Portland cements and cement replacement materials such as PFA, GGBFS, SRC cements and microsilica.

The use of a combination of admixtures in the same concrete mix and or cement replacements may alter the setting time.

Trials should always be conducted to determine such setting times.

3.2.2 SLAG CEMENT:

Slag cement, or ground granulated blast-furnace slag (GGBFS), has been used in concrete projects in the United States for over a century. Earlier usage of slag cement in Europe and elsewhere demonstrates that long-term performance is enhanced in many ways. Based on These early experiences, modern designers have found that these improved durability characteristics help further reduce life-cycle costs and lower maintenance cost.

Using slag cement to replace a portion of Portland cement in a concrete mixture is a useful method to make concrete better and more consistent. Among the measurable improvements are:

- Better concrete workability
- Easier finish ability
- Higher compressive and flexural strengths
- Lower permeability
- Improved resistance to aggressive chemicals
- More consistent plastic and hardened properties
- Lighter color

When iron is manufactured using a blast furnace, the furnace is continuously charged from the top with oxides, fluxing material, and fuel. Two products—slag and iron—collect in the bottom of the hearth. Molten slag floats on top of the molten iron; both are tapped separately. The molten iron is sent to the steel producing facility, while the molten slag is diverted to a granulator.

figure3.1: molten slag is diverted to a granulator.

This process, known as granulation, is the rapid quenching with water of the molten slag into a raw material called granules.

Rapid cooling prohibits the formation of crystals and forms glassy, non-metallic, silicates and aluminosilicates of calcium.

figure3.2: granulation process

These granules are dried and then ground to a suitable fineness, the result of which is slag cement. The granules can also be incorporated as an ingredient in the manufacture of blended Portland cement.

RELEVANT TERMINOLOGY:

Ground granulated blast-furnace slag:

(GGBFS): Hydraulic cement formed when granulated blast-furnace slag is ground to a suitable fineness. Commonly referred to as slag cement, or GGBFS.

Blast-furnace slag:

The non-metallic product, consisting essentially of silicates and aluminosilicates of calcium and other bases, that is developed in a molten condition simultaneously with iron in a blast furnace.

Granulated blast-furnace slag:

The glassy, granular material formed when molten blast-furnace slag is rapidly chilled by immersion in water. Also referred to as granules.

Portland blast-furnace slag cement:

A blended cement consisting of an intimately underground mixture of Portland cement clinker and granulated blast-furnace slag, or an intimate and uniform blend of Portland cement and fine granulated blast-furnace slag in which the amount of the slag constituent is within specified limits.

PROPORTIONING CONCRETE WITH SLAG CEMENT:

Concrete mixtures containing slag cement should be proportioned according to ACI 211.1. The specific gravity of slag cement ranges from 2.85 to 2.94, depending on the slag source, as compared to 3.15 for Portland cement. The difference in specific gravity means a greater volume of slag cement will be used to replace the same mass of Portland cement. The larger percentage of fines usually provides mixtures that are easier to place finish and consolidate. A higher percentage of coarse aggregate can be used to increase strength and reduce water demand without affecting plastic properties.

In general, water demand for any given slump may be reduced up to five percent. Slag cement should always be included when calculating the water-cementitious material ratio.

Slag cement is compatible with chemical admixtures regularly used in concrete.

The effects of chemical admixtures in concrete containing slag cement are similar to their effects in ordinary Portland cement concrete. Trial batches will determine proper admixture dosages. Slag cement does not contain carbon and therefore should not cause fluctuations in air content.   Slag cement is also compatible with pozzolans such as fly ash or silica fume.

CONCRETE PROPORTIONING:

Table 3.2: Portion of slag cement in concrete application

Concrete Application	Slag Cement
Concrete paving	25-50%
Exterior flatwork not exposed to deicer salts	25-50%
Exterior flatwork exposed to deicer salts with w/cm < 0.45	25-50%
Interior flatwork	25-50%
Basement floors	25-50%
Footings	30-65%
Walls & columns	25-50%
Tilt-up panels	25-50%
Pre-stressed concrete	25-50%
Pre-cast concrete	25-50%
Concrete blocks	25-50%
Concrete pavers	25-50%
High strength	25-50%
ASR mitigation	25-70%
Sulfate resistance**:** Sulfate resistance	25-50%
Type V equivalence	50-65%
Lower permeability	25-65%
Mass concrete	50-80%

MITIGATING SULFATE ATTACK:

Sulfate attack

Is a common form of concrete deterioration. It occurs when concrete comes in contact with water containing sulfates (SO4). Sulfates can be found in some soils (especially when arid conditions exist), in seawater, and in wastewater treatment plants.

Waterborne sulfates react with hydration products of the tri-calcium aluminates (C3A) phase of Portland cement, and with calcium hydroxide (Ca(OH)2) to form an expansive crystalline product called ettringite.

Principal factors that affect the rate and severity of sulfate attack are:

1. Permeability of the concrete.
2. Concentration of sulfates in the waterborne solution.
3. C3A content.
4. Ca(OH)2 content.

MITIGATING SULFATE ATTACK:

One of the most common ways of protecting against sulfate attack is to reduce the alumina content by limiting the C3A in Portland cement. Historically, Type II Portland cement (with C3Abetween 5 and8 percent) and Type V Portland cement (with C3A less than 5 percent) have been specified for moderate and severe sulfate environments, respectively. The use of slag cement is also an extremely effective way of reducing the potential for sulfate attack1.

SLAG CEMENT AND FLY ASH:

Slag cement and fly ash are the two most common SCMs used in concrete. Most concrete produced today includes one or both of these materials. For this reason their properties are frequently compared to each other by mix designers seeking to optimize concrete mixtures.

Slag cement is the co-product of a controlled process, iron production, which results in a very uniform composition from source to source. Fly ash is a by product of electric power generation that varies from source to source.

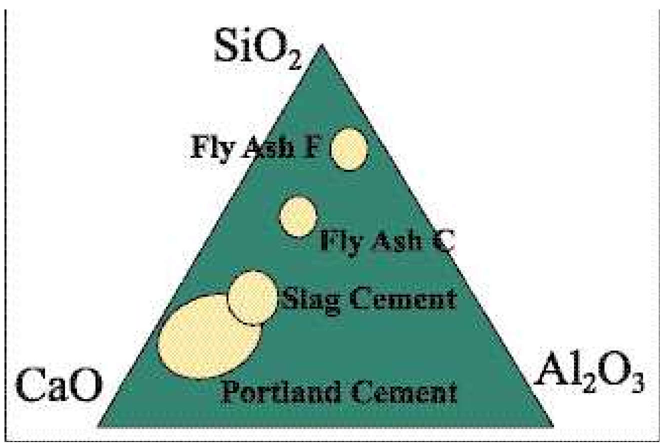

Figure 3.3: Ternary diagram of cementitious materials.

Concrete Properties:

Slag cement is a more uniform product than fly ash. As a result, concrete made with slag cement will generally have more uniform properties than concrete made with fly ash.

Plastic Properties:

Water Reduction.

The use of either material should result in a reduction of the required water content to reach a given consistency. This effect with slag cement is due to its influence on paste characteristics and absorption. With fly ash, this is primarily due to the particle shape and size distribution. This allows for small reductions in water reducing admixtures.

Air Entrainment.

Air contents can vary depending on any number of factors. Carbon content variability in fly ash is one of the major causes of fluctuating air contents.

Slag cement does not contain carbon and does not cause instability in the entrained air content.

Time of Set.

Time of initial set is influenced by the use of slag cement and fly ash. Concrete made with slag cement can have faster set times than concrete made with fly ash.

→Slag used in this project was obtained from "Al-Haddad Manufacture for steel **bars".**

3.3 Concrete Mix used:

The mixes portions of materials used in this project are shown in Tables 3.3 & 3.4.

Table3.3: mix portion used in lab. Test for B200.

Specifications of concrete mixtures used in the laboratory					
The type of concrete mixture				B 200	
The water ratio of cement is 73%					
Components	Coarse Aggregate	fine Aggregate	Sand	Cement	Water
Weight in Kg	7.81	3.34	7.40	2.75	2.00

Table3.4: mix portion used in lab. Test for B300.

Specifications of concrete mixtures used in the laboratory					
The type of concrete mixture				B 300	
The water ratio of cement is 54%					
Components	Coarse Aggregate	fine Aggregate	Sand	Cement	Water
Weight in Kg	7.60	3.10	7.20	3.70	2.00

3:4 experimental works:

In order to effectively analyze the effects that the chemical admixtures on the fresh and hardened properties of concrete, a number of different trial mix will be made. A number of different trial mixes have been made. These trial mixes are varied in water cement ratios and the percentages of plasticizer added to the concrete mix. The plasticizer chosen for this project was superplasticizer manufactured by
(Universal for modern construction); this plasticizer was chosen for us in this project for its ability to dramatically increase the workability of the fresh concrete mix. The recommend dosages for the superplasticizer was a range of 0.7 to 1.5 liters per 100 kg cement Wight used.

3:4:1 initial time set test:

TEST METHOD FOR TIME OF SETTING OF HYDRAULIC CEMENT BY THE VICAT NEEDLE (ASTM Designation: C 191)

Purpose:

The purpose of this test is to determine the time of setting of hydraulic cement by the Vicat needle.

EQUIPMENT AND MATERIALS

- 2-kg scale accurate to 0.1 grams
- Vacate apparatus which consists of a movable rod (B) weighing 400 grams; one end (C), the plunger end, being 10 mm in diameter for a distance of at least 5 cm and the other end having a movable steel needle (D), 1 mm in diameter and 5 cm in length. The rod (B) is reversible and can be raised or lowered by the set screw (E), which has an adjustable indicator (F). The latter moves over a graduated scale attached to the frame (A). The cement paste is held in a conical ring (G), which has an inside diameter of 7 cm at the bottom and 6 cm at the top and has a height of 4 cm. The truncated cone rests on a glass plate (H), which is 10 earn square.
- For a scraper, use a kitchen tool known as a plate and bowl scraper
- At least 3 kg of portland cement
- Supply of water

TEST PROCEDURE

There are three parts to this procedure: preparation of the cement paste, consistency determination, and time of setting determination.

1.Preparation of the cement paste consists of placing an estimated amount of water into the mixing bowl; adding 650 grams of portland cement and letting it sit for 30 seconds; mixing at a speed of about 140 rpm for 30 seconds; stopping the mixer for 15 seconds to allow for scraping down of any paste that may have collected on the sides of the bowl; final mixing at about 285 rpm for 60 seconds; quickly forming the cement paste into a ball with rubber gloved hands and then tossing the

ball 6 times through the air for about 15 cm; then press
the spherical-shaped ball into the Vic at ring (G) with the palm of one hand until the paste completely fills the ring, holding the bottom of the ring in the other hand; remove any excess from the bottom of the ring with the gloved hand; place the ring and cement paste onto the glass plate (H) and remove the excess paste from the top of the ring with a small steel trowel, creating a reasonably smooth plane at the top.

2.For the consistency determination, place the rod (C) at the bottom of the Vic at apparatus with the needle (D) at the top. The plunger end (C) should now be brought into contact with the top of the cement paste in the ring and the set-screw (E) tightened. Set the movable indicator (F) to the zero mark on the scale and release the rod immediately. The paste will be considered to have normal consistency if C settles 10 ± 1 mm into the paste in 30 seconds. Repeat the procedure with fresh cement batches, varying the amount of water until a paste of normal consistency is obtained. The amount of water required to obtain a cement paste of normal consistency should be determined to the nearest gram.

3.Begin the time of setting determination immediately after the normal consistency specimen in the ring has been undisturbed in a moist cabinet for 30 min. Determine the penetration of the 'l-mm needle (D) in 30 sec and every 15 (10 for Type III cement) min. thereafter, until a penetration of 25 mm or less is obtained. For this test, lower the needle (D) until it just touches the cement paste, tighten the set screw (E) and set the movable indicator (F) to the zero mark on the scale and release the rod. Allow the needle to settle for 30 sec and take the reading to determine the penetration. Record the results of all penetration readings on the table below. Determine the time of initial set by interpolating the results to find the time for a penetration of 25 mm. The final setting time is recorded when the needle (D) does not visibly sink into the paste.

3:4:2 Slump test

According to ***(ASTM Designation:* C 143)** slump test helded as the following procedures:

Purpose:

The purpose is to determine the consistency of a freshly mixed concrete by measuring the slump.

MATERIALS AND EQUIPMENT

- Frustum of a cone made of noncorrosive sheet metal not less than 1.14 mm (0.045 in.) thick, 30.5 cm (12 in.) in height, with a 20.8 cm (8 in.) base, having a diameter at the top of 10.2 cm(4 in.), with foot pieces and handles (Figure 3.4).

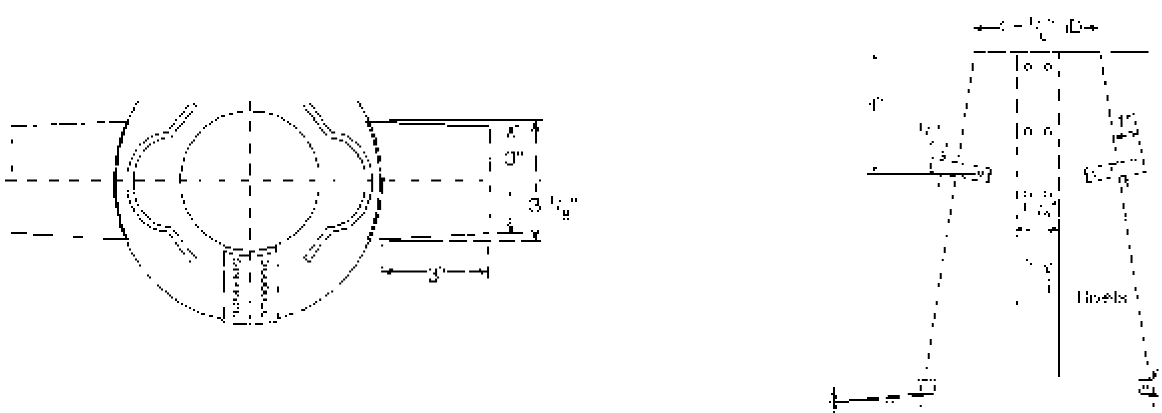

Figure 3.4: Mold for slump cone. (From ASTM. With permission.)

There should also be a metal base plate with clamps that engages the foot pieces while the concrete is being poured into the slump cone and tamped with the tamping rod

- Round steel tamping rod 16 mm (5/8 in.) diameter, having the tamping end rounded to a hemispherical tip, approximately 60 cm (24 in.) long
- Suitable, graduated metal scale approximately 50 cm (2 ft.) in length

TEST PROCEDURE

1. Dampen the slump cone and the metal base plate, and then engage the slump cone with the base plate clamps. The base plate should rest on a level surface.
2. Fill the slump cone in three lifts, tamping each lift 25 times with the tamping rod, starting from the center and working toward the perimeter. The bottom lift should be rodded the full depth down to the base plate. For the two other lifts, the strokes of the tamping rod should penetrate into the underlying concrete layer. The top lift should remain heaped above the top of the slump cone after completing the rodding. Each of the three lifts should contain approximately an equal volume of concrete. Therefore, the bottom layer should have a rodded depth of about 7 cm (2 1/2 in.) and the second lift to about 15 cm (6 in.).
3. Strike off the excess concrete with a screeding and rolling motion of the tamping rod.
4. Remove the cone carefully with a slow vertical motion without any rotational or lateral motion. The entire procedure from the time the fresh concrete is ready for testing to this point should be no more than 5 min. The time from the filling of the slump cone to the determining of the slump should be within 2 1/2 min.
5. Set the slump cone in an inverted position next to the concrete and measure the distance to the top of the original center of the specimen as shown in Figure 3.5.

Figure 3.5 Demonstration on use of a slump cone: (top) a low slump and (bottom) a high slump. (From the Canadian Portland Cement Association. With permission.)

3:4:3 compressive strength tests:

Strength of concrete is commonly considered its most valuable property, although in many practical cases other characteristics, such as durability and impermeability, may in fact be more important. Nevertheless, strength usually gives an overall picture of the quality of concrete because strength is directly related to the structure of the hardened cement paste.

Compression Tests:

Tow types of compression test specimens are used: cubes, and cylinders. Cubes are used in Great Britain, Germany, and many other Countries in Europe. Cylinders are the standard specimens in the United States, France, Canada, Australia and New Zealand. In Scandinavia tests are made on both cubes and cylinder.

The tendency in this research preference to cubes.

Cube Test:

According to ***(ASTM Designation:*** **C 39)** this test can be made as follows:

Purpose:

The purpose is to determine the compressive strength of cubical specimens molded. The 28-day compressive strength (f_{cu}) of molded cubes is normally used in design.

EQUIPMENT AND MATERIALS

- Reusable steel or wax-coated cardboard disposable cubes molds, (10x10x10) cm.
- Moist storage facility for curing the fresh concrete specimens.
- Straight steel tamping rod that is 16 mm in diameter and about 60 cm in length with one end rounded in a hemispherical tip.
- Rubber mallet weighing about 0.6 kg (1.3 lb)
- A set of special steel caps of appropriate diameter with a neoprene pad contact with the concrete for capping the specimen
- Testing machine for compressive strength.

TEST PROCEDURE:

1. Preparation of cube specimens.
   a. Prepare and cure the specimens in accordance with ASTM Designation: C 192.
   b. Perform slump tests on the fresh concrete prior to casting the specimens in cubes **in accordance with ASTM Designations: C 143, C 231, and C 360**.
   c. Fill the cubes with two lifts of freshly mixed concrete, tamping each lift 25 times with the tamping rod.
   d. Strike off the excess concrete with the tamping rod and finish to a smooth surface with a steel trowel.
   e. **It is recommended that specimens be prepared and tested in groups of three**.

2. Curing of the concrete specimens.
   a. Allow the specimens to set for about 24 hours at normal room temperature, with the top surface covered to prevent loss of moisture.
   b. Strip the mold from the specimens and place in the curing facility until ready for testing.
3. Compression Testing Procedure.
   a. Remove the specimen from the curing facility just prior to testing. Specimens shall be tested while still in a moist condition.
   b. Center the capped specimens in the testing machine.
   c. Load to failure.
   d. Record the ultimate load, the shape of failure, and any other pertinent aspects of failure such as voids.

4: results and discussion:

4:1: Laboratory Results:

Laboratory results were obtained from the experimental works during the project period. These results make a combination between the percentage of the admixture (sp561) and the compressive strength and slump respectively, and another combination between the percentage of admixture and w/c ratio, finally other combination is between the compressive strength and the age of concrete, summarized result were put in table 4.1and table 4.2 , for detailed results “see appendix A”.

Table 4.1: lab results for compressive strength for long period.

Number	mix type	W/C ratio %	slump (cm)	Avg. 1 Week test (Kg/cm2)	Avg. 4 Weeks test (Kg/cm2)	Avg. 6 Weeks test (Kg/cm2)	Avg. 8 Weeks test (Kg/cm2)
1	B 200	73	15	147.33	231.33	264.67	273.67
2	B 300	54	8	268.33	348.00	346.67	350.67

Table 4.2: Summarized results for all mixes during the project.

Number	mix type	Admix. type	%of admix.	W/C ratio %	slump (cm)	Avg. 7 days test (Kg/cm2)	Avg. 28 days test (Kg/cm2)
1	B 200	---	0.0	73	15	144.33	220.00
2	B 200	SP 561	0.5	73	18	144.67	224.00
3	B 200	SP 561	1.0	73	20	147.33	231.33
4	B 200	SP 561	1.5	73	24	135.33	193.00
5	B 200	SP 561	1.0	67	10	184.67	319.33
6	B 200	SP 561	1.0	69	12	159.33	305.00
7	B 200	SP 561	1.0	71	16	148.00	292.67
8	B 200	SP 561	1.5	67	12	178.33	305.00
9	B 200	SP 561	1.5	69	15	159.33	260.00
10	B 200	SP 561	1.5	71	19	144.67	246.00
11	B 300	---	0.0	54	8	225.33	332.00
12	B 300	SP 561	0.5	54	13	229.33	336.67
13	B 300	SP 561	1.0	54	17	268.33	348.00
14	B 300	SP 561	1.5	54	22	175.00	285.00
15	B 300	SP 561	1.0	52	8	305.33	439.33
16	B 300	SP 561	1.0	53	11	274.67	416.00
17	B 300	SP 561	1.5	50	10	305.33	435.33
18	B 300	SP 561	1.5	52	15	281.33	418.67
19	B 300	Slag	1.0	54	8	194.67	250.33
20	B 300	Slag	5.0	54	7	110.67	201.33
21	B 300	Slag	10.0	54	6	70.67	178.00
22	B 300	Slag	15.0	54	4.5	59.33	166.00
23	B 300	1st{ SP 561 }	1.0	54	15	194.67	267.67
		2nd{ Slag }	1.0				

4:2: Discussion of Results:

1- Slump of concrete increase while the percentage of super plasticizer increase.

(See fig.4:1).

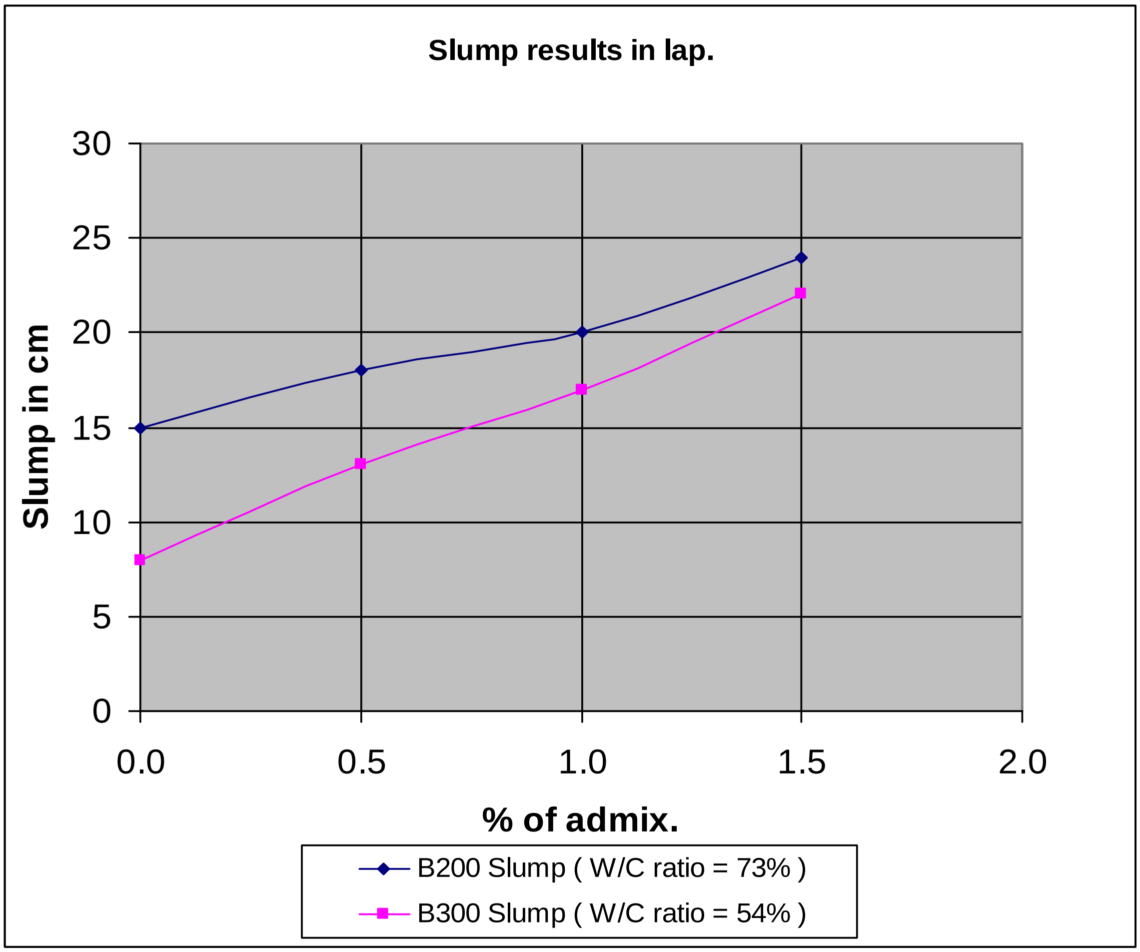

Figure 4:1: The effect of percentage of super plasticizer on slump of concrete mix.

2- Slump of concrete mix's B (200) and B (300) Affected by w/c ratio at constant percentage of superplasticizer, so when the w/c ratio increase the slump increase

(See fig. 4:2) and (fig.4.3) respectively.

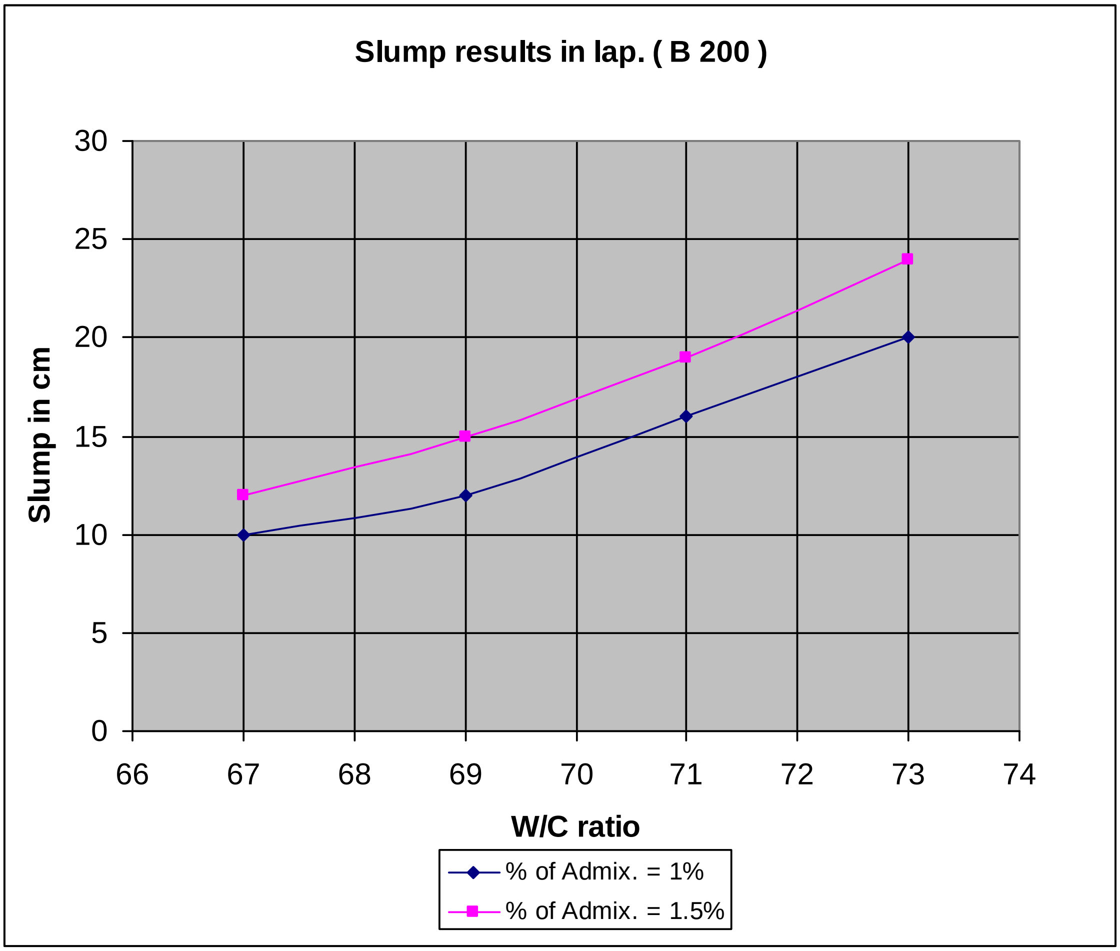

Figure 4:2 the effect of w/c ratio on slump at constant % of super plasticizer for (B200).

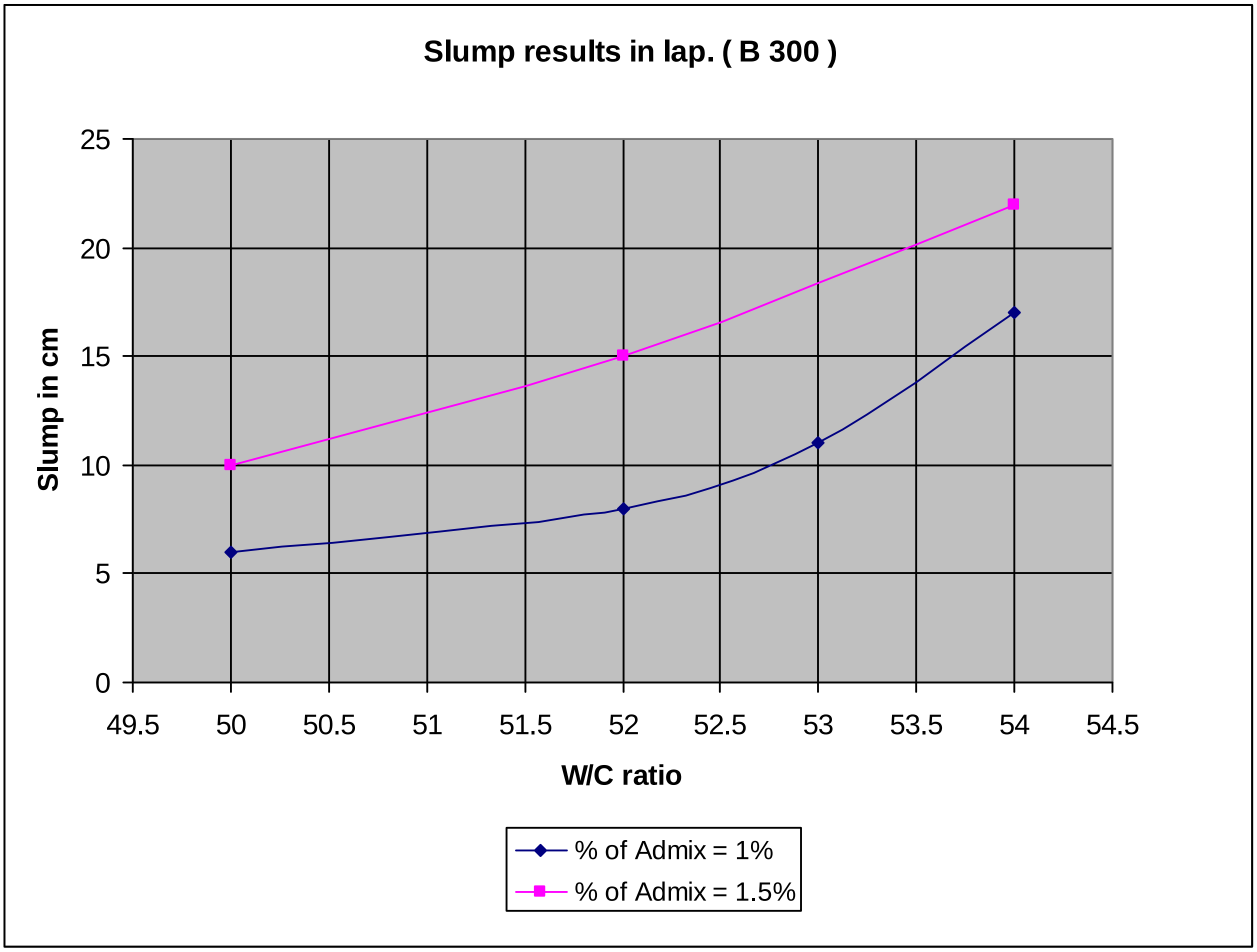

Figure 4:3: The effect of w/c ratio on slump at constant % of super plasticizer for (B300).

3- Laboratory results show that the optimum percentage that gives the most desirable compressive strength for concrete either B (300) or B (200) without reducing the amount of water is approximately around 1% form the weight of cement in the concrete mix.

See fig. (4:4) and fig. (4:5) respectively.

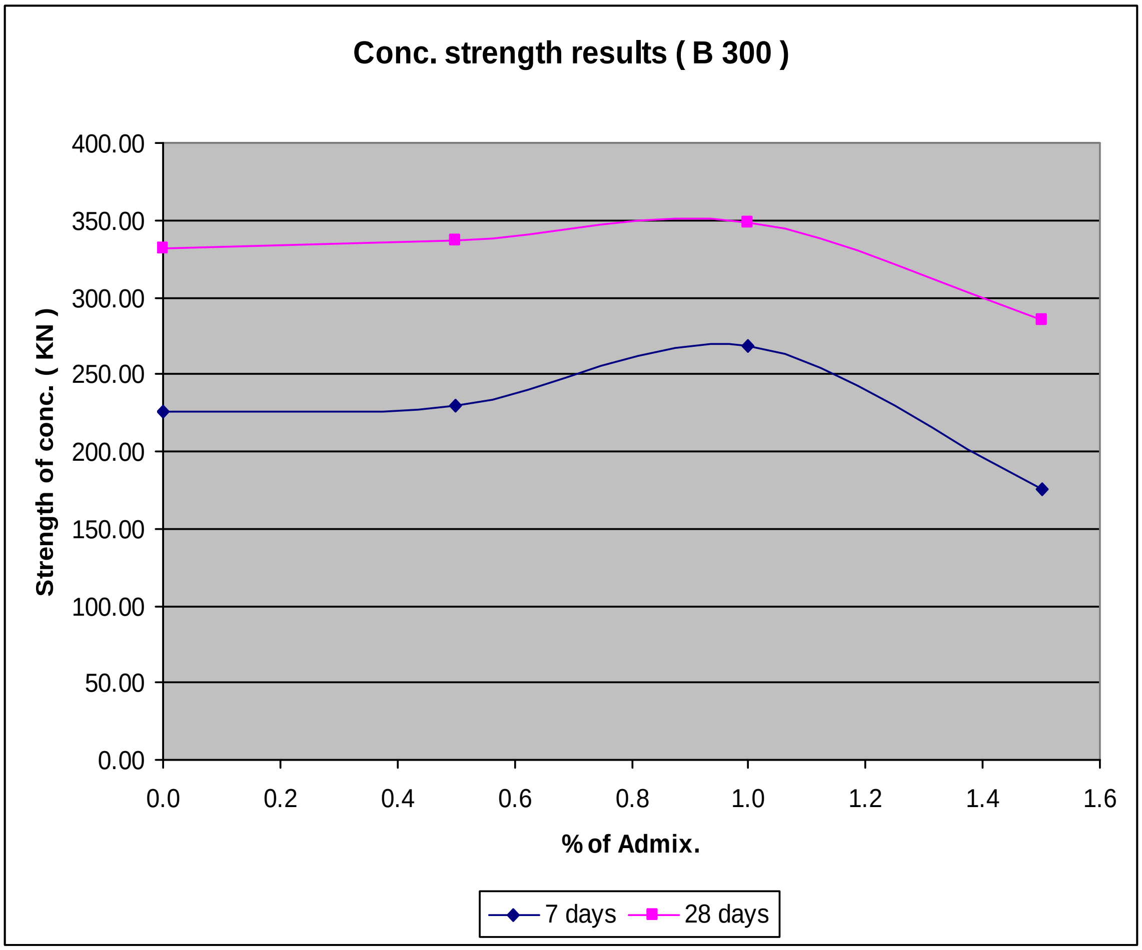

Figure: 4:4: The effect of percentage of super plasticizer on the compressive strength of B (300) concrete mix.

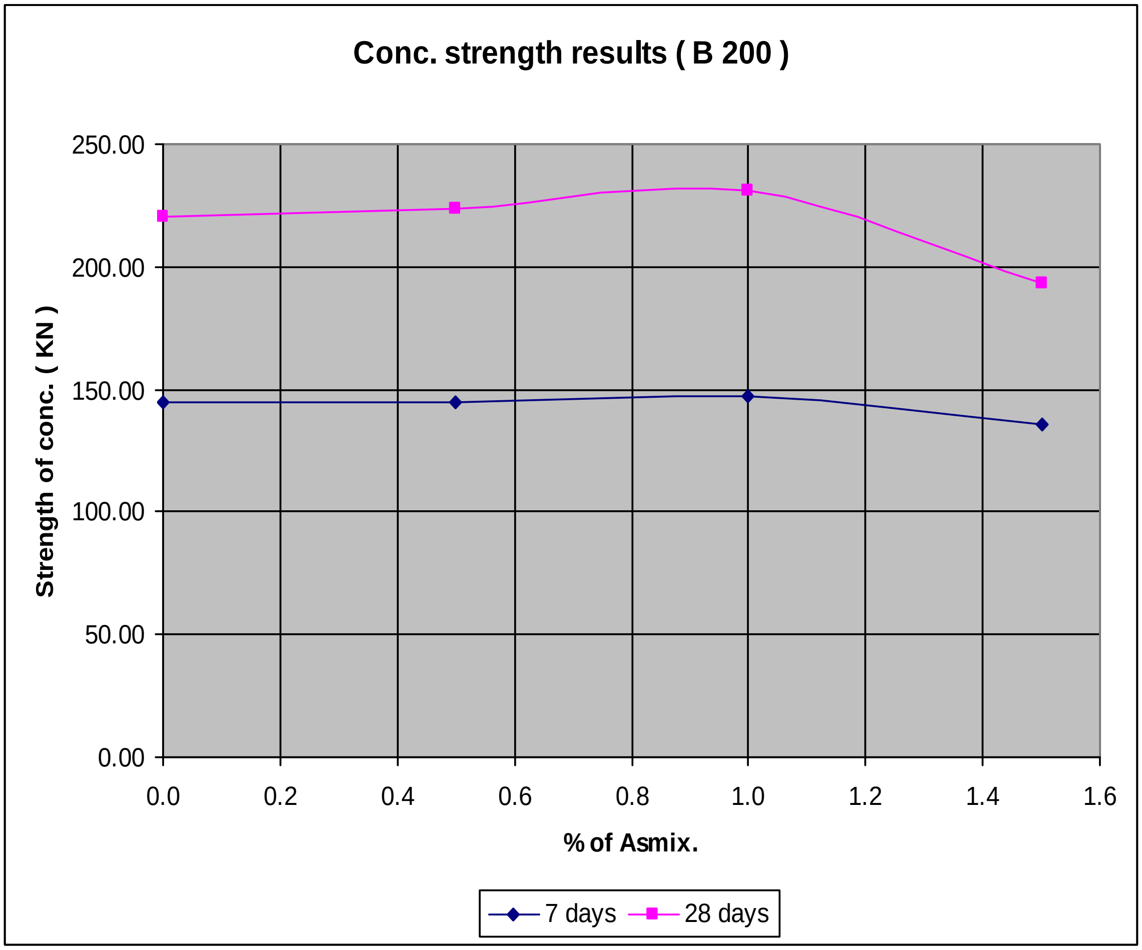

Figure: 4:5: The effect of percentage of super plasticizer on the compressive strength of B (200) concrete mix.

4- Laboratory results show that when the w/c ratio is decreased, the compressive strength increased at 1% super plasticizer for B(200) concrete mix., and the maximum average value equal (319) kg/cm2 at w/c ratio equal 67%, see fig.4:6.

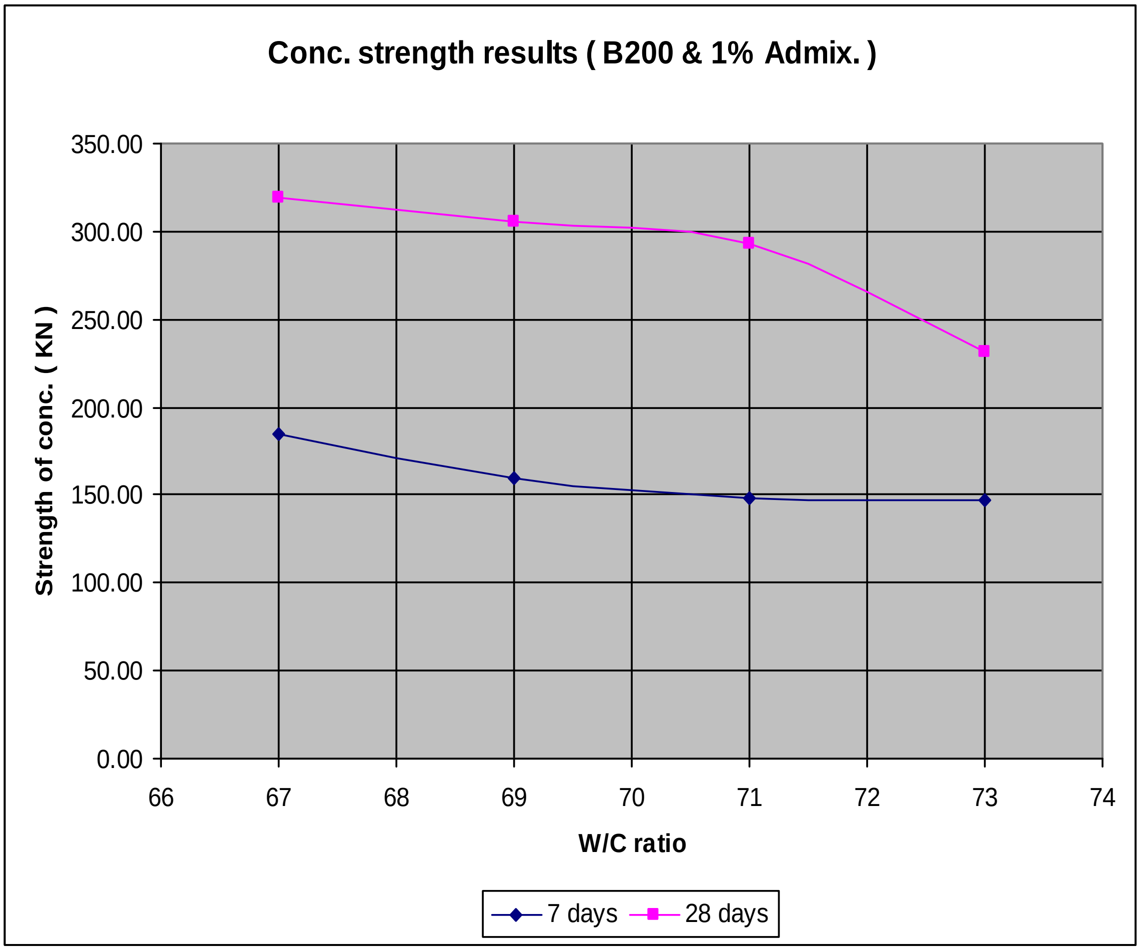

Figure: 4:6: The effect of w/c ratio on the compressive strength of B (200) concrete mix with 1% super plasticizer.

5- Laboratory results show that when the w/c ratio is decreased, the compressive strength increased at 1.5% super plasticizer for B(200) concrete mix., and the maximum average value equal (305) kg/cm2 at w/c ratio equal 67%, see fig.4:7.

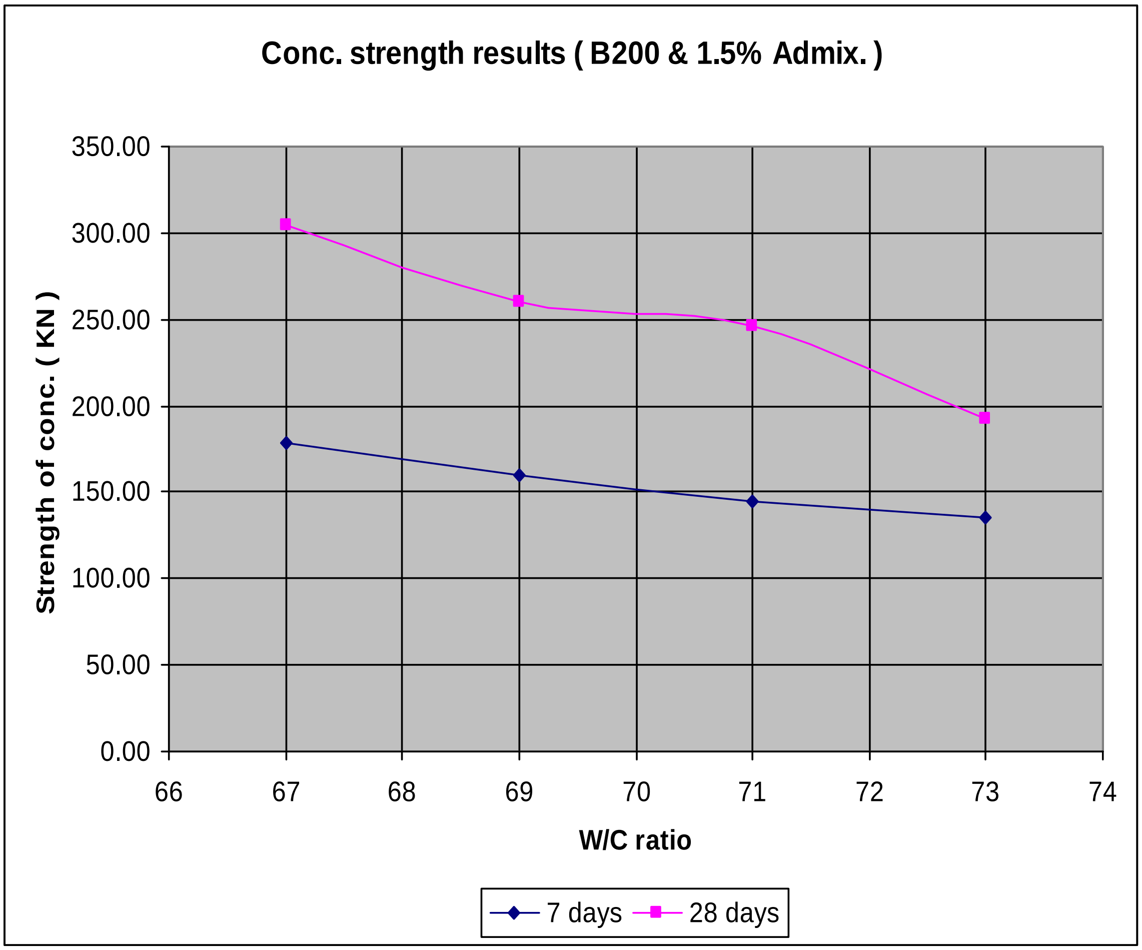

Figure: 4.7: The effect of w/c ratio on the compressive strength of B (200) concrete mix with 1.5% super plasticizer.

6- Laboratory results show that when the w/c ratio is decreased, the compressive strength increased at 1% super plasticizer for B(300) concrete mix., and the maximum average value equal (435) kg/cm2 at w/c ratio equal 52%, see fig.4:7.

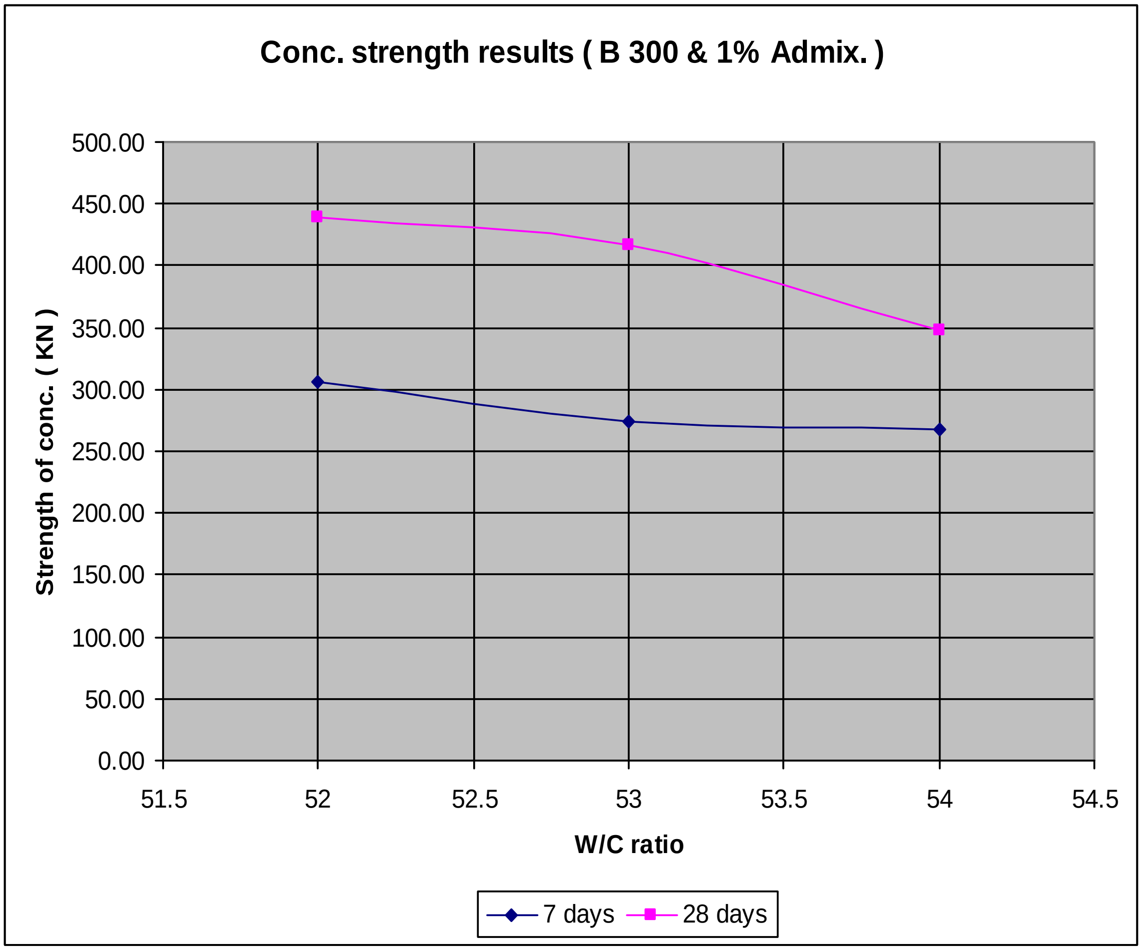

Figure: 4:8: The effect of w/c ratio on the compressive strength of B (300) concrete mix with 1 % super plasticizer.

7- Laboratory results show that when the w/c ratio is decreased, the compressive strength increased at 1.5% super plasticizer for B(300) concrete mix., and the maximum average value equal (438) kg/cm2 at w/c ratio equal 50%, see fig.4:8.

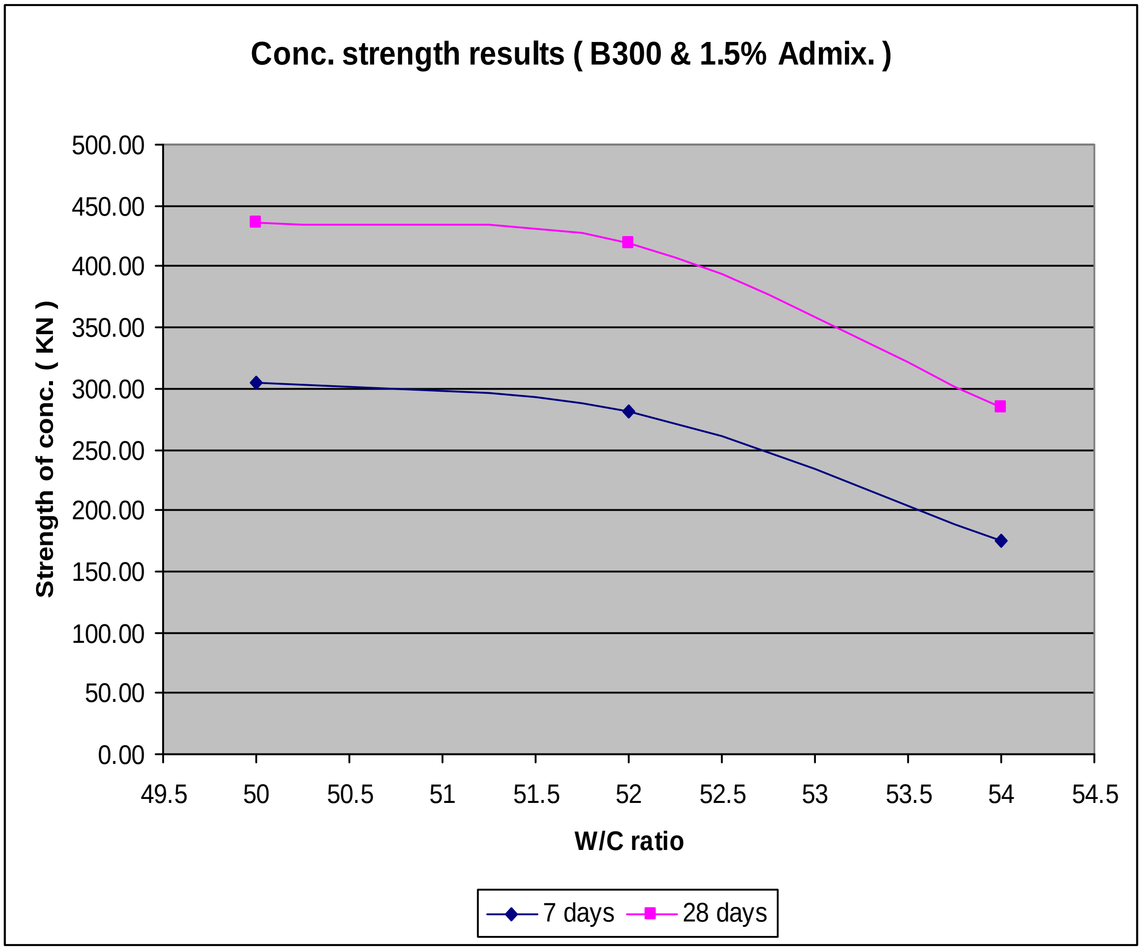

Figure: 4:9: The effect of w/c ratio on the compressive strength of B (300) concrete mix with 1.5% super plasticizer.

8- Laboratory results show the increase of compressive strength with respect to time for concrete mixes B (300) and B (200) with 1% super plasticizer, the results show that after 4 and 6 weeks it looks like constant.

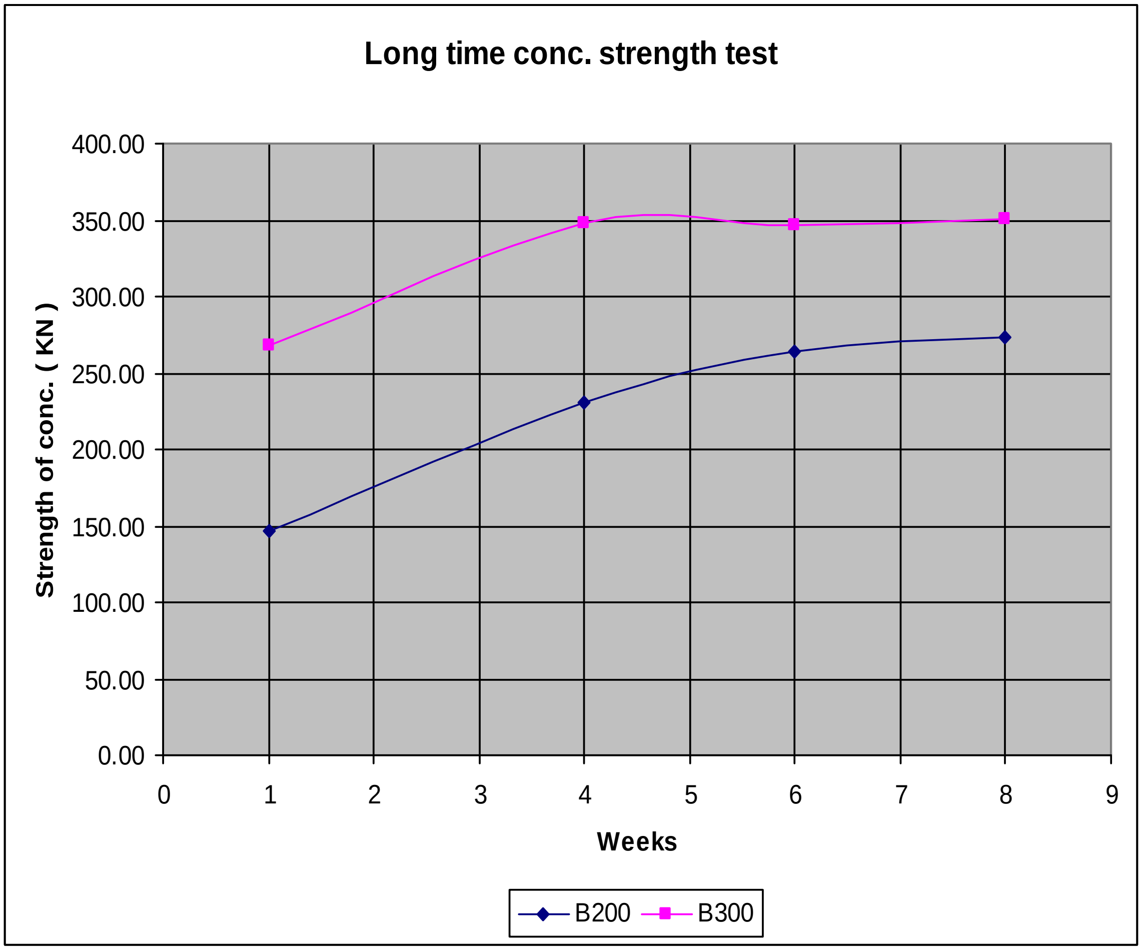

Figure: 4:10: The effect of time on the compressive strength of B (300) and B (300) concrete mixes with 1% super plasticizer.

9- Laboratory results show that slag obtained from steel manufacture decreased the compressive strength for B (300) concrete mix, see fig.4:10.

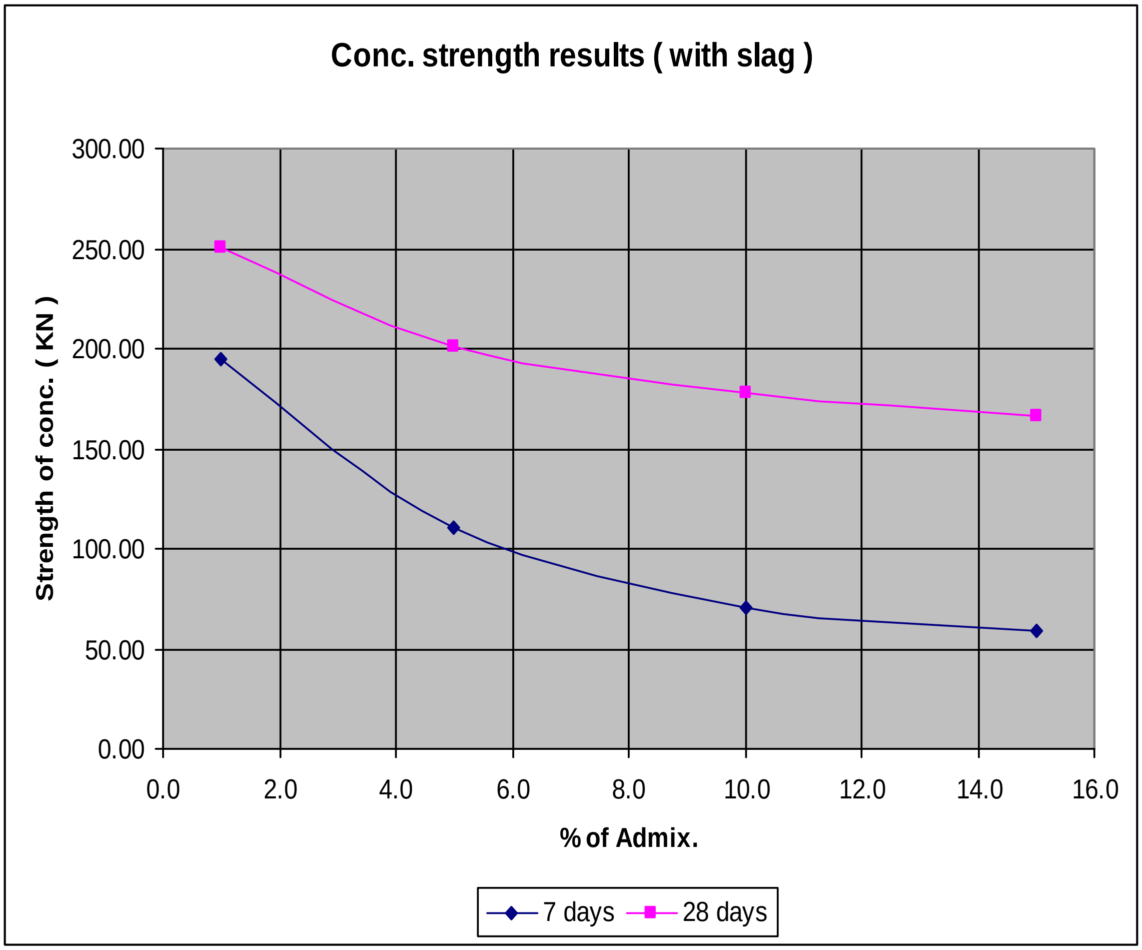

Figure: 4:11: The effect of the percentage of slag on the compressive strength of B (300) concrete mix.

Recommendations:

1- From the laboratory results for super plasticizer " SP561" there are some recommendation to use this admixture:

a) If high slump and high compressive strength is wanted, without reducing the quantity of water, the best percentage for usage is 1% is recommended.

b) If the maximum w/c ratio wanted is 50% (for B300) and slump not less than 8 cm, use 1.5 %.

c) For (B200) the recommended percents for usage are 1% with w/c ratio 67% or 1.5% with w/c ratio 67%.

2- From the laboratory results for slag cement (fly ash) :

a) This kind of slag is very bad; it decreases the compressive strength and slump of concrete.

b) According to recommendation 2.a slag cement used in this project must be treated and cleaned from sulfates and any other impurities, after that it may be used in trial mixes to investigate its compatibility.

3- For mixing two types of admixtures, don’t use any admixtures unless making a trial mixes and seeing there results.

4- Trial mixes must be made for usage any type of admixture before using it.

References:

1-Mark James Krinke ;(The Effect of Admixtures in Concrete Containing Manufactured Sand);Graduation project; University of Southern Queensland; October 2004.

2- Uwe Herterich, all; Determination of concrete admixtures by NMR spectroscopy; Otto-Graf-Journal Vol. 14,2003 .

3- A M Neville; Properties Of Concrete; Third Edition; Longman Scientific & Technical.

4- Roger Rixom & Neol Mailvaganam; Chemical Admixtures For Concrete; Third Edition; Taylor & Francis Group; 1999.

5-American Society For Testing Materials (ASTM).

6-http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SANDHP.htm

7-http://en.wikipedia.org/wiki/Sand

8-http://en.wikipedia.org/wiki/Concrete#Types_of_concrete

Appendix A|(detailed lap results)

day	Sunday	mix type	B200	slump	15 cm
date	25-10-2009	Admix type	-	% of admix	0.00
		W/C ratio	73%		
	7 days test		28 days test		
	date	1-11-2009	date	22-11-2009	
# of sample	Strength		Strength		
1	145.00	Kg/cm2	222.00	Kg/cm2	
2	140.00	Kg/cm2	214.00	Kg/cm2	
3	148.00	Kg/cm2	224.00	Kg/cm2	
Avg.	144.33	Kg/cm2	220.00	Kg/cm2	

day	Wednesday	mix type	B 200	slump	18 cm
date	29-4-2009	Admix type	SP 561	% of admix	0.50
		W/C ratio	73%		
	7 days test		28 days test		
	date	6-5-2009	date	27-5-2009	
# of sample	Strength		Strength		
1	144.00	Kg/cm2	224.00	Kg/cm2	
2	148.00	Kg/cm2	230.00	Kg/cm2	
3	142.00	Kg/cm2	218.00	Kg/cm2	
Avg.	144.67	Kg/cm2	224.00	Kg/cm2	

day	Monday	mix type	B 200	slump	20 cm
date	4-5-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	73%		
	7 days test		28 days test		
	date	11-5-2009	date	1-6-2009	
# of sample	Strength		Strength		
1	144.00	Kg/cm2	234.00	Kg/cm2	
2	150.00	Kg/cm2	228.00	Kg/cm2	
3	148.00	Kg/cm2	232.00	Kg/cm2	
Avg.	147.33	Kg/cm2	231.33	Kg/cm2	

day	Wednesday	mix type	B 200	slump	24 cm
date	29-4-2009	Admix type	SP 561	% of admix	1.50
		W/C ratio	73%		
	7 days test		28 days test		
	date	6-5-2009	date	27-5-2009	
# of sample	Strength		Strength		
1	138.00	Kg/cm2	205.00	Kg/cm2	
2	130.00	Kg/cm2	184.00	Kg/cm2	
3	138.00	Kg/cm2	190.00	Kg/cm2	
Avg.	135.33	Kg/cm2	193.00	Kg/cm2	

day	Monday	mix type	B300	slump	8 cm
date	6-4-2009	Admix type	-	% of admix	0.00
		W/C ratio	54%		
	7 days test		28 days test		
	date	13-4-2009	date	4-5-2009	
# of sample	Strength		Strength		
1	224.00	Kg/cm2	334.00	Kg/cm2	
2	230.00	Kg/cm2	320.00	Kg/cm2	
3	222.00	Kg/cm2	342.00	Kg/cm2	
Avg.	225.33	Kg/cm2	332.00	Kg/cm2	

day	Monday	mix type	B300	slump	13 cm
date	20-4-2009	Admix type	SP 561	% of admix	0.50
		W/C ratio	54%		
	7 days test		28 days test		
	date	27-4-2009	date	18-5-2009	
# of sample	Strength		Strength		
1	228.00	Kg/cm2	328.00	Kg/cm2	
2	230.00	Kg/cm2	338.00	Kg/cm2	
3	230.00	Kg/cm2	344.00	Kg/cm2	
Avg.	229.33	Kg/cm2	336.67	Kg/cm2	

day	Monday	mix type	B 300	slump	17 cm
date	4-5-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	54%		
	7 days test		28 days test		
	date	11-5-2009	date	1-6-2009	
# of sample	Strength		Strength		
1	248.00	Kg/cm2	352.00	Kg/cm2	
2	269.00	Kg/cm2	344.00	Kg/cm2	
3	288.00	Kg/cm2	348.00	Kg/cm2	
Avg.	268.33	Kg/cm2	348.00	Kg/cm2	

day	Monday	mix type	B300	slump	22 cm
date	20-4-2009	Admix type	SP 561	% of admix	1.50
		W/C ratio	54%		
	7 days test		28 days test		
	date	27-4-2009	date	18-5-2009	
# of sample	Strength		Strength		
1	170.00	Kg/cm2	305.00	Kg/cm2	
2	175.00	Kg/cm2	280.00	Kg/cm2	
3	180.00	Kg/cm2	270.00	Kg/cm2	
Avg.	175.00	Kg/cm2	285.00	Kg/cm2	

day	Sunday	mix type	B200	slump	20 cm
date	18-10-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	73%		
	6 Weeks test		8 Weeks test		
	date	29-11-2009	date	13-12-2009	
# of sample	Strength		Strength		
1	260.00	Kg/cm2	268.00	Kg/cm2	
2	270.00	Kg/cm2	278.00	Kg/cm2	
3	264.00	Kg/cm2	275.00	Kg/cm2	
Avg.	264.67	Kg/cm2	273.67	Kg/cm2	

day	Sunday	mix type	B300	slump	17 cm
date	18-10-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	54%		
	6 Weeks test		8 Weeks test		
	date	29-11-2009	date	13-12-2009	
# of sample	Strength		Strength		
1	340.00	Kg/cm2	344.00	Kg/cm2	
2	348.00	Kg/cm2	356.00	Kg/cm2	
3	352.00	Kg/cm2	352.00	Kg/cm2	
Avg.	346.67	Kg/cm2	350.67	Kg/cm2	

day	Sunday	mix type	B300	slump	8 cm
date	25-10-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	52%		
	7 days test		28 days test		
	date	1-11-2009	date	22-11-2009	
# of sample	Strength		Strength		
1	304.00	Kg/cm2	442.00	Kg/cm2	
2	312.00	Kg/cm2	438.00	Kg/cm2	
3	300.00	Kg/cm2	438.00	Kg/cm2	
Avg.	305.33	Kg/cm2	439.33	Kg/cm2	

day	Tuesday	mix type	B300	slump	11 cm
date	27-10-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	53%		
	7 days test		28 days test		
	date	3-11-2009	date	24-11-2009	
# of sample	Strength		Strength		
1	268.00	Kg/cm2	404.00	Kg/cm2	
2	280.00	Kg/cm2	424.00	Kg/cm2	
3	276.00	Kg/cm2	420.00	Kg/cm2	
Avg.	274.67	Kg/cm2	416.00	Kg/cm2	

day	Tuesday	mix type	B200	slump	10 cm
date	27-10-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	67%		
	7 days test		28 days test		
	date	3-11-2009	date	24-11-2009	
# of sample	Strength		Strength		
1	180.00	Kg/cm2	315.00	Kg/cm2	
2	184.00	Kg/cm2	310.00	Kg/cm2	
3	190.00	Kg/cm2	333.00	Kg/cm2	
Avg.	184.67	Kg/cm2	319.33	Kg/cm2	

day	Tuesday	mix type	B200	slump	12 cm
date	27-10-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	69%		
	7 days test		28 days test		
	date	3-11-2009	date	24-11-2009	
# of sample	Strength		Strength		
1	154.00	Kg/cm2	315.00	Kg/cm2	
2	148.00	Kg/cm2	300.00	Kg/cm2	
3	176.00	Kg/cm2	300.00	Kg/cm2	
Avg.	159.33	Kg/cm2	305.00	Kg/cm2	

day	Tuesday	mix type	B200	slump	16 cm
date	3-11-2009	Admix type	SP 561	% of admix	1.00
		W/C ratio	71%		
	7 days test		28 days test		
	date	10-11-2009	date	1-12-2009	
# of sample	Strength		Strength		
1	144.00	Kg/cm2	292.00	Kg/cm2	
2	160.00	Kg/cm2	290.00	Kg/cm2	
3	140.00	Kg/cm2	296.00	Kg/cm2	
Avg.	148.00	Kg/cm2	292.67	Kg/cm2	

day	Tuesday	mix type	B300	slump	10 cm
date	3-11-2009	Admix type	SP 561	% of admix	1.50
		W/C ratio	50%		
	7 days test		28 days test		
	date	10-11-2009	date	1-12-2009	
# of sample	Strength		Strength		
1	304.00	Kg/cm2	442.00	Kg/cm2	
2	312.00	Kg/cm2	434.00	Kg/cm2	
3	300.00	Kg/cm2	430.00	Kg/cm2	
Avg.	305.33	Kg/cm2	435.33	Kg/cm2	

day	Tuesday	mix type	B300	slump	17 cm
date	3-11-2009	Admix type	SP 561	% of admix	1.50
		W/C ratio	52%		
	7 days test		28 days test		
	date	10-11-2009	date	1-12-2009	
# of sample	Strength		Strength		
1	280.00	Kg/cm2	420.00	Kg/cm2	
2	288.00	Kg/cm2	424.00	Kg/cm2	
3	276.00	Kg/cm2	412.00	Kg/cm2	
Avg.	281.33	Kg/cm2	418.67	Kg/cm2	

day	Sunday	mix type	B200	slump	12 cm
date	8-11-2009	Admix type	SP 561	% of admix	1.50
		W/C ratio	67%		
	7 days test		28 days test		
	date	15-11-2009	date	6-12-2009	
# of sample	Strength		Strength		
1	180.00	Kg/cm2	300.00	Kg/cm2	
2	175.00	Kg/cm2	305.00	Kg/cm2	
3	180.00	Kg/cm2	310.00	Kg/cm2	
Avg.	178.33	Kg/cm2	305.00	Kg/cm2	

day	Sunday	mix type	B200	slump	15 cm
date	8-11-2009	Admix type	SP 561	% of admix	1.50
		W/C ratio	69%		
	7 days test		28 days test		
	date	15-11-2009	date	6-12-2009	
# of sample	Strength		Strength		
1	154.00	Kg/cm2	254.00	Kg/cm2	
2	160.00	Kg/cm2	260.00	Kg/cm2	
3	164.00	Kg/cm2	266.00	Kg/cm2	
Avg.	159.33	Kg/cm2	260.00	Kg/cm2	

day	Sunday	mix type	B200	slump	19 cm
date	8-11-2009	Admix type	SP 561	% of admix	1.50
		W/C ratio	71%		
	7 days test		28 days test		
	date	15-11-2009	date	6-12-2009	
# of sample	Strength		Strength		
1	140.00	Kg/cm2	240.00	Kg/cm2	
2	144.00	Kg/cm2	246.00	Kg/cm2	
3	150.00	Kg/cm2	252.00	Kg/cm2	
Avg.	144.67	Kg/cm2	246.00	Kg/cm2	

day	Tuesday	mix type	B300	slump	8 cm
date	17-11-2009	Admix type	Slag	% of admix	1.00
		W/C ratio	54%		
	7 days test		28 days test		
	date	24-11-2009	date	15-12-2009	
# of sample	Strength		Strength		
1	200.00	Kg/cm2	255.00	Kg/cm2	
2	190.00	Kg/cm2	250.00	Kg/cm2	
3	194.00	Kg/cm2	246.00	Kg/cm2	
Avg.	194.67	Kg/cm2	250.33	Kg/cm2	

day	Tuesday	mix type	B300	slump	7 cm
date	10-11-2009	Admix type	Slag	% of admix	5.00
		W/C ratio	54%		
	7 days test		28 days test		
	date	17-11-2009	date	8-12-2009	
# of sample	Strength		Strength		
1	100.00	Kg/cm2	194.00	Kg/cm2	
2	112.00	Kg/cm2	198.00	Kg/cm2	
3	120.00	Kg/cm2	212.00	Kg/cm2	
Avg.	110.67	Kg/cm2	201.33	Kg/cm2	

day	Tuesday	mix type	B300	slump	6 cm
date	10-11-2009	Admix type	Slag	% of admix	10.00
		W/C ratio	54%		
	7 days test		28 days test		
	date	17-11-2009	date	8-12-2009	
# of sample	Strength		Strength		
1	70.00	Kg/cm2	177.00	Kg/cm2	
2	68.00	Kg/cm2	184.00	Kg/cm2	
3	74.00	Kg/cm2	173.00	Kg/cm2	
Avg.	70.67	Kg/cm2	178.00	Kg/cm2	

day	Tuesday	mix type	B300	slump	4.5 cm
date	10-11-2009	Admix type	Slag	% of admix	15.00
		W/C ratio	54%		
	7 days test		28 days test		
	date	17-11-2009	date	8-12-2009	
# of sample	Strength		Strength		
1	60.00	Kg/cm2	168.00	Kg/cm2	
2	54.00	Kg/cm2	160.00	Kg/cm2	
3	64.00	Kg/cm2	170.00	Kg/cm2	
Avg.	59.33	Kg/cm2	166.00	Kg/cm2	

day	Tuesday	mix type	B300	slump	15 cm
date	17-11-2009	1st Admix type	SP 561	% of admix	1.00
W/C ratio	54%	2nd Admix type	Slag	% of admix	1.00
	7 days test		28 days test		
	date	24-11-2009	date	15-12-2009	
# of sample	Strength		Strength		
1	200.00	Kg/cm2	265.00	Kg/cm2	
2	190.00	Kg/cm2	268.00	Kg/cm2	
3	194.00	Kg/cm2	270.00	Kg/cm2	
Avg.	194.67	Kg/cm2	267.67	Kg/cm2	