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Investigate the Effect of Admixtures in Hot Weather Concrete

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Abstract: Concrete Admixture is one ingredient of concrete that is added to the mix before or during mixing to modify the properties of fresh and hardened concrete in order to achieve the desired objectives or purpose of the concrete mixture .It is also used for economic purpose when admixture allows reduction of concrete ingredients proportions or permits saving in construction practices. The current research studied the effect of high temperature on the behavior of fresh and hard concrete is discussed and how to overcome that using some mineral admixtures such as silica fume and lime stone powder. An experimental test program consists of six concrete mixes was planned to achieve the research objectives, also all concrete mixes were tested at both of fresh and hardened state Fresh concrete testes include slump, slump losses, and air content . Hardened concrete tests include 15*15*15cm cubes for compression test at (3, 7 and 28days) , 15*15*70cm beams for flexural test at (28 days) and cylinders with 15cm diameter and 30 cm height at (28 days), for tensile strength test. It was observed that from the results that: 1. Mix containing 1.5% s.p. &10% s.f gave best compressive strength results. 2. Mix containing 2% s.p. gave the lowest compressive strength results. Under the effect of hot weather.

Keywords: Hot Weather, Admixture, Concrete

1. Introduction

1.1. General

Concrete mix ingredients are cement, aggregates (Fine, coarse) and water. But some admixtures can be added to modify the properties of fresh and hardened concrete.

Admixtures have two main types:

Chemical admixtures are in liquid states which are used as ratio of cement classified as:

A: Water reducing admixture.

B: Set retarding admixture.

C: Set accelerating admixture.

D: Water reducing and set retarding admixture.

E: Water reducing and set accelerating admixture.

F: High range water reducing super plasticizers.

G: High range water reducing and set retarding.

In this research super plasticizers type (G) is used to reduce water by (12-30) %from concrete weight

The second type of admixture is a mineral admixture it is in a powder state putting as ratio of cement by replace and it has many types like (silica fume, fly ash) also limestone powder which isn't classified as a mineral admixture.

1.2. Research Objectives

Temperature is an important factor that affects concrete. It gives a low compressive strength and workability as it has an effect on hydration of cement as Plastic shrinkage crack will occur.

A solution had to be found for that effect and this solution is admixtures.

1) Effect of hot weather on concrete in the (plastic, hardened) state.
2) Effect of using two admixtures in the same concrete mix (according to the Egyptian code of reinforced concrete).
3) Precautions should be taken when admixtures are being used.
4) precautions are taken in placing.

Finally the aim of this research is to know the effect of admixtures on the properties of a hot weather concrete

1.3. Research Variables

In this research the effect of admixtures on the properties of elevated temperature concrete mix is discussed by using different ratios of them, and making the fresh and hardened tests for each mix. There are two control mixes which contain: super plasticizers type G with different ratios:

FIRST ONE: includes 1.5% type (G) from weight of cement.

SECOND ONE: includes 2% type (G) from weight of cement.

And there are four variable mixes that include:

1) The same mix design of control mix, but it has 1.5%type (G) and 10 % silecafume.
2) The same mix design of control mix, but it has 2%type (G) and 10% silecafume.
3) The same mix design of control mix, but it has 1.5% type (G) and 15% lime stone powder.
4) The same mix design of control mix, but it have 2% type (G) and 15% lime stone powder.

1.4. Research Outline

Chapter (1): Introduction

It includes the use of admixtures and their types, and their effect on hot weather concrete then discussing the research variables.

Chapter (2): Previous Work

It includes some researches talking about the effect of hot weather&admixtures on concrete from different point of views.

Chapter (3): Experimental Program

It includes the mix design and the quantities, and also includes types of materials that are used in research.

Chapter (4): Materials properties

It includes tests that have been done for materials in laboratory and includes tests done for afresh concrete.

Chapter (5): Results& Analysis

This chapter includes all results found from tests done at:

1) Materials.
2) Fresh concrete.
3) Hardened concrete.

Chapter (6): Conclusions & Recommendations

It includes recommendations and conclusions that are noticed from the results of this research.

2. Review of Previous Work

2.1. Introduction

Hot weather may be defined as any period of high temperature in which special precautions need to be taken to ensure proper handling, placing, finishing and curing of concrete.

Hot weather problems are most frequently encountered in the summer, but the associated climatic factors of high winds and dry air can occur at any time, especially in arid or tropical climates.

Hot weather conditions can produce a rapid rate of evaporation of moisture from the surface of the concrete and accelerated setting time, among other problems.

The heat generation in the concrete and heat transfer to the environment is influenced by the following factors:

1) The heat of hydration of the cement (i. e. Type and amount of cement)
2) The possible use of cement replacement material
3) The thermal characteristics of the concrete (transmissivity and specific heat)
4) The fresh concrete placement temperature
5) The size of the structure
6) The boundary conditions of the studied body, formwork and insulation, ambient temperature and wind.

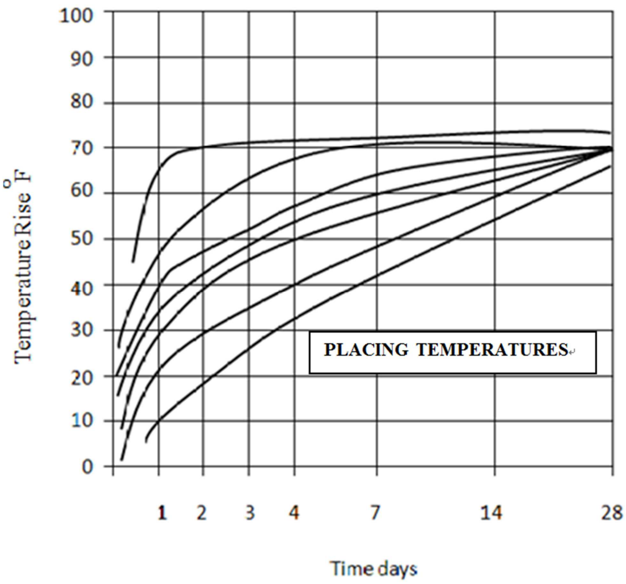

Figure 1. *Temperature Rise of Mass Concrete [1].*

2.1.1. Effect of Hot Weather on Concrete in the Plastic State

This effect can be summarized in the following:

1) Increased water demand.
2) Increased rate of slump loss and corresponding tendency to add water at job site
3) Increased rate of setting resulting in greater difficulty with handling, finishing and curing, and increasing the possibility of cold joints **[2].**

2.1.2. Effect of Weather on Concrete in the Hardened

State:

This effect can be summarized in the following:

1) Decreased 28-day and later strength resulting from higher water demand and/or increase temperature level.
2) Increased tendency for drying shrinkage and differential thermal cracking.
3) Decreased durability resulting from cracking.
4) Greater variabilityof surface appearance such as: cold joints, color difference, due to different rates of hydration on different water-cement ratios.
5) Increased potential for reinforcing steel corrosion

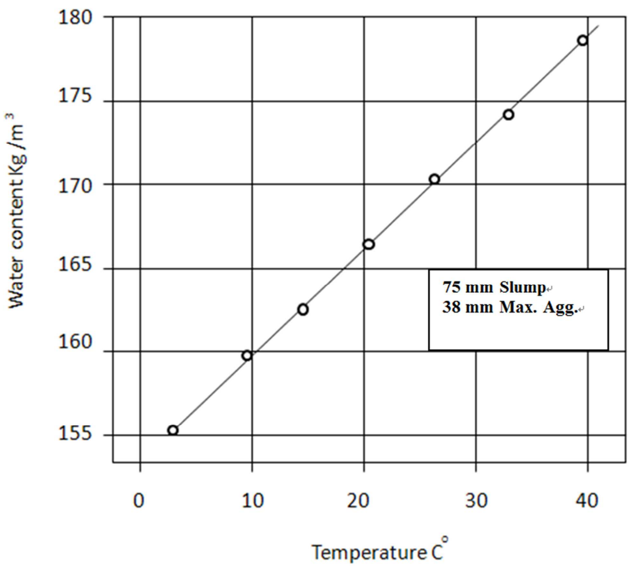

Figure 2. *Effect of temperature on the amount of water required to produce a 75-mm slump After US Bureau of Reclamation.' B in a typical concrete. [3]*

To reduce this problem may use:

(a) Chemical Admixtures.

(b) Minerals Admixtures.

2.2. Chemical Admixtures

Chemical admixtures may impart dramatic modifications to the cement reaction rateand rate of heat generated. In the United States, most of the chemical admixtures used areclassified under ASTM C 494 (1984).

In this document, seven types ofadmixtures are listed:

Type A: Water-reducing admixtures

Type B: Retarding admixtures

Type C: Accelerating admixtures

Type D: Water-reducing and retarding admixtures

Type E: Water-reducing and accelerating admixtures

Type F: High-range water-reducing admixtures(Super plasticizers)

Type G: High-range water reducing and retarding admixtures

Accelerating admixtures (Type C & E) primarily accelerate early strength development and the setting of concrete. These admixtures are most effective when used during cool weather since they greatly increase the rate of reaction.[4]

The use of accelerators at high temperatures may result in too high a rate of heat development and shrinkage cracking may develop.

Water-reducing admixtures (Type A) generally serve the purpose of permitting theuse of a lower water-cement ratio while retaining a desiredworkability or, alternatively, toimprove the workability ofa mixture with a given water-cement ratio.

Water-reducingadmixtures have little effect on the reaction rate unless increased dosages are used, thenthey usually become retarders.

The effect of water-reducing admixtures is indirectly broughtforward if the mixture proportions are known.

Retarders (Type B & D) delay the setting of the cement paste and depending on thedosage have the ability to affect the reaction rate of Portland cementscomments that retarders are useful in hot weather conditions, however in some caseshigh concrete temperatures may even shorten normal setting times.

Retarders did not produce much change in peak temperature, but the time to peaktemperature was altered.

High-range water-reducers, also referred to as super plasticizers, are admixturesthat are water reducing, but to a greater extent than water-reducingadmixtures. That some high-range water-reducing admixtures (Type F) and highrangewater reducing and retarding admixtures (Type G) can provide significant benefitsunder hot weather conditions.

Further concluded that regardless of the cement type, thesuper plasticizer also did not have a significant effect on the peak temperature rise of mixescontaining either type of fly ash.

Super plasticizer (high-range water reducer) and a plasticizer ordinary water reducewere mixed to form a new combined high-range water reducer.

The combined admixture reported in this paper not only has a similar water reducing effect as the base high-range water reducer, but can also reduce the rate of loss of workability ofthe fresh concrete andachieve a saving in the material cost.

The combined admixture was found to be particularly useful for hotweather concreting.

To have concrete possesses the specified engineering properties, its slump loss has to be compensated somehow at construction site so that concrete so far to render concrete workable could be placed and compacted properly.

Several attempts have been tried at constructionsite including starting with a high initial slump at the stationary plant, or tempering with water and/or with chemical admixtures at construction site.

In this investigation (Type G) super plasticizer was used for tempering concrete to restore its initial slump.

Concrete mixes having an initial slump of about 19 cm wereprepared and subjected to prolonged mixing with different mixing duration such as 30, 60, 90, 120, and 150 min following an initial mixing of 5 min to ensure homogeneity .At the end of each mixing period, cubespecimens of 15 cm were cast from concrete tempered to its initial slump level and tested at the age of 28 days for compressive strength .Results revealed that compared to the concrete remembered with water, those tempered with a super plasticizer admixture have yielded significantly higher strength regardless of the mixing duration.

Whether admixture is used or not, concrete subjectedto prolong mixing resulted in rather a quick slump lossup to 90 min of mixing .It is then slowed downbeyond that age.

This clearly indicates that a mixingperiod of 90 min seems to be a turning point withregard to proper placement, compaction, and subsequentoperations of concrete.

The strength of concrete with no tempering revealeda slight increase even for a rather long mixing periodof 150 min .The reason for this is preferably attributedto the reduced air content in addition to the esteemed.

Effect of proper placement and compaction of concrete.

The strength of concrete tempered with waterdecreased considerably with mixing time.

The reductionis rather sharp for up to 90 min of mixing andthen a slight decrease is observed later on.

At the endof 150 min of mixing, a strength loss of over 40 %isobserved with regard to the initial strength ofconcrete.

The strength gain of concrete tempered with super plasticizerfor a mixing duration of 90 min is about 30% with respect to the initial strength of concrete andit is slightly over 10 %compared to the strength ofreference concrete, corresponding to the same mixingduration.

The decrease in the strength observedbeyond 90 min of mixing implies that mixing durationlonger than 90 min causes a considerable strength lossdue to the possible existence of is used for temperingbleeding andsegregation even when a super plasticizer admixture.

Effect of mixing time on slump loss:

Figure (2-3) illustrates the slump loss of concretes produced with a super plasticizer and normal concrete in relation to the mixing time at ambient temperature of 23,8C. As seen from the plot, the slump loss of concrete produced with a super plasticizer of 1% by weight of the cement with respect to the elapsed time indicates the very same trend that of the plain concrete does with the exception that the trend of slump loss is a little steep for normal concrete up to 30 min of mixing and then slows down later on. This implies that when prolonged mixing is involved, the time that required for an equal slump for such concretes is about 90 min.

Overall, the plot indicates that the magnitude of slump loss is quite high for a mixing period of 90 min and it does decrease slightly for longer mixing duration whether admixture is used or not. No doubt that the magnitude and the trend of slump loss do vary depending on the ambient temperature, the initial slump level, and the admixture adsorption capacity of the cement.

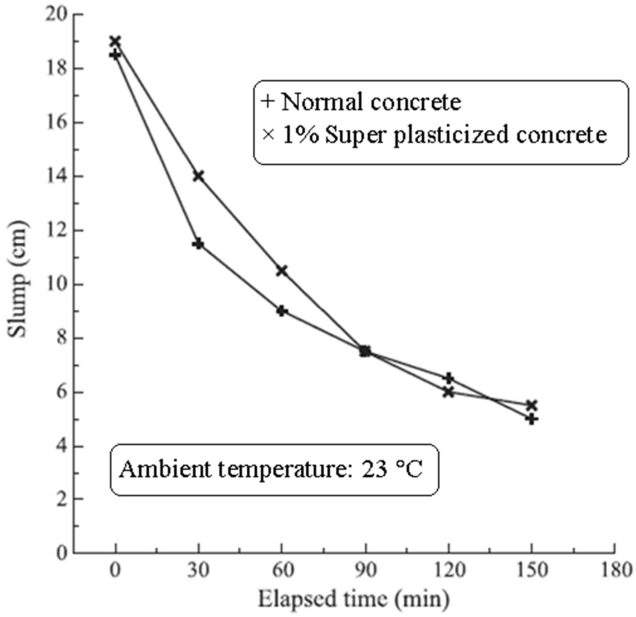

Figure 3. *Slump loss of plain and 1% super plasticized concrete. [5]*

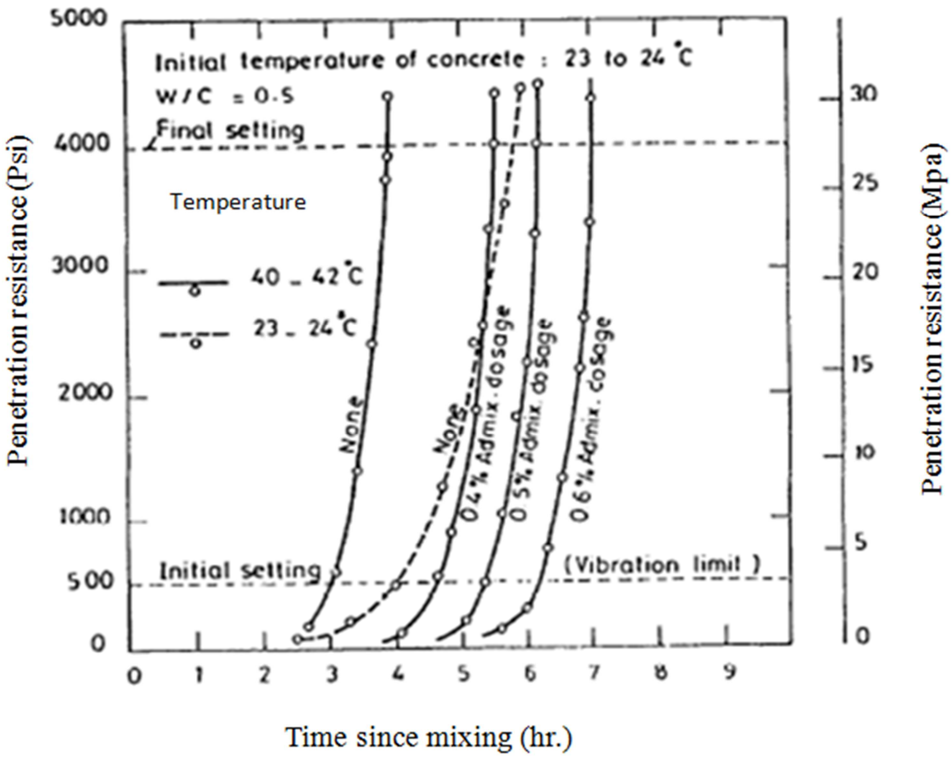

Figure 4. *Effect of temperature and type D admixture on standard penetration and setting times of concrete determined in accordance with ASTM C 403. [4].*

2.3. Mineral Admixtures

Mineral admixtures are generally added to concrete to replace some of the cement in the system .In some instances, they are obtained as by-products from other industries, and if readily available, their use could lead to cost savings.

Mineraladmixtures may enhance the workability of fresh concrete, and may decrease the permeability ofthe hardened concrete.

This leads to improved durability of concrete against sulfate attack, and alkali-silica reaction.

Improved performance in corrosive environments can be achieved due to the increased densification of the pore structure, which slows the rate of chloride penetration into the concrete element.

Mineral admixtures (fly ash, silica fume and slags) are usually added to concrete in larger amounts to enhance the workability of fresh concrete; to improve resistance of concrete to thermal cracking, alkali-aggregate expansion, and sulfate attack; and to enable a reduction in cement content [4]

2.3.1. FlyAsh

Fly ashes are finely divided residue resulting from the combustion of ground or powdered coal .They are generally finer than cement and consist mainly of glassy-spherical particles as well as residues of hematite and magnetite, char, and some crystalline phases formed during cooling

Fly ash reacts with calcium hydroxide, which is produced by hydration of clinker minerals.

Various researchers have investigated the effect of adding fly ash to concrete mixtures.

In some instances, it was found that they reduce the total heat of hydration, and the rate of hydration.

This effect was previously noted in Figure 5, where Class F Fly ash,

With a low CaO content (3.6%) was used. Barrow and Carrasquillo (1988) found that partial replacement with Texas Type A fly ash (comparable to ASTM Type F), results in a reduction in the peak temperature rise in concrete.

From Figure 6, it may be seen that cementer placement with Texas Type B (comparable to ASTM Type C) fly ash did not reduce thepeak temperature significantly, but it did prolong the time until the peak temperature was reached.

This effect can also be seen in Figure 7, which indicates that the peak heat of hydration is reduced when higher a dosage of fly ash is used. From theresults of their tests Kishi and Maekawa (1995) concluded that fly ashretards the hydration of Portlandcement, especially at early ages. The fly ash used to had a CaO content of 8.8%, which indicates that it has little cementations nature and that it could be classified as a Class F fly ash. [4] The data reviewed in this section show that fly ash could possibly be used to reduce the temperature development in PCC pavements constructed under hot weather conditions. The use of the mineral admixtures should further be explored for inclusion in mitigation measures developed throughout this Figure.

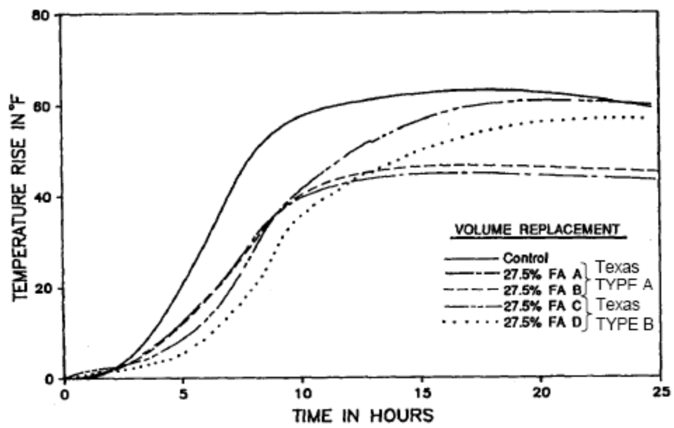

Figure 5. *The effect of different Texas fly ashes on the heat development in beam specimens [4].*

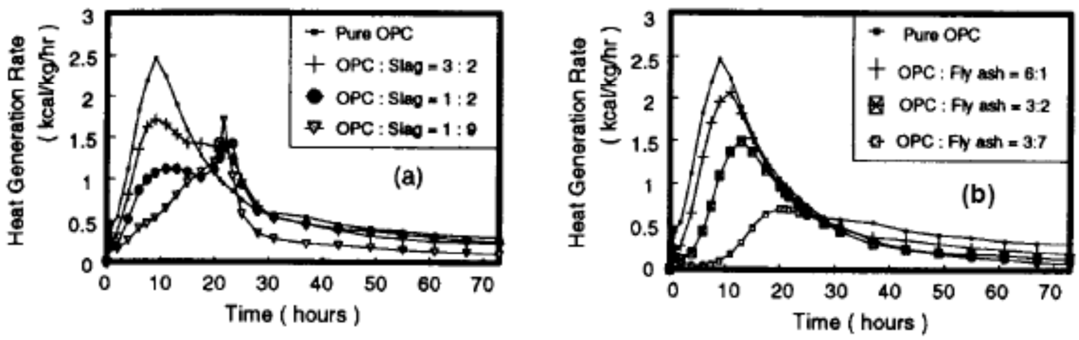

Figure 6. *The effect of (a) GGBF slag and (b) fly ash on the hydration of cement.*

2.3.2. Silica Fume

Silica Fume consists of very fine vitreous particles with a surface area ranging from 13,000 to 30,000 m^2/kg when measured by nitrogen absorption techniques, with particles approximately 100 times smaller than the average cement particle.

Because of its extreme fineness and high silica content, Silica Fume is a highly effective pozzolanic material.

Highest plastic shrinkage was noted in the concrete specimens prepared with unidentified silica fume.

The physical properties of silica fume, such as fineness and bulk density, and microscopic properties, such as average pore radius and the total pore volume, were correlated with plastic shrinkage strains.

No relationship was noted between the microscopic properties and the maximum plastic shrinkage strains.

However, a good correlation was noted between the plastic shrinkage strain and the fineness and bulk density of the silica fume.

The plastic shrinkage strain increased with increasing dosage of silica fume (5%, 7.5 %and 10 %by weight of cement).

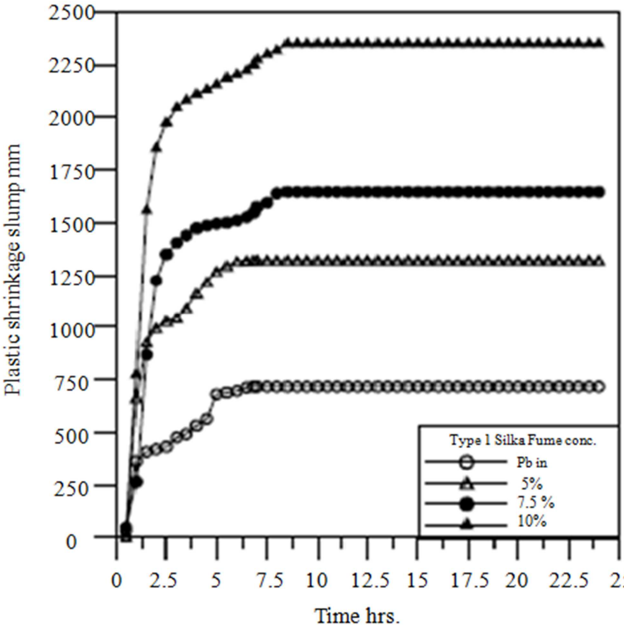

Figure 7. *Plastic shrinkage strain in silica fume cement concrete Exposed to hot weather [6].*

This trend was noted in all the silica fume cement concretes. [4]

The fineness of silica fume, as represented by its specific surface area and bulk density, are good indicators for assessing its potential for plastic shrinkage cracking under hot weather conditions

2.3.3. Lime Powder

This paper presents a study on the use of limestone fillers and their optimal replacement incement paste at different water to binder ratios (0.24, 0.26 and 0.28) and their effect on freshand hardened state. The binder was prepared by substitution of cement mass by limestonefiller with several percentages (0%, 5%, 10%, 15%, 20%, 30% and 40%) that have differentfineness. Experimental results showed that the limestone filler has substantially influenced thefresh state as well as hardened state. The results revealed that the replacement of Portlandcement by finest filler of limestone slightly decreases the water of consistency and the settingtimes (initial and final). The total porosity decreases, and accordingly the compressivestrength improve with the content and fineness of limestone. Hence, the limestone has a littleaccelerating action on the hydration process of the Portland cement but acts only as fillerreducing the porosity due to its compact structure.

Therefore, the compressive strength of thehardened cement pastes isenhanced. The addition of finely ground limestone filler only up to 15% gives better results on strength. The XRD analyses of samples cured up to 28 days showthat this amelioration is due to formation of new hydrated compounds such as the carboaluminates.

A better use of Lime Powder filler in concrete:

Between 12% and 18% of fillers where we have noticed the maximal value. Over this interval, a decrease is observed for all the curves which mean that limestone fillers have an influencesometime positive andsometime negative on the density according to their content. Thedifferent curves present a flatten bell with an optimum situated between 15% and 18% offillers. The evolution of concrete densities based on aggregates issued from site S1 is betterthan those of site S2. The influence of fillers is much more preponderant on discontinuousaggregate concrete. This confirms the porosity effect in discontinuous granular skeleton.

The Influence of Fillers on Hardened Concrete Properties:

Compressive Strength:

The results indicate Figure 8 that the compressive strength of all hardened concrete increasescontinuously with time. This is mainly due to the continual formation of hydration productswhich always deposit inside the available pore structure leading to a decrease in the totalporosity. Therefore, the specific volume and bulk density must increase resulting in a clearimprovement of compressive strength Moreover, the concrete containing limestone fillergive higher initial strength than those of the cement especially with finely ground limestoneF5 (5400 cm^2/g), this behavior increases with the amount of limestone filler but only up to 18%. This is essentially due to the acceleration effect of limestone filler related to theformation of calcium carboaluminate hydrate which may be contributed to the overall increasein the rate of hydration. Also, the increased binding capacity of carboaluminate is likely due toits compact structure. Globally, at 28 days the concrete compressive strength for 6%, 12% and 18% of fillers rate is superior to that of the concrete without fillers. On the otherhand, for the content having 24% of fillers rate, the obtained resistance is always weaker forthe two granular skeletons. Between 7 and 28 days, the increase of resistance in function ofthe age is appreciably linear. Over

28 days the fillers effect tends to stabilize gradually until90 days. This allows us to say, that at long term, the contribution to the resistance becomesminimal. The limestone fillers play therefore a beneficial role on the resistance until thecontent of 18% “the optimum value". The best compressive strength is obtained with thediscontinuous granular skeleton of the site S1. [7]

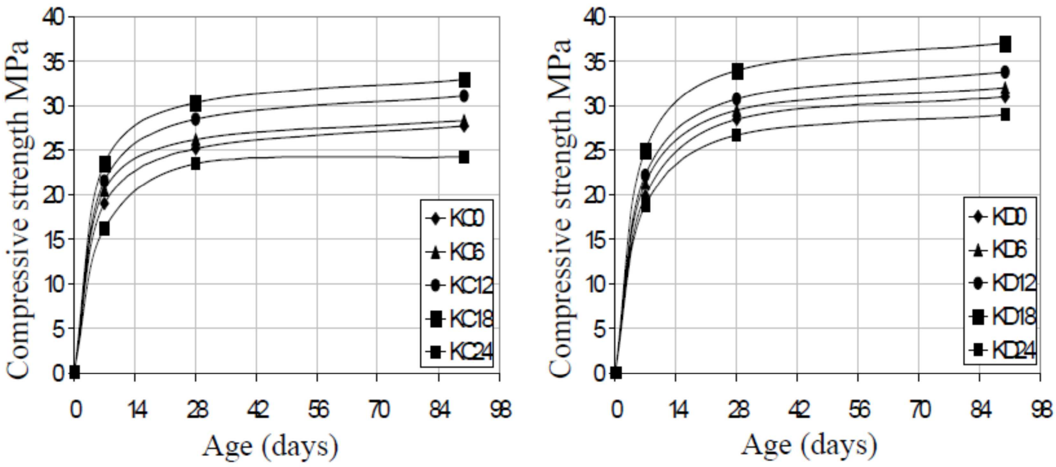

Figure 8. *Compressive strength in function of the fillers rate and age.*

2.4. Effect at Different Factors on Compressive Test

The production of strength concrete that consistently meets requirements for workability and strength development places more stringent requirements on material selection than for lower-strength concrete.

Quality materials are needed and specifications require enforcement strength concrete has been reduced. **[8]**

2.4.1. Cement

Portland cements are hydraulic cements, meaning they react and harden chemically with the addition of water. Cement contains limestone, clay, cement rock and iron ore blended and heated to 2600-3000 F.

The resulting product "clinker" is then ground to the consistency of powder.

Gypsum is added to control setting time, the influence of concrete strength, for given mix properties, is determined by its fineness and chemical composition through the process of hydration.

The gain in concrete strength as the fineness of its cement particles increases is.

The gain in strength is most marked at early ages and after 28 days the relative gain in strength is much reduced at some later age the strength of concrete made with fine cement may not be very different from that made with normal cement (300 kg/cm²).

2.4.2. Water

A concrete mix containing the minimum amount of water required for concrete hydration of its cement, if it could be fly compacted, would develop the maximum attainable strength at any given age.

A water-cement ratio of approximately 0.5 (by weight) is required for full hydration of the cement but with this water content a normal concrete mix would be extremely dry and virtually impossible to compact.

2.4.3. Aggregate

There are two types of aggregate in any concrete mix:

Fine Aggregate: normally called sand, this component can be natural sand or crushed stone, and represents particles smaller than 3/8". Generally accounts for 30%-35% of the mixture.

Coarse Aggregate: may be either gravel or crushed stone. Makes up 40%-45% of the mixture, comprised of particles greater than 1/4".

When concrete is stressed, failure may originate within the aggregate, the matrix or at the aggregate matrix interface, or any combination of these occurs.

In general the aggregates are stronger than the concrete itself and in such cases the aggregate strength has little effect on the strength of concrete. The bond (Aggregate matrix interface) is an important factor determining concrete strength. Bond strength is influenced by the shape of the aggregate, its surface texture and cleanliness.

A smooth rounded aggregate will result in a weaker bond between the aggregate and matrix than an angular or irregular aggregate with a rough surface texture the associated loss in strength however may be offset by the smaller water-cement ratio required for the same workability.

For given mix properties, the concrete strength decreases as the maximum size of aggregate is increased.

On the other hand, for a given cement content and workability this effect is opposed by a reduction in the water requirement for the larger aggregate, however, it is probable that beyond a certain size of aggregate size except perhaps in some instances when larger aggregate may be more readily available.

The optimum aggregate size varies with the richness of the mix, being smaller for the richer mixes, and generally lies between 10 and 50 mm.

3. Experimental Program

3.1. General

Admixtures are materials other than cement, aggregates and water that are added to concrete either before or during its mixing. the chemistry of concrete admixtures is a complex topic requiring in-depth knowledge and experience. Admixtures can be classified into the following five major categories :retarding admixtures, and air-entraining admixturesSet accelerating admixtures, water reducing and set retarding admixtures and water reducing and set accelerating admixtures.

Numerous benefits are available through the use of admixtures, including, extended set -time, greater concrete strength, reduced bleed-water, increased flow for the same water-to cement ratio, easier pumping, water-proofing, improved fire resistance, lower density, and greater workability. the primary benefit of a particular admixtures is generally self-evident from the type of admixtures, such as a retardant or a water reducer admixture. study of available admixtures is the best way to learn all the particular benefits possible.

3.2. Research Objectives

The main aim of the current study is to investigate the behavior of the concrete mixes incorporating different dosages of several types of mineral admixtures such as(silicafume) and lime stone powder. [9]

3.3. Experimental Program &Research Variables [12]

An experimental test program is planned to achieve the research objectives using the following variables:

1) Cement content. =350 Kg / m³
2) W/C=0.5 (constant)
3) Cement type =CEM I 42.5 (constant) .
4) Elevated temperature mixing water at 90 degree Celsius.
5) Admixtures (silicafume) .
6) Filler (lime stone powder).

3.4. Test Specimens

All concrete mixes were tested at both of fresh and hardened state .Fresh concrete testes include slump, slump losses, and air content .Hardened concrete tests include 15*15*15cm cubes for compression test at (3, 7 and 28days) , 15*15*70cm beams for flexural test at (28 days), cylinders with 15cm diameter and 30 cm height at (28 days).

3.5. Tests Carried Out on Materials Used

*Cement: [16]

1) Fineness of cement by the sieve NO. 170.
2) Water required for cement paste of standard consistency.
3) Initial & final setting times of cement paste using VICAT`S apparatus.
4) LE CHATELIER expansion of cement.
5) Compressive strength of cement mortars using portions of prisms tested in flexure.

*Aggregates:

1) Test method for the determination of sieve analysis of aggregate.
2) Apparent specific gravity of aggregate.
3) Test method for determination of bulk density & percentage of voids for aggregate.
4) Test method for uncompacted void contact.
5) Dtermination of coarse aggregate crushing value.
6) determination of abrasion resistance of coarse aggregate in LOS ANGELES machine.

3.6. Mix Proportions [10]

Table 1. *Concrete mix proportions.*

Mix	Cement Kg / m³	Fine Kg / m³	Coar.Agg. Kg / m³	Admix. SF	Filler L.P	W/C %	Temp °C	S.P. %
C1	350	634	1268	……..	…….			1.5
C2	350	634	1268	……..	…….			2
S1	315	634	1268	10%	…….	0.5	55	1.5
S2	315	634	1268	10%	…….			2
L1	297.5	634	1268	……..	15%			1.5
L2	297.5	634	1268	……..	15%			2

4. Materials Properties

4.1. General

This chapter presents the quality control tests performed on the materials used in this research according to Egyptian code (E. C. P.).

4.2. Mix Preparation

Weight of agg

Bring of sand

Sift of sand

Preparing of cube

Boiling water

pouring water

Preparation of mixer

compact Cubes

Solving the samples

Marking sample

Figure 9. *Mix processing.*

4.3. Concrete Test

4.3.1. Fresh Concrete

Slump Test

Figure 10. *Slump test.*

The slump test has witnessed many technological advances, and some countries even perform the test using automated machinery. The simplified, generally accepted method to perform the test is as follows: [13]

Figure 11. *Slump test.*

Results:

Slump test

Table 2. *Contains slump test results for fresh concrete.*

Mix	Slump (mm)	
	0min	30min
C1	90	50
C2	Collapse	70
S1	20	0
S2	60	40
L1	40	30
L2	Collapse	100

4.3.2. Hardness Concrete

(i). Testing the Compressive Strength of Concrete

General:-

Concrete mixtures can be designed to provide a wide range of mechanical and durability properties to meet the design requirements of a structure. The compressive strength of concrete is the most common performance measurement used by the engineer in designing buildings and other structures. The compressive strength is measured by breaking cubes concrete specimens in a compression-testing machine. The compressive strength is calculated from the failure load, divided by the cross-sectional area resisting the load, and reported in units of pound-force per square inch (psi) in US Customary units or megapascals (MPa) in SI units.

Objectives:-

Compressive strength test results are primarily used to determine that the concrete mixture as delivered meets the requirements of the specified strength, f'_c, in the job specification.

Strength test results from cast cubes may be used for quality control, acceptance of concrete, estimating the concrete strength in a structure for the purpose of scheduling construction operations such as form removal, or for evaluating the adequacy of curing and protection afforded to the structure. Cubes tested for acceptance and quality control are made and cured in accordance with procedures described for standard-cured specimens.

For Compressive Strength of Cube Concrete Specimens. A test result is the average of at least two standard-cured strength specimens made from the same concrete sample and tested at the same age. In most cases, strength requirements for concrete are at an age of 28 days. [14]

Apparatus:

1) Compression testing machine
2) Rod compaction length (50-60cm), dim 16mm.
3) 6cube for each mixes

Figure 12. *Compression Machine.*

Samples:

Cube specimens for acceptance testing should be 15cm x15cm x15cm.

Precautions:-

1. Cube should be centered in the compression-testing machine and loaded to complete failure.
2. The concrete strength is calculated by dividing the maximum load at failure by the average cross-sectional

area.

3. The technician carrying out the test should record the date they were received at the lab, the test date, specimen identification, cube area, test age, maximum load applied, compressive strength, type of fracture, and any defects in cube. If measured, the mass of the cube should also be noted.
4. Most deviations from standard procedures for making, curing, and testing concrete test specimens will result in a lower measured strength.
5. The range between companion cube from the same set and tested at the same age should be, on average, about 2 to 3% of the average strength. If the difference between two companion cubes exceeds 8% too often, or 9.5% for three companion cube, then the testing procedures at the laboratory should be evaluated and rectified.
6. Results of tests made by different labs on the same concrete sample should not differ by more than about 13% of the average of the two test results.
7. If one or both of a set of cube break at strength below f'_c, evaluate the cubes for obvious problems and hold the tested cubes for later examination. Opportunity to correct the problem may be lost. In some cases additional reserve cubes are made and can be tested if one cube of a set broke at a lower strength.
8. A three or seven-day test may help detect potential problems with concrete quality or testing procedures at the lab, but is not a basis for rejecting concrete, with a requirement for 28-day or other age strength.
9. Reports of compressive strength tests provide valuable information to the project team for the current and future projects. The reports should be forwarded to the concrete producer, contractor, and the owner's representative as expeditiously as possible.

Calculation:

Size of the cube =15cm x15cm x15cm

Area of the specimen (calculated from the mean size of the specimen) =225cm^2

Characteristic compressive strength at 7 days = 282.5 kg / cm^2

Results:

$$F = P / A$$

F= (failure strength) kg /cm^2
P= (failure load) kg
A= (area) cm^2

Sample after the test

Figure 13. *Tested sample.*

(ii). Splitting Tensile Strength Test on Concrete Cylinders

General:-

To determine the splitting tensile of concrete.

Apparatus:

Compression testing machine, two packing strips of plywood 30 cm long and 12mm wide. [15]

Figure 14. *Test of cylinder.*

Procedure:

1. Take the wet specimen from water after 7 days of curing
2. Wipe out water from the surface of specimen
3. Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
4. Note the weight and dimension of the specimen.
5. Set the compression testing machine for the required range.
6. Keep is plywood strip on the lower plate and place the specimen.
7. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.
8. Place the other plywood strip above the specimen.

Calculation:

Range Calculation

As per IS456, split tensile strength of concrete. = 0.7Fck

The splitting tensile strength is calculated using the formula

$$Tsp. = 2P / \pi DL$$

D = diameter of the specimen
L = length of the specimen

Figure 15. *Flexure test.*

5. Results & Analysis

5.1. General

In this chapter we get a final Results for search, this brief overview at results has characterized the main types of additives and effect on mix of concrete. Where known, in order to throw more light on the complexities of interaction with the cement hydration process. It has been shown that various additives, particularly accelerators and retarders, chemical admixtures & mineral admixtures.

5.2. Tests Carried out on Fresh Concrete

Slump Test

Table 3. *Contains slump test results for fresh concrete.*

Mix	Slump (mm)	
	0min	30min
C1	90	50
C2	Collapse	70
S1	20	0
S2	60	40
L1	40	30
L2	Collapse	100

5.3. Tests Carried out on Hardened Concrete

5.3.1. Compressive Strength

Table 4. *Compressive strength results including its average values for (Hot Weather).*

Mix	Time (days)	Compressive Strength (Kg / cm²)			Average	Details
		Cube 1	Cube 2	Cube 3		
	3	167.6	179.8	192.5	180	
C1	7	253.6	302.2	291.6	282.5	1.5% S.P.
	28	321.3	310.9	294.8	309	
	3	256.3	210.6	303.4	256.8	
C2	7	314.5	237.4	295	282.3	2% S.P.
	28	250.9	320.5	336.1	302.5	
	3	441	368.7	497.5	435.7	
S1	7	486.5	423.9	418	442.8	1.5% S.P.
	28	515.9	521.4	503	513.4	10%S.F.
	3	393.4	285	317.8	332.1	
S2	7	345	328	348	340.3	2% S.P.
	28	413.7	418.3	433.3	421.8	10% S.F.
	3	219.5	173.3	251.2	214.7	
L1	7	204.5	334	264	267.5	1.5% S.P.
	28	361.5	347.3	339.8	349.5	15% L.P.
	3	256.7	263.4	274.3	264.8	
L2	7	281	316.8	332	310	2% S.P.
	28	358.2	388.5	380.8	375.8	15% L.P.

Table 5. *Compressive strength results for mixes in (Normal Temperature).*

Mix	Time (days)	Compressive Strength (Kg / cm²)			Average	Details
		Cube 1	Cube 2	Cube 3		
	3	157	161	191	170	
C1	7	221	224	246	230	1.5%S.P.
	28	258	268	238	255	
	3	192	173	152	173	
C2	7	228	231	238	233	2%S.P.
	28	255	361	268	262	
	3	248	241	253	247	
S1	7	296	245	288	270	1.5%S.P 10%S.F
	28	301	295	326	308	
	3	275	253	258	262	
S2	7	285	274	295	285	2%S.P 10%S.F
	28	310	442	213	322	

5.3.2. Splitting Test

Table 6. *Splitting test results at (28 days) in (Hot Weather).*

Mix	Time (days)	Splitting strength Kg / cm²			Average	Details
		Cylinder 1	Cylinder 2	Cylinder 3		
C1	28	26	30.1	36.2	31	1.5% S.P.
C2		28.4	35.3	25.5	30	2% S.P.
S1		42.9	42.7	41.1	42	1.5% S.P.
S2		42.9	41.6	41	42	2% S.P.
L1		23.8	26.5	30	27	1.5% S.P.
L2		23.5	17	21.5	21	2% S.P.

Table 7. *Splitting test results at (28 days) in (Normal Temperature).*

Mix	Time (days)	Flexure strength Kg / cm²			Average	Details
		Cylinder 1	Cylinder 2	Cylinder 3		
C1	28				16	1.5% S.P.
C2						2% S.P.
S1					24	1.5% S.P.
S2					25	2% S.P.

5.3.3. Flexure Test

Table 8. *Flexure strength of beams at (28 days) in (Hot Weather).*

Mix	Time (days)	Flexure strength Kg / cm²			Average	Details
		Beam 1	Beam 2	Beam 3		
C1	28	171.1	136.9	124.4	144	1.5% S.P.
C2		105.8	140	140	129	2% S.P.
S1		186.7	171.1	155.6	171	1.5% S.P.
S2		124.4	124.4	124.4	124.4	2% S.P.
L1		124.4	124.4	155.6	135	1.5% S.P.
L2		155.6	171.1	124.4	151	2% S.P.

Table 9. *Flexure strength of beams at (28 days) in (Normal Temperature).*

Mix	Time (days)	Flexure strength Kg / cm²			Average	Details
		Beam 1	Beam 2	Beam 3		
C1	28					1.5% S.P.
C2						2% S.P.
S1						1.5% S.P.
S2						2% S.P.

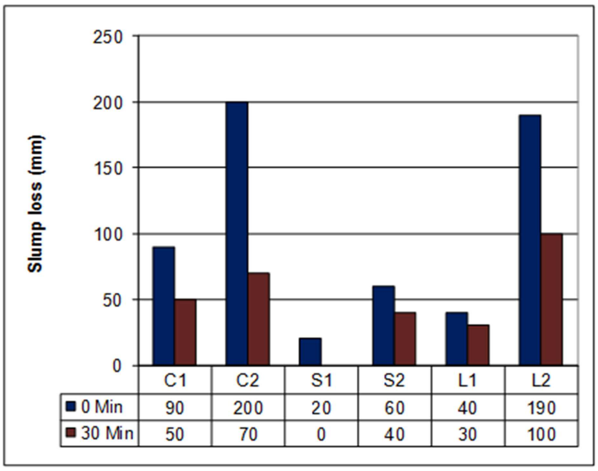

Figure 16. *slump at (0 min, 30 min).*

As shown figure16 collapse occurred at mix containing 2%S.P. and mix containing 2%S.P. &15%L.P. but the lowest value was given by mix containing 1.5%S.P. &10%S.F.

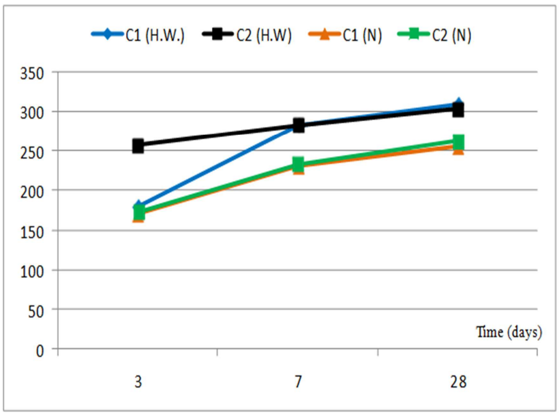

Figure 17. *Relation between c1 (1.5%s.p)&c2 (2%s.p) in hot weather and normal weather.*

As shown in figure 17 the compressive strength of mix containing 1.5% S.P. was increased by 3% comparing to mix containing 2% S.P.

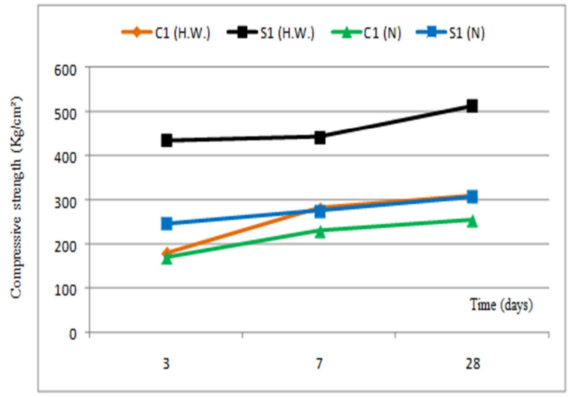

Figure 18. *Relation between c1 (1.5%s.p)&s1 (1.5%s.p – 10% s.f) in hot weather and normal weather.*

As shown in figure 18 the compressive strength of mix containing 1.5% S.P. &10% S. F. was increased by 40% comparing to mix containing 1.5% S. P.

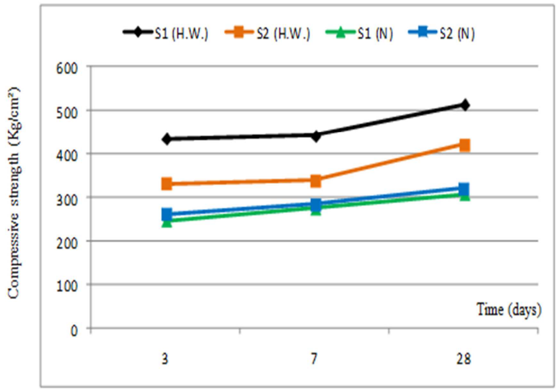

Figure 19. *Relation between s1 (1.5%s.p- 10% s.f)&s2 (2%s.p – 10% s.f) in hot weather and normal weather.*

As shown in figure 19 the compressive strength of mix containing 1.5%S.P. &10%S.F was increased by 18% comparing to mix containing 2%S.P & 10%S.F.

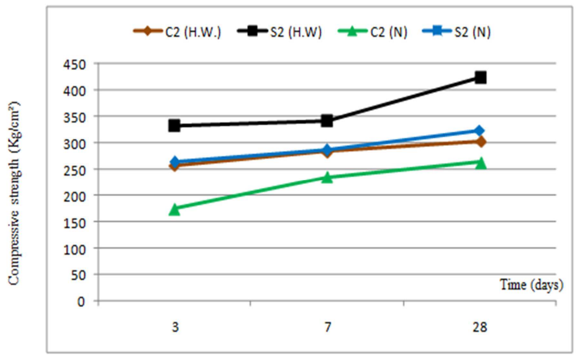

Figure 20. *Relation between c2 (2%s.p)&s2 (2%s.p – 10% s.f) in hot weather and normal weather.*

As shown in figure 20 the compressive strength of mix containing 2% S.P. &10% S.F. was increased by 29% comparing to mix containing 2% S.P.

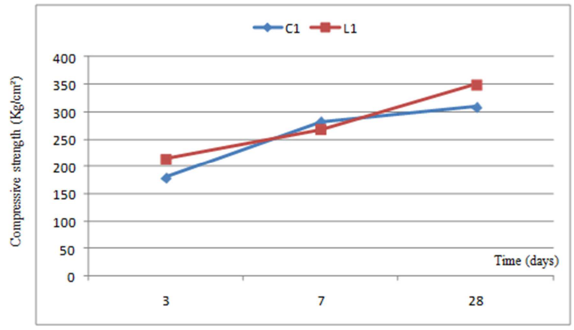

Figure 21. *Relation between c1 (1.5%s.p)&L1 (1.5%s.p -15% L.P) in hot weather.*

As shown in figure 21 the compressive strength of mix containing 1.5% S. P. &15%L. P. was increased by 22% comparing to mix containing 1.5% S. P.

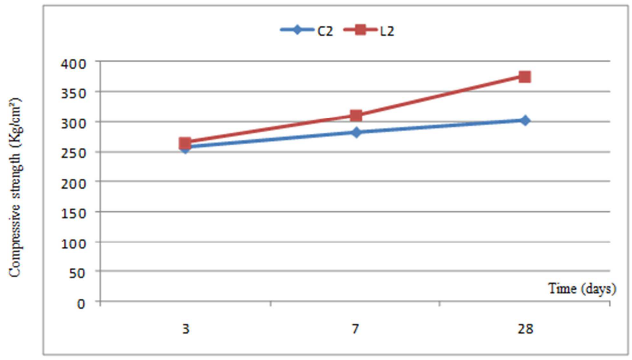

Figure 22. *relation between c2 (2%s.p)&L1 (2%s.p -15% L.P) in hot weather.*

As shown in figure 22 the compressive strength of mix containing 2% S.P. &15%L.P. was increased by 19.5% comparing to mix containing 2% S.P.

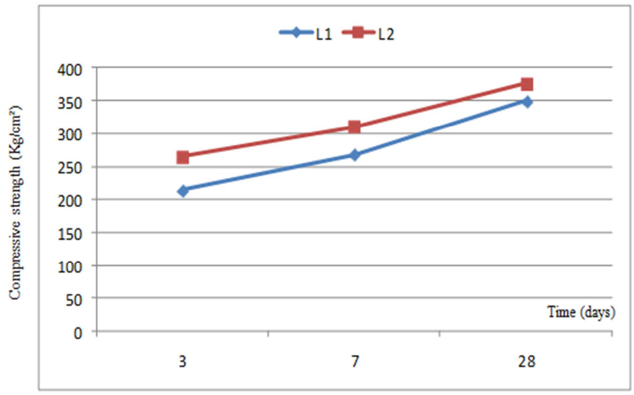

Figure 23. *relation between L1 (1.5%s.p-15%L.P)&L2 (2%s.p -15% L.P) in hot weather.*

As shown in figure 23 the compressive strength of mix containing 2% S.P. & 15% L.P. was increased by 7% comparing to mix containing 1.5%S.P &15% L. P.

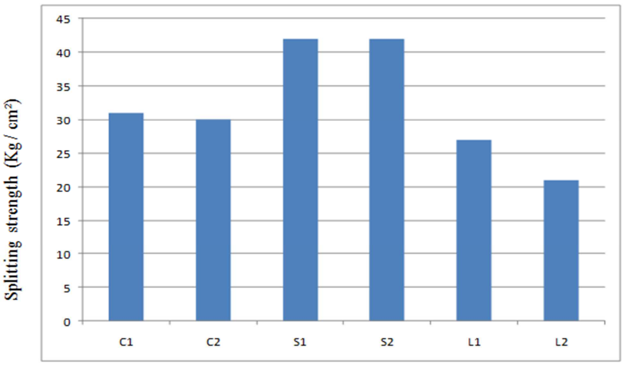

Figure 24. *Splitting strength.*

As shown figure 24 maximum results for splitting strength was given by mix containing (1.5&2)% S. P &10%S.F comparing to other mixes.Noting that the lowest value was given by mix containing 2%S.P. &15%L.P.

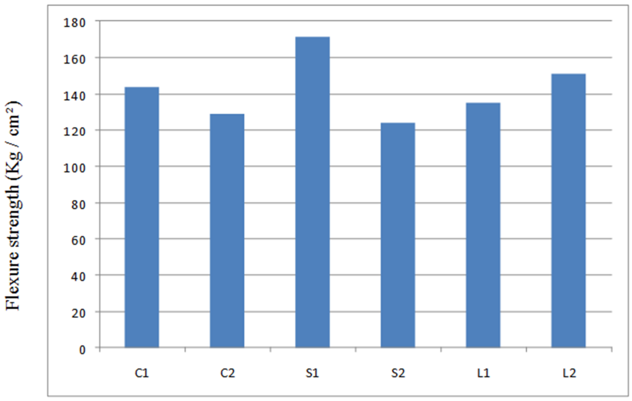

Figure 25. *Flexure strength.*

As shown figure 25 maximum results for flexure strength was given by mix containing 1.5% S.P &10%S.F comparing to other mixes. Noting that the lowest value was given by mix containing 2%S.P. &10%S.F.

6. Conclusions and Recommendations

6.1. Conclusions

6.1.1. Fresh Concrete Test

From figure 16 after analyzing the slump results, it was noticed that the mix containing 2 %S.P .and the same mix with 15 %L.P .gave collapse due to the amount of S.P .which gave high workability that caused the collapse.

6.1.2. Hardened Concrete Test

1. From figure17 It was noticed that at the early age of concrete the mix containing 2%S.P .gave higher compressive strength than 1.5%S.P.but at (28days)the compressive strength results was nearly equal.
2. From figure 18 it was noticed that at the early age of concrete the mix containing 1.5%S gave compressive strength less than 1.5% S. P .&10%S.Fand this difference in compressive strength continues till (28day) .Due to the effect of silica fume in concrete properties and this is a logic results.
3. From figure 19 itclearlyappeared the effect of lime powder in concrete properties lead to increased compressive strength due to fines of lime powder where it is a filler material thatfills avoids and increase compressive strength.
4. From figure 20 it was noticed that at the early age of concrete the mix containing 2%S.P. gave compressive strength less than 2%S.P .&10%S.Fandthis difference in compressive strength continues till (28day) noticing that increasing the dosage of S.P. 2% caused a decreased in compressive strength from 1.5%.
5. From figure 21 it was noticed that the compressive strength at the early age of concrete the mix containing 2%S.P.and mix containing 2%S.P. &15%L.P. are nearly equal but at 28 day the effect of using lime powder was clearly obvious.
6. From figure 22 Comparing between the dosages of S.P. in both mixes that varies from (1.5-2)% it was noticed that using 1.5%S. P. gives higher compressive strength than 2% S. P.
7. At the opposite of predicted the increase in the dosage of S.P. from (1.5to2) %in the lime powder mix had abettor effect than it had in silica fume mix it cleared that 2%S.P.is the optimum dosage.

6.2. Recommendations

It's recommended that to investigate the following parameters in the:

1. Study affects the materials on the result.
2. It must be using low range of S.P% at constant silica fume to gain compressive strength and to prevent to segregation.
3. It must be mixing, add the silica fume with the cement before we put in mixer because of when we add silica fume after the cement in mixer we don't gain the required compressive strength.
4. It must be at mixing, add S.P. after water add don't with water that the reaction of S.P. is decrease.
5. Don't allow using accelerator admixture in hot weather concrete.

For placing concrete in hot weather taking these precautions:

1. Use concrete materials and proportions with satisfactory records in hot weather
2. Use cool concrete
3. Use a concrete consistency that permits rapid placement and effective consolidation
4. Transport, place, consolidate, and finish with least delay
5. Protect concrete against moisture loss at all times, during placement and curing period

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