STUDYING THE EFFECTS OF THE SUPER PLASTICIZER ON THE CONCRETE MIXES CONTAINING DIFFERERNT PORTION OF CEMENT

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Abstract:

The included search casting twenty one concrete mixes, that proportion are (1:1.5:3), (1:2:4) and (1:3:6). Nine of them with out using plasticizer with three (w/c) (0.50, 0.57, 0.60) as showing at table (6).And twelve mixes contained a proportion of additive mixture of metal Gelenium No.(5) with four ratios of Gelenium as shown at table (5) and every mix has (w/c) (0.45:0.53:0.60).

- Soft conceret of non container plastizer tested by workablity (slump test). The mex (1:1.5:3) gave best result (60mm) , least mix (1:2:4) gave (40mm), least mix(1:3:6) gave (25mm) according to reference mixture.
- Soft conceret with Gelenium ratio plastizer gave best slump for Nine mixs with three (w/c) ratio (40%, 45%, 50%) And Gelenium (3%) , the best result for mix(1:1.5:3) equal (98mm),least mix (1:2:4) gave slump (85mm) , And mix (1:3:6) gave (74mm) compare with reference mixture
- Compressive strength for twelve cupics with optimum Gelenium ratio. The mix (1:1.5:3) with (2%) gave (14Mpa) at early age. And (38Mpa) at finish age, least mix (1:2:4) gave (10Mpa) at early age And (28Mpa) at finish age , And mix (1:3:6) gave (6Mpa) at early age , and (20Mpa) at finish age as shown at figure(8).
- Depend on ratio of mix , percentage(w/c) and zoom of plasticizer .these factors gave best result at mix(1:1.5:3) according to standard specification.

Keywords: Plasticizer, Concrete Mix, Admixture, Compressive Strength, Workability, Durability, Slump, Gelenium (5).

الخلاصة:

تضمن هذا البحث (21) خلطة خرسانية بثلاث نسب وهي (1:1.5:3)، (1:2:4) و(1:3:6). تسعة منها بدون مضاف وبثلاث نسب ماء (w/c) (0.5, 0.57 , 0.60) . واثناعشر خلطة حاوية على اربعة نسب من المضاف كلينيوم رقم(5) وبنسب مختلفة من الماء (40% ,45%, 50%).

- فحص الهطول للخلطاتالخرسانية الغير حاوية على المضاف كلينيوم رقم (5) لمعرفة قابلية التشغيل فالخلطة (1:1.5:3) أعطت أفضل النتائج بلغت (60mm) تليها الخلطة (1:2:4) اعطت (40mm)ثم تليها الخلطة(1:3:6) أعطت (25mm) مقارنةً بالخلطة المرجعية.

- فحص الهطول للخلطات الخرسانية الحاوية على الكلينيوم رقم (5) وبثلاث نسب للكلينيوم فأعطت الخلطة (1:1.5:3) (98mm) تليها الخلطة (1:2:4)التي اعطت (85mm) ثم تليها الخلطة (1:3:6)فأعطت هطولاً (64mm) مقارنة بالخلطة المرجعية.
- فحصت مقاومة الأنضغاط بأربعة وعشرون مكعباً للخلطات الحاوية على الكلينيوم المثالي وبثلاث نسب (2% , 3% , 4%) وبثلاث نسب (w/c) (40%, 45% , 50%) وكما مبين :-

- الخلطة (1:1.5:3) وبنسبة كلينيوم (2%) أعطت مقاومة (14Mpa) في الأعمار المتقدمة و(28Mpa) للأعمار المتأخرة
- أما الخلطة (1:2:4) بنسبة كلينيوم (3%) أعطت مقاومة في الأعمار المتقدمة (10Mpa) ومقاومة للأعمار المتأخرة (25Mpa).
- أما الخلطة (1:3:6) وبنسبة كلينيوم(4%) فأعطت مقاومة في الأعمار المتقدمة (6Mpa) ومقاومة للأعمار المتأخرة (20Mpa) وكما مبين في الجدول (8).

الأنضغاط يعتمد على عوامل هي نسبة الخلط ونسبة الماء للسمنت وكمية الجرعة المضافة من الكلينيوم فالجرع المثالية أعطت أفضل النتائج وخاصةً للخلطة (1:1.5:3) مقارنةً بالمواصفات القياسية.

Introduction:

Use of concrete began in year 1850 A.C twenty five years after the discovery of Portland cement by the engineer Aspidin. After this period, standards specification was needed for the plane and reinforced concrete. There is standard specification for this material in many countries. The importance of use of concrete was increased Since 1900 A.C and there were developments in construction especially in dams that made the concrete the first material contributes most of the new buildings.

Plane concrete is made by mixing cement with water, sand and crushed stone or a gravel. Cement works as an active material in this mix where in combine physically and chemically producing stiff mass like natural stones.

When cement is mixed with water only it's called "cement paste" and the hardened cement paste is called "stony cement". The use of only cement and water in the mix is expensive so, aggregate is used to increase the volume of the concrete mix. The components of the concrete are mixed within different ratios depending on their purposes in the mix. One of the concrete properties is that it takes the desired shape when casted in the frames. Good mix of concrete produces a solid material which can bear the compressive stress but it is weak in bearing the tensile stress therefore amount of steel is added in the zones where tensile stress is present to increase the tensile strength property and this called reinforced concrete(Jack. C. Mc,Cormac,2001).

Concrete is a nonhomogeneous material consists of particles different in size and shapes placed randomly and tied together by hardened cement. Concrete consist of pores and spaces filled with water and air. This combination of concrete identifies its physical and chemical properties.Rixon"M:R"1986 Physical and chemical phenomena that happens during hardening of concrete (like crystallization, gel shrinkage and evaporation of excess water … etc.) lead to change the concrete properties with time(B. W. Shack,1974).

First Portland cement was produced in year 1840 by Pakar, he called it the Roman cement which has a flexibility to a certain degree. Stones from top of Sheppy island that lies on the mouth of the

River Thames was used in producing the Portland Cement after burning and crushing(Lea, "the chemistry of cemente and concerete" Arnold ,1970)

After this discovery, normal or natural cement appeared in England, France and Russia. In general, this cement contained (70%) calcium carbonate ($CaCO_3$), (20%) silica (SiO_2) and (10%) alumina (Al_2O_3) that represent the main components of the present cement noting that this type of cement was damaging quickly because of its fast hardening.

The developments that occurred to the cement in France by Viket was by mixing water with four parts of lime to one part of clay which is crushed and burnt and the crushed again to produce cement looks like present Portland cement although it is not with the same fineness.

Since that time until now the industry of cement developed so its types differed but still the main mix of producing it is clay and lime.

Admixtures include some materials (except aggregate, cement and water) which are added in a low percentages to the concrete mix during mixing process in order to give the fresh or hard concrete some properties like:

- Improve workability.
- Increase or decrease setting time.
- Decrease the rate of losing slump.
- Increase the ability of pumping.
- Increase the initial strength.
- To gain a high strength concrete.
- Improve the general properties of hard concrete.

Use of plasticizers leads to increase the concrete through increasing the flow ability of the concrete mix by increasing the ratio of the plasticizer and the optimum admixture ratio added as a weight ratio of the cement in use (Mehta, P. K. 1986).

<u>Material reducing water (Plasticizers):</u>

Of the most important materials used from the chemical side:

1. **Lignosulphonates :**
   It is a complex material form (20%) of the combination of the wood produced in the paper industry as the product of an accidental. The commercial product thereof which is used as an additive composed of calcium or sodium by sugary basis with ratio (1-30%).
2. **Acids Alhaadroxa Carbosel:**
   It is an organic material containing both Alhaadroxa and carboxyl in the molecular structure. Are produced from the purification process of raw materials, whether chemical or biological way therefore have a high purity. The primary use of this material is in the food and pharmaceutical industries.
   When these materials are in salts of sodium be of high solubility but Andjemadha point and low , and most important of these acids are:
   1. Citric Acid.
   2. Tartaric Acid.
   3. Mucic Acid.
3. **Hydroxylated polymers:**
   Produced in the manufacture of some vegetable oils in the partial hydrogenation processes for the production of polymers with low molecular weight and therefore contains glucose units which number between (3 & 25).

4. **Salts of sulfuric acid for Naphthalene Formaldehyde:**
   The commercial materials of this type contain (25-45%) of the solids content increasing this content is for the purpose of self-concrete production father with content ranges between (1-3%) of the cement weight.
5. **Sulfate salts of Melamine Formaldehyde:**
   This type of chemicals were produced initially for various uses in the industry.

<u>Materials and laboratory tests:</u>

1. Laboratory Materials

- ***Cement*****:** Portland cement was used ordinary course of OPC and the corresponding Iraqi standard specifications (No.5 / 1984) as shown at table (2).

- ***Fine aggregate:*** been using sand as a fine aggregate were examined gradient and the proportion of salt in it and found that it is identical to the Iraqi specifications (No.5 / 1984). Table (2) shows the limits of this number where it is located within the region (3) of the standard gradient zones No. 4, according to British and Iraqi specifications.

- ***Coarse aggregate:***
  Natural gravel was used as coarse aggregate in experimental mixtures and in size maximum (20 mm). Gradient and the proportion of salts were examined and found that it is identical to the Iraqi specifications (No.5 / 1984). Table (4) shows the limits of the gradient of the gravel and Table (4) shows some characteristics for sand and gravel used.

- ***Additive plasticisers:***
  Gelenium (5) was used which is composed mainly of organic matter (modified atheer carboxyl). This material is working to increase the negative charge on the surfaces of cement particles causing dispersion and divergence of cement particles due to the electronic powers generated. Table (5) shows the properties of this plasticizer.

2. Methodology

*** Mixes**

Samples of test mixes were made which contained different ratios of cement. Twentyone mixes were chosen, mix (1:3:6) cement / aggregate ratio (1:9), mix (1:2:4) cement / aggregate ratio (1:6) and mix (1:1.5:3) cement / aggregate ratio (1:4.5) Nine mix without Gelenium and twelve with Gelenium listed in flow chart (1) shown.

Optimum plasticizer ratio which is added to every mix was determined as to give (100 ∓ 10 mm) slump. Suitable w/c ratio was determined also.

It is noted that mix (1:3:6) is poor with cement. Cement amount increases in the mix (1:2:4) and mix (1:1.5:3) the most amount of cement compared with the other two mixes. The details of mixes and ratios made them up are listed in tables as follows in the research.

3. Laboratory tests

3-1 Slump test:

This test was made according to the American Standard Specification **(ASTM.C.143, 1989)**. The device consist of a conical cylinder, the upper base diameter (10 cm) and the lower one

(20 cm) with height of (30 cm). The cylinder is filled with three equal layers compacted by a (16 mm) diameter steel stick (25) times then the surface is well adjusted. The cylinder at last is raised slowly and then slump is measured to the nearest (5 mm).

3-2 Compressive test:

Compressive tests were made using cubic samples with (15×15×15 cm) dimensions according to British Standard Specification (**B.S.1881, Part 116, 1989**). In every test average of three samples is taken.

Results:

1. Water reduction:

This ratio was determined to declare the effect of the plasticizers in reducing the amount of water with keeping the same plasticity of the mix that is represented by the slump (100 ∓ 10 mm). Several mixes with different ratios of plasticizer and the optimum ratio of the plasticizer for all three mix is determined. Table (6) shows the magnitude of the reduction (WR) for the three mixes as shown in Figures (1), (2) and (3).

When the relation between the plasticizer ratio and the reduction ratio for every mix are drawn, the optimum ratio of the plasticizer as weight proportion of the cement weight that achieves slump (100 ∓ 10mm).

Mix	The optimal ratio of plasticizer of cement weight
1:3:6	4%
1:2:4	3%
1:1.5:3	2%

The equation used to measure the reduction of water using plasticizer as a percentage is:

$$\boldsymbol{Percentage\ of\ water\ reduction} = \frac{\boldsymbol{w/c\ of\ the\ source\ mix - w/c\ of\ the\ test\ mix}}{\boldsymbol{w/c\ of\ the\ source\ mix}} * \mathbf{100}$$

It is noted that the optimum plasticizer ratio that gives the higher reduction amount is in the mixes that is rich with cement in which there is an enough reduction in water. This means that it is possible to produce mixes of high workability with little ratio of water because the amount of cement paste is enough to give enough plasticity with respect to mixes in which the ratio of cement is low and needs more water.

2. Slump:

Slump test was made to the test mixes with different ratios of water and without addition of plasticizer. Table (6) shows the slump test results which are also shown in Figures (4), (5) and (6). Through the results it is noted that the amount of water needed to have a specified slump decreases with increasing cement ratio in mixes i.e. whenever the aggregate ratio increases in the mix and the cement paste decrease, more amount of water is needed to restitute the effect of cement paste which is the covering the surfaces of the coarse, greasing and lubrication these surfaces (A.M , Nevel "properties of concerete " 2005).

When adding optimal percent of plasticizers material to mixes and achieve the approximate amount of slump (100 ∓ 10 mm), the water / cement ratio decreased to achieve such slump and became as follows:

1-	(1:3:6)	w/c	=	0.50
2-	(1:2:4)	w/c	=	0.45
3-	(1:1.5:3)	w/c	=	0.40

By comparison, we find that the mix (1:3:6) when it is without plasticizer and with water/cement = 0.50, the slump is not more than (5 mm), but when plasticizers material is added at the same value, or the percentage of water, it is found that slump increases to (100 ∓ 10 mm) as well as the case of the mix (1:2:4).

The mix (1:1.5:3) when it is without plasticizer material and with water to cement ratio (0.4), the amount of slump = 3.5 mm and when plasticizers is added at the same percentage of water to cement, the slump increases to (100 ∓ 10 mm).

3. Compressive strength:

Compressive strength was determined for the test mix of age (3,7,28) the day before and after the addition of plasticizers to see how much influence in increasing compressive strength.

The obtained results shown in the table (7) and illustrations figures (7), (8) and (9) show an increase in resistance to compression as follows for the three mixtures:

1- At age 3 days compressive strength increased by (44%)
2- At age 7 days compressive strength increased almost by (30%)
3- At age 3 days compressive strength increased almost by (16%)

From the results, it is evident that the increase will be more in the early stages compared with the subsequent stages and explanation of that is the reactions are more severe and more influential in the early stages, but this effect is reduced in the later stages of the life of concrete.

<u>Discussion:</u>

1- Plasticizer materials affect the fresh concrete better when cement amount is enough which leads to increase the slump to (4) times comparing to the mixes that doesn't contain admixtures.
2- The optimal ratio of plasticizer that achieves a water reduction (WR) become greater in mixes that are poor with cement, for example: mix (1:3:6) requires (4%) plasticizer while mix (1:1.5:3) requires (2%) plasticizer, i.e. half amount of the proceeding mix.

3- Use of plasticizer materials in this research helped in reduction of water which led to increase the compressive strength with an accepted ratios for the Four mixes at ages (3, 7, 14 , 28) days and it is noted that the increase is greater at early stages compared to late stages.
4- Addition of water to mixes that are rich with cement is more effective in increasing the slump compared to mixes that are poor with cement because in rich mixes there is alot of fine particles which helps to increase the mix plasticity and flow ability.

Conclusion:-

- Workability increase with adding optimum percentage of admixture Gelenium No (5).
- Compressive strength increase at early age because of hydration and reach to high value of strength.
- Mix (1:1.5:3) with Gelenium (2%) and (w/c)=(0.4) gave compressive (38Mpa) at (28days).
- Mix (1:2:4) with Gelenium (3%) and (w/c)=(0.45) gave compressive (28Mpa) at (28days).
- Mix (1:3:6) with Gelenium (4%) and (w/c)=(0.5) gave compressive (20Mpa) at (28days).

All these result according to standard specification.

Flow chart
Working search

الخلطات الخرسانية
Mixing conceret

(9) mix (without Gelenium) — (12) mix (with Gelenium)

Mix	1:1.5:3	1:2:4	1:3:6	1:1.5:3	1:2:4	1:3:6
(1)w/c	0.5	0.5	0.5	0.4	0.45	0.5
(2)w/c	0.57	0.57	0.57	-	-	-
(3)w/c	0.6	0.6	0.56	-	-	-

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Table (1): properties of cement

NO.	Test setting time	Value	Limit of Iraqi std. spci.
1	inatial time final time	118 menite 3.1 hours	45<= 10>=
2	Compressive 3 days 7 days	18.7Mpa 26.4Mpa	15<= 23<=

Table (2): Gradation of the sand used in mixes

Size (mm)	% Passing	Standard specifications (No.5/1984)
9.5	100	100
4.75	93	90-100
2.36	95	85-100
1.18	82	75-100

0.60	76	60-79
0.30	19	12-40
0.150	6	0-10

Table (3): Gradation of the gravel with maximum size (20 mm)

Size (mm)	% Passing	Standard specifications (No.5/1984)
37.5	100	100
20	90	85-100
10	13	0-25
5	3	0-5

Table (4): Physical properties of sand and gravel

	Specific weight	Sulfate salts ratio	Absorption
Sand	2.63	%*0.5>0.06	0.75%
Gravel	2.650	%*0.5>0.02	0.63%

* According to Iraqi Standard Specification No. 45 / 1980.

Table (5): Plasticizers properties

Color	Dark
Density	1.1 gm/cm^3 at 20^{o}C
PH	6.6
Viscosity	128S at 20^{o}C

Table (6): Water reduction in the mixes with different plasticizer ratio

Mix (1:3:6) w/c = 0.5		**Mix (1:2:4) w/c = 0.45**		**Mix (1:1.5:3) w/c = 0.40**	
Plasticizer ratio (%)	***Reduction ratio (%)***	***Plasticizer ratio (%)***	***Reduction ratio (%)***	***Plasticizer ratio (%)***	***Reduction ratio (%)***
3	12.5	2	15	1	22.5
3.5	13.75	2.5	18	1.5	25
4.5	12.5	3.5	18.5	2.5	27
5	10	4	17	3	25

Table (7): Slump (mm) without plasticizer

Mix (1:3:6)		**Mix (1:2:4)**		**Mix (1:1.5:3)**	
w/c	**Slump**	**w/c**	**Slump**	**w/c**	**Slump**
0.50	5	0.45	5	0.40	35
0.57	10	0.50	20	0.43	45
0.60	25	0.53	40	0.45	60

Table (8): Slump (mm) with plasticizer

w/c	**1:1.5:3 Gelenium%**	**slump**	**w/c**	**1:2:4 Gelenium%**	**slump**	**w/c**	**1:3:6 Gelenium%**	**slump**
0.4	1%	80mm	0.45	2%	77mm	0.5	3%	60mm
0.4	1.5%	90mm	0.45	2.5%	82mm	0.5	3.5%	70mm
0.4	2.5%	120mm	0.45	3.5%	122mm	0.5	4.5%	85mm
0.4	3%	140mm	0.45	4%	130mm	0.5	5%	125mm

Table (9): Compressive strength of mixes with and without plasticizer

Age (day)	**Mix (1:3:6)**		**Mix (1:2:4)**		**Mix (1:1.5:3)**	
	Without plasticizer	**With optimal plasticizer ratio**	**Without plasticizer**	**With optimal plasticizer ratio**	**Without plasticizer**	**With optimal plasticizer ratio**
3	6	8	8	10	9	14
7	12	16	16	20	20	26
28	20	22	24	28	26	26

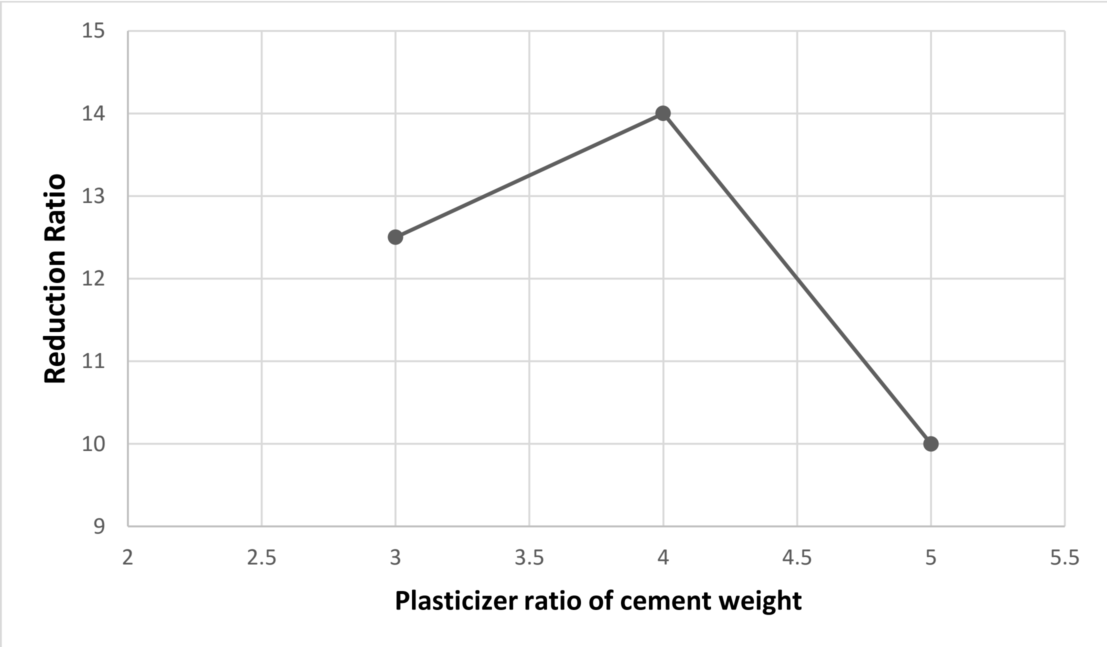

Figure (1): The percentage of water reduction by adding plasticizers for the mix (1: 3: 6) water to cement ratio (0.50)

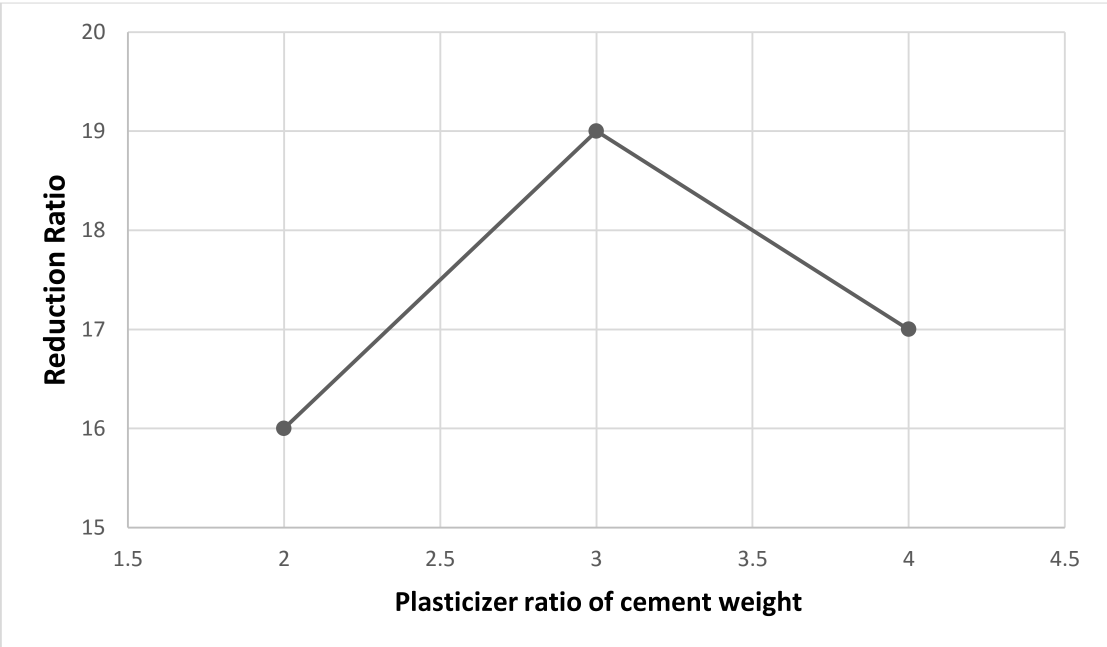

Figure (2): The percentage of water reduction by adding plasticizers for the mix (1: 2: 4) water to cement ratio (0.45)

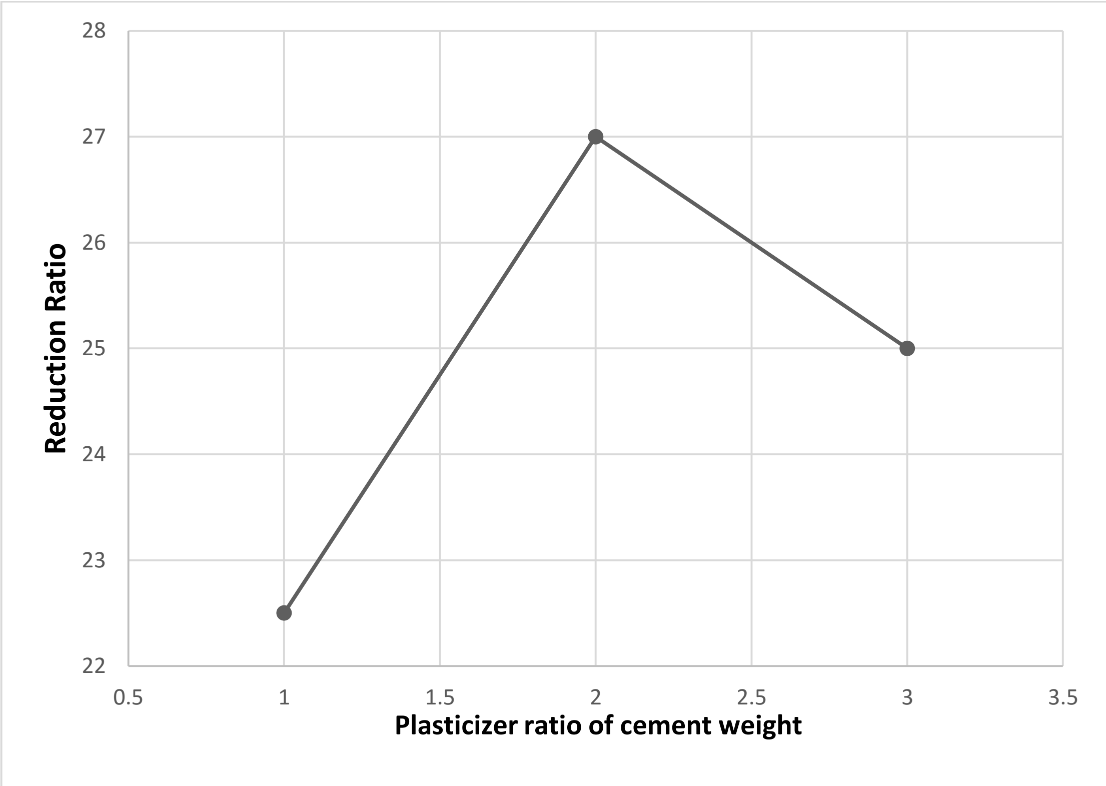

Figure (3): The percentage of water reduction by adding plasticizers for the mix (1: 1.5: 3) water to cement ratio (0.40)

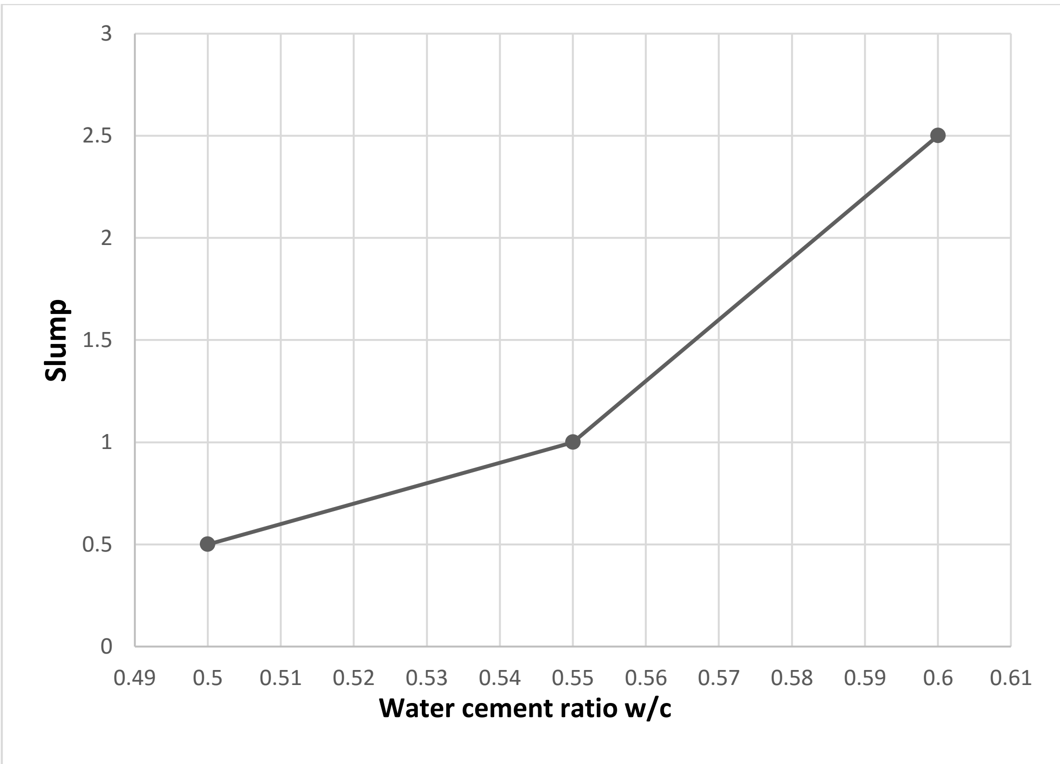

Figure (4): Slump of mix (1:3:6) without plasticizer.

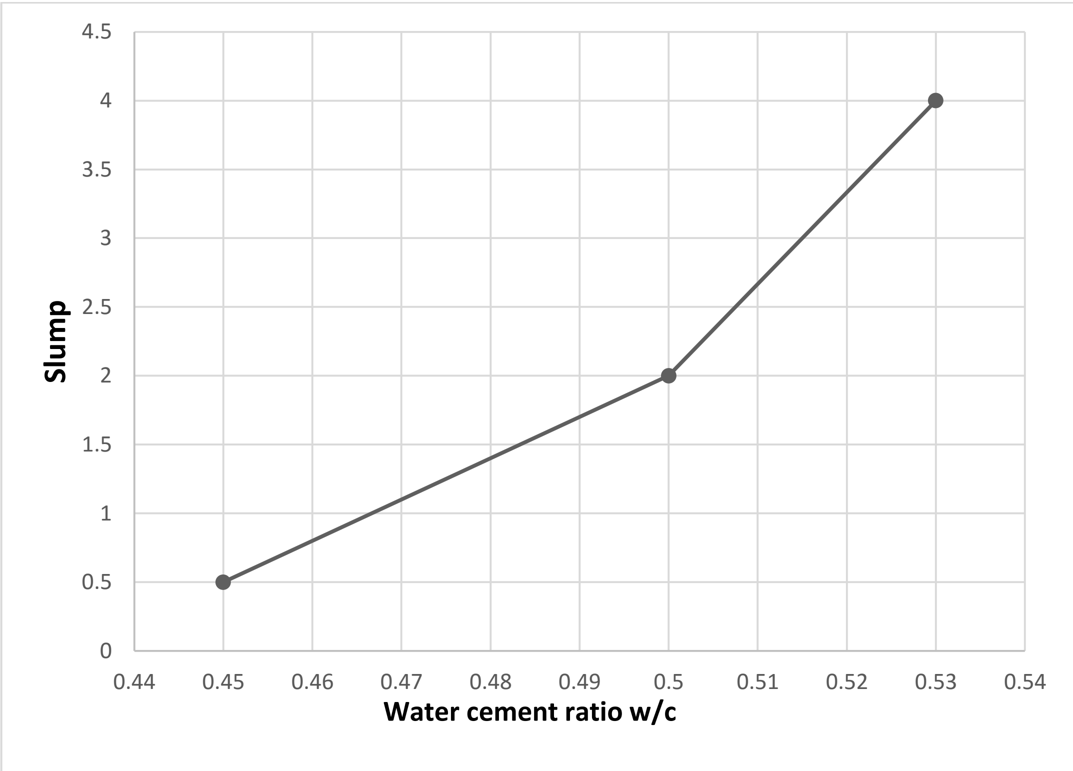

Figure (5): Slump of mix (1:2:4) without plasticizer.

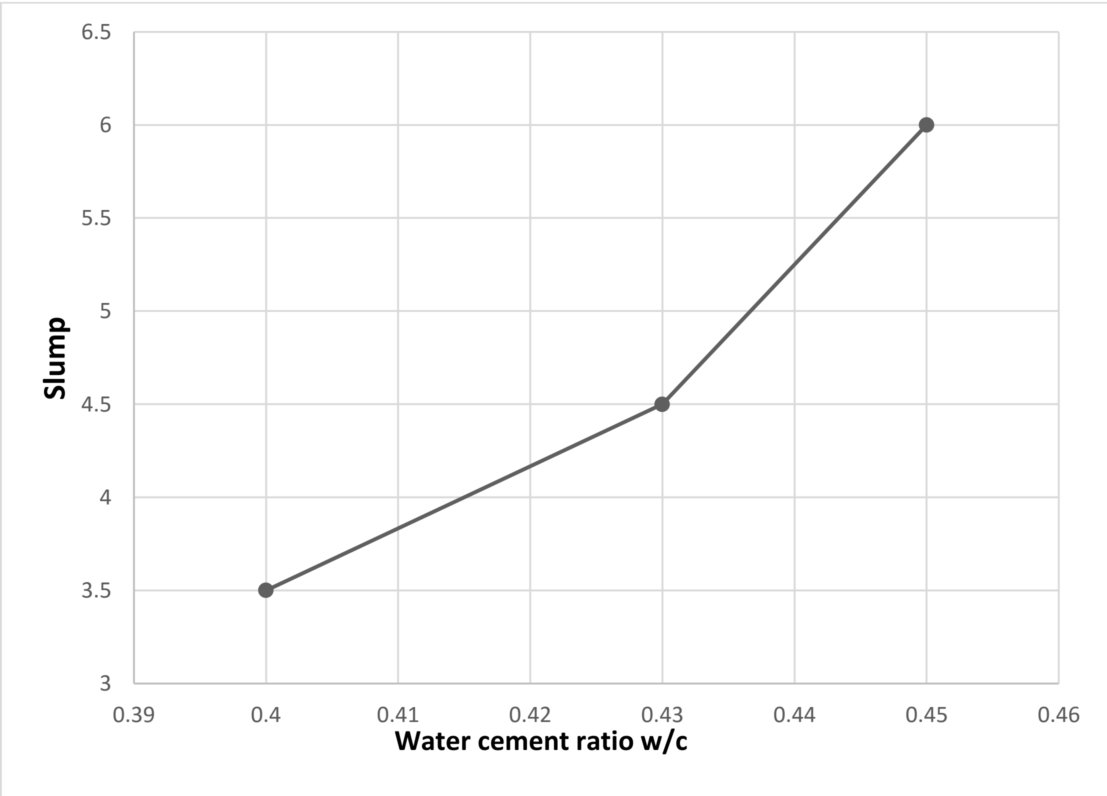

Figure (6): Slump of mix (1:1.5:3) without plasticizer.

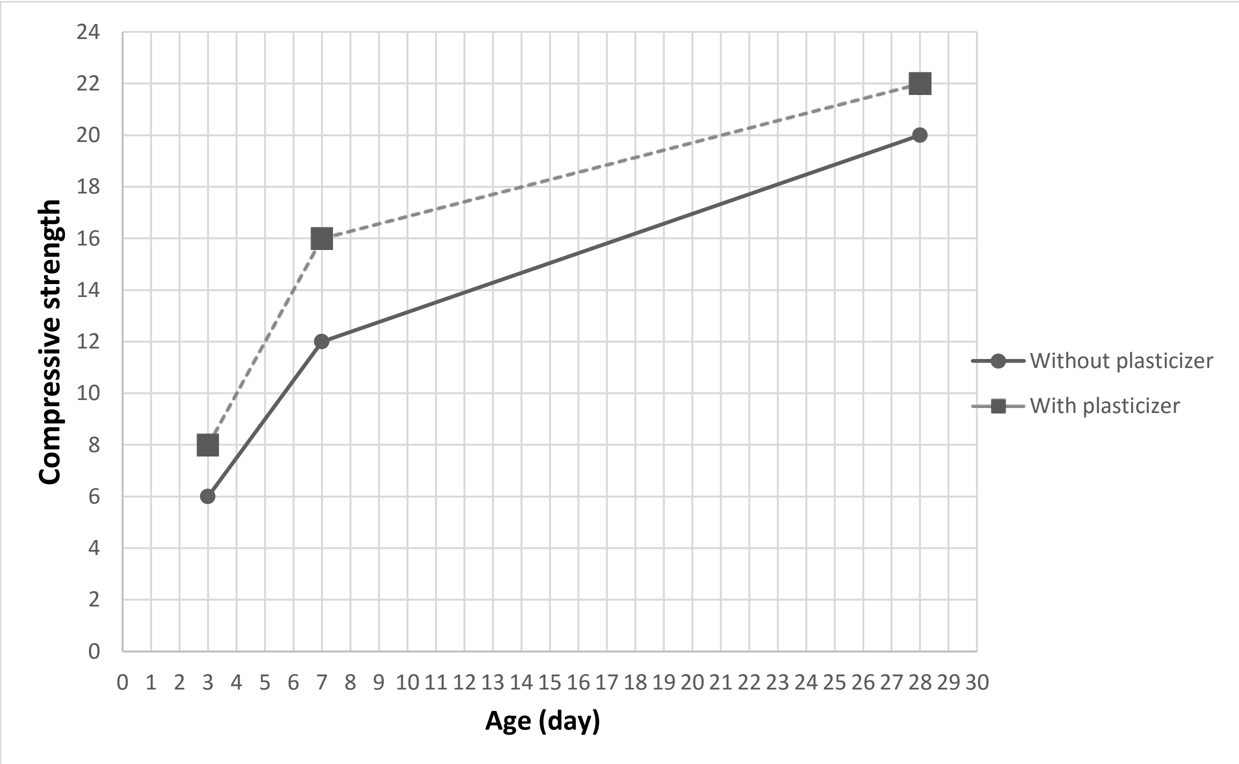

Figure (7): Compressive strength of mix (1:3:6).

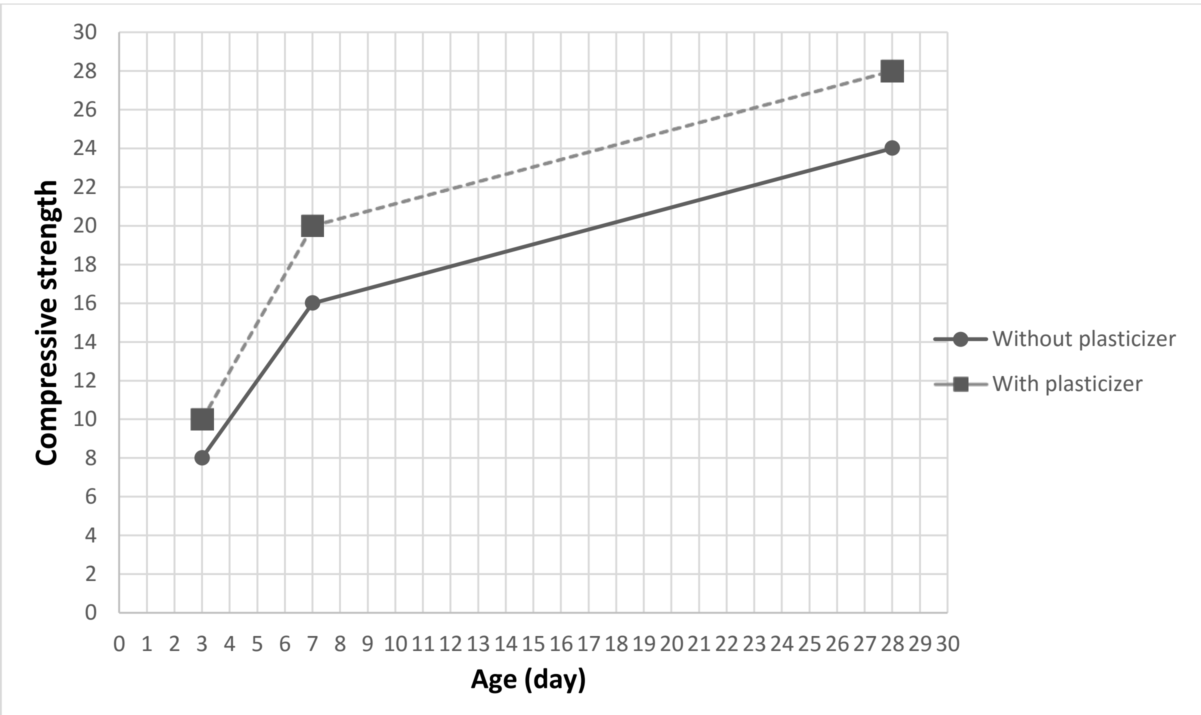

Figure (8): Compressive strength of mix (1:2:4).

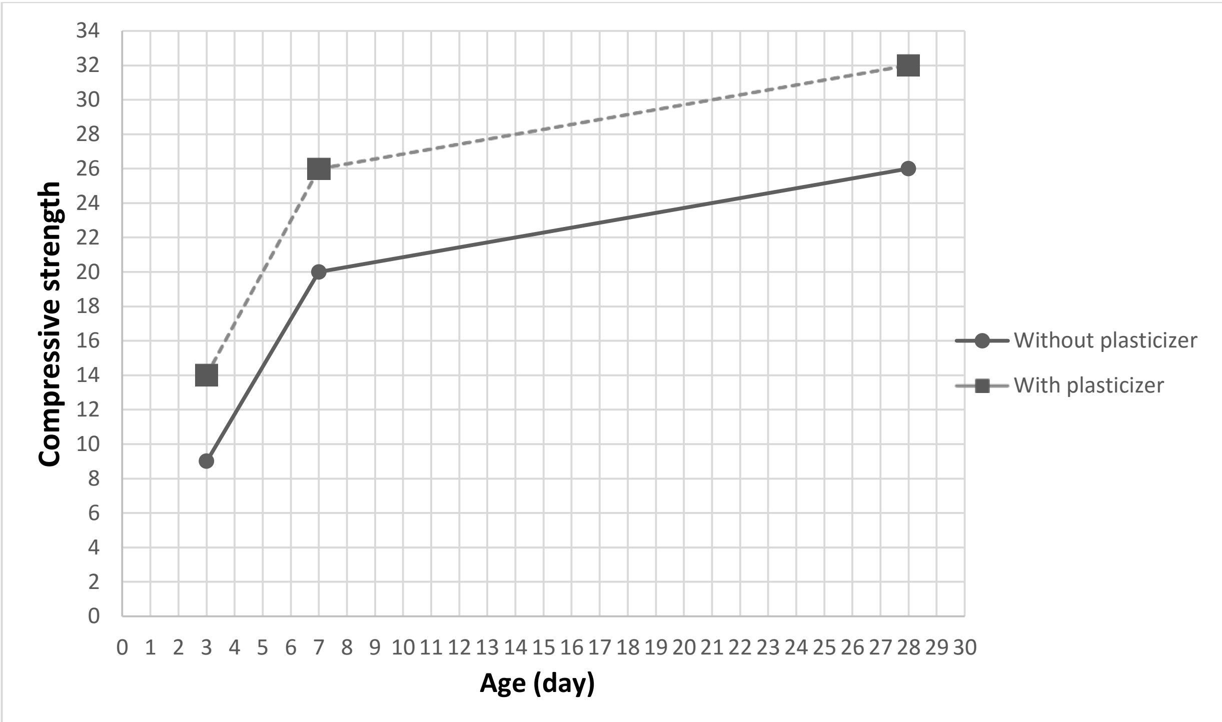

Figure (9): Compressive strength of mix (1:1.5:3).