Comparison The Compressive Strength and Chemical Analysis of Portland Cement Production from Numbers of Iraqi Cement Factoried

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Abstract:

It is advantageous to assess the cement quality within short time, to improve the variables, which may affect compressive strength of Portland cement.

The research includes comparison between the compressive strength of different types of Portland cement selected from several of Iraqi Portland cement factories. Three of their product ordinary Portland cement (Al-Mass factory, Tasloga Factory and Al Kufa factory) and five factories product the sulfate resisting Portland cement are (Tasloga factory, Al Qaim factory, Kerbala factory, Al Muthana factory and Al Sadaa factory).

The test includes two types of cubes, mortar cubes tested at age (3,7 and 28) days and concrete cubes tested at age (7 and 28) days to estimate the accurate strength of cement for different types.

The variables which have been included were the characteristics of the cement it self (phase composition and fineness in addition to other variables which may affect compressive strength of Portland cement like the magnesia (MgO), free lime(CaO),sulphate(SO_3), loss on ignition (L,o.I.), insoluble residue(I.R) which were obtained from the chemical analysis of the cement .

The compressive strength results have been shown reduction in south cement factories than north cement factory. For resisting Portland cement the percent of strength increased at age 28 days (Al Sadaa 16.5%, Tasloga 22%, Kerbala, 22.3%, Al Muthana 22.3% and Al Qaim 29.9%). For ordinary Portland cement the percent increased at age 28 day (Al kufa 21.7%, Tasloga 27.3% and Al Mass 27.5%).

مقارنة مقاومة انضغاط الاسمنت البورتلاندي المنتج من قبل مجموعة من معامل انتاج الاسمنت العراقية

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الخلاصة:-

من المفيد تقييم نوعيه الاسمنت خلال وقت قصير لمعرفه المتغيرات التي يمكن ان تؤثر على مقاومه الاسمنت البورتلاندي.

يتضمن البحث مقارنة لمقاومة انضغاط انواع مختلفة من مكعبات الاسمنت البورتلاندي التي تم اختبارها من معامل مختلفة لانتاج الاسمنت العراقي من ثلاثة معامل لانتاج الاسمنت البورتلاندي الاعتيادي وهي (معمل الماس، معمل طاسلوجة، معمل الكوفة) وخمسة معامل لانتاج الاسمنت البورتلاندي المقاوم للاملاح الكبريتية وهي (معمل طاسلوجة، معمل القائم، معمل كربلاء، معمل المثنى، معمل السدة). تم فحص نوعين من المكعبات: مكعبات مونه لعمر (28,7,3) يوم ومكعبات خرسا نية لعمر(7, 28) يوم لبيان الدقة في فحص مقاومة الانضغاط للأنواع المختلفة. إن المتغيرات التي تم شمولها هي خواص الاسمنت نفسه (التركيب الطوري والنعومة) بالإضافة إلى متغيرات أخرى يمكن إن تؤثر على مقاومة الاسمنت البورتلاندي مثل المغنسيا (MgO) والجير الحر(CaO) والكبريتات(SO_3) والفقدان بالحرق LoI ، المواد الغير قابلة للذوبانIR ومعامل الاشباع الجيري LSF التي تنتج من التحليل الكيميائي للاسمنت. أضهرت نتائج مقاومه الانضغاط معامل الاسمنت الجنوبيه انخفاض عن معامل الاسمنت الشماليه للسمنت المقاوم للاملاح. حيث كانت النسبه المؤيه للزياده لعمر 28 يوم هي (السده 16.5%، طاسلولجه 22%، المثنى 22.3%، كربلاء 22.3، القائم 29.9%) وللاسمنت البورتلاندي الاعتيادي كانت النسبه المؤيه للزياده لعمر 28 يوم هي (الكوفه 21.7%، طاسلوجه 27.3% والماس 27.5%).

1 – Introduction

The strength of mortar or concrete depends on the cohesion of the paste, and its adhesion to the aggregate particles; thus, the cement paste is the effective part in the concrete units strength.

Performance of concrete is largely affected by its properties, which in turn depend to large extent on the characteristics of the cement used (1).

2 – Literature Review

The main Factors that influencing on strength of Portland cement. These Factors are:

1 – Compound composition (C_3S, C_2S, C_3A, C_4Af).
2 –Chemical analysis parameters (MgO,Free Lime, SO_3 loss on ignition , Insoluble Residue, Lime Saturation factor).
3 – Fineness of cement (Blaine specific surface).

According to Bogue (2) it appears that C_3S exhibits both the fastest strength development and higher ultimate strength.

The strength of C_2S grows significantly slower, however, the ultimate strength of C_2S is similar to that of C_3S. C_3A and C4AF have a very low strength even after along hydration time.

Popovics (3) reported undesirable effect of C_3A on the strength of cement paste when found in high content, that is, it reacts with sulphates forming ettringite, which causes expansion and thus, disruption of hardened cement paste.

2.2 Effect of minor Oxides:

2.2.1 Effect of MgO and free CaO on strength of cement:

Unsoundness can be simply defined as a volumetric changes (expansion) after setting, which causes appearance of cracks and deterioration of concrete strength.

Unsoundness of cement takes place due to the following reasons (4).
1 – The presence of excessive free lime.
2 – The presence of excessive magnesia.
3 – The presence of excessive sulphates.

2.2.2 Effect of Sulphates on cement strength:

The presence of SO_3 in cement might come from the raw materials used in the manufacture of cement. (5)

Another source of SO_3 in cement is that added as gypsum.

The presence of gypsum must be limited, because excess gypsum content to that of the optimum limits leads to a deleterious reaction between gypsum, C_3A and water. This reaction results in the formation of calcium Sulpho aluminate hydrate (Ettringite) which is accompanied by deleterious expansion causing cracks and deterioration of the cementations materials when exceeding certain amounts (4).

2.3 Effect of Insoluble Residue and loss on Ignition.

In soluble residue is an non – cementing material which is present in Portland cement. This residue material affects the properties of cement especially its compressive strength (6).

Neville (7) and others (6),(8) reported that the insoluble resident is a function of gypsum content, and it can be also considered as a measure of adulteration of cement largely arising from impurities in gypsum. Kiattikomol (6) found that the higher the percentage is of insoluble residue in cement mortar, the lower the compressive strength becomes.

Loss on ignition is a measure of the storage period of the cement and its quality, since the longer the period of the storage the higher the loss on ignition (9). This is because the loss on ignition gives an indication to the extent of carbonation and hydration of free lime and free magnesia due to the exposure of cement to the atmosphere (7).

2.4 Fineness of cement

The term "fineness" represents the degree of division of the clinker to Avery fine state by the grinding process to increase its value as a cementing material (10). The increase of the surface area of cement particles by increasing its fineness will lead to faster formation of hydration products and result in faster development in strength.

Furthermore, increasing fineness increases the amount of gypsum required to be added and increases the amount of water necessary for the standard consistency of the paste(7).

Several researchers studied the affect of cement fineness on strength development. (11) Found the fineness of cement plays a major role during the early stages of hydration, that the high surface area cement produces significantly highs strength at early ages.

2.5 Strength of cement in international standards:

Specifications for Portland cement comprise a number of physical and chemical requirements. The compliance of cement with these requirements is assured through number of test that are prescribed in the Specifications (4).

The usual ages for testing strength of cement are ranged from (1-28) days depending on the type of cement and requirement of the international standard, for example, the Iraqi Specification IQS No.5,1984(12). Specifies the test at 3 and 7 days of age for ordinary Portland cement, but the 28 days test is not included.

Knowledge of early strength is important especially in pressurised or precast concrete or when early removal of from work is required (7).

The 28 test is included in a large number of international standards. For example, in "cement standards of the world."(European cement Association) (13).

Publish by European cement Associated. In this issue,37 countries have adopted the 28 days standard compressive strength test for Portland cement in addition to the test at early ages, which gives evidence on the importance of this age of test.

The 28 days test is important for the following reasons:

1- The choice of testing at 28 days is based on waiting until significant degree of hydration is achieved then testing for strength characterization (7).

2-The structural design is based on compressive strength of concrete, and in construction, the traditional test for acceptance and quality control is the 28 days test. Many studies have proved the direct influence of strength of cement mortar cubes on the strength of concrete made with the same cement (3),(14).

3- Several chemical reactions do not occur at early ages, but might be detected through 28 days test like (MgO, free CaO, So3).

The 28 days test in the British Standards was included as a part of their specifications of strength requirement for Portland cement BS12: 1989 (BritishStandards B.S.12 (1989)) (15) (this test is not included in BS12: 1958 and BS12:1970) as shown in table (1)

Table (1) British standard B-S-12: 1989 for compressive strength of Portland cement requirements

Cement type	Test age days	Strength	
		Concrete N/mm^2	Mortar N/mm^2
Controlled	3	Not less than13	Not less than 23
Oneness Portland	28	Not less than 29	Not less than 41
Ordinary Portland cement	3	Not less than 15	Not less than 47 and not more than 67
	28	Not less than34 and not more than 52	
Rapid hardening Portland cement	2	Not less than15	Not less than25
	28	Not less than38	Not less than52

Excessively high strength is not economic for cement procedures. For this reason, international standard included maximum value for strength of cement classes, The first country which introduced a maximum value for 28 days compressive strength of cement in its specifications was Germany. This is limitation then appeared in the British standards Bs 12:1991, and European ENV197–1: 1992.
In Table (2) – The range between minimum and maximum is 20 Mpa as determined in International standard (13).

Table (2) European standard ENV 197 – 1: 1992 for compressive strength of Portland cement requirements.

Class	Minimum strength Mpa at the age of			Maximum strength Mpa at the age of 28 days
	2 days	7 days	28 days	
32.5 N 32.5 R	– 10	16 –	32.5	52.5
42.5 N 42.5 R	10 20	– –	42.5	62.5
52.5 N	20	–	52.5	–
62.5 N	20	–	62.5	–

3 – Experimental work.

The experimental tests of the current research are conducted to support and verify the statistical approach followed in this study. They include the physical and chemical analysis of the samples taken from different cement factories.

3 – 1- Fine Aggregate.

Red sand was used in the experimental work. The physical and chemical properties of the sand are given in Table (3). It's grading was within the limits required by Iraqi specification (IQS 45: 1984) zone (3). (16).

Table (3) properties of sand.

Sieve Size (mm)	Percent Passing	IQS 45:1984 limits, zone3
9.5	100	100
4.75	95	90-100
2.36	93	85-100
1.18	79	75-100
0.6	61	60-79
0.3	28	12-40
0.1 5	5	0-10
0.075	2.22	5%
Sulfate content SO_3%	0.27	≤ 0.5

3 – 2- Coarse Aggregate.

The gravels used throughout the research was graded Table (4) shows the physical and chemical properties of the gravel. Table also includes the limits specified by (IQS 45:1984)

Table (4) properties of gravel.

Sieve size (mm)	Percent Passing	IQS45:1984 Limits (20-5)
37.5	**100**	**100**
20	**100**	**95-100**
9.5	**51**	**30-60**
4.75	**4**	**0-10**
0.075	**1**	**3%**
Sulphate content SO_3	**0.08**	**≤0.1**

3 – 3- cement.

In this study, (13) different cement samples were tested, (3) of them were ordinary Portland cement while the other (10) samples were sulphat resisting Portland cement. table (5) show's the names of the cement factories and types of their production with the number of sample.

For the mortar mix used the weight of materials was 185: 555:74 gm. (cement: sand: water) specimens were made for each age 3,7 and 28 days. The size of cubes (7.07 x 7.07 x 7.07) cm for compressive strength test and (4 x 4 x 16) cm for tensile strength. The mortar cubes were prepared according to Iraqi reference instructional guide 198: 1990 (17). Cement and sand first mixed dry for 60 second, then water was added and mixed for 4 minutes and poured in to molds and compacted for two minutes using a vibrating. Normal curing was made for cement mortar cubes after de-molding them of age of one day, by immersing them in water bath with curing temperature of 20 C°. The mortar prisms tests according to ASTM standard C293-79 (18) for the same mix proportions.1:3(cement: sand) and water /cement ratio wc =0.4 used for a compressive strength also mixing and curing except compactions using tamping by fingers.

Table (5) Cement factories and the type of their production with the number of samples

No	Factory	Type of cement	No. of samples
1	Almas (North cement plant	O.P.C	1
2	Tasloga North cement plant	O.P.C	1
3	Kufa (South cement plant)	O.P.C	1
4	Tasloga(North cement plant)	S.R.P.C	2
5	AL.Qaim (North cement plant)	S.R.P.C	2
6	Karbala(South cement plant)	S.R. P .C	2
7	AL.Muthana(South cement plant)	S.R.P.C	2
8	AL.Sadda(South cement plant	S.R.P.C	2

Tables (3–2), (3–3) shows physicals and chemical properties of O.PC respectively, while,tables (3– 4),(3–5) shows physicals and chemical properties for S.R.P.C respectively.

Table (6) physical properties of O.P.C used throughout this work.

Factory	Specific surface m^2/kg	Initial setting time (m:s)	Final setting time (m:s)	Comp. strength (N/mm^2) ,days			Tensile strength (N/mm^2) days		
				3	7	28	3	7	28
Almas	263	2:40	3:20	26	29	40	4.32	4.78	6.55
Tasloga	296	2:10	3	28	32	44	5.12	5.82	8.17
Kufa	223	3:10	3:50	18	27	34.5	2.95	4.42	5.69

Table (7) oxides analysis for O.P.C and C_3A compound content used throughout this work.

Factory	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Insoluble Residue	Losson Ignition	C_3A
Almas	20.31	5.3	3.37	66.89	1.99	2.613	0.51	2.79	8.34
Tasloga	20.33	5.05	3.05	66.75	1.84	2.308	1.34	4	8.2
Kufa	20.43	6.21	3.59	65.31	4.46	1.879	3.38	3.38	10.39

Table (8) physical properties for S.R.P.C used throughout the work.

Factory	Specific surface m^2/kg	Initial setting time m:s	Final setting time (m:s	Comp. strength (N/mm^2),days 3 7 28	Tensile strength (N/mm^2) days 3 7 28
Tasloga	267 281	2:25 2:15	3:20 3	27 31 40 28 33 42	4.69 5.32 6.94 4.78 5.56 6.97
Qaim	263 250	2:30 2:45	3:20 3:25	28 32 45 24.5 29 42	5.3 6.15 8.53 3.99 4.67 6.91
Karbala	255 292	2:40 2	3:20 2:55	27.5 33 43 27 33 42	4.72 5.66 7.43 4.87 5.87 7.41
Al-muthana	298 264	2 2:45	2:50 3:35	27.5 33 43 27 33 42	4.72 5.66 7.43 4.87 5.87 7.41
Al-sada	259 267	2:50 3	3:25 3:20	23.5 29 36 23.5 32 37	3.87 4.9 5.98 3.89 5.1 6

Table (9) Oxides analysis for S.R.P.C and C3A compound content used through out this work:

Factory	SiO2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Insoluble Residue	Loss On Ignition	C_3A
Tasloga	21.2 20.91	4.41 4.57	5.21 5.15	65.02 65.37	3.25 3.78	2.09 2.246	1.26 1.28	1.32 1.08	2.88 3.42
Qaim	22.35 22.8	3.59 3.64	5.45 5.63	66.94 67.37	2.31 2.23	2.284 1.84	1.07 0.24	1.15 1.78	0.32 0.13
Karbala	20.71 21.88	4.24 4.31	4.89 5.36	67.43 66.25	1.74 2.81	2.236 2.61	0.35 0.5	2.33 1.19	2.99 2.73
Al-Muthana	22.17 21.1	3.86 3.48	5.72 6.79	66.74 66.63	2.72 2.2	2.757 2.366	1.22 1.1	1.71 1.66	0.56 0.41
Al-Sadda	20.76 20.55	4.34 4.44	5.63 6.18	66.01 66.07	2.24 2.08	2.685 2.58	1.33 0.84	2.31 1.65	2 1.33

3-2 -Concrete mix

The mix proportion of concrete mix used was 1:1.5:3 and cement content: 400 kg/m3 W/C=0.5.(12) specimens were made for each ages 7 days and 28 days. using of cubes (150) mm for comp. strength C25.Table (10) shows the requirement of Iraqi code No1:1987 (19). The concrete specimens were prepared according to Iraqi reference instructional guide 52 (20), a horizontal pan –type of 0.1 m^3 capacity was used for mixing concrete. The interior surface of the mixer was cleaned and moisture before it was used. The half-aggregate, sand, cement and the second half-aggregate mixing drive for 60 second, then the water was added and mixed for another 3-4 minutes to gate homogenous concrete mixes. After mixing the concrete were poured in to the moulds in three layers. Each layer rod with 36 storks by tamping road gross section 25mm, length 380mm and mass 1800 gm uniformly distributed the strokes over the gross section of each layer. The excess concrete was cut and removed with a drawl from the top of the specimens. After casting all specimens were covered with plastic sheet, normal curing was made for specimens after de-moulding of age of 1 day. Then stored in tab water tanks until testing age with curing temperature off 20 C. Compressive strength of concrete specimens were tested according to Iraqi reference instructional guide 384: 1992 (21), 284:1991(22).

Table (10) Requirement of Iraqi code No.1: 1987

Mix proportion	The designed compressive strength N/mm2	The ave. designed comp. strength four group each has three concrete specimens N/mm^2	The designed compressive strength for sample of(12) concrete specimens N/mm^2
1:1.5:3	17.5(7days) 25(28days)	>14 >22	>20 >28

3-3- Compressive strength of concrete:

The result of O.P.C and S.R.P.C compressive strength shows in table (11) Fig.1 and (3-8), Fig.2 respectively.

Table (11) compressive strength of o.p.c used at ages 7 and 28 days:

Factory	The designed comp Strength four groups each has three cubes N/mm^2 7 days	Total ave.	The designed comp. Strength four groups each has three cubes N/mm^2 28 days	Total ave.
Almas	18,19,18.5,17.5	18.5	22,21.5,21,22.5	22
Tasloga	20.5,20,21,21	20.5	27.5,27.28.5,28	28
Kufa	16,15,14.5,16.5	15.5	18.5, 19,17, 17.5	18

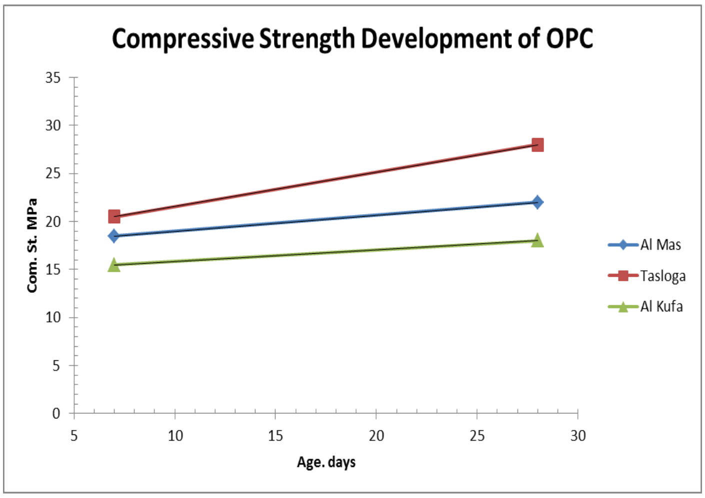

Fig. 1 : Concrete compressive strength development for OPC

Table (12) compressive strength of S.R.P.C used at ages 7and 28 days.

Factory	The designed comp Strength four groups each has three cubes N/mm^2 7 days	Total ave.	The designed comp. Strength four groups each has three cubes N/mm^2 28 days	Total ave.
Tasloga	19.5,21,18.5,19.5 20.5,21,21,20	20 20.5	27,27.5,29,28 29.5, 28.5, 27.5, 28.5	28 28.5
Qaim	20.5, 21, 19, 19 19, 18.5, 18, 17	20 18	28, 27.5, 27, 29 27, 27.5,26.5, 28	28.5 27.5
Karbala	19.5, 20, 20.5,21.5 22,21,20.5,21.5	20.5 21.5	27.5,27,28.5,28 29.5,28.5,30,29.5	28 29.5
Muthana	18.5,19.5,20.5,20.5 19.5,19,20.5,21	20 20	29, 29,27.5,28 29,29.5,27,27	28.5 28
Al-Sadda	16,15,14.5,15.5 16,15.5,17,15	15.5 16	21,18.5,18.5,22 22,20,20.5,21	20.5 21.5

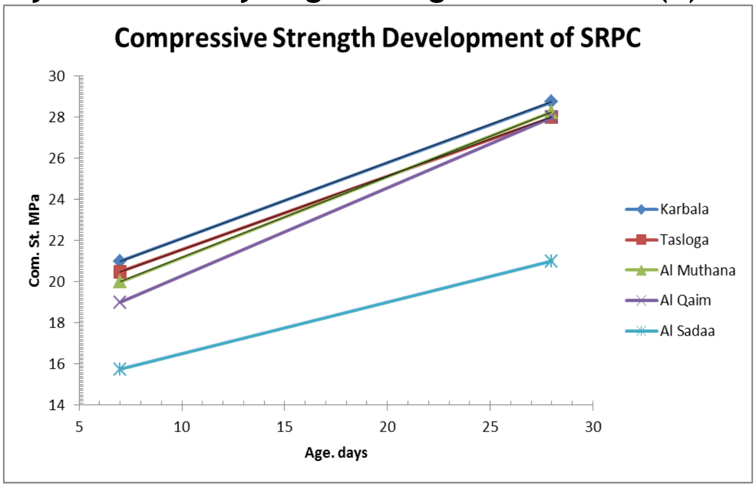

Fig.2: Concrete Compressive Strenght Development of SRPC

4 – Analysis of Results and Discussion:

The variability of test results of cement strength is simply due to variability in the raw materials used in the manufacture of cement and in the processing of these materials.

The chemical and compressive strength results for sulphate resisting Portland cement factories have been shown reduction in compressive strength due to high content of So3 especially south cement factories. Karbala and Al-Muthana factories control this reduction by increasing fineness but Al-Sadda cement factory have been showed the reduction clearly. Al-Qaim factory and Tasloga have been showed normally result.

The chemical and compressive strength results of ordinary Portland cement factories have been showed reduction in compressive strength especially Al-Kufa factory due to increase MgO content, loss of ignitions, high content of insoluble residue, decreasing in fineness and increasing in C_3A compound.

Al-mas north cement have been showed the reduction in compressive strength due to increase SO_3 content and C_3A compound. Tasloga has been showed normally result due to increasing fineness.

It was evident that the results of fineness of all factories are lowers.

Table (8) and (9) shows that the compound C_3A has a positive effect on the compressive strength of sulphate resisting Portland cement for the three ages (3 days, 7 days and 28 days) due to its effect as a catalyst. The positive effect of C_3A in more pronounced at the age of 7 days. This positive effect is reduced at the age of 28 days. Because of the additional $Al(OH)^-_4$ ions yielded from hydration progress of C_4AF compound with the age. On the other hand $Ca(OH)_2$ which liberated from the hydrolysis of C_3S decreases the concentration of aluminates ions in the solution. Especially Tasloga factory the present of strength increased 21.97 % compared with Al Qaim percentage of strength increased 29.9 at age 28 days.

Table (6) and (7) shows that C_3A has negative effect on the cement strength for the three ages (3 days, 7 days and 28 days) as it is present in a higher a mount in ordinary Portland cement because it has undesirable reaction with SO_3 accompanied by deleterious expansion.

The effect of C_3A compound as found from this confirmed (23) Results, they found that the strength increases with increasing C_3A content only to a certain value and decreases with higher C_3A content.

Table (6) and (7) shows the reactive effect of MgO is clear on the compressive strength of Portland cement decreases with increase of percentage of MgO at the three ages 3,7 and 28 days. This effect is more pronounced at 7 days strength. Especially Al Kufa factory the present of increase about 21.7 at age 28 day compared with Tasloga present the

27.27. This is due to the slow reaction of Pericles and reduced at the age 28 days due to the progress of the hydration process. The effect of MgO have been discussed in section two.

Table (8) and (9) shows the effect of SO_3 is clarified in results. It is shown that the Sulphate has negative effect on compressive strength of Portland cement at the age 3 days, 7 days and 28 days. The most negative effect was found to be at 3 and 7days strength. Especially Al Sada cement factory have been showed the present of increase about 16.47% at age of 28 days compared with Al Qaim factory have been showed 29.9 at age of 28 days. This may be due to the higher rate of Ettringite formation within these ages as found by(24).

Table (6) and (7) shows loss on ignition has negative effect on compressive strength of Portland cement of the eges 3,7 and 28 days as shown in the results. Especially Al Kufa factory. This is because the loss on ignition gives an Indication on the cement deterioration due to the exposure to the atmosphere.

Table (6) and (7) shows Insoluble residue represents an indication to the adulteration of cement by impurities in gypsum and / or on the efficiency of the burning process ((6),(7),(25)).

The results have been shown that insoluble residue has a negative effect on compressive strength of cement at 3,7, and 28 days. Especially Al Kufa factory compared with Al Mas and Tasloga. The most negative effect of the insoluble residue was at the age 3 days and reduced with the progress of hydration of cement. the effect of insoluble residue as found from this study is compatible with the research work of (6) they found that the insoluble residue has negative effect on compressive strength at different ages up 60 days.

It was quite evident from table (6),(7),(8)and (9) that cement fineness is of Fundamental importance in the hydration and strength characteristics of cement. The positive effect of fineness on the compressive strength of Portland cement is clarified in results which illustrates the relationship between cement fineness (in term of Blaine specific surface) and the compressive strength of cement at the ages 3 days, 7days and 28 days. Especially Karbala and Al Muthana cement factory have been showed the present of increase 22.3% compare with Al Sada factory 16.47% at age of 28 day. The greatest significant effect is at 3 days then it decreased at 7 days and 28 days because the long curing period permits more cement to be hydrated, thus reducing the effect of fineness.

The effect of cement fineness as was found from this study agrees with research works of(11),(4). Who found that the fineness of cement plays a major rule during the early stages of hydration and its effect is not as pronounced at later ages. Increasing cement fineness increases the intensity of the reactions of the hydration process as increasing fineness increases the surface area exposed to reaction with water (as has been discussed earlier in section tow). Consequently leads to more hydration products and development in strength.

The rapidity of strength development is the responsibility of compounds, C_3S and C_3A and their positive effect. Therefore, increasing fineness increases strength development of these compounds and hence increasing strength of cement. Increasing fineness of cement accelerates the reaction of C_2S compound (10).

It is else well known that increasing the fineness of cement increases the amount of C_3A available for reaction with the added gypsum.

5. Conclusions

Based on the results of the experimental work of this study:

1. The compressive strength results of Portland cement have been shown reduction in south cement factories than north cement factories for resisting Portland cement and ordinary Portland cement.
2. The compressive strength results of concrete shown reduction on south than north cement factories for ordinary Portland cement due increase SO_3, Mgo, L.O.I, IR,

increasing C_3A and decreasing in fineness. Some of north factories due to high content of SO_3.

3. The compressive strength result of concrete shown reduction in south than north cement factories for sulphate resisting Portland cement due to high content of SO3, some appear clearly and some not appear due to high fineness.
4. Compressive strength of cement increase with the increase of the percentage of C_4AF. This positive effect was noticed at age of 3 days.
5. The effect of modules of rapture is found to be similar to that of compressive strength in both mixes of O.P.C and S.R.P.C.

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