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QUALITATIVE EVALUATION OF FINE AGGREGATE FOR SELECTED QUARRIES IN AL-NAJAF AL-ASHRAF

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ABSTRACT

Fine aggregate considered as the oldest building materials known by human, it's not inert substance, so that each of its physical and chemical properties need theoretical and laboratory studies, because, of its effect on the compressive strength and durability of concrete, one of the most important properties is the content of sulphate salts, which must be taken into account in all construction works. This research aims to conduct laboratory qualitative assessment of fine aggregate to demonstrate its suitability for construction work and quality assurance. Sampling of fine aggregate (sand) from four quarries in Al-Najaf Alashraf [(Syd Ali (S1), Wilaya Ali (S2), Syd Ahmed (S3) and Muhand Al-Khiat (S4)]. Some of physical tests (sieve analysis, deleterious materials (clay%), bulk density, specific gravity and absorption), chemical analysis for sulphate salts content, X-Ray technology for mineral composition as well as the compressive strength test were conducted on these samples. From the results of this research, its appear that Sample Wilaya Ali (S2) is the best for concrete works where the grading and sulphate salts content (SO_3) is accepted by (IQS), and this sample gives accepted compressive strength. While Sample Syd Ali (S1) was the most fine with accepted sulphate salts content as compared with (IQS) which make it suitable for other construction works rather than concrete. Samples, Syd Ahmed (S3) and Muhand Al-Khiat (S4) are of high sulphate salts content (which cannot be treated) as compared with (IQS) which make them not compatible for concrete and other construction works.

KEY WORDS: Fine aggregate; Quarries; Grading; Sulphate salts; Compressive strength.

1. INTRODUCTION

Aggregate is a solid granular material used in many civil engineering and construction applications, such as mortar, concrete, asphalt concrete, base coarse ballast, rail roads, and as an underlying materials for foundation and pavements (Falagh and Al-Gaseer, 2016), therefore, an adequate and sustainable supply is essential for every country.

Aggregate can either be natural or manufactured. Natural aggregate is commonly taken from natural deposits and consists of rock fragments in quarries that is used without changing in its natural state during production, or it is used after the mechanical processing (washing, crushing, grinding, and grading), such as sand, gravel, and crush stone. While the artificial aggregate is an eco-friendly material, not mined or quarried produced as a main product or an industrial by-product by using the application of thermal, physical and - or chemical processes, such as expanded clay, shale, blast furnace slag, broken bricks, and fly ash (Al-Shreif, 1993).

Aggregate is considered as the most important consistent filler because it gives large volume, low cost as compared with the use of cement paste alone in the concrete mixture without sacrificing other properties. Therefore aggregate is generally used in about three quarters (70-80%) of the volume of concrete. Also aggregate reduces the volume changes resulting from setting and hardening process and from moisture changes during drying, therefore it confer higher volume stability and better durability than cement paste alone (Nemati, 2015).

Coarse and fine aggregates are two size groups of aggregates, coarse aggregate often is called gravel with size greater than 5mm where particles retained on 4.75mm sieve, and fine aggregate with less than 5mm where particles passed through 4.75mm sieve and mostly retained on a No. 200 sieve, so the granules of aggregate are generally graded in size from small and large sizes to produce a desired grading (Lea, 1970). Grading of coarse and fine aggregate is considered a very important physical property which influences concrete's freshly mixed and hardened properties. Grading refers to the determination of particles size distribution of granular materials by separation it on various sieves of different size openings. There are several reasons for specifying grading limits and nominal maximum aggregate size because they affect the amount of aggregate as well as cement and water requirements. The well graded aggregate is the aggregate with reasonable workability and minimum segregation which produces strong and economical concrete (IL-Seok, 2001).

The granules of aggregate also should be strong, hard, and do not contain harmful substances at a rate higher than the limit specified in the specifications; these substances include salts, especially sulphate, chlorides, and other chemicals, as well as organic matters and very fine materials (Jabbar, 2010).

Sulphate attack is one of the most important matters concerning the durability of concrete structures; it is described as the deterioration of concrete caused by many reactions when it exists in excessive amount. Sulphate attack can be external or internal. External is due to the penetration of sulphate in soil and ground water into concrete from outside, while the internal is due to soluble source being incorporated into the concrete at the time of mixing such as cement and aggregate (Neville, 2005). Aggregate contamination with interior sulphate is a local problem of concrete manufacture in Middle East Region (Al-Samerai, 1977). In some instance, concrete have been accepted with use of fine aggregate with sizes outside the approved grading zone provided that the content of sulphate salts within the limits of specifications, Iraqi specification (IQS No.5/1984) (Iraqi Specification, 2001) identify the upper limit of sulphate SO_3 in fine aggregate with 0.5% and for coarse aggregate with 0.1%.

Most Iraqi fine aggregate used in concrete contain relatively high amount of sulphate, so it's rare to obtain well graded sand with sulphate satisfying the existing Iraqi specifications. Most of sulphate salts in sand are composed of magnesium, potassium, sodium, and calcium sulphate. The most predominant salts in Iraqi sand are in the form of calcium sulphate (95%) because of very low solubility of this type of sulphate, which reduces the possibility of washing and drifting with surface and ground water (Abdul-Latif, 2001).

Calcium sulphate is usually found in sands in the form of gypsum where gypsum reacts with hydration products of tricalcium aluminate (C3A) phase of Portland cement to form a primary crystalline product called ettringite (3CaO. Al2O3. 3CaSO4.31H2O) (Neville, 2005). This product (calcium sulphoaluminate) has a considerably greater volume than the compounds they replace which is useful at early age of curing because this product fills the pores and decreases the voids percentage and increases density and strength (Al-Hadeithy et al., 1999). However, the presence of excessive amount of gypsum after cement paste is harden is harmful due to the formation of additional quantities of ettringite which causes increasing in solid volume at later ages, this increase to the internal stresses, cracking, and deteriorates the concrete. Thus, the compressive strength will be affected (Soroka and Abayne, 1986).

The effect of internal sulphate on compressive strength of concrete depends on the source from which it is generated. The effect of sulphate in sand is about two times compared to that from coarse aggregate, so that the effectiveness of sulphate is increased with decreasing size of gypsum particles (Al-Rawi et al., 1997).

Due to the harmful effect of the presence of sulphate, many solutions have been proposed to overcome this problem, such as separation granules of gypsum from sand used in concrete by heating, flotation, and treated by scraping and rubbing, but these processes are very expensive (Al-Kadhimi and Abdul Kadir, 1985). Reducing the ratio of gypsum added to cement during clinker grinding, so that it is possible to increase the sulphate content in sand. This proposal was based on the fact that the amount of gypsum added is usually more than the amount necessary to control the setting time of concrete (Al-Salihi, 1994) and suggested that the total sulphate content in the concrete components is adopted as a weight ratio of cement instead of determining the ratio of salts in each raw material separately, so that it is possible to use sand with relatively high salt content (higher than the current Iraqi standard) when using cement and coarse aggregate with a low ratio of sulphate, but the total percentage of salts is within the acceptable limits (Kattwan et al., 1993).

2. THE EXPERIMENTAL PART

2.1. Materials

2.1.1. Cement

Ordinary Portland Cement manufactured by the New Cement Plant of Kufa was used. The cement was tested and compared according to (IQS No.5/1984) (Iraqi Specification, 2001). Table 1 shows the chemical and physical properties of the cement used.

2.1.2. Coarse aggregate (Gravel)

Rounded gravel aggregate from Al-Nibaee of (20mm) maximum size was used. The used gravel conforms to the (IQS No.45/1984) (Iraqi Specification, 2001). Table 2 shows the grading and physical properties of the coarse aggregate which were conducted in Al-Mawal laboratory.

2.1.3. Fine Aggregate (Sand) Sampling

Fine aggregate was used through this work and selected from different quarries located in the center of Iraq in Al-Najaf Governorate.

The field work:

This work included a field visit to the quarries of aggregate (fine aggregate). Four different samples were taken randomly from four different quarries [(Syd Ali (S1), Wilaya Ali (S2), Syd Ahmed (S3) and Muhand Al-Khiat (S4)] by adopting the conventional sampling method.

The sampling area:

Fine aggregate quarries that have been estimated are located in Al-Najaf Aashraf city (south east of Baghdad 160 Km) in specific area named Madloom in Al-Najaf sea as shown in Fig. 1. Its geographic area extends between longitudes (44º27ʾ5- 44415) Eastwards and (31º96ʾ9- 32º 064̀) latitudes northwards by degrees (Al-Khafaji, 2012). It's a flat area interspersed with some valleys scattered and sandy hills on its eastern side and seduced by sediments of the four-hour sand, limestone, and gravel. The land of Al-Najaf consists of ten different layers and its level is 70m above sea level (Al-Khafaji, 2012).

Table 1. The chemical composition and physical properties of cement.

Chemical compounds	Content %	Limit of Iraqi specification No.5/1984
C3S	51.2	----
C2S	24.8	----
C3A	10.01	----
C4AF	12.52	----
Loss on Ignition (L.O.I)	2.33	< 4 %
In-soluble Residue (IR)	0.89	< 1.5 %
Physical properties	Test Results	Limit of Iraqi specification No.5/1984
Setting time (vacate apparatus)		
Initial setting (hrs.: min)	1:55	Not less than 45 min
Final setting (hrs.: min)	3:05	Not more than 10 hrs.
Fineness Blaine method (m^2/kg)	290	230 (m^2/kg) lower limit
Compressive Strength (N/mm^2)		
3- day	21.8	15 (N/mm^2) lower limit
7- day	30.2	N/mm^2) lower limit

Table 2. The grading and physical properties of coarse aggregate.

Sieve Size (mm)	Passing %	Limit of Iraqi specification No.5/1984
40	100	95-100
20	70	35-70
10	9.6	4-10
5	0.3	0-5
Physical properties	Test Results	Limit of Iraqi specification No.5/1984
Specific Gravity (S.G)	2.6	----
Absorption %	0.6	----
Fineness Materials	0.6	----

Fig. 1.The sites of Sampling.

The sampling method:

The corner stone of various tests of substance used in mixture is the sampling where the results of tests will not be realistic unless sampling is correct, so it has to be sure that the sampling of aggregate should covered as much as possible nearly whole of aggregate (here the experiment play a role) to be representative. The fine aggregate samples in this research are made up of a number of portions drawn from different parts of bulk sample (not taken from the base or dome of bulk samples because the dome usually contains mainly the small size aggregate while the base will contain a large size particles) (Neville, 2005), and not less than 10 sites and its weight within (13 Kg) according to standard British specification (British Standard Institute B.S. 812:Part 102, 1989).

In this research, the cone and quartering method was used for reducing the sample size where the bulk sample is shoveled (if the sample is dry, must be wetted with water) to form a cone on a hard, clean and leveled surface. This cone is turned over several times as the aggregate taking from the button to the dome of the cone and then the cone is flattened by pressing the top of the cone till becomes a flat circle. The diameter of this circle should be four to eight times of the circle thickness, then with the use of sharp tool dividing the circle into four equal quarters, after that remove two opposite quarters, lastly recollect the reminder specimen and redone this process several times until getting the required size (Al-Khalaf and Yousif , 1984).

2.2. The concrete mixes

Four mixes of concrete were prepared with selective mix proportions (1 cement: 2 sand: 4 gravel) by weight, W/C ratio (0.5) and with slump amount (10-30mm).

2.3. The tests for fine aggregate samples

Physical examination and compressive strength were done in Al-Mawal laboratory, chemical analysis (SO_3) was done in National Test Center in Babylon, and X-Ray test was done in Baghdad University laboratory.

2.3.1 Sieve analysis test

This test is the process of dividing the aggregate sample into fractions of same granules size within the limit of standard serial sieves holes. This test was performed and compared with the Iraqi specifications, British Standard (B.S), and American Society for Testing and Materials (ASTM).

2.3.2 Fineness modulus (FM)

Fineness modulus is an index of fineness of aggregate and computed by adding the sum of the cumulative percentages of aggregate retained on standard test sieves and dividing the sum by 100. It's useful in estimating proportions of fine aggregate in concrete.

2.3.3 Deleterious materials test

This test determines the amount of deleterious fine substance that passes the 200 sieve, such as clay, silt, and fine dust where particles size is less than 75µm. This test was done according to the Iraqi specification.

2.3.4 Bulk density test

Bulk density is defined as the weight of the aggregate particles required to fill a cylindrical container of a specified unit volume. It's helpful in estimation the proportions of mixes and the transfer the quantities by volume to the quantities by weight unit of the aggregate needed to the concrete mixture. This test was done according to the Iraqi specification.

2.3.5 Specific gravity test

This test is the ratio of the weight of aggregate to the weight of an equal volume of water. It's considered to be a measure of strength and equality of the material which is required to be specified in making a certain calculation of mixture design proportioning of concrete. This test was done according to the Iraqi specification.

2.3.6 Absorption test

Absorption is an important test that expresses the ratio of the weight of water absorbed by aggregate to the weight of dry sample; it’s important in determining the proportions of the concrete mixture. This test was done according to the Iraqi specification.

2.3.7 Sulphate content test (SO_3)

This test was conducted to calculate the SO_3 content. This test was done according to the Iraqi specification.

2.3.8 Compressive strength test

A 24- cube- shaped mold with a length of (150mm) was used to prepare concrete samples for measuring compressive strength. The molds were lubricated and filled with concrete in three layers form, hand compacted, and treated in containers on potable water at laboratory temperature after 24 hours from the casting process and opening the molds until the time of test after 7 days for three samples and 28 day for the other three samples. This test was done according to the British Standard Institution (British Standard Institute B.S. 1881: Part 116, 1989).

2.3.9 X- Ray diffraction test

The development of wave length examination in the 19th century present great benefits in the examination of structures and their composition. Physicians put a lot of wave length that corresponds each substance; this helps in detection of various minerals in the tested samples (sands).

3. RESULTS AND DISCUSSION

3.1. Sieve Analysis

As shown in Table 3, the sieve analysis results of samples was compared with Iraqi specifications (IQS), British Standard (B.S), and American Society for Testing and Materials (ASTM).

For the Iraqi specifications (IQS), Sample S1 appears to be within Grading Zone IV which is advised to be used in other construction works, such as Tiles, and Rendering, but not concrete, with little deviation in sieve No. 0.3mm with value of 2.5% as shown in Fig. 2. Sample S2 appears to be within Grading Zone III which is advised to be used in concrete where no deviation in sieves as shown in Fig. 3. Sample S3 appears to be within Grading Zone III with little deviation of value 1.4% in sieve No. 0.3mm and 1.7% for sieve No. 0.15mm as shown in Fig. 3. Sample S4 performs to be within Grading Zone III with little deviation of value 5.7% in sieve No. 0.3mm and 1.6% for sieve No. 0.15mm as shown in Fig. 3.

Table 3. The Grading of Fine Aggregate Samples.

Sieve No.	Percentage Passing				Limits of Percentage passing by weight for					
					Iraqi specification No.45/1984				B.S 882/1992	ASTM 33/88
	Sample 1 Syd Ali	Sample 2 Wilaya Ali	Sample 3 Syd Ahmed	Sample 4 Muhand Al-khiat	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV	Grading F	Grading Limit
4.75	100	98.9	99.5	95.2	90-100	90-100	90-100	95--100	89-100	95-100
2.36	97.9	94.6	94.8	89.6	60-95	75-100	85-100	95-100	80-100	80-100
1.18	95.8	89.7	85.3	83.2	30-70	55-90	75-100	90-100	70-100	50-80
0.6	89.6	79	70.9	73.7	15-34	35-59	60-79	80-100	55-100	25-60
0.3	52.5	34.3	41.4	45.7	5-20	8-30	12-40	15-50	5-70	10-30
0.15	12.3	7.8	11.7	11.6	0-10	0-10	0-10	0-15	0-15	2-10

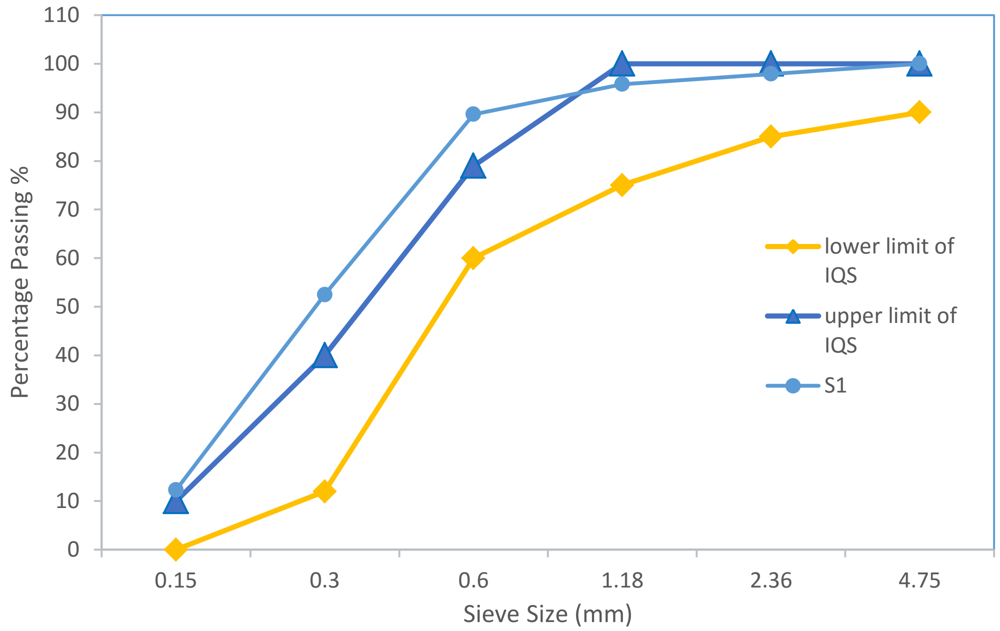

Fig. 2. The sieve analysis for Sample (S1) according to IQS.

Some deviations are accepted as they are less than 5%, as recommended by IQS, and are marked by underlines in the Table 3.

Fine aggregate with Grading Zone III is much more coarse than Grading IV, so the Sample S2 appears to be well graded (no deviation in sieves) as compared with the others samples (S1, S3,S4) and more beneficial for concrete workability.

For the British Standard (B.S), all Samples (S1, S2, S3, S4) appear to be within Grading Zone F where no deviation in sieves as shown in Fig. 4.

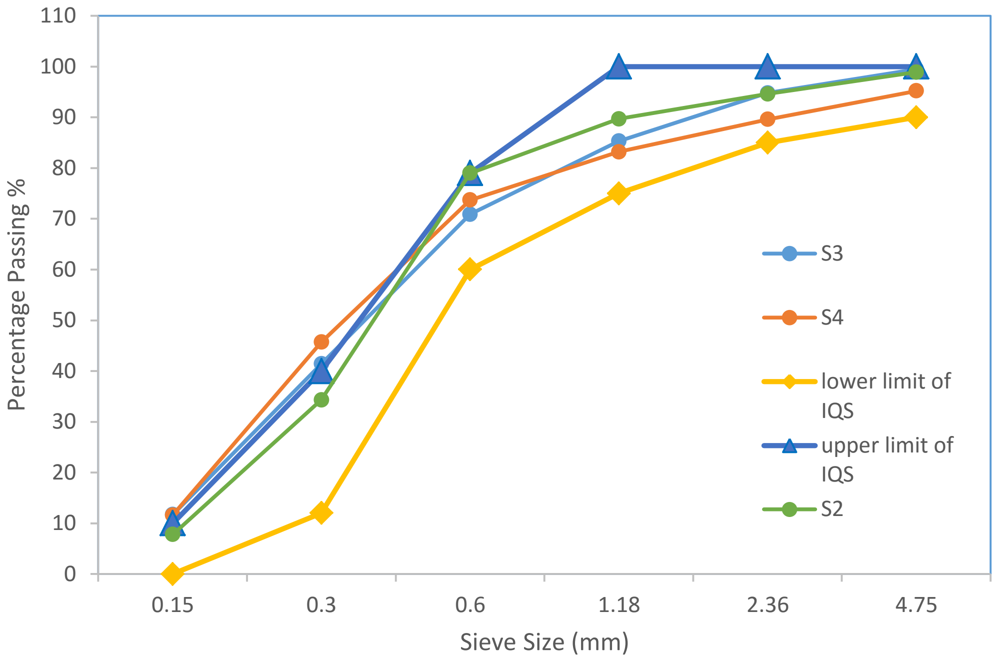

Fig. 3. The sieve analysis for Samples (S2, S3, S4) according to IQS.

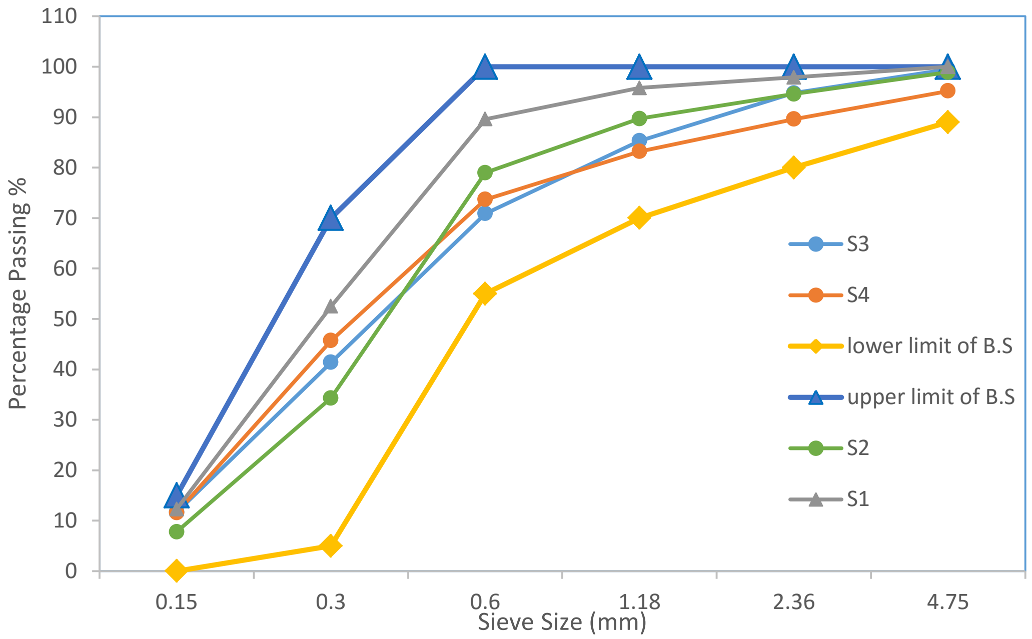

Fig. 4. The sieve analysis for Samples (S1, S2, S3, S4) according to B.S.

For the (American Society for Testing and Materials) ASTM, Samples (S1, S2, S3, S4) appear to be highly deviated as compared with Grading limit as shown in Fig. 5.

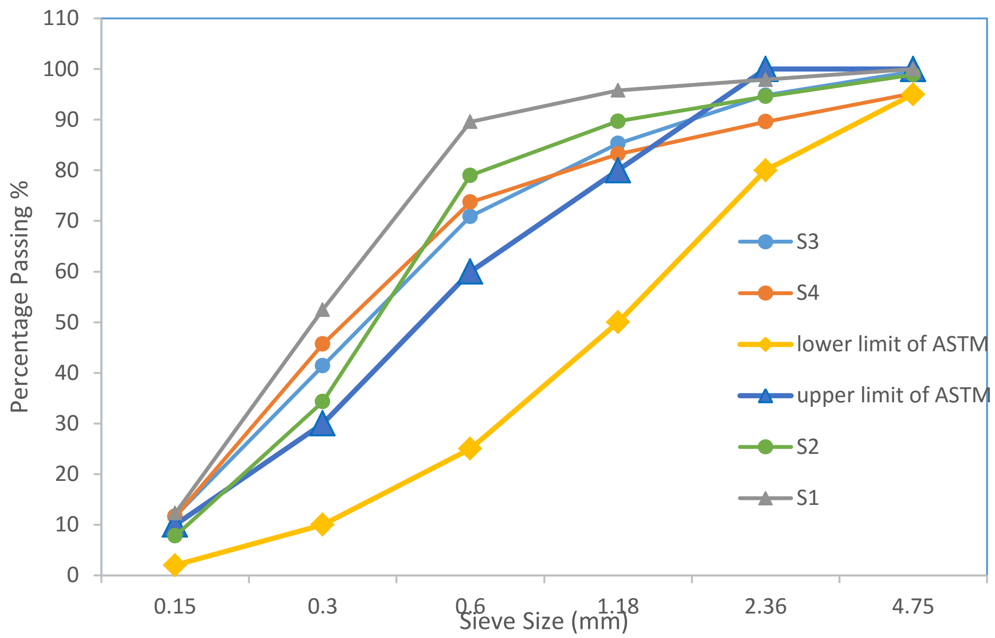

Fig. 5. The sieve analysis for Samples (S1, S2, S3, S4) according to ASTM

3.2. Fineness Modulus (FM)

As shown in Table 4, the result of FM for Sample S1 is 1.52, and it is slightly lower than FM of others Samples i.e. S2, S3, S4 by percent 0.28, 0.29, and 0.32, respectively as shown in Fig. 6.

Table 4. The Physical, Chemical and Mechanical properties of Fine Aggregate Samples.

The test		Sample 1 Syd Ali	Sample 2 Wilaya Ali	Sample 3 Syd Ahmed	Sample 4 Muhand Al-khiat	Limits of Iraqi specification No.45/1984
Fineness Modulus (F.M)		1.52	1.94	1.96	2.01	----
Physical Properties						
Deleterious Materials Clay %		7.8	6	9	4.2	5 %
Bulk Density (g/cm^3)		2.56	2.37	2.46	2.55	----
Specific Gravity (S.G)		2.6	2.40	2.5	2.5	----
Absorption %		1.21	1.01	0.81	1.21	----
Chemical Analysis						
Sulphate Salt Content (SO_3)%		0.28	0.11	10.65	2.2	0.5 %
Compressive Strength (MPa)	7-days	21	24	11	14	----
	28-day	31	33	20	25	----

The small value of FM means the sample is fine, while the large value means the sample is coarse. The finer sand is not recommended in concrete because it is not economic.

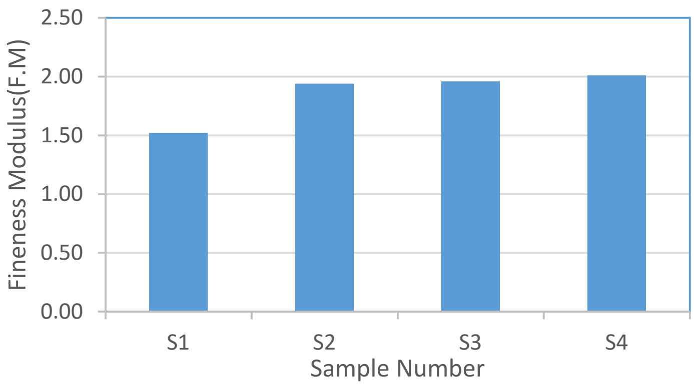

Fig. 6. The Fineness Modulus for Samples (S1, S2, S3, S4).

3.3. Deleterious Materials (Clay %)

From the results shown in Table (4), the percent of the deleterious materials (clay) is 4.2% for the Sample S4 which is accepted according to Iraq Specification Standard Limit, and states that the accepted deleterious materials content must not exceed (5%). The deleterious materials for the other samples (S1, S2, S3) is (7.8, 6.0, 9.0), respectively, which is high as compared with the Iraq Specification as shown in Fig. 7.

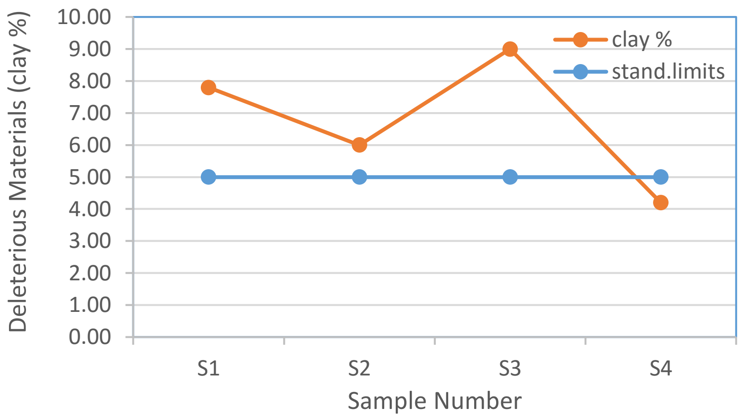

Fig. 7. The Deleterious Materials (clay %) for Samples (S1, S2, S3, S4) and Standard Iraqi limits.

In the comparison between Sample S2 and Sample S1, the clay content appears to affect the compressive strength of concrete in a way that increasing in clay content decreases the compressive strength in a way that the Sample S2 clay content 6% gives compressive strength by age (7, 28) day is (24, 33)MPa. While in Sample S1with clay content with 7.8%, the compressive strength is 21and31 MPa for 7 and 28 day, respectively as shown in Fig. 8.

The decrease of compressive strength in Sample S1 as compared with Sample S2 appeared to be due to higher percentage of clay which decreases the bond between binder and aggregate, also this may be due to difference in sulphate content (SO_3). For the Sample S4 which contains 4.2% clay content [within the accepted Iraq Specification], the compressive strength is (14, 25) MPa for (7, 28) daya age which is very low as compared with Sample S2, which may be due to high sulphate content of Sample S4 (2.2%), and the same matter for Sample S3 where sulphate content reach (10.65%) as shown in Fig. 8.

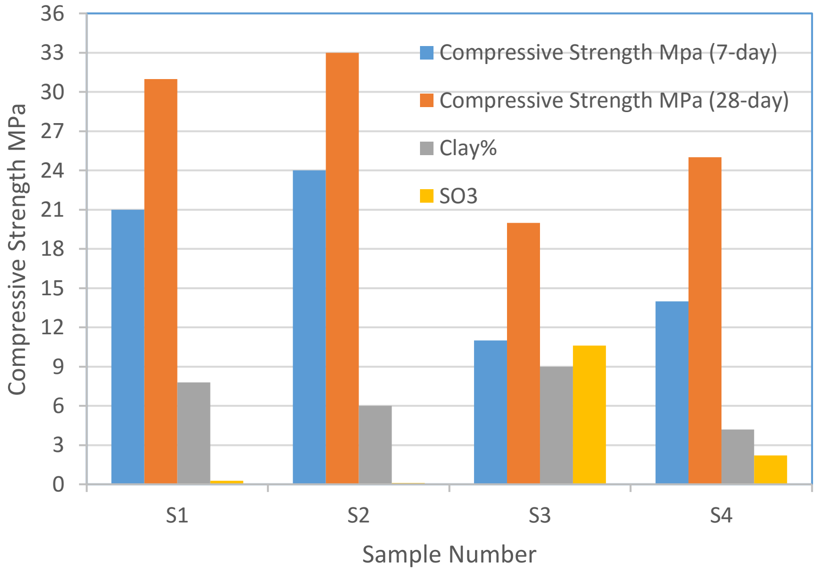

Fig. 8. The effect of percent of clay and SO_3 on compressive strength of concrete (7, 28 day) for Samples (S1, S2, S3, S4).

3.4. Bulk Density

From the results shown in Table 4, the bulk density for the Sample S1 is 2.56g/cm³ which appears to be slightly higher than other Samples (S2, S3, S4) by percent (0.07, 0.04, 0.003), respectively as shown in Fig. 9, which may be because of the source of this sample is stone with high content with heavy minerals. The bulk density of the sample S2 is 2.37g/cm³, which appears to be logic, while the bulk density of Samples (S3, S4) is (2.46, 2.55) g/cm³, respectively, with slightly increased percentage (0.04, 0.08) as compared with Sample S2. These results considered to be accepted as they are coarser than Sample S2.

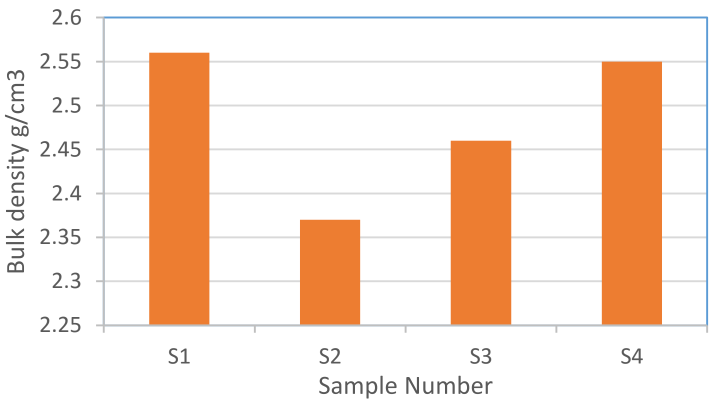

Fig. 9. The Bulk Density for Samples (S1, S2, S3, S4).

3.5. Specific Gravity (SG)

As shown in Table 4) the SG for Sample S1 is 2.6 which is slightly higher than the others Samples (S2, S3, S4) by percent (0.8, 0.04, 0.04), respectively, as shown in Fig. 10, which may be due to heavy minerals content of origin stone of aggregate. The result of SG for Sample S2 is 2.4, while that for Samples (S3, S4) is (2.5, 2.5), respectively.

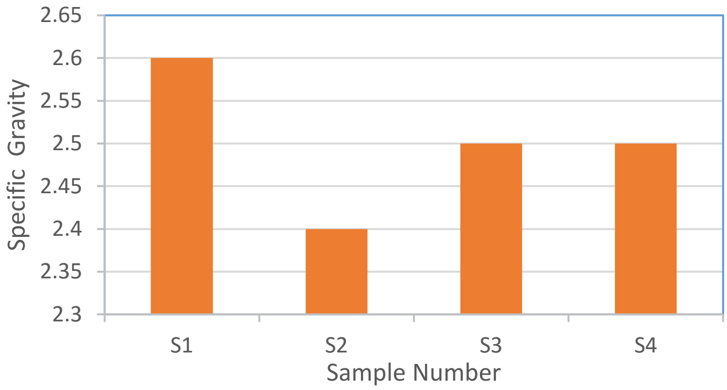

Fig. 10. The Specific Gravity for Samples (S1, S2, S3, S4).

3.6. Absorption

From the results shown in Table 4) the absorption of the Sample S1 is 1.21%, while that for Samples (S2, S3, S4) is (1.01, 0.81, 1.21) %, respectively, that to say, the Sample S2 absorption perform to be in the mid-way between Samples (S3, S4), as shown in Fig. 11. The difference in absorption depends on availability of pores and not on the space within the sample granules.

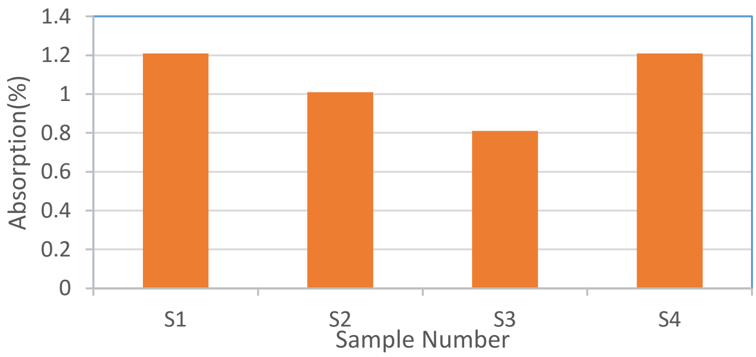

Fig. 11. The Absorption for Samples (S1, S2, S3, S4).

3.7. Suphate Salts Content (SO_3)

From the results shown in Table 4, the sulphate content for Samples (S1, S2) is (0.28, 0.11%) respectively, which are within the Iraqi Specification Standard Limit, which is stated that the accepted sulphate content must not exceed (0.5%) on the other hand,for Samples (S3, S4) is

(10.65, 2.2%) respectively as shown in Fig. 12. Samples (S3, S4) are failed and cannot be treated, not suitable for concrete and other construction works.

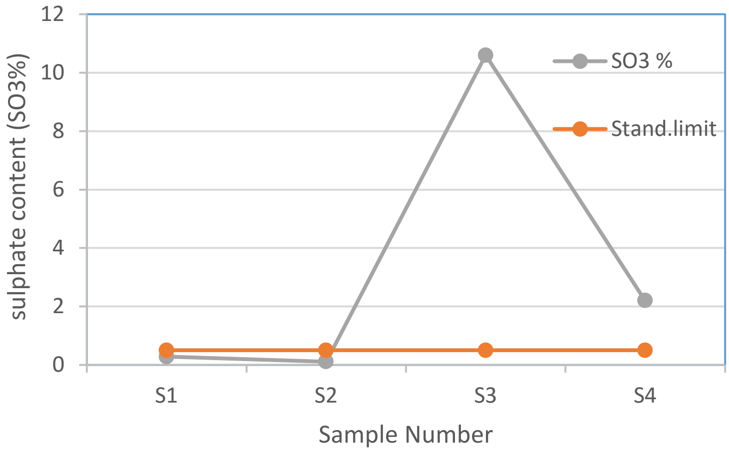

Fig. 12. The Sulphate Content (SO_3 %) for Samples (S1, S2, S3, S4) and Standard Iraqi limits.

3.8. Compressive Strength

From the results shown in Table (4), the compressive strength of the Sample S1 is (21, 31) MPa in age (7, 28) days, respectively, while that for Sample S2 is (24, 33) MPa, which is slightly higher than Sample S1, and much higher than Samples (S3, S4) which is (11, 20) MPa and (14, 25) MPa, respectively, at (7, 28) day as shown in Fig. 13. This values show that the compressive strength is inversely related with SO_3.

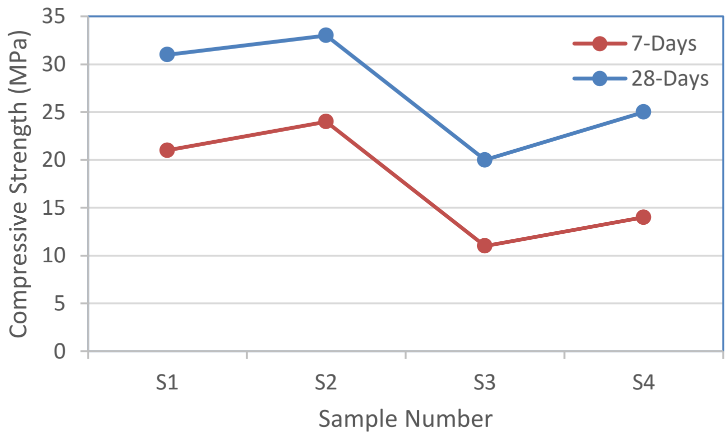

Fig. 13. The Compressive Strength of concrete for Samples (S1, S2, S3, S4) at age (7, 28) day.

The presence of SO_3 appear to have higher effect than density on Samples (S3, S4) as shown in Fig. 14 and 15. In Sample S1 although, the SO_3 content is low, and the compressive strength is slightly less than Sample S2 as shown in Fig. 14 and 15. This could be due to low fineness modulus which can be explained in way that with increase fineness, there is increase in surface of the sample where the cement amount is fixed so, it will be distributed over a longer surface area as compared with Sample S2 which result in decrease compressive strength.

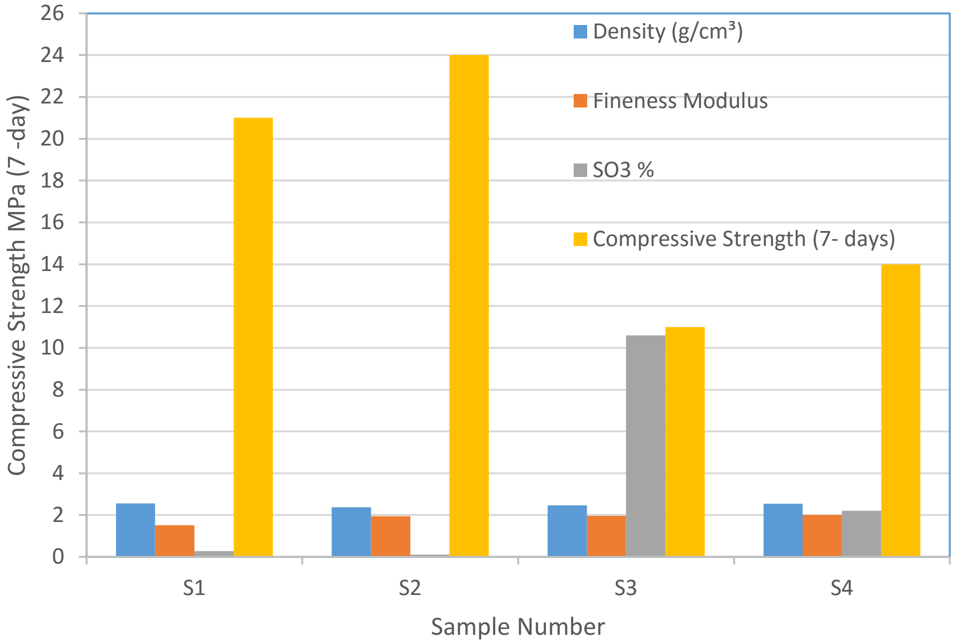

Fig. 14. The effect of density, fineness modulus and SO3 on Compressive Strength of concrete for Samples (S1, S2, S3, S4) at age (7) day.

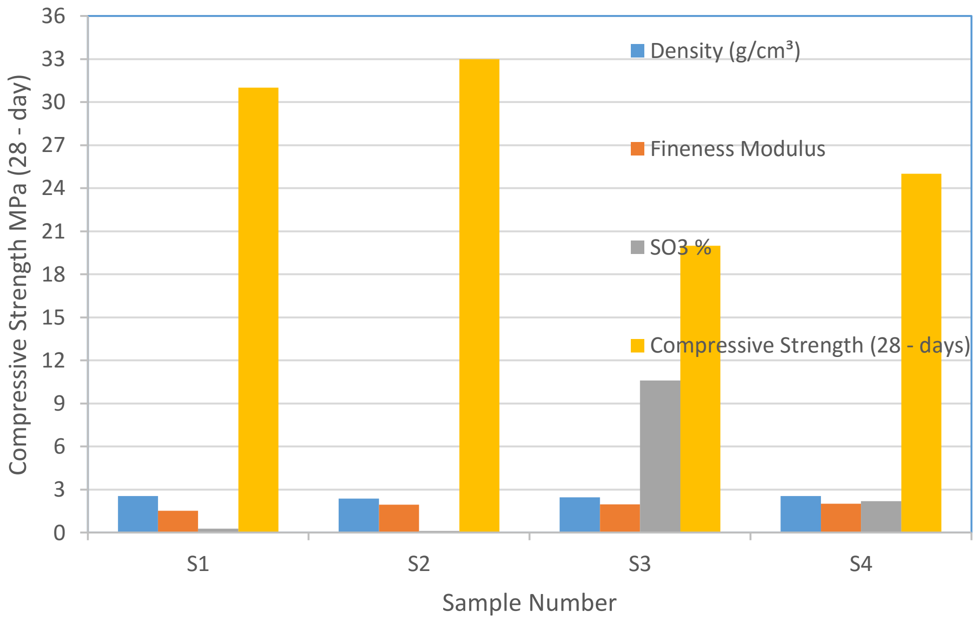

Fig. 15. The effect of density, fineness modulus and SO3 on Compressive Strength of concrete for Samples (S1, S2, S3, S4) at age (28) day.

3.9. The X-Ray Diffraction:

The X-Ray diffraction test was done in Iraqi-Germany laboratory in Baghdad University, Collage of Science, Department of Geology. The results was presence of three minerals (Gypsum, Quartz and Calcite) in Samples [(Syd Ali (S1), Syd Ahmed (S3) and Muhand Al-Khiat (S4)], while in Sample Wilaya Ali (S2) the Gypsum is not present but only (Quartz and Calcite) as shown in Table 5. Gypsum was very high in Sample Syd Ahmed (S3) which is (47.5%), moderate amount in Sample Muhand Al-Khiat (S4) which is (5.1%) and very low amount in Sa mple Syd Ali (S1) which is (1.0%). For Quartz, Sample Wilaya Ali (S2) was the highest level which is (53.8%), while less in Samples Syd Ali (S1) and Muhand Al-Khiat (S4) which are (41.0, 36.0%) respectively, and much less in Sample Syd Ahmed (S3) which is (25.1%). For Calcite, Samples Syd Ali (S1) and Muhand Al-Khiat (S4) have very high amounts reaching (58.0, 58.8%) respectively, it was high reaching (46.2%) for Sample Wilaya Ali (S2) and it was (27.4%) for Sample Syd Ahmed (S3). Fig. 16, 17, 18 and 19 show the percentage of minerals for all Samples.

Table 5. The Minerals of X-Ray Diffraction Test for Samples.

The Samples	The Minerals of X-Ray Diffraction Test		
	Gypsum%	Quartz%	Calcite%
Sample (1) Syd Ali	1.0	41.0	58.0
Sample(2) Wilaya Ali	0	53.8	46.2
Sample (3) Syd Ahmed	47.5	25.1	27.4
Sample (4) Muhand Al-khiat	5.1	36.0	58.8

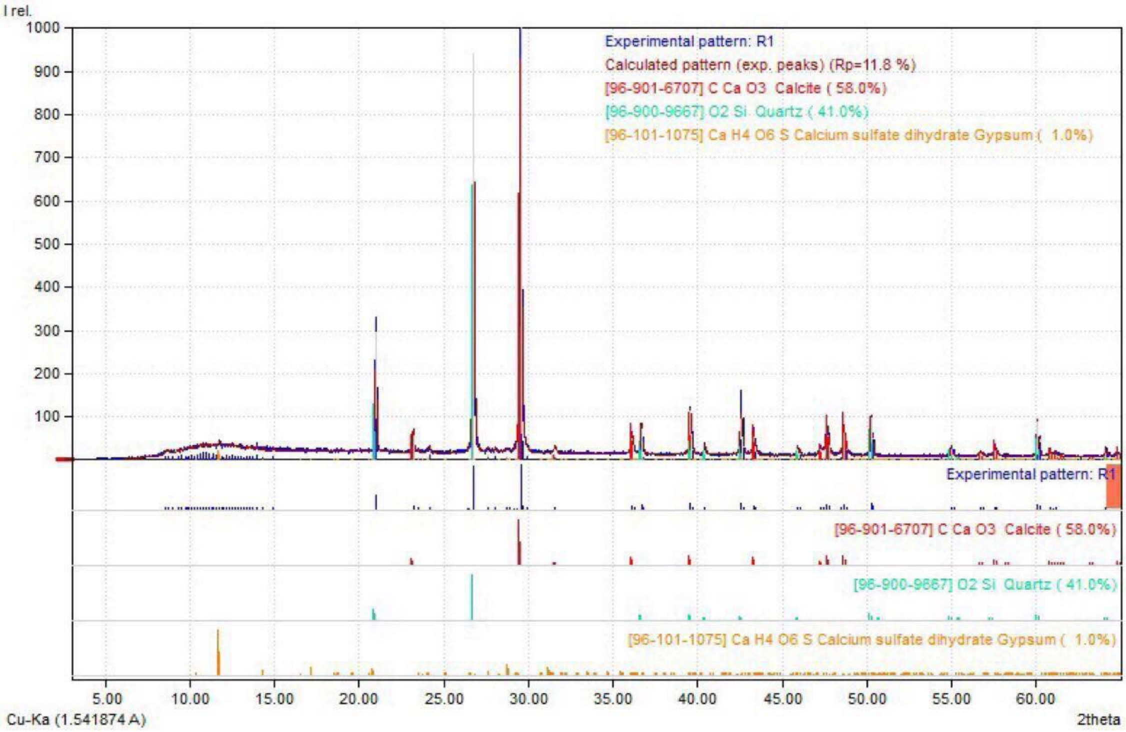

Fig. 16. The X- Ray diffraction Test for Sample Syd Ali (S1).

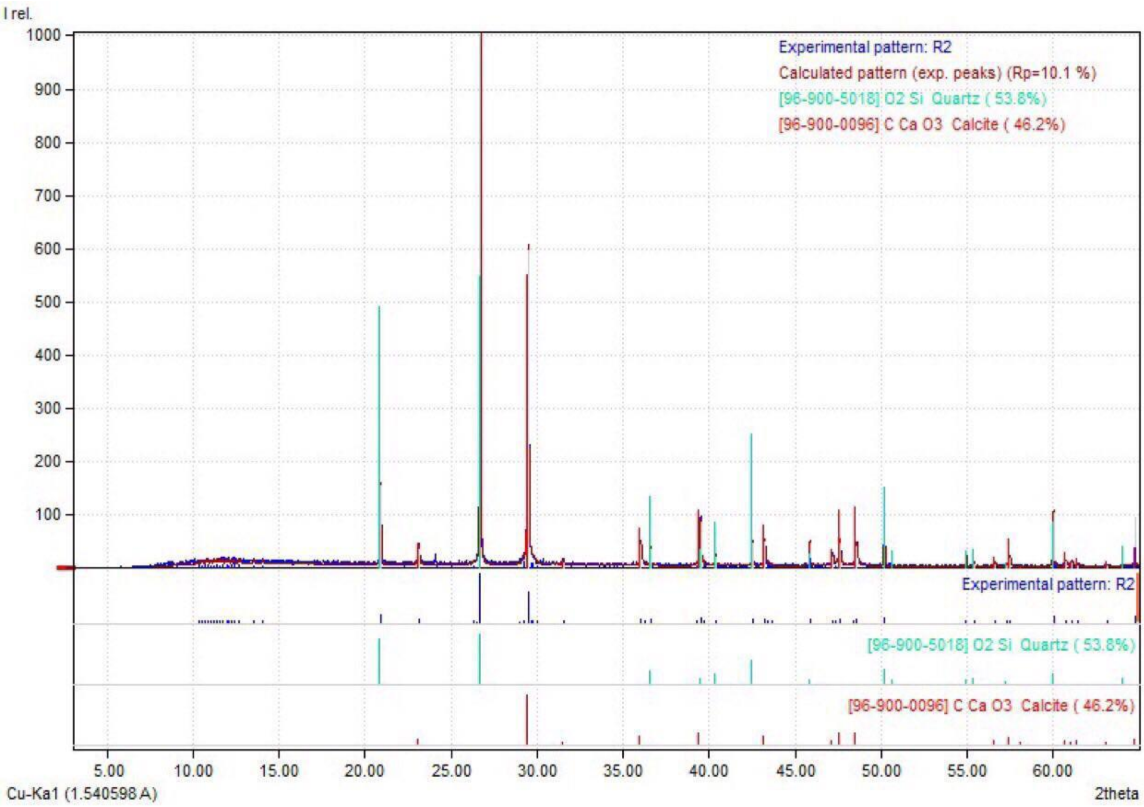

Fig. 17. The X- Ray diffraction Test for Sample Wilaya Ali (S2).

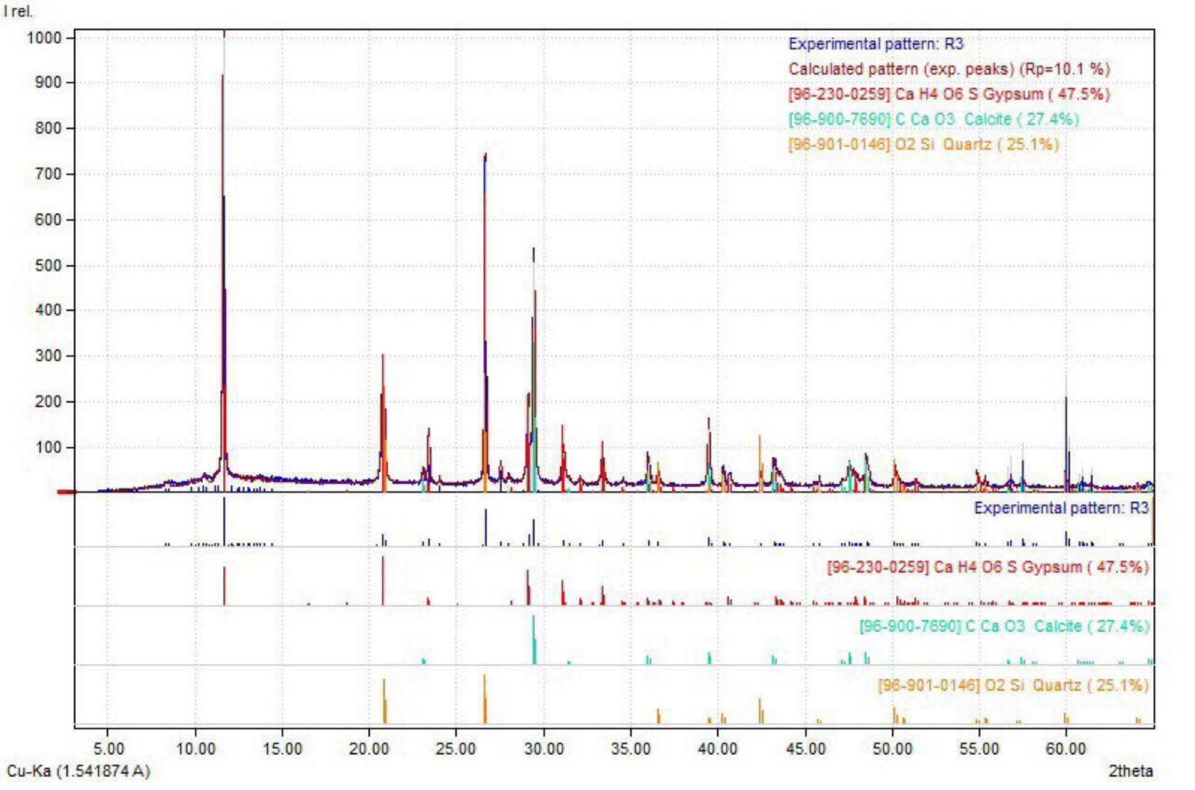

Fig. 18. The X- Ray diffraction Test for Sample Syd Ahmed (S3).

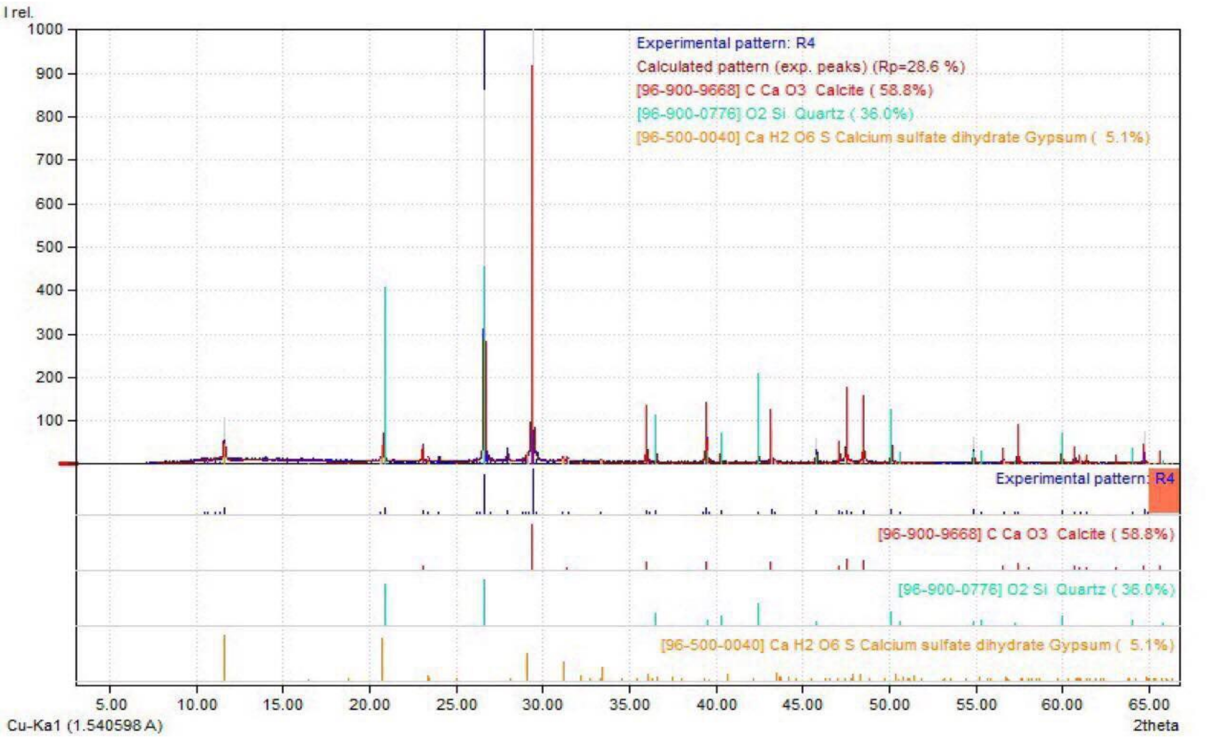

Fig. 19. The X- Ray diffraction Test for Sample Muhand Al-Khiat (S4).

4. CONCLUSIONS

1. Sample Syd Ali (S1) falls within the Grading Zone IV, while the Samples Wilaya Ali (S2), Syd Ahmed (S3), and Muhand Al-Khiat (S4) fall within the Grading Zone III as compared with Iraqi Specification.
2. A little deviation in sieve (0.3mm) for Sample Syd Ali (S1) and in sieves (0.3mm and 0.15mm) for Samples Syd Ahmed (S3) and Muhand Al-Khiat (S4), as compared with Iraqi Specification.
3. Samples Syd Ali (S1), Wilaya Ali (S2), Syd Ahmed (S3), and Muhand Al-Khiat (S4) fall within the Grading Zone limits for British standerd where no deviation in sieves were found.
4. Samples Syd Ali (S1), Wilaya Ali (S2), Syd Ahmed (S3), and Muhand Al-Khiat (S4) are highly deviated as compared with ASTM.
5. Fineness modulus of Sample Syd Ali (S1) is lower than other Samples Wilaya Ali (S2), Syd Ahmed (S3), and Muhand Al-Khiat (S4) by percent (0.28, 0.29, 0.32), respectively.
6. Deleterious materials (clay) of Sample Muhand Al-Khiat (S4) is 4.2%, and they are within the Iraqi specification 5%, while for Samples Syd Ali (S1), Wilaya Ali (S2), and Syd Ahmed (S3) is higher by ;percent (2.8 ,1.0 ,4.0)respectively, as compared with Iraqi specification.
7. Bulk density of Sample Syd Ali (S1) is slightly higher than other Samples Wilaya Ali (S2), Syd Ahmed (S3) and Muhand Al-Khiat (S4) by percent (0.07, 0.04, 0.003) respectively.
8. There is a slight increase in density (2.37, 2.46, 2.55) g/cm^3 for Samples Wilaya Ali (S2), Syd Ahmed (S3), and Muhand Al-Khiat (S4), when fineness modulus increases (1.94, 1.96, 2.01), respectively.
9. The specific gravity of Sample Syd Ali (S1) is slightly higher than other Samples Wilaya Ali (S2), Syd Ahmed (S3), and Muhand Al-Khiat (S4) by percent (0.08, 0.04, 0.04) respectively.
10. Absorption of samples Syd Ali (S1) and Muhand Al-Khiat (S4) are (1.21, 1.21%) and are higher than samples Wilaya Ali (S2) and Syd Ahmed (S3) by percent (0.16, 0.33%) respectively.
11. The sulphate content (SO_3) of Sample Syd Ali (S1) and Wilaya Ali (S2) is (0.28, 0.11%), respectively, and it is within the Iraqi specification 0.5%, while for Samples Syd Ahmed

(S3) and Muhand Al-Khiat (S4) is (10.65, 2.2%) which is higher than the Iraqi specification.

12. The compressive strength of Sample Wilaya Ali (S2) is (24, 33) MPa for (7, 28) days, and it is slightly higher than sample Syd Ali (S1) by percent (0.13, 0.06)MPa for (7, 28) days and much higher than Samples Syd Ahmed (S3) and Muhand Al-Khiat (S4) by percent (0.54, 0.39)MPa and (0.42, 0.24)MPa for (7, 28)day, respectively.
13. Three types of minerals were found (Gypsum, Quartz and Calcite) from the X-Ray diffraction test.
14. The results of X-Ray diffraction test confirm the results of chemical analysis test (SO_3).
15. Sample Syd Ali (S1) is the finest sand as compared with the other Samples with accepted sulphate salts content, so it used in other construction works and not for concrete.
16. Sample Wilaya Ali (S2) is the best among the other Samples, because it's grading, and sulphate content meets the Iraq Specification and advised to be used for concrete works.
17. Samples Syd Ahmed (S3) and Muhand Al-Khiat (S4) considered to be useless because of high sulphate content as compared with the Iraq Specification and not suitable for concrete and other construction works.
18. For the Sample Wilaya Ali (S2) clay content problem can be solved by washing sand with water, where this deleterious substance will be separated from the aggregate much more than the use of the dry sieve analysis only.

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