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Additives Effects on producing Gypsum plaster in Zurbatiyah area, Eastern Iraq

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Abstract

Gypsum deposits are wide spread in Zurbatiyah area, Eastern of Iraq, especially in Fatha Formation. Gypsum deposits have been known as a suitable materials for gypsum plaster industry. Sawdust and Palm fibers powders have been added in different ratios to gypsum plaster material mixture to improve their industrial properties. Addition of 0 %,1 %, 5%, 10% and 15 % pass of 4.75 mm size of sawdust and palm fibers powder and 0 %, 1 %, 5%, 10% and 15 % pass of 5.60 mm size of sawdust and palm fibers powder to gypsum plaster material mixture. This ratios showed results of consistency (35-75 ml/gm), setting time (11-20 min) and compressive strength (2.2-4.4 N/mm^2) for sawdust powders size 4.75 mm, whereas the results of consistency (35-63 ml/gm),setting time (11-21 min) and compressive strength (2.0-4.2 N/mm^2) for palm fibers powders size pass of 4.75 mm. The addition of 1% and 5% pass of 4.75 mm sawdust and palm fibers powder to gypsum plaster material mixture showed an improvements in consistency(37-41ml/gm), (36-40ml/gm) setting time (13-14 min), (12-13 min) and compressive strength (4.2-4.4 N/mm^2), and (4.1-4.2 N/mm^2) for sawdust and palm fibers respectively. Also the addition of 1 % and 5 % pass of 5.60 mm sawdust and palm fibers powder showed consistency (40-45 ml/gm), (39-44 ml/gm), (14-15 min.), (12-13min.), (3.5-4.2 N/mm^2), and (3.0-4.1 N/mm^2), for sawdust and palm fibers respectively. In general, the results of current study conform the requirements of the Iraqi standard specification No. 28 (1988) and ASTM C28, C472 (2010) for ordinary gypsum plaster industry.

Introduction:

Calcium sulfate, commonly known in nature in different forms, mainly as the dihydrate ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$). Occur as bed or nodular masses up to few meters thick. Gypsum formed in restricted sedimentary basins in arid and hot climate and by the hydration of Anhydrite. The depth of hydration can range from the surface of the deposit down to three hundred meters, depending on temperature and pressure, topography and the structure of the deposit.[1]. Anhydrite forms rarely at the surface but only in arid and hot supratidal environments (sabkha) in the presence of concentrated brines [1-5].

The two forms of calcium sulfate (Gypsum and Anhydrite) which are stable in the presence of any solution and the stability of one or the other form depends on the temperature and the nature of the solution with which it is in contact. In pure solution gypsum is stable only up to 66° C when it begins to be transformed into anhydrite, but as the change takes place slowly the solubility may be determined beyond the point of its stability, so pure gypsum contain 32.6 percent CaO, 46.5 percent SO_3, and 20.9 percent H_2O [6].

Ore gypsum fed into kettle calciners where it is heated to approximately 120° C to 180°C to produced Hemihydrate and with increasing heated between 180°C to 220°C to produced anhydrite [7]. Hemihydrate can exist as β and α forms. The β- Hemihydrate is produced by dry calcination and the main constituent of plaster. The α- Hemihydrate is produced by wet calcination at elevated pressures or atmospheric pressure with the addition of acid or aqueous salt solutions [8]. α and β- Hemihydrates are indistinguishable for crystal habits by common analytical techniques such as X-Ray diffraction, but they have different densities and can be distinguish through thermal analysis [9]. The literature reports clarify that the hydration process involves dissolution/reprecipitation mechanism, with dissolution of $CaSO_4.0.5H_2O$ being relatively rapid and the subsequent precipitation of $CaSO_4.2H_2O$ slower [10].

A study reported that the thermal data of the two materials show more distinct difference. The TGA (Thermgravimetric Analysis) traces clearly show that the temperature of maximum mass loss for β- $CaSO_4.0.5H_2O$ is 94°C whereas for α- $CaSO_4.0.5H_2O$ it is 105°C[11]. Addition of fibers increase the mechanical properties of gypsum products by conventional fibers strengthening mechanism [12]. There is an inverse relationship between compressive strength and the two properties water/ powder ratio and porosity, and exist a direct relationship between compressive strength and the two properties particle size and density, also there is direct reationship between setting time and the two properties particle size and water/powder ratio [13].

Area of the study

The study area is located geographically within the Zurbatiyah area about 80 km north of Kut governorate East of Iraq and between the latitudes 33° 08′ 60′′- 33° 23′ 57′′ N and longitudes 46° 02′ 60′′ - 45° 58′ 15′′ E include four sections A, B, C, and D within Fatha formation, as shown in figure 1.

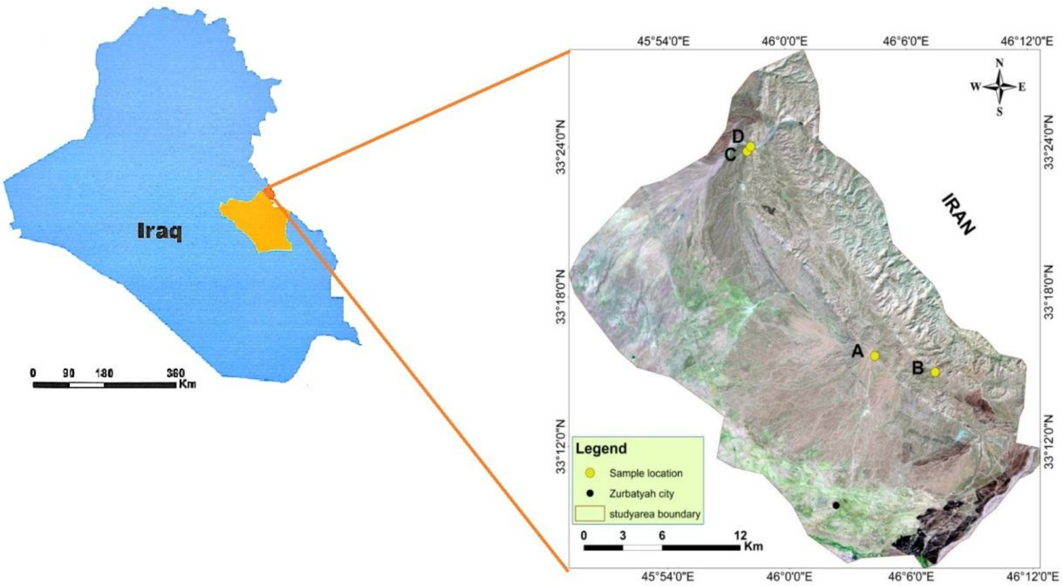

Fig. 1: Location map of study area

In the study, the presence of evaporate facies which represented mainly by thick beds of gypsum / anhydrite. These occur as part of a cyclic succession, the other components of cycles being carbonate, brownish red marl and green marl, the component of evaporate is developed mostly thickly in the presumed basinal area of Fatha Formation. The cyclicity of Fatah formation due to tectonic factors, glacioeustatic sea- level changes, and auto cyclic processes of sabkha/tidal-flat progradation. [14].

Material and Methods

Twenty five samples were collected from four gypsum sections (A, B, C, and D) from Fatha Formation in Zurbatiyah area. Figure 1. 20 sample for XRD (X-Ray Diffraction) test analysed in Iraqi-German laboratory/ Baghdad University/ College of Science/ Geology Department, Chemical analysis of twenty samples for gypsum rocks and two samples of bulk gypsum plaster were carried out in Amirkabir University and Technology laboratories/Iran by using X-Ray fluorescence spectrometry, all the physical and evaluated tests were done in laboratories of engineering college at Basrah University.

In this study choosing representative raw gypsum material from Zurbatiyah quarry to produce gypsum plaster and then addition of 0 %, 1 %, 5%, 10% and 15 % pass of 4.75 mm size by weight of sawdust and palm fibers powder and 0 %, 1 %, 5%, 10% and 15 % pass of 5.60 mm size by weight of sawdust and palm fibers powder to gypsum plaster material mixture were added to gypsum plaster materials to improve the physical properties; consistency, setting time and compressive strength of gypsum plaster.

Physical tests of gypsum plaster

The following physical tests were perform according to Iraqi standard specification No.28,(1988) [15].

I-Fineness Test

To find the percentage of particles which pass through the sieve No.16 (size 1.18mm), 200 gm of gypsum plaster were weighted using an accurate electronic digital balance and then place on this sieve and shake for 3 minutes . The residual gypsum plaster is weighed on the sieve and compute the percentage of fineness according to equation below:

$$\text{Fineness percentage} = \frac{\text{residual gypsum plaster weight on the sieve}}{\text{Sample weight}} \times 100 \quad (1)$$

II-Consistency Test

The purpose of this test is to determine the water/powder ratio. Spread 100gm of hemihydrate on a known volume water (35–50)cm^3 and mixed, then compute the consistency according to equation as bellow

$$\text{Consistency} = \frac{\text{Quantity of water used}}{\text{Quantity of gypsum plaster}} \times 100 \quad (2)$$

III-Setting Time Test

The setting time test was measured using Vicat apparatus according to Iraqi standard No.28.(1988). The total time elapsed from the starting point of mixing to that where the needle first failure penetrate the sample completely was taken as the Vicat setting time for that sample.

IV-Compressive strength test

The purpose of this test is to determine the value of load for the compressive strength used a cubic moulds with dimensions (5x5x5)cm and greased moulds to prevent cohessive the side moulds with cubic material and then loaded with rate load (1–3) newton/mm^2 until fail and compute compressive strength as below :

$$\text{Compressive strength}\left(\frac{\text{N}}{\text{mm2}}\right) = \frac{\text{Load pressure (N)}}{\text{Area(mm2)}} \quad (3)$$

In order to improve the physical properties of gypsum plaster ,two types of additives have been added; sawdust powder with size pass of 4.75 mm and 5.60 mm, and palm fibers powder with size pass of 4.75 mm and 5.60 mm to gypsum plaster mixes according to definite addition ratios to conduct compressive strength, setting time and consistency . Addition ratios (0 %, 1 %, 5%, 10% and 15 %) by weight of sawdust and palm fibers to gypsum plaster mixes table(1).

Table 1: Additives %

Sawdust with 4.75 mm size	Sawdust with 5.60 mm size	palm fibers with 4.75 mm size	palm fibers with 5.60 mm size
0	0	0	0
1	1	1	1
5	5	5	5
10	10	10	10
15	15	15	15

Results and Discussion

The X-ray diffractogram of representative gypsum and gypsum plaster samples from Zurbatiyah area shows that the gypsum samples have high purity of gypsum minerals ($CaSO_4.2H_2O$) with less amount of anhydrite, calcite, dolomite, quartz and Bassanite. Bassanite phase represent the transformed phase of gypsum and anhydrite. Figures 2 and 3 minerals were identified by comparing the peak values displayed on the diffractograms. Figures 2 and 3 indicate that the predominant of the mineralogical impurities associated with gypsum are calcite, dolomite, anhydrite and bassanite, this impurities may be mixed with gypsum because of primary sedimentary processes or present as the result of the secondary effect of solution, weathering and erosion.

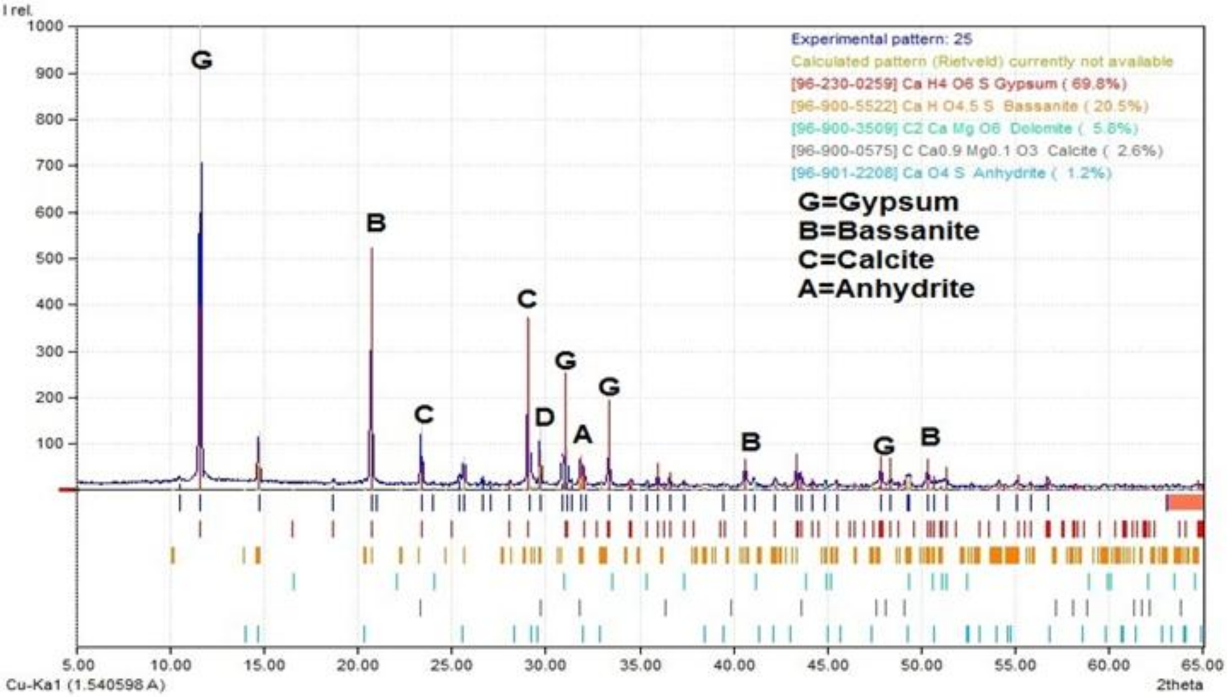

Fig. 2: X-Ray diffraction for gypsum rock inZurbatiyah area.

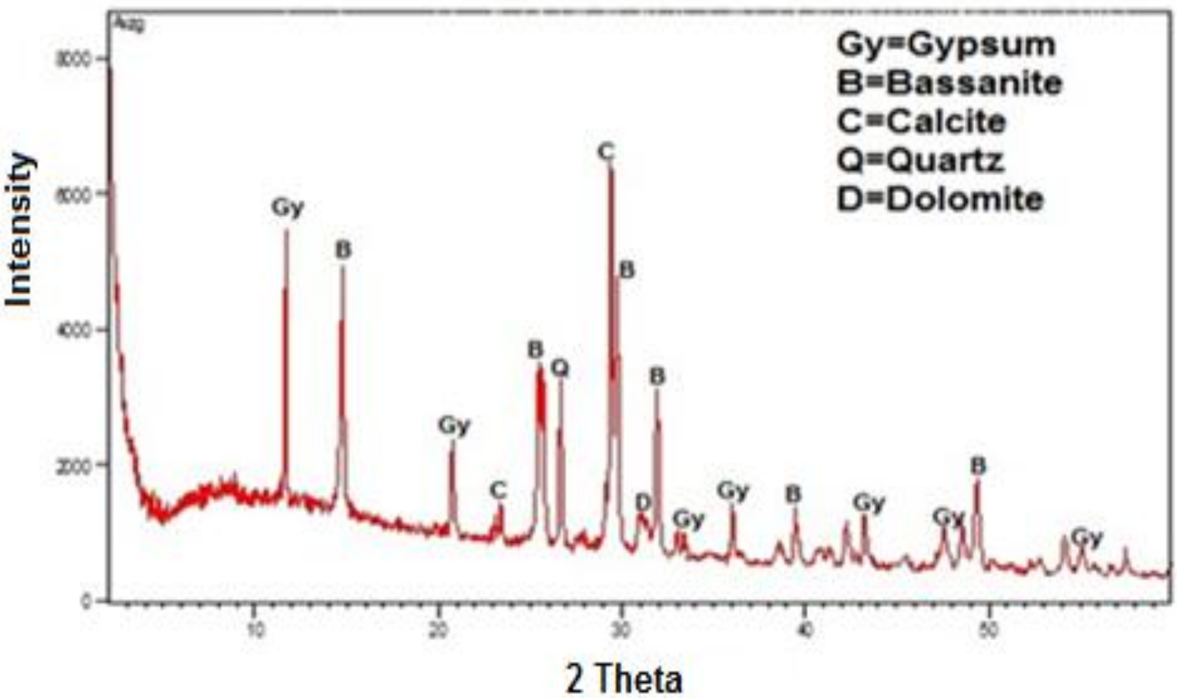

Fig.3: X-Ray diffraction for Zurbatiyah gypsum plaster

Chemical analysis

Chemical analysis of the bulk gypsum and gypsum plaster samples for major oxides was summarized in table 2 showing that the results of chemical analyses of gypsum and gypsum plaster indicates high grade for plaster industry and building purposes for SO_3 and CaO, if consider the concentration of SO_3 as indicator of quality of deposits because it is the main component of gypsum rocks reach to 45.545 %, and 53.83% for gypsum and gypsum plaster respectively. Also the concentration of CaO showed good values in the gypsum rock and gypsum plaster (31.74%, 31.19%) respectively comparing with chemical requirement in the Iraqi standard specification No.28, (1988) [15].

Table 2: Percentage of major components for gypsum rock and gypsum plaster

Area	Sam.	SiO_2 %	Fe_2O_3%	Al_2O_3%	CaO %	MgO %	SO_3 %	Na_2O%	K_2O%	Cl %	LOI%
Zurbatiyah	Z1*	0.32	0.05	0.37	31.74	0.26	45.545	0.05	0.03	0.0058	21.58
	Z2*	6.88	0.97	0.91	31.19	0.95	53.83	4.57	0.24	0.03	3

Z1*=Gypsum rock, Z2*=Gypsum plaster

Physical test of gypsum plaster

The physical tests, Fineness, Consistency, Setting time and Compressive strength have been done for gypsumplaster. Table 3 shows that all parameter compatible with the Iraqi standard No.28, (1988). [15] and ASTM C28, and C472 [16].

I–gypsum plaster improvement

Hemihydrate is suitable for Iraqi standard specification No.28,(1988) due to high chemical components of CaO and SO_3 were reach to 31.19 % and 53.83 % respectively whereas the components of CaO and SO_3 in Iraqi standard specification No.28,(1988) are above 25 %, and 35 % respectively. Table 2. Many different ratios of sawdust and palm fibers were added to gypsum plaster to show the effects on its physical properties.

II-Effect changes of water mixture ratio

The water/powder ratios were varies according to amount of additives ratio to the gypsum plaster, this ratio ranged between (35–78)ml/gm, tables 3, 4 and 5. This amount is greater than the theoretical amount required for chemical reaction (18.6)ml/gm. [17]. The influence of water to plaster ratio reported by [18]. showed that setting time was delayed with increasing volume of water, powder size, admixture amount, ageing time and decreased amount of dissolved salts.

III-Sawdust and palm fibers powder additives effect on gypsum plaster

The addition of sawdust powder with size pass of 4.75 mm to hemihydrate with ratios 0,1,5,10 and15 % reveals that ratios (1)% and (5)% give a setting time (13-14 min.) and compressive strength (4.2-4.4) N/mm^2 compatible with the Iraqi standard specification No.28, (1988) But other ratios 10 %, and 15% indicate not compatible for the Iraqi standard specification No.28, (1988).whereas the addition of palm fibers with size pass of 4.75 mm to hemihydrate with ratios 0,1,5,10 and 15 % shows an improvement in setting time from (12-

13) minutes and compressive strength from (4.1-4.2) N/mm^2 wheras The other ratios are not suitable to give a good values of compressive strength according to the Iraqi standard specification No.28, (1988), as showed in table 4.
The same additives (sawdust and palm fibers) with bigger size 5.60 mm show nearly similar than size 4.75 mm., as showed in tabe 5.

Table 3: Physical test laboratory of gypsum plaster

Test type	Result	Limit of Iraqi standard specification No.28(1988)	ASTM (2010)
Fineness modulus %	1	100% pass from sieve No.16 (1.18mm)	C28/C28M
Consistency ml/gm	35	-	
Setting time (min.)	11	8–25 min.	
Compressive strength (N/mm^2)	4	Not less than 3 (N/mm^2)	ASTM C472

Table 4: Physical test laboratory of gypsum plaster with wood and palm fiber powder (size 4.75 mm)

Ratio %	Physical tests with sawdust				Physical tests with palm fibers				Test type	Limit of Iraqi standard Specification No.28 (1988)	ASTM (2010)
	Fineness %	Consistency ml/gm	Setting time (min.)	Compressive strength (N/mm^2)	Fineness %	Consistency ml/gm	Setting time (min.)	Compressive strength (N/mm^2)			
0	1	35	11	4	1	35	11	4	Fineness %	100 pass from sieve No. 16 (1.18mm)	C28/C28 m
1	2	37	13	4.4	2	36	12	4.2			
5	6	41	14	4.2	6	40	13	4.1	Consistency ml/gm	-	
10	11	63	17	2.8	11	60	17	2.4	Setting time (min.)	8-25 min	
15	16	75	20	2.2	16	63	21	2.0	Compressive strength (N/mm^2)	Not less than 3 (N/mm^2)	ASTM C472

Table 5: Physical test laboratory of gypsum plaster with wood and palm fiber powder (size 5.60 mm)

Ratio %	Physical tests with sawdust				Physical tests with palm fibers						
	Fineness %	Consistency ml/gm	Setting time (min.)	Compressive strength (N/mm^2)	Fineness %	Consistency ml/gm	Setting time (min.)	Compressive strength (N/mm^2)	Test type	Limit of Iraqi standard Specification No.28 (1988)	ASTM (2010)
0	1	35	11	4	1	35	11	4	Fineness %	100 pass from sieve No. 16 (1.18mm)	C28/C28 m
1	2	40	14	4.2	2	39	12	4.1			
5	6	45	15	3.5	6	44	13	3.0	Consistency ml/gm	-	
10	11	68	18	2.5	11	62	17	2.4	Setting time (min.)	8-25 min	
15	16	78	22	2.1	16	65	21	2.0	Compressive strength (N/mm^2)	Not less than 3 (N/mm^2)	ASTM C472

Conclusions

This study has come to the following conclusions:-

The XRD showed the main components are gypsum minerals with less amount of anhydrite, calcite, dolomite, quartz and Bassanite. The chemical analyses reveal high amount of CaO and SO_3 for gypsum raw material. The physical tests, Fineness, Consistency, Setting time and Compressive strength have been done for gypsum plaster reveal that all parameter compatible with the Iraqi standard No.28, (1988) and ASTM C28, and C472 before add sawdust and palm fibers. In addition powder of sawdust and palm fibers to gypsum plaster with sizes 4.75 mm and 5.60 mm showed an improvement in setting time and compressive strength for the ratio 1 % and 5 % . If the ratio of (W/G) increasing, the compressive strength will decreases except the ratio 1%.Consistency and setting time increased with the increasing ratio of (W/G).

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تأثير المضافات على الجص المنتج في منطقة زرباطية شرق العراق

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الكلمات المفتاحية:

الجص، المضافات، نشارة الخشب، ليف النخيل، مقاومة الانضغاط

الخلاصة:

تنتشر الترسبات الجبسية بشكل واسع في منطقة زرباطية، شرق العراق. وهذه الترسبات مناسبة لانتاج الجص. تم اضافة نشارة الخشب وليف النخيل بحجمي العابر من 4,75 ملمتر و5,60 ملمتر وبنسب وزنية مختلفة (0، 1، 5، 10، 15) % لغرض دراسة تأثير هذه الاضافات وتحسين الخواص الفيزيائية للجص الاعتيادي. اظهرت النسب 1 % و 5 % نتائج جيدة للقوام القياسي وزمن التماسك ومقاومة الانضغاط لكل من نشارة الخشب و ليف النخيل بالحجمين المضافين من (37-41 مل/غم) للقوام القياسي و (13-14 دقيقة) لزمن التماسك و (4,2-4,4 نت/مم^2) للحجم 4,75 لنشارة الخشب ومن (36-40 مل/غم) للقوام القياسي و (12-13 دقيقة) لزمن التماسك و (4,1-4,2 نت/مم^2) للحجم 4,75 لليف النخيل ومن (40-45 مل/غم) للقوام القياسي و (14-15 دقيقة) لزمن التماسك و (3,5-4,2 نت/مم^2) للحجم 5,60 لنشارة الخشب ومن (39-44 مل/غم) للقوام القياسي و (12-13 دقيقة) لزمن التماسك و (3,0-4,1 نت/مم^2) للحجم 5,60 لليف النخيل وهذه القيم مقبولة ومطابقة للمواصفة العراقية رقم 28 لسنة 1988 والمواصفة الامريكية لمواد البناء C 28 و C 472 لسنة 2010.