Journal of Petroleum Research and Studies

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

DOI: http://doi.org/10.52716/jprs.v15i1.795

Ecological Materials to Improve Iraqi Oil Well Cement Performance

Amel H. Assi*, Ahmed A. Haiwi
Petroleum Engineering Department, College of Engineering, University of Baghdad, Baghdad, Iraq.
*Corresponding Author E-mail: amel@coeng.uobaghdad.edu.iq

Received 10/09/2023, Revised 16/11/2023, Accepted 22/11/2023, Published 21/03/2025

Abstract

Ecological materials are those that are used in projects and reduce the environmental impact of the project, help improve the quality of life for people who live and work in the facility, and reduce environmental pollutio+

n. Oil is of great importance on the economic level, as it is one of the basic resources in the economic wheel among the countries of the world. However, the use of this resource faces many challenges, as it is one of the depleted resources threatened with annihilation, not to mention the environmental problems resulting from the oil industry in its various stages. This research aims to diagnose the problem of Iraqi cement, where the problem of Iraqi cement lies in the fact that its silica content is low, about 18%, its strength is low, and its thickening time is short, in addition to its high softness, and it hardens quickly. The novelty in this research is the use of sider leaves, ground walnut shells, and silica dust as environmentally friendly additives, and demonstrating their effect on the properties of Iraqi cement. The tests were carried out on the aforementioned materials in their normal size and with a nanoparticle, as the results showed that each of the crushed walnut shells, silica dust and ground nut shells contributed to increasing the compressive strength of Iraqi cement, and the materials in their Nano size 100 nm were better than what they are in the normal size. The results showed that Nano-sized Sider paper reduced the density of the mortar because it contained saponin when 1.5% BWOC was added. One of the most important conclusions of the research is that adding Nano-silica dust at a rate of 1.5% BWOC increased the resistance strength of cement by about 3 times what it was without addition at a temperature of 38 degrees Celsius.

Keywords: Mudlog, fluid evaluation, light gas, Gas chromatograph.

استخدم مواد بيئية لتحسين أداء أسمنت آبار النفط العراقية

الخلاصة:

المواد البيئية هي تلك التي تستخدم في المشاريع لتقلل من التأثير البيئي للمشروع، وتساعد على تحسين نوعية الحياة للأشخاص الذين يعيشون ويعملون في المنشأة، وتقلل من التلوث البيئي. يحظى النفط بأهمية كبيرة على المستوى الاقتصادي، فهو أحد الموارد الأساسية في العجلة الاقتصادية بين دول العالم. إلا أن استخدام هذا المورد يواجه العديد من التحديات، فهو من الموارد

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

الناضبة والمهددة بالفناء، ناهيك عن المشاكل البيئية الناتجة عن صناعة النفط في مراحلها المختلفة. يهدف هذا البحث إلى تشخيص مشكلة الأسمنت العراقي حيث تكمن مشكلة الأسمنت العراقي في أن محتواه من السيليكا منخفض حوالي 18%، وقوته منخفضة، وزمن سماكته قصير، بالإضافة إلى نعومته العالية، وتصلبه السريع. الجديد في هذا البحث هو استخدام أوراق السدر وقشور الجوز المطحون وغبار السيليكا كمضافات صديقة للبيئة وبيان تأثيرها على خواص الأسمنت العراقي. أجريت الاختبارات على المواد المذكورة بحجمها الطبيعي وبجزيئات متناهية الصغر، إذ أظهرت النتائج أن كل من قشور الجوز المطحون وغبار السيليكا ساهمت في زيادة قوة الضغط للأسمنت العراقي، كما أن المواد بحجمها النانوي 100 نانومتر كانت أفضل مما هي عليه في الحجم الطبيعي. أظهرت النتائج أن ورق السدر بحجم النانو قلل من كثافة الملاط لاحتوائه على مادة الصابونين عند إضافة 1.5% BWOC. ومن أهم استنتاجات البحث أن إضافة غبار النانو سيليكا بنسبة 1.5% BWOC أدى إلى زيادة قوة مقاومة الأسمنت بحوالي 3 أضعاف ما كانت عليه بدون إضافة عند درجة حرارة 38 درجة مئوية.

1. Introduction:

Large quantities of toxic and non-toxic waste are generated during the extraction, refining and transportation of oil and gas. Some industrial by-products, such as volatile organic compounds, nitrogen and sulfur compounds, and spilled petroleum, can pollute air, water, and soil to biologically harmful levels when improperly managed [1]. The recent trend is to use environmentally friendly materials that compensate part of the weight of cement, thus reducing its pollution [2]. Preliminary cement operations are the process of substituting an amount of cement in the annulus space between the well bore and the casing pipes for the purpose of fixing the casing pipes and tightly spinning the excavated layers of earth from each other [3]. To complete this process, it is required to ensure that the cuttings and drilling fluids are removed from the space between the well bore and the casing tubes, and to ensure that this void is filled with the appropriate amount of cement and transformed into a solid state capable of supporting the casing tubes and carrying various well operations such as perforation, acid treatment, and various production processes throughout the life of the well [4]. Chemical additives are used to control the properties of the cement mixture in terms of density and viscosity and to reduce fluid loss in the ground layers [5]. The cement used for cementing oil wells is the same as industrial cement, except that in terms of structural composition, some materials are added to increase the pumpability of the cement slurry [6]. Cement used in oil wells must have pumpability specifications so as not to cause problems in the whole process [7]. Cement must have high compressive strength due to hydration of cement compounds and to solidify gradually and at a specific time, which can be predicted in advance so that it can be placed at a certain depth of the well by the pump [8]. In addition, it should have a low permeability so that the layered liquids do not penetrate it [9]. Cement is considered the main material in the cementation process, and it is a very fine powder with dimensions ranging between 10-150 microns. It is composed of a mixture of several crushed materials of a certain

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

mineral composition, and it is characterized by the property of solidification (turning into stone) when mixed with water [10]. Cement is produced from burning a mixture of lime (chalk and limestone) and clay to the temperature of roasting the components included in its composition, i.e. about (145 C). After that, it is grinded to its specific dimensions [11]. There are multiple classifications of cement, but in general, the classification of the American Institute is taken into consideration in most cases [12]. Well cementing operations constitute the turning point in the success of drilling operations or not, and this term is applied to well casing operations and well cementing operations [13]. In general, all cementing operations aim to increase the resistance of wells [14]. With the aim of preserving its structure throughout the estimated time of consumption of the reservoir, which may last for several decades, the importance of consolidation also comes as it represents the last stage for the implementation of the oil or gas well, which is carried out by the drilling rig, and any failure in these operations will definitely hinder the subsequent investment operations of the wells .So that it will not allow proper planning and application of systems that match the conditions of the reservoir [15]. Table (1) shows the most important studies related to the research topic, which is the use of sustainable development in well cementation operations. Through this study, light will be shed on sustainable development and its role in improving the efficiency of one of the most important stages of the oil industry, which is the well cement process. Primary cement operations are the process of pumping a quantity of cement into the annular space between the well bore and the casing tubes for the purpose of stabilizing the casing tubes and preventing fluid leakage from the formations into the casing. The main objective of this study is to use environmentally friendly materials to improve the properties of Iraqi oil well cement produced from Babylon cement plant, class G, with high sulfate resistance.

2. <u>The previous study:</u>

Bubnov et.al study included improving the properties of oil well cement, type G, produced from the Umm Qasr plant in Basra [16] Governorate, by adding glass powder, and their laboratory results proved the possibility of improving the properties of cement in terms of compressive strength [17]. Farhadet.al studied the effect of adding recycled crumb rubber on the properties of cement, where the addition of these materials contributed to increasing the strength of cement by reducing small cracks and cracking of cement as a filler material, especially when the cement develops its final strength [18]. Hossein et.al studied the effect of adding silica ash on the properties of cement was studied. Where this material contributed to increasing the strength of cement,

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

reducing the thickening time, increasing the density of cement, and reducing filtrate losses. They also proved, through their studies, the possibility of replacing 25% of the cement with silica ash, which can give strength to the cement mortar and has a lower cost [19]. Ibrahim et.al studied the Effect of adding rice straw and the cotton stalk ashes on the performance of cement. Where both materials contributed to increasing the strength of cement and reducing the thickening time [20]. Assi and Almahdawi studied the effect of adding micro silica on the performance of Iraqi cement, as this material led to an increase in compressive strength and a decrease in the thickening time [21]. Assi et.al studied the effect of adding glass fiber and glass crumbs on the performance of Iraqi cement, as this material led to an increase in compressive strength and an increase in the thickening time, being non-reactive fillers and delaying the reaction, which gives time for the cement to develop its final compressive strength [22]. Ibrahim et.al investigated the effect of adding both Nano egg shells and rice straw ash with an addition ratio of (2-10) % on the properties of cement, where they found that both materials improve the mechanical properties of cement, increase its toughness, and reduce dry shrinkage [23].

3. Materials, Research Methodology and Experimental Work:

3.1 Materials:

In this research Iraqi oil well cement glass G, high sulfur resistance was used from Babel cement plant with the bellow additives:

3.1.1 Silica dust: also known as micro silica, is a by-product of the ferrosilicon metal production process in electric arc furnaces, as it is obtained from the smoke rising through the furnace stacks by the condensation process. Some specialists accepted Condensed Silica Fume (CSF). Silicon dioxide makes up about 90% of the composition of micro silica, and its particles are spherical in shape and ultra-fine, so that they are about 100 times softer than cement [24]. Part of the cement materials used in the concrete mix can be replaced with micro silica in proportions ranging from 7-15% of its weight. Micro silica is produced in Europe, Egypt, South Africa and India.

3.1.2 Crushed walnut shells: are a natural mixture of brown or light brown ingredients and are an all-natural, biodegradable, durable material with excellent strength properties. Crushed walnut shells are made from high quality natural walnut shells [25]. It is processed by crushing, polishing, fumigation, embalming and multiple sieving. It is characterized by its high content of cellulose, which may reach 60%, and lignin, which reaches 30%.

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

3.1.3 Sidr leaves: It is a species of the zizyphus tree, which is popular in the Middle East and also in some parts of Asia. Furthermore, it is sometimes referred to as Sidr tree leaves or Buckthorn leaves [26]. Because of their various benefits for health, along with their value for beauty, these leaves have been used in traditional medicine for centuries. First, the Sidr leaves were collected from the Sidr tree, avoiding the wilted and yellow leaves. After that, the leaves were exposed to the sun for the purpose of drying, and after a period of drying, the leaves were rubbed and cut into small pieces to speed up the process of preparing the powder. After two months of drying, the leaves are now ready to be ground into a fine powder using a food processor (it should be noted that the process was during the winter season, so care must be taken not to expose the leaves to water. It may take less time to dry them if drying in the summer). After grinding, a manual sieve is used to remove impurities and large pieces to ensure the quality of the powder. Figure (1) shows the used materials.

Fig. (1): The used materials: A. silica fume, B. sider leaves, C. Crushed walnut shells, Iraqi cement.

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

3.2 Research Methodology:

The beginning was from diagnosing the problem of Iraqi cement in terms of conducting chemical tests such as X-ray diffraction (XRF) and physical tests and comparing them with API standards as in Tables (1) and (2). Where it was found that the properties of Iraqi cement are not compatible with some API standards. Figure (2) shows the most basic steps and research strategies. where the problem of Iraqi cement lies in the fact that its silica content is low, about 18%, its strength is low, and its thickening time is short, in addition to its high softness. After preparing the materials used in the study, they are carefully analyzed in order to identify any impurities that may be present in them and examine their purity. For example, an X-ray diffraction analysis of cement was conducted. As for the ground walnut shells and micro silica their purity is checked by measuring their specific gravity, which should range between (1.2-1.4) and (2.2) g/cm^3.As for the ground Sider leaves, their purity was tested by measuring the pH, where the pH ranges from (8-9). In this study, materials in both normal and Nano sizes were used, and Table (3) shows this in detail.

Equation (1) to Equation (4): for calculating the weight percent of the cement main components [27]:

$$C_3S = (2.65 * \%Al_2O_3) - (1.69 * \% Fe_2O_3) \quad (1)$$

$$C_4AF = 3.04 * \%Fe_2O_3 \quad (2)$$

When the ratio of Al_2O_3 to Fe_2O_3 is less than 0. 64, the C_3S shall be calculated as follows:

$$C_3S = (4.07 * \%CaO) - (7.6 * \%SiO_2) - (4.48 * \%Al_2O_3) - (2.86 * \%Fe_2O_3) - (2.86 * \%SO_3) \quad (3)$$

$$C_2S = (2.87 * S) - (0.754 * C_3S) \quad (4)$$

Eq. (5) and Eq. (6) used to calculate the plastic viscosity and the yield point of the cement slurry [28].

$$\mu p = 1.5(\theta 300 - \theta 100) \quad (5)$$

$$Yp = \theta 300 - \mu p \quad (6)$$

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

Table. (1): XRF analysis for Iraqi cement and the additives.

Component	% in Iraqi Cement	% in Iraqi Cement after adding 15% Silica dust	Iraqi Cement after adding 15% sider leaves	Iraqi Cement after adding 15% crushed walnut shells	%API standard
MgO	1.77	0.766	0.867	0.965	0.9
Al_2O_3	2.996	2.428	2.1	1.998	5.6
SiO_2	18.63	44.58	29.87	25.67	24.66
SO_3	3.072	1.846	2.45	1.761	1.55
CaO	69.49	57.06	60.67	63.76	61.87
MnO	0.05061	0.0789	0.765	0.087	0.75
Fe_2O_3	5.587	4.964	4.87	3.65	0.38

Table. (2): Analysis of the basic components of Iraqi cement and additives

Component	Iraqi Cement	Iraqi Cement after adding 15% Silica dust	Iraqi Cement after adding 15% sider leaves	Iraqi Cement after adding 15% crushed walnut shells	API Specification
C_3S	**39.82**	**48**	**57.57**	**56.87**	**50**
C_2S	**19.74**	**20**	**19.31**	**18.875**	**20**
C_3A	**18.51**	**8.65**	**2.97**	**9.76**	**10**
C_4AF	**14.82**	**10**	**9**	**10.5**	**10**
MgO	**4.34**	**4.38**	**2.42**	**3.87**	**10**

Table (3): Particle Size (Micron to Mesh Conversion)

US Mesh*	Microns	Inches	Millimeters	Type
60	250	0.0098	0.25	Normal
170	88	0.0035	0.088	Nano

**Values are created on (API Specification 10A) [29].*

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

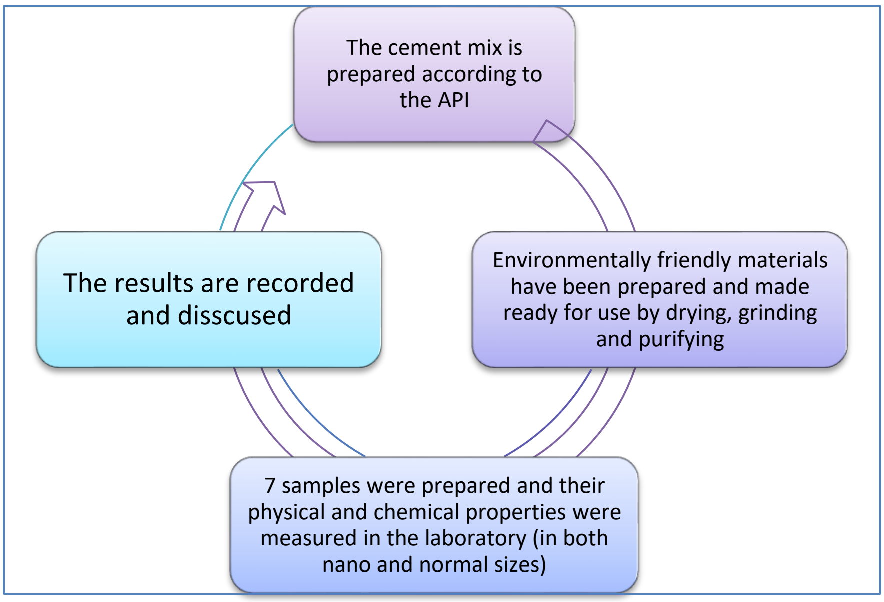

Fig. (2): Research Methodology

Figure (3) shows part of the cement bond log CBL and variable density log VDL sensors for one of the wells in the East Baghdad field. As the depths indicated in red indicate bad cement job. It should be noted that in this field the cement used is Iraqi cement, but without any additives that enhance its durability and compressive strength.

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

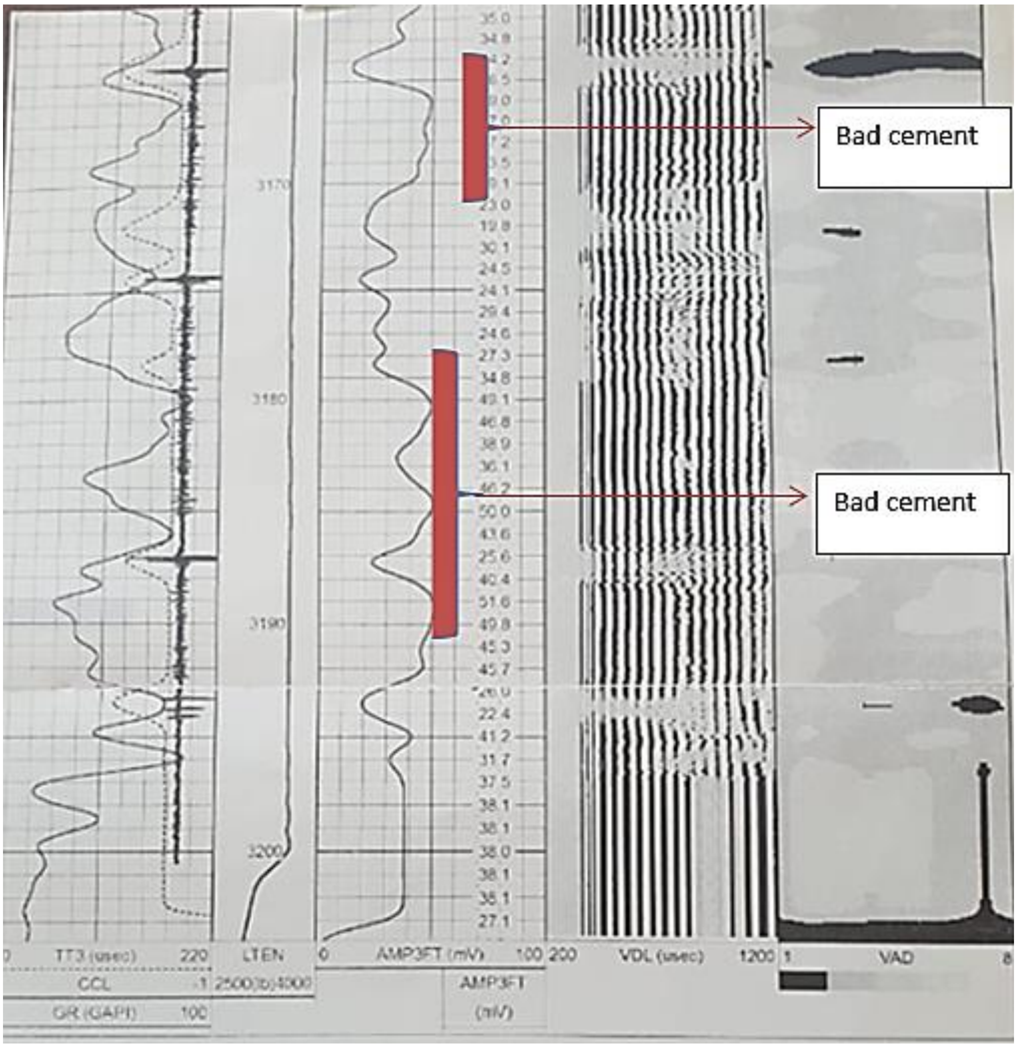

Fig. (3): CBL and VDL Log for one well in the X Field from (3150 to 3210) m

3.3 Experimental Work:

The results of seven laboratory samples of cement and additives were tested according to what is indicated in the API standards. The components of the samples are percentages and materials shown in Tables (4) and (5).

Each batch of manufactured cement must be examined before it is used to label the wells. The examination is carried out on pure cement without any additives. The quality of cement can be assessed indirectly through the following measurements:

1- Thickening time by HPHT consistometer. The thickening time is usually performed to determine the length of time that the cement remains in a liquid state and to know how long it remains pump able. As it is the time required to reach 100 Bearden units, this examination is

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

performed using a consist meter. Depending on the API, the thickness time at P=5200 Psi, T=52℃ is (90-120) min.

2- Specific gravity of cement slurry by pressurized mud balance. Cement is considered good if the specific gravity of the cement slurry is composed of water and cement with a weight ratio of (0.5) ranging between (1.80) and (1.84).

3- Free Water – Stability by graduated cylinder. Free water or stability is evaluated according to the percentage of water separated from the cement slurry. It is composed of water and cement in a weight ratio of (0.5) and is placed in a pipe with a volume equal to (250) cm^3. The cement is considered good if the amount of water separated does not exceed (1%) of the volume. The total paste was 2.5 cm^3 after leaving the slurry to rest for two hours under laboratory conditions.

4- Filtration of cement slurry by fluid losses tester. Cement slurry filtration is measured using the same method as drilling fluid filtration. Cement is considered good if the volume of cement slurry filtrate consisting of water and cement in a ratio of (0.5) does not exceed (850) cm^3 measured with a (baroid) device in a time of (30) minutes and (100) pound /inch square. The filtration must be small so as not to affect the productive layers and to not lead to high cohesion of the cement slurry, which leads to increased pressure in the pumps and sometimes stops circulation. Therefore, it is necessary to treat the cement slurry with filtration reducers. The test of fluid loss is performed as per API recommended practice for testing well cements, API does not identify ranges, in API 65 they mention that has to be low,46 ml/30 min is a low value, usually used for production zones.

5- Mechanical strength of cement rock. The mechanical resistance of cement rock is evaluated either by compressive strength or by tensile strength. The cement is considered good if it forms a cement rock with a compressive strength of no less than (500) pounds on a square knot within the first eight hours.

6- Rheology by viscometer by HPHT curing machine. After recording the dial readings, divide the Up readings by the Down readings to get their ratio. If the ratio is other than 1:1 it can be an indication the slurry may have settling or gelation problems. There may be settling problems if the readings are 5 numbers less for the down readings than for the up readings. This is for the #1 bob, sleeve and spring. API recommends this readings (maximum 300 rpm) for cement as well, the table from below is part of API 10-B-2, for testing Well cements, the results of this test has really

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

low viscosity suitable for a low rheology requirement (Coiled tubing operation for example but Thickening time is too short) Figure (4) shows the used device.

Fig. (4): The used devices.

Table (4): Mixing Quantities of the samples

Samples NO.	Iraqi Sample A	Iraqi Sample B	Iraqi Sample C	Iraqi Sample D
Cement amount(g)	792	792	792	**792**
Mixed water (ml)	349	349	349	**349**
Silica dust % BWOC	0	15	0	**0**
crushed walnut shells % BWOC	0	15	0	**0**
Superplasticizer(ml)	75	75	75	**75**
sider leaves % BWOC	0	15	0	**0**
Fiber glass% BWOC	0.5	0.5	0.5	**0.5**
KCL% BWOC	5	5	5	**5**

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

Table (5): Mixing Quantities for the Nano samples

Samples NO.	Iraqi Sample E	Iraqi Sample F	Iraqi Sample G
Cement amount(g)	792	792	**792**
Mixed water (ml)	349	349	**349**
Nano Silica dust % BWOC	1.5	0	**0**
Nano crushed walnut shells % BWOC	1.5	0	**0**
Superplasticizer(ml)	75	75	**75**
Nano sider leaves % BWOC	1.5	0	**0**
Fiber glass% BWOC	0.5	0.5	**0.5**
KCL% BWOC	5	5	**5**

4. Results and Discussion:

Table (6) shows Laboratory Results (rheology, filtration and density). All materials contributed to increasing the viscosity and yield point and reducing the size of the filtrate of the cement, but the most effective of them was Nano silica dust, and the least effective was the Sider leaves powder. And the opposite is true for the density, where all the materials contributed to the reduction of the density, and most of them were Nano powdered sider paper. The viscosity of the cement fluid must be within reasonable limits, which enables us to pump it into the well easily and then displace it into the annular space, because this viscosity is considered the main element that determines the end of the possibility of the pumping of the cementing liquid and thus the end of the cementation process, which is related to the ratio of water to cement and other additives, pressure and temperature. The cement liquid must have a small filtration loss, because if the opposite occurs, it leads to an increase in the viscosity of the cement liquid, and thus the inability to raise it in the annular space to the prescribed height. This feature is of great importance, especially in deep wells that exceed 1500 m, where the greater the pressure difference formed, the greater the percentage of water lost by leaching, and if the cement mixture loses the water necessary for reaction and bonding, it's become with low durability The fluid loss is measured using a low or high pressure baroid device, according to the conditions in the well. Table 8 shows the laboratory results of the compressive strength test of cement at 38 degrees Celsius, where the Nano-silica dust material gave the highest value for compressive strength and lowest free water because it contains a high

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

percentage of silica which has the ability to absorb water. The opposite is true in the case of thickening time, where Nano-silica dust was the least effective and even gave an unacceptable value within API standards. As for the Nano-ground walnut shells, it was the best in giving the thickening time as it is a substance rich in fiber, which slows down the reaction. Figure 5 shows the effect of adding environmentally friendly materials on the compressive strength of cement at 60 degrees Celsius, where Model E consisting of Iraqi cement and Nano silica dust was the best performance. The reason behind this is that it is composed of silica, which is known to be a material that gives durability and an increase in compressive strength. The slurry rheology is tested at different temperatures, could be more than 2, in order to use this data in hydraulic simulators, surface temperature and downhole circulating temperature (simulated or from API tables) Figure (6) shows the use of the E as a tail model and the B as a lead model by using CemCADE software (cementing design and evaluating software). To investigate the possibility of using it in the field, as the figure shows how cement is calcined.

Table (6): Laboratory Results (rheology, filtration and density).

Materials	µp (Cp)	Yield point (lb./100ft^2)	Fluid losses (ml/30 min).	ρ (gm/cc)
Nut cement	**51**	**37**	**42**	**1.88**
15 % silica dust	**58**	**41**	**36**	**1.87**
15 % sider leaves	**52**	**38**	**39**	**1.82**
15 % crushed walnut shells	**53**	**40**	**38**	**1.86**
1.5 % Nano silica dust	**69**	**48**	**20**	**1.83**
1.5 % Nano sider leaves	**60**	**47**	**25**	**1.8**
1.5 % Nano crushed walnut shells	**58**	**45**	**29**	**1.85**

Table (7): Laboratory Results (compressive strength, thickening time and free water)

Sample NO.	**Compressive strength (Psi)@ 38 C ,8 hr. Curing**	**Thickening time(min) P=5200 Psi,T=52°C**	**Free water (%)**
Sample B	750	90	2.25
Sample C	400	98	2.4
Sample D	410	103	2.3
Sample E	1100	88	0
Sample F	900	139	1.6
Sample G	850	136	1.34
API standard	300	90-120	5.9
Net cement A	390	95	2.5

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

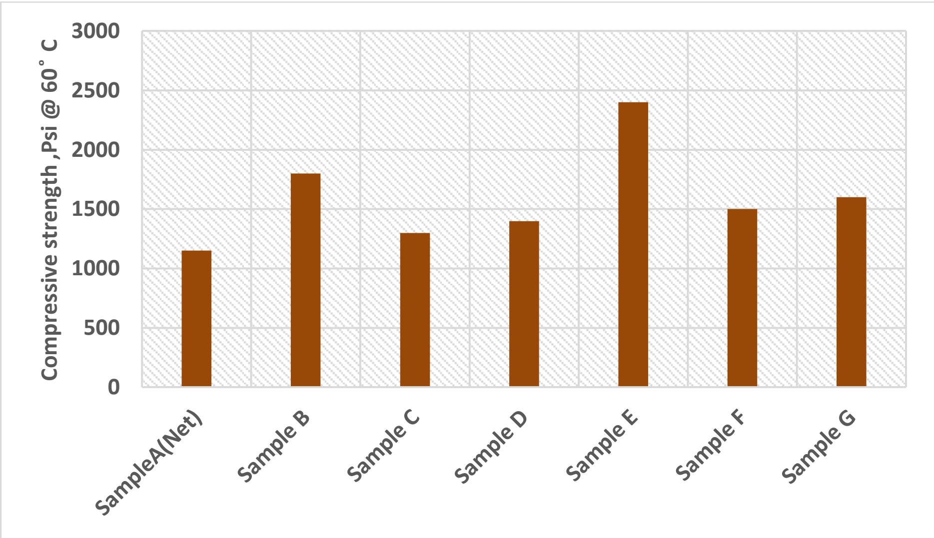

Fig. (5): Compressive strength at 60̊ C (8 hr. Curing).

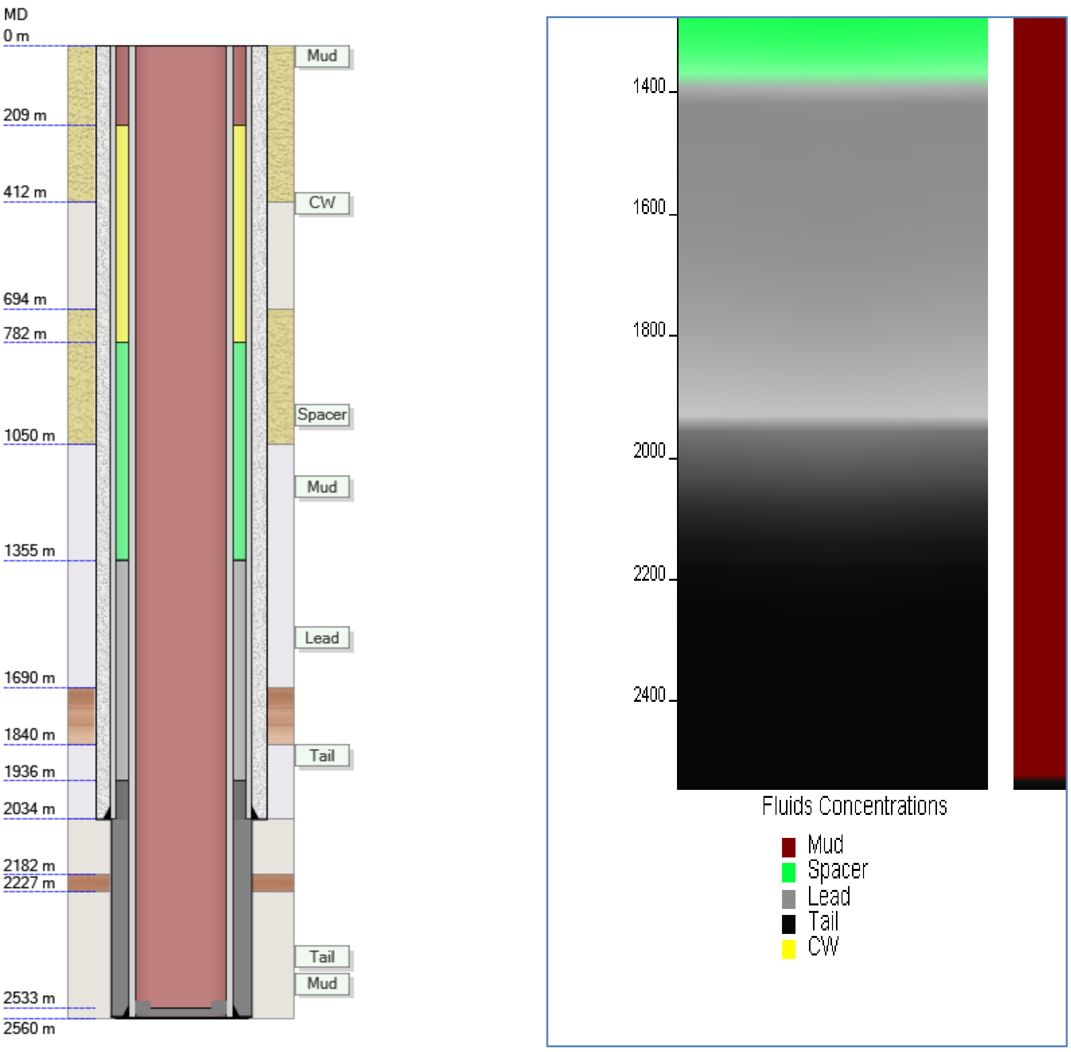

Fig. (6): Final fluid concertation

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

5. Conclusions:

From the physical and chemical laboratory results, the following conclusions can be drawn:

1. The problem of Iraqi cement is that it contains a small percentage of silica, about 18%, which is not desirable because according to API standards, the percentage must be higher than 24%, in order to give the cement, the required compressive strength.
2. The addition of Nano silica dust at a rate of 1.5% BWOC led to an increase in the strength of the cement resistance by about 3 times what it was without addition at 38 degrees Celsius.
3. The addition of crushed walnut shells reduced the thickening time at a rate of 1.5% BOWC, as this material can be considered as one of the environment-friendly thickening time delays.
4. Nano-sized Sidr paper reduced its density because it contained saponin when 1.5% BWOC was added.
5. Using the CemCADE program, it was proven that it is possible to use models B and E during cement operations.

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

References

[1] A. H. Assi, "Selection of an Optimum Drilling Fluid Model to Enhance Mud Hydraulic System Using Neural Networks in Iraqi Oil Field", *Journal of Petroleum Research and Studies*, vol. 12, no. 4, pp. 50-67, Dec. 2022. https://doi.org/10.52716/jprs.v12i4.585

[2] J. Gu, J. Huang, and H. Hao, "Influence of mud cake solidification agents on thickening time of oil well cement and its solution", *Construction and Building Materials*, vol. 153, pp. 327-336, 2017. https://doi.org/10.1016/j.conbuildmat.2017.07.128.

[3] M. Khalil, B. M. Jan, C. W. Tong, and M. A. Berawi, "Advanced nanomaterials in oil andgas industry: design, application and challenges", *Applied Energy*, vol. 191, pp. 287-310, 2017. https://doi.org/10.1016/j.apenergy.2017.01.074.

[4] F. Torabian Isfahani, E. Redaelli, F. Lollini, W. Li, and L. Bertolini, "Effects of nano-silica on compressive strength and durability properties of concrete with different water to binder ratios", *Adv. Mater. Sci. Eng.*, pp. 1–16. 2016. https://doi.org/10.1155/2016/8453567

[5] A. K. Abbas, A. H. Assi, H. Abbas, H. Almubarak, and M. Al Saba, "Drill bit selection optimization based on rate of penetration: Application of artificial neural networks and genetic algorithms", *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference ADIP*, 2019. https://doi.org/10.2118/197241-MS

[6] A. H. Assi, "The Geological Approach to Predict the Abnormal Pore Pressures in Abu Amoud Oil Field Southern Iraq", *Iraqi National Journal of Earth Science*, vol. 23, no. 2, pp. 250-265, 2023. http://dx.doi.org/10.33899/earth.2023.140601.1088

[7] Layla S. Al-Jaaf, and Sameera M. Hamd-Allah, "Huff-n-Puff Process for Enhancement Heavy Oil Recovery for the Tertiary Reservoir in the Qaiyarah Oil Field Northern Iraq", *Iraqi Geological Journal*, vol. 57, no. 2D, 2024. https://doi.org/10.46717/igj.57.2D.6ms-2024-10-16

[8] O. E. Agwu, J. U. Akpabio, and M. G. Akpabio, "Potentials of waste seashells as additives in drilling muds and in oil well cements", *Cleaner Engineering and Technology*, vol. 1, 2020. https://doi.org/10.1016/j.clet.2020.100008

[9] A. H. Assi, "Using Environmentally Friendly Materials to Improve the Properties of the Drilling Fluid", *IJCPE*, vol. 25, no. 1, pp. 121–128, Mar. 2024. https://doi.org/10.31699/IJCPE.2024.1.12

[10] American petroleum institute, "Specification for well cements", API Specification 10A, 21st ed., *Amerrcan Petroleum Institute*, Washington DC, 1991.

[11] T. Ji, "Preliminary study on the water permeability and microstructure of concrete incorporating nano-silica", *Cement and Concrete Research*, vol. 35, no. 10, pp. Pages 1943-1947, 2005. https://doi.org/10.1016/j.cemconres.2005.07.004

[12] A. H. Assi, Z. F. Rasheed, "Studying the Effect of Geological Formation and Formation Water on Drilling Fluid Performance (Case Study)", *Pet. Chem.*, vol. 64, pp. 739–746, 2024. https://doi.org/10.1134/S0965544124050013

[13] F. Aslani, G. Ma, D. L. Yim Wan, and G. Musel, "Development of high-performance self-compacting concrete using waste recycled concrete aggregates and rubber granules. Journal of Cleaner Production", vol. 182, pp. 553-566, 2018.

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

https://doi.org/10.1016/j.jclepro.2018.02.074

[14] H. Sasanipour, F. Aslani, and J. Taherinezhad, "Effect of silica fume on durability of self-compacting concrete made with waste recycled concrete aggregates", *Construction and Building Materials*, vol. 227, 10 December 2019. https://doi.org/10.1016/j.conbuildmat.2019.07.324

[15] I. S. Agwa, O. M. Omar, B. A. Tayeh, and B. A. Abdelsalam, "Effects of using rice straw and cotton stalk ashes on the properties of lightweight self-compacting concrete", *Construction and Building Materials*, vol. 235, 117541, 2020. https://doi.org/10.1016/j.conbuildmat.2019.117541

[16] H. Assi, and F. H. M. Almahdawi, "Experimental study of micro silica behavior and its effect on Iraqi cement performance by using x-ray fluorescence analysis", *Iraqi Geological Journal*, vol. 53, No. 2E, 2020 .https://doi.org/10.46717/igj.53.2E.5Ms-2020-11-27

[17] A. H. Assi, F. H. M. Almahdawi, and Q. A. Khalti, "The Influence of Glass Fiber and Milled Glass Fiber on the Performance of Iraqi Oil Well Cement", *Journal of Petroleum Research and Studies*, vol. 11, no. 2, pp. 30-48, Jun. 2021. https://doi.org/10.52716/jprs.v11i2.496

[18] I. Y. Hakeem, M. Amin, I. S. Agwa, M. H. Abd-Elrahman, O. M. O. Ibrahim, and M. Samy, "Ultra-high-performance concrete properties containing rice straw ash and nano eggshell powder", *Case Studies in Construction Materials*, vol. 19, e02291, December 2023, https://doi.org/10.1016/j.cscm.2023.e02291

[19] U. Alameedy, A. Wattan, A. H. Assi, and M. Al-Jawad, "Empirical Correlation for Determination of Shear Wave Velocities from Wireline Logs in West Qurna Oil Field", *Petroleum and Petrochemical Engineering Journal*, vol. 7, no. 2, pp. 1-16, 2023. https://doi.org/10.23880/ppej-16000346

[20] A. Abd Alhaleem, S. H. Sahi, and A. H. Assi, "Bit Performance in Directional Oil Wells", Journal of Engineering, vol. 21, no. 11, pp. 80-93. 2015. https://doi.org/10.31026/j.eng.2015.11.05

[21] A. H. Assi, "Investigation of drilling problems in Iraqi oil fields (Review)", *Iraqi Journal of Oil and Gas Research*, vol. 3, no. 2, pp.1-18, 2023. http://dx.doi.org/10.55699/ijogr.2023.0302.1041

[22] R. A. Deabl, A. A. Ramadhan, and A. A. Al-Dabaj, "Evaluation of Petrophysical Properties Interpretations from Log Interpretation for Tertiary Reservoir/Ajeel Field", *Iraqi Journal of Oil and Gas Research*, vol. 1, no. 1, pp. 28-44, 2021. http://dx.doi.org/10.55699/ijogr.2021.0101.1009

[23] A. H. Assi and A. A. Haiawi, "Enhancing the Rheological Properties of Water-Based Drilling Fluid by Utilizing of Environmentally-Friendly Materials", *Journal of Petroleum Research and Studies*, vol. 11, no. 3, pp. 66-81, Sep. 2021. https://doi.org/10.52716/jprs.v11i3.533

[24] A. H. Assi, A. A. Haiwi, "The Effect of Weighting Materials on the Rheological Properties of Iraqi and Commercial Bentonite in Direct Emulsion", *Iraqi Geological Journal*, vol. 54, no. 1F, pp. 110-121, 2021. https://doi.org/10.46717/igj.54.1F.10ms-2021-06-30

[25] V. Thakar, S. Nambiar, M. Shah, and A. Sircar, "A model on dual string drilling: on the

Open Access
Vol. 15, No. 1, March 2025, pp. 106-123

P- ISSN: 2220-5381
E- ISSN: 2710-1096

road to deep waters", *Modeling Earth Systems and Environment*, vol. 4, pp. 673–684, 2018. https://doi.org/10.1007/s40808-018-0457-6.

[26] American Petroleum Institute (API), "Specification 10A: Specification for Cements and Materials for Well Cementing", API/ANSI/ISO 10426-1. Washington, *DC: American Petroleum Institute*, 2002.

[27] A. T. Bourgoyne Jr, K. K. Millheim, M. E. Chenevert, and F. S. Young Jr, "Applied Drilling Engineering", *Society of Petroleum Engineers Text Book Series*, vol. 1: Richardson, TX. 1986.

[28] G. Bush, and K. O'Donnell, "Global cementing best practices", *Occidental Oil and Gas Corp., Global Drilling Company*, p. 65, 2007.

[29] A. H. Assi, "Potato Starch for Enhancing the Properties of the Drilling Fluids", *Iraqi Journal of Chemical and Petroleum Engineering*, vol. 19, no. 3, pp. 33-40, Sep. 2018. https://doi.org/10.31699/IJCPE.2018.3.4