

# Improve the Properties of Iraqi Bentonite Using Salts

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**Abstract.** After the success of experiments using the Iraqi Bentonite in the work of drilling oil wells as an alternative to the importer Bentonite which encouraged its use as an alternative for the work of civil excavation, such as diaphragm walls, drilling, bore pile, barriers, dams and tunnels. By changing the mixing and drilling method followed in the work of oil wells, which requires the conduct of many experimental mixtures to reach the optimal mix. Benefits were getting from the previous experiments conducted on such type of Bentonite were used by the General Company for Geological Survey and Mining and Ramadan Mubarak Company one of the formalization of the Ministry of Housing and Construction; in which the optimum mix was reached, the method of mixing was determined, the components and quantities of the materials included in the preparation of the optimal mix were determined in 1m<sup>3</sup> of water for mixing time of 5 min. This study was supported by the results obtained by the Geological Survey and Mining Company, which relied on the use of (NaOH) as an alternative to the active calcium-centric (CMC) of Bentonite, which is considered to be one of the most expensive materials. This paper will be a good index for all concerned with implementation of civil excavations and field works.

## 1 Introduction

Bentonite is the name given to clay materials that have the ability to swell and bond when mixed or dissolved in water [1].

The name Bentonite originates from the discovery of a type of clay found near the Benton area in the United States in the nineteenth century. It was used in the drilling of oil wells in the state of Dakota in the United States, the type of sodium [2]. As the time progressed, Bentonite began to work in the civil works in Iraq to its quality, its ability to swell and the formation of the thick, transparent wall that surrounds the drilling sides due to its chemical properties because it contains sodium; but because of its economic cost and the difficulty of transporting it from the United States to other parts of the world, the need of available locally Bentonite was raised in Iraq, the local Bentonite used to drill the oil wells has been directed in the country. However, there is a problem in the Iraqi Bentonite due to its chemical composition as it is a calcium type which has a negative impact on the civil excavation [3]. The effect of calcium ion concentration on fluid viscosity which can be expressed with the minimum limits of 150-200 mg/liter from filtration loss. The negativity of these liquids is when the temperature greater than (100 °C) or when drilling for deepest elevation; the oxide Calcium under a very alkaline medium leads to the formation of products similar to those formed at the hardening of the liquid. This means a sharp increase in viscosity and gel strength to reduce this phenomena is by reducing the concentration of the chloride, calcium oxide. It is worth noting this material in its natural state. It is a kind of soil characterized by high smoothness and free of calcareous materials which have a negative effect on the skin, and easily transform into very fine powder and form with water.



The gluten gel solution remains stuck and spread throughout the water content for a long time, in addition to the high purity of these soils with kaolin are almost ineffective and thus have no effect on the skin, especially when they are free of calcareous materials. All these features they play an important role in sustaining the skin's freshness and softness of hair.

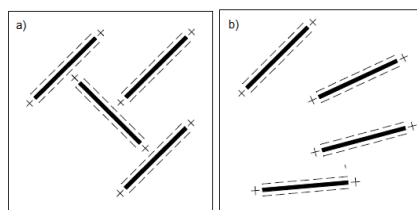
Many people may be able to observe the material presence in different parts of the Kurdish land, especially in the taxonomic areas. However, the geological studies carried out by the General Company for Geological Survey indicate that the material is located in a mining facility in the Qarabah area of Kasr Kefri, called the Catapult [4].

The main task of the drilling fluid in civil works is to prevent the hole sides from collapsing. In addition, the liquid flowing through the ring cavity deposits a protective envelope porous formation which is called as a mud cake. As a consequence of drilling operation a part of water composed of the drilling fluid will enter through the permeable layers by the hydrostatic pressure of the liquid column, the part of the water that enters will be called as (Filtration loss), and the benefits of the mud crust is to install the hole walls and prevent it from collapsing. This paper deals with the effect of additions to drilling fluids in detail; the general and specific objectives of this research. In the following section deals with the properties of drilling fluids (Muds), in addition to the different types of drilling fluids such as the American and Iraqi Bentonite.

To illustrate the manner in which research was carried out and the various experiments undertaken for this study. At the end of this research, some recommendations and engineering proposals were presented based on laboratory results in the field of drilling fluids.

## 2. Statement of the Problem

Bentonite is commonly in interaction with water; therefore the properties of clay-water are of fundamental importance to the engineering works [5]. The chemical composition of Bentonite is vital due to changes in its physical properties that is combined to its chemical compositions. Generally there are three common kinds of Bentonite in the world, namely (natural sodium; natural calcium and sodium-activated) [6]. All Bentonite have a tendency to exchange cations more than other clays when it's mixed with water; this phenomenon is known as thixotrop see Figure 1.



**Figure 1.** Thixotrop phenomenon: a) slurry to get; b) slurry becomes fluid.

Sodium bentonite is "characterized by very high swelling ability, high liquid limit and low filter loss and high cost. This Bentonite was used as the standard by which all other Bentonites were measured for many years. The predominant exchangeable cation in natural sodium bentonite is the sodium cation but there may also be significant amounts of other cations present.

Natural calcium Bentonite, where calcium is the predominant exchangeable cation, is mined worldwide. It has much lower swelling ability and liquid limit, and much higher filter or fluid loss than natural sodium Bentonite which is not suitable for the purpose of drilling" [6].

Sodium-activated Bentonite is created by the adding of  $\text{Na}_2\text{CO}_3$  to calcium Bentonite [7],[8]. This effects a base exchange on the surfaces of the clay particles, replacing calcium ions with those of sodium. The result is a Bentonite exhibiting many of the typical characteristics of a natural sodium Bentonite. Most Bentonites used in civil engineering to produce support fluids are sodium-activated. But there is a need to discover the differences between these additives ( $\text{Na}_2\text{CO}_3$  vs  $\text{NaOH}$ ) on parameters (viscosity, filter loss and pH) under the same circumstances of testing.

## 3. Practical Side

The aim of the treatment is to improve the properties of the locally Bentonite liquid only, especially with regard to the mud cake properties Not to get special fluids. The properties of the liquid are secured by mixing (Bentonite + water) and the properties of the original liquid are improved by adding

some substances such as viscous dampers, lossless filtration loss and other substances that affect the properties of the original liquid.

To simulate the mixing device used in the formation of Bentonite solution which is located in the civil excavation sites, a similar device; mud mixer used in this survey.

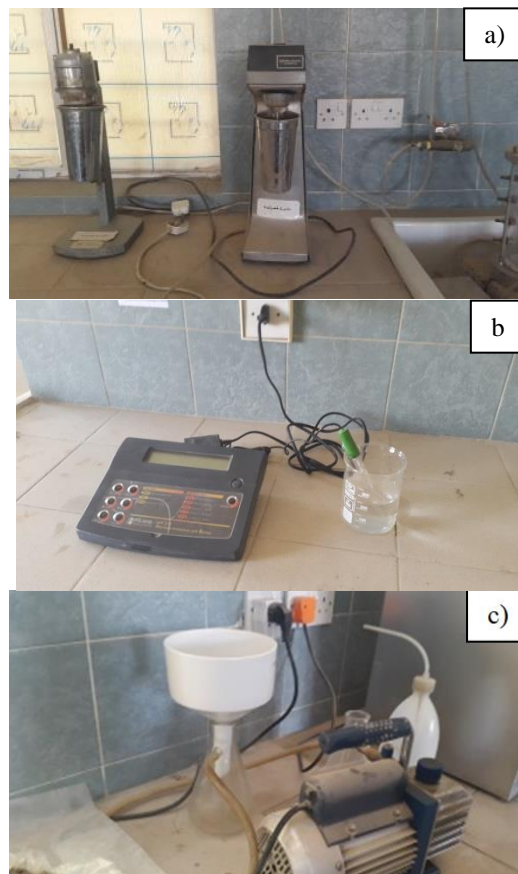
### 3.1. Method of examination

First, a mixture of non-activated local Bentonite with certain proportions shall be mixed in the mixing apparatus and shall be tested according to the international specifications after 24 hours of the mixing process, in which the solution shall be examined in terms of viscosity, density, permeability (as a filter loss) and PH. Second, taking a sample of Bentonite and activating it with sodium hydroxide in a certain percentage. It is tested according to the international specifications after 24, 48, 72, 96 hours of the mixing process, after which the solution is examined in terms of viscosity, density, permeability and pH. The same steps will be applied for Bentonite activated with soda ash (sodium carbonate).

### 3.2. The experimental procedure

Figure 2, shows the mud mixer apparatus. The water cup was filled by the specified quantity of distilled water about (1000ml), the added, solids were weighed at a specific percent as shown in Table 1-2.

Turn on the machine to move the water inside it and then add the solids gradually according to the pre-determined quantity were done waiting, for 3 to 5 minutes until the mixture is homogenized. These steps are repeated for all tested samples, for all tested samples the density was calculated with the mud balance apparatus. While the apparent viscosity will be reported according to Marsh Funnel viscosity; which is express by the time required to fill a volume ( $964\text{cm}^3$ ) during Marsh Funnel measured in size. Notice that the measured viscosity of water is 26 Sec. The filter loss was measured according to test presented in Figure 2(c); the amount of filtered water through filter paper ( $\text{cm}^3$ ); the thickness of the filter cake is measured in millimeters.



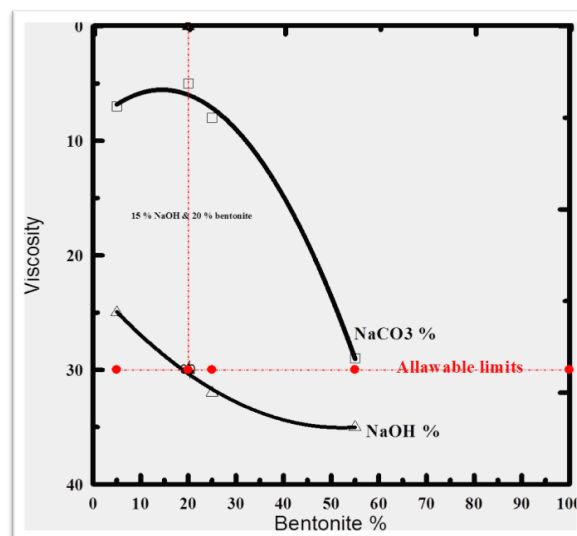
**Figure 2.** Testing apparatus: a) Mud mixer; b) pH-meter; c) Filter press.

#### 4. Discussion of Results

As is known, one of the most important difficulties that hampered access to the best mix of several and most complex was the process of converting the local Bentonite from the type of calcium to the type of sodium by the process of activation by adding both sodium ash and caustic soda [5] during the mixing process.

Through this study, several key factors have been observed that have an effect on the functioning of the activation process such as (mixer type; the time period for mixing and the percentage of additives added).

These factors can be controlled on-site through experimental mixtures [6]. The results of this test showed that the viscosity of the solution was not matched to what is required, as well as the amount of separation when mixing the additives and increasing the mixing time more over than 48 hours compared to the results obtained for the same Bentonite with certain additives and for specific time periods. The results of the tests were significantly improved when using caustic soda (NaOH), which is an alternative to CMC, as shown in Table 1-2.

**Figure 3.** Effect of additives on Iraqi Bentonite.**Table 1.** Effect of additives on Bentonite solution properties: a)  $\text{Na}_2\text{CO}_3$ , b) NaOH, c)  $\text{Na}_2\text{CO}_3 + \text{NaOH}$  (After [8])a)  $\text{Na}_2\text{CO}_3$ 

(B-W) %	Time of Testing (h)	Additives %	Density of solution $\text{g} / \text{cm}^3$	Viscosity	Loss of fluid	PH
5	48	2	1.02	8	-	10
20	=	15	1.03	6	-	10
30	=	25	1.038	25	-	10
35	=	30	1.04	25	-	10
45	=	35	1.036	34	-	10
55	=	40	1.04	35	35	10
(B-W) %	Time of Testing (h)	Additives %	Density of solution $\text{g} / \text{cm}^3$	Viscosity	Loss of fluid	PH
5	72	2	1.03	28	-	10
20	=	15	1.03	29	-	10
30	=	25	1.05	29	-	10
35	=	30	1.05	33	-	10

45	=	35	1.05	34	-	10
55	=	40	1.05	34	-	10
(B-W) %	Time of Testing (h)	Additives %	Density of solution g / cm <sup>3</sup>	Viscosity	Loss of fluid	PH
5	96	2	1.05	30	-	10
20	=	15	1.06	33	-	11
30	=	25	1.06	35	-	11
35	=	30	1.06	35	-	11
45	=	35	1.06	35	-	11
55	=	40	1.06	35	-	11

## b) NaOH

(B-W) %	Time of Testing (h)	Additives %	Density of solution g / cm <sup>3</sup>	Viscosity	Loss of fluid	PH
5	48	2	-	7	36	-
20	=	15	1.04	8	20	10
25	=	25	1.04	9	29	10
55	=	40	1.04	29	-	9
(B-W) %	Time of Testing (h)	Additives %	Density of solution g / cm <sup>3</sup>	Viscosity	Loss of fluid	PH
5	72	2	-	7	36	-
20	=	15	1.04	8	20	10
25	=	25	1.04	9	29	10
55	=	40	1.04	29	-	9
(B-W) %	Time of Testing (h)	Additives %	Density of solution g / cm <sup>3</sup>	Viscosity	Loss of fluid	PH
5	96	2	-	7	36	-
20	=	15	1.04	8	20	10
25	=	25	1.04	9	29	10
55	=	40	1.04	29	-	9

C) Na<sub>2</sub>CO<sub>3</sub>+NaOH

(B-W) %	Time of Testing (h)	Additives (Na <sub>2</sub> CO <sub>3</sub> ) %	Additives (NaOH) %	Density of solution g / cm <sup>3</sup>	Viscosity	Loss of fluid	PH
5	48	2	1	1.02	29	-	8
5	=	3.5	1	1.06	30	-	9
6	=	2	1	1.05	28	-	8
6.5	=	5.5	1	1.06	30	-	10
6.5	=	5.5	1	1.05	28	-	10
5.5	=	5	-	1.04	28	-	10
(B-W) %	Time of Testing (h)	Additives (Na <sub>2</sub> CO <sub>3</sub> ) %	Additives (NaOH) %	Density of solution g / cm <sup>3</sup>	Viscosity	Loss of fluid	PH
5	72	2	1	1.04	28	-	9
5	=	3.5	1	1.05	28	-	9
6	=	2	1	1.05	30	-	9
6.5	=	5.5	1	1.05	28	-	-
5.5	=	5.5	-	1.05	28	-	-

After examining the results of the laboratory tests of the activated Iraqi Bentonite and compared them with the specifications of Bentonite solution adopted by the Union of experts of Piles (FPS) [6], [9] has been fixed limits of specifications required for the material activator Iraqi Bentonite and according to the table 3, noting that all the results were supported the results of the General Company for Geological Survey which was advised to use caustic soda. The percentage of addition of the best

results for mixing according to this research study is 15% for sodium hydroxide for the mixing ratio of 20% Bentonite of water. Figure 3 below shows comparison between the optimum mixing percentages of both additive if used alone. The Figure illustrates that caustic soda has a great influence on viscosity more than  $\text{Na}_2\text{CO}_3$ ; while the same additives gave the same influence on Bentonite slurry if they mixed together under a specific quantity with less mixed percent for Bentonite. See Table 2.

**Table 2.** Optimum mixing percentage (After [8])

(B-W) %	Time of Testing (h)	Additives ( $\text{Na}_2\text{CO}_3$ ) %	Additives (NaOH) %	Density of solution $\text{g} / \text{cm}^3$	Viscosity	Loss of fluid	PH
5	24	5	1	1.038	27	-	9
5	48	5	1	1.037	28	-	10
5	72	5	1	1.039	29	-	10
5	96	5	1	1.04	30	-	10
(B-W) %	Time of Testing (h)	Additives ( $\text{Na}_2\text{CO}_3$ ) %	Additives (NaOH) %	Density of solution $\text{g} / \text{cm}^3$	Viscosity	Loss of fluid	PH
5	24	5	1.5	1.037	30	-	10
5	48	5	1.5	1.036	31	-	10
5	72	5	1.5	1.04	33	-	10
(B-W) %	Time of Testing (h)	Additives ( $\text{Na}_2\text{CO}_3$ ) %	Additives (NaOH) %	Density of solution $\text{g} / \text{cm}^3$	Viscosity	Loss of fluid	PH
5	24	5	2	1.039	30	-	10
5	48	5	2	1.037	31	-	10
5	72	5	2	1.038	32	-	10
5	96	5	2	1.04	33	-	11.5

**Table 3.** The permissible limits for the properties of the suspended solution and according to the Union of experts of the pillars [6], [9].

According to international standards	
Les 1.1	Density
30- 90 Sec	Viscosity
28	Loss of fluid
9.5 -12	PH
Iraqi Bentonite Activated with NaOH	
1.03-1.04	Density
10-35	Viscosity
29-32	Loss of fluid
10-12	PH

## 5. Conclusion

Treatment of Iraqi Bentonite was used successfully, noted that there are some factors directly affected the efficiency and quality of this treatment, including the following:

1. Mixer quality, the speed of the rotation and the mixing time, which requires conducting experiments before the actual commencement of work to reach the required standard.
2. The quality of the Iraqi Bentonite that's mean the sourcess of the tested samples.
3. Quality and purity of the additive materials.
4. The Iraqi Bentonite gives an internal membrane filter more than the membrane rate of the foreign Bentonite. This requires the casting process and a high balance with the concrete slab to ensure that it rises inside the casting tube according to the required specifications.
5. Do not leave Bentonite solution more than 48 hours to ensure that the thickness of the membrane is not increased, which causes difficulty in the process of casting and this problem is required to avoid the site. Bentonite dried after the activation and examinations according to the specifications required and then use it to stabilize the chemical composition.
6. The results show the vital role of NaOH combined with  $\text{Na}_2\text{CO}_3$  as a success activator for Iraqi Bentonite besides to its role as Bactericides in dirling liquid.

7. Its recommended to do the testing steps on a large mixer device model like 1\*1\*1 m (L, W, H) and make a comparison with the obtaining results and study the time effect on filter cake thickness under the variety of additives

8. Its recommended to study more factors like the temperature; gel strength; effect of Polymer % on the yield point and PH; Corrosion Inhibitors; and Thinners & Dispersants.

## **6. References**

- [1] A. Asad., et al. Suitability of bentonite clay: an analytical approach. *International Journal of Earth Science*, 2.3:88-95 (2013)
- [2] David J.DAppolonia and Christopher R.Ryan .Soil-Bentonite slurry trench cut –off walls. *Geotechnical Exhibition and Technical Conference, Chicago-March 26(1979)*
- [3] Report of the General Contracting Company for Pillars and Foundations, (1980)
- [4] Mustafa Ahmed Mohamed. Village of Jalabad and Al-Tayin Khawwah / Ghal Sahr. *Journal of Kilgamesh*, 2 (2006)
- [5] G. Arthur. Industrial application of Bentonite
- [6] Federation of piling specialists Bentonite support fluids in civil engineering (2006)
- [7] Saleh, Shakhathreh K.; Mahasneh, Mehaysen A. Activation of Jordanian Ore Bentonite by Sodium Carbonates. *Journal of Minerals and Materials Characterization and Engineering*, 3.06: 477 (2015)
- [8] Report submitted by the Ministry of Housing and Construction. Using the properties of Bentonite in Iraq (1993)
- [9] Federation of Piling Specialists, modifications (1977) to Specification for Cast in place Concrete Diaphragm Wall (published 1973) and Specification for Cast in place piles Formed under Bentonite Suspension (published 1975).

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