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THE UTILIZATION OF MALAYSIAN LOCAL BENTONITE AS AN EXTENDER AND FREE WATER CONTROLLER IN OIL-WELL CEMENT TECHNOLOGY

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Abstract

This paper presents the results of experimental studies for Malaysian bentonite from Sabah (Lahad Datu and Tawau areas) application in oil- well cementing as compared to world wide commercially used Wyoming bentonite of USA. Samples were dried, grounded and sieved into particle size of 75μm. The experiments include XRD & XRF techniques to determine the chemical compositions and mineralogical contents of bentonite. Methylene blue tests were carried out to estimate the value of cation exchange capacity (CEC) in order to determine the approximate montmorillonite content. In the cement performance tests, class-G cement slurry mixed with bentonite in the range of 2%- 16% BWOC. The cement slurries were tested in accordance of API Specification 10. Dry and wet treatment processes were also conducted for the Malaysian bentonite to upgrade its performance.

From laboratory investigations, it showed that Malaysian bentonite has less content of montmorillonite mineral and more impurity materials such as quartz, kaolinite, illite, muscovite and hematite, while Wyoming bentonite considered as high- quality bentonite. Malaysian bentonite has low values of CEC which had been improved after treatment processes. Malaysian bentonite has low degree of swelling. The free water of the cement slurry increased with the increase of bentonite concentrations as compared to Wyoming bentonite. On the other hand, after treatment processes, the free water decreases in the cement slurry with bentonite concentrations increased. The Lahad Datu's bentonite had lowered slurry density after the treatments than the Tawau's bentonite.

Introduction

Cement extender reduces slurry density and lower hydrostatic pressure during cementing operations, which in turn will help prevent the breakdown of weak formations and loss of circulation. It also reduces the amount of cement needed for the cementing operation. Since it is less expensive than cement, it brings considerable savings.

Three types of extender are normally used: water extender, low-density aggregate, and gas. Water is the commonest and cheaper extender for cement slurries. The more water that can be added to the slurry, the greater its volume or yield and, of course, the lower the slurry's density. Water extender allows the addition of water to the slurry while ensuring that solid remains in suspension, extenders such as clay and various water viscosifying agents allow the addition of excess water to achieve slurry extension. Such extenders maintain a homogeneous slurry, and prevent the development of excessive water. Low-density aggregate is material that has density less than Portland cement. Therefore, the density of the cement slurry is reduced when significant quantities of such extenders are present (Nelson, 1990). It can be obtained from volcanic ash, diatomaceous earth and fly ash. Gases such as nitrogen or air are used to prepare for lower density cement slurry without additional water. However, the disadvantage of extender is decreasing in the final compressive strength and the permeability of the set cement is increased. Extenders such as bentonite, foamed cement and microspheres decrease the cement slurry density and final compressive strength at 100°F after a 24-curing-hour period.

Although clay is one of the commonest minerals, it is not easy to define precisely. It can be said to be material of colloidal or near colloidal particle-size, made chiefly of hydrous aluminium silicates. The most frequently used clay-base extender is bentonite, a naturally occurring clay consisting largely of the mineral montmorillonite. This mineral has an expanding lattice i.e., water molecules can be incorporated in and around its structure. The extending properties of bentonite are greatly enhanced by mixing with the water and allowing it to hydrate completely prior to mixing with the cement (Dowell Schlumberger, 1989).

The objective of this paper is to investigate the application of Malaysian bentonite as an extender and free water controller in oil-well cement technology as compared to world wide commercially used Wyoming bentonite of USA.

Experimental work

Malaysian bentonite samples were collected from two different areas in Sabah; i.e Mansuli area of Lahad Datu district, and Andrassy area of Tawau district. The commercially world -wide Wyoming bentonite of USA was used for comparison and correlation. Sampling has carried out by using, Dormer auger from the required exact depth. The samples were dried in the oven for overnight at 55^0C, then crashed and ground into powder which was sieved into size of 75µm. This study focuses on blended a G-class cement with dry bentonite at concentration of 2% to 16% by weight of cement (BWOC) and evaluated its free water and density performance. The cement slurry has been prepared according to API Spec 10 Section 5. In addition, Malaysian bentonite has been treated with Na_2CO_3 (dry and wet processes) in order to improve its performance.

In addition, prior performance tests characterizations of bentonite samples have been examined by using XRD & XRF techniques. The SIEMEN D-500 X-ray diffractometer unit was used to determine the mineralogical contents of the bentonite samples. While automated Phillips PW1480 X-fluorescence spectrometer has been used for XRF technique to determine the chemical contents of the bentonite materials. Moreover methylene blue test was carried out according to API 13B to estimate the cation exchange capacity (CEC) which reflecting the approximate montmorillonite content.

Results and Discussions

Mineralogical and chemical contents

Table 1 shows that Wyoming bentonite samples contains more montmorillonite mineral than Malaysian bentonite. In addition, the Malaysian bentonite samples contain impurities such as quartz, kaolinite, illite and feldspar.

XRF data in Table 2 shows the amount of SiO_2 is higher in all bentonite samples, which indicated the presence of quartz as previously, discussed. Na_2O content is higher in the Wyoming bentonite than untreated local bentonite, but it increased after treatment, especially after the dry process. Fe_2O_3 content is higher in all local bentonite samples indicating the presence of hematite mineral.

Cation Exchange Capacity

Table 3 lists the average CEC of various bentonite samples. It shows that untreated Malaysian bentonite samples have lesser values of CEC (25 &30 meq/100g) due to the presence of other minerals such as quartz, kaolinite, illite and feldspar. CEC values of Malaysian bentonite samples after treatment have been improved, that due to the presence of sodium content in its structural composition during ionic exchange (Ca^{+2} replaced by Na^{+}). Tables 3 also shows that the treated local bentonite samples with dry process have higher values of CEC (40 & 45 meq/100g) as compared with the wet process samples (30 & 40 meq/100g) but still less competitive to Wyoming bentonite of USA.

Free Water Performance

The free water of cement slurry decreases with higher amount of bentonite added to the slurry. Figure 1 shows that the free water volume increases with untreated Malaysian bentonite increased in the slurry. This is due to the presence of the strong Ca^{+2} action, therefore, the bond between the montmorillonite structural plates is strong and the plates resisted to the invasion of water.

On the other hand, Wyoming bentonite has capable to control the free water content. Wyoming bentonite has Na^+ cation, which is relatively weak, and when mixed in slurry, the water molecules were absorbed by the Wyoming bentonite surface and separate the platelets, forming a relatively loose body with water molecules entrapped in it.

Figure 1 also shows that the free water content has been improved with treated Malaysian bentonite increases in the slurry due to increase of sodium content in its structural as previously discussed.

It is also shown in Figure 1 that the higher amount of treated Malaysian bentonite added to the cement slurry, the lesser would be that the free water content of cement slurry provided the amount is less than 2% BWOC. If the amount of bentonite added is more than 2% BWOC, the free water increases up to 8% BWOC of treated bentonite is added, after which the free water decreased with increases amount of bentonite added. As shown in Figure 1, the dry process of Malaysian bentonite samples had better control of free water content compared to wet process samples, but not as good as Wyoming bentonite.

Cement Slurry Density

In general the density of cement slurry decreased, with higher percentage of bentonite. It is in agreement with Nelson (1990) that the slurry density decreases with bentonite concentration increased.

Figure 2 shows that the density of cement slurry mixed with untreated Malaysian bentonite samples is heavier than the density of cement slurry mixed with Wyoming bentonite. This can be attributed to the highly presence of hematite mineral in the structural composition of untreated Malaysian bentonite samples rather than in the Wyoming bentonite sample. Figure 2 also shows that the density of cement slurry with treated local bentonite is lowered. This is due to the increasing of the sodium contents and slightly decreasing of Fe_2O_3 in their structural compositions as previously discussed. It is also shown in Figure 2 that Malaysian bentonite sample of dry process having better cement slurry density rather than wet process samples, but not as good as Wyoming bentonite samples.

Conclusions

Malaysian bentonite contains less montmorillonite mineral and more impurity materials i.e., kaolinite, illite, quartz and feldspar, while Wyoming bentonite has more montmorillonite mineral and less impurity materials.

Treated Malaysian bentonite sample from Andrassy area has higher value of CEC as compared to bentonite sample from Mansuli area, but less competitive to Wyoming bentonite.

The free water performance is very poor with untreated Malaysian bentonite but can be improved through dry or wet treatment process. In general, the treated Malaysian bentonite can be used as an extender and free water controllers, and it performance can be improved through the dry process treatment. In addition, further study is needed for better quality of Malaysian bentonite.

Nomenclature

WY-BEN	= Wyoming bentonite
SA5-BT	= Andrassy bentonite before treatment
SA5-DP	= Andrassy bentonite after dry process
SA5-WP	= Andrassy bentonite after wet process
M4-BT	= Mansuli bentonite before treatment
M4-DP	= Mansuli bentonite after dry process
M4-WP	= Mansuli bentonite after wet process

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TABLE 1- SEMI- QUANTITATIVE MINERAL COMPOSITIONS ANALYSIS OF BENTONITE SAMPLES BY X-RAY DIFFRACTION.

Minerals	Wyoming bentonite	Andrassy bentonite before treatment	Andrassy bentonite after dry process	Andrassy bentonite after wet process	Mansuli bentonite before treatment	Mansuli bentonite After dry process	Mansuli bentonite after wet process
Montmo-rillonite	* * * *	* *	**	*	*	*	*
Quartz	* *	* * *	***	***	***	***	* * *
Feldspar	Nd	Nd	Tr orthoclase	* albite	* muscovite	Tr muscovite	* muscovite
Kaolinite	Tr	*	*	**	*	*	*
Others	Tr illite	* illite	* illite	Nd	* illite	* illite	* illite

Key :- * * * * : dominant ; * * * : major ; * * : appreciate ; * : minor/ small; Tr: trace ; Nd : not detected

TABLE 2- CHEMICAL COMPOSITION OF BENTONITE SAMPLES BY X-RAY FLUORESCENCE.

COMPOUND	Andrassy bentonite before treatment	Andrassy bentonite after dry process	Andrassy bentonite after wet process	Wyoming bentonite	Mansuli bentonite before treatment	Mansuli bentonite after dry process	Mansuli bentonite after wet process
SiO_2	55.22	48.20	63.06	65.48	63.10	53.86	55.52
TiO_2	0.70	0.60	0.68	0.13	0.71	0.62	0.69
Fe_2O_3	8.35	7.21	7.60	3.79	7.11	6.79	8.14
Al_2O_3	22.21	19.26	16.60	18.77	16.94	16.10	20.59
MnO	0.04	0.03	0.06	0.02	0.07	0.05	0.04
CaO	0.53	0.49	0.20	1.18	0.19	0.27	0.50
MgO	0.55	< 0.01	1.04	1.04	1.12	0.54	0.50
Na_2O	< 0.01	9.96	1.30	2.03	0.29	7.73	2.42
K_2O	0.47	0.46	2.29	0.78	2.35	1.60	0.75
P_2O_5	0.02	0.01	0.03	0.06	0.03	0.02	0.02
L.O.I	11.92	14.61	7.15	6.63	8.12	11.46	10.85
Total %	100.01	100.83	100.01	100.21	100.03	99.04	100.02

TABLE 3- CATION EXCHANGE CAPACITY DATA.

Samples	CEC values for untreated bentonite (meq/100g)	CEC values after dry process (meq/100g)	CEC values after wet process (meq/100g)
Andrassy Bentonite	30	45	35
Mansuli Bentonite	25	40	30
Wyoming Bentonite	70	-	-

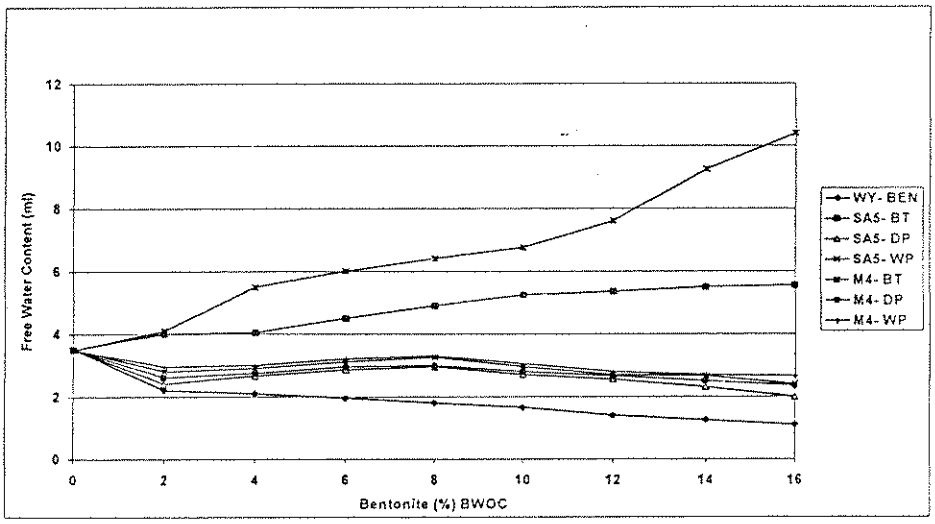

Fig. 1-Free water of cement slurry with various amount of bentonite at atmospheric condition.

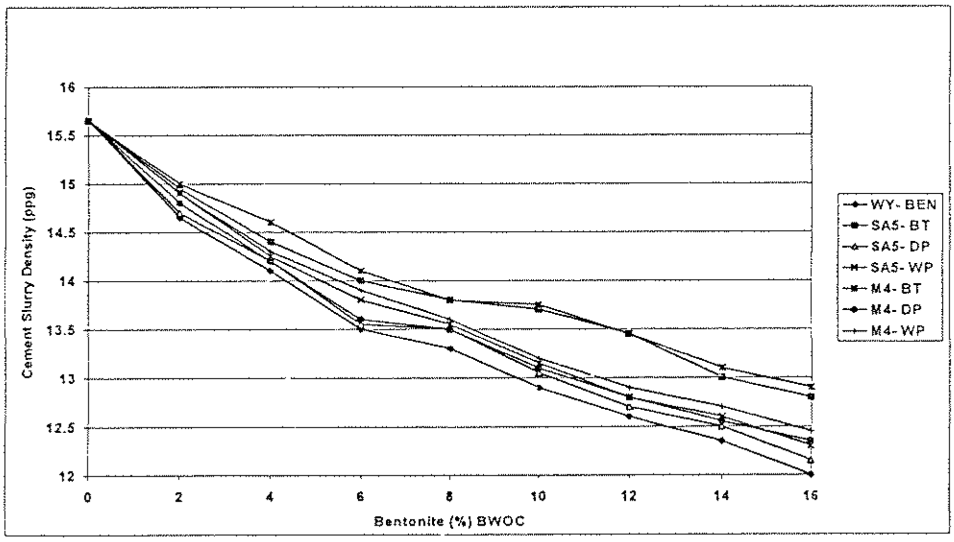

Fig. 2-Density of cement slurry with various amount of bentonite at atmospheric condition.