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The Possible Use of Local Bentonite as an Oil Well Cement Additive

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ABSTRACT

Key Words : **Cement additives, extender, bentonite,**

Bentonite was the first material extensively used as an oil well cement extender due to its ability to absorb large amounts of water. In oil well cementing, bentonite allows the use of increases amounts of mix water without water separation, which increased water content results in a lower density, greater, yield and reduces the fluid loss of cement slurry. Since it is a highly colloidal type of bentonite from Wyoming, United State, the problem of quality and its quality control have been observed in the field in recent years. In addition, the used of Wyoming bentonite also increase the material cost. Therefore, the studies have been carried out to see the possibility of using local bentonite as an oil well cement additive.

To be acceptable for use in cement slurries, the bentonite must meet API Specification as set forth in API Specification 10A. Therefore, this paper discusses the results of laboratory studies on the potential of utilizing bentonite from Sabah as an oil well cement additive. The studies included chemical analysis, characteristics and performance tests that had been conducted according to ASTM and API Specification.

The results show that montmorillonite is the main mineral detected by XRD analysis in the fresh bentonite samples from Tawau and Lahad Datu areas which have CEC values ranging from 25.0 meq/100 gram to 40 meq/100 gram, depending on the grain size. The bigger the grain size, the higher CEC values will be. The performance test results which included thickening time, fluid loss, free water and compressive strength show that cement slurries with local bentonite can meet the API Specification. In general, the local bentonite has potential to be used as an oil well additive.

INTRODUCTION

The term bentonite is well established for any clay, which is, composed dominantly a montmorillonite as its main mineral. It has numerous industrial applications which includes in glyceride oil refining, that is edible oils and fats from vegetable and animal sources, as suspension agent for oil well drilling muds and agricultural sprays, as a bonding agent in foundry moulding sands, as well as other uses amongst which as an additives in oil-well cementing.

Bentonite was the first material extensively used as cement extender due to its ability to absorb large amounts of water. The main function of bentonite is to decrease slurry density in order to reduce the bottom hole hydrostatic pressure during cementing. Bentonite is added in concentration up to 20% by weight of cement. Above 6% addition of dispersent is necessary to reduce the slurry viscosity and gel strength (Nelson, 1990). Bentonite also played an important role as fluid loss control agents when cement is placed in a cross-permeable formation under pressure filteration process is created (Michaux, 1989).

Since it is a highly colloidal type of bentonite from Wyoming, USA, the problem of quality and its quality control have been observed in the field in recent years. In addition, the used of Wyoming bentonite also increase the material cost. Therefore, the studies have been carried out to see the possibility of using local bentonite as an oil well cement additive. The finding of bentonite (montmorillonite) deposits in several areas east of Sabah (mainly around Lahad Datu and Tawau) have been reported by several authors (e.g. Ang et al. 1988, Radzuan et al. 1992a,b, and Kajibumi report .To be acceptable for use in cement slurries, the bentonite must meet American Petroleum Institute (API) specification as set forth in API Specification 10A (1990). To assist in determining whether this local material would be acceptable Wyoming bentonite subtitutes, characterization analysis comprise mineralogical, chemical and physical were tested. In addition, comparative performance tests, which included thickening time, fluid loss, free water and compressive strength, were also determined in this study.

LABORATORY WORKS

Fieldworks to collect bentonite samples representing a specific range of quality were carried out in areas predetermined by the Geological Survey Department, Malaysia. Field augering and sampling were undertaken mainly in areas of Andrassy (AN89), Sepagaya (SG170) and Mansuli (MD156), Sabah. The initial stage involves drying of sample in open air, followed by crushing and sieving for the size of 106 and 56 micon meter. The sample then underwent the chemical analysis and performance tests.

The chemical analysis or mineralogical test was done by using X Ray Diffraction and methylene blue test, whereas the characteristics and performance tests were carried out in according to API Spec. 10. The characteristic and performance tests include density, thickening time, fluid loss, free water and compressive strength. The results from the local bentonite were compared with the results for Wyoming bentonite. In general, Fig. 1 shows the laboratory works flow chart.

The X-Ray Diffraction analysis is used to determine the mineral content in the bentonite quantitively. And, the methylene blue test has been carried out to amount of reactive clay in the bentonite solution. The bentonite solution for the methylene blue test was prepared in according to the API Spec. 13B.

RESULTS AND DISCUSSION

Montmorillonite Content

Fig. 2 shows the results from XRD test on local and Wyoming bentonite. From the plot, the first peak, as summarized in Table 1 determined the montmorillonite in the sample. It can be seen from Table 1 that bentonite wyoming shows the highest content of montmorillonite, followed by AN 89, MD 156 and SG 170. Montmorillonite content in the bentonite is very important since it determine the swelling capability which plays an important role in determine the cement properties. The results show that the Wyoming bentonite has the highest swelling capability, followed by bentonite from AN 89, MD 156 and SG 170.

Cation Exchange Capacity

From the methylene blue test results, it was found that the methylene blue capacity or cation exchange capacity of Wyoming bentonite is higher than the local bentonite, as shown in Table 2. This is due to mineral content in the sample and the effect of cation exchange capability. The local bentonite contents impureties such as kaolinite and feldspar whereas Wyoming bentonite had undergone a treatment process to reduced the impureties content. In addition, main cation in Wyoming bentonite is sodium (Na^+), whereas in local bentonite is calcium (Ca^{2+}) which decreased the cation exchange capacity.

Cement Slurry Density

Table 3 shows the test results of cement slurry density measurement. It can be seen from Table 3 and Fig. 3 that local bentonite can reduced a cement slurry density but their impact much less than Wyoming bentonite. This is due to the high calcium montmorillonite content in the local bentonite, which is low cation exchange capacity, and lower swelling capability compared to Wyoming bentonite. As previously mentioned that Wyoming bentonite content more sodium montmorillonite, which is higher cation exchange capasity and better swelling capability. Therefore Wyoming bentonite cans absord much more water and coogulate better than local bentonite, which in turn will produced lower cement slurry density with higher yield volume.

Fluid Loss Characteristic

Table 4 summrized the fluid loss test results. It can be seen from Table 4 and Fig. 4 that local bentonite not capable to reduced fluid loss from the cement slurry. In contrast, Wyoming bentonite is able to reduced fluid loss from the cement slurry, which is decreasing with increasing in the bentonite percentage used. Within the local bentonite, bentonite sample from AN 89 produced less fluid loss compared with sample from MD 156 and SG 170. In general, fluid loss increases with increasing in the local bentonite added to the cement slurry.

Free Water Content

Table 5 shows the capability of Wyoming and local bentonite to control frees water content inthe cement slurry. From Fig. 5, it can be seen that the tested local bentonite has no capability to reduce free water content in the cement slurry. Free water content in the cement slurry increases with increasing of bentonite added to the slurry. In contrast, Wyoming bentonite can reduce the free water content in the cement slurry and the content decreases with increase in the amount of bentonite added. This is due to the cement hydration characteristic. Wyoming bentonite produced better hydration process and able to absorb much more water compared with the local bentonite, which in turn will reduce the free water content.

Thickening Time

From Table 6 and Fig. 6, it is clear that local bentonite produced longer thickening time than the Wyoming bentonite. For local bentonite, the thickening time increases with increasing in amount of bentonite used. But, the thickening time decreases with increasing

in Wyoming bentonite added into the cement slurry. This is due to the montmorillonite content and cation exchange capacity in the bentonite. Higher swelling capability of Wyoming bentonite will cause the cement slurry viscosity increased and finally produced gel faster than when the local bentonite was added into the cement slurry.
Silica and aluminium content in the Wyoming bentonite also play some role because their reaction with the calcium hydroxide in the cement slurry will produced gel. The produced gel will occupied space between the cement and water particles, which in turn will cause the slurry set faster. The lower swelling capability of local bentonite due to calcium ion content will cause the cement slurry need longer time to set.

Compressive Strength

Table 7 summerizes the set cement compressive strength test results. From Table 7 and Fig. 7, it can be seen that local bentonite will gives higher compressive strength when added to the cement slurry compare with the Wyoming bentonite. The set cement compressive strength wills inreased with increase in the amount of local bentonite used, but in contrast, the compressive strength decreases when more Wyoming bentonite was added to the cement slurry. In general, bentonite from SG 170 produced higher compressive strength than MD 156 and AN 89. This is due to the swelling capability of the SG 170 bentonite is less than MD 156, AN 89 and Wyoming.

CONCLUSION

Application of local bentonite as an extender to the oil well cement has significant impact to the cement physical properties. Local bentonite produced less density reduction, more fluid loss and free water, longer thickening time, and higher compressive strength than wyoming bentonite. In other words, the local bentonite perform better than wyoming bentonite in term of thickening time and compressive strength, but poor in term of fluid loss and free water content.
In respect to the fluid loss and free water content, the bentonite sample from AN 89 perform better than sample from MD 156 and SG 170. But for the thickening time and compressive strength, the bentonite sample from SG 170 produced better results than MD 156 and AN 89.
In general, local bentonite has the possibility to be used as an extender for the oil well cement but need some treatment in order to get better results, particulary calcium based montmorillonite must be change to sodium based montmorillonite in order to increase their swelling capability and improved their performance.

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Table 1. Summary of XRD Analysis

Bentonite Sample	Montmorillonite content (counts)
Wyoming	810
AN 89	525
MD 156	291
SG 170	278

Table 2. Methylene Blue Capacity

Bentonite sample	106 μm size		63 μm size	
	ml/ml	meq/100 g	ml/ml	meq/100 g
Wyoming	3.5	70	3.25	65
AN89	2.0	40	1.93	38.5
MD156	1.5	30	1.34	26.7
SG170	1.34	26.7	1.25	25.0

Table 3. Cement Slurry Density Measurement Results

		Cement Slurry Density, ppg			
Water, ml	Bentonite, % by weight	Wyoming	AN89	MD156	SG170
0	0	15.75	15.75	15.75	15.75
127.2	3	14.85	14.9	15.15	15.20
254.4	6	13.90	14.10	14.30	14.40
381.6	9	13.15	13.23	13.45	13.60
508.8	12	12.50	12.80	13.00	13.10
636.0	15	12.30	12.55	12.70	12.80
678.4	16	12.25	12.45	12.65	12.75

Table 4. Fluid Loss Test Results

		Fluid Loss, ml/30 minutes			
Water, ml	Bentonite, % by weight	Wyoming	AN89	MD156	SG170
0	0	55.0	55.0	55.0	55.0
127.2	3	32.0	233.5	247.0	251.0
254.4	6	23.8	250.0	263.0	270.0
381.6	9	17.5	273.5	289.0	292.0
508.8	12	8.3	300.0	320.5	324.0
636.0	15	3.0	334.0	348.0	357.0
678.4	16	1.7	350.0	372.0	380.0

Table 5. Free Water Content Test Results

		Free Water, ml/30 minutes			
Water, ml	Bentonite, % by weight	Wyoming	AN89	MD156	SG170
0	0	6.5	6.5	6.5	6.5
127.2	3	5.5	7.5	8.0	8.5
254.4	6	4.0	9.0	10.0	10.0
381.6	9	3.0	11.5	13.5	14.0
508.8	12	1.5	13.5	14.5	15.0
636.0	15	0.5	16.2	17.0	18.0
678.4	16	0.5	18.2	18.5	19.5

Table 6. Thickening Time Test Results

		Thickening Time, minutes			
Water, ml	Bentonite, % by weight	Wyoming	AN89	MD156	SG170
0	0	120	120	120	120
127.2	3	120	128	142	149
254.4	6	118	136	153	161
381.6	9	113	146	164	175
508.8	12	106	151	177	190
636.0	15	100	153	185	198
678.4	16	100	153	182	198

Table 7. Compressive Strength Test Results

		Compressive Strength, psi			
Water, ml	Bentonite, % by weight	Wyoming	AN89	MD156	SG170
0	0	3150	3150	3150	3150
127.2	3	2600	2700	2950	3060
254.4	6	2180	2700	2980	3130
381.6	9	1850	2800	3130	3290
508.8	12	1450	2950	3380	3560
636.0	15	1360	3250	3780	3940
678.4	16	1360	3530	4050	4200

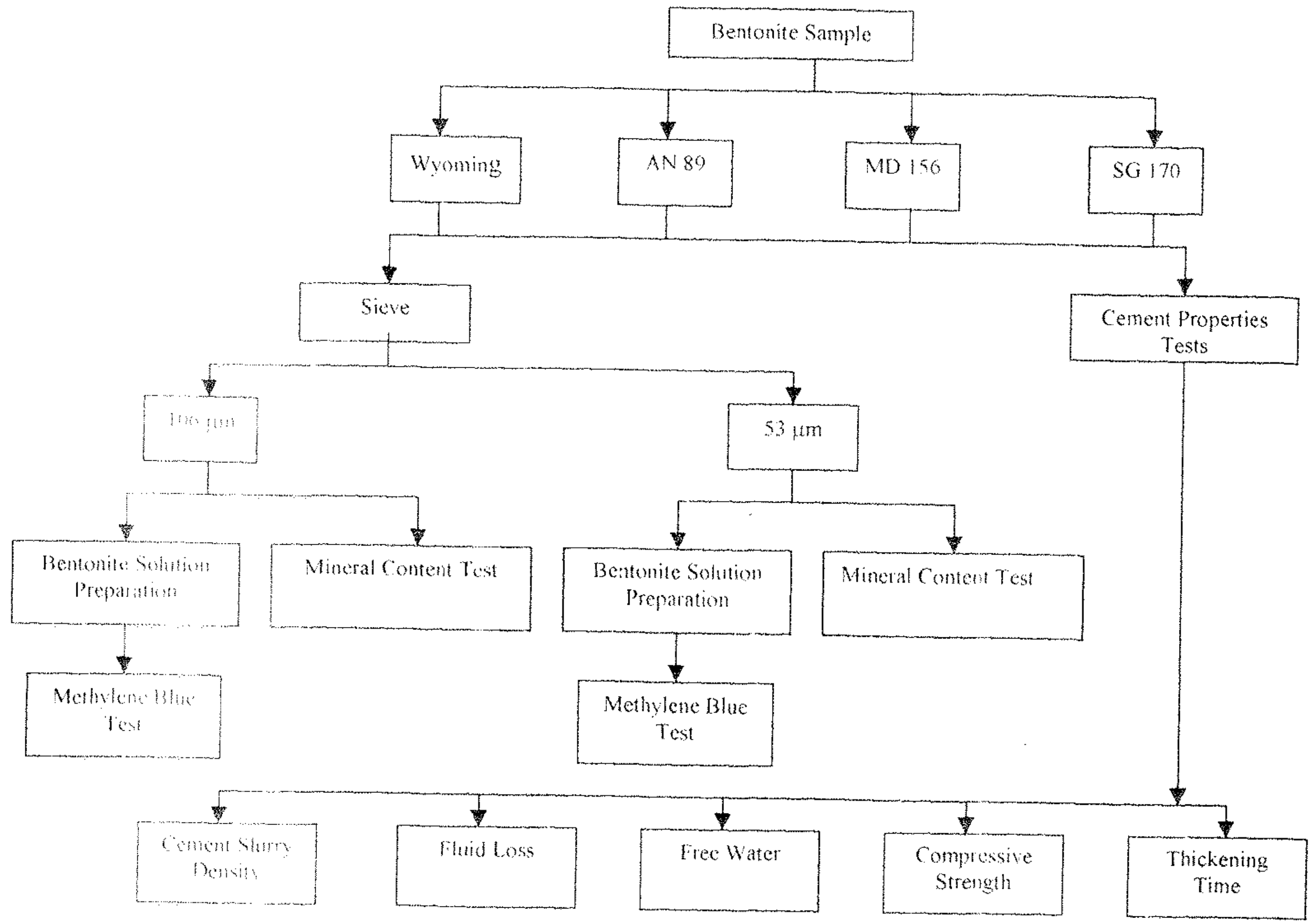
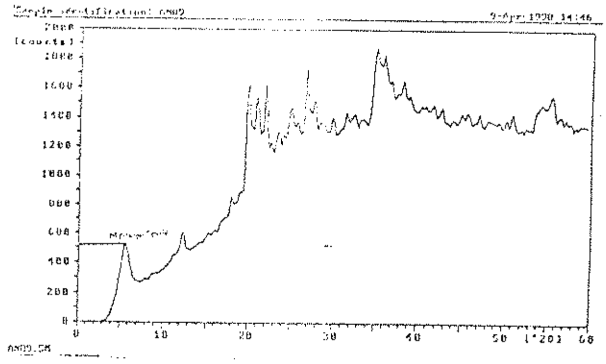
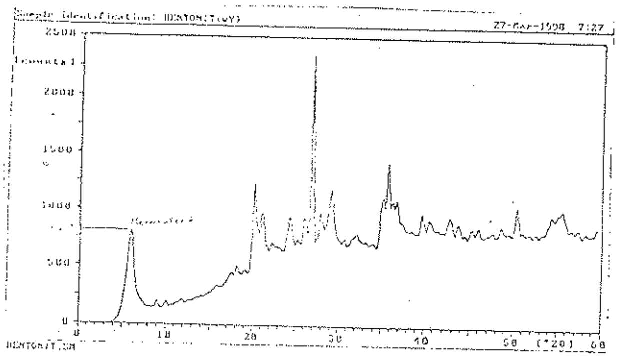


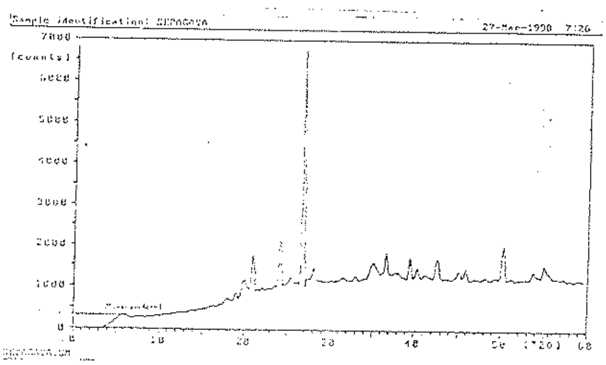
Figure 1 : Test Working Flowchart.



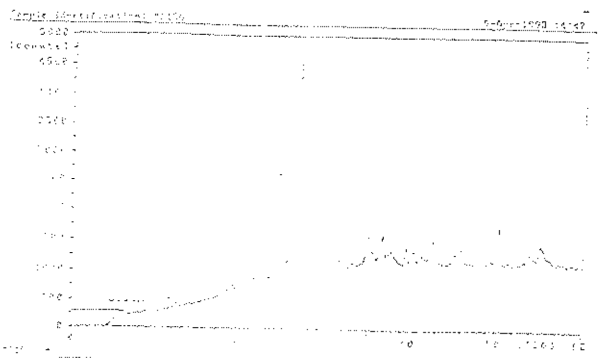
(a) AN 89



(b) Wyoming



(c) SG 170



(d) MD 156

Figure 2 : XRD Plot For Bentonite Sample.

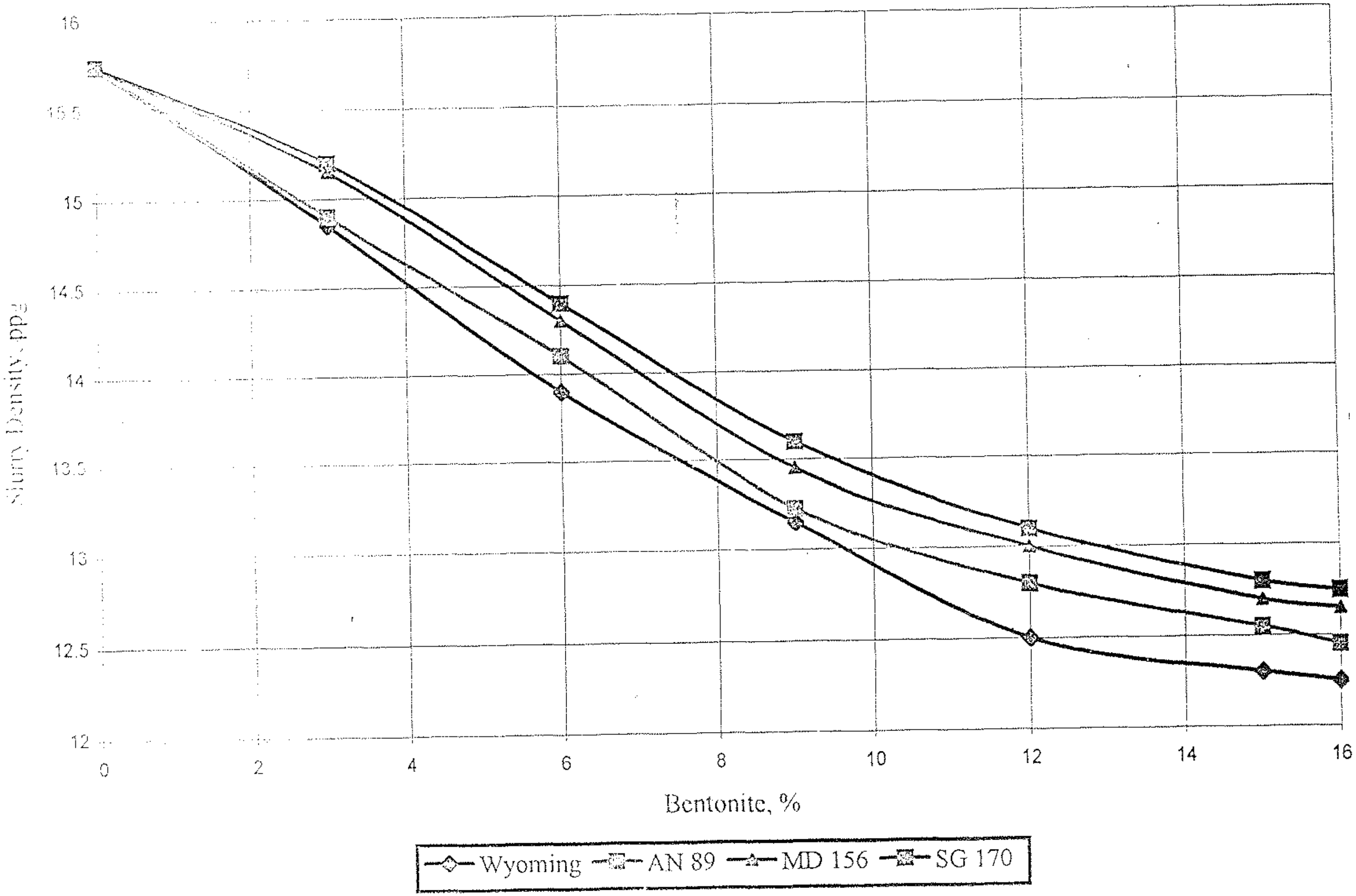


Figure 3 : Effect To The Cement Slurry Density.

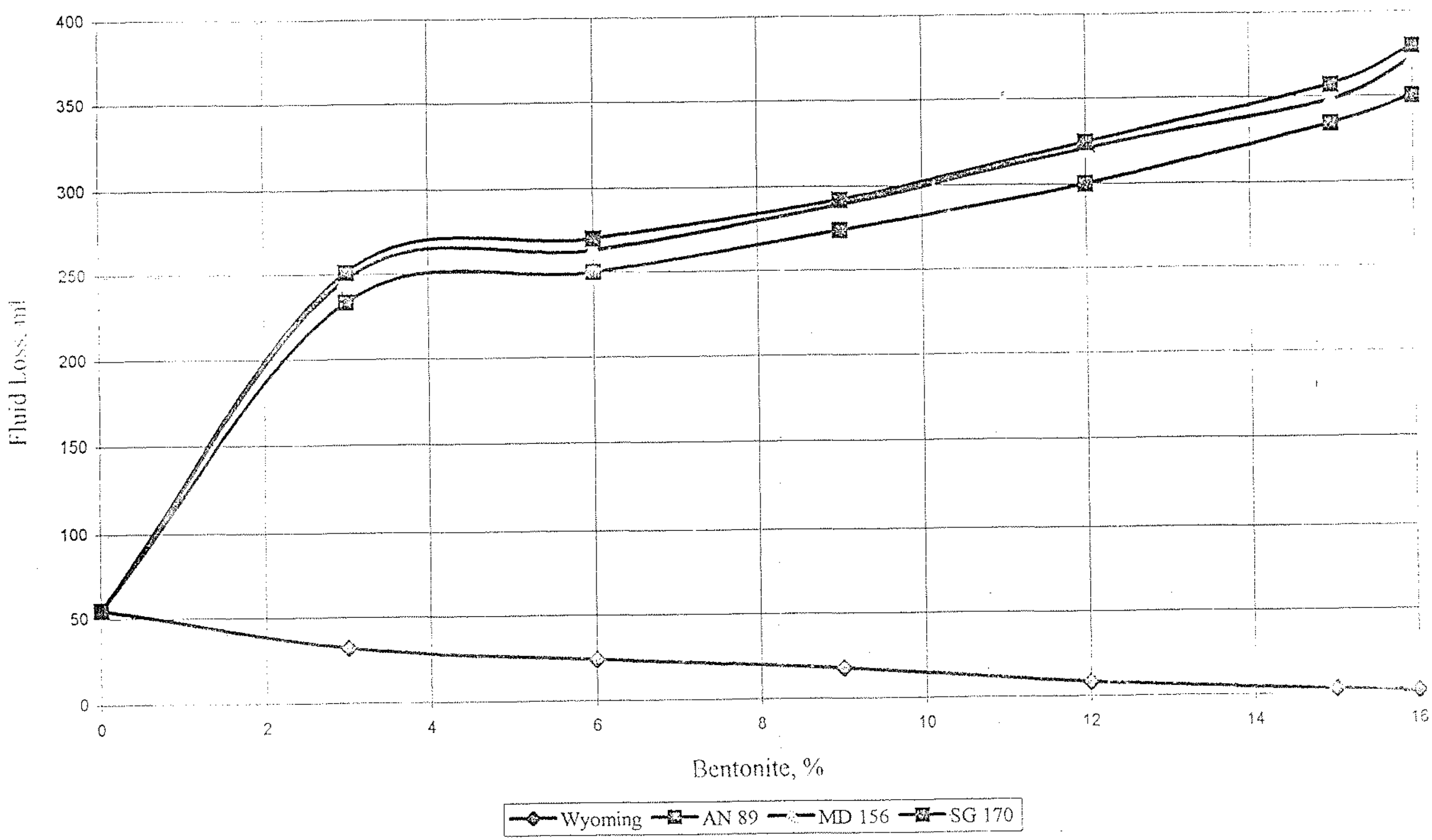


Figure 4 : Effect To Fluid Loss.

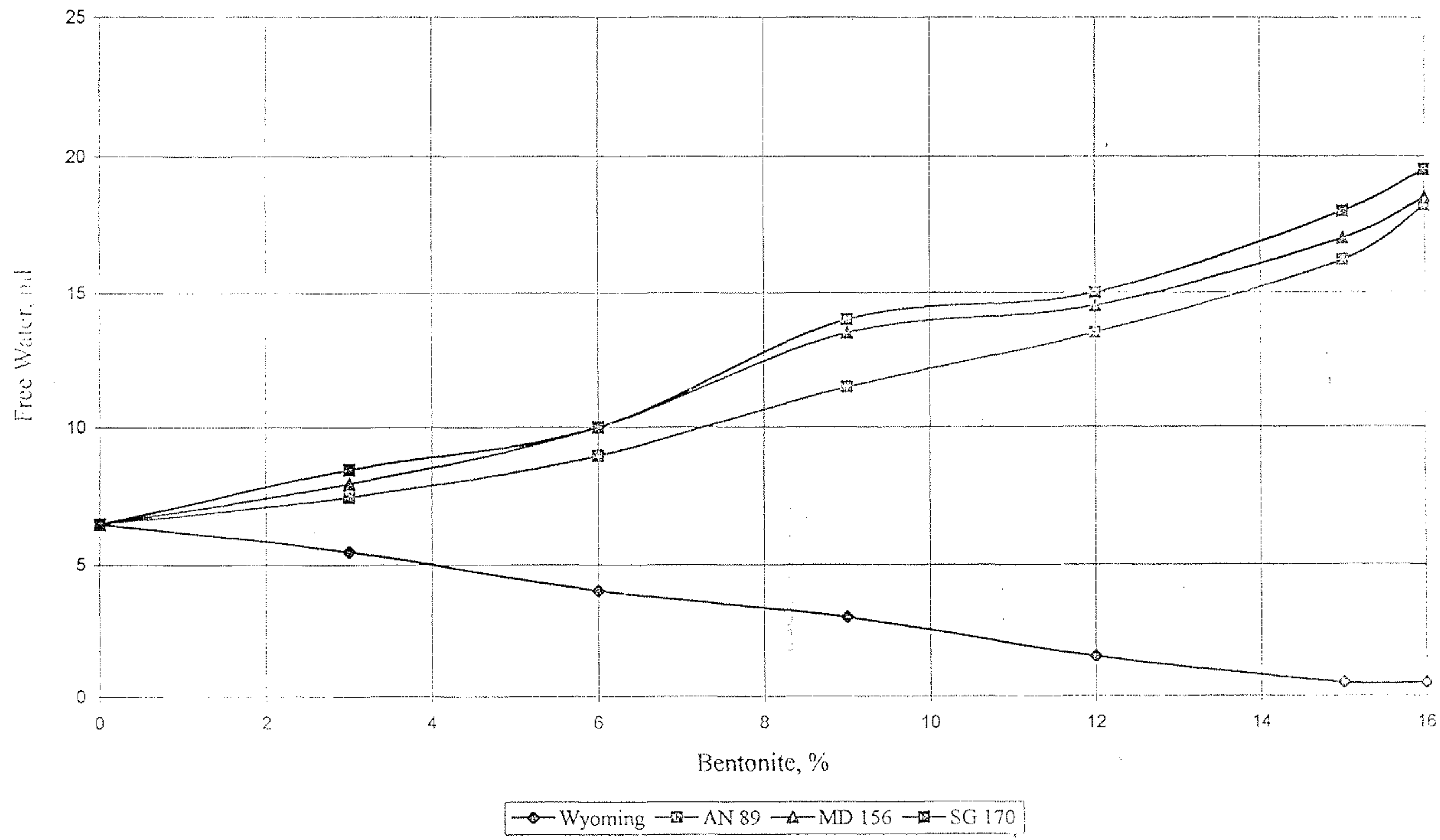


Figure 5 : Effect To Free Water Content.

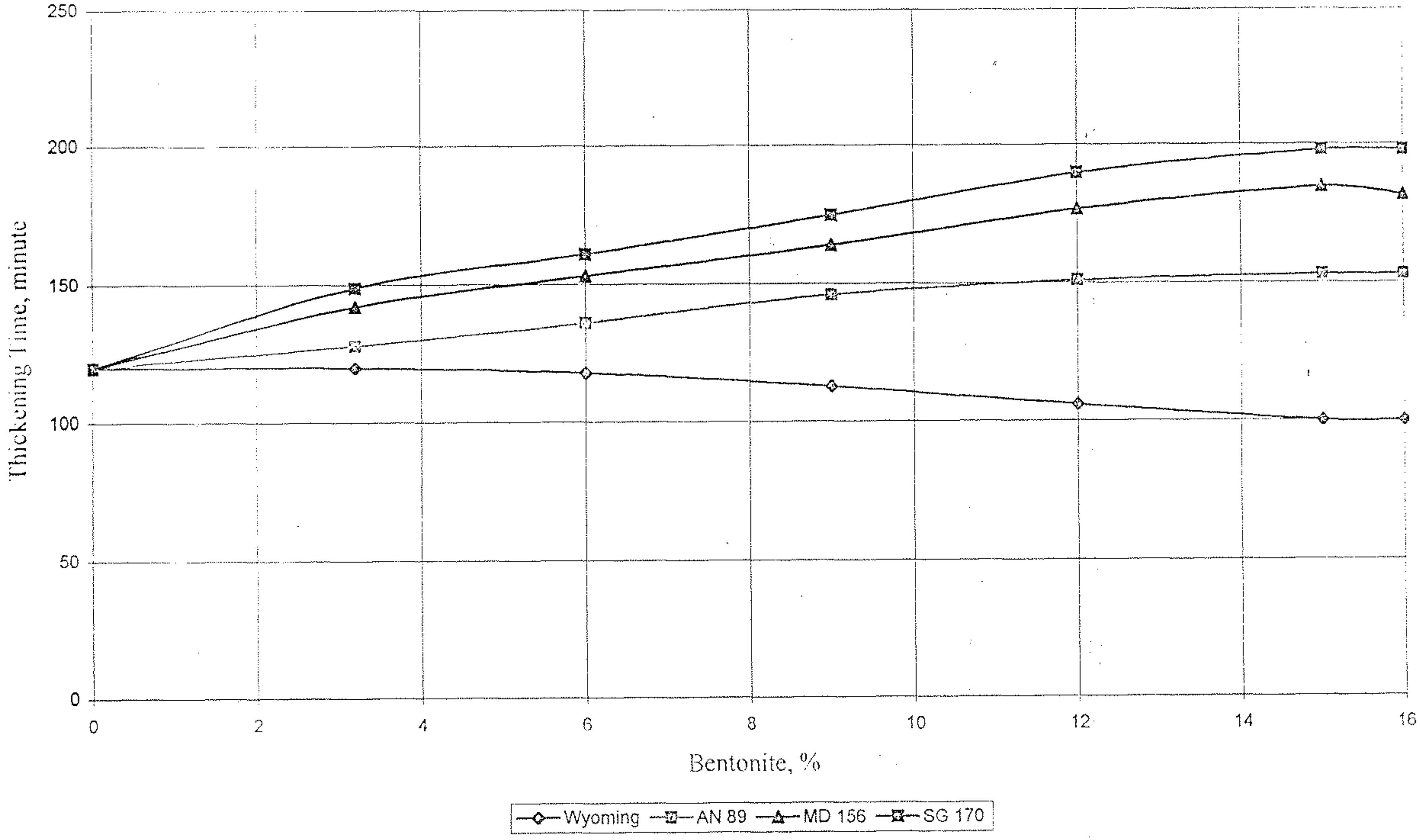


Figure 6 : Effect To Thickening Time.

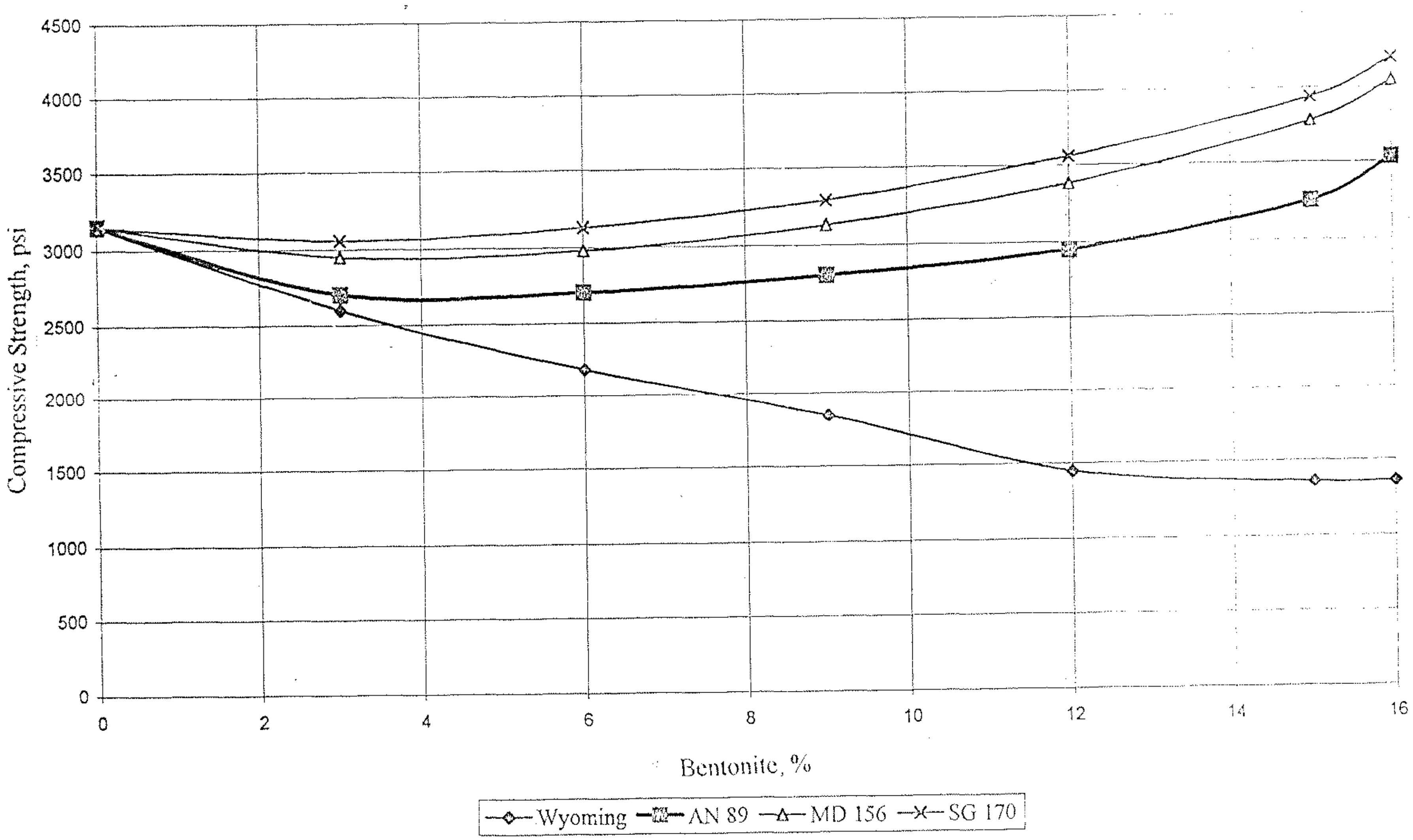


Figure 7 : Effect To Compressive Strength.