Assessment of the Effect of Increasing Local Bentonite Concentration on Drilling Fluids Rheology and Filtration Properties

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ABSTRACT: This study carried out to assess the effect of increasing bentonite percentage (solid phase) on rheological properties and filtration loss for water base drilling fluid prepared from local bentonite (Umm Ali area). Chemical tests were carried out to assess quality of local bentonite. In this study Carboxymethyle Cellulose CMC is used to increase viscosity and decrease filtration loss. The major finding showed that when adding 7% of CMC and 7% of local bentonite, the rheological properties, filter loss and yield point to plastic viscosity ratio will be within the acceptable range of American Petroleum Institute (API) specifications.

Keywords: Filter loss, Rheological Properties, Bentonite, Drilling Fluids.

المستخلص-أجريت هذه الدراسة لتقييم تأثير زيادة نسبة البنتونايت (الطور الصلب) علي الخواص الانسيابية (الريولوجية) وفاقد الرشح لسائل حفر مائي القاعدة محضر من بنتونايت محلي من منطقة أم علي. إجريت الإختبارات الكيميائية لتقييم جودة البنتونايت. أستخدمت مادة الـ CMC لزيادة اللزوجة وتقليل فاقد الرشح. أظهرت النتائج أنه عند إضافة CMC بنسبة 7% مع تركيز 7% للبنتونايت فإنه يحقق مواصفة معهد البترول الأمريكي لقياس جودة البنتونايت. خلصت الدراسة إلي أنه عند إضافة CMC بنسبة 7% مع تركيز 7% للبنتونايت في العينة فإن الخواص الإنسيابية وفاقد الرشح ومعدل المطاوعة إلي اللزوجة البلاستيكية تكون ضمن الحدود المقبولة لمواصفة معهد البترول الأمريكي.

INTRODUCTION

The history of application of drilling fluids dated back sometime between 1887 and 1907 in rotary drilling operations [1]. Drilling fluids are indispensable element of the drilling operation [2]. Drilling fluid is any type of fluid (liquid, gas, gasified liquid) that is used to assist drilling operation by means of continuous cleaning of the well being drilled at low cost [3]. In oil and gas industry, drilling fluid can be classified into three categories namely water base drilling fluids, oil base drilling fluids and air (4). The typical water base drilling fluid consists of liquid water, reactive and inert fraction and chemical additives [5]. Major types of Water base drilling fluids are non inhibitive type and inhibitive type [6]. Water base drilling fluids have many advantages that make it a most attractive choice. These advantages include low cost, availability and ease to control [7]. Bentonite is a very important element in water base drilling fluids. The main functions of bentonite are to enhance hole cleaning performance, minimize water leakage, generate filter cake and prevent loss of circulation. Bentonite concentrations in solution vary with operation conditions [8].

In the field of drilling fluids polymers are added to enhance viscosity and decrease water loss. The local bentonite was uses a concentration of Carboxymethyle Cellulose (CMC) equals to 7%.

The objective of this study is to assess the effect of increasing bentonite concentration on rheological properties and filter loss for a water base drilling fluid prepared from Umm Ali treated bentonite.

MATERIALS AND METHODS

Sampling Procedures

The bentonite samples were collected from Umm Ali site area. The region is situated in the Northern part of Sudan, 400 km north of Khartoum - the capital of Sudan - and defined by coordinates 17 and 17 30 N and 33 45, to 34 15 E [9]. Sampling has been carried out by using an auger drilling machine. Four boreholes were drilled in different depths. Borehole one (B.H #1#) at a depth ranging between 0.0 to 6.0 m, borehole two (B.H #2#) is at depth from 0.0 to 6.0 m, borehole three (B.H #3#) at depth from 0.0 to 7.5 m) and borehole four (B.H #4#) at depth from 0.0 to 8.0 m).

Preparation of Sample

Raw samples were dried in an oven, then were crushed using Retsch Crusher (RS 200) [10]. The powder was sieved by using a75 micron opening mesh.

EXPERIMENTAL WORK

The laboratory work can be divided into two types of testing, i.e. chemical tests and drilling fluids properties tests.

The chemical tests were carried out to determine loss on ignition (L.O.I) and moisture content. Loss on ignition was carried out for one gram of sample under a temperature of 105ºC and the sample was ignited to 1000ºC. Also the moisture content was performed at a temperature of 105ºC. All results of chemical testing are reported in Table 1.

A six speed rotational viscometer type (ZNN-D6) is used to quantify the rheological properties of the drilling fluids at room temperature and atmospheric pressure.

A filter press instrument type (ZNS-4) was used to investigate filtrate volume of drilling fluids under a pressure of 100 psi and 30 minutes period.

All drilling fluid tests were carried out in accordance to American Petroleum Institute (API) standards [11, 12, and 13].

RESULTS AND DISCUSSIONS

Moisture Content and Loss on Ignition of untreated Bentonite results were summarized in Table 1. Moisture Content in the study area ranged from 0.6098% to 8.057%, which is in line with the range of American Petroleum Institute (API) standards. The Loss of Ignition values ranged from 8.818% to 23.07% while for the commercial bentonite used as reference sample it reached 14.38%.

Table 2 presents a summary of rheological and filtration properties of untreated bentonite. The local bentonite without treatment fails to meet API and OCMA standards.

Figure 1 shows filtrate volume plotted against benonite percentage. It can be deduced that at increasing percentage of bentonite, fluid loss decrease and there is low leakage of the liquid phase drilling fluid. The treated samples meet API specification for filtrate volume at bentonite percentage of 6.4 and CMC concentration of 7, except for dark clay borehole (1) that is reached at percentage of 7%.

Figures 2 and 4 show the viscometer dial reading at 600 rpm. It is clear that the plastic viscosities increase with increases of amount of bentonite percentage. All types of Umm Ali treated bentonite reaches to API specification for viscometer dial reading at 600 rpm at concentration of CMC of 7% and bentonite percentage of 6.4. Addition of different percentages of Umm Ali treated bentonite, enhances gel strength and yield point. Figures 3 and 5 show that the gel strength and yield point increase while the bentonite percentage increases. This refers to an increase of solid particles in liquid that increases electrochemical forces or attraction force in the liquid [1]. Furthermore, Figures 6 to 9 show that shear stress, at a given shear rate, increases with the increase in clay percentage.

CONCLUSSIONS AND RECOMMENDATIONS

Based on the results of the tests performed, the following conclusions were drawn:

- Moisture content for all samples meet API standard.
- Loss on Ignition of untreated Bentonite lies in the range of standard. This is true except for grey in borehole (2) at a depth of 1.5m, dark in borehole (3) at depth 4.5m and dark in borehole (4) which is equal to 19.71, 21.89 and 23.07, respectively.
- The untreated bentonite samples of Umm Ali failed to meet API and OCMA specifications.
- Adding 7% of CMC enhances Umm Ali Bentonite rheology and filtration properties.
- The filter loss decreased with an increase in bentonite percentage for treated samples.
- Viscometer dial reading 600 rev/min, plastic viscosities, gel strength and yield point for water base mud prepared from Umm Ali treated bentonite increases with an increase in bentonite percentage.

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Table (1) Moisture Content and Loss on Ignition of untreated Bentonite

NO.	Borehole No.	Depth	Color	Moisture Content%	Loss on Ignition%
1	Borehole (1)	1.5m	Grey	0.6098	12.10
2	Borehole (1)	3.0m	Grey	1.369	8.818
3	Borehole (1)	4.5m	Dark	4.108	7.238
4	Borehole (1)	6.0m	Grey	3.139	13.45
5	Borehole (2)	1.5m	Grey	3.009	19.71
6	Borehole (2)	3.0m	Grey	2.079	8.616
7	Borehole (3)	1.5m	Grey	5.478	13.66
8	Borehole (3)	4.5m	Dark	6.297	11.73
9	Borehole (3)	7.5m	Dark	6.958	21.89
10	Borehole (4)	3.0m	Dark	8.057	14.56
11	Borehole (4)	4.5m	Dark	5.868	23.07
12	Reference Sample			8.137	14.38

Table (2): Viscometer and Filter Press Readings of Untreated Umm Ali Bentonite

	Borehole (1)			Borehole (2)	Borehole (3)			Borehole (4)	
	Dark	**Grey 3.0m**	**Grey 6.0m**	**Grey**	**Dark**	**Grey 1.5-2.2m**	**Grey 3.0-4.5m**	**Dark**	**Grey 6.5-7.5m**
θ_3	-	-	-	-	-	-	-	-	-
θ_6	-	-	-	-	-	-	-	-	-
θ_{100}	1.5	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.5
θ_{200}	2.5	2.0	2.0	1.5	1.5	1.5	1.5	1.5	2.0
θ_{300}	3.0	2.5	2.5	2.0	2.5	2.0	2.5	2.0	2.5
θ_{600}	5.5	5.5	6.0	5.0	4.0	5.0	5.5	4.5	5.5
θ_3 at 10 sec	-	-	-	-	-	-	-	-	-
θ_3 at 10 mint	-	-	-	-	-	-	-	-	-
Filter loss (ml)	34	32	47	46	47	102	86	109	49
Plastic Viscosity (cp)	2.5	3.0	3.5	3.0	1.5	3.0	3.0	2.5	3.0

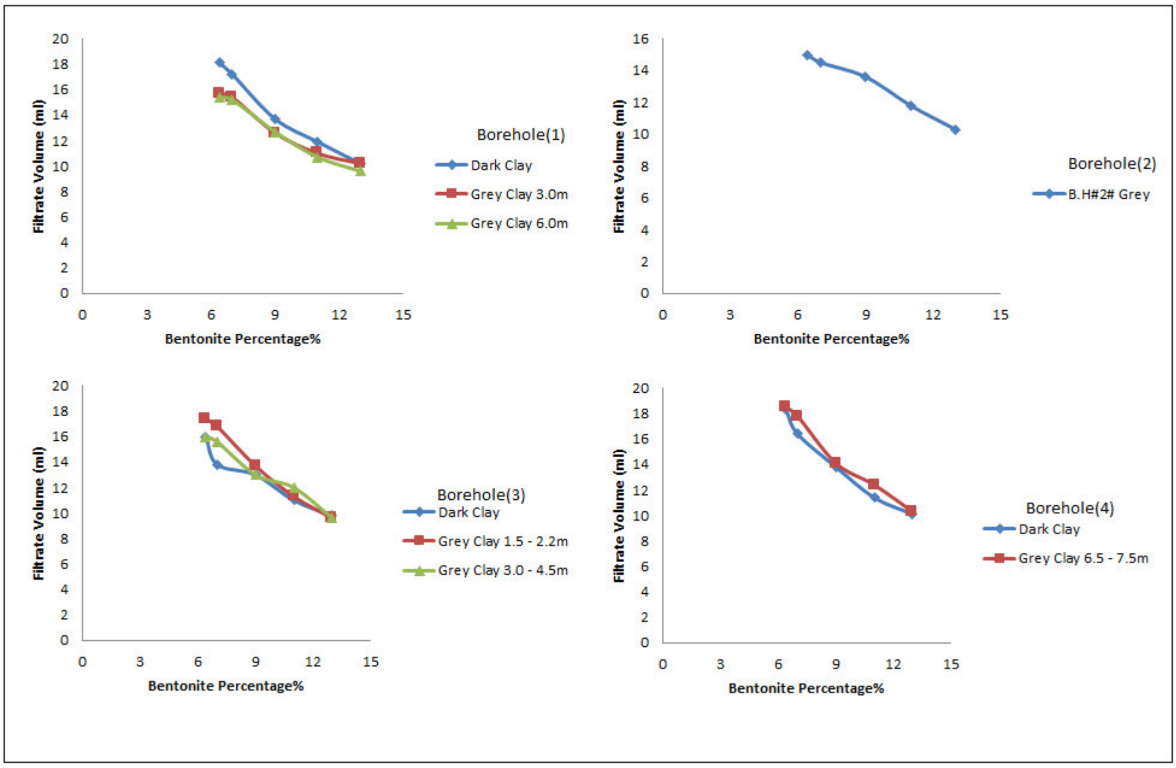

Figure 1: Bentonite Percentage vs Filtrate Volume

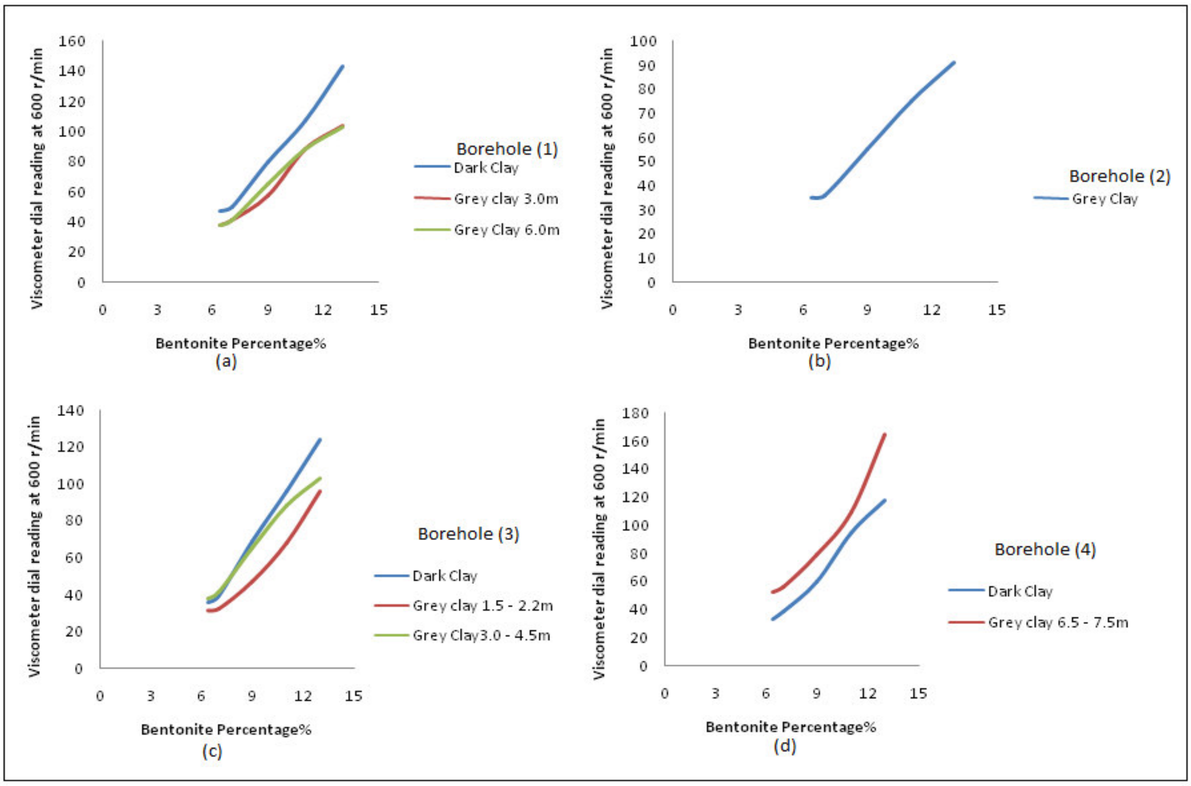

Figure 2: Bentonite Percentage vs. Viscometer dial reading at 600 (a) borehole (1) (b) borehole (2) (c) borehole (3) (d) borehole (4)

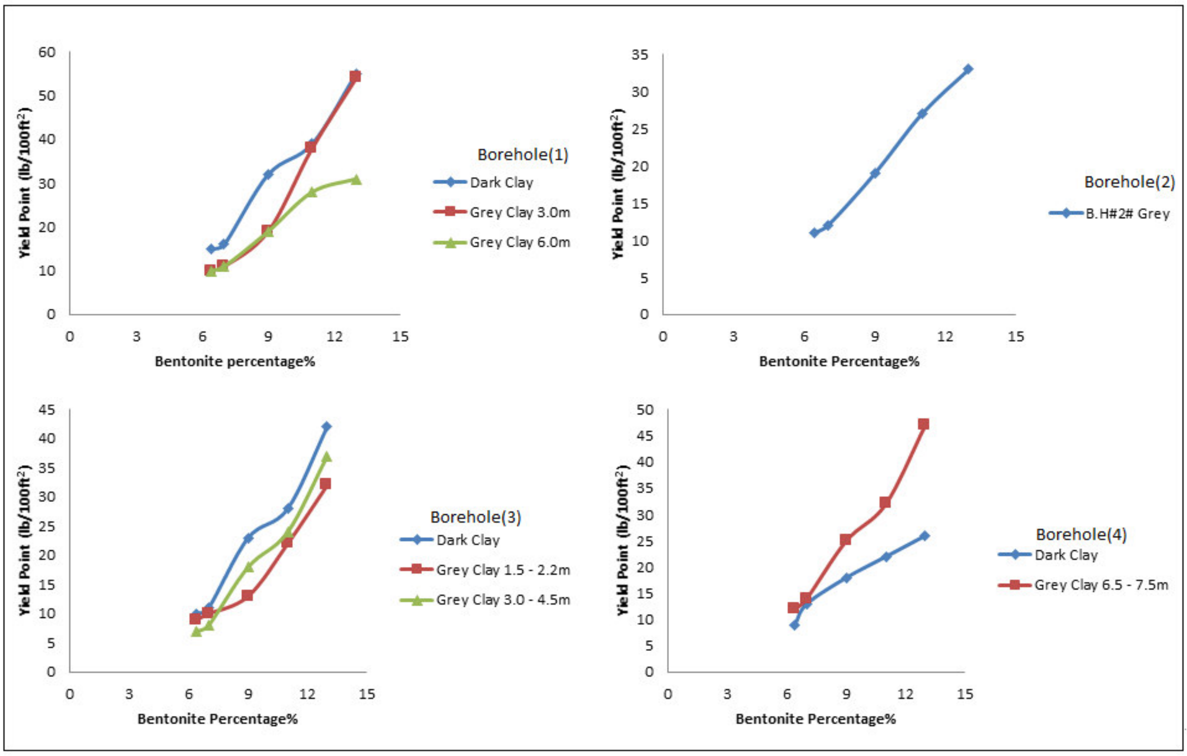

Figure 3: Bentonite Percentage vs. Yield Point

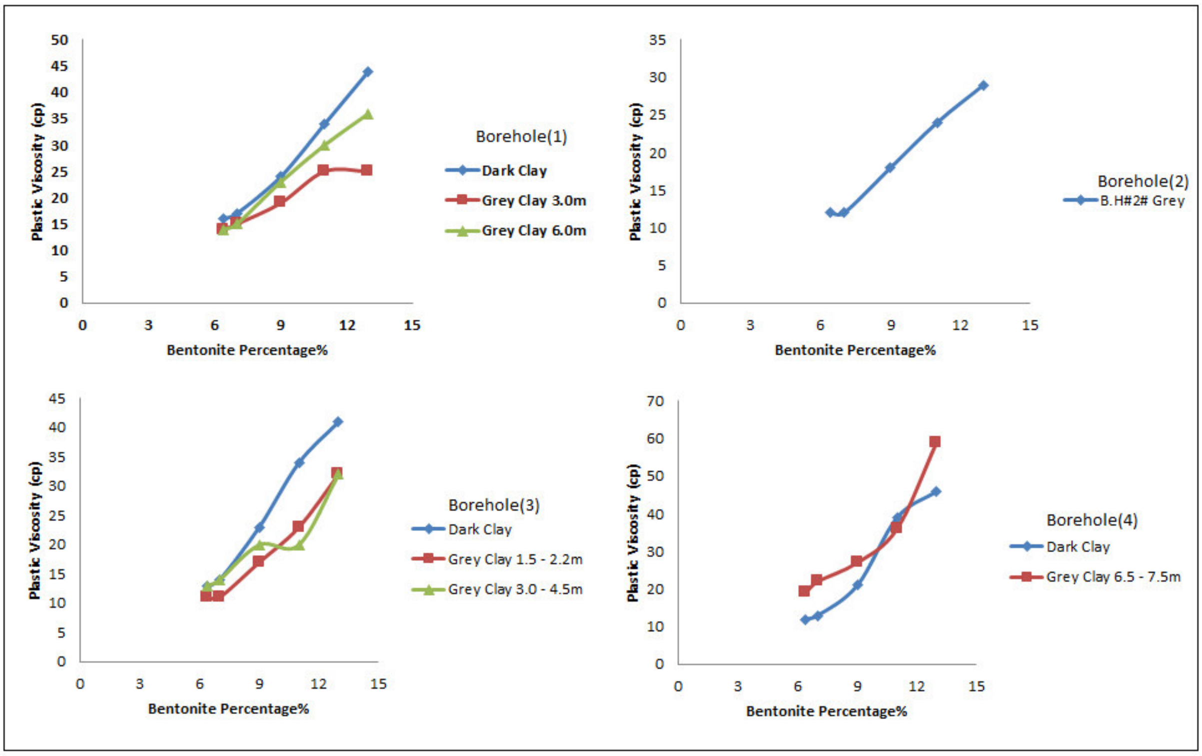

Figure 4: Bentonite Percentage vs Plastic Viscosity

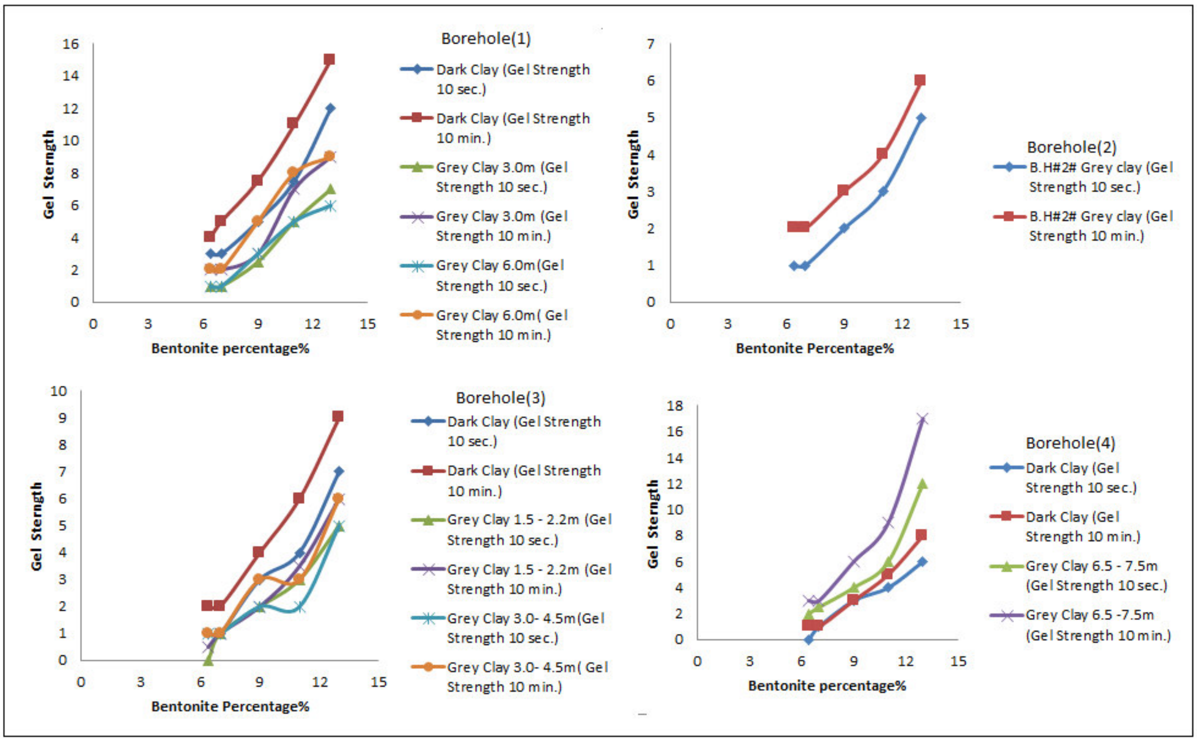

Figure 5: Bentonite Percentage vs Gel Strength

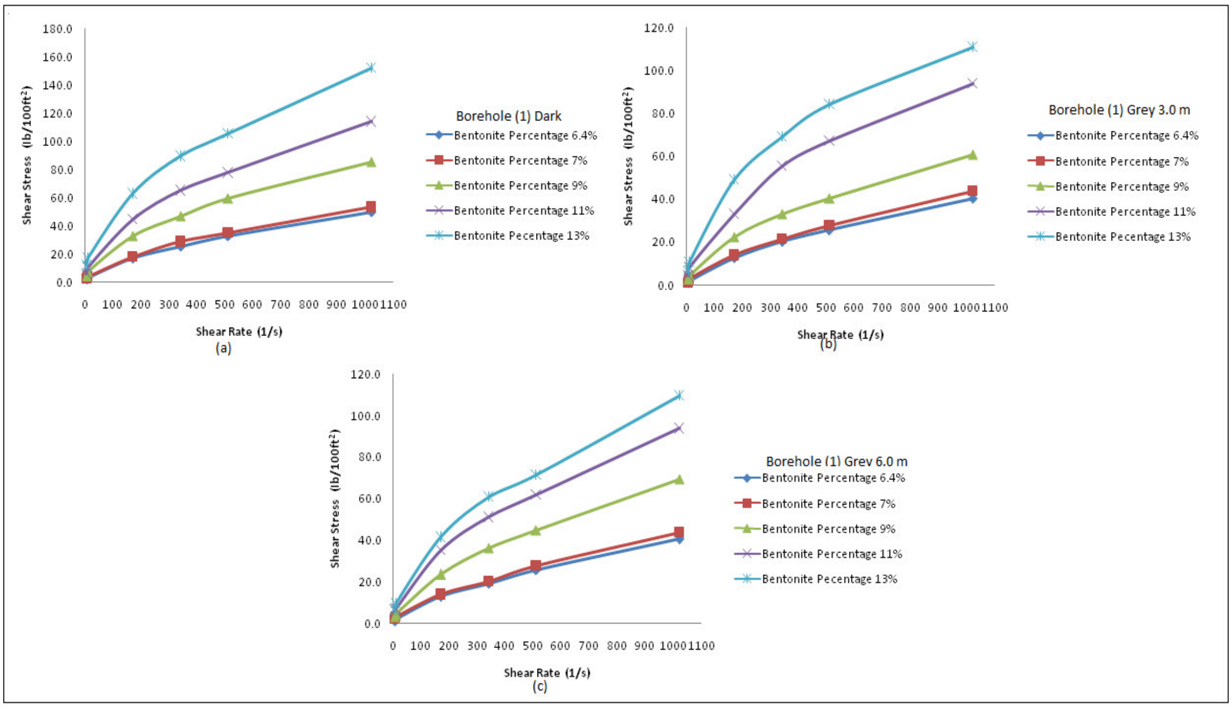

Figure 6: Shear rate vs shear Stress for borehole (1) (a) Dark (b) Grey 3.0m (c) Grey 6.0.

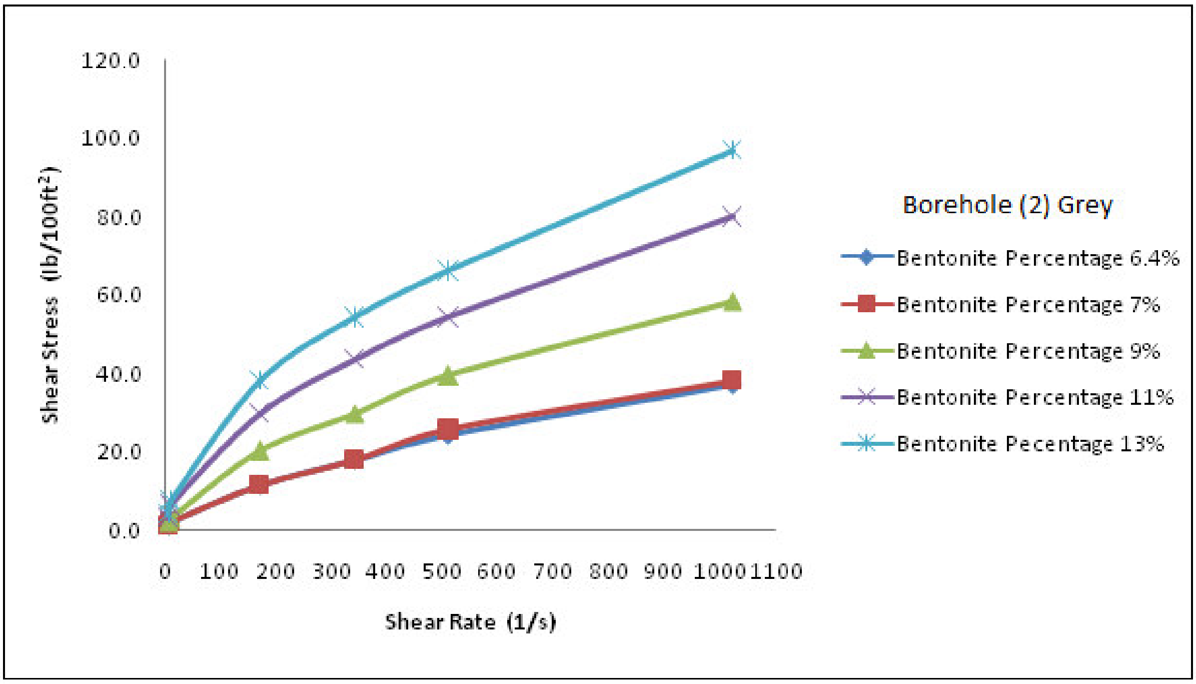

Figure 7: Shear rate vs shear Stress for borehole (2)

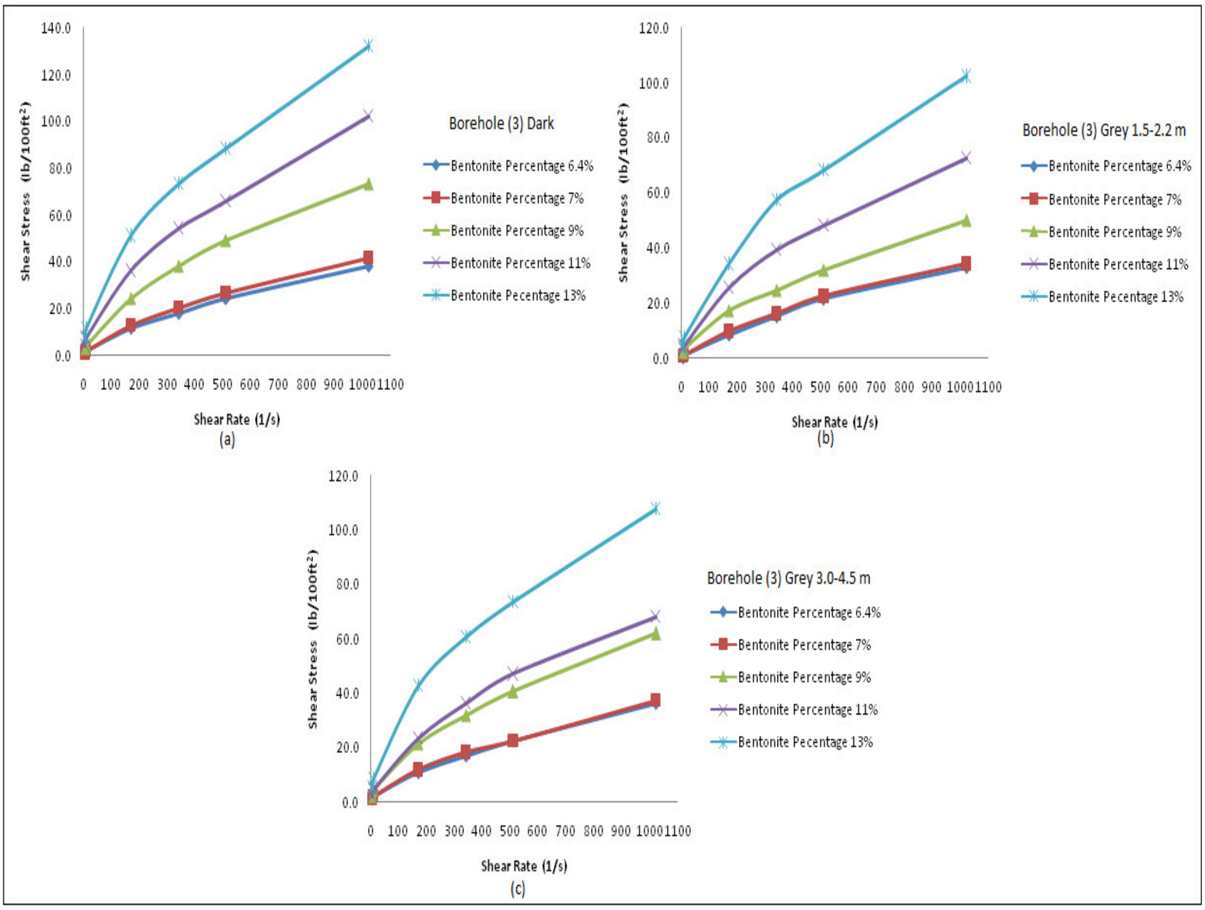

Figure 8: Shear rate vs shear Stress for borehole (3) (a) Dark (b) Grey 1.5-2.2m (c) Grey 3.0-4.5m

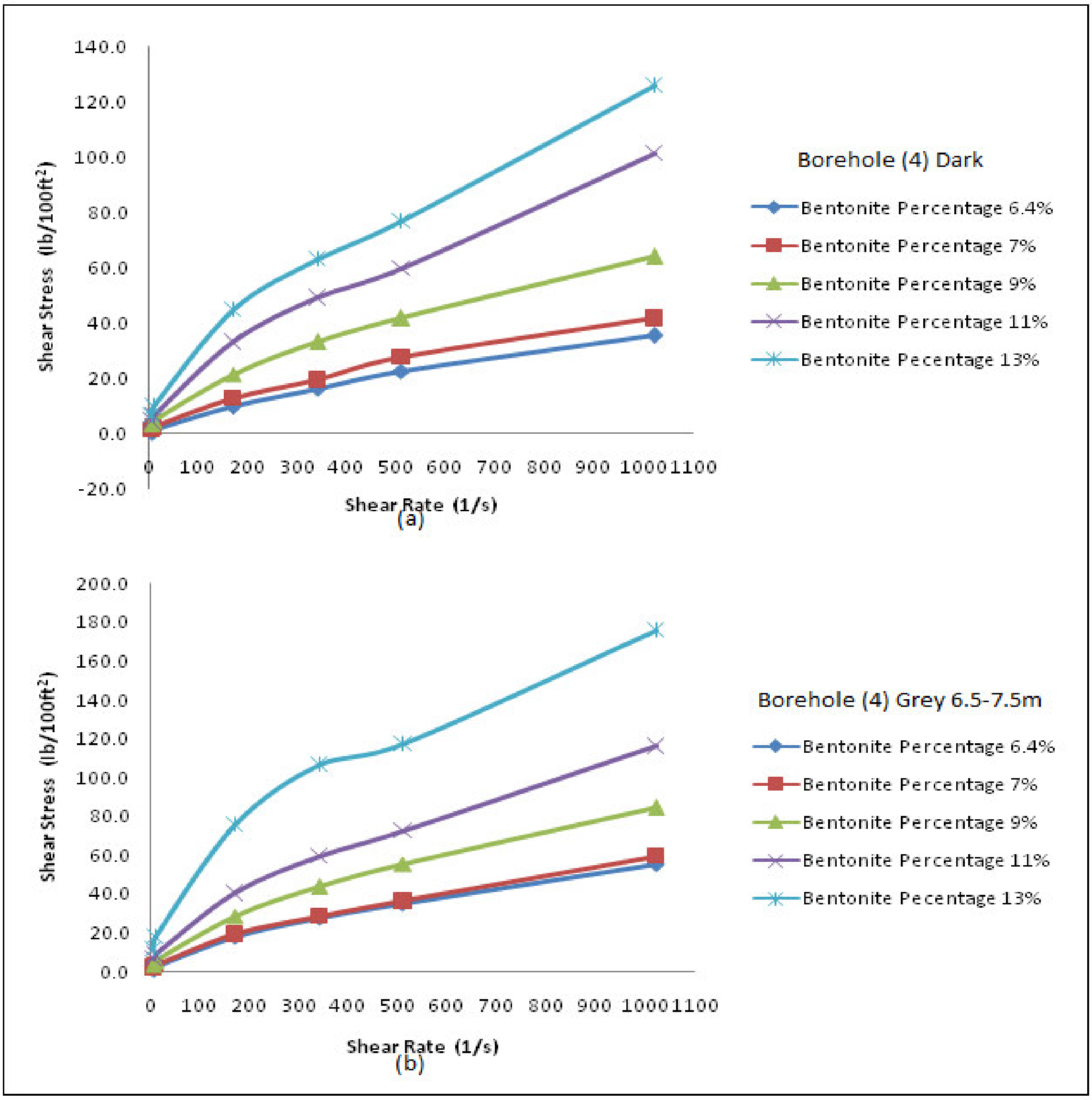

Figure 9: Shear rate vs shear Stress for borehole (4) (a) Dark (b) Grey 6.5-7.5m