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LOCALLY PRODUCED CEMENT AS A POSSIBLE ALTERNATIVE FOR THE OILWELL CEMENT

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ABSTRACT

Calcareous and argillaceous materials are raw materials used in making ordinary portland cement and portland cement class G with their main chemical compound consists of Tricalcium silicate, Dicalcium silicate, Tricalcium aluminate and Tetracalcium aluminoferrite. Currently, the class G cement used for the oil and gas wells cementing operations is imported from other countries. Therefore, suitability studies of our locally produced ordinary portland cement and blended cement were carried out to overcome this matter. To justify their ability to be used in the oil and gas wells cementing operations, they must comply with the standards set by the American Petroleum Institute (API) interms of their chemistry and physical properties requirements. Chemical analysis according to ASTM C 115 were carried out to determine the composition. Compressive strength, free water, thickening time and fluid loss were carried out according to API Specification 10 and were conducted at simulated reservoir condition. Generally, locally produced cement proved chemically and physically to comply within the API Specification and has the possibility to be used for the oil and gas wells cementing operations.

INTRODUCTION

Cement play an important role in sealing the annulus between the wall of the wellbore and the steel casing. Besides providing zonal isolation, cement also perfom two other important functions: (1)

- to protect the casing against aggressive wellbore fluids, and
- to protect the casing against collapse by rock creeping in on the wellbore.

From a chemical standpoint, the materials blends may be considered to be a mixture of the oxides of calcium (CaO), alumina (Al_2O_3), silica (SiO_2), magnesium (MgO), iron (Fe_2O_3), potassium (K_2O), and sodium (Na_2O). During heating to the temperature of about 2700 ^{o} F, these oxides combine to form calcium silicates and aluminates which commonly referred to as clinker.

Currently in Malaysia, portland cement class G is being used during the oil and gas wells cementing operation and this material is imported from other countries. Therefore, affords have been made to study the suitability of locally produced cement to replace the G type cement.

In order to be able to be used as an oil well cement, locally produced cements must comply in terms of their chemistry and physical properties to the standards set by the American Petroleum Institute (API).(2)

content of oxide minerals and chemical compounds are very much different compared to the G cement. The differences involved between them were due to the percentange of raw materials used during the manufacturing process. The differences involved will also have an effect on their performances.

FLUID LOSS ANALYSIS

Table 2 shows the amount of fluid loss of each cement tested at 52 degree Celcius circulating temperature, and it was found that blended cement released less water as compared to the class G and ordinary portland cement. It proves that, during the cement reaction and with the existing of water, fine particles of fly ash will react with the excess calcium oxide and calcium hydroxide produce during the early reaction to form additional cementitious material of tricalcium silicate hydrates which filled the existing voids and thus will reduce the number of voids, and consequently will reduce the permeability of the cement. (3) With higher content of tricalcium aluminate in ordinary portland cement, it will react at a faster rate during hydration and means less water is released compared to class G cement. (4)

THICKENING TIME ANALYSIS

Table 3 shows the results of the thickening time of each cement tested at 8000 feet and 52 degree celcius. It was found that the ordinary portland cement will set at a shorter period, followed by the blended cement and then the class G cement. With the difference in the content of fast reacting substance; that is tricalcium aluminate explains why each cement will set at different time. Chemically, the ordinary portland cement has the highest amount of tricalcium aluminate (7.85 %) and therefore, will have a very high rate of reaction during the hydration period and therefore, will set at a faster time. The blended cement which has about 6.28 % of tricalcium aluminate will take a little longer period to set compared to the ordinary portland cement and of course the class G cement which has about 1.48 % of tricalcium aluminate will have a longer time to set compared to the others.

COMPRESSIVE STRENGTH TEST ANALYSIS

Results of the compressive strength test cured for different period are shown in table 4. At the 8 hours curing period, the ordinary portland cement has the higher strength, followed by the blended cement and then the class G cement. With high pressure and temperature, high content of tricalcium aluminate, a very fast rate of reaction during hydration and a very fast setting time explains why it has higher strength compared to others. The blended cement which comes second in setting time has higher strength compared to the class G cement.

For 1 day period, the ordinary portland cement still has the highest strength, followed by the class G cement and then the blended cement. Surprisingly the class G cement has higher strength than the blended cement. With low content in tricalcium aluminate and slow reactivity of the fly ash; at this period, the hydration process of G cement produce more tricalcium silicate hydrate, the strength substance as compared to the blended cement and therefore explain why its strength is higher compared to the blended cement.

The result for 3 days curing period showed that. the ordinary portland cement still has the highest strength followed by the blended cement and then class G cement. At this period, the blended cement has shown an increased in strength development and it is believed that the fly ash has played an important role in providing the strength to the cement with the formation of extra cementitious material of tricalcium silicate hydrate.

The strength development progess for each type of the cement is clearly shown in Figure 1.

Table 1
Oxide minerals and chemical compounds of cements

OXIDE	G - CEMENT (%)	LOCAL OPC (%)	LOCAL BLENDED (%)
CALCIUM OXIDE	65.13	64.36	53.67
SILICON DIOXIDE	22.15	20.72	27.81
IRON OXIDE	4.72	3.9	3.48
ALUMINIUM OXIDE	3.57	5.46	8.33
MAGNESIUM OXIDE	0.71	0.6	0.6
SULFUR TRIOXIDE	2.18	2.37	2.45
POTASIUM OXIDE	0.35	0.58	0.43
LOSS OF IGNITION	1.13	1.62	2.34
CHEMICAL COMPOUND	**(%)**	**(%)**	**(%)**
TRICALCIUM SILICATE	59.7	55.00	44.00
DICALCIUM SILICATE	18.81	18.02	14.42
TRICALCIUM ALUMINATE	1.48	7.85	6.28
TETRACALCIUM ALUMINOFERITE	14.37	11.9	9.52

Table 2
Fluid loss tested at 52 deg. C and 1000 psi differential pressure.

SAMPLE	FLUID LOSS (ml)
G CEMENT	680
OP CEMENT	648
BLENDED CEMENT	628

Table 6
Economic analysis for the price of cement

CEMENT	DEPTH (ft.)	NUMBER OF SACKS	PRICE PER SACK	TOTAL VALUE
G CEMENT	7500	4000	RM 21.00	RM 84,000.00
LOCAL CEMENT	7500	4000	RM 9.00	RM 36,000.00

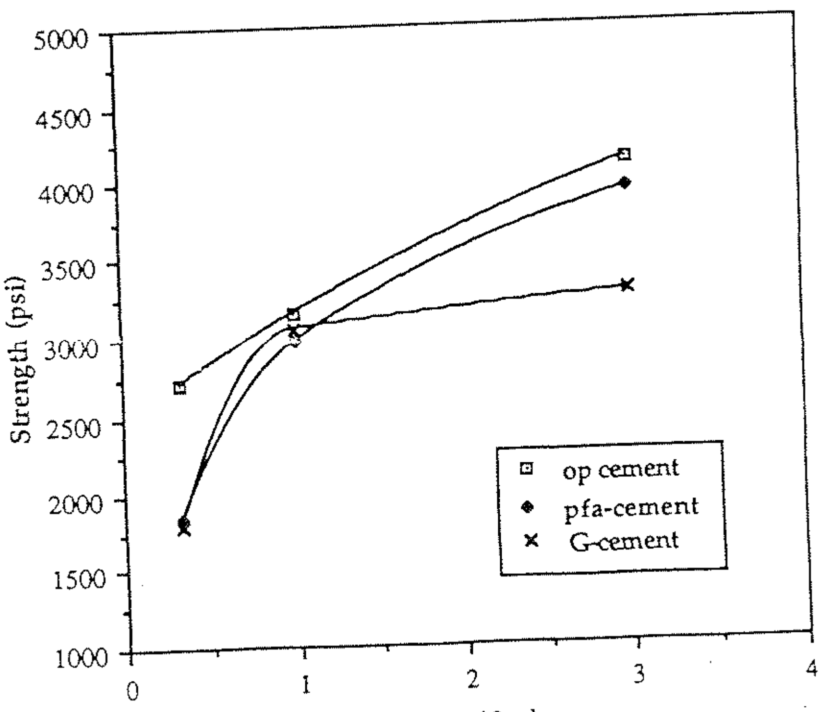

Figure 1 : Strength profile cured according to schedule 5g API Specification 10.

The Effect Of Adding Palm Oil Fly Ash To The Development Of Strength On Oilwell Cement

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ABSTRACT

Calcareous and argillaceous materials are raw materials used in making oilwell cement class G with their main chemical compound consists of Tricalcium silicate, Dicalcium silicate, Tricalcium aluminate and Tetracalcium aluminoferrite. Pozzolanic reactions existed in some of the fly ashes when added with water helps in improving the cement strength when they are added to the cement. Therefore, palm oil fly ash, a locally waste material is chosen for the study. Chemical analysis according to ASTM C 115 were carried out to determine the composition. Compressive strength tests were carried out according to American Petroleum Institute Specification 10 and were conducted at simulated reservoir condition. The analysis and the results proved that palm oil fly ash is a pozzolan material and can be used to improve the strength development of the oilwell cement.

INTRODUCTION

Cement plays an important role in sealing the anulus between the wall of the wellbore and the steel casing. Besides providing zonal isolation, cement also perform two other important functions:[1] 1) to protect the casing against aggressive wellbore fluids, and 2) to protect the casing against collapse by rock creeping in on the wellbore

In oil and gas production, the cement strength data are useful for:[2] 1)establishing Wait On Cement (WOC) time, 2) determining the optimum time to perforate, and 3) monitoring the stability of the set material

From a chemical standpoint, the material blends may be considered to be a mixture of the oxides of calcium (CaO), alumina (Al_2O_3), silica (SiO_2), magnesium (MgO), iron (Fe_2O_3), potassium (K_2O), and sodium (Na_2O). During heating to the temperature of about 1450 ^{o}C, these oxides combine to form calcium silicates and aluminates which commonly referred to as clinker.

Fly ashes are heterogenous fine powder consisting mostly of rounded or spherical particles of variable silica (SiO_2), alumina (Al_2O_3) and iron (Fe_2O_3) content. The structures, composition and properties of the particles depend upon the structure, composition and the combustion processes by which they are formed.[3]

Currently, only coal ash is the popular pozzolan being used as a pozzolanic material that is added to the blended cement. With the same characteristics and chemical composition, palm oil fly ash, a locally waste material has been chosen to be studied with the class G cement for its suitability as a pozzolanic material.

The purpose of this paper is to present the results of laboratory studies on the development of strength of class G cement when it is added with a different percentage of palm oil fly ash by weight of cement.

LABORATORY WORK

Palm oil fly ash and imported class G cement were studied. Laboratory works were carried out on dry palm oil fly ash, dry cement powder and hard set cement. The performed tests were chemical composition and the compressive strength development. The chemical analysis was done by wet analysis method. The compressive strength development tests were conducted by closely followed the Specification for Materials and Testing for Well Cements (API Specification 10, Fifth Edition, July 1, 1991).[4] and was tested at simulated reservoir condition.

COMPRESSIVE STRENGTH TEST

Slurry is prepared according to section 5 API Specification 10, and immediately poured in the prepared molds in a layer equal to 1/2 the mold depth and puddled for 25 times per specimen with a puddling rod. After puddling the layer, the remaining slurry is stirred to eliminate segregation and the molds are filled to overflowing and puddled as before. The prepared molds are then placed in the high pressure high temperature curing chamber and cured according to schedule 5g, Well Simulation Test Schedules for Curing Compressive Strength Specimens for a period 8 hours, 24 hours, 3 days and 7 days and then removed and crushed with the compressive strength testing machine.

RESULTS AND DISCUSSION

CHEMICAL ANALYSIS

Table 1 shows the oxide minerals of the palm oil fly ash and the class G cement. The oxide minerals existed in the palm oil fly ash are reasonably good in terms of their pozzolanic activities as their content fall within the Malaysian Standard (MS 1226 : 1991) set for the ashes to be used in the blended cement. For G cement, at 1450 ^{o} C these oxides will react between each others and will form the four major compounds that existed in the end product and their percentage is shown Table 2. With quite low in aluminium oxide content the produced Tricalcium aluminate will be reasonably low and the cement will serve its purpose as a high sulfate resistance cement with low rate of hydration.

COMPRESSIVE STRENGTH TEST ANALYSIS

Results of compressive strenght test cured for different period are shown in Table 3. There is an increased in cement strength for 8 hours, 1 day, 3 days and 7 days curing period when 5 % of palm oil fly ash is added to the neat cement. The pozzolanic reactivity provided by the ash has helped in developing the extra gel of tricalcium silicate hydrate which contribute to the strength development. The results also shown that, by increasing the ash content further to 10 %, 15 % and 20 %, a further increase in strength development of the cement can be achieved. It was found that, the best results in strength development of the cement can be achieved when 15 % of the ash is added to the cement. A reduction in cement strength can be noticed when 20 % of the ash is added but the strength is still higher as compared to the neat cement strength. Further increase the ash content to 25 % will results in a reduction of strength below the strength of the neat cement and this is due to the too much pozzolanic activities which does not further helps to enhance the strength of the cement but to reduce the strength. The strength development progress for these cement mixture are clearly shown in Figure 1,2 and 3.

CONCLUSION

From the chemical analysis and the laboratory studies, it proves that palm oil fly ash is one of the ashes that has a good pozzolanic materials in it. Its also helps in improving the strength development of the cement and the increase in strength development is proportion to the amount of the ash added to the neat cement. The best results can be achieved when 15 % of the ash is added to the neat cement and further increased to more than 20 % of the ash will result in a decreasing in strength.

REFERENCE

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2. Exxon Production Research Company, Completion Section, December 1983

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4. API Specification 10, July 1, 1990. Specification For Materials and Testing For Well Cements. American Petroleum Insitute, 1220 L Street, Northwest, Washington DC, USA.

TABLE 1
OXIDE MINERALS OF CEMENT AND PALM OIL FLY ASH

OXIDE	G CEMENT (%)	FLY ASH (%)
CALCIUM OXIDE	65.13	18.48
SILICON DIOXIDE	22.15	48.05
IRON OXIDE	4.72	8.33
ALUMINIUM OXIDE	3.57	5.87
MAGNESIUM OXIDE	0.71	4.47
SULFUR TRIOXIDE	2.18	1.21
POTASIUM OXIDE	0.35	8.54
LOSS OF IGNITION	1.13	4.3

TABLE 2
CHEMICAL COMPOUND OF G CEMENT

COMPOUND	PERCENT
TRICALCIUM SILICATE	59.7
DICALCIUM SILICATE	18.81
TRICALCIUM ALUMINATE	1.48
TETRACALCIUM ALUMINOFERITE	14.37

TABLE 3
COMPRESSIVE STRENGTH CURED AT DIFFERENT PERIOD ACCORDING TO SCHEDULE 5G API SPECIFICATION 10.

SAMPLE	8 HOURS STRENGTH (psi)	1 DAY STRENGTH (psi)	3 DAYS STRENGTH (psi)	7 DAYS STRENGTH (psi)
G CEMENT	1650	2800	3100	3120
G CEMENT + 5 % FA	1700	3000	3200	3260
G CEMENT + 10 % FA	1850	3250	3500	3550
G CEMENT + 15 % FA	2000	3500	3800	3850
G CEMENT + 20 % FA	1900	2700	3500	3300
G CEMENT + 25 % FA	1500	2650	3000	2950

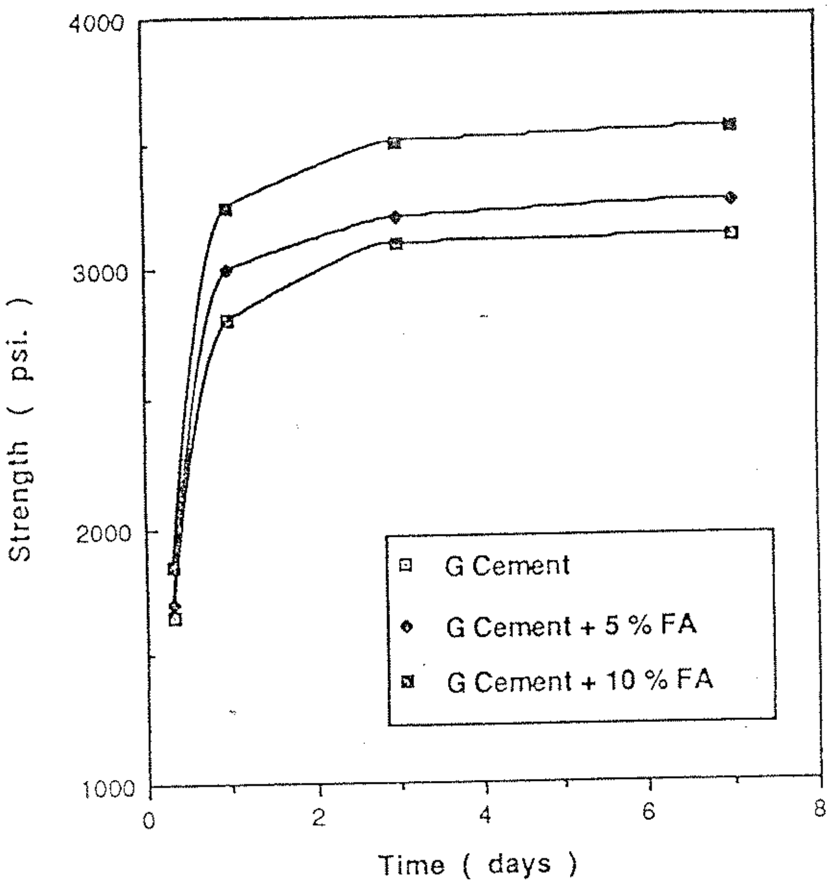

Figure 1: Strength profile cured according to schedule 5g Api Specification 10.

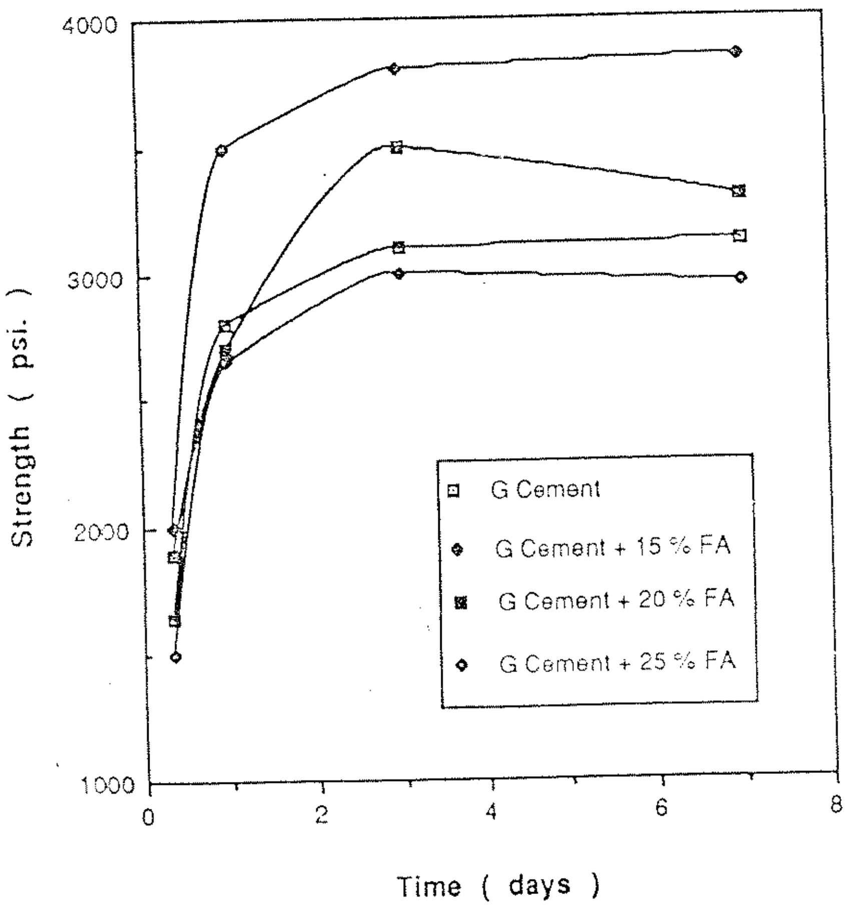

Figure 2 : Strength profile cured according to schedule 5g API Specification 10.