International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 06 June 2025, pp: 156-165 www.ijaem.net ISSN: 2395-5252

Effect of Organic Derived Fiber, (Coconut and Plantain) on Rheology and Mechanical Properties of Oil Well Cement

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Date of Submission: 28-05-2025 Date of Acceptance: 08-06-2025

ABSTRACT
Cement is primarily used in drilling operations to protect the casing against the corrosive tendency of formation fluid and to support the casing with the external load on it. Cement slurry is formed by mixing water with Portland cement or with cement containing various essential additives as the case may be and pumping it down to critical points in the annulus around the casing using various pumping techniques. Class G cement is widely used in cementing jobs because itallows the use of accelerators and retarders for a wide range of well depths and temperatures. It is of paramount importance to shorten the wait on cement time before the commence of drilling of the next section of the well. Many plant wastes have been generated from agriculture produce and as the current global drive towards a greeneconomy continues, more plant-based wastes will be generated in the future. Some of these wastes are being used presently as a form of renewable energy. The main aim of this study is to investigate the effect of plantain and coconut fibers in oil well cement in terms of mechanical properties and rheological properties to improve the toughness (compressive strength and tensile strength) and rheological parameters. Plantain and coconut fibers were added in increasing concentrations from 0 to 1g, 2g, 3g, 4g, and 5g by weight 3769mm^2. Compressive strength and tensile strength of cement samples were evaluated in this research. The results show that 3 g of the admixtures yield a considerable lower plastic viscosity while the gel strength increase. 0 g to 4g coconut fiber slurry and 0 g to 3g of plantain fiber slurry is desirable because it has lower plastic viscosity and gel strength, which is very desirable to ensure low pumping pressure. Also, the addition of coconut fiber at a concentration of 4g/3769mm^2 provided maximum values for both compressive strength (11 .3 MPa) and Tensile strength (12.4 MPa) while that of Plantain provided maximum values for both compressive strength (9.2 MPa) arid Tensile strength (9.2 MPa) compared to the other concentrations used and the reference sample after curing the samples for 9 days.

Keywords: Essential Additives, Plantain fibers, Cocoa nut fiber. Compressive strength, Tensile strength.

I. INTRODUCTION

The major phases in the production of oil and gas include drilling and completion. Drilling the well, lowering the casing, cementing, and completion are the main conventional operation. The wellbore may fail as a result of poor drilling and completion procedures, which could also have catastrophic environmental effects. An oil well cementing failure which occurred in 2010 in the Gulf of Mexico caused the world's largest accidentalmarine oil spill in the history of petroleum industry in which a blowout led to a huge fire and oil spill in the Gulf of Mexico (Garg & Gokavarapu, 2012). The petroleum sector has been providing money for creative approaches aimed at enhancing oil extraction and lowering production-related risks. One of the most important steps in the drilling and completion of a well is well cementing.

Oil-well cementing involves pumping down cement slurry down the stringand up the annulus or pumping directly into the annulus between the casing and wellbore. This is called, primary cementing. The purpose is to form a hard cement sheath that will ensure zonal isolation, support, and protect the casing after solidification It also involves process of forcing a cement slurry through holes or splits in the casing or liner. Such operation is performed after primary cementing arc called Remedial cementing. Pumping cement behind the casing provides a barrier to the fluids flow from or into the formation, and bonds the casing to the formation.

There is a growing need for inexpensive, sustainable, and widely accessible alternative cementing operation materials. In response to this need, investigations have been conducted to determine whether certain plant residues are suitable for use in cement. To save energy, natural fiber applications should receive more focus when it comes to oil well cementing materials. The use of natural fiber as an additive in cement slurry can help lessen the negative environmental effects of waste disposal. As cement-based composites have advanced, so too have innovations and strategies in designs that aim to use readily available raw materials in an environmentally and economically responsible manner. Utilizing plant leftovers in oil and gas sector contributes to a sustainable supply of cementing materials. Using locally produced cementing materials is one-way emerging economies may encourage sustainable development. Pseudostem is a valuable plant residue that can be used as cementing materials. It is often derived from plantain and banana plants. Another is Mesocarp from coconut fruit. A banana or plantain plant's trunk, which produces tightly overlapping sheaths, is known as the pseudostem. Hard fibrous overlapping layers that are spirally organized to fold around the central pith make up the pseudostem (trunk). The bonded filaments of lignin, hemicelluloses, and cellulosic forms make up the pseudostem. The lignocellulose material found in the pseudostem is based on woody fibers and has favorable qualities for use in oil and gas cementing. Research has demonstrated that cement composites' characteristics can be strengthened by using banana pseudostem fiber. Malarvizhi et al. examined the characteristics of concrete slabs reinforced with banana fiber, they found that the properties improved significantly in terms of compressive and tensile strengths. Similarly, when Kumaat et al. examined the features of concrete reinforced with banana stem fiber, they found that the concrete's flexible and tensile

For this reason, it's critical to progress the application of coconut fiber and plantain fiber in cement slurry by incorporating them into the cement-base matrix. This study, therefore, investigates the Rheology properties of cement Slurry reinforced with plantain fiber and coconut fiber and after solidification, to determine the Toughness influence by the fibre. This study will contribute to knowledge in the application of fibre in sustainable oil well cementing materials. Plantain and coconut are common plant that grows well in Africa. The plantain pseudostern and coconut mesocarp is abundantly available, affordable, and possesses mechanical properties which can contribute to sustainable oil well cementing materials applicable in Cementing Operation.

II. METHODOLGY

The major goal of this project is to investigate the effect of Coconut and Plantain fiber on rheological properties of cement slurry and mechanical properties after 9 days of curing. The experimental work was split into four main parts. The first part deals with preparing Fiber for the experiment. The second part is preparing the cement slurry. The third part is performing the Laboratory experiment. The last part is performing analysis after introduction of fiber and after a curing time of 9days.

2.1 Process Flow Chart

This section outlines the methodology used in carrying out this research work. The block diagram is depicted in Plate 3.1 below.

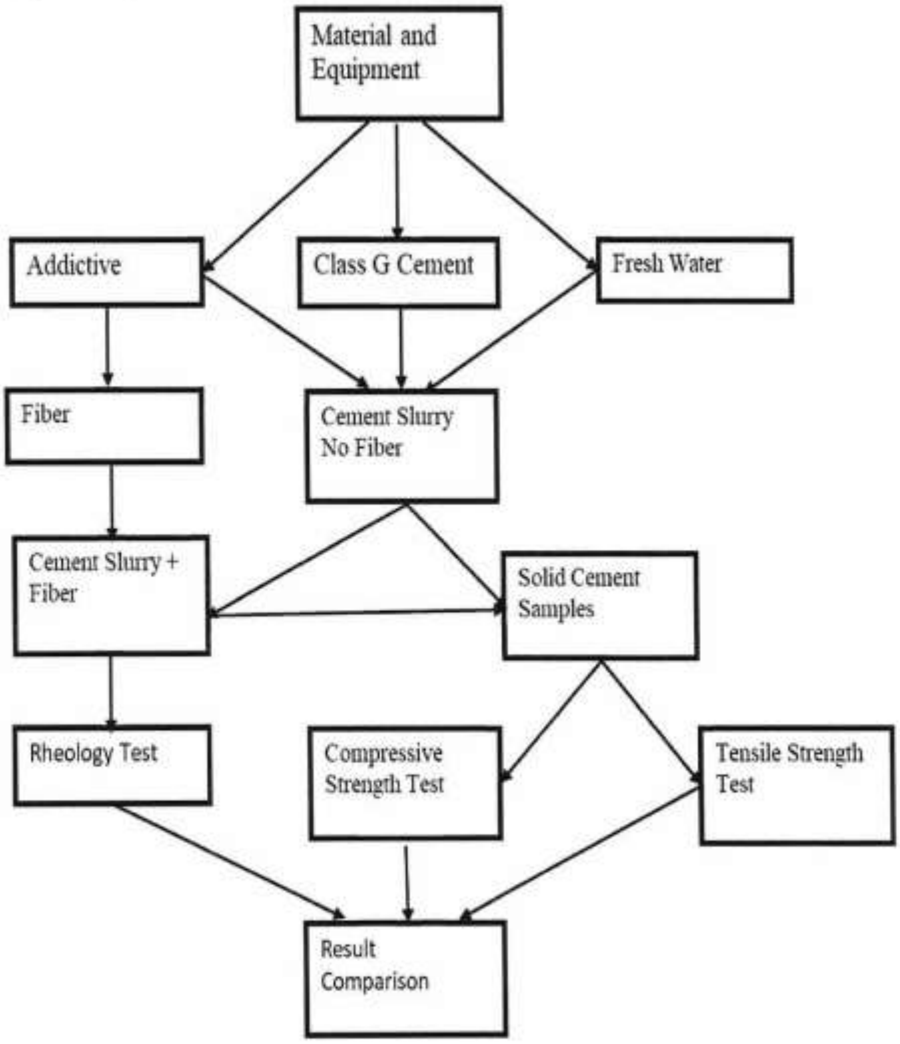

Figure 2.1 Process Flow Chart

Plantain fibre and coconut fibers were prepared from plantain pseudostem and coconut mesocarp both from a farm in Obiaruku, Delta State. The plantain residue was soaked in NaOH solution for 24 hours, and the fiber was mechanically extracted washed, and dried in the sun. Coconut fibers were also mechanically extracted from coconut mesocarp. Photographs of the plantain fibres and coconut are shown below. The average diameter of the fibre measured is +/- 1mm, specific

2.2 Slurry Preparation

Class G cement was mixed with fresh water and additives to form Cement Slurry as per plan for lead cement slurry to cement well Enyie SE 7. 15 liters of cement slurry was taken to the Lab. For this experiment. 13.5 ppg Lead Slurry of 57 bbl, Mixed fluid of 66 bbl was prepared in mixing tank as per below order.

i. Fresh water of 65 bbl was put in a clean tank,
ii. Added 3 gal of CEMFOAM.
iii. Slowly transferred 514 lb of Bentonite while Re-circulating and agitating at average RPM.
iv. Kept agitating at mm RPM for **mm of** 40 mins to pre-hydrate the bentonite.
v. Just before mixing the slurry, Added 214 lb of CEMFLMP, 57 lbs of CEMGPS and 22 lbs of CEMRHTL (s)

2.3 Rheological Measurements

Rheological measurements were performed by using a standard Viscometer. The device is presented in Plate 3.8 This device comprises a rotor and a bob.

Test Procedure

i. Prepared mud was poured into the beaker.
ii. Lower down the rotor into the mud until the sleeve is in the line with the surface of the mud
iii. Tighten up the locking nut on the leg of the Rheometer
iv. The samples were stirred for 60 sees @ 600 rpm, 300 rpm, 200 rpm, 100 rpm, 60 rpm, 30rpm, 6 rpm and 3rpm
v. The dial readings were taken for each sample when it stabilized.
vi. The dial readings were recorded at each rpm.

Rheological Calculations

i. Plastic Viscosity = value at 600 rpm — value at 300 rpm
ii. Yield Point = value at 300 rpm — Plastic Viscosity
iii. Apparent Viscosity Half of the value at 600 rpm
iv. Low Shear Rate Yield Point=2(3 rpm) - 6 rpm

2.4 Determination of Unconfined Compressive Strength and Tensile Strength

The cement samples were put into cylindrical plastic molds with an inner diameter of 20 mm and a height of 100 mm in order to conduct the unconfined compressive strength test. Before the cement slurry was added to the molds, the clean interior surfaces were lubricated with a non-reactive releasing agent to facilitate sample extraction after the cement had solidified. The samples were free of air bubbles after a few minutes of striking the mold from the bottom. All the cement samples were solid after being allowed to cure for one day, five days, and nine days at room temperature (24°C) and atmospheric pressure. After that, abrasive papers were used to polish the cement samples out of the mold and lessen the roughness of their base and top surfaces.

III. RESULTS AND DISCUSSIONS

3.1 Effect of Coconut Fiber on Rheology Properties

The effect of adding different percentage of Coconut fiber on cement slurry is shown in table below.

Table 3.1 Rheological properties of cement samples with increasing concentration of coconut fiber

COCO FIBER MIXTURE (g)	PLASTIC VISCOSITY cp	YIELD POINT (Ib/100sqft)	LOW SHEAR RATE YIELD POINT (Ib/100sqft)	GEL STRENGTH (Ib/100sqft)	
				10S	10M
0	31	11	1	3	9
1	37	26	3	3	9
2	39	28	4	3	9
3	41	29	6	5	10
4	45	31	8	5	10
5	82	33	47	48	43

It can be seen from Table 14.1, 5g Fiber slurry has the highest Plastic viscosity and Gel Strength which suggests that the pump-ability of this slurry could be the worst compare to 0 g to 4g Fiber Slurry. 0 g to 4g Fiber slurry is desirable because it has lower plastic viscosity and Gel strength which is very desirable to ensure low pumping pressure.

3.2 Effect of Plantain Fiber on Rheology Properties

The effect of adding different percentage of Plantain fiber on cement slurry is shown in table below

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Table 3.2 Rheological properties of cement samples with increasing concentration of plantain fiber

PLANTAIN FIBER MIXTURE (g)	PLASTIC VISCOSITY cp	YIELD POINT (Ib/100sqft)	LOW SHEAR RATE YIELD POINT (Ib/100sqft)	GEL STRENGTH (Ib/100sqft)	
				10S	10M
0	31	11	1	3	9
1	45	15	2	3	9
2	55	30	8	3	9
3	70	40	30	6	19
4	80	50	34	33	35
5	90	120	136	139	138

It can be seen from Table, 14.2, 4g and 5g Fiber slurry has the highest plastic viscosity and gel strength, which suggests that the pump-ability of this slurry could be the worst compare to Og to 3g Fiber Slurry. This slurry is desirable because it has lower plastic viscosity and gel strength, which is very desirable to ensure low pumping pressure.

3.3 Effect of Coconut Fiber on Compressive Strength

The graphs below show the Compressive Strength of cured sample containing Og, lg , 2g 3g, 4g and 5g of coconut fiber.

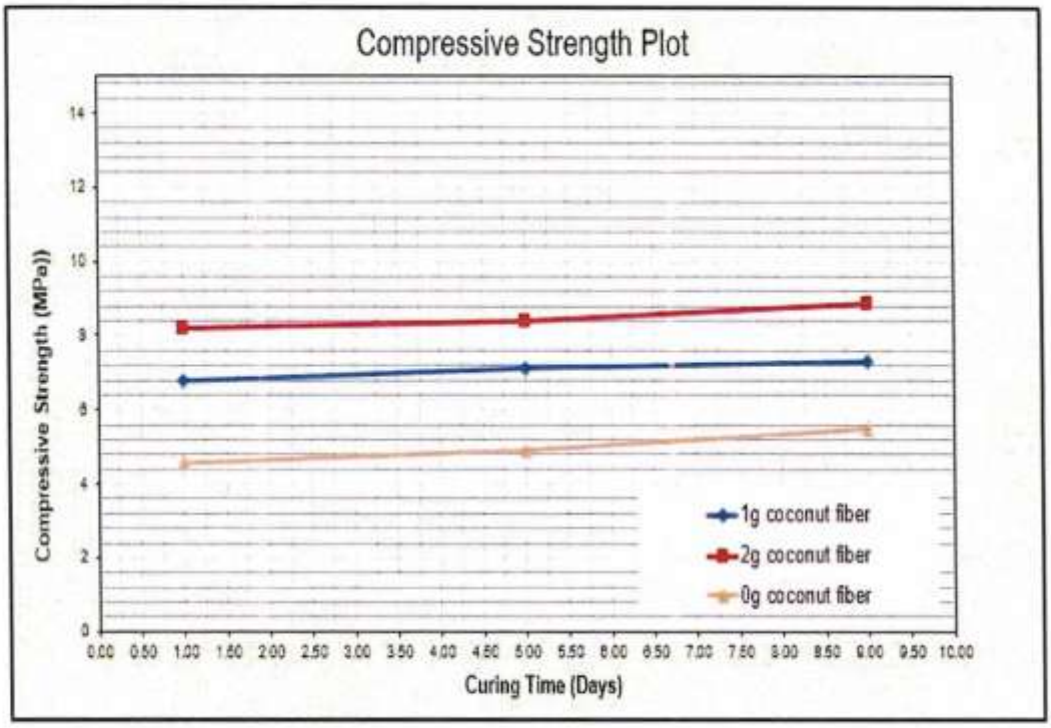

Figure 3.1 Compressive Strength of coconut fiber sample0 g to 2g)

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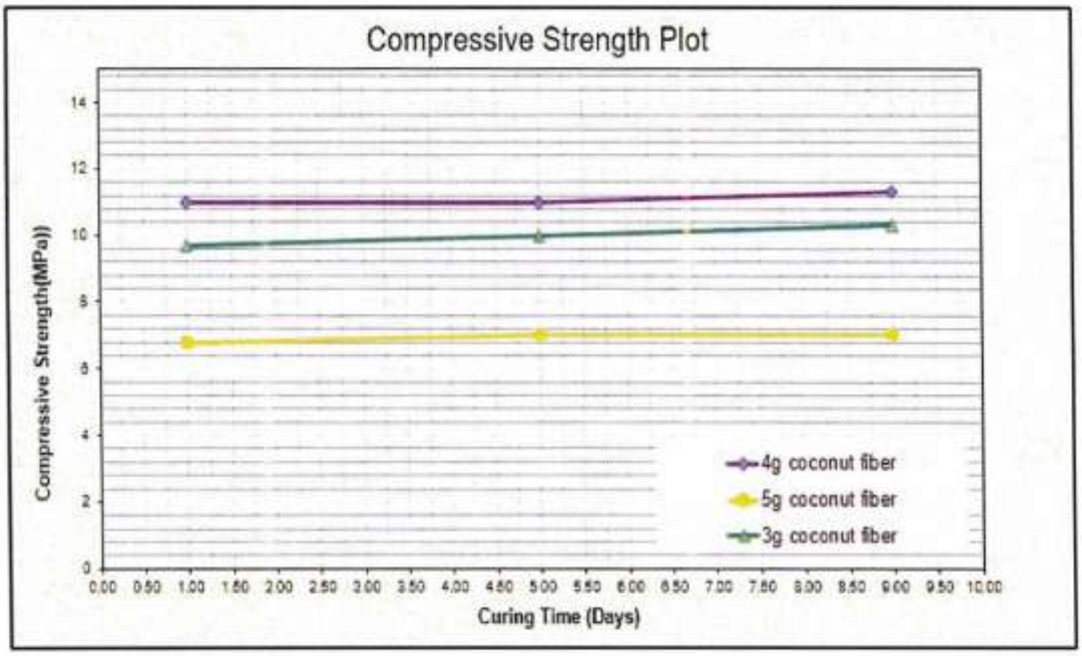

Figure 3.2 Compressive Strength of coconut fiber sample(3g to 5g)

3.4 Effect of Coconut Fiber on Tensile Strength

The graphs below show the Tensile Strength of cured sample containing 0g, 1g, 2g 3g, 4g and 5g of coconut fiber.

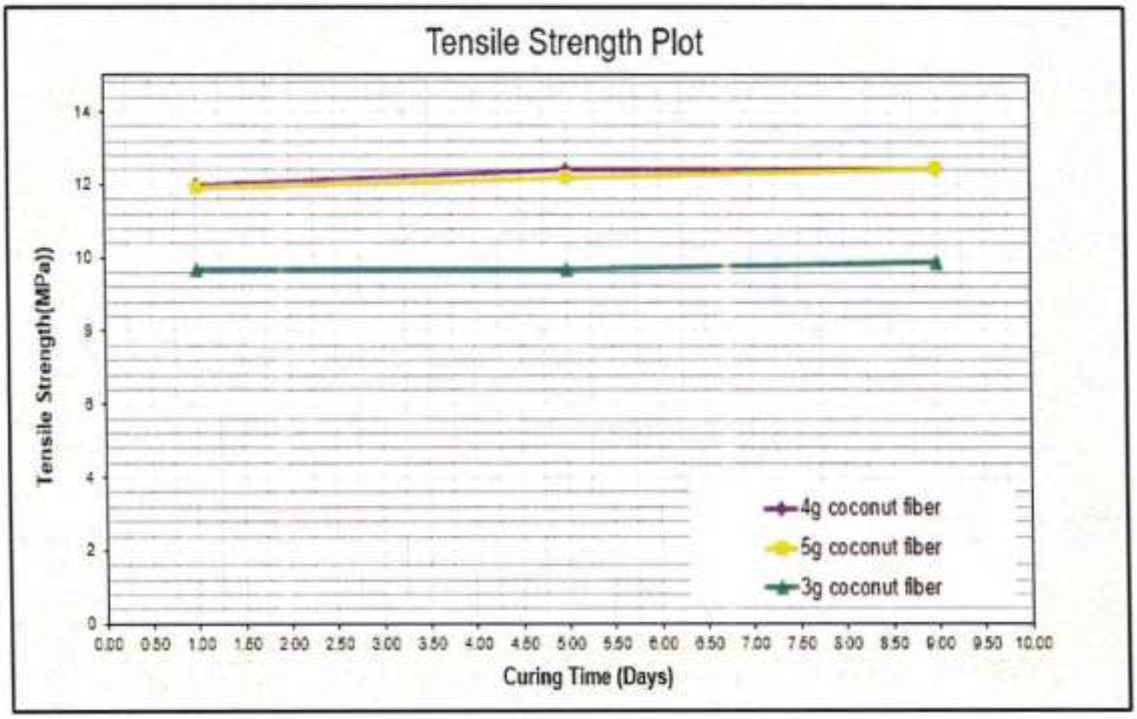

Figure 3.3 Tensile Strength of coconut fiber sample(3g to 5g)

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3.5 Effect of Plantain Fiber on Compressive Strength

The graphs below shows the Compressive Strength of cured sample containing 0g, Ig, 2g 3g, 4g and 5g of plantain fiber.

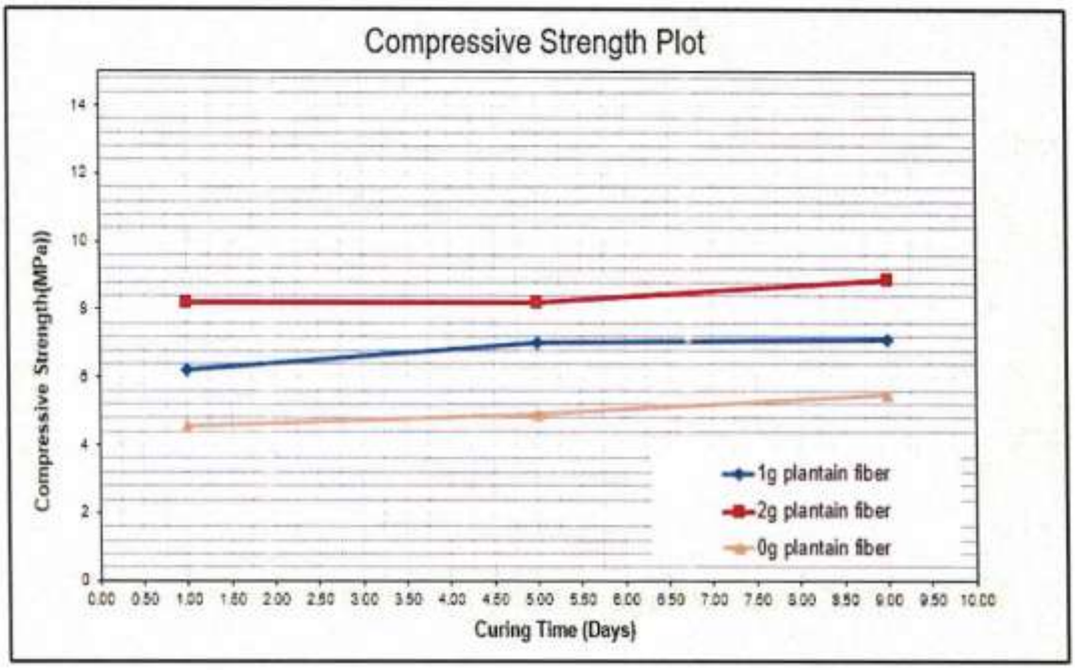

Figure 3.4 Compressive Strength of Plantain fiber sample(0g to 2g)

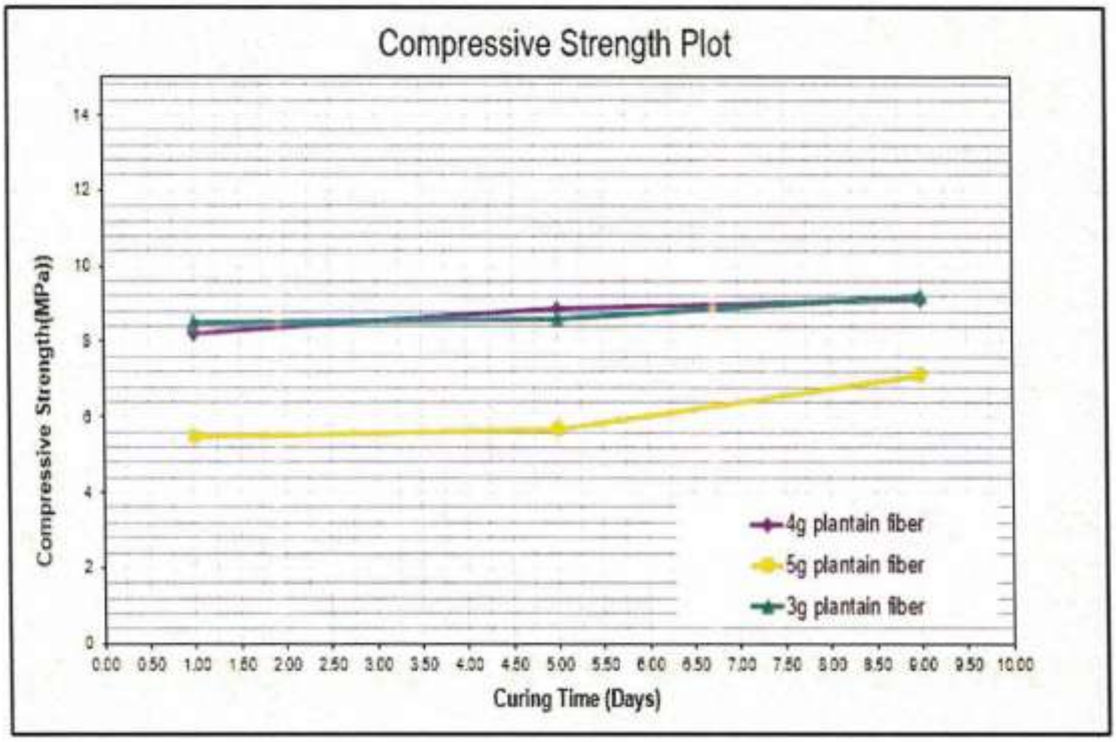

Figure 3.5 Compressive Strength of plantain fiber sample(3g to5g)

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3.6 Effect of Plantain Fiber on Tensile Strength

Thegraphs below show the Tensile Strength of cured sample containing 0g, 1g, 2g 3g, 4g and 5g of coconut fiber.

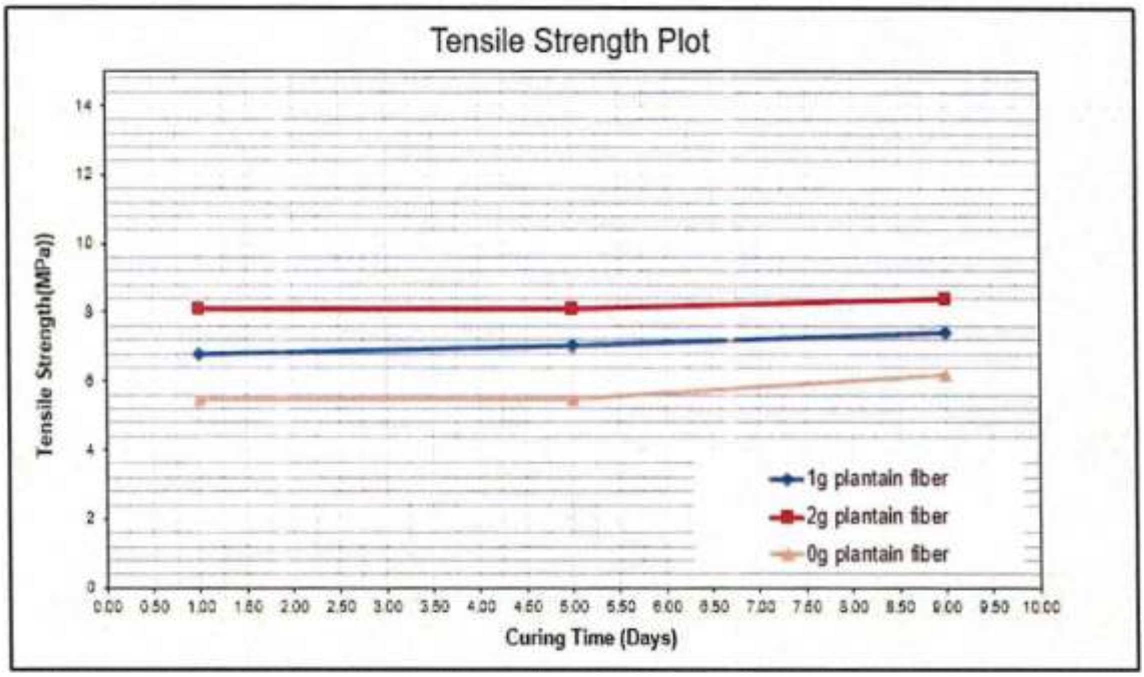

Figure 3.6 Tensile Strength of Plantainfiber sample(0g to 2g)

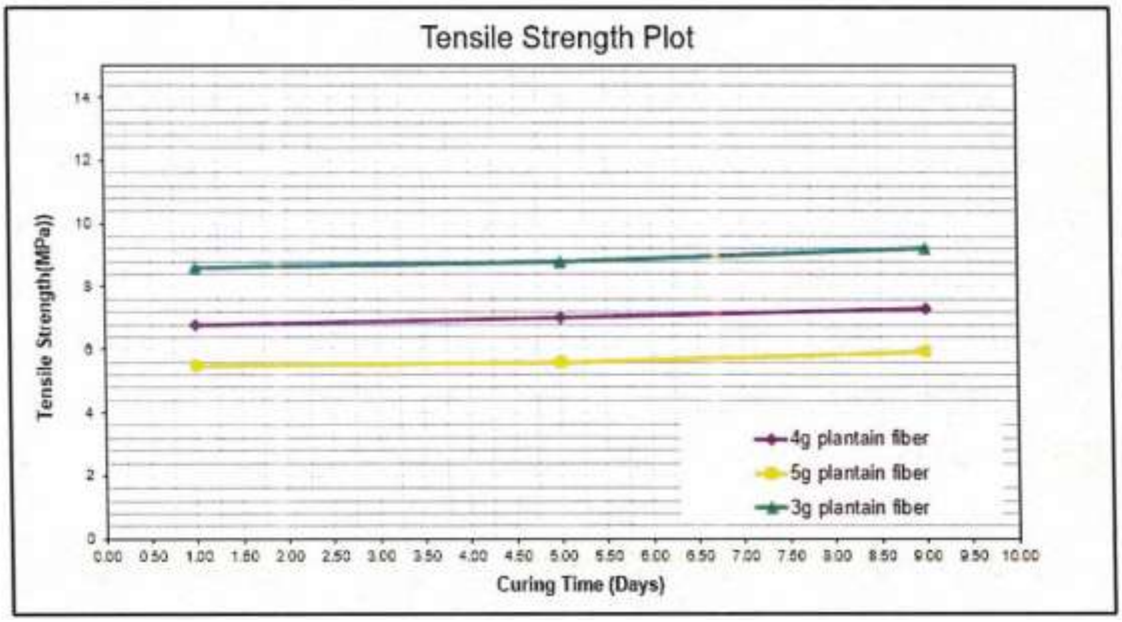

Figure 3.7 Tensile Strength of Plantain fiber sample(3g to5g)

The effect of plantain and coconut fiber on the compressive strength and tensile strength is shown in figure 4.1 to figure 4.8. The concentration of fiber used are I g, 2g, 3g. 4g and 5g. It shows the compressive strength and tensile strength test results of cylindrical cement samples containing increasing concentrations of fibers at different cured times. From this figure, it is clear to say that adding fibers to well cement improves compressive strength and tensile strength. - The highest

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increasing rate in compressive strength after adding coconut fiber was 58%, 55% and 51% and after adding plantain fiber was 45%, 43% and 40% for the curing time of 1, 5 and 9 days. The highest increasing rate in Tensile Strength after adding coconut fiber was 54%, 57% and 50% and after adding Plantain Fiber was 36%, 37% and 32% for the curing time of 1, 5 and 9 days respectively. The improved fiber orientation and long length distribution in the cement slurry, which results in better performing specimens with fewer micro-cracks, are responsible for the strength gain. After adding 5g of Coconut fiber and 4g of plantain fiber, there was a drop in both compressive and tensile strength. This could have been caused by the sample's poor homogenous dispersion within the cement slurry. Another explanation would be that a high fiber concentration weakens the oil well cement bonding power and interferes with the interlocking mechanism. When cement is mixed with the fibers of coconut and plantain, a fiber network is created that can extend vertically, horizontally, or in multiple directions. This network forms a bridge across the crack and a chain that holds molecules together, which reduces the size of the primary fracture, as seen in plate 4.1 and 4.2. Here, the fibers add its strength to the cement and sustain the compressive and tensile strengths of the cement stress.

IV. CONCLUSION

Ultimately, this research has led to an understanding of the effectiveness of adding plantain and coconut fibers to cement slurry in order to improve its mechanical qualities while keeping it within the pumpable limit.

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