Evaluation of Sugarcane Bagasse as Lost Circulation Materials

by

Syafiq Syazwan Bin Abdullah

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Petroleum Engineering)

JAN 2012

Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

Petroleum Engineering Programme

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Approved by,

____

(Jasmi Bin Ab Talib)

Date: 13 April 2012

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JAN 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I, Syafiq Syazwan Bin Abdullah (I/C No: 890322-03-6215), am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

____

SYAFIQ SYAZWAN BIN ABDULLAH

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ABSTRACT

Sincere goes to Mr. Jasmi Abd Talib UTP supervisor that have encourage, support and have spent time to discussing some matters regarding to my final year project. He also supported me and encouraged me to complete this task so that I will not procrastinate in doing it.

As my project all about the drilling fluids which evaluates the greenery material as drilling fluid additives in water based system. Lost circulation is defined as the total loss of drilling fluid into the formation. This project is mainly focus on how to prevent unwanted issues by evaluating the lost circulation materials (LCM) in water based mud system which based on green LCM - environmental friendly and has a lower cost than contemporary LCM. Contemporary LCM made from, mica, raw cotton, nut shell, wood fibre, corn cobs and etc. Several of this material can be toxic to environment or take long time to dispose if the drilling company decides to dumb the mud into the sea or the mud lost in to formation.

The project involves several experiments such as rheology, permeability plugging test and fluid loss to determine the properties and performance of green LCM. The experiments require several lab equipment such as Fann 35 viscometer, API Filtration Loss, and etc. Hopefully, the green LCM which based on sugarcane can achieve the target successfully.

ACKNOWLEDGEMENTS

The special thank goes to my supportive supervisor, Mr Jasmi Ab Talib. The supervision and guidance that he gave truly help the progression and smoothness of my final year project. The co-operation is much indeed appreciated.

My traning coordinator, Mr Erwin Aryanto also the one who continuous supports me in looking the career future was truthfully appreciated by mine personally. My grateful thanks also go to Mr Luqman, Mr Neethia Raj and Mr Vignesh Nambiar. A big contribution and hard worked from all of you is very great indeed whenever guide me in SCOMI's GRTC.

Not forgotten thanking to my family for providing everything, such as money, to buy anything that are related to this project work and their advise, which is the most needed for this project. They also supported me and encouraged me to complete this task so that I will not procrastinate in doing it.

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ABBREVIATIONS AND NOMENCLATURES

API	American Petroleum Institute
ECD	Equivalent Circulating Density
FB	Fibro-Seal
GS	Groundnut shell
LCM	Lost circulation materials
PV	Plastic viscosity
RH	Rice husk
SB	Sugarcane bagasse
WBM	Water-based mud
YP	Yield point

1.0 INTRODUCTION

1.1 BACKGROUND

Drilling fluid is one of the vital factors in drilling a successful well. Any drilling fluid must have common properties which facilitate safe and satisfactory completion of the well such as bottom hole cleaning, removal of cuttings to the surface, controlling formation pressure, and maintain wellbore stability. These functions are controlled by the rheological and filtration properties of mud.

Lost circulation is one of the most common and potentially one of the most expensive problems encountered in a drilling operation. In the best case results are often additional operating time and increased mud and operating costs, in the worst case results are often blowouts and lost hole. Whenever loss circulation is anticipated a lost circulation contingency plan should be put in place. This will ensure that, when losses are encountered, the appropriate treatments are executed competently and methodically. In this manner the time and costs associated with losses can be controlled.

Incentive to that, green lost circulation materials (LCM) would be introduced to apply as lost circulation materials as alternative for current commercial LCM. Today, sugarcane is grown in over 110 countries which estimated 1,683 million metric tons were produced worldwide which amount to 22.4% of the total world agricultural production by weight. From that, the wasteful of sugarcane bagasse are taken as sample projects. Potential for further treatment as drilling fluid additive, in lost circulation materials. Abundant of waste from the sugarcane industry such as sugarcane bagasse will be produced each year. Thus, it is important to conduct a study on the sugarcane bagasse for potential development in drilling fluid technology.

Figure 1: Sugarcane farm

1.2 PROBLEM STATEMENT

Lost circulation is a problem as old as rotary drilling. In the interior United States and Canada it is the major factor in most high drilling-cost wells. Where the average well may have a mud cost of $4,000, the lost-circulation well will have one of $8,000 to $50,000. To the cost of lost mud materials must be added that of the rig time consumed and the cost of the occasionally accompanying stuck drill pipe, lost hole, blowout, or abandonment. There are also cases of missed production chargeable to lost circulation, from failure to secure production tests and samples and of decreased productivity from the plugging of productive zones.

Lost-circulation materials are mud additives designed to ensure that the fluid circulated down the hole in the rotary method of well drilling returns to the surface for recirculation rather than disappearing into the formation drilled. These materials are substances added to drilling mud to increase the maximum particle size present in order to plug the pores or cracks which the mud alone is unable to seal. In order to perform this function, they must contain particles large enough to lodge in the largest apertures present. In as much as the maximum size material which can be handled through mud pumps is limited, this places an upper limit on the size openings which can be sealed by this method. A little consideration will also show that there must be a suitable gradation of lost-circulation particle sizes to pack in such a manner that they form a base on which a mud filter cake can build.

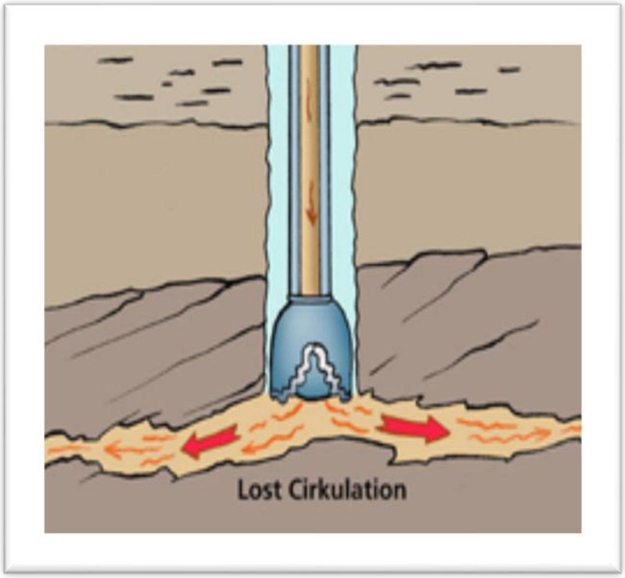

Figure 2: Lost circulation diagram

Commercially available LCM products encompass a wide array of materials which LCM made from contemporary materials has a high cost and not environment friendly. Example of fibrous material are raw cotton and wood fiber while dumping of the mud into the sea which contains flake type of LCM like mica and cotton seed can cause toxic problem to the aquatic creatures. Limestone or $CaCO_3$ is the most common and popular commercial lost circulation material (LCM) in the drilling fluid currently. As result it is significant to develop green LCM that friendly to the environment and low cost as well. Expectantly this green LCM can minimize drilling cost operation and secure the well.

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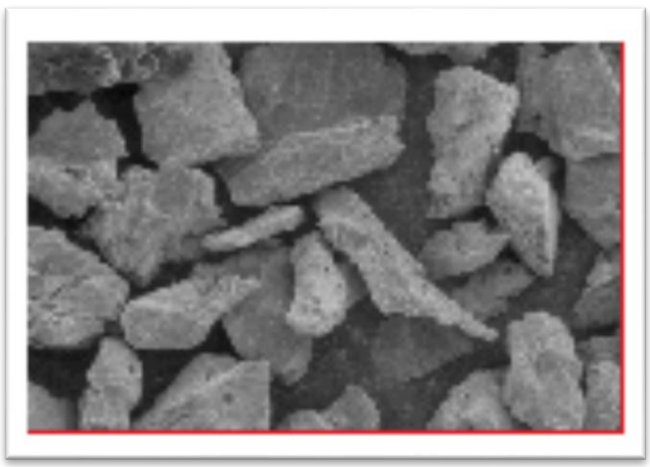


Figure 3: Commercial LCM – STEELSEAL (HALLIBURTON)

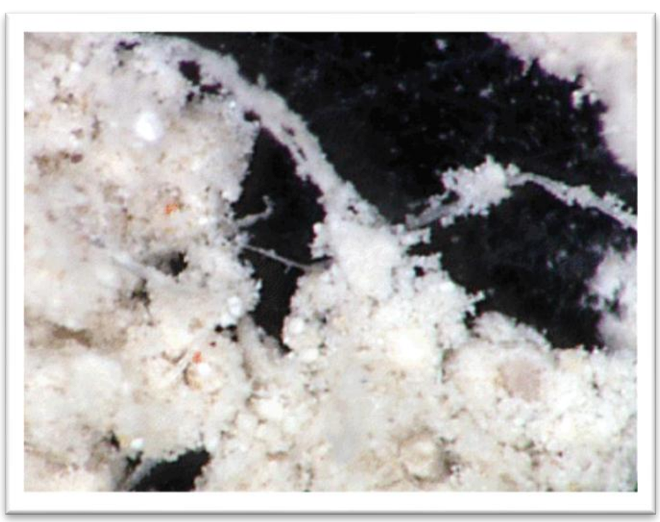


Figure 4: Commercial LCM – DIASEAL (CHEVRON PHILLIPS)

1.3 OBJECTIVES & SCOPE OF STUDY

1.3.1 OBJECTIVES

a. To optimize performance and efficiency in seal off lost circulation formation

b. To apply environmental friendly

c. To get lower cost than contemporary LCM

1.3.2 SCOPE OF STUDY

- Research
  - WBM and sugarcane bagasse
  - equipment and materials required
- Evaluate
  1. Properties of sugarcane bagasse
     - *Particle size distribution*
     - *Moisture content*
     - *Specific gravity*
  2. Performance as drilling fluid additive
     - *Fluid loss*
     - *Mud cake thickness*
     - *Plastic viscosity*
     - *Yield point*
     - *Gel Strength*
- Compare - green LCM with commercial LCM
  - *Fibro-Seal*
  - *Baker-Squeeze*
  - *Form-A-Seal*
  - *Ultra-Fiber*

2.0 LITERATURE REVIEW / THEORY

2.1 DRILLING FLUIDS

Drilling fluid is a fluid used to aid the drilling of boreholes into the earth. Often used while drilling oil and natural gas wells and on exploration drilling rigs. The three main categories of drilling fluids are water-based mud (which can be dispersed and non-dispersed), non-aqueous mud, usually called oil-based mud, and gaseous drilling fluid, in which a wide range of gases can be used. [1]

Drilling fluids are designed and formulated to perform the primary function and secondary function.

PRIMARY FUNCTIONS	
Control formation pressure	A drilling fluid controls the subsurface pressure by its hydrostatic pressure. Hydrostatic pressure is the force exerted by a fluid column and depends on the mud density and true vertical depth (TVD).
Transport cuttings	As drilled cuttings are generated by the bit, they must be removed from the wellbore. To do so, drilling fluid is circulated down the drill string and through the bit, transporting the cuttings up the annulus to the surface. Cuttings removal is a function of cuttings size, shape and density combined with rate of penetration (ROP), drill string rotation, plus the viscosity, density and annular velocity of the drilling fluid.
Maintain stable wellbore	Borehole instability is a natural result of the unequal mechanical stresses and physico-chemical interactions and pressures created when surfaces are exposed in the process of drilling a well. The drilling fluid must overcome both the tendency for the hole to collapse from mechanical failure and/or from chemical interaction of the formation with the drilling fluid.

Table 1: Primary functions of drilling fluids

SECONDARY FUNCTIONS	
Support weight of tubular	Drilling fluid buoyancy supports part of the weight of the drill string or casing. The buoyancy factor is used to relate the density of the mud displaced to the density of the material in the tubular; therefore, any increase in mud density results in an increase in buoyancy.
Cool and lubricate the bit and drill string	Considerable heat and friction is generated at the bit and between the drill string and wellbore during drilling operations. Contact between the drill string and wellbore can also create considerable torque during rotation, and drag during trips. Circulating drilling fluid transports heat away from these frictional sites, reducing the chance of pre-mature bit failure and pipe damage.
Transmit hydraulic horsepower to bit	Hydraulic horsepower generated at the bit is the result of flow volume and pressure drop through the bit nozzles. This energy is converted into mechanical energy which removes cuttings from the bottom of the hole and improves the rate of penetration.
Provide medium for wireline logging	Air/gas-based, water-based, and oil-based fluids have differing physical characteristics which influence log suite selection. Log response may be enhanced through selection of specific fluids and conversely, use of a given fluid may eliminate a log from use. Drilling fluids must be evaluated to assure compatibility with the logging program.
Assist in formation evaluation	The gathering and interpretation of sub-surface geological data from drilled cuttings, cores and electrical logs is used to determine the commercial value of the zones penetrated. Invasion of these zones by the fluid or its filtrate, whether it is oil or water, may mask or interfere with the interpretation of the data retrieved and/or prevent full commercial recovery of hydrocarbon.

Table 2: Secondary functions of drilling fluids

2.2 SUGARCANE FIELD STUDIES

In recent years the sugarcane harvested area has averaged between 20 000 and 24 000 hectares. Production is concentrated in the Northwest extremity of peninsular Malaysia in the states of Perlis and Kedah. This area has a distinct dry season needed for cost-efficient sugarcane production. Most of the cane areas are under the management of three sugarcane plantations, two in the State of Perlis and one in the state of Kedah, with smallholders contributing only about 15 percent of the total. [2]

Sugarcane yields have increased steadily over the years. They rose from 40 tonnes per hectare in 1980 to 65 tonnes per hectare in 1990 and reached 68 tonnes per hectare in 1996. The increase in yields can be attributed to the planting of improved varieties and greater input use. There are some annual fluctuations, but in recent years yields have remained relatively constant. Differences in yields also exist between plantations and smallholders with the latter are yields averaging generally around 40 tonnes per hectare owing to reduced access to irrigation water. Production of sugarcane generally ranges between 1.3 to 1.6 million tonnes annually depending largely on yields. Sugar content has been around 7 percent. The harvest takes place between January and April.

The largely consistency trend market of sugarcane production is extremely suit in oil and gas industry. The properties of sugarcane which is fibrous will strengthen the possibility to use it as drilling fluid additives. Moreover from taking the bagasse of sugarcane, it shows no residual wasteful into surplus of dumping rubbish. Apart of the greenery approachable, the using of sugarcane bagasse where taken from Malaysia has a potential values to be developed and commercialized as commercial lost circulation material since Malaysia’s sugarcane industry produced abundant of sugarcane bagasse resources which can be cost effective compared to the commercial lost circulation material (LCM).

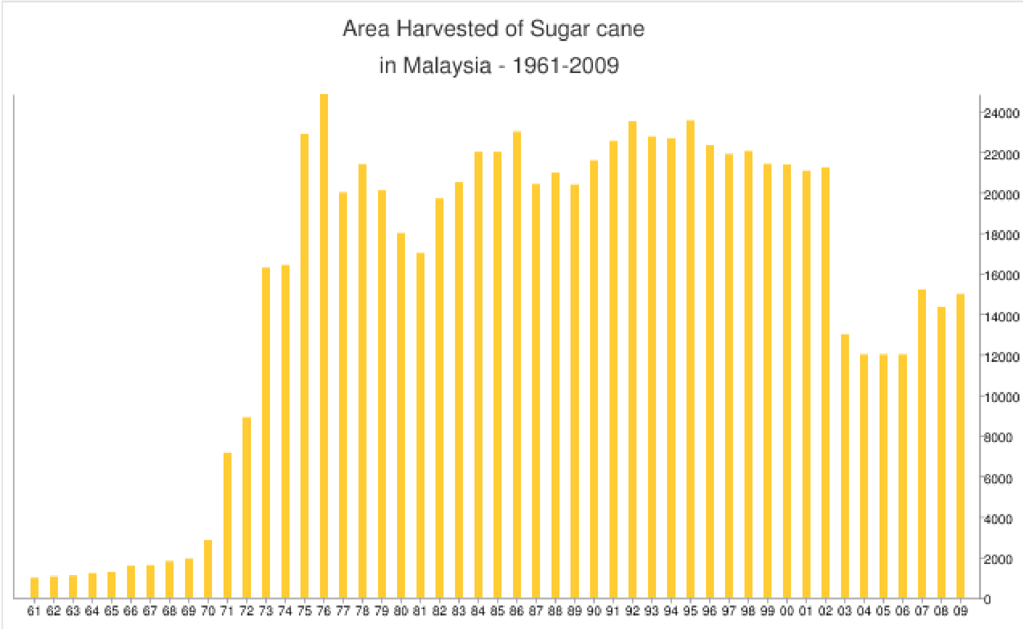


Figure 5: Sugarcane Area Harvested

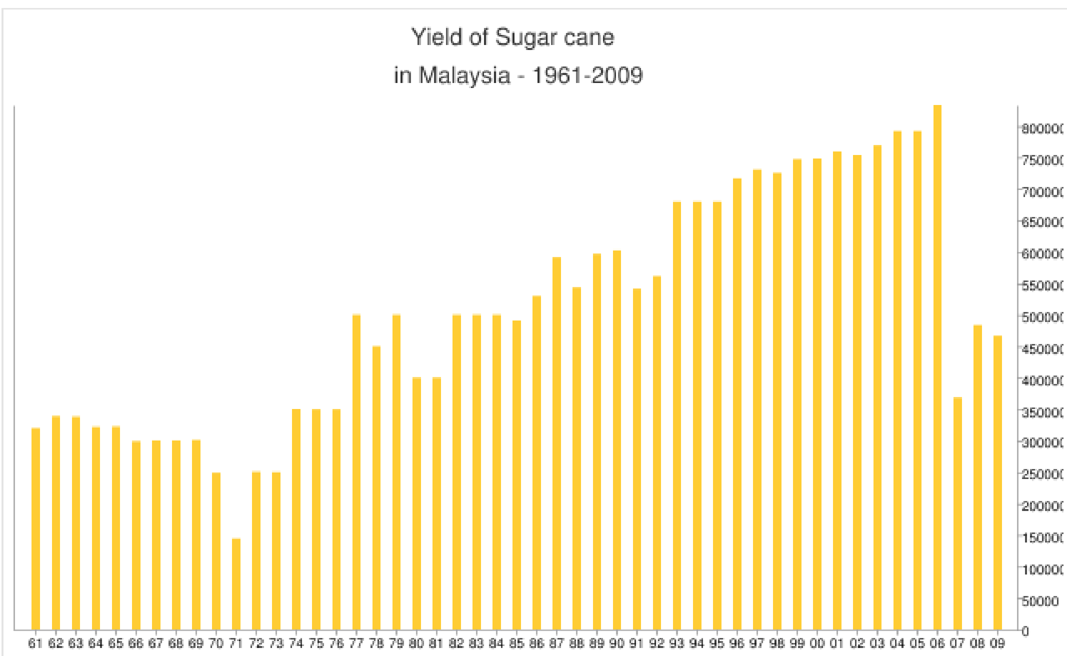


Figure 6: Sugarcane Yield

2.3 LOST CIRCULATION

Lost circulation is both troublesome and costly. After the lost circulation occurs, the level of drilling fluids in the annulus may drop and the stabilization at a particular level, depending on the formation pressure. Thus, the additives of bridging agents had been used for reducing lost circulation. [3]

2.3.1 MAIN FORMATION TYPES WHICH LOSSES OCCUR

- **Unconsolidated & High Permeability**

  It commonly occurred in horizontal beds at shallow depths. The formations can be gravel beds, sand, sea shells or combination of these. Typical losses are slight, but can worsen dramatically. It can be cured by reduce hydrostatic or foam drilling, apply proper of LCM types and sizes as well create cement plugs.

Figure 7: Unconsolidated & High Permeability

- **Naturally Fractured**

  Usually occur at greater depth either horizontal or vertical fractures. For horizontal fractures usually above 2500 ft while for Vertical fractures usually below 2500 ft. Fractures more common in areas of tectonic activity. Commonly associated with limestone, dolomite, chalk, hard sands, hard shale. It can be cured by reduce hydrostatic or foam drilling, LCM pills and create cement plugs.

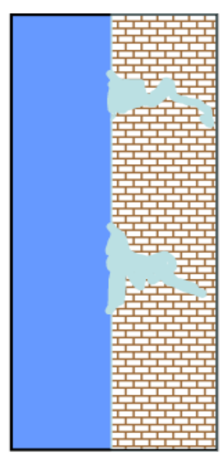


Figure 8: Naturally Fractured

- ## Induced Fractured

Occur at any depth (horizontal < 2500 ft, vertical > 2500 ft) and any type of formation and usually associated with weak bedding planes. Often results from sudden surges against the formation due to running casing too quickly, pumping too quickly, gel strengths too high and mud weight is too high.

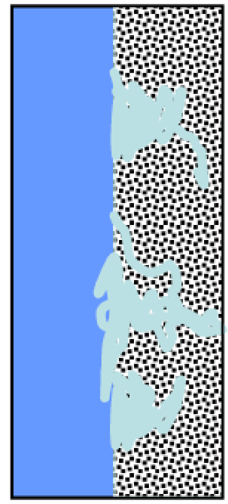


Figure 9: Induced Fractured

- ## Cavernous

Cavernos associated with limestone and dolomite. Losses are usually sudden and complete. Pressures are normally subnormal which lower than hydrostatic pressures. This formation is most difficult loss zone to cure. It can be cured by case-off zone or limited success with conventional techniques.

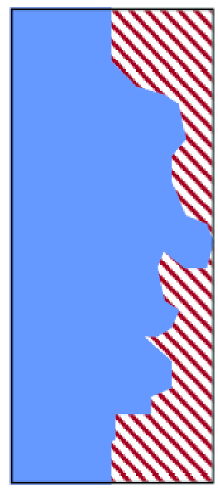


Figure 10: Cavernous

2.3.2 TYPES OF LOSS ZONE

- **Seepage losses (< 25 WBM or 10 OBM bbls/hour)** [4]

Commonly, initial seepage losses will be minimal and will increase with drilling as more of the specific formation is exposed. Losses of this severity are commonly encountered in porous sands and fractured formations. The type of loss, naturally occurring or mechanically induced, can usually be resolved by suspending drilling, circulating the hole clean and observing the losses whilst varying the pump rate and pressure

- **Partial losses (25 – 100 WBM or 10 – 30 OBM bbls/hour)**

Losses of this severity are commonly encountered in unconsolidated formations, vugular carbonates and fractured formations. The type of loss, naturally occurring or mechanically induced, can usually be resolved by suspending drilling, circulating the hole clean and observing the losses whilst varying the pump rate and pressure.

- **Severe losses (> 100 WBM or > 30 OBM bbls/hour)**

Severe losses are instantaneous as fluid is lost to a void, the initial olume lost can range from tens to hundreds of barrels after which the losses may moderate or cease. Losses of this severity are commonly encountered in vugular carbonates and fractured formations. The type of loss can be assumed to be naturally occurring.

- **Complete losses (No returns to surface)**

Complete or total losses is often difficult, if not impossible, to mix new mud volume at the rate required to maintain a full annulus with high static losses, such a situation may result in a well control situation as the mud column and resultant hydrostatic pressure is diminished. Losses of this severity are commonly encountered in vugular carbonates and fractured formations. The type of loss can assumed to be naturally occurring.

2.3.3 TYPES OF LOSS CIRCULATION MATERIALS

- **Fibrous**

Fibrous LCM's include raw cotton, nylon fiber, bark fiber, textiles fiber and etc. These types are generally plants fibers, though representatives of animal and mineral fibers are also found as well as synthetic fibers. These materials are used mainly in drilling muds to lessen the mud loss into large fracture or vugular formations. When added to a drilling mud, the fibrous LCM's form a mat-like bridge over porous formations. These mat effects a reductions in the size of openings into the formations, permitting the colloidal particles in the mud to rapidly deposit a filter cake thus completely sealing the formation. Fibers generally have little strength and cannot withstand high differential pressures. [5]

- **Flake**

It includes cellophane, mica, corn-cobs cottonseed hulls and vermiculite. The flake-type LCM's are designed to bridge and to form a mat on the formation face. These materials can plug and bridge many types of porous formation to stop the mud loss or to establish an effective seal over many permeable formation.

- **Granular**

Granular LCM includes nutshells, calcium carbonate, sized salt, hard rubber, asphalt, gilsonite, plastic. It form bridges either at the formation face or within the formation matrix. The effectiveness of granular LCM's depend primarily on proper particles size distribution to build a bridge with decreasing permeability. These materials work better in high solids ratio systems such as cement slurries than in lower-solids drilling mud systems.

○ Blended

Blended of two or more of the preceeding LCM's have proved to be useful and effective in the field. A popular blend of various LCM's furnishes the advantage of having gradation of particles sizes and variation of types of materials blended in a sack mixture to provide effective sealing. This blend is a combination of granular, flake and fibrous material varying in size, shape and toughness. This blend will penetrates fractures, vugs or extremely permeable zones and seal them off more effectively.

Fibrous Materials	Flake Materials	Granular Materials
Raw Cotton	Mica	Nut Shells
Wood Fibre	Cellophane	Nut hulls
Bark Fibre	Cork	Rice hulls
Textile Fibre	Corn cobs	Wood
Mineral Wool	Cotton seed	Corn cobs
Straw	Plastics	Asphalt
Asbestos		Ground Rubber
Leather		Salt
Peat Moss		Bentonite
Feathers		Limestone/$CaCO_3$
Flax		Perlite

Figure 11: Main Morphology Types of LCM

2.3.4 CASE STUDIES ON LOST CIRCULATION

- **Case 1**

In South Louisiana the 'Net' line was penetrated using expanded aggregate as the lost circulation treatment. Drilling progressed without incident 200 ft into the zone using the 250 sacks of expanded aggregate on location with no additional aggregate available. The balance of drilling was hampered by lost circulation problems and the use of conventional material was marginally successful. A "gunk squeeze" and controlled drilling with partial return permitted the well reach the next casing point. [6]

- **Case 2**

Lost circulation occurred while drilling out below the casing shoe with 11 ppg mud. An attempt to squeeze the casing shoe and annulus was filled repeatedly with 9.3 ppg brine. A 200 bbl pill of expanded aggregate was spotted at the shoe and the hole allowed healing. The shoe was successfully re-cemented and drilling was reused.

- **Case 3**

Stuck pipe was experienced after lost circulation while drilling at 6500 with 10 ppg mud weight. Drilling was attempt with 9 and 8 ppg mud after successful fishing operation. Lost circulation recurred. Various lost circulation products were pumped without success A 50 bbl pill of expanded aggregate mixed at 15 ppb was spotted and the hole was allowed to heal for 2 hours. Drilling was resused with 10 ppg mud without incident to the next casing seat.

2.4 COST COMPARISON

In aspect of economic, it had been found that there is too much different between sugarcane bagasse with current commercial products of LCM.

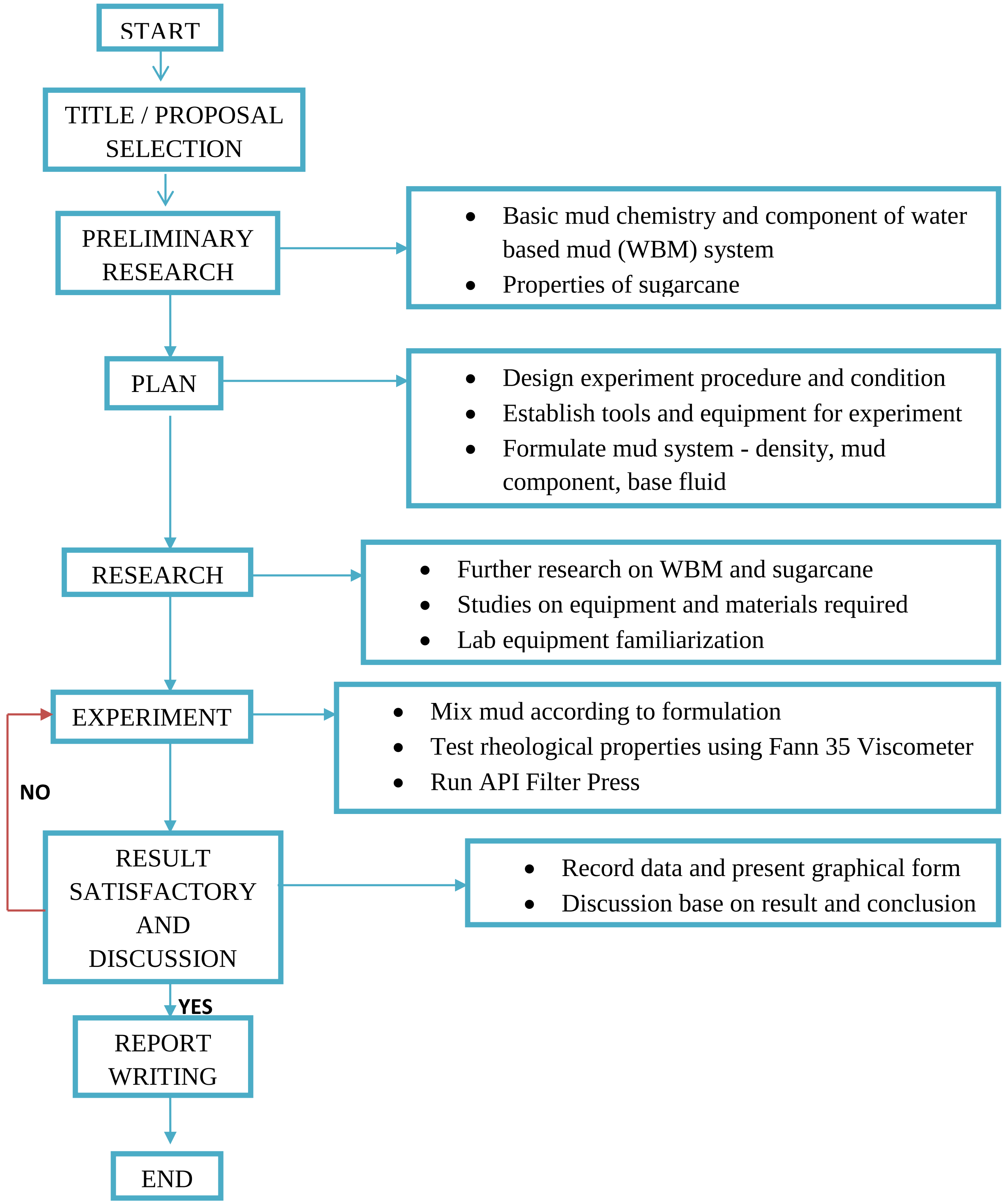
LOST CIRCULATION MATERIALS	**PRICE**
FORM-A-SEAL	RM 276 / sacks
FIBRO-SEAL	RM 165 / sacks
ULTRA -FIBER	RM 117 / sacks
MICA	RM 74 / sacks
SUGARCANE BAGASSE	***RM 10 / sacks***

Table 3: Cost comparison between sugarcane bagasse with commercial LCM

Thus, it has highly potential to be recommended as new alternative for LCM to commercialize due to its price compared to current LCM. By that way, the marketability of sugarcane bagasse will get increasing surely especially for oil company appliance and drilling fluid oil well services.

3.0 METHODOLOGY / FLOW WORK

3.1 RESEARCH METHODOLGY



3.2 EXPERIMENTAL WORKS

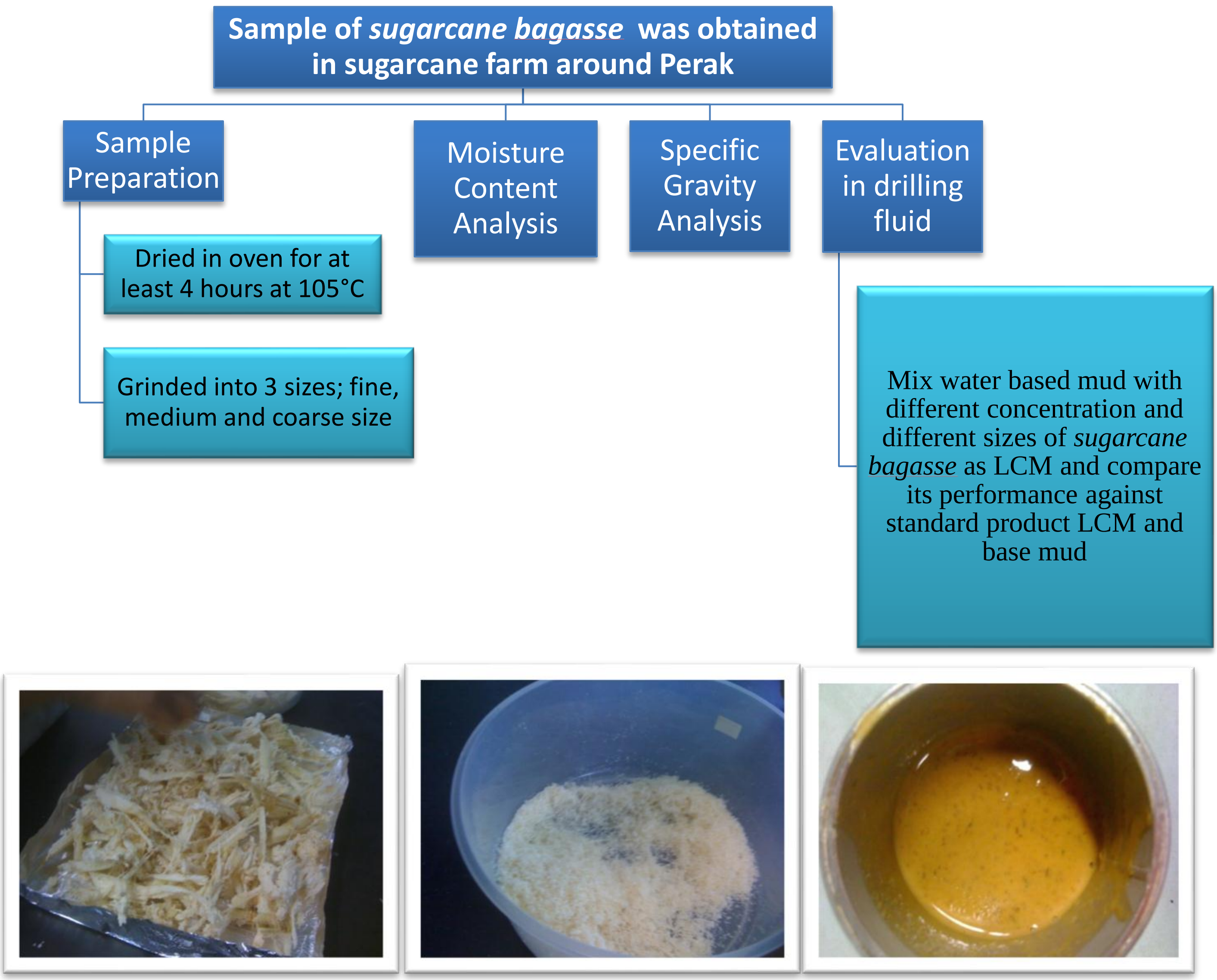
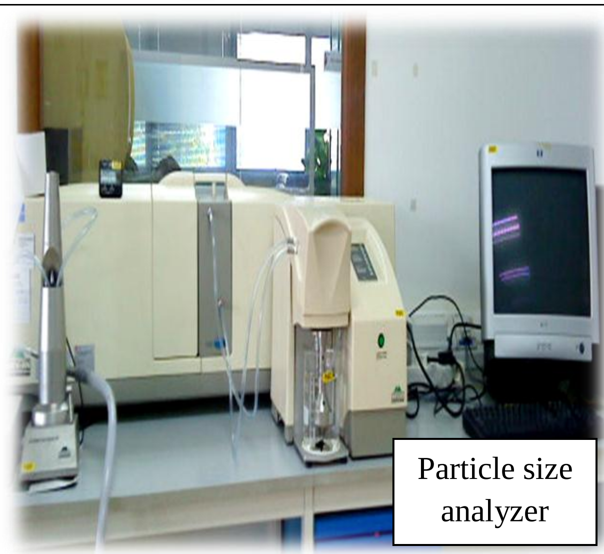


Figure 12: Experimental works

3.2 TOOLS

Lab Equipments	Descriptions	Quantity
 Fann 35 Viscometer	The rheology will be determined using a motor driven Fann 6 speed viscometer. The six readings (600, 300, 200, 100, 6, and 3 rpm) will be taken at 120°F. A heated cup will be used for this purpose. The gelling characteristics of the fluid can be determined from taking a 10-second and a 10-minute gel reading.	2
 API filter press	API filter press normally we use for water based mud system. We only apply 150psi pressure at the top of the cell. Then we will collect the filtrate for 30 minutes	1
 Mud Balance	Mud balance we use to determine mud weight. The unit will be in SG or ppg.	2

 Sieve Shaker	Sieve shaker normally functions as medium for isolation size for sugarcane bagasse in form of powder. It has variety uniform size which from large up to 4.75mm down to 0.020mm.	2
 Hamilton Beach Mixer	The fluids are mixed or sheared for times appropriate to achieve a homogenous mixture	2
 Particle size analyzer	Particle size analysis is to determine the particle size distribution of wet and dry samples by measuring the captured scattering pattern from a field of particles.	1

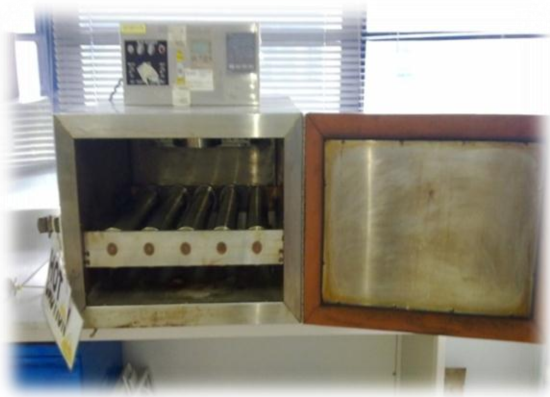
 Oven	Aging cells will put inside the oven which will be rotated by the roller inside and air flow will spread uniformly by fan at the ceiling of oven. The temperature is up to 500 F.	1
 Mortar grinder	Mortar grinder grind the samples till it become powder	1
 Aging cells	The mud sample has been put inside the cells as simulation to real condition in the wellbore. The aging cell then was put into oven in certain period time.	3

Table 4: Lab equipments descriptions

3.3 PROJECT ACTIVITIES

Initially, research study on basic knowledge of LCM materials, and the concept how it will function from the cause happened. The understanding of basic would followed by the choices of criteria of sugarcane where are; in term of shape (fiber, flake, granular) and size (coarse, medium, fine).

As research done, the experiment involves basic properties testing such as rheology (plastic viscosity and yield point), fluid loss, density and particle size analysis. At first testing, we have to make sure the properties of sugarcane passes the specification as LCM additives. It will be checked on particle size analysis and the density of the sugarcane particles. Then, we can test for other properties testing to record the rheology properties and fluid loss.

At last, the result will be obtained from the equipment as stated above recorded to analyze and compare with the contemporary LCM. From that, a conclusion can be made whether the LCM made from sugarcane bagasse has a potential to be commercialized based on its performance and cost compared to the contemporary LCM.

3.4 GANTT CHART

Activities	Week														
	1	2	3	4	5	6	7		8	9	10	11	12	13	14
FYP briefing	■							**S**							
Selection of Project Topic	■	■						**E**							
Preliminary Research Work		■	■	■	■			**M**							
Submission of Extended Proposal Defense						■									
Proposal Defense								**B**	■	■					
Project work continues								**E**			■	■	■		
Submission of Interim Draft Report								**A**						■	
Submission of Interim Report Final Draft								**K**							■

Table 5: Gantt chart – FYP I

Activities	Week															
	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
Project Work Continues	■	■	■	■	■	■	■	**S**								
Submission of Progress Report								**E**	■							
Project Work Continues								**M**	■	■	■	■	■			
Pre-EDX												■				
Submission of Draft Report								**B**					■			
Submission of Dissertation (Soft Bound)								**E**						■		
Submission of Technical Paper								**A**						■		
Oral Presentation								**K**							■	■
Submission of Project Dissertation (Hard Bound)																

Table 6: Gantt chart – FYP II

3.5 KEY MILESTONES

Milestone	Final Year Project II (FYP-2)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Completion of sample preparation														
Completion of specific gravity and moisture content determination														
Completion of particle size distribution determination														
Completion of sample evaluation as drilling fluid material														

Table 7: Key milestone for FYP 2

4.0 RESULTS AND DISCUSSIONS

Starting from week 1 till week 12, there are 2 types of variations which covered over 30 formulations at all that I had done to get the best result by using sugarcane bagasse as lost circulation materials (LCM).

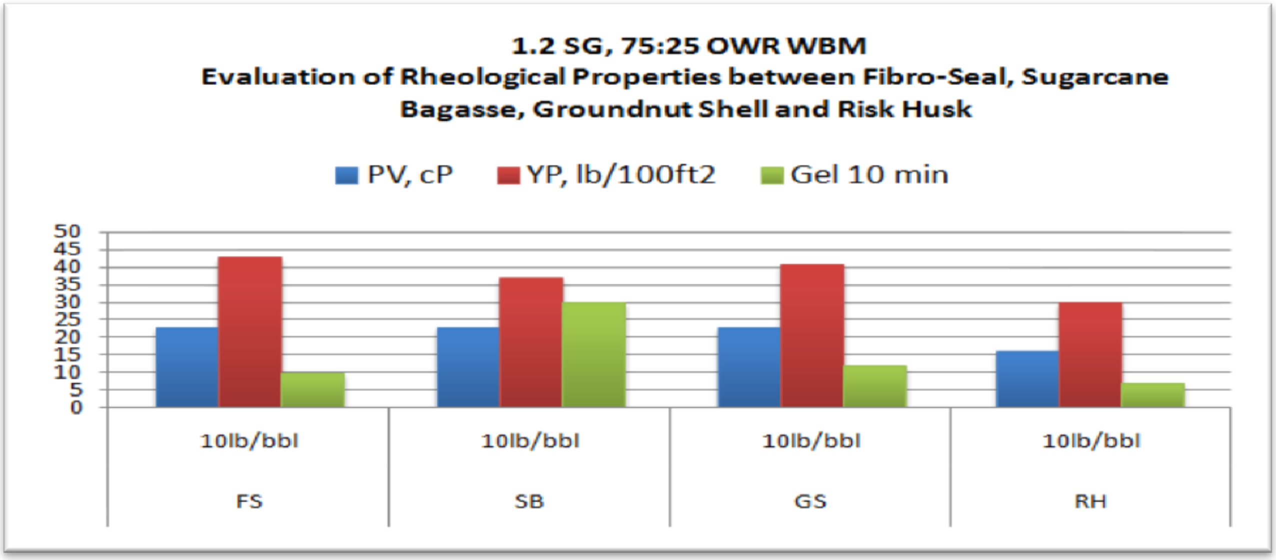
i. Comparison performance of drilling fluid between sugarcane bagasse with others LCM.
ii. The variation of concentration between commercial LCM with sugarcane bagasse.

Below are the products had been used with its function of each addictives:-

PRODUCT NAME	FUNCTIONS
Water **$CaCl_2$**	Brine
OPTA-STAR	Filtration controller
OPTA-ZAN	Viscosifier
MgO	pH controller
Sugarcane Bagasse	Lost circulation materials
FIBRO-SEAL	Lost circulation materials
Barite	Weighting agent

Table 8: Supplementary products

4.1 COMPARISON PERFORMANCE OF DRILLING FLUID BETWEEN SUGARCANE BAGASSE WITH OTHERS LCM



FS–FIBRO-SEAL, **SB**–Sugarcane Bagasse, **GS**-Groundut Shell, **RH**-Rice Husk

Figure 13: Evaluation of rheological properties between Fibro-Seal, sugarcane bagasse, groundnut shell and rice husk

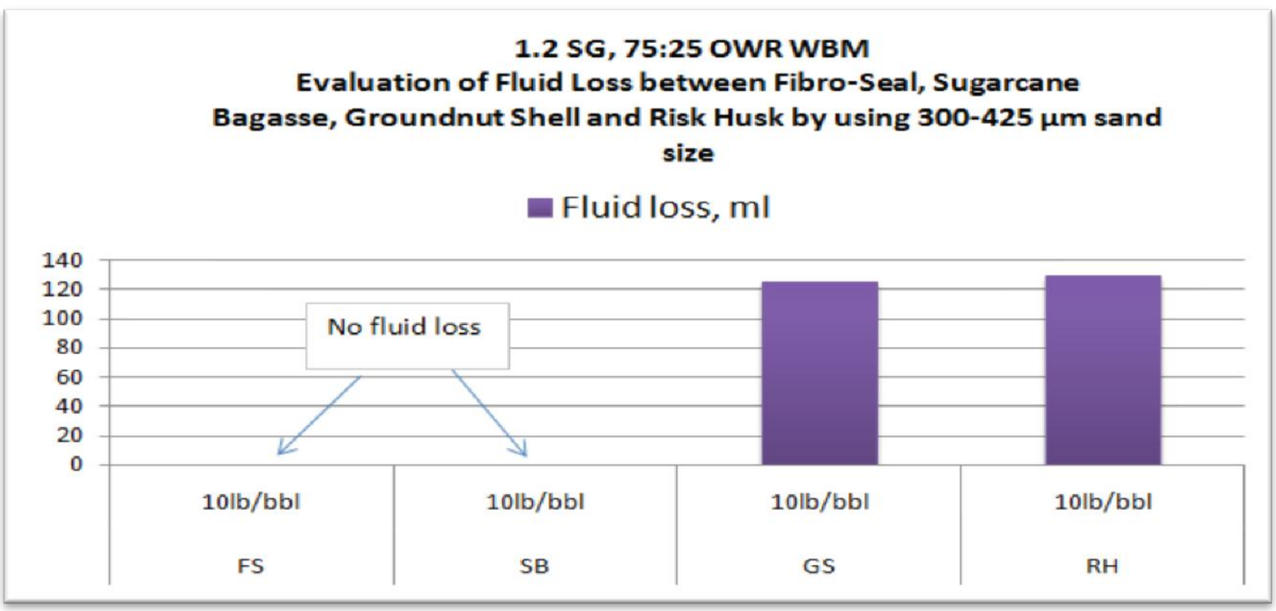


Figure 14: Evaluation of fluid loss between Fibro-Seal, sugarcane bagasse, groundnut shell and rice husk by using 300-425µm sand size

All additives that been used is in medium size (300-425μm) at 10 lb/bbl. There are 4 different additives was used which is Fibro-Seal as being standard product, and the rest is green LCMs'. The green LCMs' encompassed sugarcane bagasse (fibrous), groundnut shell (fibrous) and rice husk (granular).

The rheology properties of the mud were taken by using Fann 35 viscometer. It covered plastic viscosity (PV), yield strength (YP) and 10 min gel strength. PV value for all additives is slightly higher from the standard range which in 14-20. The PV indicates the quantity solid particles in the mud. Thus, a high PV indicates that the mud is incapable of drilling rapidly because of the high viscosity of mud exiting at the bit. Then it will lead cause the efficiencies of the pump. However it can be controlled by reducing additives of LCM to balance the PV value.

The standard range of YP is 20-30. Most YP of the LCMs is slightly higher from the standard range unless for the rice husk. YP shows the ability of the mud to lift up to the surface. In this case, all the additives capable to bring up mud from sagging occurred at bottom of the bore.

The 10 minutes gel strength result is indication on how the mud suspend the cutting while the mud in static condition. From the plotting graph, the average result is 10 unless for sugarcane bagasse which is more than 20. The low value of gel will give poor hole cleaning problems. Too viscous gel caused in contributing to high ECD's. So, we need large energy to pump back the drilling fluid flow into the drilling process. By using OPTA-ZAN, it can be controlled by adding it into the mud in order to increase the gel or by reducing the quantity of the OPTA-ZAN to reduce it.

The most important in LCM is to control fluid loss continuously occurred. Only for standard LCM (Fibro-Seal) and sugarcane bagasse have no fluid loss at all. It means the additives capable to seal off the fluid loss to the formation. For rice husk and groundnut shell, it has too much fluid loss which over than 100 ml.

4.2 THE VARIATION OF CONCENTRATION BETWEEN COMMERCIAL LCM WITH SUGARCANE BAGASSE

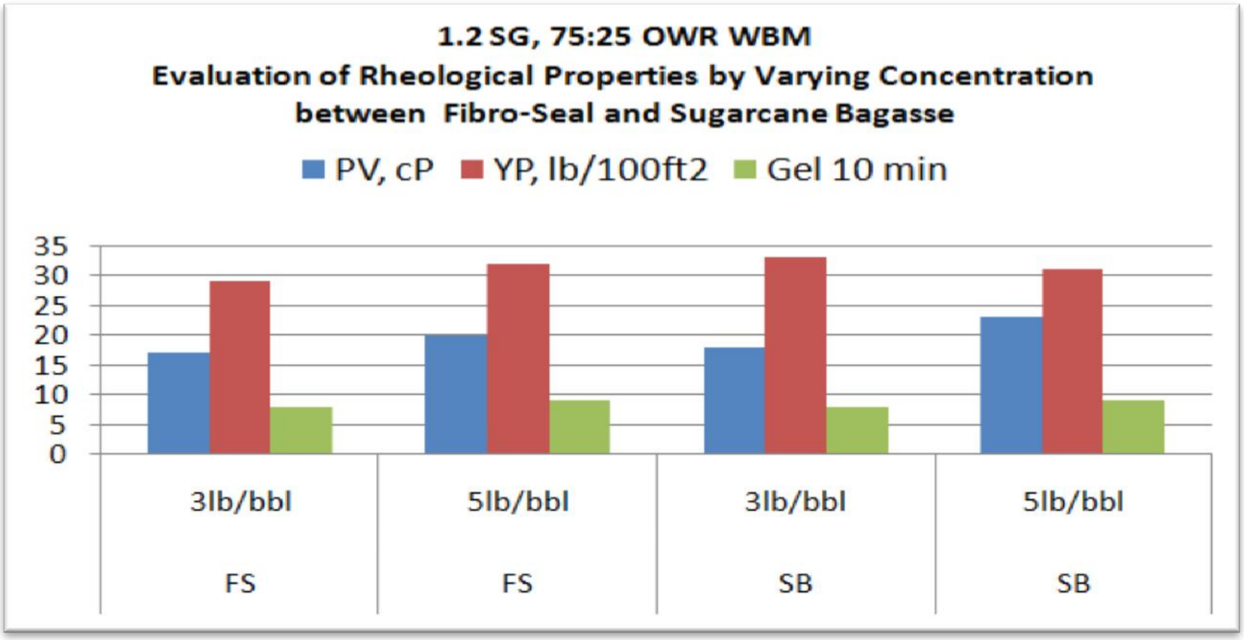


Figure 15: Evaluation of rheological properties by varying concentration between Fibro-Seal, and sugarcane bagasse

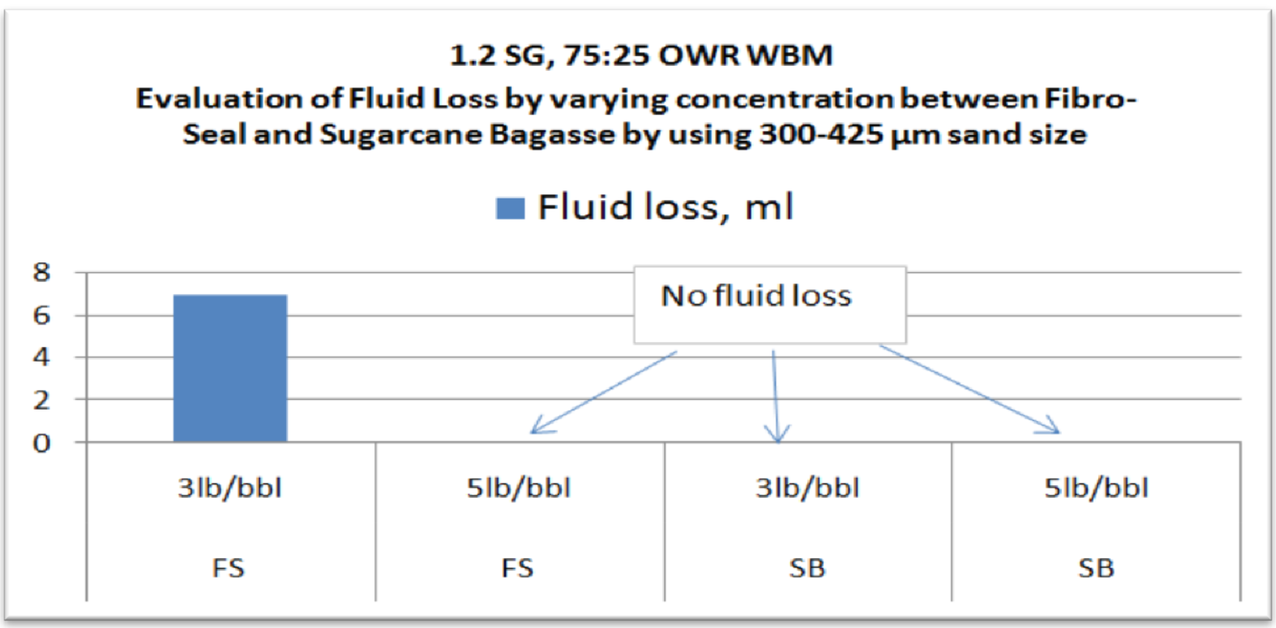


Figure 16: Evaluation of fluid loss by varying concentration between Fibro-Seal and sugarcane bagasse by using 300-425µm sand size

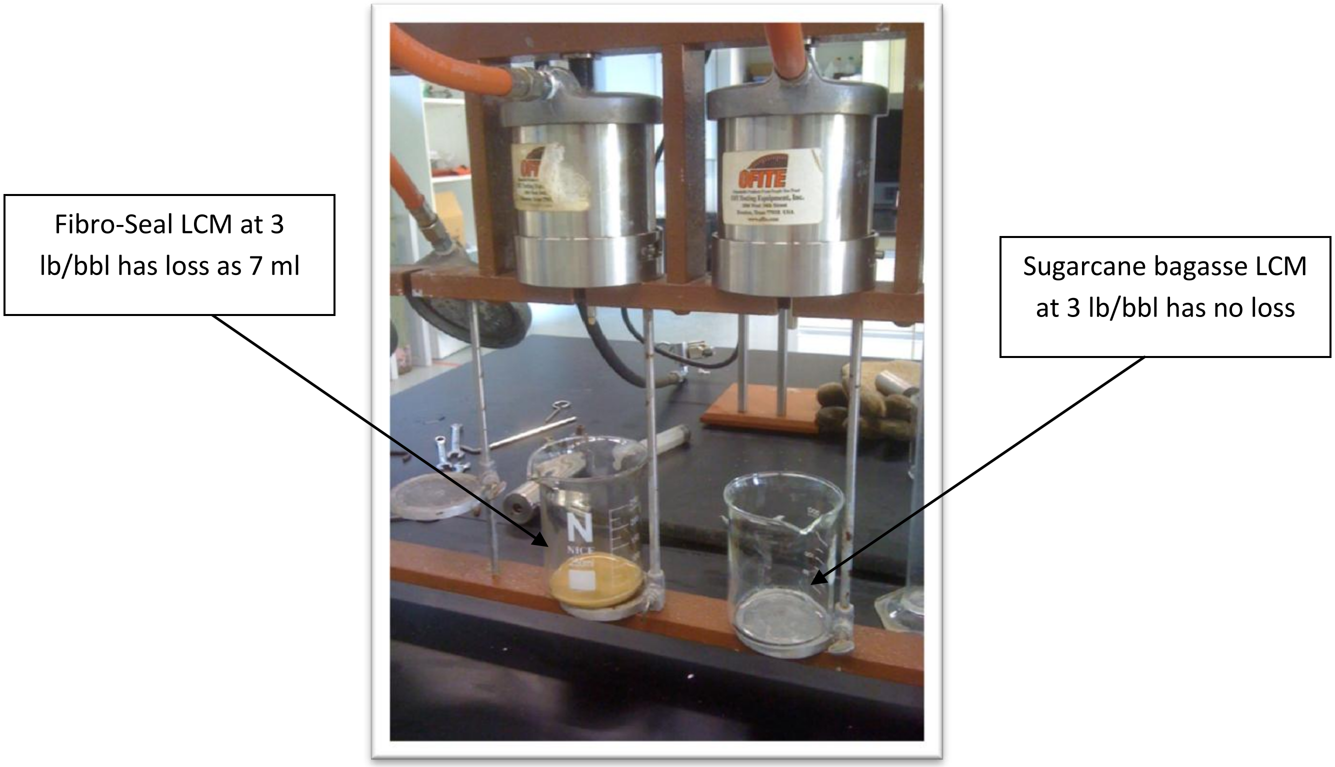


Figure 17: The API Filter Press is used to measure fluid loss

The mud continuously had been tested by the time with varying the concentration of the additives. As 50 lb/bbl, 30 lb/bbl, 15 lb/bbl, 10 lb/bbl, 7 lb/bbl, 5 lb/bbl and 3 lb/bbl were experienced in order to obtain the best formulation. After done aver 30 formulation of the mud, 5 lb/bbl and 3 lb/bbl were selected to be highlighted in this project whereas at 10 lb/bbl the result of sugarcane bagasse for rheology properties is quite high.

Both additives show that the PV value is good since it being in the range of standard specification (14-20) except for sugarcane bagasse at 5lb/bbl which 4% higher. However the trend could be seen whenever the increase of concentration of additives, the PV will increase as well. The result for YP also indicates the mud is capable to bring up the mud up to the surface. For the 10 minutes gel strength, there is not much between sugarcane bagasse and commercial LCM – Fibro-Seal. The rheology results proved that sugarcane bagasse has similar behaviour with Fibro-Seal.

To determine which one is the best whether Fibro-Seal or sugarcane bagasse is much effective, fluid loss for both mud had been taken. At 5 lb/bbl, both mud have no fluid loss. However at 3 lb/bbl, Fibro-Seal has 7 ml of fluid loss but sugarcane bagasse has still maintained with no loss. Thus, it demonstrates that sugarcane has potential to be as new lost circulation materials even at the low concentration it has already capable to prevent loss of the mud into formation.

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The end of the result has met the objectives of project by using medium size of sugarcane bagasse. As conclusion which is listed below, it synchronized with the initial objectives of the project;

1. Sugarcane bagasse shows similar behavior with the current commercial LCM, but is ENVIRONMENTAL FRIENDLY and RENEWABLE RESOURCES.

2. Sugarcane bagasse also practices the ECONOMICAL financial besides avoiding from any hazardous effect on human.

3. It has potential to replace the standard LCM for medium size of formation since the sugarcane bagasse has capability to seal off the mud from continuously loss into formation.

5.2 RECOMMENDATIONS

Recommendations for the project:

- Promote the green concept into industry widely
- All HSE regulations must be followed during experiment.
- Proper attire is highly recommended during the experiment.
- For any test and experiment, the temperature for the drilling fluid should be recorded.
- It is important to read the Material Safety Data Sheet (MSDS) for each material used.
- Before starting any test, all the equipments must be calibrated and check for failure or defect.
- While using the Fann 35 Viscometer, it is recommended to ensure that the bob is totally dry and temperature is not higher than 200^0F to avoid it from explode

5.0 REFERENCES

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14. *API RP 13-B1Recommended Practice For Field Testing Water-Based Drilling Fuids 4th Edition 2009*
15. *SPE/IADC: Lost Circulation Material Selection, Particle Size Distribution and Fracture Modelling with Fracture Simulation Software – Don Whitfill*

6.0 APPENDICES

Material	Type	Name under Which Sold
Raw cotton	Fibrous	Coto Fiber, Kotten Plug
Bagasse	Fibrous	Fibertex, Mud Fiber, Milfiber
Flax shive	Fibrous	Fiber Seal
Wood fiber	Fibrous	Balsam Wool, Simpson Treewool, Stratafiber, Magco Fiber, Bell-Seal
Bark fiber	Fibrous	Silvacel, Control Fiber, Palco Seal, Cedar Seal
Textile fiber	Fibrous	Reclaim Textile Fiber
Mineral fiber	Fibrous	Control Wool, Asbestos
Leather	Fibrous	Leather Seal, Leather Floc, Leath-O
Glass fiber	Fibrous	Ultra Seal
Peat moss	Fibrous	Expanso Seal, Peat Moss
Feathers	Fibrous	Feathers
Beet pulp	Fibrous	Beet Pulp
Cellophane	Flake	Jel Flake, Cell-O-Seal, Sealflake, Milflake
Cork	Flake	Silvaflake
Mica	Flake	Micatex, Mica
Corn cobs	Flake	Fergie Seal Flakes
Cotton-seed hulls	Flake	Kotten Seal, Cotton-Seed Hulls
Vermiculite	Flake	Vermiculite
Perlite	Granular	Strataseal, Panaseal, Cal Perl, Mojave Seal, Controlite, Wellite, Circ-U-Lite
Coarse bentonite	Granular	L C Clay, Coarse Bentonite
Ground plastic	Granular	Gel Foam
Nut shells	Granular	Tuf Plug, Masterseal, Multi Seal
Nut hulls	Granular	Elseal
Ground tires	Granular	Rubber Seal, Cal Stop, Strata Cord, Cord Seal
Asphalt	Granular	Forma Seal
Wood	Granular	Super Bridge, Sawdust
Corn cobs	Granular	Fergie Seal Granular
Coke, plain and with bentonite	Granular	Coke, Tapon
Film, fiber, perlite	Mixed	Star Dust
Textile fiber and sawdust	Mixed	Kingseal
Cellulose fiber and sawdust	Mixed	Queenseal
Perlite and coarse bentonite	Mixed	Instaseal
Mineral and textile fiber and sawdust	Mixed	Fibermix
Perlite, coarse bentonite and sawdust	Mixed	Mojave Super Seal

Table 9: Materials for Preventing Lost Circulation Mud Additives

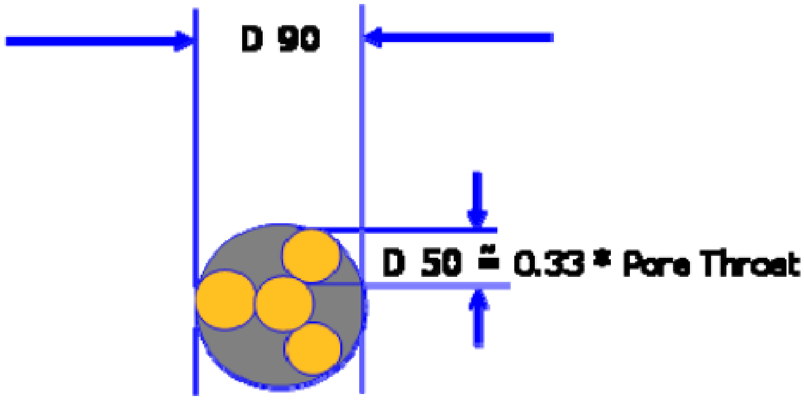

Figure 18: Considerations for determining optimal particle sizes distribution

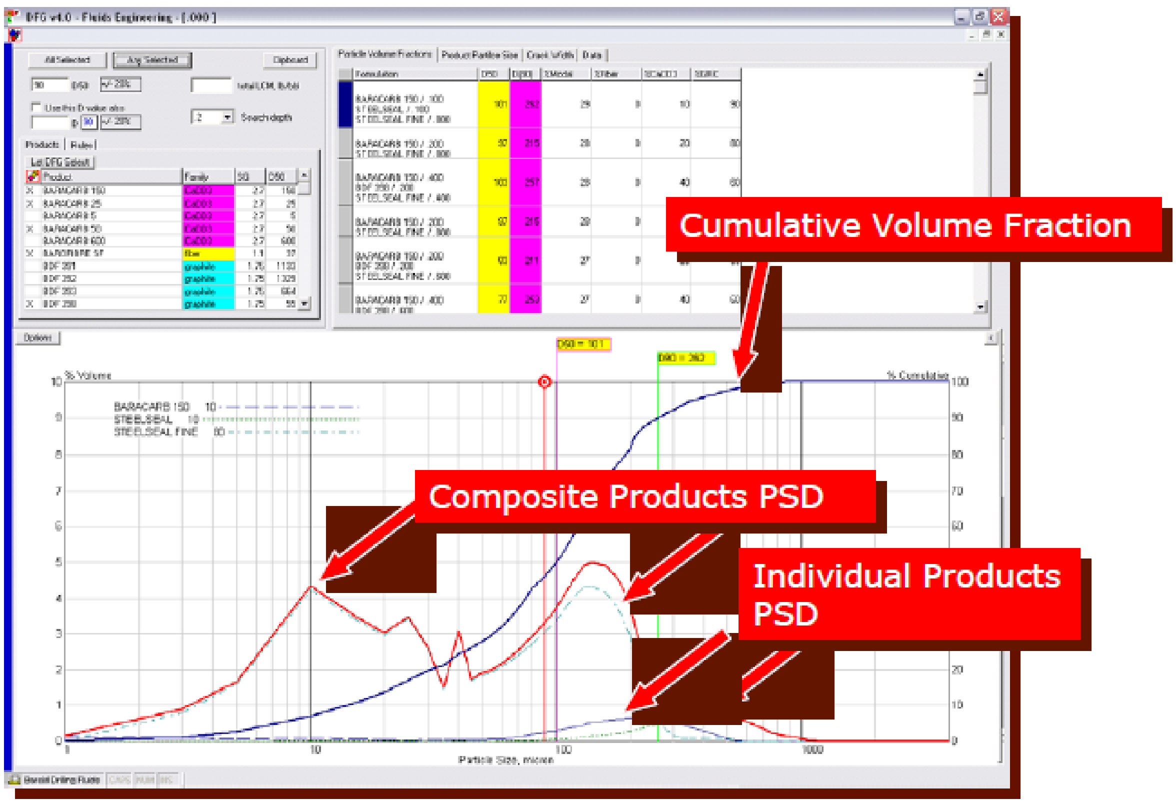

Figure 19: Modeling demonstrates the PSA of the various products

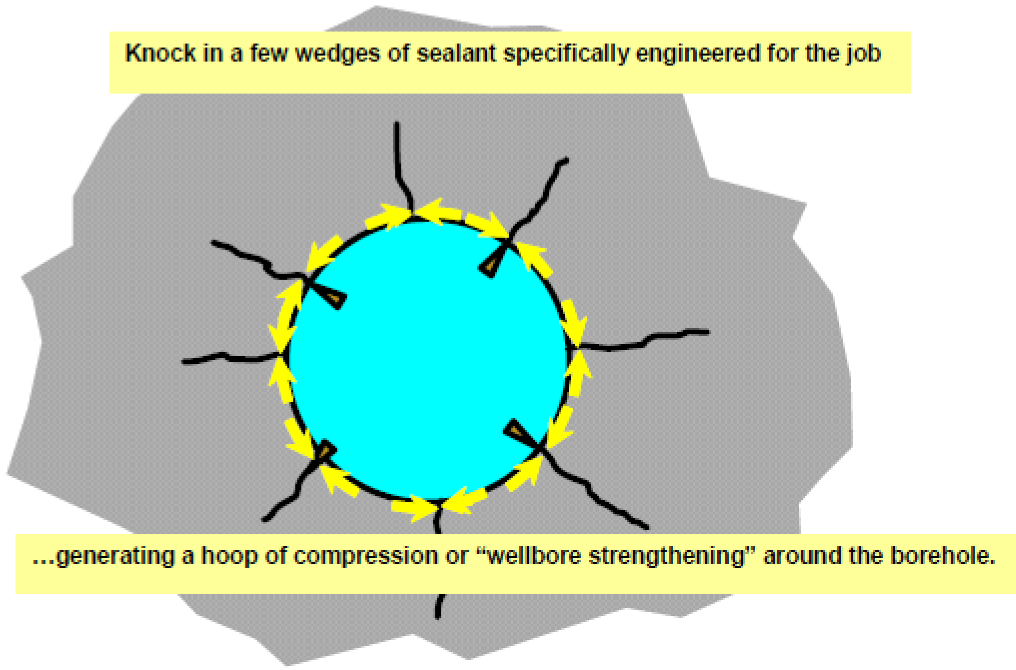

Figure 20: Stress cage theory

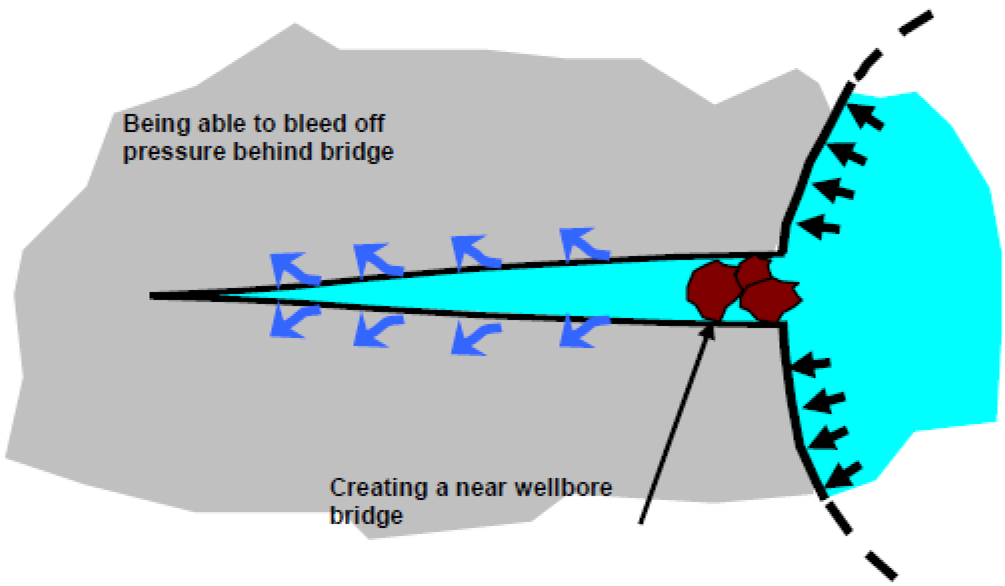

Figure 21: How stress cage works in the near well bore area