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CERTIFICATION

CERTIFICATION OF ORIGINALITY

This is to certify that I 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.

____

(NOR AINI BT DAUD @ ABDUL RAHIM)

ABSTRACT

The purpose of this project is to improve well treatment method which employs resin coated material. The project is experimental oriented which study the affect of percentage of resin in coating method to the compression strength, permeability and porosity.

For this project we are using local sand taken from Terengganu area. Results to be achieved are the best compressive strength and good permeability and porosity. There are possibilities to use local sand as resin coated which will be very economical method and can be commercialized. This project will be the first to use local sand as resin coated sand.

ACKNOWLEDGEMENT

It is my sincere hope to express the utmost gratitude to all people and departments that had directly or indirectly contributed to the successful completion of my final year project I and II.

First and foremost, I would like to praise Allah the Almighty, for His guidance and blessings that had made my final year project went smoothly and successfully.

Besides that, I would like to express my appreciation to Ms Dahlila Kamat, master student of Petroleum Engineering Department for her guidance throughout the project, all technicians in Civil Engineering Department and Mr Jukhairi who assist me with permeability and porosity machine in Core lab (block 15). All of them had greatly assisted me during my project by sharing their knowledge and experiences.

Also, I would like to extent my gratitude to my UTP Supervisors, Ms Raja Rajeswary Suppiah for keeping good supervision throughout my final year project. Last but not least, I would like to express my special thanks to my fellow colleagues, friends and family who had inspired and gave full support to me in completing this project successfully.

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

This project relates to the performance evaluation of local sand in Malaysia. The purpose is to improve well treatment method which employs resin coated material.

In oil and gas field, well completion, production engineers and researchers are trying to find out the best and economical method in increasing the production of the wells. Some wells in Malaysia, such as in Terengganu field, the wells produce a lot of sand. This sand production will affect the productivity of the well.

A porous and permeable reservoir is very beneficial to the increment of oil production. Whereas for unconsolidated formation, sand flow into the well together with oil. Sand can damage equipment such as valves, pipelines and separators, it can cause poor performance in injection wells, and can lead to lost production.

The sand problem is not new and affects the entire industry. In some cases several tonnes of sand can emanate from a reservoir in a single day. The traditional methods of sand control, applied as part of the well completion, include gravel packing and sand screens (Frontiers, December 2001), and all have the same aim: to provide a barrier to keep sand from entering the well along with the hydrocarbons. Depending on the physical characteristics of the reservoir and the geographical setting, such preventative techniques can and do work well but they are not always reliable.

In Malaysia, there is no further study about evaluation of performance on local sand into resin coated sand. Whereas there are possibilities to use local sand as resin coated which will be very economical method and can be commercialized. This project will be the first to use local sand as resin coated sand.

1.2 PROBLEM STATEMENT:

To come out with best modification of local sand as resin coated, temperature is an important criteria. Some resins are not cured at temperature below 130 degree

Fahrenheit. This means, excessive set time also required for low reservoir temperature. From this experiment, we need to come out with a specific curing time, temperature, heat and concentration to obtain satisfactory compressive strength and permeability result.

Other than that, there is no local provider of proppant in Malaysia. Malaysia is fully depending on USA, China, and Canada. Malaysian silica sand also has lower strength. This project will be the first to use local sand as resin coated sand to solve this problem.

1.3 OBJECTIVES OF THIS PROJECT:

i. To experimentally study the best compression strength of resin coated sand with specific resin concentration.

ii. To perform experimentally study on best permeability result of resin coated sand to enhance production with different percentage of resin.

iii. Investigate the optimum design of resin coated silica sand.

1.4 SCOPE OF PROJECT:

The project mainly involves resin coating method and it is experimental oriented. The parameters of evaluation will be the effect on curing time, temperature, heat and concentration of resin to get the best coating result of local sand. Focus of the project is to achieve the best compression strength and permeability result as it is the important criteria to enhance production of oil and gas.

1.5 FEASIBILITY OF PROJECT:

a) Experiment conducted in lab
b) Related research journal
c) Assistant from master student
d) Chemicals in market

CHAPTER 2: LITERATURE REVIEW

Dewprashad, Brahmadeo, Abass, H.H., Meadows, D.L., Weaver, J.D., Bennett pointed out that resin-coated proppants are commonly used in hydraulic fracturing to increase fracture conductivity, prevent proppant flow back, stop formation fines from migrating toward the wellbore, maintain a long-term fracture permeability, and prevent reduction in fracture permeability resulting from crushing and/or embedment. Proppants are either pre-coated with resin in a factory and taken to location or coated "on the fly" in the field during a hydraulic fracturing treatment.

Epoxy or phenolic resins are most commonly used to coat proppants. The former is a mixture of epoxide resin and amine hardener or crosslinker. Phenolic resins are usually a mixture of novalac resin and hexamethylenetetramine as a crosslinker. In both of these cases, the properties of the cured resin depend on the stoichiometry of resin and crosslinker. Maximum thermal properties are obtained when stoichiometric amounts are used. The properties are also dependent on the cure time and temperature. The carrier fluids may also affect these properties because these fluids are of varying pH and this may affect the cure rate. Also, the possibility exists that the crosslinkers/hardeners could preferentially be leached by the aqueous carrier fluids as they have greater water solubility than the resin.

Jim M. Trela, Philip D. Nguyen, and Billy R. Smith yields a field results which indicate that application of on-the-fly resin coating treatments effectively stops proppantflowback while allowing production rates to be maintained as designed.These treatments have drastically decreased the number of workovers for treated wells compared to those treated with resin precoatedproppant or without resin treatments. This resin treatment process provides an economical means for controlling proppantflowback in wells with marginal reserves.

Nguyen et al. pointed out that contributing to this enhanced consolidation strength is the fact that particular embodiments of the present invention use coated particulates that feature a thicker coating of consolidating agent than those found in traditional subterranean applications. For example, in traditional applications, consolidating agent-coated particulates are normally coated with a consolidating agent in an amount in the range of 3% to 5% by weight of the particulates. However, in particular embodiments of the present invention, the particulates used may be coated with a consolidating agent in an amount of at least about 5%, or in the range of from about 5.5% to about 50% by weight of the particulates. A stylized view of the distinction between the traditional consolidating agent coating and the consolidating agent coatings of the present invention is provided in FIG 1.

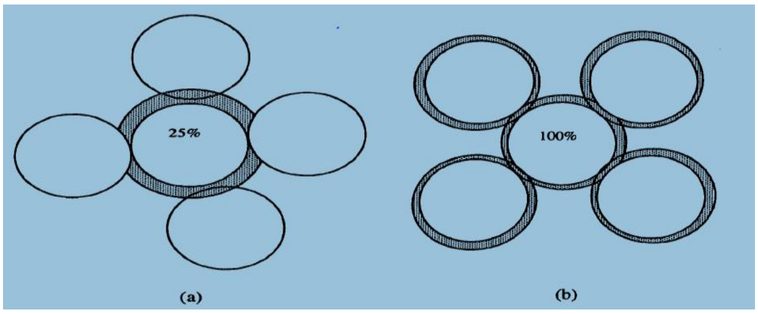


Figure 1(a) and 1(b): Present invention and traditional

FIG. 1(a) illustrates a situation wherein only about 20-25% of the particulates are coated with consolidating agent, but that percentage is coated with a relatively greater coating of consolidating agent. FIG. *1(b)* illustrates a situation wherein about 90-100% of the particulates are coated with a traditional thickness coating of consolidating agent. In FIGS. 1(a) and *1(b),* the same amount of consolidating agent has been used to coat, but in FIG. 1(a) all of the consolidating agent is on one particulate while in FIG. *1(b)* the resin is spread among five particulates.

The greater coating of consolidating agent on the first (coated) portion of the particulates may have numerous benefits. By coating only a portion of the particulates with this greater coating, more consolidating agent is concentrated at the contact points between the grains of particulates. This may allow the consolidating agent to build stronger grain-to-grain adhesions. Additionally, it is believed that the thicker coating of consolidating agent on the particulate may help to create larger interstitial spaces between the individual particulates. These larger interstitial spaces, or voids, may help enhance the conductivity of the particulate packs without reducing their consolidation strength.

The methods of the present invention may be used, inter alia, such that the total volume of consolidating agent used is less than that traditionally needed to effect good consolidation, thus resulting in a direct cost decrease due to the use of less consolidating agent. Alternatively, as described above, the methods of the present invention may use the same amount of consolidating agent coated on a smaller portion of the particulates, in that case while a direct cost benefit of reduced consolidating agent usage may not be seen, cost savings may still occur due to the fact that coating fewer particulates may result in simplified operating procedures, reduced horsepower requirement, and reduced equipment usage. It is within the ability of one skilled in the art to determine the minimum level of consolidation needed for a job and to select the level of consolidating agent accordingly.

In other embodiments, the particulates used may be coated with a consolidating agent in an amount of at least about 7%. In other embodiments, the particulates used may be coated with a consolidating agent in an amount of at least about 10%. In other embodiments, the particulates used may be coated with a consolidating agent in an amount of at least about 15%. In accordance with certain methods of the present invention, one method of achieving such greater coatings of consolidating agent without greatly increasing costs is to use the same amount of consolidating agent that would be used to coat an entire batch of particulates in a traditional subterranean application, but use that amount of consolidating agent to coat only a fraction of the total amount of particulates.

Brahmadeo Dewprashad, Jimmie D. Weaver, Duncan, finding on the impact of temperature and curing time. Each resin-coated sand material was used to form a consolidated blend (i.e., consolidated blends 1-14) by packing the resin-coated sand material into a glass tube and then curing the epoxy resin system for 20 hours at 275° F. After curing, the compressive strength of each consolidated blend was determined at 72° E, 250° E, and/or 275° F. Additionally, the glass transition temperature and melt temperature of each of the cured resin systems was determined.

Issued in the name of John W. Graham et al, particles coated with a fusible thermosetting resin are placed in the well and permitting to cure. The resin at formation temperature softens and then cures to a solid infusible condition. This produces a strong, consolidated and permeable framework for conducting formation fluids. They also observed that the curing solution contains a resin-softening agent capable of lowering the fusion temperature of the resin. The concentration of the alcohol will depend on its solubility in the resin.

A wide variety of alcohols are soluble in resins useful 60 in the present invention. The preferred alcohols, however, are isopropanol, methanol, and ethanol. The concentration of the alcohol will depend upon its solubility in the resin selected for the treatment. It should be present in sufficient concentration in the curing solution 65 to reduce the fusion temperature (i.e. softening temperature) by at least 20° F. With phenol-formaldehyde resins, alcohol (methanol) concentrations of 5 to 20 vol % (preferably 10-15 vol %) have given satisfactory results.

Fluid	Brine (2% NaCl) Vol. %	Methanol Vol. %	Surfactant Vol. %
A	100	0	0
B	85	15	0
C	99	0	1
D	84	15	1

Table 1: Test on different softening agents

The above test results clearly show the effect of the softening agents on compressive strength of the cured samples. While the sample (B and C) with only one of the softening agents gave improved results, the sample D with both softening agents gave best results.

Sample	Compressive Strength, psi
A	400
B	740
C	860
D	1420

Table 2: Test on compressive strength

Although resin coated proppants phenomenon has been studied extensively, there is very little; almost none information available on the modification of local sand as resin coated sand. Most resin coated research and experiments have been restricted only to proppants. This is the motivation of this research; of which to study the modification of local sand as resin coated sand.

CHAPTER 3: METHODOLOGY

3.1 RESEARCH METHODOLOGY

3.1.1 WEIGHT OF RESIN

Resin contained of 50% Epoxy and 50% hardener. Average weight of sand to be used is 200g. From average weight, apply the weight of resin for 5%, 10%, 15%, 20%, 30%, 40% and 50%. From the test, find the best three result of compressive strength.

3.1.2 CONCENTRATION OF RESIN AND SAND

After found out the best three percentage of resin concentration, as example best three are 5%, 10% and 15% of average weight. From these, we do resin coated 100%, 75% and 50% to the local sand.

3.1.3 TEMPERATURE, HEAT AND CURING TIME

Final test will be held after find the best weight of resin and concentration of resin and sand. Then apply these tests for 165 degree Celsius for 20 hours. These parameters of temperature will vary. In temperature measurement, experiment will be conducted using static oven with different temperature reading to show the effect of low and high temperature on the resin coated sand. Heating value will be varied until the result show the best compressive strength of the resin coated sand. Whereas for curing time, experiment will be varies to 12 hours, 20 hours, 1 days and etc.

3.1.4 COMPRESSIVE STRENGTH

Using Compressive Strength Tester we will select the best concentration, temperature, heat and curing time for resin coated sand.

3.1.5 PERMEABILITY AND POROSITY

In advance, we want to make sure from the preferred resin coated sand, the production will be enhanced. Test on permeability and porosity will fulfilled the objective of the experiment.

3.2 PROJECT PREPARATION

3.2.1 OVERALL ACTIVITIES

Title Selection

Selection of the most appropriate final year project title

Preliminary Research

Understanding fundamental theories and concepts, performing a literature review and tools identification.

Hardware/Experimental Setup

Selection and design of experimental apparatus, materials, and procedures.

Experimental Work

Conduct experiment and collect results

Analysis of Results

Analyze the findings, relate with theoretical facts and correlate with other researchers' findings (if any)

Discussion of Analysis

Discuss the findings from the results obtained and make a conclusion out of the study, determine if the objective has been met

Report Writing

Compilation of all research findings, literature reviews, experimental works and outcomes into a final report

Table 3: Activities

3.2.2 WEEK ACTIVITIES

No	Action Item	Date	Note
1	**Briefing & update on students progress**	**8 Feb**	**WEEK 3**
2	**Project work commences**		**WEEK 1-8**
3.	**Submission of Progress Report**	**16 March**	**WEEK 8**
4.	PRE-EDX combined with seminar/ Poster Exhibition/ **Submission of Final Report (CD Softcopy & Softbound)**	**2 April**	**WEEK 11**
5.	EDX	**9 April**	**WEEK 12**
6.	Delivery of Final Report to External Examiner / Marking by External Examiner	**13 April**	**WEEK 12**
7.	Final Oral Presentation	**23 April**	**WEEK 14**
8.	Submission of hardbound copies	**11 May**	**WEEK 16**

Table 4: Week activities

3.2.3 EXPERIMENTAL SETUP AND STEP BY STEP

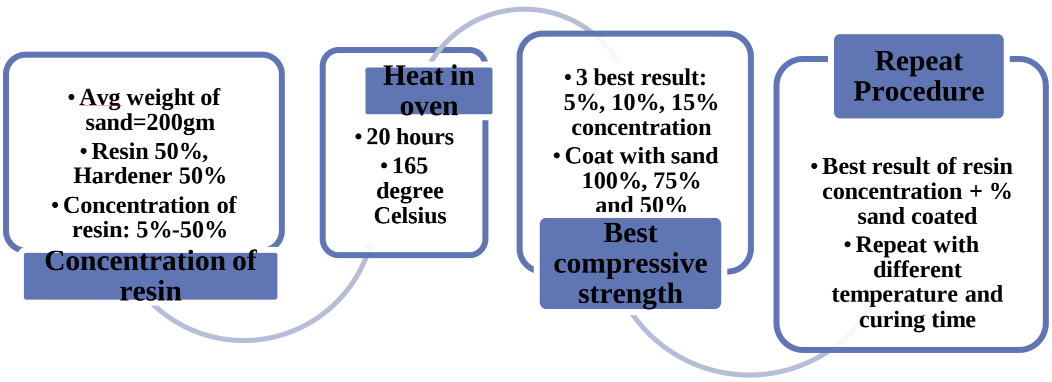


Table 5: Step by Step

HAND MIX

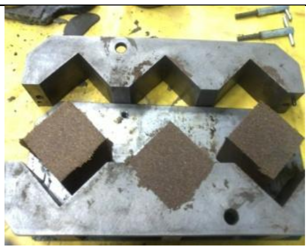
	**Preparation of sand and resin.** • From average weight, apply the weight of resin for 5%, 10%, 15%, 20%, 30%, 40% and 50%. • **First trial**: Resin is coated 50% to the local sand.
	**After 2-3 hours take out the core from the mold.** • Each core will completely heat at all area.
	**Continue heat in oven for 20 hours with 176 degree Celsius** • Repeat all step for different weight of resin • **Next trial:** Time and temperature will vary • **Next step:** Test on compressive strength

Figure 2: Hand mix experiment

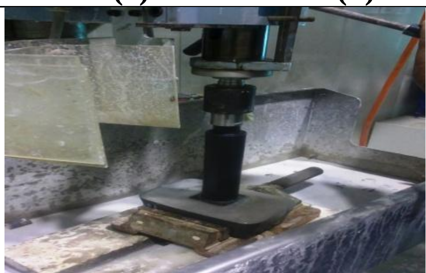
MIXER MIX

	• Prepare sand, resin according to concentration, methanol. Same as hand mix description above.
	• Use mixer machine instead of hand mix to compare the result. It is important to achieve accurate result.

	• After mix the sand and resin, put it in the mold (same as hand mix procedure). Then heat it in oven for 20 hours with 176 degree Celsius.
	• 7 samples are ready to be tested. Before use the samples for compressive strength test, I managed to test for some minor test such as transit time, path length, elastic modulus and velocity.
	• Test the 7 samples for transit time, path length, elastic modulus and velocity. This minor test will give clearer information about the samples. • **Done for both hand mix and mixer mix samples.**

Figure 3: Mixer mix experiment

PREPARATION FOR PERMEABILITY AND POROSITY TEST

 **(a)** **(b)**	• Cement each core for ease of coring into cylinder shape. Cylinder shape sample is the criteria for permeability and porosity test. Picture (a) before cement harden and picture (b) after cement harden.
	• Coring all 7 samples into cylinder shape.
	• Picture show the remaining after coring.

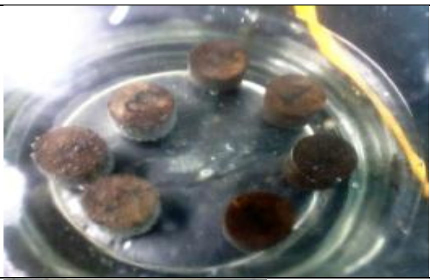
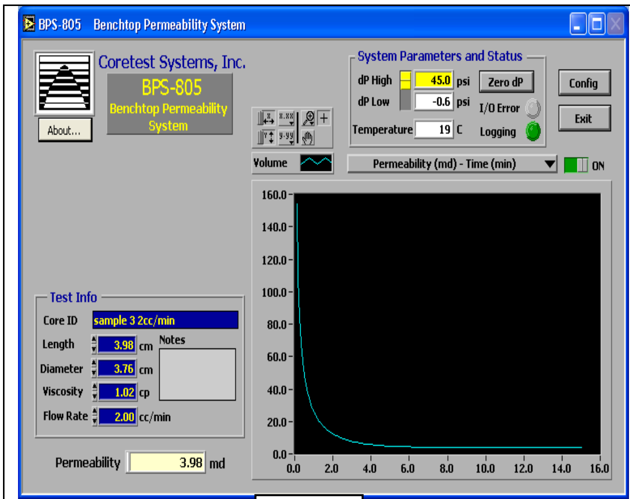
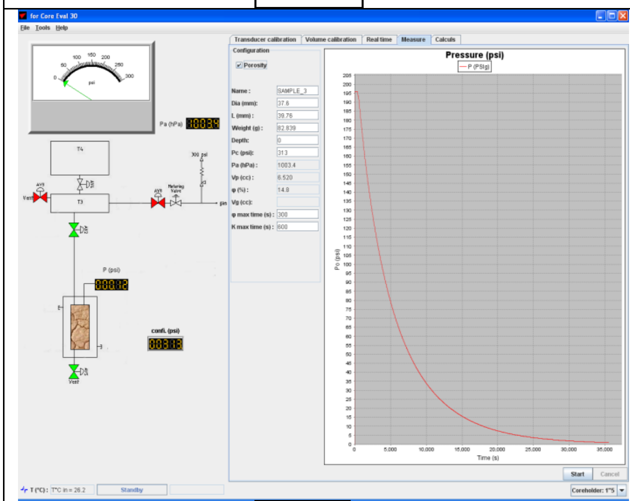
	• 7 samples (cylinder shape) are saturated in dessander. All the cores are saturated with brine.
	• Use 30% Nacl for each 1000ml distilled water. Stirrer is used for making brine. • **Next step:** Permeability and porosity tests

Figure 4: Permeability and porosity test preparation

PERMEABILITY AND POROSITY TEST

 **(i)**	Machine used: Benchtop Permeability Kick in data such as core length, diameter, viscosity of brine and flow rate. Wait until the permeability result show a stabilize curve and get the permeability value. Picture (i) Permeability graph Repeat the procedure for each sample.
 **(ii)**	Machine used: Poroperm (Make sure core is dry. At least, let the core stay one day in the oven.) Kick in data such as core length, diameter and weight. Result of porosity will be display when the machine stops. Picture (ii) Porosity graph Repeat the procedure for each sample.

3.2.4 TOOLS AND EQUIPMENT

The following equipment is required for this experiment:

Figure 5: Compressive strength tester

Figure 6: Static oven

Figure 7: Coring machine

Figure 8: Mixer machine

Figure 9: Benchtop Permeability System

Figure 10: Dessander

Figure 11: PoroPerm

CHAPTER 4: RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 HAND MIX

Sample	Resin concentration (%)	Resin coated sand (%)	Weight of core	Density of core
1	5	50	215.91	173
2	10	50	228.38	183
3	15	50	232.88	187
4	20	50	217.79	174
5	30	50	223.86	179
6	40	50	216.38	173
7	50	50	230.45	184

Table 6: Data of sample

Sample	Transit time (µsec)	Path length (mm)	Velocity (m/s)	Elastic Modulus (GN/m2)
1	29.9	9	316	0.423
2	27.9	9	395	0.347
3	26.1	8	450	0.456
4	26.9	10	341	0.415
5	34.4	10	277	0.340
6	25.1	7	423	0.347
7	23.9	9	335	0.401

Table 7: Result of various tests on sample

Sample	Maximum load (KN)	Stress (MPA)
1	38.2	15.29
2	78.2	31.28
3	122	48.8
4	54.8	21.93
5	91	36.41
6	87.2	34.89
7	119.1	47.63

Table 8: Result of compressive strength test

4.1.2 MIXER MIX

Sample	Resin concentration (%)	Resin coated sand (%)	Weight of core	Density of core
1	5	50	215.91	173
2	10	50	228.38	183
3	15	50	232.88	187
4	20	50	217.79	174
5	30	50	223.86	179
6	40	50	216.38	173
7	50	50	230.45	184

Table 9: Data of sample

Sample	Transit time (µsec)	Path length (mm)	Velocity (m/s)	Elastic Modulus (GN/m2)
1	23.4	8	321	0.356
2	25.5	9	393	0.365
3	26.3	10	401	0.464
4	26.8	12	408	0.468
5	27.4	10	411	0.419
6	25.7	9	355	0.401
7	24.2	8	335	0.365

Table 10: Result of various tests on sample

Sample	Maximum load (KN)	Stress (MPA)
1	26.2	10.49
2	42.7	17.09
3	54.6	21.84
4	82.1	32.84
5	106.9	42.77
6	84.3	33.72
7	121.0	48.4

Table 11: Result of compressive strength test

4.1.3 COMPRESSIVE STRENGTH TEST

Sample	Hand Mix	Mixer Mix
1 (5%)		
2 (10%)		
3 (15%)		
4 (20%)		
5 (30%)		
6 (40%)		
7 (50%)		

Figure 12: After compressive strength test

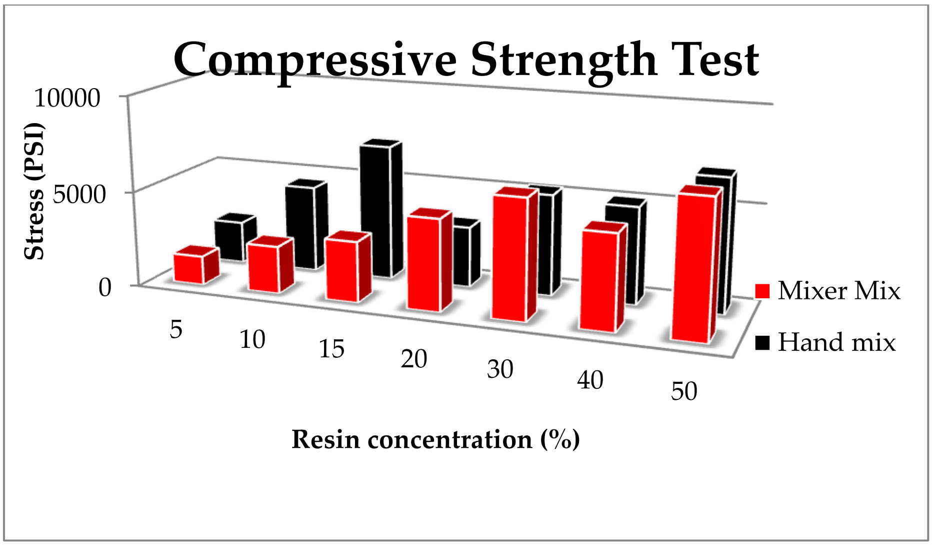


Chart 1: Compressive Strength Test

4.1.4 BENCHTOP PERMEABILITY TEST AND POROPERM TEST

Resin concentration (%)	Permeability, K (Md)	Porosity, φ (%)
5	346.533	36.59185291
10	339.628	27.64888251
15	331.332	29.13913825
20	329.209	23.96946869
30	227.912	14.768
40	225.433	29.76528475
50	221.979	20.61438942

Table 12: Permeability and Porosity Result

Resin concentration (%)	Pore Volume,Vp (cc)	Grain Volume,V grain (cc)	Bulk Volume,V bulk (cc)
5	16.98446722	29.43151302	46.41598024
10	13.88137599	36.32454457	50.20592055
15	12.81387222	31.16090874	43.97478097
20	9.722292397	30.83885863	40.56115103
30	6.52	37.628	44.148
40	14.45840744	34.11632505	48.57473249
50	9.464801489	36.44876547	45.91356696

Table 13: Pore, Grain and Bulk Volume

4.2 DISCUSSION

4.2.1 THEORY

Density is stated as weight of mass divided by volume unit.

$$\rho = \frac{M}{V}$$

For this experiment, we use ρ in kg/m³, volume in m³

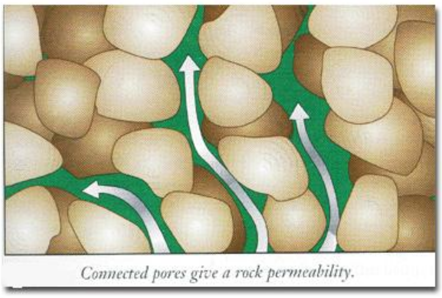
An **elastic modulus**, or modulus of elasticity, is the mathematical description of an object or substance's tendency to be deformed elastically (i.e., non-permanently) when a force is applied to it. The elastic modulus of an object is defined as the slope of its stress–strain curve in the elastic deformation region: As such, a stiffer material will have a higher elastic modulus.

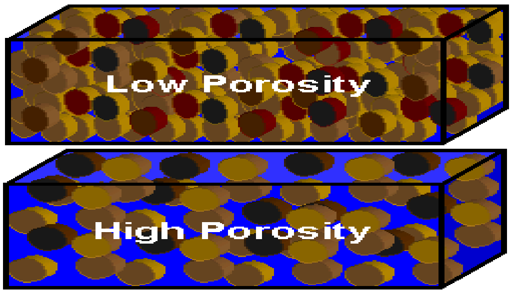
$$\lambda = \frac{\text{stress}}{\text{strain}}$$

Where lambda (λ) is the elastic modulus; stress is the restoring force caused due to the deformation divided by the area to which the force is applied; and strain is the ratio of the change caused by the stress to the original state of the object.

Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials are crushed. Concrete can be made to have high compressive strength, e.g. many concrete structures have compressive strengths in excess of 50 MPa, whereas a material such as soft sandstone may have a compressive strength as low as 5 or 10 MPa.

Two rock properties should be stated here because they are the essential elements to do everything about petroleum issues; they are Picture (A) **Permeability** and Picture (B) **Porosity**.





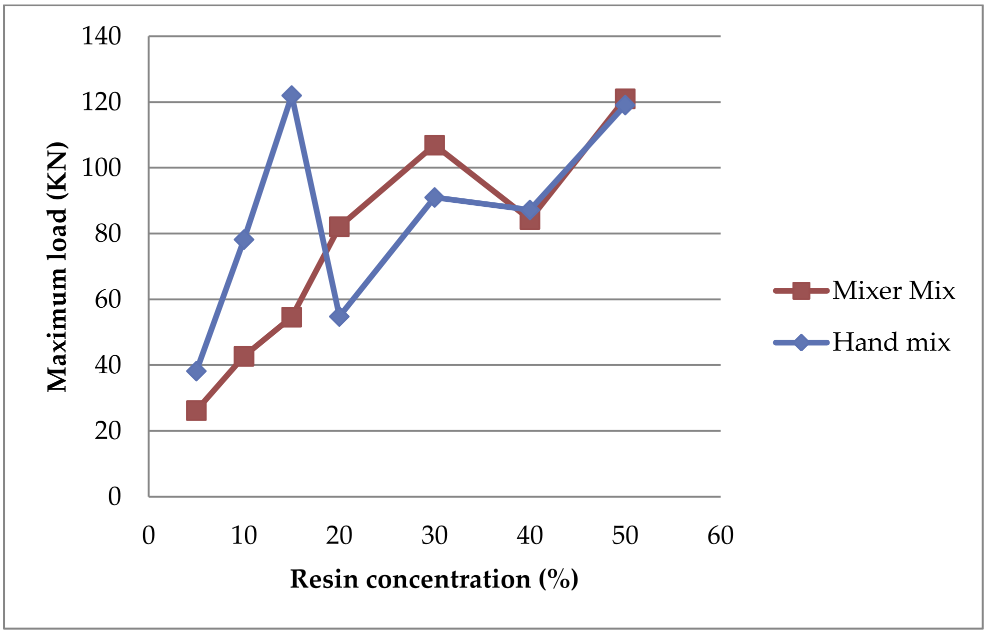
(A) (B)

Permeability is the ability of a rock to transmit fluid through the pore spaces. It is a key influence on the rate of flow, movement and drainage of the fluids. There is no necessary relation between porosity and permeability. A rock may be highly porous and yet impermeable if there is no communication between pores. Highly porous sand is usually highly permeable.

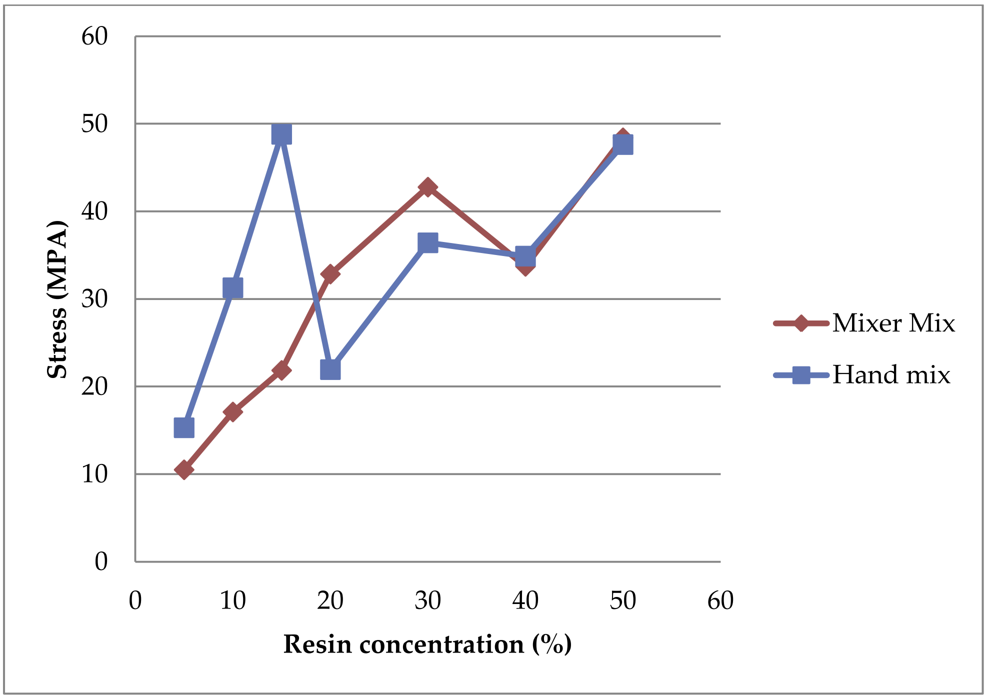
Porosity defined as the ratio between pore space and rock bulk volume. Higher porosity indicates a great storage potential of a rock. High porosity sometimes can't guarantee an optimum prospect. Because those pore spaces are not fully communicated with each other, only when those pores are efficiently connected, then the oil can be recovered from the formation.

4.2.2 RESULT ANALYSIS

a) Compressive strength test: Maximum load and stress



Graph 1: Maximum load



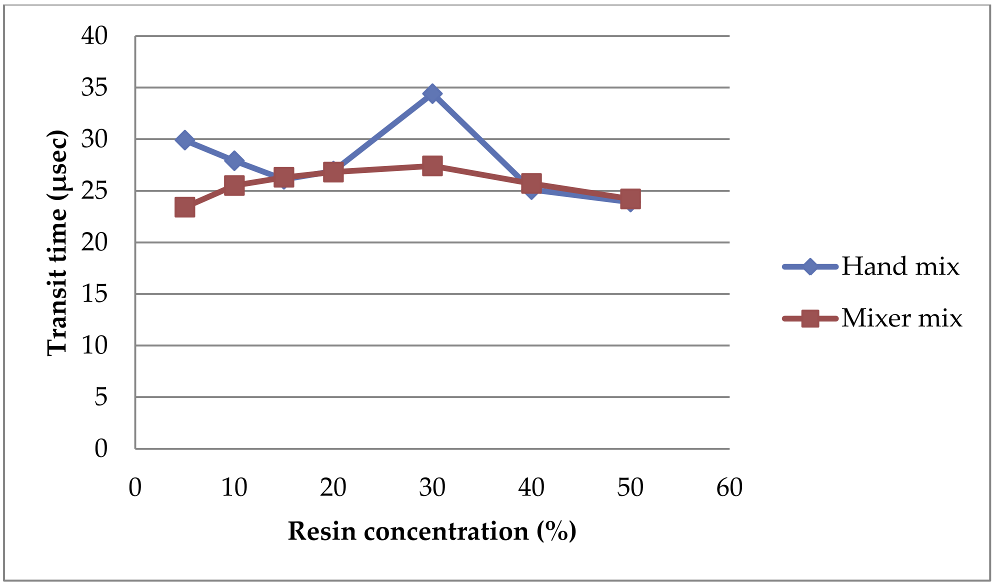
Graph 2: Stress

The good result of resin coating best compressive strength will give us the best compressive strength. The highest compressive strength is chosen so that resin coated can withstand any pressure changes inside the formation.

Graph 2 shows us the best compressive strength result by hand mix is sample 3 with maximum load value 122 KN and stress value 48.8 MPA. Second best result is sample 7 gives maximum load value 119.1 KN and stress value 47.63 MPA.

Whereas by mixer mix, the best compressive strength result is sample 7 with maximum load value 121 KN and stress value 48.4 MPA. Second best result is sample 5 gives maximum load value 106.9 KN and stress value 42.77 MPA.

b) Transit time

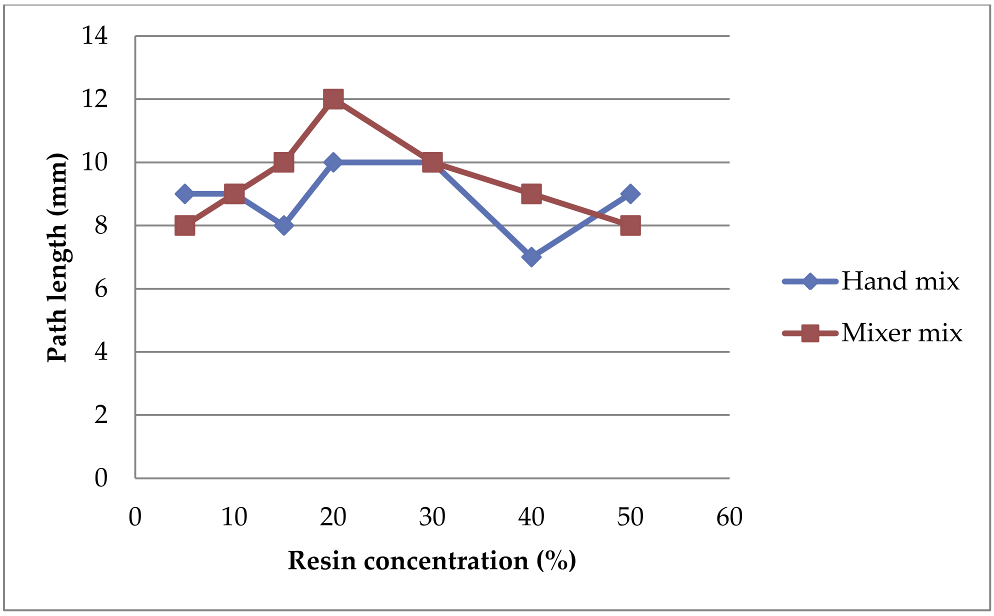


Graph 3: Transit time

Graph 3 shows result of transit time. Solid is given the highest transit time compare with liquid and gas. Density is related to transit time, more dense the core, the fastest time transit through it.

Both experiments (Hand mix and Mixture mix) show Sample 5 has the highest result of transit time.

c) Path length

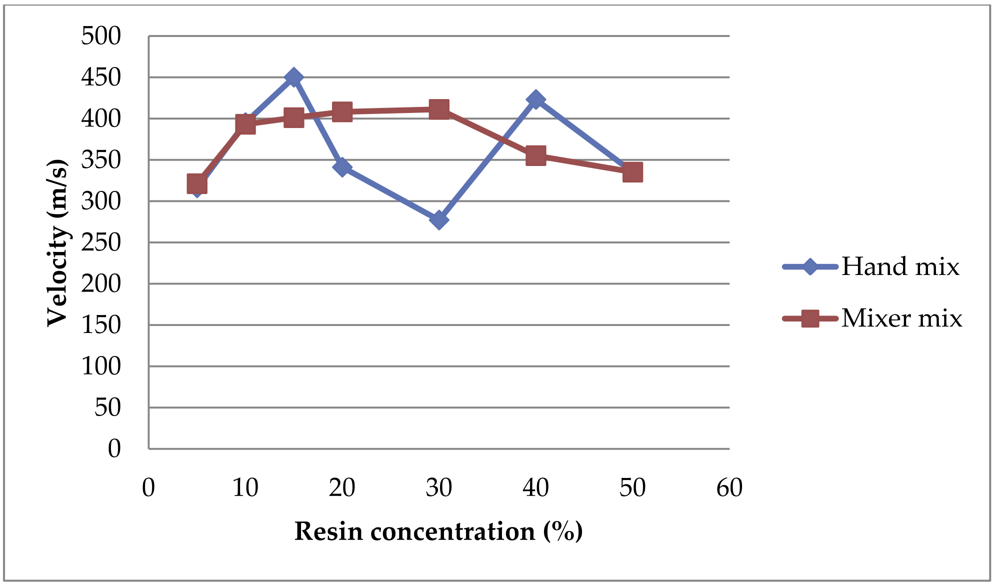


Graph 4: Path length

Graph 4 is related to path length test. Path length test is important to measure the distance which pulses travel in. Path length must be measure to enable the velocity.

Hand mix experiment gives the result of 10 mm as the highest path length by sample 4 and 5. Mixer mix experiment recorded sample 4 as the highest path length which is 12 mm.

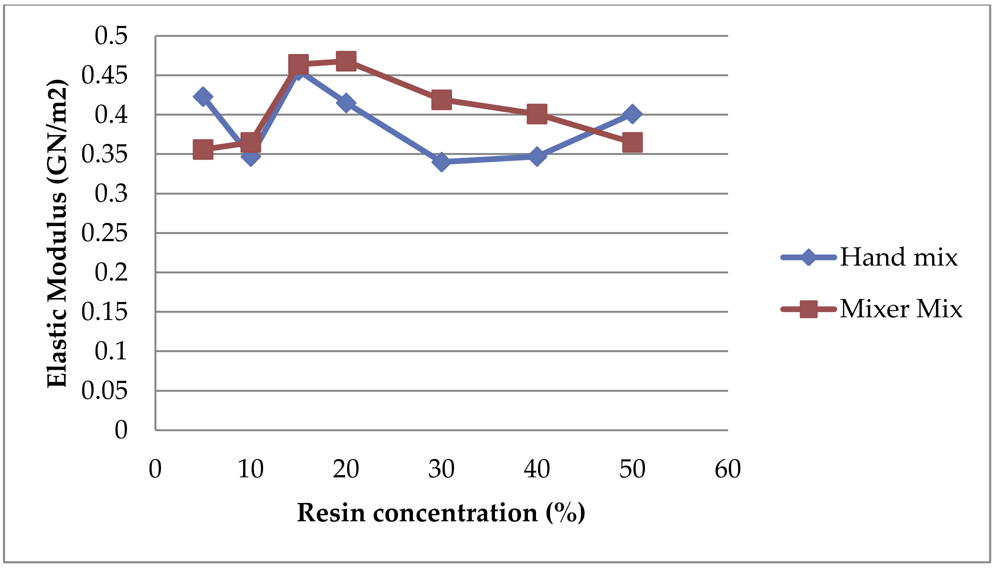
d) Velocity



Graph 5: Velocity

Graph 5 shows the result of velocity. By hand mix, sample 3 gives the highest velocity value which is 450 m/s whereas by mixer mix, sample 5 recorded as the highest velocity value which is 411 m/s.

e) Elastic modulus



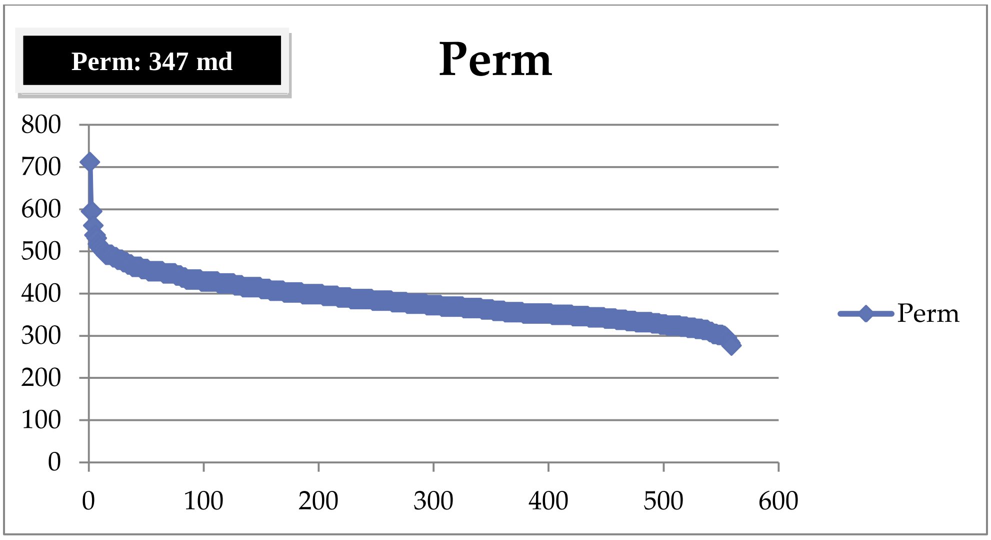
Graph 6: Elastic modulus

Graph 6 is related to elastic modulus test. A stiffer material will have a higher elastic modulus.

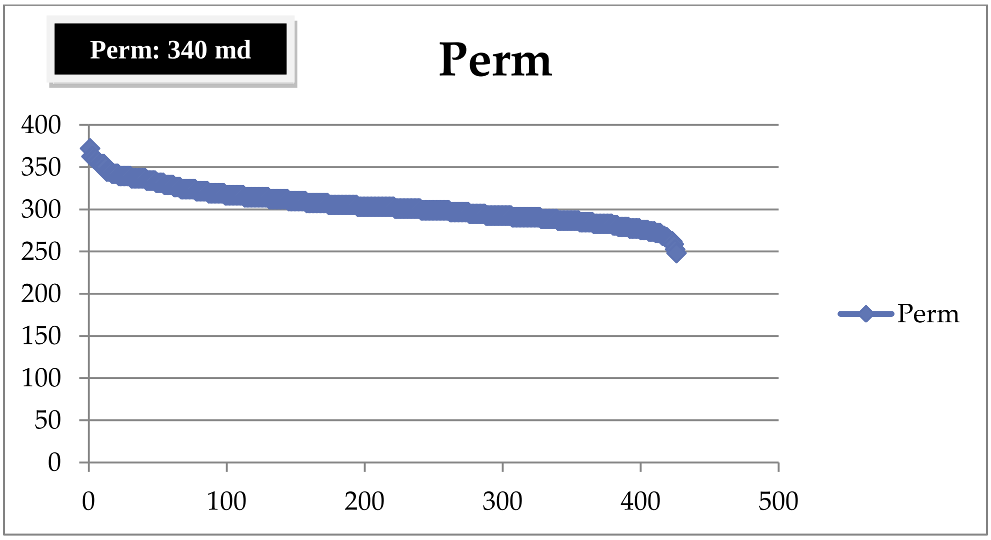
Hand mix experiment gives the highest result which is 0.456 GN/m^2 by Sample 3. Second highest result is sample 1 with the value 0.423 GN/m^2.

Experiment by mixer gives highest result of 0.468 GN/m^2 by Sample 4. Second highest result is sample 3 with the value 0.464 GN/m^2.

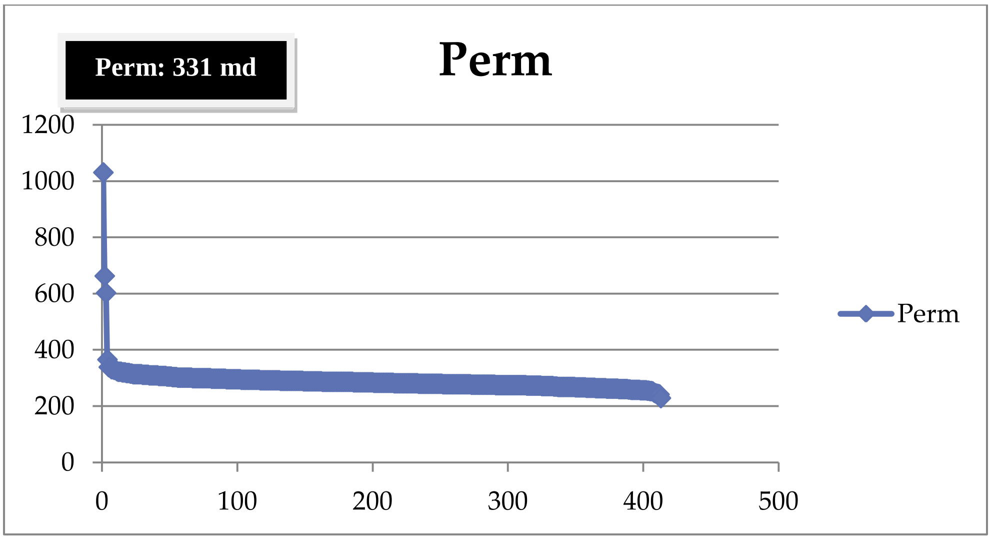
f) Benchtop Permeability Test



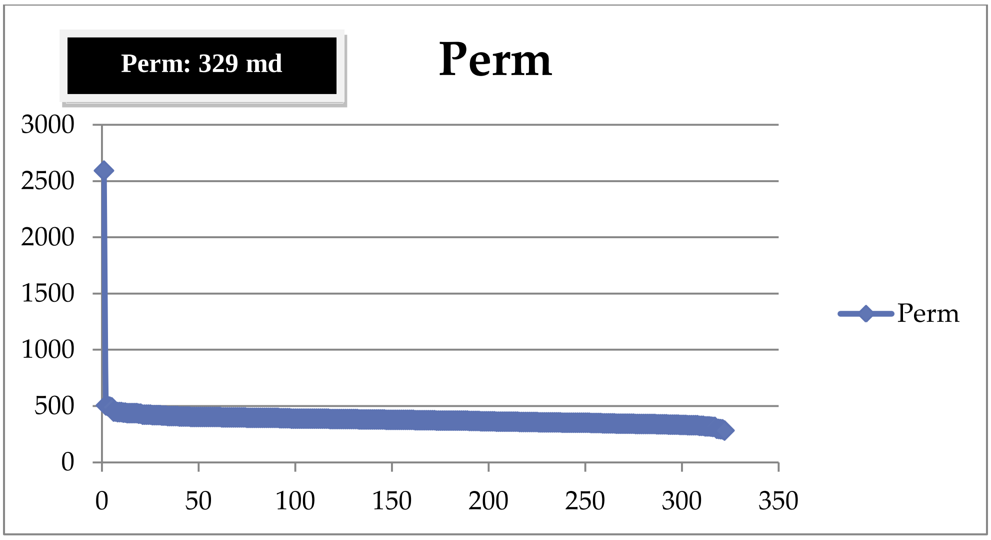
Graph 7: 5% Resin concentration



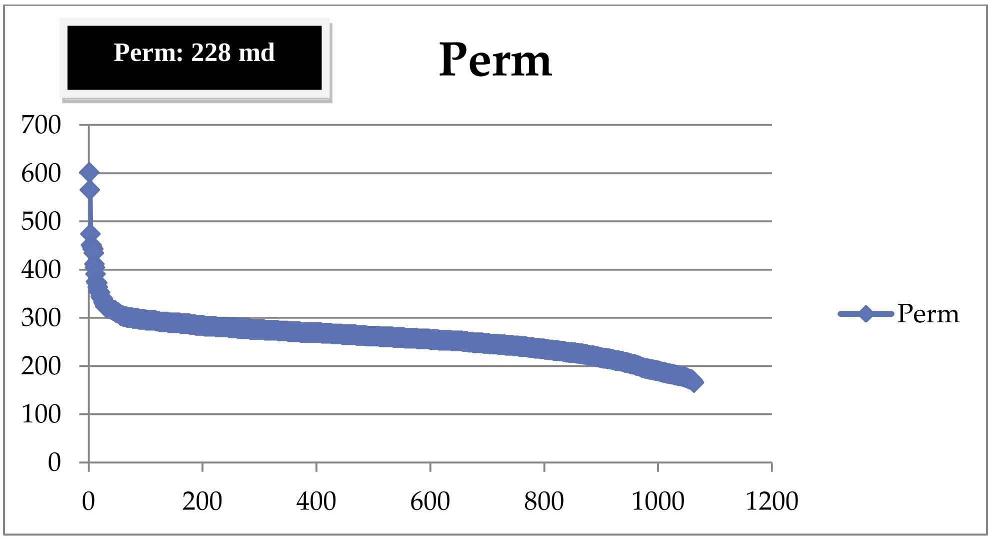
Graph 8: 10% Resin concentration



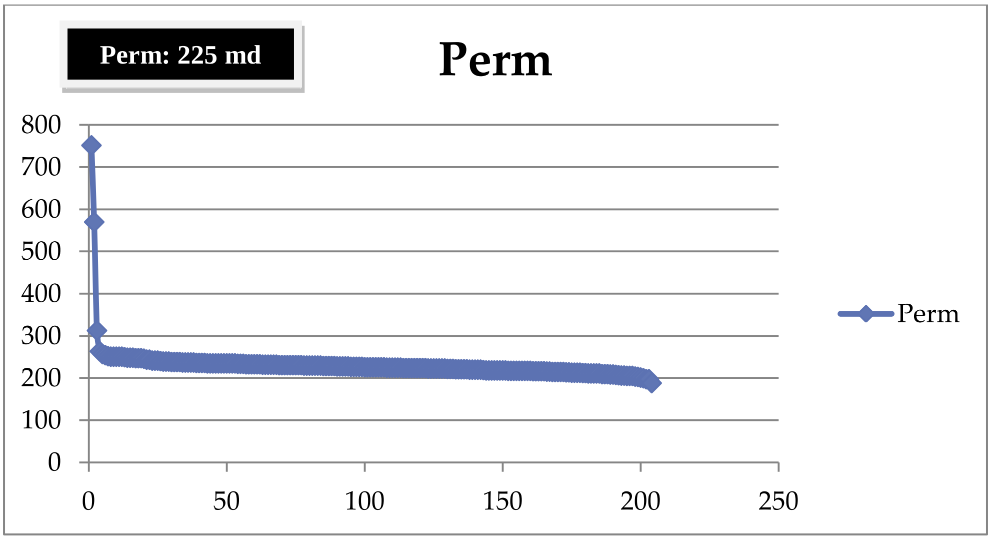
Graph 9: 15% Resin concentration



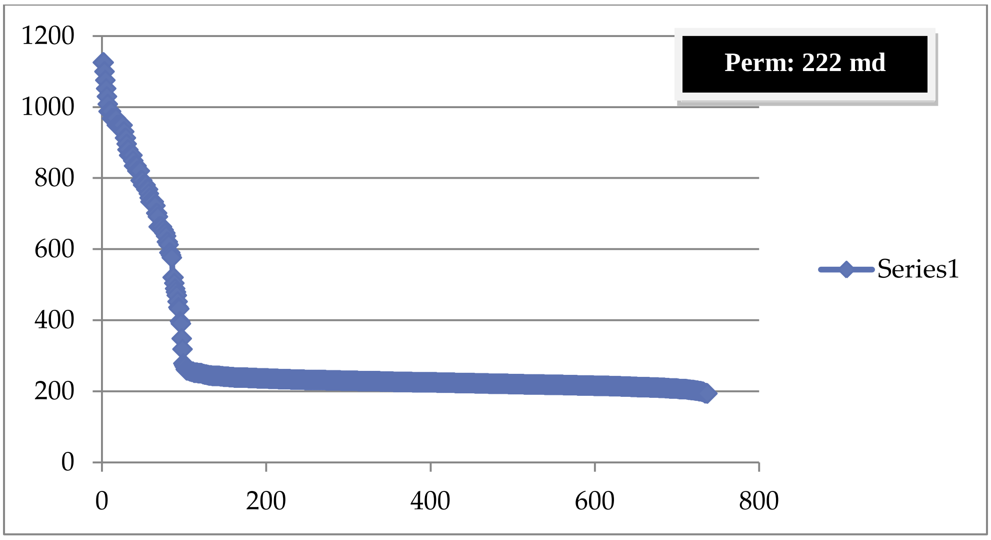
Graph 10: 20% Resin concentration



Graph 11: 30% Resin concentration

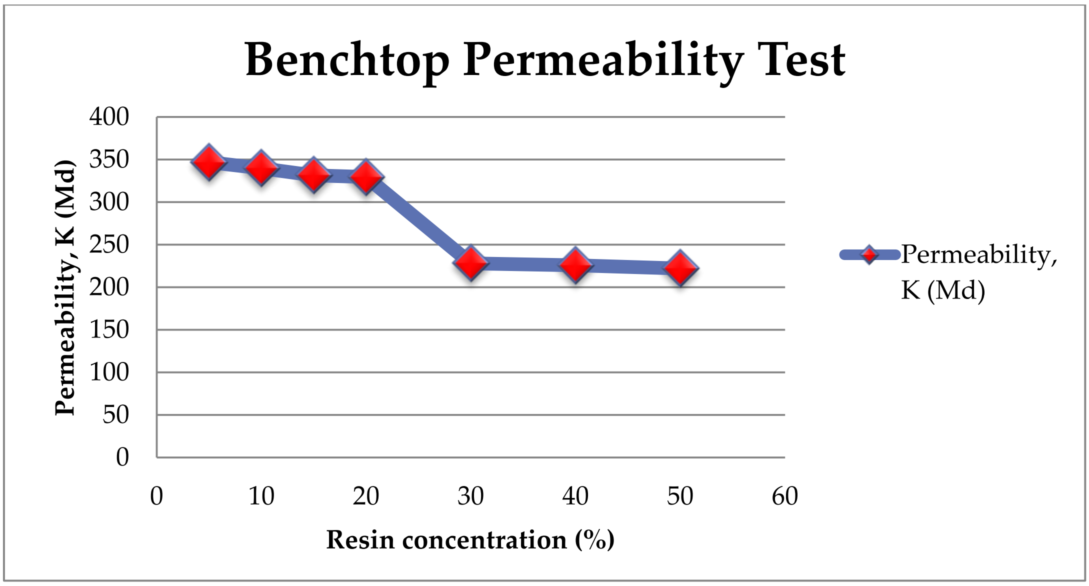


Graph 12: 40% Resin concentration



Graph 13: 50% Resin concentration

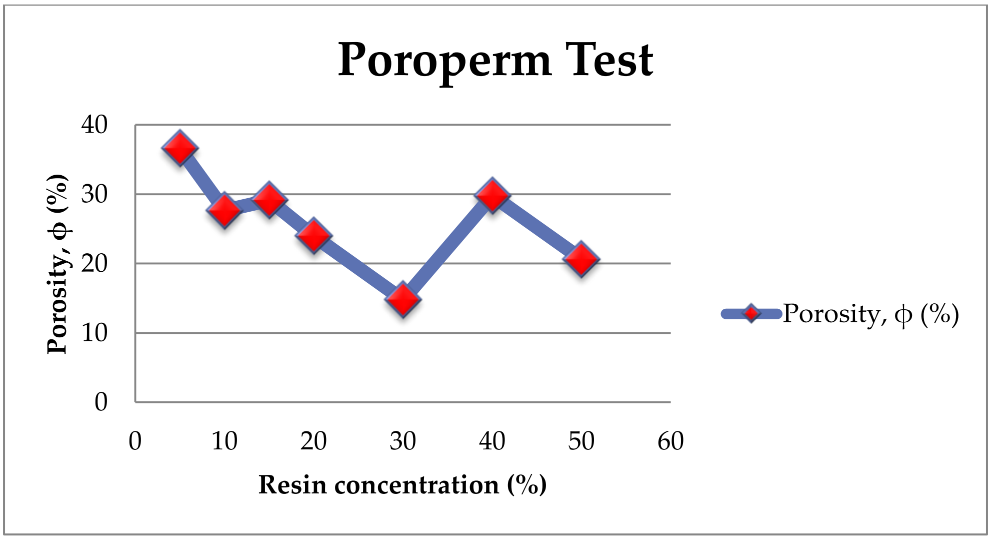
Comparison for all samples:



Graph 14: Permeability comparison for all samples

From the graph above, the highest permeability is belong to 5 % resin concentration which is 347 md whereas the second highest is 340 md by 10% resin concentration. Resin concentration of 15% to 50% gives an average result of permeability (222-331 md). The trend of graph shows that by increasing concentration of resin, permeability of sample decreasing.

g) PoroPerm Test



Graph 15: Porosity comparison for all samples

Porosity graph above show that the highest result is belong to 5% resin concentration which is 37% and followed by 15% resin concentration with 29%. Resin concentration of 40% also gives high porosity result which is 29%.

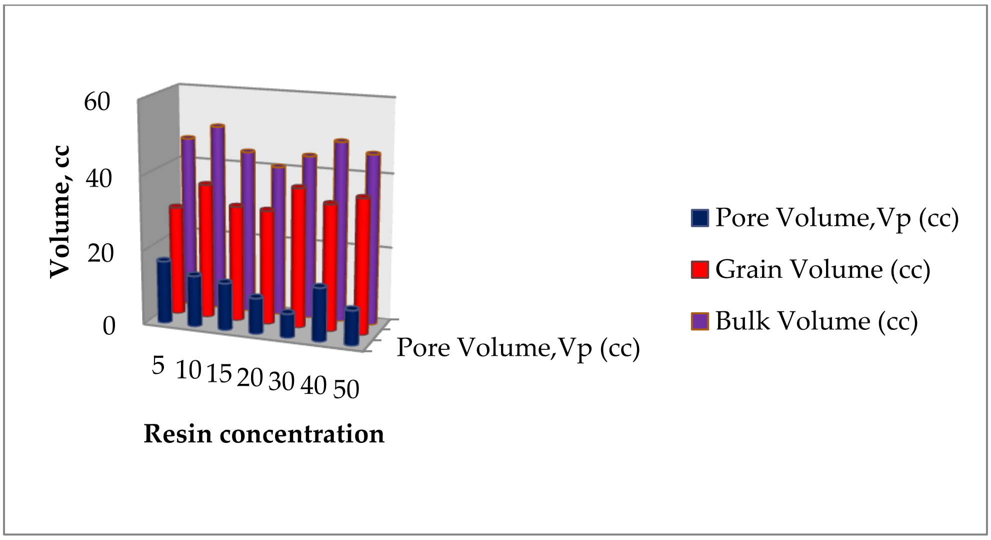


Chart 2: Pore, Grain and Bulk Volume

Pore volume of 5% resin concentration gives the highest result (17 cc) which support the result of it highest porosity value (37%). The reason of high porosity result of 40% of resin concentration is because of high value of pore volume which is 14cc.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

- Graphs of maximum load and stress show that the range of resin concentration in between 20% to 40% is the range that give the highest compressive strength result.

- The highest compressive strength is 7020 psi (Mixer mix) and 6908 psi (Hand mix) which stronger than range of concrete (2500-4000 psi).

- Graph of mixer mix shows more accurate trend to compare with hand mix. This may be the result of inconsistent mixing.

- By increase resin concentration, permeability will decrease.

In conclusion, these results can help to determine how many percent of resin should be used for different reservoir characteristics.

5.2 RECOMMENDATIONS

a) Experiment should be done in more accurate way to mix the sand with resin. A mixer can be used so that we are sure the resin coated sand is coated very well. Human error can be a slightly effect the result.

b) Curing time should be same for all samples to avoid any error of results. As an example for this experiment 20 hours is the curing time.

c) An accurate equipment use for weighting the resin, hardener and sand should be taken into account.

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