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SELECTING AN APPROPRIATE CARBON-BASED NANOCOMPOSITE ADDITIVE FOR ENHANCING CEMENT STRENGTH: A COMPARATIVE FOR OIL-WELL CEMENTING JOB

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Abstract

The shell and Palm shell have successfully enhanced the strength of the cement. Increasing the concentration of the additive yields to high the compressive-strength and shear-bond-strength value. Comparing each objective of this study is to observe the effectiveness of the nanocomposite additives in enhancing the cement strength in oil well cementing job. A well cementation job is a crucial aspect in oil well productivity and sustainability. An oil well with good quality of cementation can prolong its durability in production stage. Moreover, it will reduce the well repair cost and efficiently decrease the workover-job frequency. Cement slurry should be enriched by additives to improve its properties and escalate the bonding. Through this experimental study, two nanocomposite, nanosilica-coconut shell waste with palm shell and nanosilica-palm shell waste, have been introduced. Either coconut shell and palm shell should be in chracoal form before making the nanocomposite additive. The investigation is focused on the Shear-Bond-Strength and Compressive-Strength parameters, two parameters which reflects the quality of the cement bond. Those parameters are obtained from biaxial loading test. Before conducting the test, various samples of cement with different concentration of the nanocomposite additives should be prepared for mixing, drying and hardening processes. Result from the test have indicated that both of the nanocomposite from the Coconut sample with different additive shows its unique efficacy of the additive. Additive from the palm-shell has positively grown the compressive-strength while the other dominant in shear-bond-strength improvement. Another exciting interest reveals from this study is both coconut shell and palm shell waste, which is an abundant resource in Indonesia, can be developed to produce a product with its higher economic value.

Keyword: Nanocomposite, Compressive Strenght, ShearBond Strenght, Coconut shell, Palm shell

INTRODUCTION

Cementing job in the drilling operation have objectives such as to support the casing strings, prevent the fluid movement in the outside casing, blockade its flow into fractured formations, and close the well due to an abandonment reason. Technique and composition of the cementing job should be chosen effectively to achieve an adequate strength after being placed in the specific location (Bourgoyne). Basically, cement slurry was composed of a mixture of water, cement, and additives. The wellbore condition should be reconsidered before designing cement slurry with specific strength. An appropriate additive should be carefully picked to meet the required condition of the cement slurry. Compressive strength (CS) and Shear Bond Strength (SBS) are the parameter which

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can describe the ability of the Concrete to overcome the load and formation problems. CS is defined as the concrete strength in resisting force from the formation while SBS is defined as the cement capability in supporting the weight force from the casing string. Various scenarios have been implemented to reduce the cement usage and to improve the wellbore cement strength by adding pozzolanic material partially. Adding pozzolanic material can increase The CS value of the cement (Erik B. Nelsson, 1990)

Indonesia has an abundant resource of palm tree due its location in Tropical region and makes Indonesia become the second country in the world with a large plantation area. Moreover, there will be a huge amount of palm shell waste. The Silica content of which is approximately 0.92% (Tjutju Nurhayati et al, 2005) and can be enhanced by heating process (Patcharin Worathanakul et al., 2009). Hence, the active carbon in the palm shell can be represented as pozzolanic material. This material, known as Palm Shell Carbon (PSC) can be produced by heating the palm shell waste at temperature up to 300 ^oC . Other abundant resource in Indonesia is coconut tree. The charcoal from the coconut shell, known as Coconut Shell Carbon (CSC), contains silicon oxide, Iron Oxide, and Aluminum oxide. These chemical compounds can be a pozzolanic material because the combination of silica, alumina, calcium, and water will form a solid material with tight bonding and water soluble. Furthermore, CSC has another function and lightweight additive and effectively reduced the density of the cement suspension (Imam Pranadipta, 2010)

The objective of this study is to compare the effectiveness of two nanocomposites, PSC-nanosilica and CSC-nanosilica in enhancing the cement strength. Nanosilica is a very finest material and has been introduced in civil, oil, and gas industries. Due to its highly reactive behavior, nanosilica is well-known in improving the impermeability characteristic of the suspension. This “nano-size” material can significantly lower the porosity and permeability. Through this study, a suitable additive for enhancing cement strength can be decided from these nanocomposites additives.

Material and Procedure

Materials and apparatus for this experimental study should be prepared. Class G cement from PT. Holcim has been purchased. According to Kaswir Badu, 2006, Class G Cement is a basic cement, which is suitable for wellbore cementing job with depth up to 8000 ft (2440 meter). Moreover, nanosilica was synthesized from TEOS (Tetra-Ethyl-Organo-Silicate) by using sol-gel method. TEOS was poured into water-ammonia mixture and follows hydrolysis through the heating procedure, and condensation processes, leaving the nanosilica powder at the bottom. The PSC material is acquired from Central Kalimantan Province, Indonesia. This material will be sieved by using 200 mesh sieve to obtain a uniform size. The same procedure will be applied to the CSC material. The characteristic of nanosilica, PSC, and CSC are listed in table 1, Table 2, and table 3 respectively.

Table 1: Characteristic of Nanosilica

Physical properties	Explanation
Densitas	2.17-2.66 gr/cm^3
Melting point	± 1700 ^0C
Boiling point	2230 ^0C
Warna	Putih
Ukuran Partikel	10-20 nanometer
Bulk Density	0.011 gr/ml

Table 2: Characteristic of Palm Shell Carbon

Physical properties	Explanation
Moisture	3.49%
Ash	1.82%
Volatile Matter	4.24%
Fixed Carbon	90.45%
Calori	5402 kcal/kg

Table 3: Characteristic of Coconut Shell Carbon

Physical properties	Explanation
Colour	Black
Specific Gravity	0.48
Density	0.208 g/cm^3
Ash Concentration	10 %
Spesific Heat	1 J/(g^{o}C)
Thermal Conductivity	0.2 W/(mK)
Moisture Content	4%

All cement-nanocomposite suspension sample with different composition of nanosilica and the nanocomposite Additives should be organized based on the table 4 and table 5. “SD” is defined as a basic cement mixture, which comprises of cement and other supportive additive like bentonite and Calcium Chloride. Those materials will be mixed in container by using a high speed mixer. The speed of the mixer will be maintained constant for a certain time (4000 200 RPM) to ensure that the blend is homogeneous. The speed is then lowered to (1200 500 RPM) for 15 minutes. The mixing process will be terminated if all of the component is completely dispersed. After finishing the mixing stage, all slurry samples will be transferred into the mold and dried for 24 hours in the room conditions. Tri-axial loading test is conducted for each of cement samples so that the CS and SBS Value can be determined. Therefore, a hydraulic press apparatus, equipped with pressure gauge should be set. A certain amount of force will be imposed to the sample until the failure occurs. The pressure where the phenomenon is happened will be recorded as reference load for determining the CS and SBS value. The crystal structure and its correlation with cement strength will be analyzed from X-Ray Diffraction (XRD) and Scanning Electron Microscope test results.

Table 4: Composition of Nanosilika + Palm Shell Carbon in Cement Slurry

Sample Name	Composition of Nanosilika + Palm Shell Carbon
S1	SD + 0.019% Nanosilika + 1% PSC
S2	SD + 0.019% Nanosilika + 2 % PSC
S3	SD + 0.019% Nanosilika + 2.5 % PSC
S4	SD + 0.019% Nanosilika + 3 % PSC
S5	SD + 0.019% Nanosilika + 3.5 % PSC

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Table 5. Composition of Nanosilika + Coconut Shell Carbon in Cement Slurry

Sample Name	Composition of Nanosilika + Coconut Shell Carbon
S1	SD + 0.019% Nanosilika + 0.1% CSC
S2	SD + 0.019% Nanosilika + 0.5% CSC
S3	SD + 0.019% Nanosilika + 1 % CSC
S4	SD + 0.019% Nanosilika + 1.3 % CSC
S5	SD + 0.019% Nanosilika + 1.5 % CSC

RESULT AND DISCUSSION

The effect on PSC-nanosilica and CSC-nanosilica to the CS and SBS value can be shown in the figure 1 and 2. The CS and SBS from this experiment is in the acceptable range, according to the respectful standards (in this case, we refer to American Petroleum Standards (API)). Figure 1 has clearly displayed the increment of PSC- nanosilica additive yield a high CS value for the cement sample. Escalating the CSC concentration up to 3% will raise the CS Value up to 1100 psi. However, more growth in CSC concentration will not lead to the higher CS value. The CS value drops significantly to 410 psi for sample with 3.5% CSC-nanosilica concentration. An optimum CS value has been obtained for the sample with 1% concentration of CSC-nanosilica, where the recorded CS value rises up to 994.7. A decrement trend revealed for the sample with higher CSC- nanosilica concentration. Similar tendency is exposed in the SBS values for sample with PSC-nanosilica and CSC Nanosilica. The optimum concentrations of those additives, which generates the highest value of SBS, are 3% and 1.3% for samples with PSC-nanosilica and CSC-nanosilica respectively.

Comparing the CS and SBS value from samples with different additives lead to a unique insight regarding the effectiveness of the PSC and CSC utilization for enhancing the cement strength. PSC is effective for CS value improvement while CSC is for SBS enhancement. However, low concentration of CSC, compared to PSC to obtain the optimum point, CSC additive has a beneficial side due to its low concentration. Hence, it will affect to the economical aspect. Moreover, a study about the combination of the PSC and CSC material should be reconsidered.

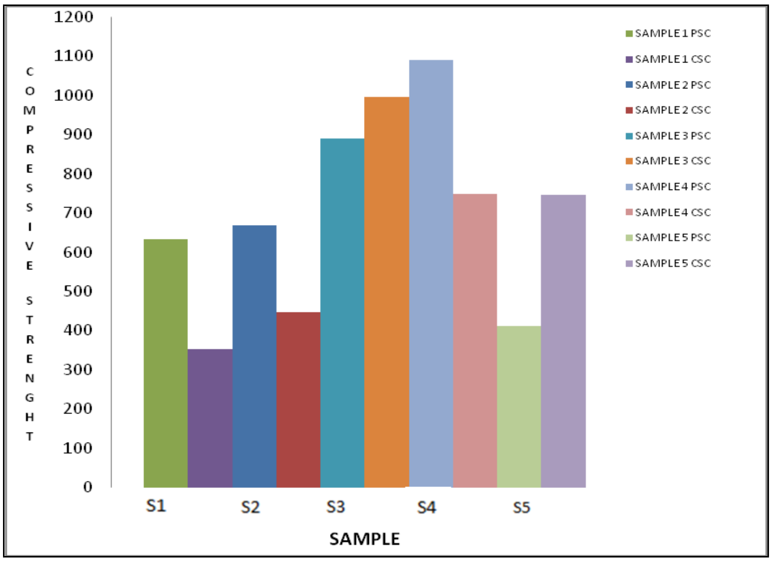

Figure 1: Compressive Strenght of Sample

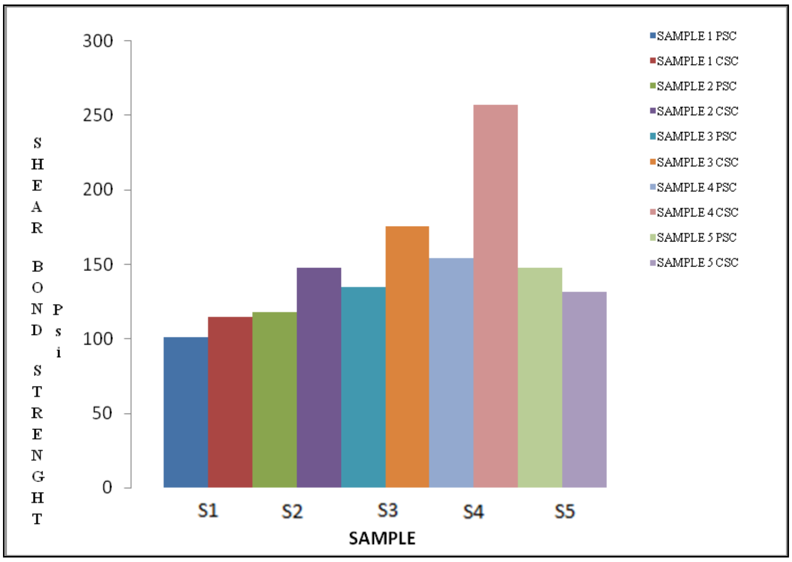

Figure 2: Shear Bond Strenght of Sample

Figure 3 and 4 demonstrates the result from the SEM test for sample with3% PSC-nanosilica and CSC-nanosilica additive at the optimum point. A compact structure where the black spot (represents pore) is not dominant. This observable fact has confirmed that both additives have successfully plugged the inter-particle pore, resulting a solid bonding concrete.

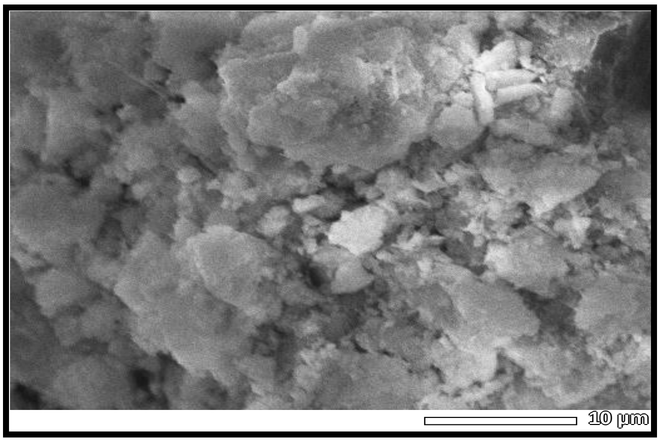

Figure 3: Surface Structur of Sample 4 PSC

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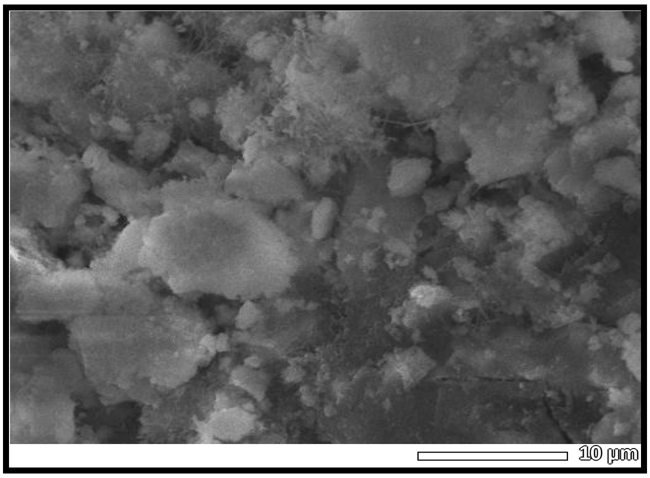

Figure 4: Surface Structure of Sample 4 CSC

Result from the XRD test has been shown in Figure 5 and 6. Comparing these XRD results reveals a fact the crystal content of the cement sample with CSC-nanosilica additive is higher than the one with the PSC-nanosilica (74% compared to 69%). Higher content will increase the inter-particle bonding, resulting a concrete with greater strength.

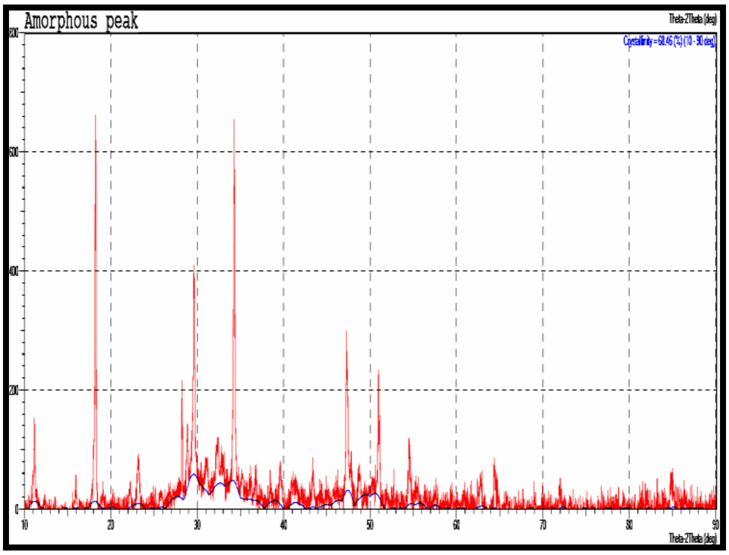

Figure 5: XRD Curve From Sample 4 PSC

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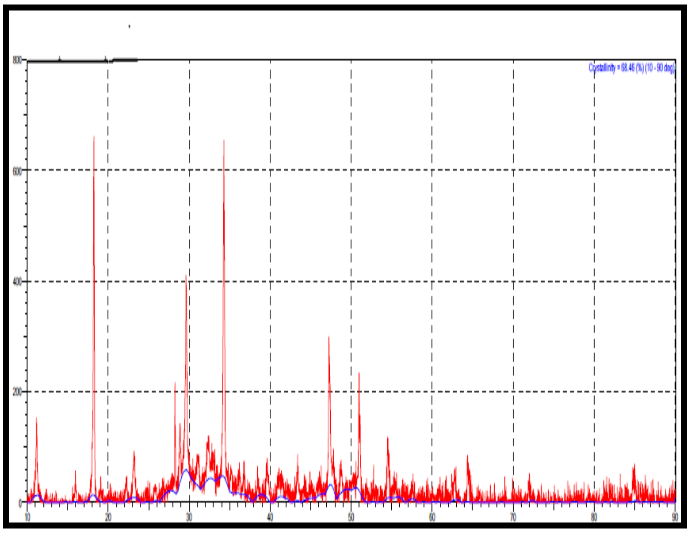

Figure 6: XRD Curve From Sample 4 CSC

CONCLUSION

Experimental study to compare the efficiency of the two carbon-based nanocomposite additive have been conducted by performing a tri-axial loading test to determine the CS and SBS values. Two carbon-based nanocomposite additives, PSC-nanosilica and CSC-nanosilica have been introduced in this study. Result from the test indicates that the PSC-nanosilica is effective to increase the CS value while CSC-nanosilica successfully make the SBS higher. However, the low concentration factor becomes a beneficial factor for CSC-nanosilica and it becomes a consideration part inselecting the proper additive for enhancing the cement strength. Moreover, Higher crystal content in the sample with CSC-nanosilica additive is an imperative evidence that the potential of this additive for advancing the cement strength is high.

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