Fabrication and Characterization of Adding Coconut Shell Actived Nanocarbon to Lightweight Concrete

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Abstract. Coconut Shell actived Nanocarbon to Lightweight Concrete have done. LWC mixture of CS actived nanocarbon fillers made by mixing PPC cement, sand, broken stone, coconut shell actived nanocarbon fillers and water in various proportions. The ratio of CS actived nanocarbon on filler used (x = 0%, 5%, 10%, and 15%), with the aim of getting a different level of compressive strength testing. The particle size of activated CS carbon using the high temperature physical activation method 800°C and chemistry (immersion of ZnCl₂ solution) has an average diameter of 4,842.8 nm. The SEM shows that high porosity occurs and the shape is not homogeneous. EDS analysis to determine composition of the elements in the sample is known that the CS activated carbon samples have a maximum value in the element Carbon, Oxygen. The sample of CS actived Nanocarbon to LWC x= 0% ,the results of the maximum value of % mass and % atom are the elements Oxygen, Carbon, and Calcium. For x = 10% the maximum value are the elements Oxygen, Carbon, and Silicon. The value of the strength of the objects in the CS activated carbon filler concrete sample (x= 5%) has maximum strength value 12.9 Mpa.

1. Introduction
The increasing development of building material technology accord the development of civil engineering. The development of civil engineering is not only in strength but in architectural, economical, effective and efficient aspects. The use of Lightweight Concrete (LWC) in residential buildings and offices has been widely used. Advantages in terms of the use of LWC is earthquake resistant structures, thermal insulation, having good sound protection, and cheap freight costs. So that, many researchers try to utilize industrial wastes used in concrete mixtures. According to the Indonesian National Standard (abbreviated SNI) 03-2834-2000, Normal Concrete is a mixture of Portland cement or other hydraulic cement, aggregate, coarse aggregate and added water with or without material to form a solid mass which has a fill weight (2200-2500) kg/m³ [1]. Lightweight Concrete (LWC) is concrete that contains light aggregate and has a specific gravity of no more than 1900 kg/m³ (SNI-03-2847-2002) [2].
The problem found in the manufacture of LWC is an effort to increase the strength of concrete. Alternative natural materials can be used for mixtures manufacture of LWC can be increase the strength of the concrete. So that the concrete has better properties. Indonesia being the world's largest coconut producer. The Estate Crop Statistics of Indonesia 2015-2017 according Area and Tall Coconut Production of Smallholder by Province and Tree Crop Classification Sumatera Utara in 2015-2017 presents.

Table 1. Area and Tall Coconut Production of Smallholder by Province and Tree Crop Classification [3]

| No | Years | Province       | Area  | Mature | Damaged | Total  | Production | Productivity |
|----|-------|----------------|-------|--------|---------|--------|------------|-------------|
| 1  | 2015* | Sumatera Utara | 7.724 | 69.057 | 7.877   | 84.658 | 87.417     | 1.266       |
| 2  | 2016**| Sumatera Utara | 7.719 | 68.318 | 7.252   | 83.289 | 86.261     | 1.263       |
| 3  | 2017***| Sumatera Utara | 7.722 | 68.274 | 5.608   | 81.603 | 86.124     | 1.261       |

Note: *Fixed, **Preliminary, ***Estimation
Production : Copra

Coconut shell categorized as Metal matrix composites (MMC). Dried Coconut shell contains 33.61% cellulose, 36.51% lignin, 29.27% pentosans and 0.61% Ash CS has low ash content but high volatile matter, 65-75% [4] [5]. The working temperature resistance of CS ash is around 1500 °C without load [6-10].

In general, the behavior of coconut shell aggregate concrete pipes is comparable to conventional concrete pipes. The test results show that the performance of coconut shell aggregate concrete pipe encourages the use of coconut shell as an aggregate for conventional coarse aggregate replacement in the production of reinforced concrete pipes [11]. According to Gunasekara. et al on the strength of the experimental bond of concrete with a CS exhibit a bond strength that is much higher than the bond strength as predicted by BS 8110 and IS 456: 2000 for the selected mixture. There are several significant properties of CS such as average water content and CS water absorption, each of which is 4.20% and 24.00%. Specific gravity averages 1.05-1.20 and pseudo specific gravity 1.40-1.50. This relative value is smaller than conventional aggregate density. This requires that, when a CS can be used in a LWC [12].

Coconut shell has a porous structure and absorbs water which paves the way for internal draining of concrete. The use of activated carbon has a large influence on the time needed for concrete to reach the final setting [13]. Coconut Shell activated carbon in the size of the nanoparticles causes increased joint permeability with high strength and improves the mechanical and physical properties of the specimens [14]. CS contains silicate (SiO₂). Silicate materials are classified as admixture minerals, which increase the viscosity of fresh concrete while reducing the tendency for bleeding and segregation in fresh concrete. So that in the process of hardening concrete, Coconut Shell activated carbon can fill the cavities in the concrete, it is expected to increase the compressive strength of the concrete produced and reduce permeability in the concrete [15]. The manufacture of LWC with the activated nanocarbon filler of CS considered the most promising material to be applied to the manufacture of LWC. The data obtained in the form of surface topography spectrum (microstructure) through Scanning Electron Microscopy (SEM) analysis technique, spectrum showing element composition based on energy level through Energy Dispersive Spectroscopy (EDS), particle size testing using particle size analysis (PSA) and compressive strength testing.
2. Experimental and Methods

2.1. Raw Materials

Portland Pozzolan Cement (PPC) SNI 15-2049-1994, Fine Aggregate and Rough Aggregate SNI 03-1750-1990, water PDAM Tirtanadi Medan, coconut shell activated nanocarbon are the constituents used for making LWC. The minimum strength of 37 Mpa at 28 days was fixed as target strength with minimum workability considerations.

2.2. Mixtures Preparation

Lightweight concrete mixture of coconut shell activated nanocarbon fillers made by mixing PPC cement, sand, broken stone, coconut shell activated nanocarbon fillers and water in various proportions. the ratio of coconut shell activated nanocarbon on filler used (x = 0%, 5%, 10%, and 15%), with the aim of getting a different level of compressive strength testing. The test to be performed is particle size testing using PSA, SEM analysis technique for the form of surface topography spectrum (microstructure), spectrum showing element composition based on energy level through Energy Dispersive Spectroscopy (EDS), and compressive strength testing.

Table 2. Approximate Compressive Strength (MPa) of Concrete with a Water-Cement and Rough Aggregate Factor commonly used in Indonesia (SNI 03-2834-2000)

| Type Cement | Type of Rough Aggregate | Compressive strength | Test Form |
|-------------|-------------------------|----------------------|-----------|
|             |                         | 3  7  28  91         |           |
| Portland    | Stone does not break    | 17 23 33 40          | Cylinder  |
| Cement Type I | Broken stone            | 19 27 37 45          |           |
| Portland    | Stone does not break    | 20 28 40 48          | Cube      |
| Cement Type II | Broken stone             | 23 32 45 54          |           |
| Portland    | Stone does not break    | 21 28 38 44          | Cylinder  |
| Cement Type III | Broken stone            | 25 33 44 48          |           |
|             | Broken stone            | 25 31 46 53          | Cube      |

Note: 1 Mpa ~ 1N/mm² ~ 10 kg/cm²
Compressive strength of cylinder (150x300) mm ~ 9.83 compressive strength of cube (150x150x150) mm

Determination of the free cement water factor value. Known for the type of rough aggregate in the form of broken stone, and using PPC type I for compressive strength of 28 days with the form of a cylinder obtained compressive strength of 37 MPa. This price is used to make the curve in Graph 1 to find the concrete cement water factor planned in the following way: From a compressive strength point of 37 MPa, draw a flat line to cross the main line showing the cement water factor 0.50. Through this intersection then draw a curve that is the same shape as the 28-days curve above and below it (dashed line). Then from the planned point of compressive strength of 34.33 MPa draw a flat line to cut the dotted line curve earlier. From this cut point, then draw a plumb line down until it intersects the x-axis and reads the cement water factor obtained which is 0.58.
Figure 1. Graph Relationship Between Compressive Strength and Cement Water Factor (cylinder 150 mm x 300 mm)

| Cement (kg) | Fine Aggregate (kg) | Rough Aggregate (kg) | Water (kg) |
|------------|---------------------|----------------------|------------|
| 1.553      | 3.912               | 6.348                | 0.893      |
| 1          | 2.518               | 4.087                | 0.575      |

2.3. Coconut Shell Activated Nanocarbon Aggregate Concrete

The availability of abundant coconut shell is considered a waste of the coconut processing industry but it is renewable and inexpensive. The management of coconut shell to activated carbon has a high economic value.

For the preparation of activated from coconut shell using a combination of chemical methods (immersing with ZnCl₂ activating solution) and physics (high temperature heating). Coconut shell is heated with T = 800 °C, t = 6 h. Then the charcoal is soaked with 25% ZnCl₂ solution with t = 12h. The results of activation are washed with aqudest, filtered using filter paper and dried in the oven. The activated carbon is crushed and filtered using a 100 mesh filter.
Table 3. Properties of coconut shell, oil palm shell, crushed granite and river sand.

| SL No | Physical and mechanical properties | Coconut shells | Oil palm shells | Crushed granite | River sand |
|-------|-----------------------------------|----------------|----------------|----------------|-----------|
| 1     | Maximum size (mm)                 | 12.5           | 12.5           | 12.5           | -         |
| 2     | Moisture content (%)              | 4.20           | -              | -              | -         |
| 3     | Water Absorption (24h)(%)         | 24.00          | 23.32          | 0.50           | -         |
| 4     | Specific gravity                  | 1.05-1.20      | 1.17           | 2.82           | 2.57      |
| 5     | Impact value (%)                  | 8.15           | 7.86           | 12.40          | -         |
| 6     | Crushing value (%)                | 2.58           | -              | 6.30           | -         |
| 7     | Abrasion value (%)                | 1.63           | 4.80           | 1.85           | -         |
| 8     | Bulk density (kg/m$^3$)           | 650            | 590            | 1650           | -         |
| 9     | Fineness modulus                  | 6.26           | 6.24           | 6.94           | 2.56      |
| 10    | Shell thickness (mm)              | 2-8            | 1.5-2.5        | -              | -         |

a saturated surface dry

According to The Construction and Building Materials (2011), the use of coconut shells has a greater impact value and water absorption (24h) compared to oil shells is 8.15 %; 24.00 %.

3. Result and Discussion

3.1 Particle Size Analysis

Particle Size Analyzer (PSA) use as the determination of particle size distribution of particles in a substance. Figure 2 shows that distribution results of coconut shell activated carbon peak 1 with diameter (nm) 1.432.3 Std. Dev 317.3; peak 2 diameter (nm) 44.646.9 Std.Dev 10.268.5. The Average Distribution Results (Contin) with Diameter (nm) 4.842.8 Std.Dev 12.007.0.

![Figure 2. Particle Size Analysis of Coconut Shell Activated Nanocarbon](image)

3.2. Scanning Electron Microscopy (SEM)

Analysis of Coconut Shell activated Nanocarbon to Lightweight Concrete Microstructure morphology and the grain size of coconut shell activated nanocarbon and sample lightweight concrete filler coconut shell activated nanocarbon with addition of 0% and 10%. The Figure 3 shows that distribution of particles coconut shell are not evenly distributed both in size and distribution. The pyrolysis stage the weight loss of the sample is due to the impregnation of ZnCl2 which has an increase in packing
density of around 2000°C. The presence of maximum porosity of activated carbon at a certain temperature during the chemical activation process with H3PO4 or ZnCl2 is a common behavior [16-19].

Figure 3. SEM Image of Coconut Shell Activated Nanocarbon

Figure 4 and Figure 5. SEM morphology results showed that the grain and porosity were not uniform. This is consistent with the formation of ettringite in coconut shell carbon fillers. Increased bond between coconut shells and cement has an effect on increasing bonding.

3.3. Analysis of Energy Dispersive Spectroscopy (EDS)
Coconut Shell activated Nanocarbon to Lightweight Concrete Analysis of Energy Dispersive Spectroscopy from Figure. 6 shows that element C, O, Na, Mg, Al, Si, Cl, K, Ca, Ti, Fe with % atom 86.27; 11.05; 0.89; 0.04; 1.18; 0.33; 0.10; 0.04; 0.09. and value of % atom is 90.23; 8.68; 0.49; 0.02; 0.42; 0.11; 0.03; 0.01; 0.02. From the results of the maximum value of % mass and % atom are the elements Carbon, Oxygen.
Figure 7. EDS Analysis of Coconut Shell activated Nanocarbon to Lightweight Concrete $x=0\%$

Figure 8. EDS Analysis of Coconut Shell activated Nanocarbon to Lightweight Concrete $x=10\%$

Figure 7 shows that element C, O, Mg, Al, Si, Ca, Fe, Mo, Au each have a value % Mass 9.09; 49.94; 0.78; 2.55; 6.87; 26.49; 1.25; 273; 0.30 and % atom 15.25; 62.89; 0.65; 1.91; 4.93; 13.32; 0.45; 0.57; 0.03. From the results of the maximum value of % mass and % atom are the elements Oxygen, Carbon, and Calcium. Figure 8 shows that element C, O, Mg, Al, Si, Ca, Fe, Mo, Au each have a
value % Mass 15.67; 45.48; 0.20; 0.67; 32.53; 0.10; 5.02; 0.32 and % atom 23.85; 51.94; 0.15; 0.45; 21.17; 0.05; 2.29; 0.10. From the results of the maximum value of % mass and % atom are the elements Oxygen, Carbon, and Silicon.

3.4. Analysis of Strength Value

Figure 9. Strength Value Of Sample

Figure. 9 shows that the value of the strength of the objects in the coconut shell activated carbon filler concrete sample (x= 0%) (point.1) has a compressive strength value of 11.08 MPa, and for x = 5% (point.2) the compressive strength value is 12.09 MPa, x = 10% (point.3) is 9.8 MPa, x = 15% (point.4) value compressive strength is 7.7 MPa. This is consistent with SEM results that show a high level of porosity.

4. Conclusion

The study is the particle size of activated coconut shell carbon using the high temperature physical activation method 8000C and chemistry (immersion of ZnCl2 solution) has an average diameter of 4,842.8 nm and Std Dev 12,007.0. SEM Image of Coconut Shell activated Nanocarbon to Lightweight Concrete shows that high porosity occurs and the shape is not homogeneous. EDS analysis to determine the composition of the elements in the sample is known that the coconut shell activated carbon samples have a maximum value in the element Carbon, Oxygen. The sample of Coconut Shell activated Nanocarbon to Lightweight Concrete x= 0%, the results of the maximum value of % mass and % atom are the elements Oxygen, Carbon, and Calcium. For x = 10% the maximum value of % mass and % atom are the elements Oxygen, Carbon, and Silicon. The value of the strength of the objects in the coconut shell activated carbon filler concrete sample (x= 5%) has maximum strength value 12.9 Mpa.

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