P-ISSN : 2598-1277
E-ISSN : 2621-3966

JOURNAL OF GREEN SCIENCE AND TECHNOLOGY

# MATERIAL TESTING FOR THE DEVELOPMENT OF ENVIRONMENTALLY FRIENDLY CONCRETE WITH CONVENTIONAL AGGREGATE SUBSTITUTES

**Firmanilah Kamil[1*], Julyan Purnomo[1]**

*[1*]) Program Studi Teknologi Rekayasa Konstruksi Jalan dan Jembatan, Politeknik Negeri Ketapang, Ketapang.*
*Email Penulis Korespondensi : firmanilahkamil@politap.ac.id*
*Nomor HP Penulis Korespondensi : 082332979897*

## ABSTRACT

In Ketapang District, there is potential to reduce the environmental impact of concrete production by utilizing local agricultural waste. This study aims to determine the comparison between the physical properties of coconut fiber and palm kernel shells as aggregate substitutes in concrete, with the physical properties of conventional aggregates such as sand and crushed stone. Coconut coir came from tourism waste in Ketapang Regency, while palm kernel shells were taken from the waste of the local palm oil processing industry. Laboratory tests were conducted to compare the physical properties of coconut fiber and palm kernel shell with conventional aggregates, namely sand and crushed stone. The test results showed significant differences. Coconut husk had a specific gravity of 1.19 and palm kernel shell 1.59, compared to sand 2.09 and crushed stone 2.81. The moisture content of palm kernel shell (17.40%) was much higher than that of crushed stone (1.15%), while the water absorption of palm kernel shell reached 37.16%, far above the water absorption of crushed stone (4.05%). Coconut husk and palm kernel shell have lower specific gravity than conventional aggregates, making them ideal for lightweight concrete. However, the high water absorption of palm kernel shells requires adjustments to the concrete mix design. This study shows that the use of local waste materials can contribute to the development of environmentally friendly concrete, but careful composition control is required to maintain concrete performance.

***Keyword:*** *aggregate, concrete, material testing.*

## 1. INTRODUCTION

Concrete is the main construction material used in various infrastructure development projects due to its strength and flexibility[1]. However, conventional concrete production faces major challenges related to environmental impacts, especially in terms of natural resource use and carbon emissions[2]. The use of conventional aggregates such as sand and crushed stone contributes to environmental degradation and utilization of non-renewable resources. In Ketapang District, there is potential to reduce the environmental impact of concrete production by utilizing local agricultural waste. Coconut husk, which comes from tourism waste in the form of used young coconuts in food stalls along Sungai Kinjil Beach and Tanjung Belandang Beach, offers strong and flexible fiber properties. Meanwhile, palm kernel shells, which are waste from the palm oil processing industry found in Ketapang Regency, have a high silica content and good hardness.

Replacing conventional aggregates with alternative materials such as coconut fiber and palm kernel shell in concrete mixtures can be a solution to reduce the environmental impact of concrete production [3]. This research aims to test various materials, including sand, crushed stone, cement, water, coconut fiber, and palm kernel shell, to evaluate their potential in the development of environmentally friendly concrete. By optimally utilizing local waste, this research not only contributes to the reduction of environmental impact but also to better waste management in the area[4]. Based on the above background, the problem formulation obtained is “How is the comparison of the physical properties of coconut fiber and palm kernel shell as aggregate replacement materials in concrete, compared to the physical properties of conventional aggregates such as sand and crushed stone?”. The purpose of this study is to determine the comparison between the physical properties of coconut fiber and palm kernel

P-ISSN : 2598-1277
E-ISSN : 2621-3966

shells as aggregate substitutes in concrete, with the physical properties of conventional aggregates such as sand and crushed stone. The limitation of this research problem is that the tests are only on water content, content weight, specific gravity, water absorption, and sieve analysis. If this research is not conducted, the potential utilization of coconut husk and palm kernel shell wastes as alternative construction materials will be neglected, and the environmental problems caused by the accumulation of these wastes will continue. On the other hand, the dependence on the increasingly limited conventional aggregates will increase. On the contrary, if this research is conducted, the results can contribute to the development of environmentally friendly concrete, open up opportunities for the construction industry to utilize local waste materials, and provide solutions for reducing environmental impacts while reducing the cost of concrete production. It will also provide economic benefits to local communities involved in the management of such waste.

## 2. METHODOLOGY

This research is a laboratory experiment conducted at the Materials Laboratory of Politeknik Negeri Ketapang for two months (May-June 2024). Coconut fiber and palm kernel shells were taken from tourism waste and palm oil processing industry in Ketapang Regency, while sand, crushed stone, cement, and water were obtained from conventional sources. Tests conducted included moisture content, content weight, specific gravity and water absorption, sieve analysis, and mud content. Tools used included drying ovens, scales, sieves, and mud content and water absorption test equipment. The research flow can be seen in Figure 1.

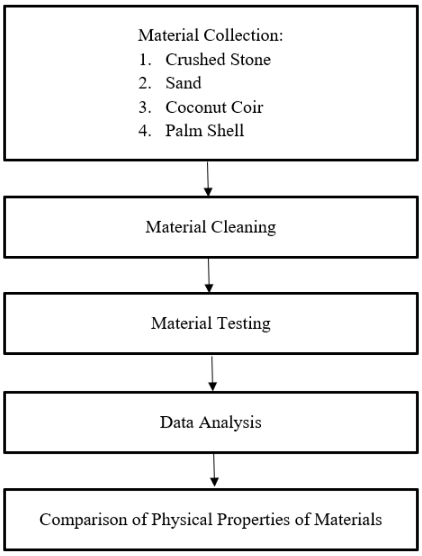


**Figure 1.** Research Flow

## 3. RESULTS AND DISCUSSION

### 3.1. Sand Material Testing Results

### A. Sand Sieve Analysis

The results of the sand sieve analysis test can be seen in Table 1. Based on the results of sand sieve analysis as in Table 1, the retained sand varies, which means that in each of the sieves there is a retained weight. The result of the fineness modulus obtained is 5.61 from a total of 2000 grams of sand used.

**Table 1.** Sand Sieve Analysis Testing Data

| Sieve Size (mm) | Retained weight (gram) | Retained weight (%) | Cumulative Retained weight (%) | Cumulative Pass (%) |
|---|---|---|---|---|
| 2,36 | 6,61 | 0,33 | 0,33 | 99,67 |
| 1,18 | 145,01 | 7,25 | 7,58 | 92,42 |

| Sieve Size (mm) | Retained weight (gram) | Retained weight (%) | Cumulative Retained weight (%) | Cumulative Pass (%) |
|---|---|---|---|---|
| 1,00 | 164,78 | 8,24 | 15,82 | 84,18 |
| 0,60 | 819,04 | 40,95 | 56,77 | 43,23 |
| 0,30 | 608,59 | 30,43 | 87,20 | 12,80 |
| 0,20 | 177,98 | 8,90 | 96,10 | 3,90 |
| 0,15 | 33,34 | 1,67 | 97,77 | 2,23 |
| 0,08 | 31,99 | 1,60 | 99,37 | 0,63 |
| pan | 12,66 | 0,63 | 100,00 | 0 |
| Total | 2000,00 | 100,00 | 560,94 | |
| Modulus of Smoothness | | 5,61 | | |

## B. Sand Moisture Content

The results of the sand moisture content test can be seen in Table 2. Based on the results of the sand moisture content test as in Table 5.3 from a total of 3 tested specimens, the average moisture content value is 8.05%.

**Table 2.** Sand Moisture Content Testing Data

| | Sand 1 | Sand 2 | Sand 3 |
|---|---|---|---|
| Containers | 5,01 | 4,93 | 5,31 |
| Container + Dry Test Material | 52,58 | 49,19 | 57 |
| Container + Wet Test Material | 56,73 | 53,41 | 61,15 |
| Water Content | 8,02 | 8,70 | 7,43 |
| Average Moisture Content | | 8,05 | |

## C. Sand Silt Content

The results of the mud content test can be seen in Table 3. Based on the results of the sand mud content test as shown in Table 5.5 from a total of 2 test objects tested, the average mud content value of sand is 0.97%.

**Table 3.** Fine Aggregate Sludge Content Testing Data

| Inspection | Test Item | |
|---|---|---|
| | 1 | 2 |
| Mud Reading Scale (A) | 3,9 | 3,0 |
| Sand Reading Scale (B) | 3,7 | 2,9 |
| Sludge Content | 0,95 | 1,00 |
| Average | 0,97 | |

## D. Sand Content Weight

The results of the solid content weight test can be seen in Table 4. Based on the results of the solid content weight test as shown in Table 5.6 from a total of 3 test specimens tested, the average solid content weight value of sand is 1.55 Kg/ $cm^3$. The results of the loose content weight test can be seen in Table 5. Based on the loose content weight test results as shown in Table 5.7 from a total of 3 tested specimens, the average solid content weight value of sand is 1.44 Kg/ $cm^3$.

**Table 4.** Testing Data of Solid Content Weight (Sand)

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 8,06 | 7,97 | 8,01 |
| Test Item Weight | 4,51 | 4,42 | 4,46 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 1,57 | 1,53 | 1,55 |
| Average Fill Weight | | 1,55 | |

P-ISSN : 2598-1277
E-ISSN : 2621-3966

**Table 5.** Test Data for Loose Weight (Sand)

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 7,68 | 7,73 | 7,70 |
| Test Item Weight | 4,13 | 4,18 | 4,15 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 1,43 | 1,45 | 1,44 |
| Average Fill Weight | | 1,44 | |

## E. Specific Gravity and Absorption of Sand

The results of testing the specific gravity and absorption of sand can be seen in Table 6. Based on the results of the specific gravity and absorption tests as in Table 6 from a total of 2 tested specimens, the average specific gravity value of sand is 2.09% and the average water absorption value of sand is 3.5%.

**Table 6:** Test Data for Specific Gravity and Absorption of Sand

| Inspection | Sample | | Average |
|---|---|---|---|
| | 1 | 2 | |
| Weight of SSD dry surface saturated specimen (S) grams | 250,00 | 250,00 | |
| Weight of oven-dried test specimen (A) grams | 246,75 | 235,52 | |
| Weight of pycnometer + water (B) grams | 421,71 | 421,71 | |
| Weight of pycnometer + water + SSD sand (C) grams | 561,01 | 541,76 | |
| Specific gravity of SSD sand | 2,26 | 1,92 | 2,09 |
| Water Absorption | 1,30 | 5,80 | 3,50 |

## 3.2. Testing Results of Coconut Coir Material

## A. Coconut Coir Sieve Analysis

**Table 7.** Testing Data for Coconut Fiber Sieve Analysis

| Sieve Size (mm) | Retained weight (gram) | Retained weight (%) | Cumulative Retained weight (%) | Cumulative Pass (%) |
|---|---|---|---|---|
| 9,5 | 0 | 0 | 0 | 100 |
| 4,75 | 73,29 | 3,66 | 3,66 | 96,34 |
| 2,36 | 92,14 | 4,61 | 8,27 | 91,73 |
| 1,18 | 269,54 | 8,68 | 16,75 | 83,25 |
| 0,85 | 337,32 | 16,87 | 33,61 | 66,39 |
| 0,425 | 603,16 | 30,16 | 63,77 | 36,23 |
| 0,15 | 593,21 | 29,66 | 93,43 | 6,57 |
| 0,075 | 129,37 | 6,47 | 99,9 | 0,10 |
| PAN | 1,97 | 0,10 | 100 | 0 |
| TOTAL | 2000 | 100 | 419,73 | |
| Modulus of Smoothness | | | 4,20 | |

## B. Coconut Coir Moisture Content

**Table 8.** Coconut Coir Moisture Content Testing Data

| | Coconut 1 | Coconut 2 | Coconut 3 |
|---|---|---|---|
| Containers (W1) | 5 | 5 | 5 |
| Container + Wet Test Material (W2) | 7,85 | 8,4 | 8,58 |

 P-ISSN : 2598-1277
E-ISSN : 2621-3966

| | Coconut 1 | Coconut 2 | Coconut 3 |
|---|---|---|---|
| Weight of test specimen (W3=W2-W1) | 2,85 | 3,4 | 3,58 |
| Container + Dry Test Material (W4) | 7,67 | 8,07 | 8,23 |
| Weight of oven-dried test specimen (W5=W4-W1) | 2,67 | 3,07 | 3,23 |
| Water Content | 6,74 | 10,75 | 10,84 |
| Average Moisture Content | | 9,44 | |

## C. Coconut Coir Content Weight

**Table 9.** Solid Content Weight Testing Data (Coconut Coir)

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 4,41 | 4,33 | 4,33 |
| Test Item Weight | 0,86 | 0,78 | 0,78 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 0,3 | 0,27 | 0,27 |
| Average Fill Weight | | 0,28 | |

**Table 10.** Test Data of Loose Weight Content (Coconut Coir)

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 4,13 | 4,04 | 4,07 |
| Test Item Weight | 0,58 | 0,49 | 0,52 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 0,2 | 0,17 | 0,18 |
| Average Fill Weight | | 0,18 | |

## D. Specific gravity and absorption of coconut fiber

**Table 11.** Specific gravity and absorption test data of coconut fiber

| Inspection | Sampel | | Rata- rata |
|---|---|---|---|
| | 1 | 2 | |
| Weight of SSD dry surface saturated specimen (S) grams | 250 | 250 | |
| Weight of oven-dried test specimen (A) grams | 223 | 224 | |
| Weight of pycnometer + water (B) grams | 641 | 641 | |
| Weight of pycnometer + water + SSD sand (C) grams | 680 | 683 | |
| Specific gravity of SSD sand | 1,18 | 1,20 | 1,19 |
| Water Absorption | 0,108 | 0,104 | 0,106 |

 P-ISSN : 2598-1277
E-ISSN : 2621-3966

## 3.3. Test Results of Crushed Stone Material

### A. Crushed Stone Sieve Analysis

Based on the results of the crushed stone sieve analysis as in Table 12, the retained crushed stone varies, which means that in each of the sieves there is a retained weight. The result of the fineness modulus obtained is 8.24 from a total of 2000 grams of crushed stone used.

**Table 12.** Crushed Stone Sieve Analysis Testing Data

| Sieve Size (mm) | Retained weight (gram) | Retained weight (%) | Cumulative Retained weight (%) | Cumulative Pass (%) |
|---|---|---|---|---|
| 25 | 71,68 | 3,584 | 3,584 | 1928,32 |
| 19 | 565,84 | 28,292 | 31,876 | 1362,48 |
| 14,25 | 1145,86 | 57,293 | 89,169 | 216,62 |
| 13 | 214,04 | 10,702 | 99,871 | 2,58 |
| 9,5 | 0,8 | 0,04 | 99,911 | 1,78 |
| 4,75 | 0,83 | 0,0415 | 99,9525 | 0,95 |
| 2,36 | 0,95 | 0,0475 | 100 | 0 |
| 1,18 | 0 | 0 | 100 | 0 |
| pan | 0 | 0 | 100 | 0 |
| Total | 2000 | 100 | 824,36 | |
| | Modulus of Smoothness | | 8,24 | |

### B. Water Content of Crushed Stone

Based on the results of testing the water content of crushed stone as in Table 13 from a total of 3 test objects tested, the average water content value of crushed stone is 1.15%.

**Table 13.** Crushed Stone Water Content Testing Data

| | Stone 1 | Stone 2 | Stone 3 |
|---|---|---|---|
| Containers | 5,05 | 4,69 | 4,71 |
| Container + Dry Test Material | 126,38 | 117,37 | 129,71 |
| Container + Wet Test Material | 127,13 | 118,81 | 131,69 |
| Water Content | 0,61 | 1,26 | 1,56 |
| Average Moisture Content | | 1,15 | |

### C. Crushed Stone Sludge Content

**Table 14.** Crushed Stone Sludge Content Testing Data

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Dry stone weight before washing | 295,20 | 290,35 | 275,20 |
| Weight of oven-dried stone after washing | 294,03 | 289,21 | 273,94 |
| Sludge Content | 0,40 | 0,39 | 0,46 |
| Average | | 0,42 | |

The results of the mud content test can be seen in Table 14. Based on the results of the crushed stone mud content test as in Table 14 from a total of 3 test objects tested, the average mud content value of crushed stone is 0.42%.

P-ISSN : 2598-1277
E-ISSN : 2621-3966

### D. Weight of Crushed Stone Fill

**Table 15.** Crushed Stone Solid Content Testing Data

| Inspection | Benda Uji | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 8,09 | 8,02 | 8,05 |
| Test Item Weight | 4,54 | 4,47 | 4,50 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 1,58 | 1,55 | 1,56 |
| Average Fill Weight | | 1,56 | |

The results of the solid content weight test can be seen in Table 15. Based on the results of the solid content weight test of crushed stone as shown in Table 15 from a total of 3 test specimens tested, the average solid content weight value of crushed stone is 1.56 Kg/ cm3. Based on the results of the coarse aggregate loose content weight test as shown in Table 16 from a total of 3 test specimens tested, the average solid content weight value of crushed stone is 1.43 Kg/ cm3.

**Table 16.** Testing Data of Loose Weight of Crushed Stone

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 7,69 | 7,67 | 7,66 |
| Test Item Weight | 4,14 | 4,12 | 4,11 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 1,44 | 1,43 | 1,43 |
| Average Fill Weight | | 1,43 | |

### E. Specific gravity and absorption of crushed stone

The results of testing the specific gravity and absorption of coarse aggregate can be seen in Table 17. Based on the results of testing the specific gravity and absorption of crushed stone as in Table 17 from a total of 2 tested specimens, the average specific gravity value of crushed stone is 2.81% and the average value of water absorption of crushed stone is 4.05%.

**Table 17.** Test Data for Specific Weight and Absorption of Crushed Stone

| Inspection | Sample | | Average |
|---|---|---|---|
| | 1 | 2 | |
| Weight of oven-dried test specimen | 961,49 | 959,80 | |
| Weight of surface dry saturated test specimen in air | 1000 | 1000 | |
| Weight of test specimen in water | 647,7 | 642 | |
| Specific gravity | 2,80 | 2,83 | 2,81 |
| Water Absorption | 4,0 | 4,1 | 4,05 |

## 3.4. Testing Results of Palm Kernel Shell Material

### A. Palm Kernel Shell Sieve Analysis

The results of the sieve analysis test can be seen in Table 18. Based on the results of the palm kernel shell sieve analysis as in Table 18, the retained palm shell varies, which means that in each of the sieves there is a retained weight. The result of the fineness modulus obtained is 5.83 from a total of 2000 grams of palm kernel shells used.

**Table 18.** Palm Kernel Shell Sieve Analysis Testing Data

| Sieve Size (mm) | Retained weight (gram) | Retained weight (%) | Cumulative Retained weight (%) | Cumulative Pass (%) |
|---|---|---|---|---|
| 25 | 0 | 0 | 0 | 100 |
| 19 | 0 | 0 | 0 | 100 |
| 14,25 | 8 | 0,4 | 0,4 | 99,6 |
| 13 | 784 | 39,2 | 39,6 | 60,4 |
| 9,5 | 356 | 17,8 | 57,4 | 42,6 |
| 4,75 | 567 | 28,35 | 85,75 | 14,25 |
| 2,36 | 285 | 14,25 | 100 | 0 |
| 1,18 | 0 | 0 | 100 | 0 |
| pan | 0 | 0 | 100 | 0 |
| Total | 2000 | 100 | 583,15 | |
| Modulus of Smoothness | | | 5,83 | |

## B. Moisture Content of Palm Kernel Shell

Based on the results of testing the water content of palm kernel shells as in Table 19 from a total of 3 tested specimens, the average water content value of palm kernel shells is 17.40%.

**Table 19.** Palm Kernel Shell Moisture Content Testing Data

| | Palm 1 | Palm 2 | Palm 3 |
|---|---|---|---|
| Containers | 4,76 | 4,38 | 4,65 |
| Container + Dry Test Material | 41,9 | 44,03 | 40,07 |
| Container + Wet Test Material | 49,92 | 52,08 | 47,62 |
| Water Content | 17,76 | 16,88 | 17,57 |
| Average Moisture Content | | 17,40 | |

## C. Weight Content of Palm Shell

**Table 20.** Palm Kernel Shell Solid Weight Testing Data

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 5,38 | 5,35 | 5,33 |
| Test Item Weight | 1,83 | 1,8 | 1,78 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 0,64 | 0,63 | 0,62 |
| Average Fill Weight | | 0,63 | |

Based on the results of testing the solid content weight of palm kernel shells as in Table 20 from a total of 3 test specimens tested, the average solid content weight value of palm kernel shells is 0.63 Kg / cm3. Based on the results of the loose content weight test of palm kernel shells as in Table 21 from a total of 3 tested specimens, the average loose content weight of palm kernel shells is 0.56Kg/ $cm^3$.

**Table 21.** Palm Kernel Shell Loose Weight Test Data

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Mold Weight | 3,55 | 3,55 | 3,55 |
| Weight of Mold + Test Piece | 5,15 | 5,16 | 5,19 |

 P-ISSN : 2598-1277
E-ISSN : 2621-3966

| Inspection | Test Item | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Test Item Weight | 1,6 | 1,61 | 1,64 |
| Weight of Mold + Water | 6,43 | 6,43 | 6,43 |
| Berat Udara / Volume Cetakan | 2,88 | 2,88 | 2,88 |
| Weight of Aggregate Content | 0,56 | 0,56 | 0,57 |
| Average Fill Weight | | 0,56 | |

### D. Specific gravity and absorption of palm kernel shell

The results of testing the specific gravity and absorption of palm kernel shells can be seen in Table 22. Based on the results of testing the specific gravity and absorption of palm kernel shells as in Table 22 from a total of 2 test specimens tested, the results obtained the average specific gravity value of palm kernel shells is 1.59% and the results obtained the average value of water absorption of palm kernel shells is 37.16%.

**Table 21.** Test Data for Specific Weight and Absorption of Palm Kernel Shells

| Inspection | Sample | | Average |
|---|---|---|---|
| | 1 | 2 | |
| Weight of oven-dried test specimen | 313,37 | 315,01 | |
| Weight of surface dry saturated test specimen in air | 500 | 500 | |
| Weight of test specimen in water | 186,63 | 184,99 | |
| Specific gravity | 1,60 | 1,59 | 1,59 |
| Water Absorption | 37,33 | 37,00 | 37,16 |

## 3.5. Comparison of Physical Properties of Substitute Aggregates and Conventional Aggregates

**Table 22.** Overall Aggregate Testing Results

| | **Agregat Halus** | | **Agregat Kasar** | |
|---|---|---|---|---|
| Testing | **Sand** | **Coconut Coir** | **Crushed Stone** | **Palm Kernel Shell** |
| Water Content | 8,05 % | 9,44 % | 1,15 % | 17,40 |
| Fineness Modulus | 5,61 | 4,20 | 8,24 | 5,83 |
| Specific gravity | 2,09 | 1,19 | 2,81 | 1,59 |
| Water Absorption | 3,50 | 0,106 | 4,05 | 37,16 |
| Solid Weight | 1,55 | 0,28 | 1,56 | 0,63 |
| Loose Weight | 1,44 | 0,18 | 1,43 | 0,56 |
| Sludge Content | 0,97 % | | 0,42 | |

*Source: Data Analysis, 2024*

Based on the test results of the physical properties of the aggregates shown in Table 22, there are significant differences between the conventional aggregates and the replacement aggregates in various aspects. The moisture content of coir and sand showed quite high values compared to crushed stone, which had the lowest moisture content. This indicates that coir and sand can absorb more water, which may affect the consistency of the concrete mix. On the other hand, palm kernel shell has the highest moisture content, which may affect the weight and characteristics of the concrete if used in the mix. The fineness modulus indicates the grain size of the aggregate [5], where crushed stone shows the highest value, indicating a larger grain size compared to palm kernel shell which has the lowest fineness modulus. This implies that crushed stone will provide a coarser and stronger concrete structure [6], while coir tends to produce a finer concrete mix [7].

The specific gravity of the aggregates showed that coir had the lowest specific gravity among all aggregates, while crushed stone had the highest specific gravity. The lower specific gravity of coir and palm kernel shell suggests that they can reduce the density of concrete, which may be beneficial in certain applications, such as lightweight concrete [8].

The water absorption of palm kernel shell is very high, which may affect the water absorption of concrete and require adjustments in concrete mix design[9]. In contrast, coconut husk has very low water absorption, which can improve the quality of concrete if used in the right proportion. In terms of content weight, both in solid and loose conditions, coir and palm kernel shell show very low values compared to conventional aggregates. This means that both materials are very light, which can reduce the total weight of concrete and affect its structural characteristics[10] Finally, the silt content of sand is higher than that of crushed stone and coir, which can affect the quality of concrete if not managed properly. High silt content can cause problems in the consistency and strength of concrete, so it is important to control the silt content in the concrete mix.

**Table 23.** Comparison Value of Substitute Aggregate and Conventional Aggregate

| Testing | Coconut Coir vs Sand | Palm Kernel Shell vs Crushed Stone |
|---|---|---|
| Water Content (5%) | 1,17 | 15,13 |
| Modulus of Smoothness | 0,75 | 0,71 |
| Specific Weight | 0,57 | 0,57 |
| Water Absorption (%) | 0,03 | 9,18 |
| Weight of Solid Contents (kg/m$^3$) | 0,18 | 0,40 |
| Loose Fill Weight (kg/m$^3$) | 0,13 | 0,39 |

*Source: Data Analysis, 2024*

Based on the overall comparison results in Table 23, it can be seen that the physical properties of coconut fiber and palm kernel shell as aggregate substitutes have significant differences compared to conventional aggregates such as sand and crushed stone. Coconut fiber has a moisture content that is 1.17 times higher than sand, while palm kernel shell has a much greater moisture content of 15.13 times that of crushed stone. This shows that palm kernel shells have very high water absorption properties. In addition, the water absorption of coconut fiber is much lower than that of sand, only about 3% of the water absorption of sand, while palm kernel shell shows a very large water absorption, reaching 9.18 times that of crushed stone. This can affect the durability and performance of concrete, especially in humid environments.

In terms of specific gravity, both coir and palm kernel shell have lower values than sand and crushed stone, with a ratio of 0.57 each. This indicates that coir and palm kernel shells are lighter than conventional aggregates, which can affect the strength and density of concrete. Meanwhile, in terms of fineness modulus and weight content (both solid and friable), coir and palm kernel shell have lower values, indicating that they are finer and less dense than conventional aggregates. To ensure that coir and palm kernel shells can be used as a substitute for conventional aggregates in concrete, it is important to compare them with the applicable Indonesian National Standard (SNI). Some of the key tests regulated by SNI, such as moisture content, fineness modulus, specific gravity, water absorption, and content weight, provide important guidance on the quality of aggregates in concrete mixes. Based on SNI 03-1970-1990, the moisture content of the aggregate should not be too high so as not to affect the strength of the concrete. In this study, the moisture content of coconut husk and palm kernel shell exceeded the moisture content of conventional aggregates, so it is necessary to consider its effect on the concrete mix.

## 4. CONCLUSIONS

This study showed significant differences between the physical properties of the replacement aggregates (coconut fiber and palm kernel shell) and the conventional aggregates (sand and crushed stone), in accordance with SNI standards. Coconut fiber and palm kernel shell have lower specific gravity, 1.19 and 1.59, respectively, compared to sand (2.09) and crushed stone (2.81). The water absorption of palm kernel shell reached 37.16%, well above the SNI limit of 3%, while coconut husk had a very low water absorption (0.106%). The fineness modulus of coir (4.20) and palm kernel shell (5.83) is close to the SNI standard for fine aggregates, although finer than crushed stone (8.24). Therefore, although coir and

 P-ISSN : 2598-1277
E-ISSN : 2621-3966

palm kernel shells have potential as aggregate substitutes in concrete, adjustments are needed to the concrete mix to meet the mechanical standards according to SNI.

## ACKNOWLEDGMENTS

I would like to express my sincere gratitude to Politeknik Negeri Ketapang for their tremendous support during this research process. Thanks also to all parties involved, especially for the assistance from the APTV (Association of Vocational Higher Education) research grant program which has facilitated and provided financial support through a research grant from the Ministry of Education and Culture Ristek. This grant enabled this research to run smoothly and make a meaningful contribution to the development of environmentally friendly concrete. Hopefully, the results of this research can provide great benefits for the advancement of science and innovation in the field of construction

## REFERENCES

[1] K. Liman dan H. Sulistio, "WASTE MATERIAL BETON PADA PROYEK KONSTRUKSI DI JAKARTA," *JMTS J. Mitra Tek. Sipil*, vol. 3, no. 1, hlm. 183, Feb 2020, doi: 10.24912/jmts.v3i1.7066.

[2] I. Mashabai, I. Adiasa, dan S. Ardiansyah, "ANALISIS MATERIAL HANDLING PADA PEKERJAAN PEMBUATAN PAVING BLOK DI SURYATAMA BETON," *J. Ind. Teknol. SAMAWA*, vol. 2, no. 1, hlm. 32–37, Apr 2021, doi: 10.36761/jitsa.v2i1.1021.

[3] N. L. P. S. E. Setyarini, A. N. Tajudin, dan J. Pratama, "KARAKTERISTIK MARSHALL LAPISAN AUS ASPAL BETON MENGGUNAKAN AGREGAT TERSELIMUT LIMBAH PLASTIK LDPE (LOW DENSITY POLYETHYLENE)," *J. Muara Sains Teknol. Kedokt. Dan Ilmu Kesehat.*, vol. 3, no. 1, hlm. 123, Okt 2019, doi: 10.24912/jmstkik.v3i1.1697.

[4] D. Y. Kurniawati *dkk.*, "Pengembangan UMKM Berkelanjutan: Pemanfaatan Ekonomi Lokal dan Teknologi Dalam Pengolahan Limbah Untuk Pertumbuhan Ekonomi dan Lingkungan Desa Kayuapak," *SWARNA J. Pengabdi. Kpd. Masy.*, vol. 3, no. 3, hlm. 309–318, Mar 2024, doi: 10.55681/swarna.v3i3.1265.

[5] B. G. Dimalouw dan P. Saelan, "Tinjauan Kembali Mengenai Pengaruh Modulus Kehalusan Pasir terhadap Kuat Tekan Beton," 1981.

[6] R. T. Jurnal, "ANALISIS PENGARUH BESAR BUTIRAN AGREGAT KASAR TERHADAP KUAT TEKAN BETON NORMAL," *Forum Mek.*, vol. 7, no. 1, hlm. 35–42, Nov 2018, doi: 10.33322/forummekanika.v7i1.87.

[7] H. Hermansyah dan M. R. Sachroudi, "PENGARUH PENAMBAHAN SABUT KELAPA SEBAGAI MATERIAL SERAT TERHADAP KUAT TEKAN BETON," *J. Kacapuri J. Keilmuan Tek. Sipil*, vol. 6, no. 1, hlm. 23, Jul 2023, doi: 10.31602/jk.v6i1.10997.

[8] M. R. Firdaus, S. Nisumanti, dan K. Al Qubro, "Pengaruh Pengerasan Beton Menggunakan Superplasticizer Terhadap Kuat beton Busa," *J. Tekno Glob.*, vol. 11, no. 2, hlm. 56–61, Des 2022, doi: 10.36982/jtg.v11i2.3049.

[9] A. Amir, F. Idris, dan A. Rahman, "KARAKTERISTIK BETON LOLOS AIR (PERVIOUS CONCRETE) MEMANFAATKAN FLY ASH DAN SERAT LIMBAH PLASTIK SEBAGAI PENUNJANG BANGUNAN RENDAH KARBON," *J. Arsip Rekayasa Sipil Dan Perenc.*, vol. 7, no. 1, hlm. 23–31, Mar 2024, doi: 10.24815/jarsp.v7i1.36478.

[10] D. W. Al Fauzi, N. A. Affandy, H. R. Agustapraja, dan Z. Lubis, "PENGARUH PENAMBAHAN FLY ASH (CANGKANG TELUR DAN SEKAM PADI) DENGAN KUAT TEKAN BETON NON STRUKTURAL," *J. Ilm. MITSU Media Inf. Tek. Sipil Univ. Wiraraja*, vol. 12, no. 1, hlm. 1–14, Apr 2024, doi: 10.24929/ft.v12i1.2128.