Analysis of the Use of Palm Shells as a Substitute for Fine Aggregate on the Water Absorption Capacity of Concrete

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ABSTRACT

Concrete, as one of the main elements in construction, has received special attention and is commonly used in infrastructure development in various countries in the world. Along with the increasing need for infrastructure, such as towers, high-rise buildings, and long-span bridges, high-quality concrete is increasingly needed. This type of concrete is made with a low amount of FAS; FAS or water to cementitious ratio is the ratio of the total weight of water to the total weight of cement in the concrete mixture. The purpose of this study is to analyze the water absorption of concrete using palm shells as a substitute for fine aggregate using an experimental method by curing. From the results of testing palm shells such as the water absorption value which is directly proportional to the increasing percentage of CKS use as a substitute for fine aggregate, it shows that the use of CKS as a substitute for fine aggregate in normal concrete increases the water absorption of concrete, the higher the percentage of palm shell substitution, the higher the percentage of absorption value obtained.

Keywords: water absorption, concrete, curing, palm oil, shell.

INTRODUCTION

Almost all building structures use concrete material in their structural elements, this is because concrete has advantages compared to other materials, namely that concrete is easy to form, relatively cheap and requires easy maintenance, but the increasing need for concrete results in the need for concrete components also increasing, this results in large-scale mining of natural resources which has an impact on the declining quality of the ecosystem which can damage the environment [1], [2]. Therefore, as an alternative building material that can be used to overcome the problem of increasing needs for buildings by utilizing waste. Industrial and construction waste that has no economic value can be reused for concrete material mixtures [3], [4].

The development of science and technology has a significant influence on all aspects of human life, including in the field of construction. Concrete, as one of the main elements in construction, has received special attention and is commonly used in infrastructure development in various countries in the world. Along with the increasing need for infrastructure, such as towers, high-rise buildings, and long-span bridges, high-quality concrete is increasingly needed. This type of concrete is made with a low amount of FAS; FAS or water to cementitious ratio is the ratio of the total weight of water to the total weight of cement in the concrete mixture [5]-[8].

However, behind its advantages, concrete production is often synonymous with environmental destruction. The production process involving lime excavation, burning, and carbon emissions in the air, contributes greatly to environmental degradation. Therefore, innovation in making environmentally friendly concrete is very important for the sustainability of infrastructure development. One solution that has emerged is to utilize local materials that are more environmentally friendly [9]-12].

Indonesia, as one of the largest agricultural countries in the world, has great potential in providing environmentally friendly local materials, one of which is from the palm oil plantation sector. Almost all regions in Indonesia have extensive palm oil plantations, including in East Luwu Regency, which

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is the center of community plantations. With four palm oil processing factories spread across various sub-districts, this regency produces abundant waste materials, including palm shells that can be further utilized [13].

Activities in the palm oil processing process at PTPN XIV in Burau, East Luwu Regency, which continue to cause piles of shell material. The impact of activities that cause waste has the potential to affect land availability, while the environmental capacity has its own limitations [14].

Each ton of FFB (Fresh Fruit Bunches) from oil palm produces 21-23% CPO oil and 5% palm kernel or shell waste [15]. These palm shells, as the hardest part of oil palm, are waste from palm oil processing activities that have not been utilized optimally until now. The process of pressing oil palm fruit produces shells that have great potential to be used as additional materials in concrete, without changing the main chemical components such as holocellulose and lignin [16].

Analyzed the use of palm shells as aggregates in concrete, but there are shortcomings in their research that focus on the differences in performance between coarse and fine aggregates made from palm shells [17], [18]. Further research is needed to specifically compare the effects of using palm shells as coarse and fine aggregates on the strength, durability, and mechanical properties of concrete. Most current studies have not clearly distinguished how variations in aggregate size and type (coarse vs fine) affect the overall performance of concrete, such as compressive strength, water absorption, and volumetric stability [19]-[21]. Thus, research is needed on the interaction between fine aggregates in concrete mixtures using palm shells to determine the optimal proportions and mixing techniques that can effectively improve concrete performance [22]-[24].

RESEARCH METHODS

Materials

Research Implementation

As a scientific research, this research was carried out using a systematic and planned method, so that the results of this research can be accounted for. For this reason, this study was conducted in several stages, including:

Experimental Design

The design of the test object in this study refers to the mix design plan according to SNI 03-2834-2000 Procedures for Making Normal Concrete Mixtures. The concrete test object is placed in a cylinder measuring 10 x 20 cm using palm shells as a substitute for fine aggregate.

Working Steps

The working steps in this study are as follows:

1. **Stage I (Preparation Stage/Literature Study)**

At this stage, a search for material related to the study will be carried out as a reference.

2. **Stage II (Material and Equipment Preparation Stage)**

At this stage, all materials and equipment to be used are prepared in advance so that the study runs smoothly.

3. **Stage III (Material Testing Stage)**

At this stage, testing is carried out on materials which are concrete mixtures intended to determine the properties and characteristics of the material. Material testing in this study only focuses on testing natural materials with heterogeneous conditions, qualities and sizes, so strict control is needed to obtain the required materials. This test uses requirements that are in accordance with the aggregate characteristic specifications standardized by the Indonesian National Standard (SNI),

1) Coarse Aggregate Testing (Split)

a. Mud content
b. Water content
c. Volume weight
d. Absorption and specific gravity
e. Sieve analysis

2) Fine Aggregate Testing (Sand)
a. Mud content
b. Organic content
c. Wear
d. Water content
e. Volume weight
f. Absorption and specific gravity
g. Sieve analysis

4. Stage IV (Mix Design Planning Stage)

The planning of making this test object in this study refers to the mix design planning in accordance with standars concerning concrete mix design planning. In this process, the manufacture of test specimens for the dimensions of a 10 cm x 20 cm cylinder mold will be planned.

5. Stage V (Test Object Manufacturing Stage)

The manufacturing of test objects is divided into 2, namely normal concrete and concrete with a mixture of palm shell materials.
a. The steps for making normal concrete test objects are as follows:
b. The tools to be used are cleaned first, then weigh the materials to be used according to the composition of the Mix Design results.
c. Prepare a concrete mixer or mixer that has been moistened.
d. Then first pour fine aggregate, coarse aggregate, and cement into the mixer. Stir until the three ingredients are evenly mixed.
e. After the three ingredients are evenly mixed, add water little by little.
f. After evenly mixed, a Slump flow test is carried out to measure the Workability level of the mixture.
g. If the Slump flow value has met the specifications, the concrete mixture is then poured into a cylindrical mold and pierced evenly with a compactor stick so that the concrete mixture becomes solid.
h. Leave it for 24 hours.
i. After 24 hours, the mold is opened and then concrete treatment is carried out.

1) Steps for making concrete test objects with the addition of palm shells are as follows:
a. The process of making fine aggregate from palm shells, the palm shells are dried, then the dried palm shells are ground by pounding them until they meet the size as fine aggregate
b. The tools to be used are cleaned first, then weigh the materials to be used according to the composition of the Mix Design results.
c. Prepare a concrete mixer or mixer whose inside has been moistened.
d. Then pour the fine aggregate into the mixer then add the palm shells that have passed the No. 50 sieve with the specified variations.
e. Then add the coarse aggregate.
f. Then add cement into the concrete mixer or mixer.
g. After the four ingredients are evenly mixed, add water little by little.
h. Then add Sika Viscocrete 3115 N little by little with the specified dosage.
i. After evenly mixed, a Slump test is carried out to measure the Workability level of the mixture.
j. If the Slump value has met the specifications, the concrete mixture is then poured into a cylindrical mold and evenly pierced using a compactor stick so that the concrete mixture becomes solid.
k. Let it stand for 24 hours.

2) After 24 hours, the mold is opened and then concrete treatment is carried out.

6. Stage VI (Slump Test Measurement)

Testing on concrete slump can be done if the combination of materials to form concrete has reached plastic properties. Basically, the purpose of testing the slump value is to determine the level of looseness or thinness of the concrete mixture that is made. The effect of this looseness is useful for assessing the workability of the concrete.

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7. Stage VII (Test Specimen Treatment)

This test specimen treatment is carried out by soaking the molded test specimen in a soaking tank for 3, 7 and 28 days. After the age of the test object or concrete has reached the specified age, the test object is lifted from the soaking tank, then left and dried by wiping or leaving it for 24 hours.

8. Stage VIII (Water Absorption Testing)

The absorption of water absorption in concrete is carried out when it is 28 days old where the number of concrete samples to be tested is 2 samples with 3 variations of the mixture, the testing process is as follows:

a. The test specimen at the age of 28 days is taken from the soaking tub and then dried by wiping the entire surface of the test specimen to avoid excessive water. Furthermore, the dried test specimen is then weighed in order to take the basic mass of the concrete sample.
b. Then let the sample stand for 24 hours, then weighed again to take the dry mass of the sample.
c. This procedure is repeated for the next sample.

Methods

The sampling location was taken at a different location, coarse aggregate was taken in the Palopo Industrial Area and fine aggregate was taken in the Masamba River. While the additional material, namely palm shells, was taken at PT. Perkebunan Nusantara XIV in Burau District, East Luwu Regency. The data collection and sample testing were carried out at the Structure and Materials Laboratory of the Faculty of Engineering, Andi Djemma University, Palopo. Data collection and sample testing were carried out from August 2024 to October 2024.

Data Analysis

Data analysis was conducted using an experimental method on the water absorption capacity of concrete using palm shells as a substitute for fine aggregate. In addition, data analysis was also supported by literature studies related to this study.

RESULT AND DISCUSSION

The water absorption test on concrete was intended to determine the results of the concrete's ability to absorb water. The high water absorption in concrete is directly proportional to the pores in the concrete and the ability of the concrete's components to absorb water. The results of the water absorption test on concrete are as follows:

Concrete without additional palm shells 0% (Normal)

The results of the water absorption test on fresh concrete for normal concrete with a 24-hour soaking can be seen in Table 1 below.

Table 1. Percentage of Water Absorption in Normal Concrete

Code	Age (day)	Water absorption percentage (%)
S1	3	3,52
S2	3	3,43
S3	3	3,63
Average		3.53
S1	7	4,30
S2	7	4,20
S3	7	4.13
Average		4.21
S1	28	5,00
S2	28	4,14
S3	28	4,14
Average		4,38

Source: Analysis Results, 2024

From Table 1. the comparison can be seen in Figure 1

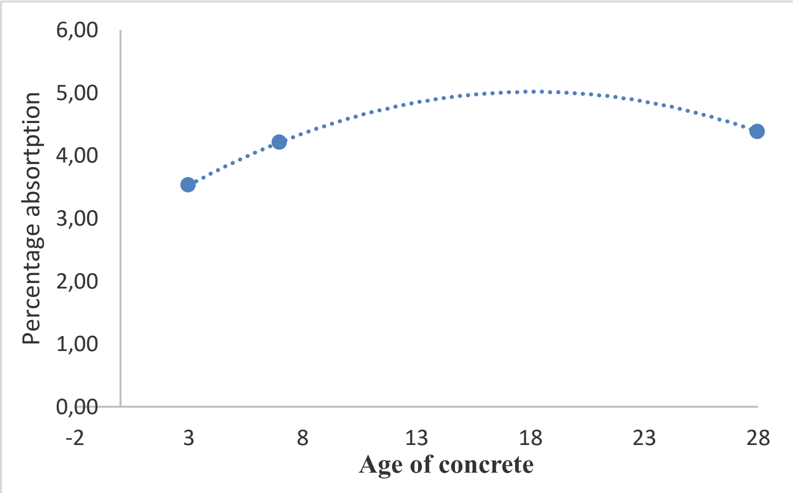

Figure 1. Comparison of Water Absorption in Normal Concrete Aged 3, 7 and 28 days

Figure 1 shows that there is an increase in water absorption in concrete along with the increase in the curing period of the test specimen by immersion. According to SK SNI S–36–1990–03, the absorption value in concrete is a maximum of 2.5% of the oven dry weight for immersion for 10+0.5 minutes, and 6.5% of the oven dry weight for immersion for 24 hours, so that concrete is included in waterproof concrete.

Concrete with 5% palm shell substitution as fine aggregate

The results of water absorption tests on fresh concrete for concrete with the addition of 5% palm shells with immersion for 24 hours can be seen in Table 4.26.

Table 2. Percentage of Water Absorption in Concrete Variation 5% CKS.

Code	Age (day)	Water absorption percentage (%)
S1	3	3,60
S2	3	3,60
S3	3	3,70
Average		3,63
S1	7	3,90
S2	7	5,10
S3	7	4,10
Average		4.37
S1	28	5,8
S2	28	5,10
S3	28	4,00
Average		4,97

Source: Analysis Results, 2024

From Table 2, the comparison can be seen in Figure 2.

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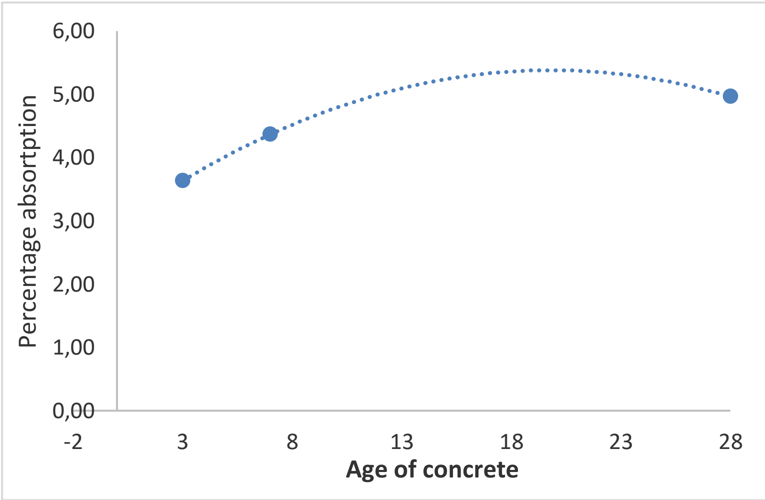

Figure 2. Comparison of Water Absorption in Concrete with 5% Palm Shell Addition Aged 3, 7 and 28 Days

Figure 2 shows that there is an increase in water absorption in concrete along with the increase in the curing period of the test specimen by immersion. According to SK SNI S–36–1990–03, the absorption value in concrete is a maximum of 2.5% of the oven dry weight for immersion for 10+0.5 minutes, and 6.5% of the oven dry weight for immersion for 24 hours, so that concrete is included in waterproof concrete.

Concrete with 10% palm shell addition

The results of water absorption tests on fresh concrete for concrete with 10% palm shell addition with immersion for 24 hours can be seen in Table 3

Table 3. Percentage of Water Absorption in Concrete Variation of 10% Palm Shell.

Code	Age (day)	Water absorption percentage (%)
S1	3	5,00
S2	3	3.90
S3	3	4.50
Average		4,47
S1	7	4,10
S2	7	5,30
S3	7	5,62
Average		5,01
S1	28	5,20
S2	28	5,80
S3	28	5,10
Average		5,37

Source: Primary Data

From Table 3, the comparison can be seen in Figure 3 below.

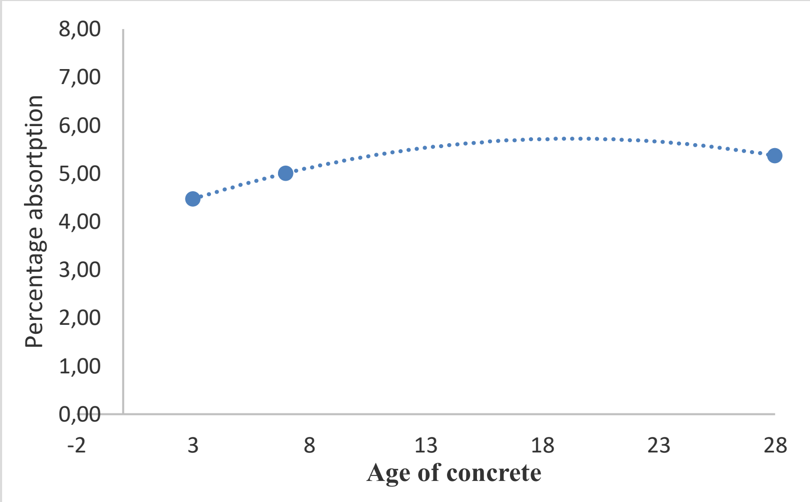

Figure 3. Comparison of Water Absorption in Concrete with 10% Palm Shell Addition Aged 3, 7 and 28 Days

Figure 3 shows that there is an increase in water absorption in concrete along with the increase in the curing period of the test specimen by immersion. According to SK SNI S–36–1990–03, the absorption value in concrete is a maximum of 2.5% of the oven dry weight for immersion for 10+0.5 minutes, and 6.5% of the oven dry weight for immersion for 24 hours, so that the concrete is included in waterproof concrete.

Concrete with 15% palm shell addition

The results of water absorption tests on fresh concrete for concrete with 15% palm shell addition with immersion for 24 hours can be seen in Table 4

Table 4. Percentage of Water Absorption in Concrete Variation of 15% Palm Shell.

Code	Age (day)	Water absorption percentage (%)
S1	3	5,00
S2	3	4,60
S3	3	5,00
	Average	4,87
S1	7	5,54
S2	7	6,20
S3	7	5,40
	Average	5,71
S1	28	5,94
S2	28	5,99
S3	28	6,12
	Average	6,02

Source: Primary Data

From Table 4. the comparison can be seen in Figure 4 below,

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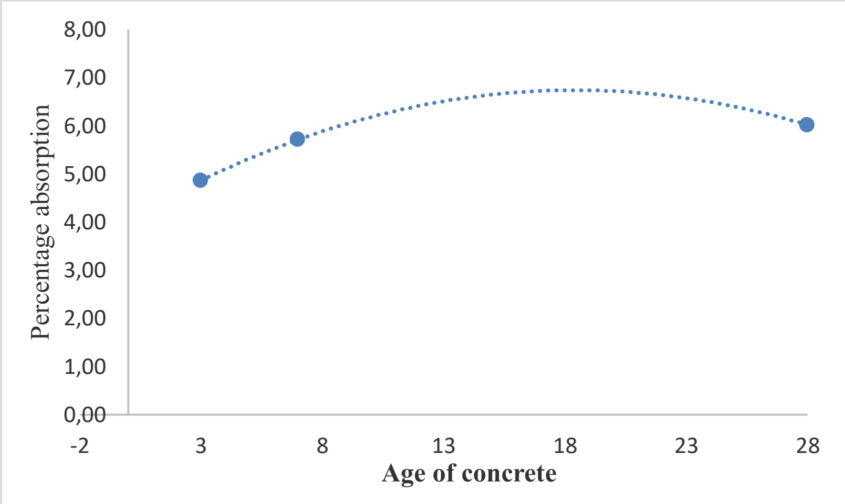

Figure 4. Comparison of Water Absorption in Concrete with 15% Addition of Palm Shells Aged 3, 7 and 28 Days

Figure 4 shows that there is an increase in water absorption in concrete along with the increase in the curing period of the test specimen by immersion. According to SK SNI S–36–1990–03 the absorption value in concrete is a maximum of 2.5% of the oven dry weight for immersion for 10+0.5 minutes, and 6.5% of the oven dry weight for immersion for 24 hours, so that concrete is included in waterproof concrete.

CONCLUSION

From the results of testing palm shells such as the water absorption value which is directly proportional to the increasing percentage of CKS use as a substitute for fine aggregate, it shows that the use of CKS as a substitute for fine aggregate in normal concrete increases the water absorption capacity of concrete, the higher the percentage of palm shell substitution, the higher the absorption percentage value obtained.

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