The Influence of Palm Shell as Aggregate Substitution to The Compressive Normal Concrete Strength

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Abstract. The main objective of this paper was to study the influence of palm shell used as aggregate substitution to achieve structural concrete with lighter weight than normal concrete. Instead of normal aggregate, the alternative aggregate palm shell was used with variation of substitution consisting of 0%, 15%, 30%, 35% and 65% of palm shell by weight of aggregates. Water-cement ratio was 0.40 of and f'c 30 MPa. The test result conducted on the 28th day showed that the strength was increased. However, as the Palm Shell percentages increased, the compressive strength decreased. The normal concrete (0%) of palm shell was resulted 46.188 MPa of strength and the substitution of 15%, 30%, 45% and 60% was 42.917 MPa, 23.287 MPa, 18.860 MPa and 8.468 MPa. There was a reduction in the strength at 0% substitution compared to 60% substitution, and it occurred reduction weight of concrete with 0%, 15%, 30%, 45% and 60% substitution of palm shell that gave result 2528 kg/m³, 2359 kg/m³, 2053 kg/m³, 1990 kg/m³ and 1809 kg/m³ concrete weight. As a result, it shows that the concrete using 0% of palm shell substitution can be categorized as a high strength concrete for 60% substitution palm gave non-structural concrete with lightweight concrete.

1. Introduction

West Aceh is dominated by Palm Oil Industry that produces Palm Shell as agricultural solid waste. As industrial waste, palm shells are potential to be used as aggregates substitution. There are a lot of researches to express a wide range of industrial disposal uses. Looking at these waste utilization opportunities, many people try to utilize the industrial disposal used in concrete mixtures. One of them is palm shells which are the waste of palm oil processing industry in the form of coarse aggregate. The problems discussed in this paper were the influences of palm shells used as the substitute for aggregates on concrete mixtures and those of using percentage variation of palm shell to substitute on the weight of concrete.

The main objective of this research was to study the influence of palm shell used as aggregate substitution to achieve structural concrete with lighter weight than normal concrete. From the results of this study can be used as the basis for further research, especially in the use of oil palm shells in a variety of composition. Instead of normal aggregate, the researchers tried to use alternative aggregate palm shell with the variation of substitution consisting of 0%, 15%, 30%, 35% and 65% s of palm shell by weight of aggregates. Superplasticizer as admixture was Viscocrete N 10 as much as 1% by weight of cement. Concrete was designed with 0.40 of water-cement ratio and compressive strength of concrete was f'c 30 MPa. Palm shells are the hardest part of the components found in oil palm. Each ton of Fresh Fruits produces 21-23% CPO oil and 5% kernel or palm shell. Palm oil shells are potential to be added substances in the concrete. Based on the research results conducted by Subiyanto, et.al., before and after the concrete was made based on statistical tests, the chemical components of the palm shells such as holocellulose and lignin were unchanged, while for the level of benzene ethanol extract (1:2), condensation in hot water, condensation in cold water experienced changes in composition.
of a superplasticizer caused the cement particles to be mutually dispersed [1]. In other words, superplasticizer has two functions that are dispersing the cement particles from particles clumps and preventing cemental cohesion. The phenomenon of cement particle dispersion with the addition of superplasticizer can decrease the viscosity of paste cement so that the cement paste becomes more fluid (easy flow). This shows that the use of water derivation with the addition of superplasticizer. Antoni said that an increased dose of superplasticizer from 0.5% to 1% increases the time of initial Set and also the Final Set for all cement pastes [2]. The superplasticizer used was Viscocrete N-10 from PT. Sika Indonesia.

2. Experimental/Methods

2.1. Materials, mix design, sample and test

2.1.1 Materials

Materials used in this research was Portland Cement type II that is Palm Shell used as aggregate substitution and Viscocrete N-10. Laboratory inspection for this cement is not conducted because it has fulfilled the Indonesian Standard Institution (SNI) 15-20490-1994. In this research, aggregate used was taken from a river i.e. Krueug Meureubo in West Aceh. The source of Palm shell was from CPO factory in Nagan Raya. Then, it was manually selected to get good quality palm shells.

![Figure 1. Palm Shell for Aggregate Substitution](image)

| Table 1. Characteristics of Palm Shell |
|--------------------------------------|
| **Parameter**                      | **Value (%)** |
| Moisture in analysis               | 7.8           |
| Ash content                        | -             |
| Volatile matter                    | 2.2           |
| Fixed carbon                       | 69.5          |

2.1.2. Mixed design, samples and test
The composition of the concrete mixture (concrete mix design) was planned based on ACI (American Concrete Institute) 211.1.91 [3]. The mix design concrete strength in this research was f′c 30 MPa with concrete cylinder (Ø 15, T=30 cm), water-cement ratio 0.40. The percentage of palm kernel substitution was 0%, 15%, 30%, 45% and 60% for the weight of the crude aggregate. For this research, the test of cylindrical test object was 15 pcs with (Ø 15 cm, T = 30 cm). The compressive strength test was performed on the 28th day. Compressive test conducted with Compressive Machine Test. The concrete mix design for all aggregate variations is shown in Table 2.
### Table 2. Mix design for 6 specimens of concrete cylinder (Ø 15, T30 cm)

| Materials         | 0%   | 15%  | 30%  | 45%  | 60%  |
|-------------------|------|------|------|------|------|
|                   | (kg) | (kg) | (kg) | (kg) | (kg) |
| Portland cement   | 17.04| 17.04| 17.04| 17.04| 17.04|
| Water             | 6.816| 6.816| 6.816| 6.816| 6.816|
| Coarse aggregate  | 50.76| 36.56| 20.45| 7.217| 3.776|
| Fine aggregate    | 21.75| 16.87| 15.34| 14.43| 11.33|
| Palm shell        | 0    | 8.44 | 15.34| 21.65| 22.66|
| Viscocrete N-10   | 0.170| 0.170| 0.170| 0.170| 0.170|

### 3. Result and discussion

The inspection of palm shells analyzed was adapted from the results of inspection analysis of coarse aggregate which results of the examination indicate that the aggregate used qualifies as concrete forming material. The result shows that the fineness modulus of palm shell obtained value i.e. 6.7. The results of the specific gravity of the oil palm shell obtained by the same gravity i.e. 1.19 grams / cm³, the specific gravity of SSD was 1.40 gram / cm³, and the illusion were 1.50 gram / cm³. The moisture content was equal to 27.27%. The results of inspection of the clay content of two tests contained sludge content in average i.e. 0.86%. An inspection result of bulk density is equal to 0.74 gram / cm³ [4]. From the result of the test on the slump yielded, it can be seen that the slump value influenced by the percentage of use of palm shell mixed into concrete. At 0% palm shell substitution, the value of slump was 30 mm, 15% was 35 mm, 30% was 40 mm, 45% was 45 mm and 60% was 50 mm.

Figure 2 shows that the lowest slump value is in the percentage of 0% palm shell substitution i.e. 30 mm, whereas 60% of the palm shell substitution yields the highest deterioration value i.e. 50 mm. This means the greater the percentage of the palm shell substitution, the greater the value obtained from the deterioration of the value.

![Figure 2. Diagram Slump Values](image)

Compressive test concrete was conducted when the test object was at the age of 28 days. Result is as shown in Table 3.
Table 3. Result of compressive strength concrete cylinder (Ø 15, T30 cm)

| No | Percentage of palm shell | Average of compressive strength concrete (MPa) |
|----|--------------------------|-----------------------------------------------|
| 1  | 0%                       | 46,188                                        |
| 2  | 15%                      | 42,917                                        |
| 3  | 30%                      | 23,287                                        |
| 4  | 45%                      | 18,860                                        |
| 5  | 60%                      | 8,468                                         |

Table 3 shows the test of concrete compressive strength at the age of 28 days with 15% substitution of palm shell that is equal to 42,917 MPa. Comparison of the strength of concrete occurred in the substitution of palm shells at 0% and 15%. This occurs because the concrete compressive strength was decreased.

Figure 3. Diagram Compressive of Strength Concrete and Aggregate Substitution of Correlation

Figure 4 shows the weight of concrete included in the lightweight concrete category found in the percentage of 45% of the palm shell substitution (1990 kg / m³) and 60% of palm shell substitution (1809 kg / m³). The weight of reinforced concrete based on SNI 03-2847-2002, concrete included in lightweight concrete weight is <1900 kg / m³.

Figure 4. Diagram Weight of Concrete and Aggregate Substitution Correlation

4. Conclusions
The use of palm shells on concrete mixtures decreased the compressive strength of concrete. However, the substitution 15% of palm shells was capable of producing concrete with compressive strength above the plan. The use of palm shells in concrete mixture increased the compressive strength of concrete. The maximum compressive strength concrete was 42,917 Mpa with 15 % palm shell substitution, while the
minimum compressive strength concrete was 8,468 MPa with 60% palm shell substitution. This research aims to obtain compressive strength of f’c 30 MPa concrete which is lighter weight instead of normal concrete through the addition of palm shell and 1% visocrete additives. The results show that 15% substitution of palm shells was above 30 MPa, then 45% and 60% of palm shells gave concrete weight i.e. 1990 kg / m$^3$ and 1809 kg / m$^3$. It means that the concrete included lightweight concrete category. The research study shows that increasing the number of palm shells as substitution progressively improves the slump value. The highest value of compressive strength at the age of 28 days was in 0% percentage of palm shell that is 46,143 MPa. Based on the results, lightweight concrete was categorized at 45% substitution (1990 kg/m$^3$) and 60% (1809 kg/m$^3$) of palm shell.

5. References
[1] Bambang S, dkk.2006. Pengaruh Penambahan Cangkang Sawit terhadap Kuat Tekan Beton f’c 25 MPa. Final Project Report, F.T. Riau.
[2] Nugraha P, and Antoni, Teknologi Beton , UKP, Surabaya, 2007. p 92-93.
[3] American Standard Institute, Recommended Practice for Selecting Proportion for Normal and Heavy Weight Concrete, American Institute Committee 211, ACI Standard 211.1-91, Michigan, 1991.
[4] Serwinda, 2013, Pengaruh Penambahan Cangkang Sawit terhadap Kuat Tekan Beton f’c 25 MPa. Final Project, Fakultas Teknik Universitas Pasir Pengaraian.

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