EINSTEIN (e-Journal)
Jurnal Hasil Penelitian Bidang Fisika
Available online http://jurnal.unimed.ac.id/2012/index.php/einsten
e-issn: 2407 – 747x, p-issn 2338 – 1981

THE EFFECT OF CONCRETE DOPING USING PALM PALM BOILER ASH AND SUPERPLASTICIZER ON THE STRENGTH OF K-300 CONCRETE

Surya Kurniawan Hutabarat[1], Nurdin Siregar[1]
[1] Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan
suryak.hutabarat0512@gmail.com

Submit: April 2026. Approved: May 2026. Published: June 2026.

ABSTRACT

Concrete is a favorite reinforcement material that is commonly used in Indonesia because it has superior properties compared to other materials. Some of the advantages of concrete include economical prices, cheap manufacturing processes, heat resistance, strong strength and materials that are easy to obtain. Every year the number.The population in Indonesia is increasing, which causes high demand for building materials, in this case there is a shortage of mixed materials for making concrete. This concrete synthesis research was carried out to determine the effect of a mixture of palm oil boiler ash and superplasticizer on concrete strength, water absorption capacity and concrete morphology. The concrete is made in the shape of a cube with dimensions of 15 cm x 15 cm x 15 cm according to the SNI 7394(2008) k-300 standard. The mixture variations used are ABKS 100 Mesh (0%, 1.5%, 3%, 4.5% and 7.5%) and superplasticizer 0% and 2%. After a period of 28 days the concrete was tested using the compressive strength test method using existing procedures. The highest compressive strength was in a mixture composition of 7.5 ABKS and 2% SP of 34.55 Mpa and the lowest compressive strength was in concrete without a mixture of 20. 88 Mpa. With the highest water absorption capacity of 0.52% in the unmixed concrete variation and the lowest in the 7.5 ABKS and 2% SP mixture of 0.27%. EDX analysis results show that unmixed concrete contains the highest element of 32.49 % Calcium (C) And in the highest quality concrete the mixture of boiler ash and superplasticizer with the highest element of Silica (Si) is 20.55%. The compressive strength results exceed the SNI provisions that have been set. The higher the addition of the mixture composition, the higher the compressive strength concrete and the concrete's absorption capacity is getting lower.

Keywords: Effect of boiler ash and superplasticizer, morphology, absorption capacity, compressive strength

INTRODUCTION

The Indonesian construction world is developing rapidly. The need for concrete as a construction material continues to increase. Concrete is mostly used in housing construction, building structures, roads and bridges (Effendi et al., 2018). Concrete is a structural component made from the main ingredients of a mixture of cement, fine aggregate, water, coarse aggregate, with or without other additional materials. (Harahap, 2013).

Concrete is often used in various forms of construction because it is very strong,

durable and easy to maintain. Concrete quality depends on the basic materials, additional materials and tools used when making the mix. Good quality concrete if good materials are used, mixed properly (homogeneous), and with good tools(Irlan et al., 2020). One of the basic materials that plays an important role in the strength of concrete is coarse aggregate and fine aggregate.

The increasing technological developments resulting in demand for cement and increasing cement prices have become the basis for researchers to use additives and admixtures to reduce cement use without reducing the quality of concrete. One of the mixtures for making concrete is the use of unused palm oil industry waste.

Based on data released by the national leading plantation statistics for 2020-2022, the area of oil palm production in Indonesia reached 14,586,597 Ha, of which 6,044,058 Ha belonged to Community Plantations, 565,241 Ha belonged to State plantations and 7,977,298 Ha belonged to private plantations. Where North Sumatra has a plantation area of 1,286,623 Ha (Directorate General of Plantations, 2020).

To help reduce waste and recover energy, palm oil shells and fiber will be burned and produce steam in the palm oil factory. Palm oil boiler ash is ash that goes through the process of grinding and burning the shells in the waiting boiler.

One of the constituent materials in loading concrete in this study is cement, fine aggregate, coarse aggregate, water and the addictive material Superplasticizer. The concrete in this study is targeted at K-300 quality referring to SNI 7394 (2008) where the ratio of ingredients is 1: 1, 64 : 2.47 and cement water factor 0.52. Palm shell boiler ash in this study was used as a partial replacement for cement and superplasticizer was used to reduce water use.

Portland cement is a hydrolysis cement produced by grinding Portland calcium silicate slag (xCaO.SiO2) which is hydrolyzed and mixed with one or more crystalline calcium sulfate compounds (CaSO4.xH2O) and other additional materials can be added. (Vitri Gusni, 2019)

Aggregate is a natural material that functions as a filler in mortar or concrete mixtures. In concrete mixtures there are 2 types of aggregates used, namely:

1. Fine aggregate in the form of sand from stone crushing, according to SNI 02-6820-2002, has a fineness of 2 mm – 4.75 mm. Based on SNI 03-6821-2002, fine aggregates are generally as follows:

   a. The aggregate must be sharp and hard.
   b. Fine grains are not broken and destroyed by weather hardening.
   c. Does not contain more than 5% sludge

Coarse aggregate in the form of gravel resulting from natural disintegration of rocks in the form of crushed stone obtained from breaking gravel. The conditions that must be met are as follows:

a. Hard grain and non-porous
b. Contains no reactive substances to alkali.
c. Sludge content must be < 1%.

Water is the basic ingredient that binds cement and becomes an aggregate binding paste. Water will cause the concrete to experience bleeding where water and cement move up the mixture. SNI 03-2847-2002 provisions for water used are as follows:

a. Free from damaging materials such as oil, acid, alkali, salt and organic materials.
b. The mixing water used is water that has aluminum metal embedded in it, does not contain excessive amounts of chloride ions. (Fandi Pratama, 2019)

Palm oil boiler ash is a partial substitute for cement. Boiler ash produces palm oil from the shells and fibers of burnt fruit. Palm oil contains the chemical element silica (SiO2) as much as 31.45% and lime (CaO) as much as 15.2%. If silica (SiO2) is added to the mixture concrete, the silica will react with free lime Ca(OH)2, which is a weak element in concrete, creating a new CSH gel. CSH gel is the main component that influences the strength of

cement paste and concrete as a whole (Prima et al., 2016)

Superplasticizer is used in this research to control and produce optimal slump values in fresh concrete, so that it can produce good casting performance.

This research was conducted to determine the results of concrete synthesis using a mixture of palm oil boiler ash and superplasticizer on concrete strength, concrete morphology, concrete element content and concrete quality.

RESEARCH METHOD

The method used in this research is an experimental study. The sampling location was carried out at the material testing laboratory of the Faculty of Engineering, Medan State University, and the SEM EDX samples were tested at the Bogor National Police Bareskim Center for Labfor.

The tools used in this research are 1000 mL measuring cup, molen machine, concrete mold, cement spoon, rubber hammer, shacker machine, bucket, analytical balance, 150 Mesh Sieve, Compression Testing Test), SEM EDX. Materials used in this research Portland cement, fine aggregate, coarse aggregate, palm kernel shell boiler ash, superplasticizer, water.

Preparing waste from palm oil shell boilers, cleaning the equipment used, grinding palm oil shell boiler waste, using a ball mill. Sift boiler ash with a 100 Mesh sieve. Provide concrete forming materials in the form of portland cement, sand, gravel, superplasticizer and water. Weigh the materials to be used according to the specified data.

Clean the tools and materials before use. Pour in crushed stone, sand, cement, palm oil boiler ash, turn the molen until the 4 ingredients are evenly mixed then pour in the water little by little, after the ingredients form a cement paste, pour in the superplasticizer and stir again using the molen. After mixing evenly. Put the mixture in then insert the large pan into the concrete mold with a size of 1/3 of the height of the mold and squeeze the cement paste, Put 2/3 of the part back into the mold, put 3/3 of the part back into the mold until it is full, then compact it again, then the concrete is stored in the processing room for 24 hours. It can be seen in Table 1.

Table 1. Mixing Composition of Concrete Raw Materials

Volum		code Sample	Composition				
SP	ABKS		Cement (kg)	Gravel (kg)	ABKS (kg)	Sand (kg)	Water (kg)
E0%	0%	A1,	5,028	12,42	0	8,24	2,92
1,5%	2%	A2, A3	5,028	12,42	0,0675	8,11	2,75
3%	2%	B1, B2,	5,028	12,42	0,135	7,99	2,75
4,5%	2%	B3	5,028	12,42	0,37	7,86	2,75
7,5%	2%	C1, C2, C3 D1,D2, D3 E1, E2, E3	5,028	12,42	0,618	7,63	2,75

RESULT AND DISCUSSION

Water absorption capacity

Concrete has been successfully made using a concrete mixture according to SNI 7394 (2008) with concrete quality K-300. This water absorption test is carried out to determine how much the concrete is able to absorb water. Where the concrete will be weighed after being lifted from the soaking tub and dried for 24 hours to be weighed again, the dry weight of the concrete. By observing the difference in wet mass and dry mass, it can be calculated how much a lot of water is absorbed by concrete during the soaking and drying process. As determined by table 2.

Table 2. Water Absorption Capacity of Concrete with A mixture of Palm Oil Boiler Ash and Superplasticizer.

Volume		Sample Code	Average Wet Mass (Kg)	Average Dry Mass (Kg)	Average Water Absorption (%)
ABKS	SP				
0%	0%	A1, A2,	7,920	7,879	0,52
1,5%	2%	A3	7,903	7,866	0,46
3%	2%	B1, B2,	8,064	8,037	0,32
4,5%	2%	B3	8,273	8,248	0,30
7,5%	2%	C1, C2, C3 D1,D2, D3 E1, E2, E3	8,362	8,339	0,27

Table 2 shows that using a mixture of palm oil boiler ash and superplasticizer can reduce water absorption capacity. As shown in Figure 1 below.

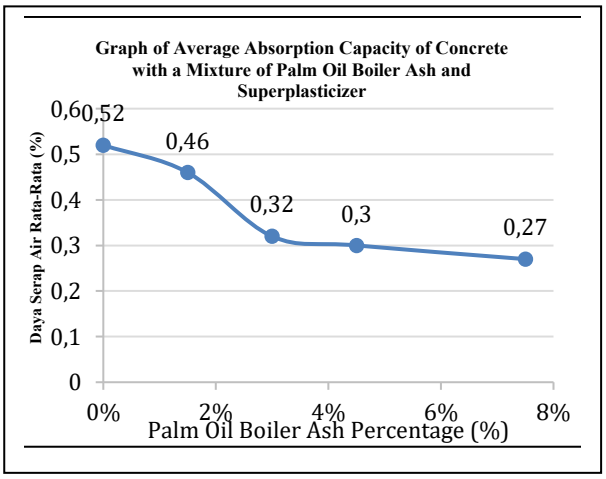

Figure 1. Using A Mixture Of Palm Oil

Based on Figure 1, the average water absorption capacity of concrete with a mixture of ABKS 1.5%, 3%, 4.5% and 7.5% is 0.46, 0.32, 0.3 and 0.27%, while normal concrete amounting to 0.52%.

According to (Dzikri M, 2018), previous research stated that the percentage of concrete compressive strength aged 28 days with the addition of superplasticizer increased by up to an addition of 2%. This shows that as the hardening process progresses, hydration in the cement will proceed normally.

Previous research (Abdullah Faqihuddin, 2021) shows that the use of superplasticizer as a partial replacement for water in the concrete mixture can increase workability and ease of work, reduce the amount of water by up to 20%, and increase the strength of the concrete. This research explains that the more superplasticizer used, the heavier the volume. concrete which results in smaller concrete porosity.

Compressive Strength of Concrete

This concrete compressive strength test was carried out to ensure that the concrete met the previous requirements. The results of the compressive strength test on concrete mixed with palm oil boiler ash and superplasticizer are as shown in Table 3.

Table 3. Compressive Strength Test Results on Concrete Mixed with Palm Oil Boiler Ash and Superplasticizer.

Volume		Sample Code	Area Surface (m^2)	Average Pressure Free (N)	Average Compressive Strength (Mpa)
ABKS	SP				
0%	0%	A1,	0,0225	468,7	20,83
1,5%	2%	A2, A3	0,0225	506	22,48
3%	2%	B1, B2,	0,0225	607,7	27,01
4,5%	2%	B3	0,0225	635,66	28,25
7,5%	2%	C1, C2, C3 D1,D2, D3 E1, E2, E3	0,0225	777,51	34,55

The compressive strength of the 7.5%ABKS and 2%SP composition has a maximum compressive strength of 34.55 MPa, while the minimum compressive strength of the 0%ABKS,0%SP composition is 20.83 MPa. The compressive strength of concrete can be influenced by palm oil boiler ash and superplasticizer. The more palm oil boiler ash added to the concrete mixture, the stronger the concrete is to see more clearly as in Figure 2 below.

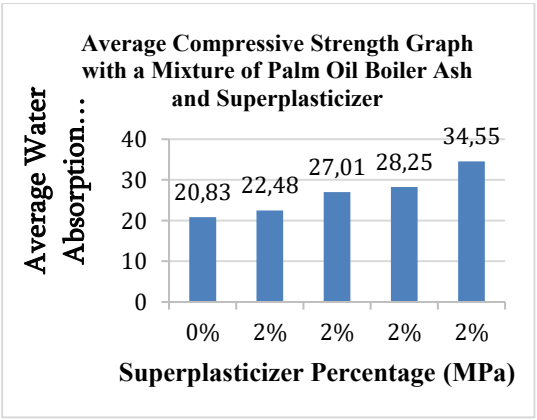

Figure 2. Average Concrete Compressive Strenght

Based on Figure 2, the average concrete compressive strength of concrete with a mixture of 1.5%, 3%, 4.5% and 7.5% ABKS and 2% Superplasticizer is 22.48 MPa, 27.01 MPa, 28.25. MPa and 34.55 MPa while normal concrete is

20.83 MPa and Superplasticizer is at 0% composition.

According to (Dzikri M, 2018) In previous research, the percentage of concrete compressive strength at 28 days with the addition of superplasticizer experienced increase up to an additional 2%. This shows that as the hardening process progresses, hydration in the cement will proceed normally.

Research by Puspita Sari et al., (2023) using a composition of 1%, 2%, 5% and 4% concrete containing ash from palm oil boilers with 1% superplasticize experienced an increase of 62.91% compared to normal concrete. In this study there are several factors that can cause this to happen, namely because the percentage of superplasticizer use is added to 1%. So researchers recommend using a higher percentage of palm oil boiler ash.

Meanwhile, based on research conducted by Putri Yani et al., (2021) concluded that adding palm oil boiler ash to concrete can cause lower compressive strength. If more palm oil boiler ash is added when the cement is reduced, the resulting compressive strength will be lower but will not be comparable to the compressive strength of ordinary concrete

Scanning Electron Microscope Energy Dispersive X-Ray (SEM- EDX)

The SEM test was used to observe particle morphology in concrete samples mixed with palm oil bolier ash and superplasticizer in concrete. From SEM magnifications of 20,000x and 30,000x, the following are the SEM test results on concrete samples with the highest strength in concrete ABKS 7.5% AND SP 2 % As in figure 3.

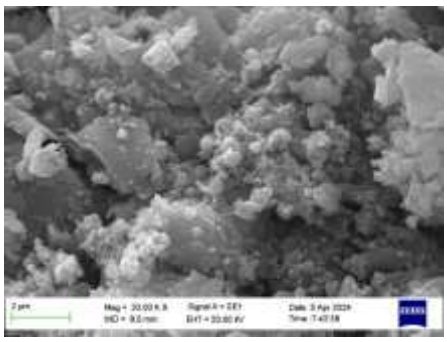

Figure 3. Concrete Morphology with SEM Photo Magnification 20,000 Times

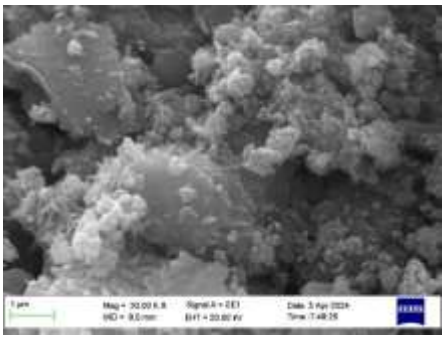

Figure 4. Concrete Morphology with SEM Photo Magnification 30,000 Times

SEM on the concrete sample with the greatest compressive strength with a magnification of 20,000x and 30,000x, the morphology (shape and size of the particles) in the mixed concrete composition of 7.5% ABKS 2% SP was measured using SEM testing, this concrete has a maximum strength of 34.55 MPa. Based on the image, it shows that SEM with a magnification of 20,000 – 30,000 times on the surface there are pores marked with black (dark). In Figure 3 there are pores in the concrete so that the concrete surface is not even. And the pores that are formed will cause the concrete to mix

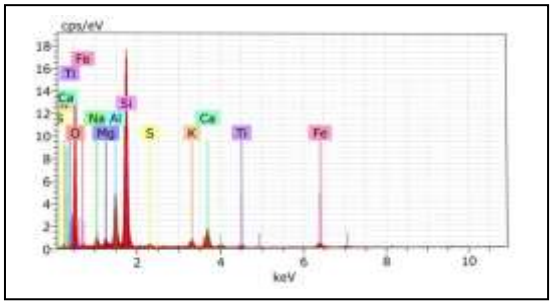

Figure 5. Spectrum of EDX Test Results for Concrete with A Composition of 7.5% ABKS 2% SP

Figure 5 shows the EDX spectrum with the highest peak being silica (Si), followed respectively by Aluminum, Calcium, Iron, Sodium, Potassium, Magnesium, Titanium and Sulfur. Below are presented the results of the EDX spectrum analysis of a concrete sample with composition 7, 5 % ABKS 2 % SP.

Table 4. Composition of compounds and particles for EDX analysis of concrete with a composition of 7.5% ABKS 2% SP

Name	Chemical Element	Mass %
Oksigen	O	52,45
Silika	Si	20,55
Aluminium	Al	6,72
Kalsium	Ca	5,11
Besi	Fe	2,51
Natrium	Na	2,12
Kalium	K	1,68
Magnesium	Mg	1,06
Titanium	Ti	0,94
Sulfur	S	0,52

Testing of normal K-300 quality concrete with a cube-shaped test object 15cm x 15 cm x 15 cm. The tool used is EDX. The results of the EDX characterization can be shown in Figure 3.

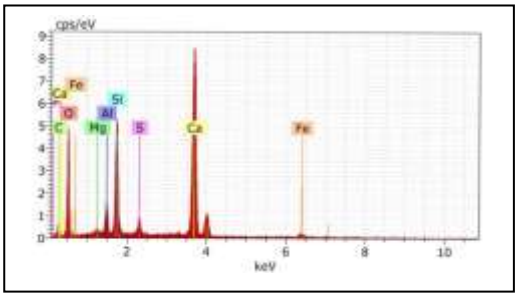

Figure 6. Spectrum of SEM EDX Testing Results for Normal Quality K-300 Concrete

Figure 6 shows the EDX spectrum with the highest peak being silica (Si), followed by Aluminum, Calcium, Iron, Sodium, Potassium, Magnesium, Titanium and Sulfur. The following are the results of the EDX spectrum analysis of a concrete sample with a composition of 0%. ABKS 0 % SP. Where the elements contained in concrete are described in table 5.

Table 5 Composition of Compounds and Particles EDX Analysis of Normal Concrete K-300

Name	Chemical Element	Mass %
Oksigen	O	54,11
Kalsium	Ca	32,49
Silika	Si	8,26
Karbon	C	5,70
Aluminium	Al	2,51
Besi	Fe	1,82
Sulfur	S	1,54
Magnesium	Mg	0,41

Composition of elements in normal concrete K-300 Oxygen(O), Calcium(Ca), silica(Si), Carbon(C), Aluminum(Al), Iron(Fe), Sulfur(S), and Magnesium(Mg). From the EDX analysis results, it is known that the highest element concentration in ordinary concrete samples is Calcium (Ca), amounting to 32.49%.

CONCLUSION AND SUGGESTION

Based on the results of compressive strength testing by synthesizing palm oil boiler ash and superplasticizer with mixtures of (0%, 1.5%, 3%, 4.5%, and 7.5% ABKS) and (0%, 2% SP) namely ((20.83 MPa, 22.48 MPa, 27.01 MPa, 28.25 MPa and 34.55 MPa). The optimum pressure is found in a composition of 7.5% ABKS and 2% SP, namely 34.55 MPa. It can be seen that the addition of palm oil boier ash can increase the strength of concrete. Compressive strength data obtained from a mixture of 7.5% ABKS and 2% SP has reached K-300.

From testing the water absorption capacity with the influence of palm oil boiler ash and superplasticizer, it shows that mixtures (0%, 1.5%, 3%, 4.5%, and 7.5% ABKS) and (0%, 2% SP) have strong water absorption of 0.52%, 0.46%, 0.32%, 0.30% and 0.27% shows that the more boiler ash used and the use of 2% superplastizicer, the less water used compared to normal concrete. From this data, the smallest water absorption capacity occurs in

concrete with a composition of 7.5% ABKS and 2% SP.

SEM-EDX testing of water with the influence of palm oil boiler ash and superplasticizer shows mixtures of (0%, 1.5%, 3%, 4.5%, and 7.5% ABKS) and (0%, 2% SP) where in SEM testing showed that pores were fewer and smaller in size, resulting in concrete with the highest strength absorbing less water. EDX testing was found in normal concrete to produce the elements Oxygen (O), Calcium (Ca), silica (Si), Carbon (C), Aluminum (Al), Iron (Fe), Sulfur (S), and Magnesium (Mg). From the EDX analysis results, it is known that the highest element concentration in ordinary concrete samples is Calcium (Ca), amounting to 32.49%.

Compared with concrete with a mixture of 7.5% ABKS and 2% SP, it shows an EDX spectrum with the highest peak being silica (Si), Next in sequence are Aluminum, Calcium, Iron, Sodium, Potassium, Magnesium, Titanium and Sulfur. The highest element concentration in ordinary concrete samples is Silica (Si) at 20.55%.

In future research, researchers hope that the use of palm oil boiler ash will increase its composition and reduce the use of superplasticizer to achieve perfect concrete strength.

REFERENCES

Abdullah Faqihuddin, H. E. (2021). Tinjauan Campuran Beton Normal Dengan Penggunaan Superplasticizer Sebagai Bahan Pengganti Air Sebesar 0%; 0,3%; 0;5% Dan 0,7% Berdasarkan Berat Semen. Journal of Civil Engineering and Planning, 34-45.

Direktorat Jendral Perkebunan. (2020). Statistik Perkebunan Non Unggulan Nasional 2020-2022. Sekretariat Direktorat Jendral Perkebunan, 1–572.

Dzikri, M., & Firmansyah, M. (2018). Pengaruh Penambahan Superplasticizer Pada Beton Dengan Limbah Tembaga (Copper Slag) Terhadap Kuat Tekan Beton Sesuai Umurnya. Jurnal Rekayasa Teknik Sipil, 1–9.

Effendi, Z., Saidi, T., & Aulia, T. B. (2018). Studi Komparasi Variasi Jenis Superplasticizer Terhadap Sifat Mekanis Beton Mutu Tinggi Dengan Menggunakan Fly Ash Abu Cangkang Kelapa Sawit Sebagai Aditif. Jurnal Arsip Rekayasa Sipil dan Perencanaan, 1(3), 158–170

Fandi Pratama, M. K. (2019). Pengaruh Variasi Suhu Pembakaran Abu Cangkang Sawit Sebagai Bahan Tambah Dan Superplasticizer Terhadap Kuat Karakteristik Tekan Beton. Civil Engineering,, 586-604 .

Harahap, V. H. (2013). Pengaruh Karakteristik Pasir Merah Labuhan Batu Selatan Terhadap Sifat Mekanik (Uji Sem,Difraksi Sinar X, Uji Impak) Dari Beton . Jurnal Einstein, 64-75.

Prima, D., Ui, R., & Si, M. (2016). Seminar Nasional Kimia. 1–13.

Puspitasari, D., Lutfiani, B., & Zakina, A. (2023). Seminar Nasional Teknik Sipil Semen Dengan Penambahan Superplasticizer Terhadap Kuat Tekan Dan Kuat Lentur Beton Seminar Nasional Teknik Sipil. 1(1), 63–74.

Putri yani et al., (2021). Pengaruh Campuran Partikel Abu Boiler Cangkang Kelapa Sawit Terhadap Kuat Tean Beton. Jurnal Hasil Penelitian Bidang Fisika, 23-29.

Vitri Gusni, H. H. (2019). Pemanfaatan Limbah Kelapa Sawit Sebagai Material Tambahan Beton. Jurnal Teknik Sipil ITP, 78-87.