

Waste Paper Ash as Additives for High Strength Concrete Mix 45 MPa

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ABSTRACT

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High strength concrete is very widely used today to support the construction of buildings, roads, dams, bridges and so on. To make high quality concrete, additional material is needed as a concrete mixture, the added material today is very much in the market as well as added ingredients derived from fly ash, and rice husk, especially rice husk is most widely used as a mixture in making concrete, due to the chemical content of SiO₂ contained in rice husk ash. In this study we made high strength concrete using ash derived from waste paper. Paper ash was burned manually and then filtered using sieve number 150. Paper ash was then tested for its chemical content. The results of the chemical content test derived from paper waste ash have a CaO of 92.70 while SiO₂ is only 2.63%. The making of test specimens was made as many as 90 pieces with some additional variations of noble ash from 0%, 5%, 10%, 15%, 20%, and 25%. Concrete compressive strength test results with a code of 0% could not achieve the quality plan of 45 MPa, while the addition of ash by 5% reached 41 MPa compressive strength more, the highest compressive strength produced by a mixture of 10% paper ash which achieved a compressive strength of more than 45 MPa plan. Whereas specimens with a mixture of 15%, 20%, and 25% produce concrete with compressive strength below 36 MPa. From the results of the study it can be concluded that the use of 5% and 10% waste paper ash can increase the compressive strength of concrete. Ash from paper waste can be an alternative material added to the concrete mixture.

1. INTRODUCTION

Although high strength concrete is often considered a relatively new material, its development has been carried out in stages over many years. As development continues, the definition of high strength concrete has changed. In the 1950s, concrete with a compressive strength of 5000 psi (34 MPa) was considered high strength. In the 1960s, concrete with 6,000 and 7500 psi (41 and 52 MPa) compressive strength was used commercially. In the early 1970s, 9000 psi (62 MPa) concrete was being produced. Recently, compressive strength approaching 20,000 psi (138 MPa) has been used in building castings in place [1].

Concrete is the most widely used material in the infrastructure of making roads, bridges, and buildings. So that manufacturers of building materials, especially competing to make added materials or concrete substitutes with various uses using chemicals, of course, this causes high prices for concrete. There are three concrete groupings according to SNI (Indonesian National Standard) [2] procedures for planning high strength concrete with Portland cement and fly ash based on compressive strength, low strength concrete (slow strength concrete) concrete with compressive strength below 20 MPa, quality concrete medium (medium strength concrete) with compressive strength of 20 Mpa-40 Mpa, and high strength concrete (high strength concrete) with compressive strength above 40 Mpa. Whereas according to SNI 6468 high strength concrete is defined as concrete having compressive strength above 41.4 MPa [3]. To make high strength concrete, it needs added material as a concrete mixture [4].

Various methods are carried out research to strengthen the quality of concrete such as Strength and Some Durability Properties of Concrete Containing Rice Husk Ash Produced in a Charcoal Incinerator at Low Specific Surface [5] Waste steel wires modified structural lightweight concrete [6]. Some use the nature of concrete fiber reinforced concrete material made with recycled earthquake waste [7].

The use of waste as a material making constituents of concrete materials has been done a lot to aim at reducing and utilizing waste into useful materials [8-11]. Rice husk ash has been widely researched as an added material or as a substitute material for a part of the cement matrix, the experiment of using rice husk ash is used as a concrete for high strength concrete, concrete with additional rice husk ash is able to provide additional strength of rice husk which has a chemical content of SiO₂ which high, Calculation of the formation of mineral or phase types of rice husk ash showed that the rice husk ash did not have alite (C3S) and belite (C2S) compound whereas aluminate (C3A) and ferrite (C4AF) were very low, each of which amounted to 0.44% and 0.98%. Because rice husk ash does not have a C3S and C2S compound phase, rice husk ash cannot be classified as a matrix in the sense of cement [12]. However, because rice husk ash has a high content of SiO₂, rice husk ash can be used as a partial replacement for the cement matrix of the chemical content of rice husk ash according to the paper [13] the chemical content of rice husk ash has a chemical content of SiO₂ between 76%-86%.

This research includes testing the waste material from paper ash in the form of chemical content, density and specific gravity, and the manufacture of high strength concrete

specimens with a compressive strength of 45 MPa. The making of concrete specimens using paper ash material was carried out with some degree of adjusting the research conducted to make concrete with high quality 45 MPa so that the results of the test specimens in this research can be concluded whether the paper ash added material can get high strength concrete according to the plan and whether the concrete is higher than the quality of the planned concrete or not, this study is to examine things that have not been done by previous researchers where the previous research that was referred to in this study did not test the chemical content and paper ash mixture. Such experiments have not been carried out in the manufacture of normal concrete.

Paper Waste Ash As A High strength concrete mixture Additive 45 Mpa (Alasbata Bom T45) is a waste paper ash as a high strength concrete mixture added 45 MPa, Alasbata BOM T45 is a study with the idea to utilize paper waste and reduce the cost of making concrete from getting higher. Therefore, a lot of research has been done to reduce the cost of concrete from waste, one of which is coal fly ash, coal fly ash has been considered successful in influencing the strength of concrete, but with difficulty and requires high operational costs to obtain coal fly ash ash, causing the use of coal fly ash cannot be applied until now. The output from our research will have an impact on reducing the high cost of concrete production and in terms of paper waste utilization. The chemical content of paper ash is very necessary for this study by knowing the chemical content of paper ash can be concluded classified as what paper ash is in the manufacture of normal concrete with high quality. Previous research made various levels of paper ash as an added material, the strength of concrete with a mixture of paper ash obtained an additional compressive strength of concrete at 25% paper ash content at the age of 28 days compressive strength increased from 240.74 kg/cm² (without paper ash) to 391, 85 kg/cm² (with additional paper ash) there is an increase of approximately 80% strength of concrete with the use of paper ash, with an 80% increase in compressive strength of concrete in the SCC (Self-Compacting Concrete). The use of inexpensive super hydrophobic powder as a waterproof mixture or waterproof surface coating for concrete has been investigated. The powder is produced from sludge ash (PSA) paper, a by-product of recycled paper making. The effects of hydrophobic PSA on work properties, strength and transport properties, including sorptivity, water absorption, diffusivity, permeability, and electrical conductivity are reported. Samples using a water/cement ratio of 0.38, were used up to 28 days and conditioned at 50°C for a constant mass before testing. That replacing Portland cement with a 12% hydrophobic PSA reduces water absorption, absorption and conductivity by 84%, 86% and 85%, respectively, without major adverse effects on hydration, strength and density. When used as a surface coating, hydrophobic PSA is reduced by both absorption and absorption by 85-99% depending on the adhesive used. The surface of the sample coated with hydrophobic PSA shows excellent water repellent characteristics and self cleaning [14].

2. MATERIAL AND METHOD

The main variables tested in this study consisted of independent variables and dependent variables. Independent variable.

2.1 Paper ash making

The paper used is paper, books, and paper used in various offices. The paper is put into a drum and burned at a temperature of ± 700°C after all the paper is perfectly turned into ash, let it cool down, then the ash is sieved using a sieve No.150 after it is tested on the ash of the paper. The results of making paper ash see Figure 1.



Figure 1. Paper ash that has been completed

Material testing is carried out based on the steps in accordance with SNI and ASTM, [15-23], the test result data as for the tests conducted, chemical content, specific gravity, heavy content of solid/loose paper ash, loose weight density and coarse aggregate solid, and, fine aggregate, specific gravity and absorption of coarse aggregate, and, fine aggregate. And coarse and fine aggregate mud content.

2.2 Making concrete test objects

The test specimens were made as many as 90 specimens, concrete materials for making specimens using ex palu crushed stone, ex palu sand, PCC cement, clean water, and paper ash, concrete designs using SNI 03-6468-2000 [3]. Making cylindrical specimens with a diameter of 15 cm x 30 cm 03-4810-1998 [24] 30 mm slump plan, with various variations in the percentage of mixed specimens with 0% ash content are comparative test specimens, the composition of mixtures and plans for the number of specimens can see Table 1.

Table 1. Number and age of testing objects

Age of Testing	Paper Ash Percentage					
	0%	5%	10%	15%	20%	25%
3	3	3	3	3	3	3
7	3	3	3	3	3	3
14	3	3	3	3	3	3
21	3	3	3	3	3	3
28	3	3	3	3	3	3

Manufacture and maintenance of test specimens see Figure 2(a) and 2(b).



(a). Manufacture of test specimens



(b). Care of test specimens

Figure 2. Making test objects and maintaining test specimens

2.3 Slump test

Wet the mold and place it on a flat, damp, non-absorbent and stiff surface. The mold must be held firmly in place during filling, by the operator standing on the stampede. From the concrete samples obtained, immediately fill the mold in three layers, each layer approximately one third of the volume of the mold.

Solid each layer with 25 stitches using a compacting rod. Spread the stitching evenly over the surface of each layer. For the lower layer this will require a skewed incision and make approximately half of the number of punctures close to the edge of the mold, and then continue the vertical stabbing in a spiral around the center of the surface. Compact the entire layer down to its depth. Avoid puncturing sticks about the mold base plate. Compact the second layer and the top layer all the way to its depth, so that the puncture penetrates the boundary layer below.

In filling and compacting the top layer, add the concrete mixture over the mold before compaction begins. If solidification results in concrete falling below the top end of the mold, add a concrete stir to keep the excess concrete at the top of the mold. After the top layer is compacted, flatten the concrete surface at the top of the mold by rolling the piercing rod over it. Remove the mold from the concrete immediately by carefully lifting it in the vertical direction. Lift the mold 300 mm apart in 5 ± 2 seconds without lateral or torsional movements. Complete all test work from the start of filling to removing the mold without interruption, in no more than $2\frac{1}{2}$ minutes.

After the concrete shows a decrease in surface, measure the slump immediately by determining the vertical difference between the top of the mold and the center of the top surface of the concrete. In the event of collapse or collapse of concrete shear on one side or a portion of the concrete mass, ignore the

test and make a new test with another portion of the sample [25].

2.4 Compressive strength testing

The test specimen is finished after 24 hours the specimen is removed from the cylindrical mold, the specimen is weighed, and put into a curing container every day the specimen is removed for weighing to determine the progress of the specimen from day to day each observation is recorded. Two days before concrete testing must be removed from the curing tub and placed in a shady and safe place [24].

Test specimens testing were carried out at three stages of ages; 7 days, 14 days, and 28 days by using compressive strength testing machines, before testing the test specimens, they were weighed and got capping by using sulfur on the upper surface. The testing was carried out by following the procedures and calculation method of ASTM [21].

Calculation of the test results was done by applying Eqns. (1) and (2):

$$f_{cm} = \frac{4000 P_{max}}{\pi D^2} \quad (1)$$

Inch-pund unit:

$$f_{cm} = \frac{4P_{max}}{\pi D^2} \quad (2)$$

where,

f_{cm} = compressive strength, MPa (psi),
 P_{max} = maximum load, kN (lbf), and
 D = Average measured diameter, mm (in)

3. RESULTS AND DISCUSSION

3.1 Ash paper chemical content test results

Paper ash test results obtained results see Table 2.

Table 2. Test results of the chemical content of paper ash

SAMPLE CODE	ABU LIMBAH KERTAS(ALK)	
PARAMETER		RESULT
SiO ₂	% db	2.63
Al ₂ O ₃	% db	0.60
Fe ₂ O ₃	% db	0.71
CaO	% db	92.70
MgO	% db	1.19
Na ₂ O	% db	0.42
K ₂ O	% db	0.07
MnO ₂	% db	0.03
TiO ₂	% db	0.40
P ₂ O ₅	% db	0.30
SO ₃	% db	0.22
Undetermined	% db	0.73

Note: Test results of the chemical content of the waste paper

From the results of testing paper ash as shown in Table 2 the dominant chemical content in paper ash is CaO while SiO₂ is very small, this is the opposite of rice husk ash, as is known the chemical content found in ordinary cement is CaO [26]. Chemical content contained in cement can be seen in Table 3.

Table 3. Chemical content of cement

Chemical Compound	%
CaO	64.40
SiO ₂	2.60
Al ₂ O ₃	4.30
Fe ₂ O ₃	2.40
MgO	2.10
SO ₃	2.30
Na ₂ O+K ₂ O	1.20

Note: Chemical content of ordinary cement according to M. B. Varma and P. Gadling

When compared to the chemical content of paper ash and the chemistry of cement, the two materials have more similarities, both of which have the same high CaO chemistry, between cement and ash. Whereas rice husk ash has a very low CaO chemical content.

3.2 Material testing results

The results of testing of coarse aggregate, fine aggregate, paper waste ash, and rice husk ash include specific gravity, fill weight, absorption, gradation, etc. are presented in Table 4.

Table 4. Material testing results

NO	Material	Coarse Aggregate	Sand	Husk Ash Paper
1	Solid fill weight	1,485,90	1631,29	443,5
2	Crumbly fill weight	1,408,30	1,476,61	441,8
3	Specific gravity	2,51	2,473	2,59
4	Water Absorption	2,04	0,012	29,76
5	Fine-grain modulus	7,67	3,16	-
6	Abrasion	32,826	-	-
7	Organic matter	-	1	-
8	Sludge content	1,58	0,31	-

Note: The results of testing the material that will be used to make test specimens

3.3 Mix design

Mix design using SNI 03-6468-2000 with compressive strength of 45 MPa plan, 30 mm slump. after the mix design results are generated then the addition of ash paper in accordance with the percentage of each experiment. Mix designs can be seen in Table 5.

Table 5. The results of the mix design

Code ALK	Water (kg)	Cement (kg)	Coarse Aggregate (kg)	Fine Aggregate (kg)	Paper Ash (kg)
0 %	190	527	944	683	0,00
5 %	190	527	944	683	9,50
10 %	190	527	944	683	19,00
15 %	190	527	944	683	28,50
20 %	190	527	944	683	38,00
25 %	190	527	944	683	47,50

Note: The percentage of the mixture is multiplied by the amount of cement used

3.4 Slump test results

Slump test results obtained 0% concrete results slump according to the plan 30 mm while the addition of paper ash

by 5% results obtained 25 mm, 10% 21 mm, 15% 18 mm, 20% 11 mm, and 25% 6 mm. the greater the percentage of the addition of paper ash the smaller the slump produced.

3.5 Compressive strength test

From the compressive strength test results of the specimens, the concrete compressive strength test results can be seen in Table 6.

Table 6. Compressive strength test results

Age of Test Object (days)	Compressive Strength (MPa) based on Percentage of Paper Ash					
	0%	5%	10%	15%	20%	25%
3	19.52	17.44	23.91	22.87	17.41	16.07
7	30.44	21.22	33.25	25.15	31.27	25.45
14	36.54	39.88	40.80	27.09	34.57	31.34
21	37.73	40.85	41.64	32.62	33.34	33.17
28	38.95	41.30	45.47	37.46	33.75	33.55

From Table 6 it can be seen that the compressive strength of concrete using 10% additional paper ash has better compressive strength than the compressive strength with various percentages of paper ash. Increasing the amount of paper ash in the mixture above 10% has decreased strength.

All variations in the mixture of paper ash additions have increased in the age of the test object. But the increase in strength is not significant when compared with a mixture of paper ash by 5%, and 10%. Test specimens with 10% content always dominate the strength of concrete from 3 days to 28 days.

3.6 Discussion

The results of the chemical ash testing of paper have higher CaO and SiO₂ are very small, the chemical ash of paper ash is very different from rice husk ash and fly ash, where rice husk ash and fly ash have very large SiO₂. while the chemical content contained in cement has a higher CaO chemical content. chemicals contained in paper ash have similarities with the chemical content held by ordinary cement.

The results of comparative test specimens (0%) did not achieve the compressive strength of the plan of 45 MPa, this is in line with the almufid theory that to get high quality concrete must use additional additives, without the addition of concrete materials, concrete cannot produce high quality concrete. Test specimens with the addition of 5% and 10% paper ash have a strength of 41.30 Mpa and 45.47 MPa, so that both variations of the additional ash mixture can already be said to be made of high-quality concrete. The highest strength is obtained by a mixture of paper ash by 10% which produces compressive strength according to plan. while variations of the mixture above 10% cannot reach the strength of the plan, or still below the strength of the mixture with 5% and 10% content. the chemical content of CaO contained in paper ash, gives a reaction to the addition of a certain degree of concrete strength. The development of concrete compressive strength from ages 3, 7, 14, 21, and 28 days is shown in Figure 3. And the concrete compressive strength of various variations is shown in Figure 4.

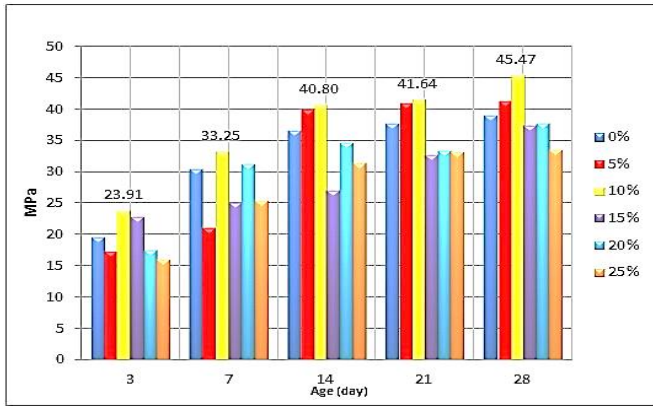


Figure 3. Development of concrete compressive strength of 3, 7, 14, 21, and 28 days

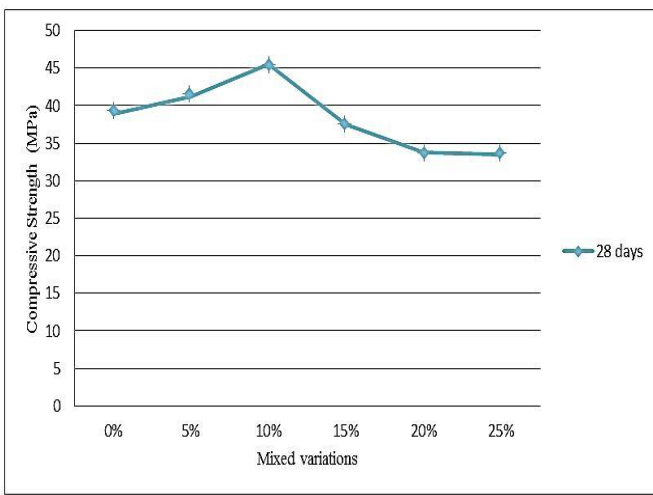


Figure 4. Compressive strength of each 28-day age variation

4. CONCLUSIONS

From the results and discussion it can be concluded the results of this study:

(1) The results of testing the chemical content of paper ash, paper ash has a very high CaO chemical content that is above 92.70% while SiO₂ is only 2.63%.

(2) The chemical content of paper ash is similar to the chemical found in ordinary cement.

(3) The greater the addition of paper ash, the smaller the slump obtained.

(4) To make concrete with high quality, a mixture of added materials is needed in making concrete.

(5) The addition of 5% and 10% paper ash can increase the strength of concrete, and the highest compressive strength of concrete is produced by concrete with an additional 10% of paper ash.

(6) The addition of paper ash as much as 10% of the weight of cement, producing a concrete compressive strength of 45.47 MPa. there is an increase in compressive strength of 6,52 MPa when compared with the comparative test object (0%), which only produces a compressive strength of 38,95 MPa.

(7) Paper waste ash can be used as an alternative material for high-performance concrete mixes.

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