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Effectiveness Of Adding *Fly Ash* And *Bottom Ash* In Building Construction

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Abstract. *Jayapura City is center administrative from Papua Province , Indonesia, with wide region reaching 940 km2. As Mother city province located at the end eastern Indonesia, city This border direct with country neighboring Papua New Guinea , located on the Gulf Jayapura . One of initiatives taken is use waste from burning rock embers in the Generator Electricity Power Steam (PLTU) Holtekamp as material main For make brick. Research This aim For determine composition sand , Portland cement (PC), fly ash, and bottom ash with do making object test with proportions of 40% and 50%, tested on aged 7, 14, and 28 days . Testing done in accordance with SNI Specifications 03-1974-1990 concerning Method Testing Strong Press Concrete , and results strong press average meets standard Condition General Material Buildings in Indonesia 1982. Results testing show that on object test I with proportion 50% on 7 and 14 days old , strong press average no reach standard quality plan A1 minimum 25 Kg/cm2, however on 28 days old fulfil standard quality plan A1. Whereas object test II on the proportion of 40% meets standard quality plan A2 minimum 40 Kg/cm2 on all age testing (7, 14, and 28 days), as appropriate with Condition General Material Buildings in Indonesia 1982.*

Keywords: *Composition , percentage of FABA mixture , average value of compressive strengt*

INTRODUCTION

Jayapura City is a city and also the capital of the province of Papua, Indonesia. Provincial capital with an area of 940 km2, this city is the easternmost provincial capital in Indonesia, and directly borders the neighboring country of Papua New Guinea, which is located in Jayapura Bay. Jayapura City consists of 5 districts, namely: Muara Tami District, Heram District, District Abepura, South Jayapura District and North Jayapura District. Fly Ash and Bottom Ash FABA are categorized as waste containing hazardous materials, so regulations and management permits are needed to reduce environmental impacts. Meanwhile, Indonesia is currently increasing infrastructure development. Housing construction requires materials that can be replaced by FABA.

LITERATURE REVIEW

Definition of Building

Buildings are man-made structures consisting of walls and roofs that are permanently erected in a place. Buildings are also commonly referred to as houses or buildings, namely all facilities, infrastructure or infrastructure in culture or human life in building civilization. Buildings have various shapes, sizes and functions, and have undergone adjustments throughout history due to several factors, such as building materials, weather conditions, price, soil conditions and aesthetic reasons.

Understanding Compressive Strength

Compressive strength is the capacity of a material or structure to withstand loads that will reduce its size. Compressive strength can be measured by plugging it into a stress-strain curve from data obtained from a testing machine. Some materials will fracture at the compressive limit, some undergo irreversible deformation. Certain deformations can be considered as limiting compressive strength, even though they have not yet broken, especially in materials that cannot return to their original condition (*irreversible*).

Definition of *Fly Ash* and *Bottom Ash*

Fly-ash or fly ash is material from the remains of burning coal, which flows from the combustion chamber through the boiler in the form of a burst of smoke (soot), which has been used as a mixture in concrete. Fly-ash or fly ash is known in England as burning ash powder.

Bottom Ash refers to the unburned part of coal or other materials and is generally attached to the bottom or walls of the combustion furnace found after burning/incineration.

Contents of *Fly Ash* and *Bottom Ash*

This material analysis was carried out on Fly Ash and Bottom Ash materials. This aims to determine the classification of the type of Fly Ash used and also the oxide content of Bottom Ash. The results of XFR Fly Ash and Bottom Ash can be seen in the table below.

Table 1 Weight Comparison of Fly Ash Oxidation Composition

FA	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO
%	34,29	16,62	15,38	0,73	18,18	7,52
	K_2O	Na_2O	SO_3	MnO_2	P_2O_5	LOI
	1,35	2,97	1,63	0,17	0,25	0,36

Source: Klarens K, 2018

Table 2 Weight Comparison of Bottom Ash Oxidation Composition

BA	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO
%	34,29	10,02	18,41	0,65	21,16	9,70
	K_2O	Na_2O	SO_3	MnO_2	P_2O_5	LOI
	0,90	0,24	0,66	0,22	0,25	0,54

Source: Klarens K, 2018

Understanding Brick Bricks

Bricks or cast-lime printed stones are bricks made by molding and preserving in a damp atmosphere, a mixture of limestone, limestone and water with or without other additives.

Hollow bricks are bricks that have a cross-sectional area of holes and the contents of the holes, each of which does not exceed 25% of the entire cross-sectional area and the entire cross-sectional area and the entire contents of the brick.

Table 3 Standard Brick Sizes and Tolerances

Jenis	Ukuran nominal, mm [1]			Tebal Kelopak, minimum (mm) [2]	
	Panjang	Lebar	Tebal	Luar	Dinding pemisah lubang
Tipis	400 ± 3	200 ± 3	100 ± 2	20	15
Sedang	400 ± 3	200 ± 3	150 ± 2	20	15
Tebal	400 ± 3	200 ± 3	200 ± 2	25	20

Source: Table 16-2 Article 16 General Requirements for Building Materials in Indonesia 1982

RESEARCH METHODOLOGY

Research Location

The research location was carried out at the Civil Engineering Laboratory of Cenderawasih University which is located on Jln Kamp Wolker Yabansai, Jayapura Papua. Which is located between 02°35°00°S and 140°38°54°E.

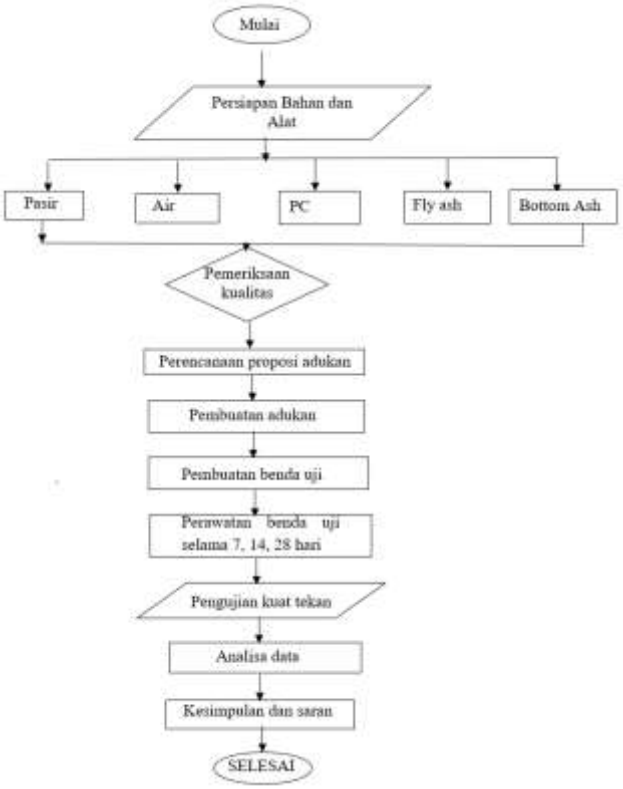
The location for collecting material samples was at PLTU Holtekamp Jayapura Papua, which is located between 02°36°57° South Latitude and 140°47°25° East Longitude.

Data Collection Methods

Data collection is divided into two, namely primary data and secondary data. Primary data is data obtained by research directly (from first hand), while secondary data is data obtained by researchers from existing sources.

Research Flow Chart

This section outlines the steps in the research which are displayed in the flow chart as follows:



CALCULATION ANALYSIS AND DISCUSSION

Fine and Coarse Sieve Analysis Test (SNI ASTM C136:2012)

This inspection was carried out to determine the gradation of fine aggregate used as aggregate in making concrete bricks. The gradation of fine aggregate can be divided into four types according to its gradation, namely fine, slightly coarse and coarse aggregate.

Table 4. Fine Aggregate Sieve Analysis Test Results

Berat Bahan Kering = 2000 gram

ANALISA SARINGAN				
Saringan	Massa Tertahan	Jumlah Tertahan	Presentase kumulatif	
mm (inci)	Gram (a)	Gram (b)	Tertahan ©	Lolos (d)
3/4	0	0	0	100
3/8	4.02	4.02	0.20	99.8
4	29.55	33.57	1.69	98.3
8	139.18	172.75	8.71	91.3
16	391.8	564.55	28.47	71.5
30	420.18	984.73	49.67	50.3
50	474.23	1458.96	73.59	26.4
100	320.83	1779.79	89.77	10.2
200	150.02	1929.81	97.33	2.7
PAN	52.85	1982.66	100.00	0.0
Jumlah	1982.66	1982.66	100.00	0.0
Wassling Lose	17.34			
Pan Total	1982.66			
Total	2000			
MHB	2.52			%

Fine Aggregate Gradation Graph

From the results of the sand gradation test above, the following conclusions can be obtained:

1. The fineness modulus of fine sand aggregate = 2.521, which in general fine aggregate has a fine grain modulus between 1.5 to 3.8.
2. Based on the graph of fine aggregate fineness modulus of sand, the gradation includes ZONE II gradation (medium/rather coarse).
3. Including the fine modulus of sand grains which can be used as building materials.

Specific Gravity and Absorption Testing of Fine Aggregates

1. Testing of Specific Gravity and Absorption of Fine Aggregate in Sand

Table 5 Tests for Specific Gravity and Water Absorption of Fine Aggregate

BERAT JENIS DAN PENYERAPAN AIR

Penggujian	Notasi	I	II	Rata-Rata	Satuan
Berat benda uji kondisi jenuh kering permukaan (SSD)	Bj	500	500	500.00	gram
Berat benda uji kering oven	Bk	494.97	494.43	495	gram
Berat piknometer berisi air	B	652.85	645.3	650.50	gram
Berat piknometer dengan benda uji + air sampai batas pembacaan	Bt	971.29	957.65	979.47	gram

Perhitungan	Notasi	I	II	Rata-rata	Satuan
Berat jenis curah kering	Bk / (B + Bj - Bt)	2.726	2.786	2.756	gram
Berat jenis curah jenuh kering permukaan	Bj / (B + Bj - Bt)	2.754	2.818	2.785	gram
Berat jenis semu	Bk / (B + Bk - Bt)	2.804	2.877	2.840	gram
Penyerapan air	[Bj-Bk / Bk] X 100%	1.016	1.127	1.071	gram

Source: Laboratory Test Results

The results of the specific gravity and absorption tests for fine aggregate obtained an apparent specific gravity value of 2.840 and absorption of 1.071%, therefore the test met the requirements for apparent specific gravity > 2.5 < 3% and absorption.

Based on existing specifications, the specific gravity of fine aggregate and absorption meet specifications. Because aggregates with many pores generally have a low level of hardness, it is easy for quality to decrease.

2. Testing of Specific Gravity and Absorption of Fine Aggregate in *Fly Ash*

Table 6 Testing of Specific Gravity and Water Absorption of Fine Aggregate in *Fly Ash*

BERAT JENIS DAN PENYERAPAN AIR (*FLY ASH*)

Pengujian	Notasi	I	Satuan
Berat benda uji kondisi jenuh kering permukaan (SSD)	Bj	250	gram
Berat benda uji kering oven	Bk	245	gram
berat piknometer berisi air	B	652.76	gram
Berat piknometer dengan benda uji + air sampai batas pembacaan	Bt	750.72	gram

Perhitungan	Notasi	I	Rata - rata
Berat jenis curah kering	Bk/(B + Bj - Bt)	1.70	1.70
Berat jenis curah jenuh kering permukaan	Bj/(B + Bj - Bt)	1.74	1.74
Berat jenis semu	Bk/(B + Bk - Bt)	1.76	1.76
Penyerapan air	[Bj - Bk / Bk] X 100%	0.02	0.02

Source: Laboratory Test Results

The results of testing samples for specific gravity and fine aggregate absorption showed an apparent specific gravity value of 1.76 and absorption of 0.02%. Therefore, this test does not meet the requirements for apparent specific gravity > 2.5 and absorption < 3%.

3. Testing of Specific Gravity and Absorption of Fine Aggregate in *Bottom Ash*

Table 7 Specific Gravity Test and Water Absorption of Fine Aggregate in Bottom Ash

BERAT JENIS DAN PENYERAPAN AIR (*BOTTOM ASH*)

Pengujian	Notasi	I	Satuan
Berat benda uji kondisi jenuh kering permukaan (SSD)	Bj	250	gram
Berat benda uji kering oven	Bk	247.04	gram
berat piknometer berisi air	B	650	gram
Berat piknometer dengan benda uji + air sampai batas pembacaan	Bt	748	gram

Perhitungan	Notasi	I	Rata - rata
Berat jenis curah kering	Bk/(B + Bj - Bt)	1.63	1.63
Berat jenis curah jenuh kering permukaan	Bj/(B + Bk - Bt)	1.64	1.64
Berat jenis semu	Bk/(B + Bk - Bt)	1.66	1.66
Penyerapan air	[Bj - Bk / Bk] X 100%	0.01	0.01

Source: Laboratory Test Results

The results of testing samples for specific gravity and fine aggregate absorption showed an apparent specific gravity value of 1.66 and absorption of 0.01%. Therefore, this test does not meet the requirements for apparent specific gravity > 2.5 and absorption < 3%.

Fine Aggregate Water Content Testing

a. Place weight + initial sand weight (W) = 60.29 grams
b. Spot weight + oven dry test object weight (W1) = 56.35 grams
c. Water weight (W3) (W-W1)= 3.94 grams

d. Place weight (Wr) = 10.29 grams

e. Dry sample weight (Ws) (W1-Wr) = 46.06 grams

f. % water content W3/WS×100 %= 3.94/46.06 100% = 8.6 %

From the data calculations that have been carried out, it can be seen that the water content of fine aggregate is 8.6%

Fine Aggregate Sludge Content Testing

Table 8 Sludge Content Inspection Test Results

KADAR LUMPUR

	Pengujian	Notasi	I	Satuan
1	Berat pasir awal sebelum dicuci	B1	500.04	gram
2	Berat setelah dicuci dan dikeluarkan dari oven	B2	489.17	gram
3	Berat yang hilang	B1- B2	10.87	gram
4	% kadar lumpur	(B1-B2)/(B1)x100	2.2	gram

Source: Data Analysis Results

Presentase kadar lumpur $= \frac{B1-B2}{B1} \times 100\%$

$= \frac{500,04-489,17}{500,04} \times 100\%$

$= 2,17\% = 2,2\%$

Mixture Composition Planning

To make the concrete brick mixture, the first thing to do is determine the proportion of fine aggregate using Faba as the main ingredient with the planned percentage ratio of 50% and 40%.

1. Calculation of concrete blocks with the planned addition of 40% fly ash and bottom ash aggregates

   Cement =1.078x20%= 0.216 kg

   Sand =5,390x20%= 1.078 kg

   Water =0.431 = 0.431 kg

   FABA =5.390x40%= 2.156 kg

   The brick required for 40% is 9 pieces

   Cement = 1,940

   Sand = 9.702

   Water = 3.881

   FABA = 19.404 / 2= 9.702

2. Calculation of bricks with the addition of 50% fly ash and bottom ash aggregates

   Cement =0.862x15%= 0.162 kg

Sand =4.312x35%= 1.886 kg

Water =0.345 = 0.431 kg

FABA =4.312x50%= 2.695 kg

The brick required for 50% is 9 pieces

Cement = 0.162

Sand = 1.886

Water = 0.431

FABA = 2.695/ 2= 1.347

Compressive Strength Test Results

Table 9 Day Brick Compression Test Results

No.	Nama Benda Uji	Tanggal Pembuatan	Tanggal Pengujian	Umur (hari)	Berat Benda Uji (Kg)	Luas Penampang (cm2)	Luas Penampang (mm²)	Beban Tekan (kN)	Konversi (Kg)	Beban Tekan (N)	Kuat Tekan Pengujian (7 Hari) Kg/cm2	Rata-Rata Kuat Tekan Pengujian (Kg/cm2)	Kuat Tekan Pengujian (MPa)	Rata-rata Kuat Tekan Pengujian (MPa)
1	50%	22/08/2023	29/08/2023	7	2.932	200	20000	20	101.97	20000	10.197	9.687	1.00	0.95
2		22/08/2023	29/08/2023	7	2.967	200	20000	20	101.97	20000	10.197		1.00	
3		22/08/2023	29/08/2023	7	2.954	200	20000	17	101.97	17000	8.667		0.85	
4	40%	23/08/2023	30/08/2023	7	3.472	200	20000	120	101.97	120000	61.182	46.736	6.00	4.58
5		23/08/2023	30/08/2023	7	3.446	200	20000	65	101.97	65000	33.148		3.25	
6		23/08/2023	30/08/2023	7	3.414	200	20000	90	101.97	90000	45.887		4.50	

Source: Data Analysis Results

From the table above, the results of the 7 day concrete block compression test with test object I with a percentage of 50% faba showed an average compressive strength value of 9.687 Kg/cm2 and the average compressive strength of the test in MPa was 0.95 MPa. Meanwhile, for test specimen II with a percentage of 40%, an average compressive strength value of 46.736 kg/cm2 was obtained and the average compressive strength of the test in MPa was 4.58 MPa.

Table 10 14 Day Compressive Strength Test Results

No.	Nama Benda Uji	Tanggal Pembuatan	Tanggal Pengujian	Umur (hari)	Berat Benda Uji (Kg)	Luas Penampang (cm2)	Luas Penampang (mm²)	Beban Tekan (kN)	Konversi (Kg)	Beban Tekan (N)	Kuat Tekan Pengujian (14 Hari) Kg/cm2	Rata-Rata Kuat Tekan Pengujian (Kg/cm2)	Kuat Tekan Pengujian (MPa)	Rata-rata Kuat Tekan Pengujian (MPa)
1	50%	22/08/2023	5/9/2023	14	2.914	200	20000	30	101.97	30000	15.296	21.244	1.50	2.08
2		22/08/2023	5/9/2023	14	2.848	200	20000	55	101.97	55000	28.042		2.75	
3		22/08/2023	5/9/2023	14	2.809	200	20000	40	101.97	40000	20.394		2.00	
4	40%	23/08/2023	6/9/2023	14	3.326	200	20000	90	101.97	90000	45.887	47.416	4.50	4.65
5		23/08/2023	6/9/2023	14	3.260	200	20000	80	101.97	80000	40.788		4.00	
6		23/08/2023	6/9/2023	14	3.201	200	20000	109	101.97	109000	55.574		5.45	

Source: Data Analysis Results

From the table above, the results of the 14 day concrete block compression test with test object I with a percentage of 50% faba showed an average compressive strength value of 21.244 Kg/cm2 and the average compressive strength of the test in MPa was 2.08 MPa. Meanwhile, for test object II with a percentage of 40%, an average compressive strength value

of 47.416 Kg/cm2 was obtained and the average compressive strength of the test in MPa was 4.65 MPa.

Table 11 28 Day Compressive Strength Test Results

No.	Nama Benda Uji	Tanggal Pembuatan	Tanggal Pengujian	Umur (hari)	Berat Benda Uji (Kg)	Luas Penampang (cm2)	Luas Penampang (mm2)	Beban Tekan (KN)	Konversi (Kg)	Beban Tekan (N)	Kuat Tekan Pengujian (28 Hari) Kg/cm2	Rata-Rata Kuat Tekan Pengujian (Kg/cm2)	Kuat Tekan Pengujian (MPa)	Rata-rata Kuat Tekan Pengujian (MPa)
1	50%	23/08/2023	20/09/2023	28	2.856	200	20000	55	101.97	55000	28.042	28.722	2.75	2.82
2		23/08/2023	20/09/2023	28	2.885	200	20000	45	101.97	45000	22.943		2.25	
3		23/08/2023	20/09/2023	28	2.933	200	20000	69	101.97	69000	35.180		3.45	
4	40%	23/08/2023	20/09/2023	28	3.295	200	20000	130	101.97	130000	66.295	62.372	6.5	6.12
5		23/08/2023	20/09/2023	28	3.158	200	20000	120	101.97	120000	61.182		6	
6		23/08/2023	20/09/2023	28	3.307	200	20000	117	101.97	117000	59.652		5.85	

Source: Data Analysis Results

From the table above, the results of the 28 day concrete brick compression test with test object I with a percentage of 50% faba showed an average compressive strength value of 28.722 Kg/cm2 and the average compressive strength of the test in MPa was 2.82 MPa. Meanwhile, for test object II with a percentage of 40%, an average compressive strength value of 62.372 Kg/cm2 was obtained and the average compressive strength of the test in MPa was 6.12 MPa.

Graph of 7 Day Compressive Strength Test for Brick Bricks

(Source: Data Analysis Results)

Graph of 14 Day Compressive Strength Test for Brick Bricks

(Source: Data Analysis Results)

Graph of 28 Day Compressive Strength Test for Brick Bricks

(Source: Data Analysis Results)

CONCLUSION

Based on the analysis of calculations and discussion of laboratory testing, it can be concluded as follows:

1. The composition of the faba mixture used to obtain compressive strength obtained by the mixture composition for 50% in the use of Faba is faba = 20 kg = 20,000 grams, sand = 14 kg = 14,000 grams, cement = 6 kg = 6,000 grams for a total of = 40 kg = 40,000 grams and the composition of the 40% mixture when using faba is faba = 16 kg = 16,000 grams, sand = 16 kg = 16,000 grams, cement = 8 kg = 8,000 grams for a total of = 40 kg = 40,000 grams.
2. In test object I with a percentage of 50% for 7 days of age with an average compressive strength test result obtained of 9,687 Kg/cm2, it does not meet the quality requirements of plan A1 of at least 25 Kg/cm2, 14 days with an average test compressive strength result of 21,244 cm2 does not meet the A1 plan quality requirements of at least 25 Kg/cm2 and at the age of 28 days with an average compressive strength test result of 28.722 meets the plan quality requirements, namely A1 quality of at least 25 Kg/cm2. Meanwhile, test specimen II was at 40% for age 7 with the average compressive strength results obtained from the test being 46,736 Kg/cm2, fulfilling the quality requirements of plan A2 of at least 40 Kg/cm2, 14 days with the average compressive strength results obtained from the test being 47,416 Kg/cm2. cm2 meets the A2 plan quality requirements of at least 40 Kg/cm2, and 28 days with an average compressive strength test result obtained of 63,372 Kg/cm2 meets the plan quality requirements, namely A2 quality of at least 40 Kg/cm2 based on the 1982 General Requirements for Building Materials in Indonesia.

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