

DAFTAR PUSTAKA

- Ambia, D. (2021). *Pemanfaatan fly ash batubara sebagai adsorben pada penyerapan polutan di pengolahan air lindi TPA Blang Bintang Aceh Besar*. 91.
- Badan Standardisasi Nasional. (1994). *SNI 03-3241-1994 :Pemilihan Lokasi Tempat Pembuangan Akhir Sampah*.
- Bakri, E. P., Rolliyah, Zen, I., Artono, A. R., & Karim, A. (2019). *Nilai Ekonomi Pemanfaatan Fly Ash dan Bottom Ash PLTU-PLN di Berbagai Sektor*.
- Budihardjo, M. A. (2017). Kemampuan Tanah Liat dengan Campuran Serbuk Gergaji sebagai Penahan Lindi di Tempat Pengolahan Akhir Sampah. *Jurnal Presipitasi : Media Komunikasi Dan Pengembangan Teknik Lingkungan*, 14(2), 97. <https://doi.org/10.14710/presipitasi.v14i2.97-101>
- Bukit, F. R. A., Frida, E., Bukit, N., & Bukit, B. F. (2021). *Karakterisasi Dan Analisis Bentonit Alam Sebagai Bahan Pengisi Komposit*. JUI TECH: Jurnal Ilmiah Fakultas Teknik Universitas Quality, 5(2), 54–62. <http://www.portaluniversitasquality.ac.id:5388/ojsystem/index.php/JUI TECH/article/view/631>
- Das, B. M. (1995). *Mekanika Tanah (Prinsip-prinsip Rekayasa Geoteknik*. Penerbit Erlangga, 1–300.
- Departemen, P. U. dan P. R. (2006). *Pedoman Pengoperasian Dan Pemeliharaan Tempat Pembuangan Akhir (Tpa)*.
- Dewi, P. A. I. K., Suarya, P., & Sibarani, J. (2015). *Adsorpsi Ion Logam Pb²⁺ Dan Cu²⁺ Oleh Bentonit Teraktivasi Basa (NaOH)*.
- Fajarini, S. (2014). *Analisis Kualitas Air Tanah Masyarakat Di Sekitar Tempat Pembuangan Akhir (TPA) Sampah Kelurahan Sumur Batu Bantar Gebang, Bekasi Tahun 2013*. Universitas Islam Negeri Syarif Hidayatullah.
- Fathurrozi, & Rezqi, F. (2016). *Sifat-Sifat Fisis Dan Mekanis Tanah Timbunan Badan Jalan Kuala Kapuas*. 8(1), 16–24.
- Gunawan, L. I., Hendrawan, A. P., Chandrasasi, D., Asmaranto, R., Saputra, A. W. W., & Abidin, Z. (2015). *Kriteria Kadar Air-Kepadatan Bentonite Dicampur Dengan Fly Ash Untuk Compacted Soil Liner*. Universitas Brawijaya.



I. Z. (2020). *Fly Ash Teraktivasi KOH Sebagai Material Penyerap mium*. Skripsi, 1–98.

R. A., Sompie, O. B. A., & Jansen, F. (2014). *Penambahan Campuran onit Dan Kaolin Pada Tanah Pasir Terhadap Koefisien Permeabilitas*

Dengan Kondisi Plastisitas Berbeda Pada Tingkat Kepadatan Maksimum. Jurnal Ilmiah Media Engineering, 4(2), 127–134. www.dim.esdm.go.id

Juhaidah, S. (2018). *Pengelolaan Sampah TPA Tamangapa Kota Makassar.* Jurnal Fakultas Teknik Universitas Brawijaya, 8(0341), 1–112.

Karim, M. A., Hassan, A. S., & Kaplan, A. (2020). Optimization Of Soil To Fly-Ash Mix Ratio For Enhanced Engineering Properties Of Clayey Sand For Subgrade Use. *Applied Sciences* (Switzerland), 10(20), 1–13. <https://doi.org/10.3390/app10207038>

Kusuma, R. I., & Mina, E. (2016). *Tinjauan Sifat Fisis Dan Mekanis Tanah (Studi Kasus : Jalan Carenang Kabupaten Serang).* Fondasi : Jurnal Teknik Sipil, 5(2). <https://doi.org/10.36055/jft.v5i2.1255>

Mahvash, S., López-Querol, S., & Bahadori-Jahromi, A. (2017). *Effect Of Class F Fly Ash On Fine Sand Compaction Through Soil Stabilization.* Heliyon, 3(3), e00274. <https://doi.org/10.1016/j.heliyon.2017.e00274>

Pemerintah Republik Indonesia. (2021). *Peraturan Pemerintah Nomor 22 Tahun 2021 tentang Pedoman Perlindungan dan Pengelolaan Lingkungan Hidup.* Sekretariat Negara Republik Indonesia, 1(078487A), 483. <http://www.jdih.setjen.kemendagri.go.id/>

Puspitarini, R., Sn, A. K., & Ar, R. (2019). *Pengaruh Ukuran Partikel , Zat Aktivator , Waktu Aktivasi Dan Waktu Kontak Adsorben Fly Ash Untuk Mengurangi Kadar Kadmium (Cd) Pada Air Lindi Di Tempat Pembuangan Akhir Purworejo , Jawa Tengah.* 13(2), 109–118.

Putri, A. A. (2020). *Sintesis Dan Karakterisasi Bentonit Terpilas Logam Besi Dan Kromium Sebagai Katalis Untuk Konversi Etanol Menjadi Gasolin.*

Rahadiani, E. S. (2016). *Pengurangan Kadar Pencemar Pada Air Lindi Sampah Menggunakan Karbon Aktif Dari Tempurung Kelapa.* 1–38.

Ramadani, D. S., Budiharjo, M. A., & Samadikun, B. P. (2018). *Kinerja Pengurangan Pb (Ii) Pada Lapisan Semi-Kedap Komposit Bentonit Dan Zeolit.*

Sari, K. N., Syafrudin, & Hadiwidodo, M. (2016). *Kemampuan Geosynthetic Clay Liner (GCL) Sebagai Pelapis Dasar TPA Terhadap Penyisihan Konsentrasi Besi (Fe) dan Timbal (Pb) Dalam Lindi.* 5.

Sobti, J., & Singh, S. K. (2017). *Strength And Compaction Analysis Of Sand-Bentonite-Coal Ash Mixes.* IOP Conference Series: Materials Science and Engineering, 225, 012091. <https://doi.org/10.1088/1757-899x/225/1/012091>



F. (2011). *Study Kandungan Logam Berat Timbal (Pb), Dan Bakteri coli Pada Air Sumur Di Sekitar Tempat Pembuangan Akhir (TPA) Antang 1 Makassar.* Skripsi. In *Journal of Chemical Information and Modeling*

(Vol. 53, Issue 9).

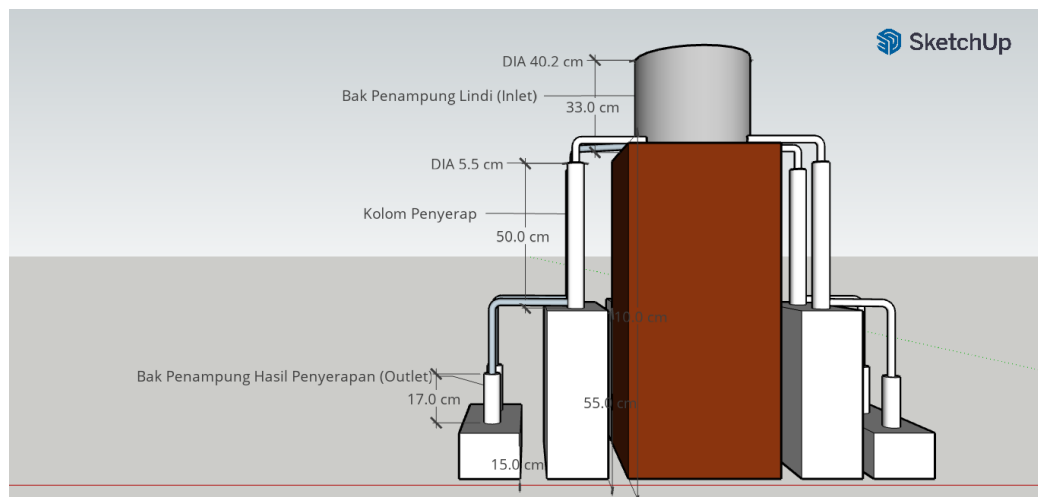
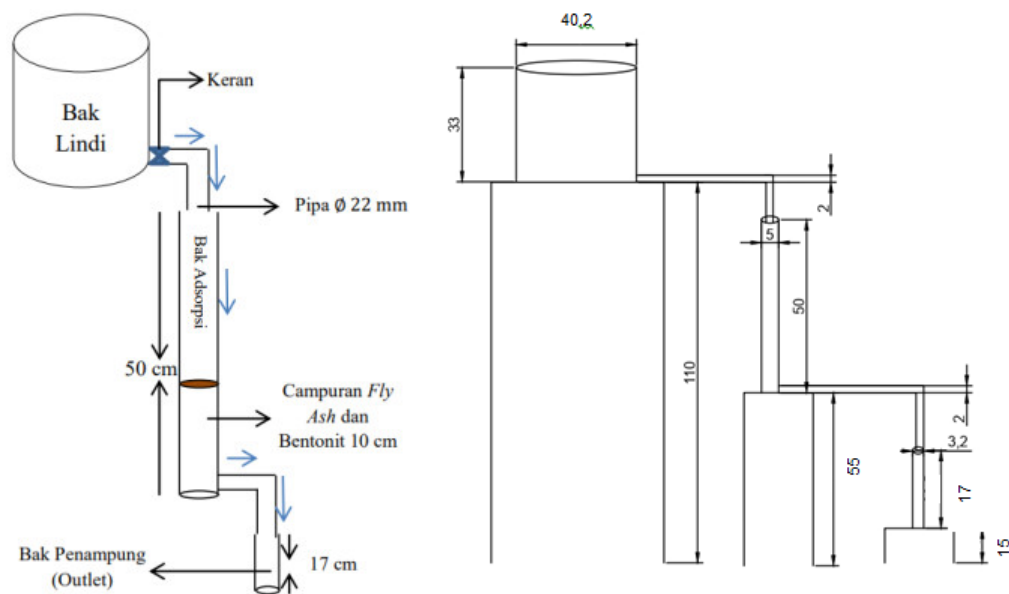
Wasil, M. (2020). *Effect Of Bentonite Addition On The Properties Of Fly Ash As A Material For Landfill Sealing Layers*. Applied Sciences (Switzerland), 10(4). <https://doi.org/10.3390/app10041488>

Yenti, E. (2016). *Analisis Potensi Lempung Olahan Dalam Mereduksi Logam Berat Pada Lindi Di Sekitar Tempat Pembuangan Akhir (TPA) Kota Pekanbaru*. 6.

Yusuf, N. I. A., Arifah, S., & Rell, F. (2021). *Deteksi Logam Kadmium Dan Timbel Pada Sapi Peranakan Ongole Yang Digembalakan Di Tempat Pembuangan Akhir Tangapa Makassar*, 7(1), 23–31.



Lampiran 1 Desain Reaktor



Sumber-sumber rancangan reaktor:

- Bak Lindi, Bak Penampung, Percabangan (Farastika dkk, 2017; Sari dkk, 2016)
- Tinggi bak adsorpsi dan ketebalan campuran pada bak adsorpsi (Kasman dkk, 2014)
- Ketinggian dudukan masing-masing bak dan pemberian katup (Kasman dkk, 2014; Imania 2018)

Perhitungan (Widodo dkk, 2016)

Luas Tabung: πr^2

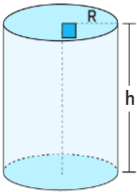
$$e: \frac{\pi}{4} D^2 x h$$

$$\text{atan aliran: } \sqrt{2 x g x h}$$

Volume x Luas Tabung



Lampiran 2 Perhitungan Reaktor

Volume				
Volume of a Right Circular Cylinder Formula				
				
Volume, $V = \pi r^2 h$				
Tabung	Diameter (m)	Tinggi (m)	Luas Penampang (m ²)	Volume (m ³)
Bak Inlet	0.402	0.33	0.13	0.041885
Kolom Adsorpsi	0.055	0.5	0.002	0.001188
Bak Outlet	0.06	0.17	0.003	0.000481

Kecepatan Aliran dan Debit			
Ukuran Pipa		Kecepatan Aliran (m/s)	Debit (m ³ /s)
D (m)	A (m ²)		
0.022	0.0003801	2.54	0.0010
Berdasarkan jurnal tidak ada perbedaan debit dan kecepatan aliran antara satu lubang dan lubang lain, kecuali terdapat perlakuan yang berbeda seperti beda ketinggian			

Hasil Pengukuran di Lapangan						
Pipa ke-	Ukuran Pipa		Volume Air (m ³)	Waktu (s)	Debit (m ³ /s)	Kecepatan Aliran (m/s)
	D (m)	A (m ²)				
1	0.022	0.00038	0.03	23.94	0.00125	3.2965667
2	0.022	0.00038	0.031	24.41	0.00127	3.3408630
3	0.022	0.00038	0.029	22.34	0.00130	3.4149125
4	0.022	0.00038	0.032	24.67	0.00130	3.4122873
5	0.022	0.00038	0.028	22.15	0.00126	3.3254396
6	0.022	0.00038	0.031	24.51	0.00126	3.3272324



Lampiran 3 Data Pengujian Specific Gravity

SPECIFIC GRAVITY TEST RESULTS									
PROJECT	: SOIL INVESTIGATION FLY ASH								
LOCATION	: PLTU BARRU								
QUARRY	: -								
BORING DEPTH	: -								
TESTING METHOD	: ASTM D 854-58(72)					TESTED BY	: EMANUELA PRIMA E.T.		
LABORATORY	: HASANUDDIN UNIVERSITY					DATE	: MEI 2023		
Sample	-	1							
Sample Depth & Inclination	m								
Number of Volumetric Flask	-	A	B						
Weight of Vol. Flask + Soil (W2)	Gram	31.82	38.21						
Weight of Vol. Flask (W1)	Gram	21.82	28.21						
Weight of Soil	Gram	10.00	10.00						
Temperature, T (°C)	Degree	28.0	28.0						
Weight of Vol. Flask+Water at T (W4)	Gram	76.77	75.80						
Weight of Vol. Flask+Water+Soil (W3)	Gram	83.79	82.62						
Unit Weight of Water at T, γ_T	Gram/Cm ³	0.99624	0.99624						
Temp. Corr. Coefficient, $\alpha=\gamma_T/\gamma_{20}^{\circ}\text{C}$	-	0.99803	0.99803						
Weight of Dry Soil, Ws	Gram	10.12	10.27						
Specific Gravity of Soil ($G_s=\alpha \cdot W_s/W_u$)	-	3.258	2.971						
Average of Gs	-	3.115							
Remarks:	Unit Weight of Water, $\gamma_{w,20}^{\circ}\text{C}= 0.99821$								

SPECIFIC GRAVITY TEST RESULTS									
PROJECT	: SOIL INVESTIGATION BENTONITE								
LOCATION	: CV ANUGRAH MINERAL								
QUARRY	: -								
BORING DEPTH	: -								
TESTING METHOD	: ASTM D 854-58(72)					TESTED BY	: EMANUELA PRIMA E.T.		
LABORATORY	: HASANUDDIN UNIVERSITY					DATE	: MEI 2023		
Sample	-	1							
Sample Depth & Inclination	m								
Number of Volumetric Flask	-	A	B						
Weight of Vol. Flask + Soil (W2)	Gram	26.82	33.21						
Weight of Vol. Flask (W1)	Gram	21.82	28.21						
Weight of Soil	Gram	5.00	5.00						
Temperature, T (°C)	Degree	28.0	28.0						
Weight of Vol. Flask+Water at T (W4)	Gram	76.77	75.84						
Weight of Vol. Flask+Water+Soil (W3)	Gram	80.20	78.56						
Unit Weight of Water at T, γ_T	Gram/Cm ³	0.99624	0.99624						
Temp. Corr. Coefficient, $\alpha=\gamma_T/\gamma_{20}^{\circ}\text{C}$	-	0.99803	0.99803						
Weight of Dry Soil, Ws	Gram	5.21	4.75						
Specific Gravity of Soil ($G_s=\alpha \cdot W_s/W_u$)	-	2.921	2.335						
Average of Gs	-	2.628							
Remarks:	Unit Weight of Water, $\gamma_{w,20}^{\circ}\text{C}= 0.99821$								



Lampiran 4 Data Pengujian Kadar Air

WATER CONTENT TEST		
PROJECT	: KADAR AIR FLY ASH	
LOCATION	: LABORATORIUM MEKANIKA TANAH FT-UH	
TESTED BY	: EMANUELA PRIMA E.T.	
DATE	: MEI 2023	
TESTING METHOD	: ASTM D 2216-19, ASTM C29/C29M-16, SNI 1971:2011	
LABORATORY	: HASANUDDIN UNIVERSITY	
		
Item	Test No.	
	1	2
Can No.	A	B
Mass of can, W ₁ (g)	8.15	8.15
Mass of can + wet soil, W ₂ (g)	28.96	32.43
Mass of can + dry soil, W ₃ (g)	28.43	31.76
Mass of moisture, W _w (g) = W ₂ - W ₃	0.53	0.67
Mass of moisture, W _s (g) = W ₃ - W ₁	20.28	23.61
Moisture content, w(%) =	2.6	2.8
Average w (%)	2.7	

WATER CONTENT TEST		
PROJECT	: KADAR AIR BENTONIT	
LOCATION	: LABORATORIUM MEKANIKA TANAH FT-UH	
TESTED BY	: EMANUELA PRIMA E.T.	
DATE	: MEI 2023	
TESTING METHOD	: ASTM D 2216-19, ASTM C29/C29M-16, SNI 1971:2011	
LABORATORY	: HASANUDDIN UNIVERSITY	
		
Item	Test No.	
	1	2
Can No.	A	B
Mass of can, W ₁ (g)	8.2	8.12
Mass of can + wet soil, W ₂ (g)	34.27	40.53
Mass of can + dry soil, W ₃ (g)	29.11	34.08
Mass of moisture, W _w (g) = W ₂ - W ₃	5.16	6.45
Mass of moisture, W _s (g) = W ₃ - W ₁	20.91	25.96
Moisture content, w(%) =	24.7	24.8
Average w (%)	16.5	



Lampiran 5 Data Pengujian Analisa Saringan Fly Ash

no saringan	Berat Saringan + Tanah	Berat Saringan	Berat Tertahan
3"	0	0	0
2"	0	0	0
1 1/2"	0	0	0
1"	0	0	0
3/4"	0	0	0
3/8"	0	0	0
4	441	441	0
10	410	404	6
20	368	363	5
40	319	317	2
60	290	287	3
100	275	271	4
200	412	387	25
Pan	712	257	455
total			500

SIEVE ANALYSIS			
PROJECT	: SOIL INVESTIGATION REPORT		
LOCATION	: PLTU BARRU		
SAMPLE NO.	: FLY ASH		
SAMPLING DEPTH	:		
TESTING METHOD	: ASTM D 424-59, D 4318-(00), AASHTO T89/T90	TESTED BY	: EMANUELA PRIMA E.T
LABORATORY	: HASANUDDIN UNIVERSITY	DATE	: MEI, 2023



Hasil Perhitungan Analisa Saringan					
	Sebelum	Sesudah			
Berat tanah kering + Container	-				
Berat Container	-				
Berat tanah Kering	500				
Saringan No.	Diameter (mm)	Berat Tertahan (gram)	Berat Kumulatif (gram)	Persen (%)	
				Tertahan	Loos
3"	75.00	0	0	0.00	100.00
2"	50.00	0	0	0.00	100.00
1 1/2"	37.50	0	0	0.00	100.00
1"	25.00	0	0	0.00	100.00
3/4"	19.00	0	0	0.00	100.00
3/8"	9.500	0	0	0.00	100.00
4	4.750	0	0	0.00	100.00
10	2.000	6	6	1.20	98.80
20	0.840	5	11	2.20	97.80
40	0.425	2	13	2.60	97.40
60	0.250	3	16	3.20	96.80
100	0.150	4	20	4.00	96.00
200	0.075	25	45	9.00	91.00
Pan	-	455	500	100.00	0.00



Lampiran 6 Data Pengujian Analisa Saringan dan Hidrometer Bentonit

No. Saringan	total sar.+sampel	saringan	Berat tanah
4	441	441	0
10	404	404	0
20	311	311	0
40	317	317	0
60	268	268	0
100	282	282	0
200	266	266	0
pan	757	257	500
Total			500

TEST RESULTS OF GRAIN-SIZE ANALYSIS																
(Sieve-Mechanical and Hydrometer Methods)																
PROJECT		: TUGAS AKHIR														
LOCATION		: CV ANUGRAH MINERAL														
QUARRY		:														
TESTING METHOD		: ASTM D 424-59, D 4318-(00), AASHTO T89/T90														
LABORATORY		: HASANUDDIN UNIVERSITY														
TESTED BY		: EMANUELA PRIMA E.T.														
DATE		: MEI 2023														
Berat Tanah Kering :		500		gr		Spec. Gravity, G _s :			2.628		T :		28.0		°C	
Analisa Saringan						Analisa Hidrometer										
Saringan No.	Diameter (mm)	Berat Tertahan (Gram)	Berat Kumulatif (gram)	Persen Tertahan (%)	Persen Lolos (%)	Waktu (menit)	R	R _{cp} =R+F _t -F _z	% Finer = ((a x R _{cp})/W ₉)x100% * %Finer Sieve Analysis	R _{cl} = R + F _m	L (cm)	A	D=A/L/t (mm)			
4	4.75	0	0	0	100	0.25	55.00	50.15	100.81	56.00	7.30	0.0123	0.06647			
10	2	0	0	0	100	0.5	53.00	48.15	96.79	54.00	7.60	0.0123	0.04795			
20	0.84	0	0	0	100	1	52.00	47.15	94.78	53.00	7.80	0.0123	0.03435			
40	0.425	0	0	0	100	2	51.00	46.15	92.77	52.00	7.90	0.0123	0.02445			
60	0.25	0	0	0	100	4	50.00	45.15	90.76	51.00	8.10	0.0123	0.01750			
100	0.15	0	0	0	100	8	48.00	43.15	86.74	49.00	8.40	0.0123	0.01260			
200	0.075	0	0	0	100	15	46.00	41.15	82.72	47.00	8.80	0.0123	0.00942			
Pan	-	500	500	100	0	30	45.00	40.15	80.71	46.00	8.90	0.0123	0.00670			
						60	43.00	38.15	76.69	44.00	9.20	0.0123	0.00482			
						90	42.00	37.15	74.68	43.00	9.40	0.0123	0.00398			
						120	41.00	36.15	72.67	42.00	9.70	0.0123	0.00350			
						240	40.00	35.15	70.66	41.00	9.90	0.0123	0.00250			
						1440	39.00	34.15	68.65	40.00	10.10	0.0123	0.00103			



Lampiran 7 Data Pengujian Batas-batas Atterberg Bentonit

ATTERBERG LIMITS TEST												
PROJECT	:	BENTONIT INVESTIGATION REPORT										
LOCATION	:	CV Anugrah Mineral Industri										
QUARRY	:	-										
SAMPLING DEPTH	:	-										
TESTING METHOD	:	ASTM D4318-10, ASTM D4943-08, ASTM D2487										
LABORATORY	:	HASANUDDIN UNIVERSITY										
TESTED BY	:	EMANUELA PRIMA E.T.										
DATE	:	MEI 2023										
Sample No.	:	Sampel 70% Bentonite - 30 % Tanah Asli										
Depth of Sample	:	11,50-12,00 m										
	Unit	Plastic Limit		Liquid Limit								Shrinkage Limit
Test Number	-	1	2	1	2	3	4	1				
Number of Blows, N	-	-	-	19	24	27	29	-				
Container No. or Can No.	-	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1
Weight of Wet Soil+Can, W1	gram	12.69	12.57	39.66	37.99	35.55	34.61	39.20	35.76	32.43	34.64	52.37
Weight of Dry Soil+Can, W2	gram	12.10	11.98	21.84	21.44	20.40	20.01	21.91	20.49	19.15	20.11	28.49
Weight of Water, Ww=W1-W2	gram	0.59	0.59	17.82	16.55	15.15	14.60	17.29	15.27	13.28	14.53	23.88
Weight of Can, W3	gram	11.38	11.19	9.70	9.72	9.70	9.67	9.64	9.68	9.70	9.76	10.29
Weight of Dry Soil, Ws=W2-W3	gram	0.72	0.79	12.14	11.72	10.70	10.34	12.27	10.81	9.45	10.35	18.2
Water Content, w=Ww/Ws*100%	%	81.9	74.7	146.8	141.2	141.6	141.2	140.9	141.3	140.5	140.4	131.21
Average of Water Content, w	%	78.31	144.00	141.39	141.09	140.46						131.21
Weight of Can+Hg, W1	gram											427
Weight of Shrink dish	gram											35
Weight of displaced Hg + Shrink dish	gram											166
Hg content	gr/cm³											13.6
Volume of Wet Soil	cm³											30.64
Volume of Dry Soil	cm³											9.63
Shrinkage Limit	%											15.78
Average Shrinkage Limit	%											15.78



Lampiran 8 Kompaksi 100% Bentonit

STANDARD COMPACTION TEST RESULTS							
PROJECT	: SOIL INVESTIGATION REPORT						
LOCATION	: CV ANUGRAH MINERAL						
QUARRY	: -						
SAMPLE / SAMPLE NO.	: 100% BENTONITE						
TESTING METHOD	: ASTM D 698-12e2, SNI 1742:2008						
LABORATORY	: HASANUDDIN UNIVERSITY						
	TESTED BY EMANUELA PRIMA E.T.						
	DATE MEI 2023						
Weight of soil	gram	2000	2000	2000	2000	2000	
Initial water content	%	24.18	24.18	24.18	24.18		
Water addition	ml	400	500	600	700		
Molding water content	%	49.0	55.2	61.4	67.6		
Wet Density							
Mold No.	-	1	2	3	4	5	
Weight of Mold	gram	1893	1893	1893	1893		
Weight of wet soil + mold	gram	3433	3461	3447	3413		
Weight of wet soil, W _{wet}	gram	1540	1568	1554	1520		
Volume of Mold	cm ³	979	979	979	979		
Wet unit weight	gr/cm ³	1.572	1.601	1.587	1.552		
Water Content							
Container No.	-	1	2	1A	1B	2A	2B
Weight of wet soil + container	gram	36.62	37.07	36.23	36.69	34.80	33.50
Weight of dry soil + container	gram	23.95	27.64	27.4	27.2	20.87	25.01
Weight of water	gram	12.67	9.43	8.83	9.49	13.93	8.49
Weight of container	gram	3.58	3.58	9.62	9.72	3.65	3.60
Weight of dry soil	gram	20.37	24.06	17.78	17.48	17.22	21.41
Water Content	%	62.2	39.2	49.7	54.3	80.9	39.7
Avg. water content	%	50.7		52.0		60.3	
Dry Density							
Weight of dry soil	gram	1021.92	1031.74	969.59	919.73		
$W_{dry} = \frac{W_{wet}}{1 + \left(\frac{W}{100}\right)}$							
Dry unit weight	gr/cm ³	1.043	1.054	0.990	0.939		
$\gamma_{dry} = \frac{W_{dry}}{V_{mould}}$							
gzav = gw/(w+(1/Gs))	gr/cm ³	1.13	1.11	1.02	0.97		



Lampiran 9 Kompaksi 85% FA+15%BE

STANDARD COMPACTION TEST RESULTS												
PROJECT		: SOIL INVESTIGATION REPORT										
LOCATION		: PLTU BARRU, CV ANUGRAH MINERAL										
QUARRY		: -										
SAMPLE / SAMPLE NO.		: 85% FLY ASH 15% BENTONIT										
TESTING METHOD		: ASTM D 698-12e2, SNI 1742:2008										
LABORATORY		: HASANUDDIN UNIVERSITY										
		TESTED BY EMANUELA PRIMA E.T										
		DATE JUNI 2023										
Weight of soil	gram	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Initial water content	%	19.81	19.81	19.81	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
Water addition	ml	300	400	500	600	600	600	600	600	600	600	600
Molding water content	%	37.8	43.8	49.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8	55.8
Wet Density												
Mold No.	-	1	2	3	4	5	6	7	8	9	10	11
Weight of Mold	gram	1893	1893	1893	1893	1893	1893	1893	1893	1893	1893	1893
Weight of wet soil + mold	gram	3468	3556	3555	3562	3562	3562	3562	3562	3562	3562	3562
Weight of wet soil, W_{wet}	gram	1575	1663	1662	1669	1669	1669	1669	1669	1669	1669	1669
Volume of Mold	cm ³	979	979	979	979	979	979	979	979	979	979	979
Wet unit weight	gr/cm ³	1.608	1.698	1.697	1.704	1.704	1.704	1.704	1.704	1.704	1.704	1.704
Water Content												
Container No.	-	1	2	1	2	1A	1B	2A	2B	3A	3B	4
Weight of wet soil + container	gram	28.54	24.93	23.85	26.94	32.35	39.91	28.44	27.07			
Weight of dry soil + container	gram	24.89	21.74	20.83	22.49	28.64	29.85	23.22	21.70			
Weight of water	gram	3.65	3.19	3.02	4.45	3.71	10.06	5.22	5.37			
Weight of container	gram	8.11	8.17	8.21	8.08	8.22	8.09	8.11	8.21			
Weight of dry soil	gram	16.78	13.57	12.62	14.41	20.42	21.76	15.11	13.49			
Water Content	%	21.8	23.5	23.9	30.9	18.2	46.2	34.5	39.8			
Avg. water content	%	22.6	27.4	32.2	37.2	37.2	37.2	37.2	37.2			
Dry Density												
Weight of dry soil	gram	1284.35	1305.28	1257.19	1216.68	1216.68	1216.68	1216.68	1216.68	1216.68	1216.68	1216.68
Dry unit weight	gr/cm ³	1.311	1.333	1.284	1.242	1.242	1.242	1.242	1.242	1.242	1.242	1.242
$\gamma_{dry} = \frac{W_{dry}}{V_{mould}}$	gr/cm ³	1.311	1.333	1.284	1.242	1.242	1.242	1.242	1.242	1.242	1.242	1.242
$g_{zav} = g_w / (w + (1/G_s))$	gr/cm ³	1.65	1.53	1.42	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33



Lampiran 10 Kompaksi 70%FA+30%BE

STANDARD COMPACTION TEST RESULTS												
PROJECT		: SOIL INVESTIGATION REPORT										
LOCATION		: PLTU BARRU, CV ANUGRAH MINERAL										
QUARRY		: -										
SAMPLE / SAMPLE NO.		: 70% FLY ASH 30% BENTONIT										
TESTING METHOD		: ASTM D 698-12e2, SNI 1742:2008										
LABORATORY		: HASANUDDIN UNIVERSITY										
		TESTED BY EMANUELA PRIMA E.T.										
		DATE JUNI 2023										
Weight of soil	gram	2000	2000	2000	2000	2000						
Initial water content	%	15.13	15.13	15.1	15.1							
Water addition	ml	400	500	600	700							
Molding water content	%	38.2	43.9	49.7	55.4							
Wet Density												
Mold No.	-	1	2	3	4	5						
Weight of Mold	gram	1893	1893	1893	1893							
Weight of wet soil + mold	gram	3389	3572	3574	3508							
Weight of wet soil, W_{wet}	gram	1496	1679	1681	1615							
Volume of Mold	cm ³	979	979	979	979							
Wet unit weight	gr/cm ³	1.528	1.714	1.716	1.649							
Water Content												
Container No.	-	1	2	1	2	1A	1B	2A	2B	3A	3B	
Weight of wet soil + container	gram	33.83	33	26.38	29.82	26.78	30.82	40.07	40.45			
Weight of dry soil + container	gram	29.39	28.37	21.81	25.52	21.81	25.52	31.51	30.95			
Weight of water	gram	4.44	4.63	4.57	4.3	4.97	5.3	8.56	9.5			
Weight of container	gram	7.88	7.95	8.06	8.06	8.06	8.06	8.30	7.96			
Weight of dry soil	gram	21.51	20.42	13.75	17.46	13.75	17.46	23.21	22.99			
Water Content	%	20.6	22.7	33.2	24.6	36.1	30.4	36.9	41.3			
Avg. water content	%	21.7	28.9	33.3	39.1							
Dry Density												
Weight of dry soil	gram	1229.68	1302.24	1261.54	1161.02							
Dry unit weight	gr/cm ³	1.256	1.330	1.288	1.186							
$\gamma_{dry} = \frac{W_{dry}}{V_{mould}}$	gr/cm ³	1.69	1.51	1.41	1.31							
$g_{zav} = g_w / (w + (1/G_s))$	gr/cm ³											



Lampiran 11 Kompaksi 55%FA+45%BE

STANDARD COMPACTION TEST RESULTS											
PROJECT		: SOIL INVESTIGATION REPORT									
LOCATION		: PLTU BARRU, CV ANUGRAH MINERAL									
QUARRY		: -									
SAMPLE / SAMPLE NO.		: 55% FLY ASH 45% BENTONIT									
TESTING METHOD		: ASTM D 698-12e2, SNI 1742:2008									
LABORATORY		: HASANUDDIN UNIVERSITY									
		TESTED BY EMANUELA PRIMA E.									
		DATE JUNI 2023									
Weight of soil	gram	2000	2000	2000	2000	2000					
Initial water content	%	11.16	11.16	11.2	11.2						
Water addition	ml	400	500	600	700						
Molding water content	%	33.4	39.0	44.5	50.1						
Wet Density											
Mold No.	-	1	2	3	4	5					
Weight of Mold	gram	1893	1893	1893	1893						
Weight of wet soil + mold	gram	3397	3621	3628	3580						
Weight of wet soil, W_{wet}	gram	1504	1728	1735	1687						
Volume of Mold	cm ³	979	979	979	979						
Wet unit weight	g/cm ³	1.536	1.764	1.772	1.723						
Water Content											
Container No.	-	1	2	1	2	1A	1B	2A	2B	3A	3B
Weight of wet soil + container	gram	37.98	33.68	40.48	35.18	28.91	40.29	45.16	49.70		
Weight of dry soil + container	gram	34.14	27.87	34.14	27.87	23.25	27.68	33.59	36.57		
Weight of water	gram	3.84	5.81	6.34	7.31	5.66	12.61	11.57	13.13		
Weight of container	gram	9.62	9.66	9.62	9.66	3.58	3.61	9.70	9.61		
Weight of dry soil	gram	24.52	18.21	24.52	18.21	19.67	24.07	23.89	26.96		
Water Content	%	15.7	31.9	25.9	40.1	28.8	52.4	48.4	48.7		
Avg. water content	%	23.8	33.0	40.6	48.6						
Dry Density											
Weight of dry soil											
$W_{dry} = \frac{W_{wet}}{1 + \left(\frac{W}{100}\right)}$	gram	1215.03	1299.25	1234.16	1135.52						
Dry unit weight											
$\gamma_{dry} = \frac{W_{dry}}{V_{mould}}$	g/cm ³	1.241	1.327	1.260	1.159						
gzav = gw/(w+(1/Gs))	g/cm ³	1.67	1.45	1.31	1.18						



Lampiran 12 Kompaksi 45%FA+55%BE

STANDARD COMPACTION TEST RESULTS														
PROJECT	: SOIL INVESTIGATION REPORT													
LOCATION	: PLTU BARRU, CV ANUGRAH MINERAL													
QUARRY	: -													
SAMPLE / SAMPLE NO.	: 45% FLY ASH 55% BENTONIT													
TESTING METHOD	: ASTM D 698-12e2, SNI 1742:2008						TESTED BY	EMANUELA PRIMA E.						
LABORATORY	: HASANUDDIN UNIVERSITY						DATE	JUNI 2023						
Weight of soil	gram	2000	2000	2000	2000	2000								
Initial water content	%	9.31	9.31	9.3	9.3	9.3								
Water addition	ml	400	500	600	700	700								
Molding water content	%	31.2	36.6	42.1	47.6	47.6								
Wet Density														
Mold No.	-	1	2	3	4	5								
Weight of Mold	gram	1893	1893	1893	1893	1893								
Weight of wet soil + mold	gram	3495	3620	3600	3490	3490								
Weight of wet soil, W _{wet}	gram	1602	1727	1707	1597	1597								
Volume of Mold	cm ³	979	979	979	979	979								
Wet unit weight	gr/cm ³	1.636	1.763	1.743	1.631	1.631								
Water Content														
Container No.	-	1	2	1	2	1A	1B	2A	2B	3A	3B			
Weight of wet soil + container	gram	24.86	31.26	32.71	30.67	27.81	32.60	30.76	38.14					
Weight of dry soil + container	gram	21.39	26.17	26.8	24.87	22.25	26.08	23.84	29.37					
Weight of water	gram	3.47	5.09	5.91	5.8	5.56	6.52	6.92	8.77					
Weight of container	gram	8.22	8.09	8.21	8.08	8.12	8.21	8.12	8.18					
Weight of dry soil	gram	13.17	18.08	18.59	16.79	14.13	17.87	15.72	21.19					
Water Content	%	26.3	28.2	31.8	34.5	39.3	36.5	44.0	41.4					
Avg. water content	%	27.3	33.2	37.9	42.7	42.7	42.7	42.7	42.7					
Dry Density														
Weight of dry soil	$w_{dry} = \frac{W_{wet}}{1 + \left(\frac{w}{100}\right)}$	gram	1258.94	1296.86	1237.70	1119.10	1119.10	1119.10	1119.10					
Dry unit weight	$\gamma_{dry} = \frac{W_{dry}}{V_{mould}}$	gr/cm ³	1.286	1.324	1.264	1.143	1.143	1.143	1.143					
gzav = gw/(w+(1/Gs))		gr/cm ³	1.59	1.45	1.36	1.28	1.28	1.28	1.28					



Lampiran 13 Kompaksi 30%FA+70%BE

STANDARD COMPACTION TEST RESULTS												
PROJECT		: SOIL INVESTIGATION REPORT										
LOCATION		: PLTU BARRU, CV ANUGRAH MINERAL										
QUARRY		: -										
SAMPLE / SAMPLE NO.		: 30% FLY ASH 70% BENTONIT										
TESTING METHOD		: ASTM D 698-12e2, SNI 1742:2008							TESTED BY		EMANUELA PRIMA E.T.	
LABORATORY		: HASANUDDIN UNIVERSITY							DATE		JUNI 2023	
Weight of soil	gram	2000	2000	2000	2000	2000						
Initial water content	%	6.13	6.13	6.1	6.1							
Water addition	ml	400	500	600	700							
Molding water content	%	27.4	32.7	38.0	43.3							
Wet Density												
Mold No.	-	1	2	3	4	5						
Weight of Mold	gram	1893	1893	1893	1893							
Weight of wet soil + mold	gram	3454	3620	3586	3543							
Weight of wet soil, W_{wet}	gram	1561	1727	1693	1650							
Volume of Mold	cm ³	979	979	979	979							
Wet unit weight	gr/cm ³	1.594	1.763	1.729	1.685							
Water Content												
Container No.	-	1	2	1	2	1A	1B	2A	2B	3A	3B	
Weight of wet soil + container	gram	27.77	30.68	30.97	30.68	33.38	38.71	35.40	37.47			
Weight of dry soil + container	gram	25.44	24.73	25.44	24.73	26.24	30.65	27.72	28.46			
Weight of water	gram	2.33	5.95	5.53	5.95	7.14	8.06	7.68	9.01			
Weight of container	gram	7.88	7.96	7.88	7.96	8.17	8.12	8.06	8.05			
Weight of dry soil	gram	17.56	16.77	17.56	16.77	18.07	22.53	19.66	20.41			
Water Content	%	13.3	35.5	31.5	35.5	39.5	35.8	39.1	44.1			
Avg. water content	%	24.4	33.5	37.6	41.6							
Dry Density												
Weight of dry soil	gram	1255.08	1293.77	1229.99	1165.22							
Dry unit weight	gr/cm ³	1.282	1.321	1.256	1.190							
$g_{zav} = gw/(w+(1/Gs))$	gr/cm ³	1.69	1.46	1.38	1.31							



Lampiran 14 Kompaksi 15%FA+85%BE

STANDARD COMPACTION TEST RESULTS													
PROJECT		: SOIL INVESTIGATION REPORT											
LOCATION		: PLTU BARRU, CV ANUGRAH MINERAL											
QUARRY		: -											
SAMPLE / SAMPLE NO.		: 15% FLY ASH 85% BENTONIT											
TESTING METHOD		: ASTM D 698-12e2, SNI 1742:2008						TESTED BY EMANUELA PRIMA E.T.					
LABORATORY		: HASANUDDIN UNIVERSITY						DATE JUNI 2023					
Weight of soil	gram	2000	2000	2000	2000	2000							
Initial water content	%	3.12	3.12	3.1	3.1								
Water addition	ml	400	500	600	700								
Molding water content	%	23.7	28.9	34.1	39.2								
Wet Density													
Mold No.	-	1	2	3	4	5							
Weight of Mold	gram	1893	1893	1893	1893								
Weight of wet soil + mold	gram	3460	3402	3479	3628								
Weight of wet soil, W_{wet}	gram	1567	1509	1586	1735								
Volume of Mold	cm ³	979	979	979	979								
Wet unit weight	gr/cm ³	1.600	1.541	1.619	1.772								
Water Content													
Container No.	-	1	2	1	2	1A	1B	2A	2B	3A	3B		
Weight of wet soil + container	gram	38.94	39.40	36.07	38.18	36.07	38.18	36.28	38.97				
Weight of dry soil + container	gram	30.98	29.34	31.20	32.93	30.13	32.33	30.98	29.34				
Weight of water	gram	7.96	10.06	4.87	5.25	5.94	5.85	5.3	9.63				
Weight of container	gram	8.22	8.08	8.21	8.08	8.21	8.08	8.22	8.08				
Weight of dry soil	gram	22.76	21.26	22.99	24.85	21.92	24.25	22.76	21.26				
Water Content	%	35.0	47.3	21.2	21.1	27.1	24.1	23.3	45.3				
Avg. water content	%	41.1		21.2		25.6		34.3					
Dry Density													
Weight of dry soil													
$W_{dry} = \frac{W_{wet}}{1 + \left(\frac{W}{100}\right)}$	gram	1110.20	1245.51	1262.63	1291.97								
Dry unit weight													
$\gamma_{dry} = \frac{W_{dry}}{V_{mould}}$	gr/cm ³	1.134	1.272	1.289	1.319								
$g_{zav} = gw/(w+(1/Gs))$	gr/cm ³	1.33	1.81	1.67	1.46								



Lampiran 15 Pengujian Permeabilitas Bentonit



LABORATORIUM KIMIA DAN KESUBURAN TANAH
DEPARTEMEN ILMU TANAH FAKULTAS PERTANIAN
UNIVERSITAS HASANUDDIN
Kampus Tanalanrea Jl. Perintis Kemerdekaan Km. 10, Makassar
Telp. (0411) 587 076, Fax (0411) 587 076

HASIL ANALISIS CONTOH TANAH

Nomor : 040.T.LKKT/2023
Permintaan : Buya Ibnu Fulqan
NIM : D131191014
Emanuela Prima Enjelin Tambila
NIM : D131191061
Asal Contoh/Lokasi : Fakultas Teknik, Univ. Hasanuddin
Objek : Uji Fisik
Tgl. Penerimaan : 4 Juli 2023
Tgl. Pengujian : 17 Juli 2023
Jumlah : 1 Contoh Tanah Utuh

Nomor Contoh			Contoh Tanah Utuh			
Urut	Laboratorium	Pengirim	Permeabilitas	BD	PD	Porositas
		BE	---cm/jam---	---gr/cm3---		---%---
1	EM 1	100	0,000017	-	-	-

Catatan :

Hasil pengujian ini hanya berlaku bagi contoh yang diuji dan tidak untuk diperbanyak
dimana pengambilan contoh tanah tersebut tidak dilakukan oleh pihak Laboratorium Kimia dan Kesuburan Tanah

Makassar, 31 Juli 2023
Laboratorium
Dr. Ir. H. Muh. Jayadi, MP
Nip. 19590926 198601 1 001



Lampiran 16 Pengujian Permeabilitas Komposisi Campuran *Fly Ash* dan Bentonit

LABORATORIUM KIMIA DAN KESUBURAN TANAH
DEPARTEMEN ILMU TANAH FAKULTAS PERTANIAN
UNIVERSITAS HASANUDDIN
Kampus Tatananraa Jl. Perintis Kemerdekaan Km.10, Makassar
Telp. (0411) 587 076, Fax (0411) 587 076

HASIL ANALISIS CONTOH TANAH

Nomor : 040.T.LKKT/2023
Permintaan : Emanuela Prima Enjelin Tambila
NIM : D131191061
Asal Contoh/Lokasi : Fakultas Teknik, Univ. Hasanuddin
Objek : Uji Fisik
Tgl. Penerimaan : 4 Juli 2023
Tgl. Pengujian : 17 Juli 2023
Jumlah : 6 Contoh Tanah Utuh

Nomor Contoh			Contoh Tanah Utuh			
Urut	Laboratorium	Pengirim	Permeabilitas	BD	PD	Porositas
			---cm/jam---	---gr/cm3---		---%---
1	EM 1	15-85	0,000022			
2	EM 2	30-70	0,00004			
3	EM 3	45-55	0,0009			
4	EM 4	55-45	0,0013			
5	EM 5	70-30	0,0025			
6	EM 6	85-15	0,028			

Catatan :

Hasil pengujian ini hanya berlaku bagi contoh yang diuji dan tidak untuk diperbanyak
dimana pengambilan contoh tanah tersebut tidak dilakukan oleh pihak Laboratorium Kimia dan Kesuburan Tanah

Makassar, 31 Juli 2023
Laboratorium

Dr. Ir. H. Muh. Jayadi, MP
Nip. 19590926 198601 1 001



Lampiran 17 Pengujian Kadar Timbal



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BADAN STANDARDISASI DAN KEBIJAKAN JASA INDUSTRI
LABORATORIUM PENGUJI BBSPJIHPMM
Jalan Prof. Dr. H. Abdurrahman Basalamah, MA No.28 Makassar 90231
Telp: (0411) 441207 Fax: (0411) 441135 Website: www.bbhp.kemenperin.go.id E-mail: bbhp@kemenperin.go.id



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Laboratorium Penguji
LP-118-2018

LAPORAN PENGUJIAN
Nomor : 1.5387/LU-BBSPJIHPMM/VIII/2023

Nomor Analisis : P. 4811
Tanggal Penerimaan : 27 Juli 2023
Nama Pelanggan : Emanuela Prima Enjelin Tambila
Alamat : Teknik Lingkungan, Fakultas Teknik, Universitas Hasanuddin
Nama Contoh : Air Lindi
Keterangan Contoh : Kemasan Botol, Keadaan Contoh Baik, Untuk Analisis Kimia
Pengambilan Contoh : -
Berita Acara : -
Tanggal Analisis : 28 Juli 2023
Tanggal Penerbitan : 18 Agustus 2023



Setelah dilakukan pengujian, diperoleh hasil sebagai berikut :

Kode Contoh	Parameter	Satuan	Hasil	Metode Uji
1090.1548.1	Timbal (Pb)	mg/L	0,142	SNI 06-6989.8-2004
1168.1660.1	Timbal (Pb)	mg/L	0,084	
1168.1660.2	Timbal (Pb)	mg/L	0,061	
1168.1660.3	Timbal (Pb)	mg/L	0,047	
1168.1660.4	Timbal (Pb)	mg/L	0,035	
1168.1660.5	Timbal (Pb)	mg/L	0,025	
1168.1660.6	Timbal (Pb)	mg/L	0,01	



Koordinator Inspeksi Teknis, Pengujian dan Kalibrasi
MAMANG



Lampiran 18 Surat Pengeluaran *Fly Ash*

 PT. INDONESIA POWER PLTU BARRU OMU	INTEGRATED MANAGEMENT SISTEM		NO. Dokumen : PMUJPBRU 17.00	
	UNIT JASA PEMBANGKIT PLTU BARRU		Tgl Terbit : 06/09/2016	
	SURAT IZIN PENGELUARAN BARANG		Revisi :	
			Hal : 1	
NO :IPM.UJPBRU/SIPB/17.00/2019 DAFTAR BARANG YANG DIKELUARKAN				
NO	NAMA / JENIS BARANG DAN LOKASI AMBIL	JUMLAH	SATUAN	KETERANGAN
1	Fly Ash	3	karung	Untuk Penelitian
Barro...12 Mei 2015				
Pihak yang Menyerahkan Barang PT. INDONESIA POWER UNIT PLTU BARRU OMU  <u>201 KILU</u>		Pihak yang menerima Barang  <u>Manajemen Barro K.T.</u>		
Asli : Arsip Bidang K3L Rangkap 1 : Tamu Rangkap 2 : User Terkait Rangkap 3 : Satpam				



Lampiran 19 Dokumentasi Penelitian



Diskusi di PLTU Barru



Mencatat hasil penimbangan



Menimbang cawan



Memasukkan bahan ke oven



Menyaring bahan



Memasukkan aquades





Pengujian Batas Cair



Pengujian Hidrometer



Pengujian Analisa Saringan



Penimbangan Berat Tertahan



ngan Berat Tanah di PAN



Saringan dan Berat Tanah Tertahan





Memasukkan Sampel Ke Oven



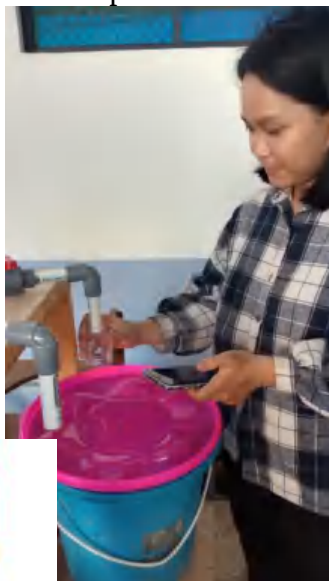
Pengujian Kompaksi



Hasil kompaksi untuk di oven



Pembuatan sampel untuk bak penyerap



ukuran debit aliran pipa



Pengambilan sampel air lindi





Lindi dimasukkan ke botol



Lindi dimasukkan ke jerigen



Sampel tanah pada reaktor



Memasukkan air lindi ke bak inlet

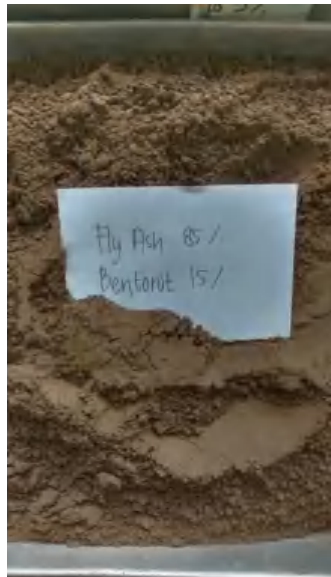


Reaktor dan hasil adsorpsi



Hasil adsorpsi

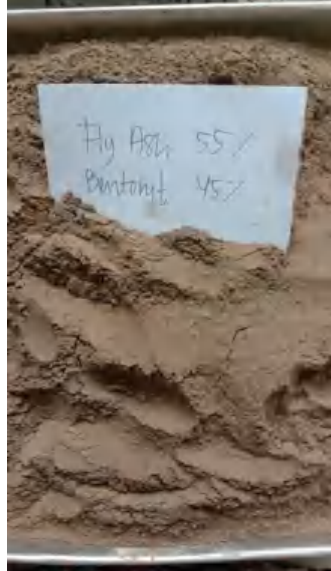




Fly Ash 85%+15% Bentonit



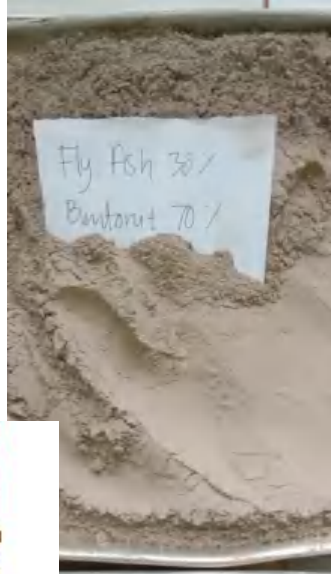
Fly Ash 70%+30% Bentonit



Fly Ash 55%+45% Bentonit



Fly Ash 45%+55% Bentonit



Fly Ash 30%+70% Bentonit



Fly Ash 15%+85% Bentonit

