

LAMPIRAN

Lampiran 1. Perhitungan Berat Jenis

Tabel 1 Kalibrasi piknometer

No	Uraian	Kadar Semen			
		0%		10%	
		1	2	1	2
1	Berat Piknometer Kosong (W_p)	23.08	24.95	25.33	26.86
2	Berat Piknometer + Air ($W_{pw,c}$)	73.41	75.55	75.48	77.33
3	Temperatur dalam piknometer (T)	29.1	29.1	29.5	29.5
4	Berat Volume air ($P_{w,c}$)	1.00	1.00	1.00	1.00
5	Volume Piknometer (V_p)	50.54	50.81	50.36	50.68

Tabel 2 Perhitungan berat jenis

No	Uraian	Kadar semen 0%		Kadar semen 10%	
		1	2	1	2
		1	Berat Piknometer Kosong (W_p)	23.08	24.95
2	Berat Piknometer + tanah kering (W_{ps})	33.09	34.96	35.35	36.88
3	Berat Piknometer + tanah + air ($W_{pws,t}$)	79.57	81.67	81.83	83.71
4	Berat Piknometer + Air ($W_{pw,t}$)	73.41	75.54	75.49	77.34
5	Temperatur (T)	29.4	29.5	28.8	28.8
6	Berat Jenis ($G_{s,t}$)	2.60	2.58	2.72	2.74
7	Berat Jenis pada $T=20^{\circ}C$ (G_s)	2.60	2.57	2.72	2.74
8	Berat Jenis Rata-rata (G_s)	2.58		2.73	

Tabel 3 Data lain

Temperatur saat pengujian (T_p)	28.8	28.8
Berat volume dalam T_p ($P_{w,c}$)	0.99601	0.99601
Koefisien Temperatur (K)	0.9978	0.9978

Tabel 4 Rapat massa air terhadap temperatur dan koefisien temperatur (K)

T (°C)	ρ_w (g/mL)	K	T (°C)	ρ_w (g/mL)	K	T (°C)	ρ_w (g/mL)	K	T (°C)	ρ_w (g/mL)	K
15.0	0.99910	1.00090	16.0	0.99895	1.00074	17.0	0.99878	1.00057	18.0	0.99860	1.00039
.1	0.99909	1.00088	.1	0.99893	1.00072	.1	0.99876	1.00055	.1	0.99858	1.00037
.2	0.99907	1.00087	.2	0.99891	1.00071	.2	0.99874	1.00054	.2	0.99856	1.00035
.3	0.99906	1.00085	.3	0.99890	1.00069	.3	0.99872	1.00052	.3	0.99854	1.00034
.4	0.99904	1.00084	.4	0.99888	1.00067	.4	0.99871	1.00050	.4	0.99852	1.00032
.5	0.99902	1.00082	.5	0.99886	1.00066	.5	0.99869	1.00048	.5	0.99850	1.00030
.6	0.99901	1.00080	.6	0.99885	1.00064	.6	0.99867	1.00047	.6	0.99848	1.00028
.7	0.99899	1.00079	.7	0.99883	1.00062	.7	0.99865	1.00045	.7	0.99847	1.00026
.8	0.99898	1.00077	.8	0.99881	1.00061	.8	0.99863	1.00043	.8	0.99845	1.00024
.9	0.99896	1.00076	.9	0.99879	1.00059	.9	0.99862	1.00041	.9	0.99843	1.00022
19.0	0.99841	1.00020	20.0	0.99821	1.00000	21.0	0.99799	0.99979	22.0	0.99777	0.99957
.1	0.99839	1.00018	.1	0.99819	0.99998	.1	0.99797	0.99977	.1	0.99775	0.99954
.2	0.99837	1.00016	.2	0.99816	0.99996	.2	0.99795	0.99974	.2	0.99773	0.99952
.3	0.99835	1.00014	.3	0.99814	0.99994	.3	0.99793	0.99972	.3	0.99770	0.99950
.4	0.99833	1.00012	.4	0.99812	0.99992	.4	0.99791	0.99970	.4	0.99768	0.99947
.5	0.99831	1.00010	.5	0.99810	0.99990	.5	0.99789	0.99968	.5	0.99766	0.99945
.6	0.99829	1.00008	.6	0.99808	0.99987	.6	0.99786	0.99966	.6	0.99764	0.99943
.7	0.99827	1.00006	.7	0.99806	0.99985	.7	0.99784	0.99963	.7	0.99761	0.99940
.8	0.99825	1.00004	.8	0.99804	0.99983	.8	0.99782	0.99961	.8	0.99759	0.99938
.9	0.99823	1.00002	.9	0.99802	0.99981	.9	0.99780	0.99959	.9	0.99756	0.99936
23.0	0.99754	0.99933	24.0	0.99730	0.99909	25.0	0.99705	0.99884	26.0	0.99679	0.99858
.1	0.99752	0.99931	.1	0.99727	0.99907	.1	0.99702	0.99881	.1	0.99676	0.99855
.2	0.99749	0.99929	.2	0.99725	0.99904	.2	0.99700	0.99879	.2	0.99673	0.99852
.3	0.99747	0.99926	.3	0.99723	0.99902	.3	0.99697	0.99876	.3	0.99671	0.99850
.4	0.99745	0.99924	.4	0.99720	0.99899	.4	0.99694	0.99874	.4	0.99668	0.99847
.5	0.99742	0.99921	.5	0.99717	0.99897	.5	0.99692	0.99871	.5	0.99665	0.99844
.6	0.99740	0.99919	.6	0.99715	0.99894	.6	0.99689	0.99868	.6	0.99663	0.99842
.7	0.99737	0.99917	.7	0.99712	0.99892	.7	0.99687	0.99866	.7	0.99660	0.99839
.8	0.99735	0.99914	.8	0.99710	0.99889	.8	0.99684	0.99863	.8	0.99657	0.99836
.9	0.99732	0.99912	.9	0.99707	0.99887	.9	0.99681	0.99860	.9	0.99654	0.99833
27.0	0.99652	0.99831	28.0	0.99624	0.99803	29.0	0.99595	0.99774	30.0	0.99565	0.99744
.1	0.99649	0.99828	.1	0.99621	0.99800	.1	0.99592	0.99771	.1	0.99562	0.99741
.2	0.99646	0.99825	.2	0.99618	0.99797	.2	0.99589	0.99768	.2	0.99559	0.99738
.3	0.99643	0.99822	.3	0.99615	0.99794	.3	0.99586	0.99765	.3	0.99556	0.99735
.4	0.99641	0.99820	.4	0.99612	0.99791	.4	0.99583	0.99762	.4	0.99553	0.99732
.5	0.99638	0.99817	.5	0.99609	0.99788	.5	0.99580	0.99759	.5	0.99550	0.99729
.6	0.99635	0.99814	.6	0.99607	0.99785	.6	0.99577	0.99756	.6	0.99547	0.99726
.7	0.99632	0.99811	.7	0.99604	0.99783	.7	0.99574	0.99753	.7	0.99544	0.99723
.8	0.99629	0.99808	.8	0.99601	0.99780	.8	0.99571	0.99750	.8	0.99541	0.99720
.9	0.99627	0.99806	.9	0.99598	0.99777	.9	0.99568	0.99747	.9	0.99538	0.99716

Keterangan: ρ_w = rapat massa air; T = temperatur, K = koefisien temperatur

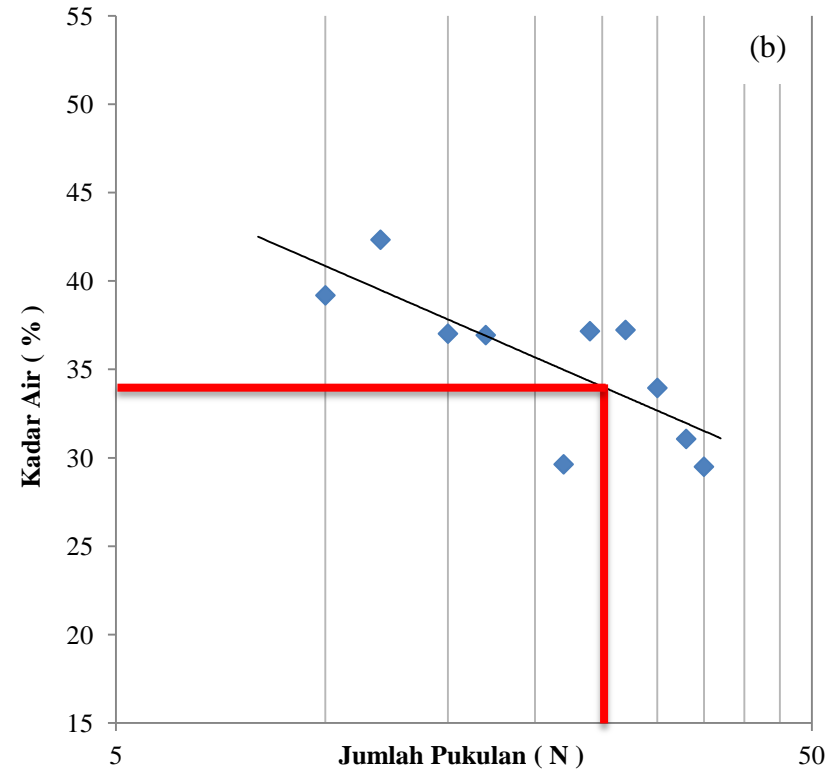
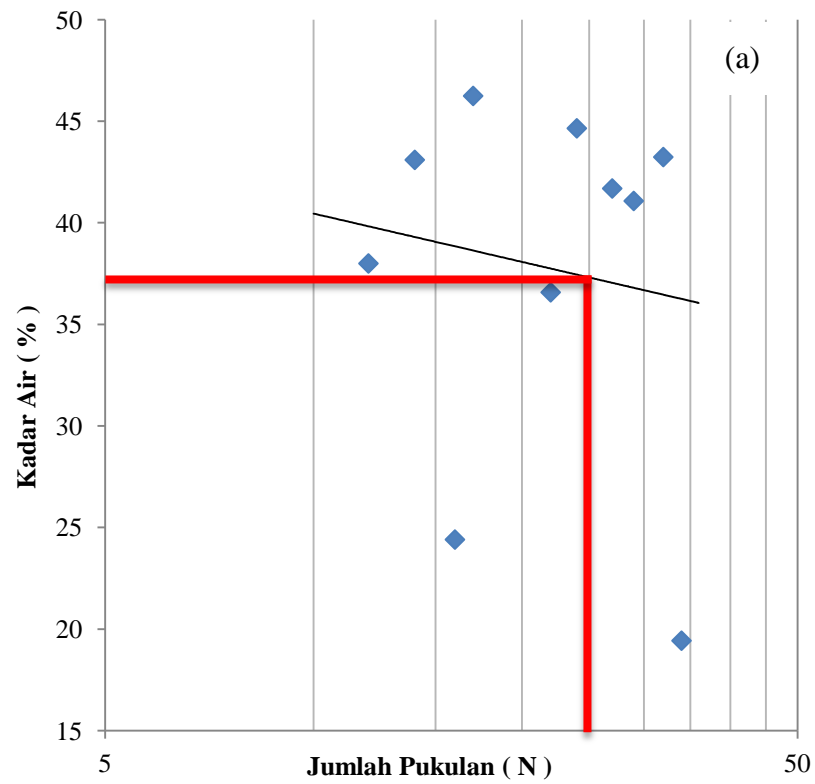
Lampiran 2. Perhitungan *Atteberg Limit*

Tabel 1 Perhitungan batas cair benda uji kadar semen 0%

No	Parameter	Kadar semen 0%									
		A	B	A	B	A	B	A	B	A	B
1	Jumlah pukulan	34	32	29	27	24	22	17	16	14	12
2	Nomor cawan	1	2	3	4	5	6	7	8	9	10
3	Berat cawan kosong (W1), g	9.01	8.99	9.25	10.3	8.89	9.13	9.06	9.11	9.81	9.43
4	Berat cawan + tanah basah (W2), g	25.98	29.73	29.55	29.13	29.56	28.66	29.87	26.75	29.8	28.97
5	Berat cawan + tanah kering (W3), g	23.22	23.47	23.64	23.59	23.18	23.43	23.29	23.29	23.78	23.59
6	Berat air, $W = W2 - W3$, g	2.76	6.26	5.91	5.54	6.38	5.23	6.58	3.46	6.02	5.38
7	Berat tanah kering, $W_s = W3 - W1$, g	14.21	14.48	14.39	13.29	14.29	14.30	14.23	14.18	13.97	14.16
8	Kadar air, $W = W_w / W_s$, %	19.42	43.23	41.07	41.69	44.65	36.57	46.24	24.40	43.09	37.99
9	Rata - rata kadar air, %	31.33		41.38		40.61		35.32		40.54	
10	Batas cair, %	37.5									
11	<i>Flow Index</i>	3.13									

Tabel 2 Perhitungan batas cair benda uji kadar semen 10%

No	Parameter	Kadar semen 10%									
		A	B	A	B	A	B	A	B	A	B
1	Jumlah pukulan	35	33	30	27	24	22	17	15	12	10
2	Nomor cawan	1	2	3	4	5	6	7	8	9	10
3	Berat cawan kosong (W1), g	9.35	9.49	9.37	9.45	9.18	9.27	9.23	9.22	10.53	9.47
4	Berat cawan + tanah basah (W2), g	29.55	30.25	30.6	30.5	30	29.66	30.4	30.69	32.69	30.5
5	Berat cawan + tanah kering (W3), g	24.95	25.33	25.22	24.79	24.36	25	24.69	24.89	26.1	24.58
6	Berat air, $W = W2 - W3$, g	4.60	4.92	5.38	5.71	5.64	4.66	5.71	5.80	6.59	5.92
7	Berat tanah kering, $W_s = W3 - W1$, g	15.60	15.84	15.85	15.34	15.18	15.73	15.46	15.67	15.57	15.11
8	Kadar air, $W = W_w / W_s$, %	29.49	31.06	33.94	37.22	37.15	29.62	36.93	37.01	42.32	39.18
9	Rata - rata kadar air, %	30.27		35.58		33.39		36.97		40.75	
10	Batas cair, %	34									
11	<i>Flow Index</i>	0.18									



Gambar 1 Kurva batas cair (a) kadar semen 0% (b) kadar semen 10%

Tabel 3 Perhitungan batas plastis

No	Uraian	Kadar semen 0%			Kadar semen 10%		
		1	2	3	1	2	3
1	Berat cawan kosong (W_1), g	10.4 1	11.8 2	8.97	9.13	9.37	9.33
2	Berat cawan + tanah basah (W_2), g	28.6	29.8 9	28.6 6	30.8 9	29.7 3	30.5 9
3	Berat cawan + tanah kering (W_3), g	25.3 4	26.6 6	25.0 6	24.7 4	25.2 2	25.3 8
4	Berat air (W_w), g	3.26	3.23	3.6	6.15	4.51	5.21
5	Berat tanah kering (W_s), g	14.9 3	14.8 4	16.0 9	15.6 1	15.8 5	16.0 5
6	Kadar air (W), %	21.8 4	21.7 7	22.3 7	39.4 0	28.4 5	32.4 6
7	Kadar air rata – rata, %	21.99			33.44		
8	Batas plastis, %	21.99			33.44		
9	Indek plastisitas, %	15.51			0.56		

Tabel 4 Kalibrasi cawan susut

No	Uraian	Hasil pengukuran		
		1	2	3
1	Berat cawan susut + pelat kaca (W_2), g	19.61	19.69	19.72
2	Berat cawan susut + pelat kaca + air (W_1), g	31.96	32.1	33.14
3	Berat air (W_w), g	12.35	12.41	13.42
4	Volume cawan susut, $v = w_w/\rho_w$, cm^3	12.35	12.41	13.42
5	Volume cawan susut rata-rata, cm^3	12.73		
6	Deviasi volume cawan susut, cm^3	0.23		

Tabel 5 Kalibrasi rapat massa lilin

No	Uraian	Hasil pengukuran		
		1	2	3
1	Diameter silinder lilin, d_{wp} , cm	4.74	4.75	4.68
2	Tinggi silinder lilin, h_{wp} , cm	1.27	1.18	1.23
3	Volume silinder lilin, cm^3	22.41	20.91	21.16
4	Volume silinder lilin rata-rata (V_{wp}), cm^3	21.49		
5	Berat silinder lilin (W_{wp}), g	19.06		
6	Rapat massa lilin ($\rho_x = w_{wp}/v_{wp}$), g/cm^3	0.89		

Tabel 6 Perhitungan batas susut

No	Uraian	Kadar semen 0%		Kadar semen 10%	
		1	2	1	2
1	Berat cawan susut (wsd), g	13.39	14.93	15.44	13.84
2	Berat cawan susut + pasta tanah (w sdw), g	35.76	37.87	42.05	36.88
3	Berat cawan susut + tanah kering, (w sdd), g	29.80	34.04	36.93	32.70
4	Berat tanah kering, (Ws = W sdd - W sd), g	16.41	19.11	21.49	18.86
5	Kadar air tanah awal (w), %	36.32	20.04	23.83	22.16
6	Berat tanah kering + lilin (Wsx), g	24.10	27.39	26.51	24.28
7	Berat tanah kering + lilin dalam air (W sxw), g	5.08	6.81	5.00	5.00
8	Berat air yang didesak oleh tanah kering + lilin (W wsx), g	19.02	20.58	21.51	19.28
9	Volume tanah kering + lilin (V dx), cm ³	19.02	20.58	21.51	19.28
10	Berat lapisan lilin pada tanah kering (Wx), g	7.69	8.28	5.02	5.42
11	Volume lapisan lilin pada tanah kering (Vx), cm ³	8.67	9.34	5.66	6.11
12	Volume tanah kering (Vd), cm ³	10.35	11.24	15.85	13.17
13	Batas susut (SL), %	21.83	12.28	38.35	24.50
14	Batas susut tanah rata-rata (SL), %	17.05		31.43	
15	Angka susut tanah (SR)	1.59		1.36	
16	Susut volumetric (VS)	0.31		0.1	
17	Susut linier (LS)	0.1		0.03	

Lampiran 3. Perhitungan Ukuran Butir Tanah

Tabel 1 Berat tanah

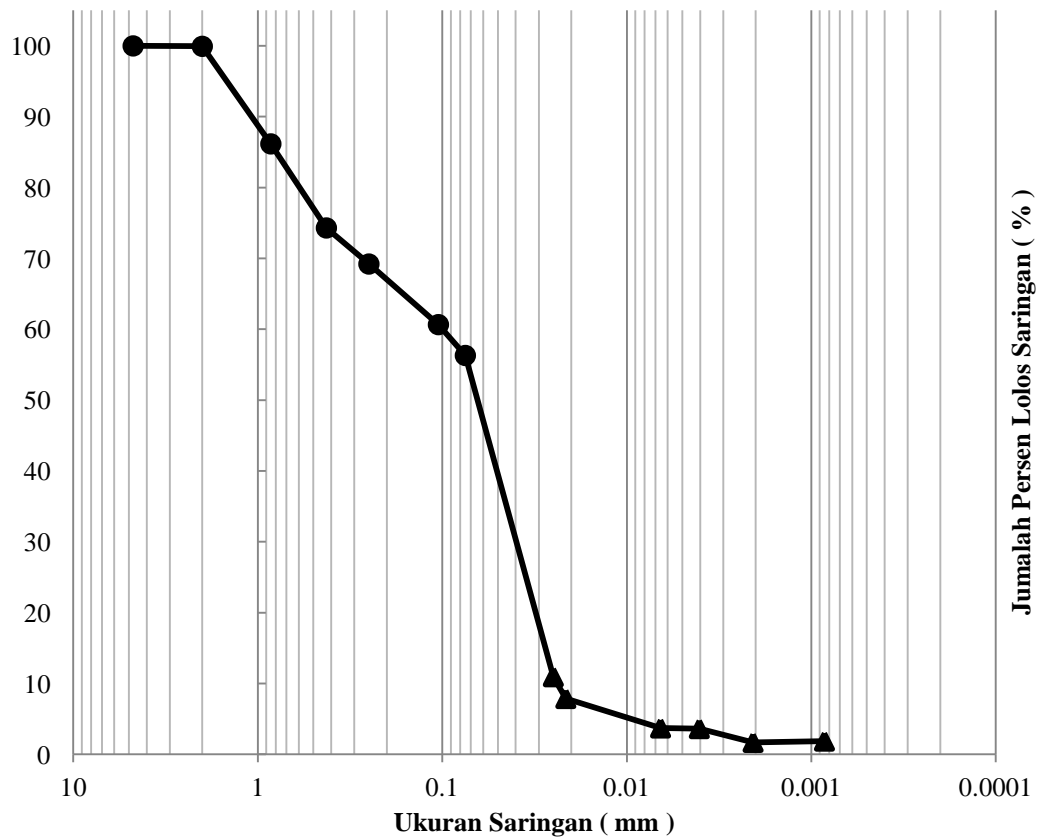
Uraian	Hasil	
	Kadar semen 0%	Kadar semen 10%
Berat total contoh tanah kering (w), g	65.00	65.00
Berat tanah berdiameter <0.075 mm (B2), g	8.20	32.27
Berat tanah berdiameter >0.075 mm (B1), g	56.80	32.73

Tabel 2 Hasil analisis pengendapan tanah kadar semen 0%

Waktu pembacaan t (menit)	Larutan tanah (R ₁)	Larutan reagent (R ₂)	Temperatur t(°C)	R' = R ₁ + m m=1	Kedalaman L (mm)	Konstanta	Diameter Butiran D (mm)	Skala Hidrometer R=R'-R ₂ +C _T	Persen Berat P	Adjust Percent Pa
2	0	-8	26.5	1	7.5682	0.01284	0.0249774	10.83	16.82	10.93
5	-4	-9	26.4	-3	7.0506	0.01802	0.0213985	7.79	12.10	7.87
30	-9	-10	26.1	-8	6.4036	0.01419	0.0065559	3.69	5.73	3.72
60	-9	-8	29.7	-8	6.4036	0.01240	0.004051	3.58	5.56	3.61
250	-9	-8	26.0	-8	6.4036	0.01291	0.0020662	1.65	2.56	1.67
1440	-10	-9	26.5	-9	6.2742	0.01284	0.0008475	1.83	2.84	1.84

Tabel 3 Hasil analisis saringan tanah kadar semen 0%

Nomor Saringan ASTM	Ukuran Butir (mm)	Berat Tertahan pada Saringan (g)	Persen Berat Tertahan pada Saringan (%)	Persen Lolos Saringan (%)
#4	4.47	0	0	100
10	2	0.04	0.06	99.94
20	0.85	8.95	13.77	86.17
40	0.425	7.71	11.86	74.31
60	0.25	3.31	5.09	69.22
140	0.105	5.56	8.55	60.66
200	0.075	2.83	4.35	56.31
pan	<0,075	28.4	43.69	36.60
Jumlah		56.8		



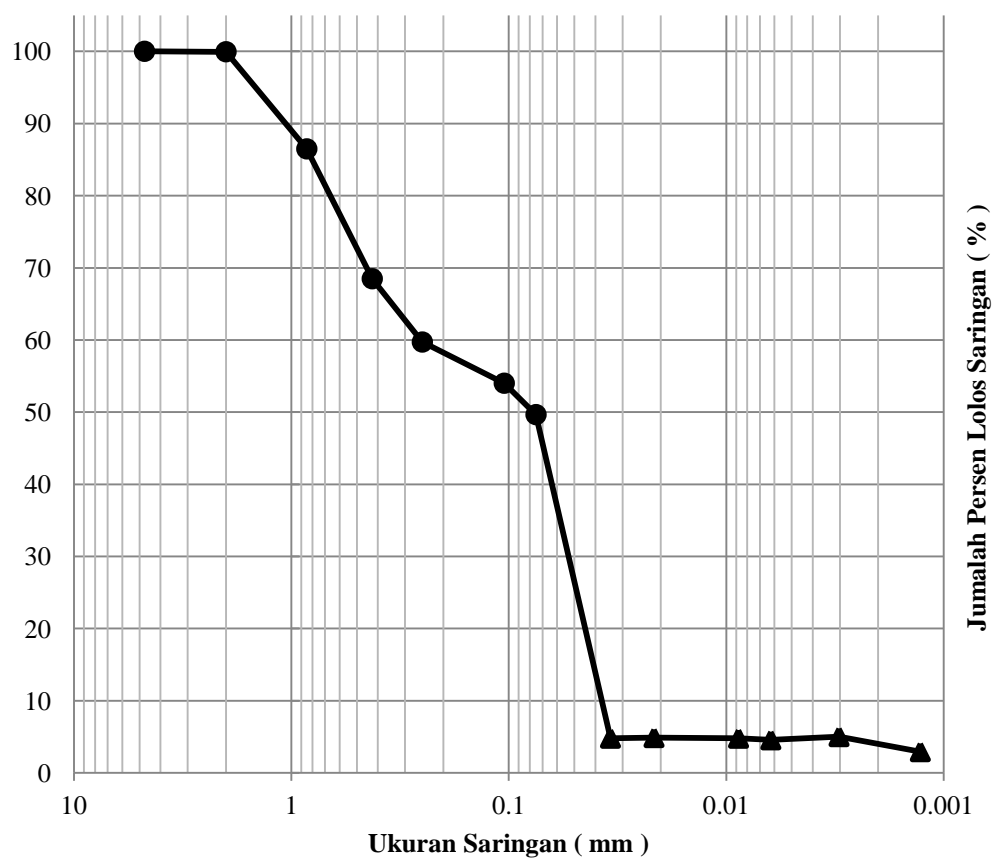
Gambar 1 Kurva gradasi ukuran butir tanah kadar semen 0%

Tabel 4 Hasil analisis pengendapangan tanah kadar semen 10%

Waktu pembacaan t (menit)	Larutan tanah (R ₁)	Larutan reagent (R ₂)	Temperature t(°C)	$R' = R_1 + m$ m=1	Kedalaman L (mm)	Konstanta	Diameter Butiran D (mm)	Skala Hidrometer $R=R'-R_2+C_T$	Persen Berat P	Adjust Percent Pa
2	-5	-6	28.5	-4	14.6430	0.01257	0.0340123	4.78	7.42	4.82
5	-5	-6	28.6	-4	14.6430	0.01255	0.021477	4.83	7.51	4.88
30	-5	-6	28.5	-4	14.6430	0.01257	0.0087819	4.78	7.42	4.82
60	-5	-6	28.1	-4	14.6430	0.01263	0.0062394	4.55	7.07	4.60
250	-5	-6	28.9	-4	14.6430	0.01251	0.0030276	5.00	7.76	5.04
1440	-5	-4	27.8	-4	14.6430	0.01267	0.0012776	2.90	4.51	2.93

Tabel 5 Hasil analisis saringan tanah kadar semen 10%

Nomor Saringan ASTM	Ukuran Butir (mm)	Berat Tertahan pada Saringan (g)	Persen Berat Tertahan pada Saringan (%)	Persen Lolos Saringan (%)
#4	4.47	0	0	100
10	2	0.04	0.06	99.94
20	0.85	8.75	13.46	86.48
40	0.425	11.7	18.00	68.48
60	0.25	5.7	8.77	59.71
140	0.105	3.71	5.71	54.00
200	0.075	2.83	4.35	49.65
pan	<0,075	32.73	50.35	32.27
Jumlah		32.73		



Gambar 2 Kurva gradasi ukuran butir tanah kadar semen 10%

Lampiran 4. Pengujian *Slake Durability*

Tabel 6 Hasil Pengujian *mudrock* tanpa semen

Kondisi			Kanan	Kiri
Sampel awal	basah (g)		483	466
	Kering oven (g)		399	382
Setelah Siklus 1	Kering oven (g)	Benda uji	66.5	7.18
		Endapan	200.68	282.31
Setelah Siklus 2	Kering oven (g)	Benda uji	50.94	3.29
		Endapan	11.4	3.35
Setelah Siklus 3	Kering oven (g)	Benda uji	41.35	2.04
		Endapan	5.36	1.34
Setelah Siklus 4	Kering oven (g)	Benda uji	33.95	1.46
		Endapan	4.23	0.29
Setelah Siklus 5	Kering oven (g)	Benda uji	28.14	0.95
		Endapan	4.25	0.52

Tabel 7 Analisis data pengujian *mudrock* tanpa semen

Drum	Kiri	Kanan
C	1603	1585
B	1985	1984
Wf2	1606.29	1635.94
Id2	0.861257	12.76692
Wf3	1605.04	1626.35
Id3	0.534031	10.36341
Wf4	1604.46	1618.95
Id4	0.382199	8.508772
Wf5	1603.95	1613.14
Id5	0.248691	7.052632

Tabel 8 Hasil Pengujian *mudrock* dengan kadar semen 10%

Kondisi			Kanan	Kiri
Sampel awal	basah (g)		473	480
	Kering oven (g)		442.16	446.55
Setelah Siklus 1	Kering oven (g)	Benda uji	383.08	382.66
		Endapan	53.24	59.56
Setelah Siklus 2	Kering oven (g)	Benda uji	351.26	349.05
		Endapan	20.91	22.55
Setelah Siklus 3	Kering oven (g)	Benda uji	333.68	320.08
		Endapan	18.02	19.07
Setelah Siklus 4	Kering oven (g)	Benda uji	299.08	295.28
		Endapan	15.76	16.69
Setelah Siklus 5	Kering oven (g)	Benda uji	277.97	274.05
		Endapan	14.89	13.76

Tabel 7 Analisis data pengujian *mudrock* dengan kadar semen 10%

Drum	Kiri	Kanan
C	1603	1585
B	2049.55	2027.16
Wf2	1952.05	1936.26
Id2	78.16594	79.44183
Wf3	1923.08	1918.68
Id3	71.67842	75.46589
Wf4	1898.28	1884.08
Id4	66.12473	67.64067
Wf5	1877.05	1862.97
Id5	61.37051	62.86638