

## 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 $T=20^\circ\text{C}$ ( $G_s$ )	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)	$\rho_w$ (g/mL)	K	T (°C)	$\rho_w$ (g/mL)	K	T (°C)	$\rho_w$ (g/mL)	K	T (°C)	$\rho_w$ (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:  $\rho_w$  = rapat massa air; T = temperatur, K = koefisien temperatur

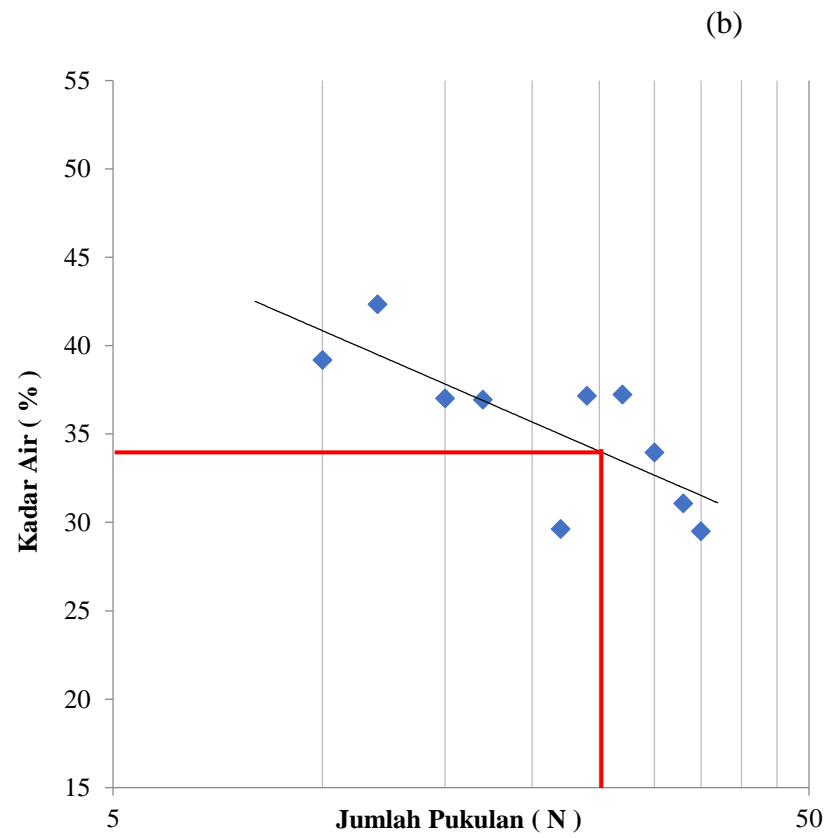
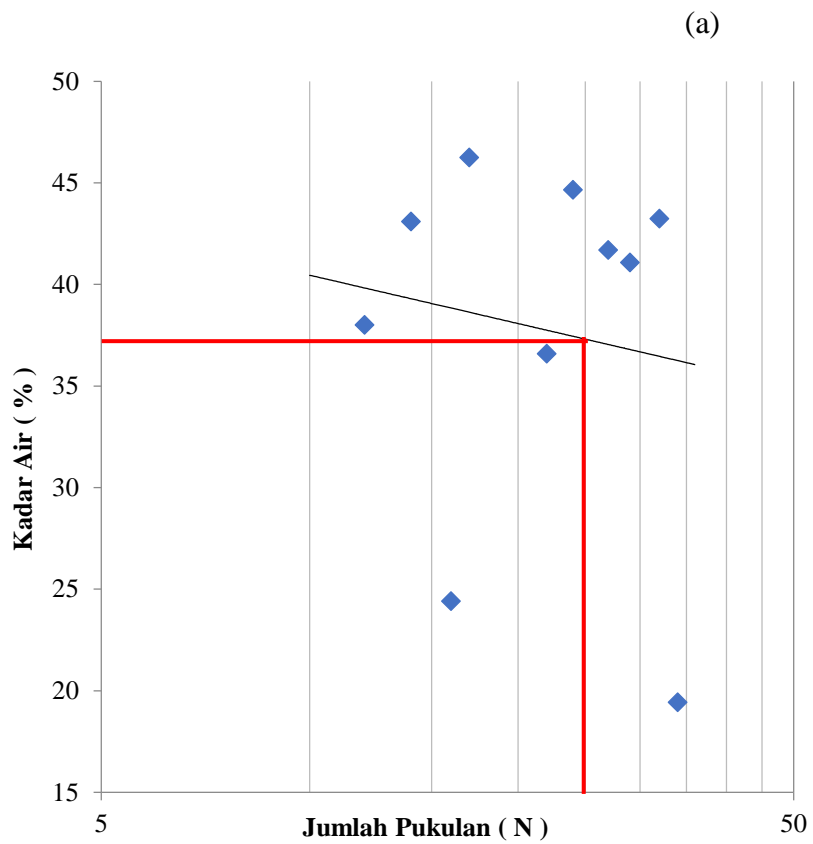
Lampiran 2. Perhitungan *Atteberg Limit*

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	10.41	11.82	8.97	9.13	9.37	9.33
2	Berat cawan + tanah basah ( $W_2$ ), g	28.6	29.89	28.66	30.89	29.73	30.59
3	Berat cawan + tanah kering ( $W_3$ ), g	25.34	26.66	25.06	24.74	25.22	25.38
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	14.93	14.84	16.09	15.61	15.85	16.05
6	Kadar air ( $W$ ), %	21.84	21.77	22.37	39.40	28.45	32.46
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 <sub>a</sub> ), 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 <sup>3</sup>	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 <sup>3</sup>	8.67	9.34	5.66	6.11
12	Volume tanah kering (Vd), cm <sup>3</sup>	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

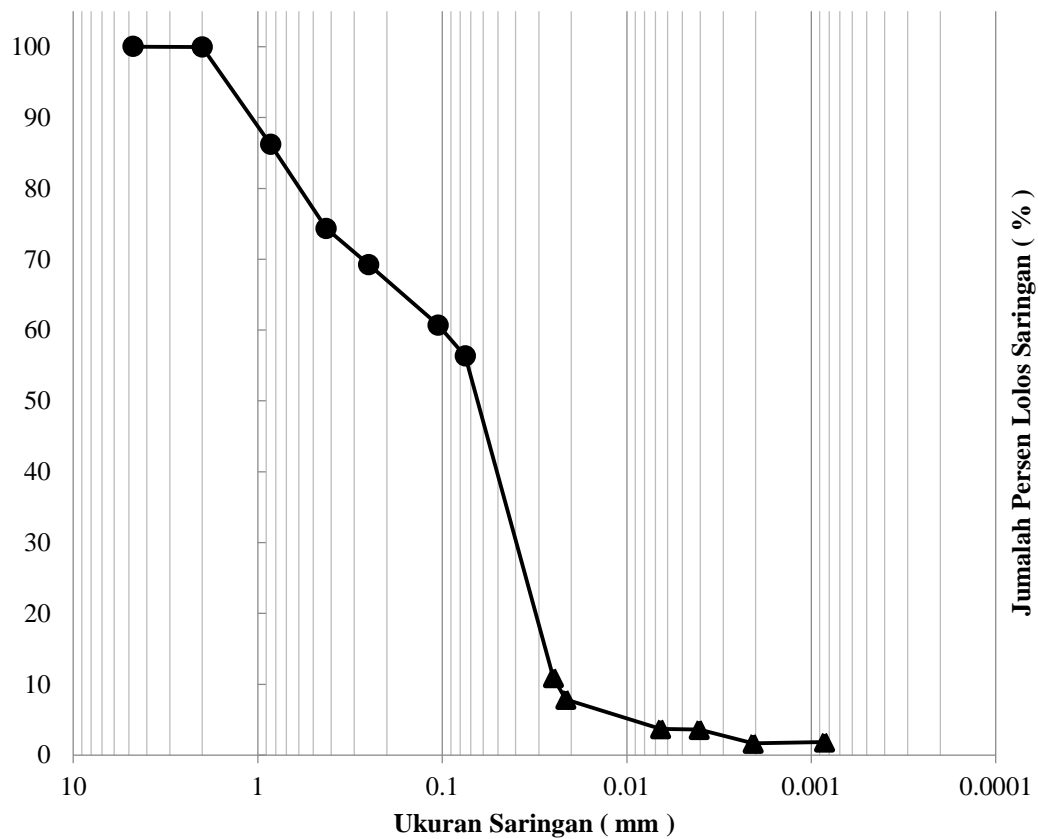
Tabel 2 Hasil analisis pengendapan tanah kadar semen 0%

Waktu pembacaan t (menit)	Larutan tanah (R <sub>1</sub> )	Larutan reagent (R <sub>2</sub> )	Temperatur t(°C)	R' = R <sub>1</sub> + m m=1	Kedalaman L (mm)	Konstanta	Diameter Butiran D (mm)	Skala Hidrometer R=R'-R <sub>2</sub> +C <sub>T</sub>	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		



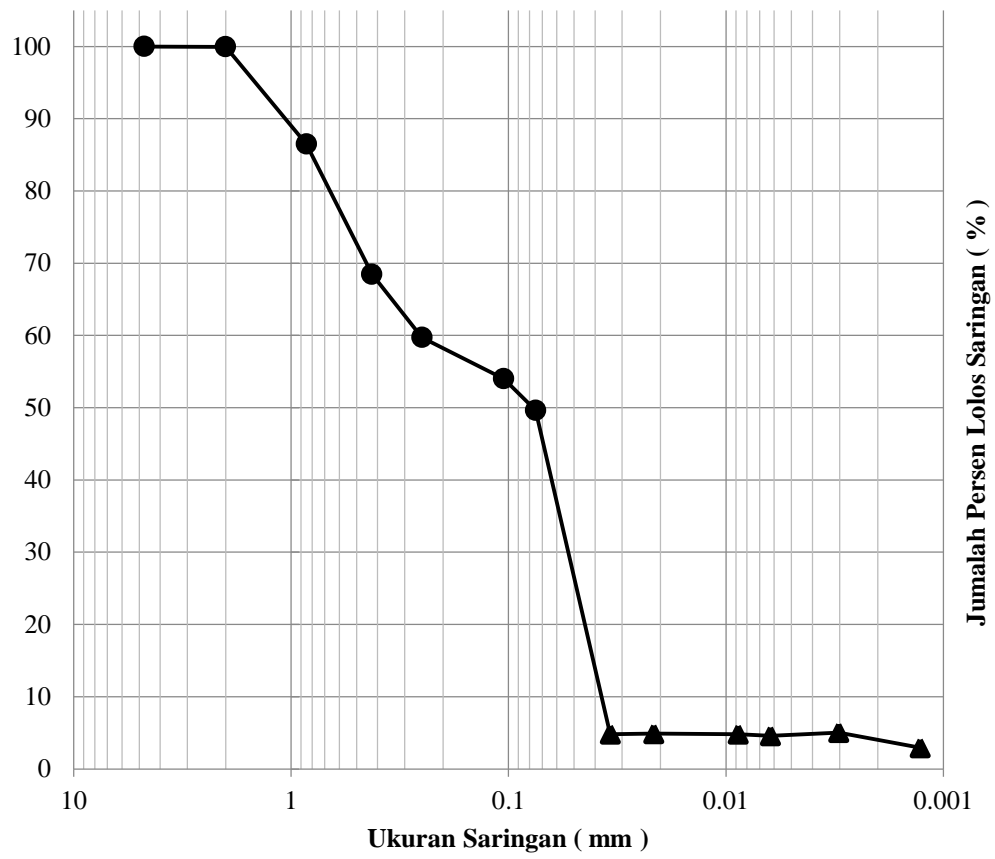
Gambar 1 Kurva gradasi ukuran butir tanah kadar semen 0%

Tabel 4 Hasil analisis pengendapan tanah kadar semen 10%

Waktu pembacaan t (menit)	Larutan tanah (R <sub>1</sub> )	Larutan reagent (R <sub>2</sub> )	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. Perhitungan *Slake Durability Index*

Tabel 1 Perhitungan  $I_{d1-5}$  Benda Uji Kiri

<b>Benda Uji (KIRI)</b>						
Kadar	Siklus Benda Uji	Tanah Kering (g)	Id1-5 (%)	Kadar	Siklus Endapan	Tanah Kering (g)
0.0%	Awal	436		0.0%	Awal	0
	Siklus I	39.45	9.048165138		Siklus I	396.55
	Siklus II	30.17	6.919724771		Siklus II	9.28
	Siklus III	24.48	5.614678899		Siklus III	5.69
	Siklus IV	21.51	4.933486239		Siklus IV	2.97
	Siklus V	19.39	4.447247706		Siklus V	2.12
10.0%	Awal	430		10.0%	Awal	0
	Siklus I	379.53	88.2627907		Siklus I	50.47
	Siklus II	335.52	78.02790698		Siklus II	44.01
	Siklus III	296.67	68.99302326		Siklus III	38.85
	Siklus IV	267.64	62.24186047		Siklus IV	29.03
	Siklus V	248.32	57.74883721		Siklus V	19.32

Tabel 1 Perhitungan  $I_{d1-5}$  Benda Uji Kanan

<b>Benda Uji (KANAN)</b>						
Kadar	Siklus Benda Uji	Tanah Kering (g)	Id1-5 (%)	Kadar	Siklus Endapan	Tanah Kering (g)
0.0%	Awal	433		0.0%	Awal	0
	Siklus I	38.74	8.946882217		Siklus I	394.26
	Siklus II	29.62	6.840646651		Siklus II	9.12
	Siklus III	23.77	5.48960739		Siklus III	5.85
	Siklus IV	19.99	4.616628176		Siklus IV	3.78
	Siklus V	17	3.926096998		Siklus V	2.99
10.0%	Awal	427		10.0%	Awal	0
	Siklus I	376.65	88.20843091		Siklus I	50.35
	Siklus II	336.15	78.7236534		Siklus II	40.5
	Siklus III	300.96	70.4824356		Siklus III	35.19
	Siklus IV	270.99	63.46370023		Siklus IV	29.97
	Siklus V	247.77	58.02576112		Siklus V	23.22

Tabel 3 Data  $I_{d1-5}$  Rata-Rata

Siklus	Kadar Semen (%)	
	0%	10%
0	100	100
1	8.997523677	88.23561081
2	6.880185711	78.37578019
3	5.552143145	69.73772943
4	4.775057207	62.85278035
5	4.186672352	57.88729917