CHAPTER VI

CONCLUSION AND SUGGESTION

6.1 Conclusion

This research was performed to investigate the influence of polyurethane resin percentage and curing time, on the shear strength of stabilized volcanic sand. The results of the research are presented on following conclusions:

1. The soil sample for this research is classified as sand.
2. The strength of sand at 0 day curing time, will decrease with increment of polyurethane resin contents. The worst shear strength properties reduced about 39.7% at specimens that consist sand + 8% polyurethane resin.
3. After 7 days of curing time, the shear strength of specimens will increase with increment of polyurethane resin contents.
4. The most shear strength belong to specimens that consist of sand + 8% polyurethane resin at 7 days curing time. The shear strength of this specimens are increased about 14.91%.

6.2 Suggestion

1. Make some variation of polyurethane resin content more than 8% to get more optimum additive material content.
2. Do the test with curing time variation 7 days and 14 days in order to analyze in more detail.
3. Use the other polyurethane resin type to know the characteristic of each brand.

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APPENDIX A

SIEVE ANALYSIS

Project : Sieve Analysis of Original Sand
Source : Merapi
Date : April, 14th 2016

Sieve No.	Grain Size (mm)	Retained Weight (gr)	Passed Weight (gr)	Passing % C/W x 100 (%)
No. 200	0.075	0.70	1.14	**1.14**
No. 140	0.106	22.58	1.84	**1.84**
No. 60	0.250	31.71	24.42	**24.42**
No. 40	0.425	31.90	56.13	**56.13**
No. 20	0.850	10.80	88.03	**88.03**
No. 10	2.000	2.17	98.83	**98.83**
Weight for d < 0.075 mm		1.14		
Total		**99.86**		

SPECIFIC GRAVITY TEST

Project : Specific Gravity of Original Sand

Source : Merapi

Date : April, 14-15th 2016

1	Picnometer		**III A**	**IV B**
2	Weight of Empty Picnometer	**W1 (gr)**	31.00	30.00
3	Weight of Picnometer + Dry Sand	**W2 (gr)**	60.00	57.00
4	Weight of Picnometer + Sand + Water	**W3 (gr)**	100.45	98.47
5	Weight of Water	**W4 (gr)**	82.18	81.19
6	Temperature (^{o}C)		27.50	27.50
7	A = W2-W1 (gr)		29.00	27.00
8	B = W3-W4 (gr)		18.27	17.28
9	C = A-B (gr)		10.73	9.72
10	Specific Gravity = A/C		2.7027	2.7778
11	Average Specific Gravity		**2.7402**	
12	Specific Gravity of Soil at 27.5 ^{o}C $G_{27.5^0C} = G_t \cdot \frac{G_{water}\ at\ t^0C}{G_{water}\ at\ 27{,}5^0C}$		**2.7402**	

APPENDIX B

DIRECT SHEAR TEST

Variable = Original Sand
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 128.93 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.68 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
3	25	0.00393	21	0.93	31.781	0.029	0.126
7	50	0.00786	27	1.19	31.779	0.038	0.126
11	75	0.01179	30	1.33	31.778	0.042	0.126
14	100	0.01572	32	1.42	31.777	0.045	0.126
19	125	0.01965	34	1.50	31.776	0.047	0.126
22	150	0.02358	34	1.50	31.774	0.047	0.126
27	175	0.02752	34	1.50	31.773	0.047	0.126
Max Value				**1.50**	**31.781**	**0.047**	**0.126**

Moisture Content Before Test

Code of Bowls		**0-B1**	**0-B2**
Weight of Empty Bowls	W_c	14.09	13.72
Weight of Bowls + Wet Soil	W_1	42.97	36.57
Weight of Bowls + Dry Soil	W_2	41.12	35.33
Weight of Water	$W_w = W_1 - W_2$	1.85	1.24
Weight of Dry Soil	$W_s = W_2 - W_c$	27.03	21.61
Moisture Content		6.84%	5.74%
Moisture Content Average		6.29%	

Moisture Content After Test 4kg

Code of Bowls		**0-A1/4**	**0-A2/4**
Weight of Empty Bowls	W_c	14.11	13.63
Weight of Bowls + Wet Soil	W_1	41.89	54.92
Weight of Bowls + Dry Soil	W_2	40.34	52.6
Weight of Water	$W_w = W_1 - W_2$	1.55	2.32
Weight of Dry Soil	$W_s = W_2 - W_c$	26.23	38.97
Moisture Content		5.91%	5.95%
Moisture Content Average		5.93%	

DIRECT SHEAR TEST

Variable = Original Sand
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 128.02 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.66 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	35	1.55	31.781	0.049	0.252
1	50	0.00786	55	2.43	31.779	0.077	0.252
4	75	0.01179	73	3.23	31.778	0.102	0.252
9	100	0.01572	84	3.71	31.777	0.117	0.252
13	125	0.01965	91	4.02	31.776	0.127	0.252
19	150	0.02358	98	4.33	31.774	0.136	0.252
25	175	0.02752	99	4.38	31.773	0.138	0.252
30	200	0.03145	100	4.42	31.772	0.139	0.252
36	225	0.03538	100	4.42	31.771	0.139	0.252
40	225	0.03538	100	4.42	31.771	0.139	0.252
Max Value				**4.42**	**31.781**	**0.139**	**0.252**

Moisture Content Before Test

Code of Bowls		**0-B1**	**0-B2**
Weight of Empty Bowls	W_c	14.09	13.72
Weight of Bowls + Wet Soil	W_1	42.97	36.57
Weight of Bowls + Dry Soil	W_2	41.12	35.33
Weight of Water	$W_w = W_1 - W_2$	1.85	1.24
Weight of Dry Soil	$W_s = W_2 - W_c$	27.03	21.61
Moisture Content		6.84%	5.74%
Moisture Content Average		6.29%	

Moisture Content After Test 8kg

Code of Bowls		**0-A1/4**	**0-A2/4**
Weight of Empty Bowls	W_c	13.87	14.51
Weight of Bowls + Wet Soil	W_1	32.43	42.54
Weight of Bowls + Dry Soil	W_2	31.32	41.43
Weight of Water	$W_w = W_1 - W_2$	1.11	1.11
Weight of Dry Soil	$W_s = W_2 - W_c$	17.45	26.92
Moisture Content		6.36%	4.12%
Moisture Content Average		5.24%	

DIRECT SHEAR TEST

Variable = Original Sand
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 137.44 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.79 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	43	1.90	31.781	0.060	0.378
1	50	0.00786	64	2.83	31.779	0.089	0.378
4	75	0.01179	81	3.58	31.778	0.113	0.378
5	100	0.01572	88	3.89	31.777	0.122	0.378
9	125	0.01965	97	4.29	31.776	0.135	0.378
13	150	0.02358	105	4.64	31.774	0.146	0.378
17	175	0.02752	109	4.82	31.773	0.152	0.378
22	200	0.03145	111	4.91	31.772	0.154	0.378
26	225	0.03538	112	4.95	31.771	0.156	0.378
31	250	0.03931	112	4.95	31.769	0.156	0.378
30	275	0.04324	112	4.95	31.768	0.156	0.378
Max Value				**4.95**	**31.781**	**0.156**	**0.378**

Moisture Content Before Test

Code of Bowls		**0-B1**	**0-B2**
Weight of Empty Bowls	W_c	14.09	13.72
Weight of Bowls + Wet Soil	W_1	42.97	36.57
Weight of Bowls + Dry Soil	W_2	41.12	35.33
Weight of Water	$W_w = W_1 - W_2$	1.85	1.24
Weight of Dry Soil	$W_s = W_2 - W_c$	27.03	21.61
Moisture Content		6.84%	5.74%
Moisture Content Average		6.29%	

Moisture Content After Test 12kg

Code of Bowls		**0-A1/4**	**0-A2/4**
Weight of Empty Bowls	W_c	9.2	8.84
Weight of Bowls + Wet Soil	W_1	34.32	36.53
Weight of Bowls + Dry Soil	W_2	33.14	35.16
Weight of Water	$W_w = W_1 - W_2$	1.18	1.37
Weight of Dry Soil	$W_s = W_2 - W_c$	23.94	26.32
Moisture Content		4.93%	5.21%
Moisture Content Average		5.07%	

APPENDIX C

DIRECT SHEAR TEST

Variable = Sand + 2 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 134.44 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.75 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
2	25	0.00393	7	0.31	31.781	0.010	0.126
5	50	0.00786	14	0.62	31.779	0.019	0.126
6	75	0.01179	15.5	0.69	31.778	0.022	0.126
7.5	100	0.01572	16	0.71	31.777	0.022	0.126
10	125	0.01965	17	0.75	31.776	0.024	0.126
11.5	150	0.02358	18	0.80	31.774	0.025	0.126
14	175	0.02752	16.5	0.73	31.773	0.023	0.126
16	200	0.03145	15.5	0.69	31.772	0.022	0.126
18	225	0.03538	15.5	0.69	31.771	0.022	0.126
20	250	0.03931	15.5	0.69	31.769	0.022	0.126
Max Value				**0.80**	**31.781**	**0.025**	**0.126**

Moisture Content Before Test

Code of Bowls		**0-2B1**	**0-2B2**
Weight of Empty Bowls	W_c	14.66	14.77
Weight of Bowls + Wet Soil	W_1	52.28	60.69
Weight of Bowls + Dry Soil	W_2	50.85	58.93
Weight of Water	$W_w = W_1 - W_2$	1.43	1.76
Weight of Dry Soil	$W_s = W_2 - W_c$	36.19	44.16
Moisture Content		3.95%	3.99%
Moisture Content Average		3.97%	

Moisture Content After Test 4kg

Code of Bowls		**0-2B1/4**	**0-2B2/4**
Weight of Empty Bowls	W_c	10.55	9.23
Weight of Bowls + Wet Soil	W_1	27.46	25.23
Weight of Bowls + Dry Soil	W_2	26.84	24.69
Weight of Water	$W_w = W_1 - W_2$	0.62	0.54
Weight of Dry Soil	$W_s = W_2 - W_c$	16.29	15.46
Moisture Content		3.81%	3.49%
Moisture Content Average		3.65%	

DIRECT SHEAR TEST

Variable = Sand + 2 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 144.83 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.88 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	21	0.93	31.781	0.029	0.252
5	50	0.00786	30	1.33	31.779	0.042	0.252
2	75	0.01179	38	1.68	31.778	0.053	0.252
5	100	0.01572	45	1.99	31.777	0.063	0.252
7	125	0.01965	50	2.21	31.776	0.070	0.252
10	150	0.02358	53	2.34	31.774	0.074	0.252
14	175	0.02752	54	2.39	31.773	0.075	0.252
18	200	0.03145	54.5	2.41	31.772	0.076	0.252
22	225	0.03538	55	2.43	31.771	0.077	0.252
25	250	0.03931	55	2.43	31.769	0.077	0.252
28	275	0.04324	55	2.43	31.768	0.077	0.252
Max Value				**2.43**	**31.781**	**0.077**	**0.252**

Moisture Content Before Test

Code of Bowls		**0-2B1**	**0-2B2**
Weight of Empty Bowls	W_c	14.66	14.77
Weight of Bowls + Wet Soil	W_1	52.28	60.69
Weight of Bowls + Dry Soil	W_2	50.85	58.93
Weight of Water	$W_w = W_1 - W_2$	1.43	1.76
Weight of Dry Soil	$W_s = W_2 - W_c$	36.19	44.16
Moisture Content		3.95%	3.99%
Moisture Content Average		3.97%	

Moisture Content After Test 8kg

Code of Bowls		**0-2B1/8**	**0-2B2/8**
Weight of Empty Bowls	W_c	14.11	13.63
Weight of Bowls + Wet Soil	W_1	34.75	30.43
Weight of Bowls + Dry Soil	W_2	34.02	29.88
Weight of Water	$W_w = W_1 - W_2$	0.73	0.55
Weight of Dry Soil	$W_s = W_2 - W_c$	19.91	16.25
Moisture Content		3.67%	3.38%
Moisture Content Average		3.53%	

DIRECT SHEAR TEST

Variable = Sand + 2 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 133.30 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.73 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	25	1.11	31.781	0.035	0.378
-0.5	50	0.00786	50	2.21	31.779	0.070	0.378
-0.5	75	0.01179	65	2.87	31.778	0.090	0.378
0	100	0.01572	78	3.45	31.777	0.109	0.378
0	125	0.01965	85	3.76	31.776	0.118	0.378
5	150	0.02358	95	4.20	31.774	0.132	0.378
7	175	0.02752	100	4.42	31.773	0.139	0.378
10	200	0.03145	104	4.60	31.772	0.145	0.378
13	225	0.03538	106	4.69	31.771	0.148	0.378
16	250	0.03931	108	4.78	31.769	0.150	0.378
19	275	0.04324	110	4.86	31.768	0.153	0.378
22	300	0.04717	109	4.82	31.767	0.152	0.378
24	325	0.05110	109	4.82	31.766	0.152	0.378
Max Value				**4.86**	**31.781**	**0.153**	**0.378**

Moisture Content Before Test

Code of Bowls		**0-2B1**	**0-2B2**
Weight of Empty Bowls	W_c	14.66	14.77
Weight of Bowls + Wet Soil	W_1	52.28	60.69
Weight of Bowls + Dry Soil	W_2	50.85	58.93
Weight of Water	$W_w = W_1 - W_2$	1.43	1.76
Weight of Dry Soil	$W_s = W_2 - W_c$	36.19	44.16
Moisture Content		3.95%	3.99%
Moisture Content Average		3.97%	

Moisture Content After Test 12kg

Code of Bowls		**0-2B1/12**	**0-2B2/12**
Weight of Empty Bowls	W_c	9.47	10.34
Weight of Bowls + Wet Soil	W_1	37.15	33.67
Weight of Bowls + Dry Soil	W_2	36.23	32.95
Weight of Water	$W_w = W_1 - W_2$	0.92	0.72
Weight of Dry Soil	$W_s = W_2 - W_c$	26.76	22.61
Moisture Content		3.44%	3.18%
Moisture Content Average		3.31%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 143.80 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.87 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
2	25	0.00393	9	0.40	31.781	0.013	0.126
5	50	0.00786	19	0.84	31.779	0.026	0.126
7	75	0.01179	20	0.88	31.778	0.028	0.126
9	100	0.01572	23	1.02	31.777	0.032	0.126
13	125	0.01965	23	1.02	31.776	0.032	0.126
15	150	0.02358	23	1.02	31.774	0.032	0.126
Max Value				**1.02**	**31.781**	**0.032**	**0.126**

Moisture Content Before Test

Code of Bowls		**0-4B1**	**0-4B2**
Weight of Empty Bowls	W_c	13.97	14.74
Weight of Bowls + Wet Soil	W_1	55.61	61.95
Weight of Bowls + Dry Soil	W_2	53.53	59.58
Weight of Water	$W_w = W_1 - W_2$	2.08	2.37
Weight of Dry Soil	$W_s = W_2 - W_c$	39.56	44.84
Moisture Content		5.26%	5.29%
Moisture Content Average		5.27%	

Moisture Content After Test 4kg

Code of Bowls		**0-4B1/4**	**0-4B2/4**
Weight of Empty Bowls	W_c	9.37	8.84
Weight of Bowls + Wet Soil	W_1	42.53	38.74
Weight of Bowls + Dry Soil	W_2	40.87	37.29
Weight of Water	$W_w = W_1 - W_2$	1.66	1.45
Weight of Dry Soil	$W_s = W_2 - W_c$	31.5	28.45
Moisture Content		5.27%	5.10%
Moisture Content Average		5.18%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 140.92 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.83 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	13	0.57	31.781	0.018	0.252
0	50	0.00786	23	1.02	31.779	0.032	0.252
-1	75	0.01179	31	1.37	31.778	0.043	0.252
-1	100	0.01572	39	1.72	31.777	0.054	0.252
0	125	0.01965	47	2.08	31.776	0.065	0.252
0	150	0.02358	47	2.08	31.774	0.065	0.252
1	175	0.02752	50	2.21	31.773	0.070	0.252
3	200	0.03145	53	2.34	31.772	0.074	0.252
4	225	0.03538	54	2.39	31.771	0.075	0.252
6	250	0.03931	55	2.43	31.769	0.077	0.252
8	275	0.04324	56	2.48	31.768	0.078	0.252
10	300	0.04717	56	2.48	31.767	0.078	0.252
11	325	0.05110	56	2.48	31.766	0.078	0.252
Max Value				**2.48**	**31.781**	**0.078**	**0.252**

Moisture Content Before Test

Code of Bowls		**0-4B1**	**0-4B2**
Weight of Empty Bowls	W_c	13.97	14.74
Weight of Bowls + Wet Soil	W_1	55.61	61.95
Weight of Bowls + Dry Soil	W_2	53.53	59.58
Weight of Water	$W_w = W_1 - W_2$	2.08	2.37
Weight of Dry Soil	$W_s = W_2 - W_c$	39.56	44.84
Moisture Content		5.26%	5.29%
Moisture Content Average		5.27%	

Moisture Content After Test 8kg

Code of Bowls		**0-4B1/8**	**0-4B2/8**
Weight of Empty Bowls	W_c	10.23	9.87
Weight of Bowls + Wet Soil	W_1	37.92	34.67
Weight of Bowls + Dry Soil	W_2	36.58	33.47
Weight of Water	$W_w = W_1 - W_2$	1.34	1.2
Weight of Dry Soil	$W_s = W_2 - W_c$	26.35	23.6
Moisture Content		5.09%	5.08%
Moisture Content Average		5.09%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 146.45 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.90 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	42	1.86	31.781	0.058	0.378
1	50	0.00786	64	2.83	31.779	0.089	0.378
3	75	0.01179	75	3.32	31.778	0.104	0.378
5	100	0.01572	84	3.71	31.777	0.117	0.378
8	125	0.01965	90	3.98	31.776	0.125	0.378
12	150	0.02358	94	4.16	31.774	0.131	0.378
15	175	0.02752	96	4.25	31.773	0.134	0.378
19	200	0.03145	96	4.25	31.772	0.134	0.378
22	225	0.03538	96	4.25	31.771	0.134	0.378
Max Value				**4.25**	**31.781**	**0.134**	**0.378**

Moisture Content Before Test

Code of Bowls		**0-4B1**	**0-4B2**
Weight of Empty Bowls	W_c	13.97	14.74
Weight of Bowls + Wet Soil	W_1	55.61	61.95
Weight of Bowls + Dry Soil	W_2	53.53	59.58
Weight of Water	$W_w = W_1 - W_2$	2.08	2.37
Weight of Dry Soil	$W_s = W_2 - W_c$	39.56	44.84
Moisture Content		5.26%	5.29%
Moisture Content Average		5.27%	

Moisture Content After Test 12kg

Code of Bowls		**0-4B1/12**	**0-4B2/12**
Weight of Empty Bowls	W_c	14.32	14.09
Weight of Bowls + Wet Soil	W_1	45.07	41.73
Weight of Bowls + Dry Soil	W_2	43.61	40.36
Weight of Water	$W_w = W_1 - W_2$	1.46	1.37
Weight of Dry Soil	$W_s = W_2 - W_c$	29.29	26.27
Moisture Content		4.98%	5.22%
Moisture Content Average		5.10%	

DIRECT SHEAR TEST

Variable = Sand + 6 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 146.02 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.90 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
3	25	0.00393	18	0.80	31.781	0.025	0.126
7	50	0.00786	21	0.93	31.779	0.029	0.126
10	75	0.01179	23	1.02	31.778	0.032	0.126
15	100	0.01572	25	1.11	31.777	0.035	0.126
19	125	0.01965	25	1.11	31.776	0.035	0.126
22	150	0.02358	25	1.11	31.774	0.035	0.126
Max Value				**1.11**	**31.781**	**0.035**	**0.126**

Moisture Content Before Test

Code of Bowls		**0-6B1**	**0-6B2**
Weight of Empty Bowls	W_c	24.39	24.36
Weight of Bowls + Wet Soil	W_1	68.66	74.79
Weight of Bowls + Dry Soil	W_2	66.59	72.41
Weight of Water	$W_w = W_1 - W_2$	2.07	2.38
Weight of Dry Soil	$W_s = W_2 - W_c$	42.2	48.05
Moisture Content		4.91%	4.95%
Moisture Content Average		4.93%	

Moisture Content After Test 4kg

Code of Bowls		**0-6B1/4**	**0-6B2/4**
Weight of Empty Bowls	W_c	10.65	9.81
Weight of Bowls + Wet Soil	W_1	36.81	42.33
Weight of Bowls + Dry Soil	W_2	35.74	40.82
Weight of Water	$W_w = W_1 - W_2$	1.07	1.51
Weight of Dry Soil	$W_s = W_2 - W_c$	25.09	31.01
Moisture Content		4.26%	4.87%
Moisture Content Average		4.57%	

DIRECT SHEAR TEST

Variable = Sand + 6 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 143.25 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.86 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	23	1.02	31.781	0.032	0.252
-1	50	0.00786	33	1.46	31.779	0.046	0.252
-1	75	0.01179	43	1.90	31.778	0.060	0.252
0	100	0.01572	52	2.30	31.777	0.072	0.252
2	125	0.01965	58	2.56	31.776	0.081	0.252
4	150	0.02358	60	2.65	31.774	0.084	0.252
5	175	0.02752	62	2.74	31.773	0.086	0.252
7	200	0.03145	63	2.79	31.772	0.088	0.252
10	225	0.03538	63	2.79	31.771	0.088	0.252
Max Value				**2.79**	**31.781**	**0.088**	**0.252**

Moisture Content Before Test

Code of Bowls		**0-6B1**	**0-6B2**
Weight of Empty Bowls	W_c	24.39	24.36
Weight of Bowls + Wet Soil	W_1	68.66	74.79
Weight of Bowls + Dry Soil	W_2	66.59	72.41
Weight of Water	$W_w = W_1 - W_2$	2.07	2.38
Weight of Dry Soil	$W_s = W_2 - W_c$	42.2	48.05
Moisture Content		4.91%	4.95%
Moisture Content Average		4.93%	

Moisture Content After Test 8kg

Code of Bowls		**0-6B1/8**	**0-6B2/8**
Weight of Empty Bowls	W_c	10.51	10.71
Weight of Bowls + Wet Soil	W_1	38.22	41.72
Weight of Bowls + Dry Soil	W_2	36.95	40.38
Weight of Water	$W_w = W_1 - W_2$	1.27	1.34
Weight of Dry Soil	$W_s = W_2 - W_c$	26.44	29.67
Moisture Content		4.80%	4.52%
Moisture Content Average		4.66%	

DIRECT SHEAR TEST

Variable = Sand + 6 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 146.42 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.90 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	35	1.55	31.781	0.049	0.378
1	50	0.00786	60	2.65	31.779	0.083	0.378
3	75	0.01179	75	3.32	31.778	0.104	0.378
6	100	0.01572	82	3.63	31.777	0.114	0.378
10	125	0.01965	90	3.98	31.776	0.125	0.378
13	150	0.02358	94	4.16	31.774	0.131	0.378
17	175	0.02752	95	4.20	31.773	0.132	0.378
20	200	0.03145	95	4.20	31.772	0.132	0.378
Max Value				**4.20**	**31.781**	**0.132**	**0.378**

Moisture Content Before Test

Code of Bowls		**0-6B1**	**0-6B2**
Weight of Empty Bowls	W_c	24.39	24.36
Weight of Bowls + Wet Soil	W_1	68.66	74.79
Weight of Bowls + Dry Soil	W_2	66.59	72.41
Weight of Water	$W_w = W_1 - W_2$	2.07	2.38
Weight of Dry Soil	$W_s = W_2 - W_c$	42.2	48.05
Moisture Content		4.91%	4.95%
Moisture Content Average		4.93%	

Moisture Content After Test 12kg

Code of Bowls		**0-6B1/12**	**0-6B2/12**
Weight of Empty Bowls	W_c	9.18	10.31
Weight of Bowls + Wet Soil	W_1	43.26	42.48
Weight of Bowls + Dry Soil	W_2	41.88	41.08
Weight of Water	$W_w = W_1 - W_2$	1.38	1.4
Weight of Dry Soil	$W_s = W_2 - W_c$	32.7	30.77
Moisture Content		4.22%	4.55%
Moisture Content Average		4.39%	

DIRECT SHEAR TEST

Variable = Sand + 8 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 155.60 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 2.02 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	9	0.40	31.781	0.013	0.126
3	50	0.00786	15	0.66	31.779	0.021	0.126
8	75	0.01179	21	0.93	31.778	0.029	0.126
12	100	0.01572	25	1.11	31.777	0.035	0.126
16	125	0.01965	26	1.15	31.776	0.036	0.126
21	150	0.02358	28	1.24	31.774	0.039	0.126
26	175	0.02752	28	1.24	31.773	0.039	0.126
30	200	0.03145	28	1.24	31.772	0.039	0.126
34	225	0.03538	26	1.15	31.771	0.036	0.126
Max Value				**1.24**	**31.781**	**0.039**	**0.126**

Moisture Content Before Test

Code of Bowls		**0-8B1**	**0-8B2**
Weight of Empty Bowls	W_c	23.98	25.06
Weight of Bowls + Wet Soil	W_1	58.14	61.76
Weight of Bowls + Dry Soil	W_2	56.29	59.52
Weight of Water	$W_w = W_1 - W_2$	1.85	2.24
Weight of Dry Soil	$W_s = W_2 - W_c$	32.31	34.46
Moisture Content		5.73%	6.50%
Moisture Content Average		6.11%	

Moisture Content After Test 4kg

Code of Bowls		**0-8B1/4**	**0-8B2/4**
Weight of Empty Bowls	W_c	9.36	9.78
Weight of Bowls + Wet Soil	W_1	35.72	36.24
Weight of Bowls + Dry Soil	W_2	34.22	34.78
Weight of Water	$W_w = W_1 - W_2$	1.5	1.46
Weight of Dry Soil	$W_s = W_2 - W_c$	24.86	25
Moisture Content		6.03%	5.84%
Moisture Content Average		5.94%	

DIRECT SHEAR TEST

Variable = Sand + 8 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 155.37 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 2.02 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
1	25	0.00393	10	0.44	31.781	0.014	0.252
3	50	0.00786	16	0.71	31.779	0.022	0.252
5	75	0.01179	25	1.11	31.778	0.035	0.252
8	100	0.01572	30	1.33	31.777	0.042	0.252
10	125	0.01965	35	1.55	31.776	0.049	0.252
13	150	0.02358	40	1.77	31.774	0.056	0.252
17	175	0.02752	44	1.95	31.773	0.061	0.252
21	200	0.03145	45	1.99	31.772	0.063	0.252
25	225	0.03538	47	2.08	31.771	0.065	0.252
30	225	0.03538	50	2.21	31.771	0.070	0.252
34	250	0.03931	50	2.21	31.769	0.070	0.252
39	275	0.04324	50	2.21	31.768	0.070	0.252
Max Value				**2.21**	**31.781**	**0.070**	**0.252**

Moisture Content Before Test

Code of Bowls		**0-8B1**	**0-8B2**
Weight of Empty Bowls	W_c	23.98	25.06
Weight of Bowls + Wet Soil	W_1	58.14	61.76
Weight of Bowls + Dry Soil	W_2	56.29	59.52
Weight of Water	$W_w = W_1 - W_2$	1.85	2.24
Weight of Dry Soil	$W_s = W_2 - W_c$	32.31	34.46
Moisture Content		5.73%	6.50%
Moisture Content Average		6.11%	

Moisture Content After Test 8kg

Code of Bowls		**0-8B1/8**	**0-8B2/8**
Weight of Empty Bowls	W_c	10.13	9.26
Weight of Bowls + Wet Soil	W_1	44.79	40.12
Weight of Bowls + Dry Soil	W_2	42.91	38.41
Weight of Water	$W_w = W_1 - W_2$	1.88	1.71
Weight of Dry Soil	$W_s = W_2 - W_c$	32.78	29.15
Moisture Content		5.74%	5.87%
Moisture Content Average		5.80%	

DIRECT SHEAR TEST

Variable = Sand + 8 % PU
Curing Time = 0 Day
Date = April , 26th 2016
Sample Weight = 147.45 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.92 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
-2	25	0.00393	10	0.44	31.781	0.014	0.378
-4	50	0.00786	20	0.88	31.779	0.028	0.378
-5	75	0.01179	33	1.46	31.778	0.046	0.378
-5	100	0.01572	40	1.77	31.777	0.056	0.378
-5	125	0.01965	46	2.03	31.776	0.064	0.378
-6	150	0.02358	53	2.34	31.774	0.074	0.378
-4	175	0.02752	57	2.52	31.773	0.079	0.378
-2	200	0.03145	61	2.70	31.772	0.085	0.378
0	225	0.03538	64	2.83	31.771	0.089	0.378
3	250	0.03931	66	2.92	31.769	0.092	0.378
6	275	0.04324	67	2.96	31.768	0.093	0.378
8	300	0.04717	68	3.01	31.767	0.095	0.378
11	325	0.05110	69	3.05	31.766	0.096	0.378
12	350	0.05503	70	3.10	31.764	0.097	0.378
13	375	0.05896	69	3.05	31.763	0.096	0.378
15	400	0.06289	69	3.05	31.762	0.096	0.378
16	425	0.06682	69	3.05	31.761	0.096	0.378
Max Value				**3.10**	**31.781**	**0.097**	**0.378**

Moisture Content Before Test

Code of Bowls		**0-8B1**	**0-8B2**
Weight of Empty Bowls	W_c	23.98	25.06
Weight of Bowls + Wet Soil	W_1	58.14	61.76
Weight of Bowls + Dry Soil	W_2	56.29	59.52
Weight of Water	$W_w = W_1 - W_2$	1.85	2.24
Weight of Dry Soil	$W_s = W_2 - W_c$	32.31	34.46
Moisture Content		5.73%	6.50%
Moisture Content Average		6.11%	

Moisture Content After Test 12kg

Code of Bowls		**0-8B1/12**	**0-8B2/12**
Weight of Empty Bowls	W_c	13.42	14.11
Weight of Bowls + Wet Soil	W_1	41.64	43.93
Weight of Bowls + Dry Soil	W_2	40.17	42.31
Weight of Water	$W_w = W_1 - W_2$	1.47	1.62
Weight of Dry Soil	$W_s = W_2 - W_c$	26.75	28.2
Moisture Content		5.50%	5.74%
Moisture Content Average		5.62%	

DIRECT SHEAR TEST

Variable = Sand + 2 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 130.25 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.67 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	12	0.53	31.781	0.017	0.126
0	50	0.00786	20	0.88	31.779	0.028	0.126
0	75	0.01179	25	1.11	31.778	0.035	0.126
2	100	0.01572	30	1.33	31.777	0.042	0.126
3	125	0.01965	34	1.50	31.776	0.047	0.126
4	150	0.02358	38	1.68	31.774	0.053	0.126
6	175	0.02752	40	1.77	31.773	0.056	0.126
8	200	0.03145	45	1.99	31.772	0.063	0.126
9	225	0.03538	45	1.99	31.771	0.063	0.126
11	250	0.03931	45	1.99	31.769	0.063	0.126
Max Value				**1.99**	**31.781**	**0.063**	**0.126**

Moisture Content Before Test

Code of Bowls		**7-2B1**	**7-2B2**
Weight of Empty Bowls	W_c	9.89	9.29
Weight of Bowls + Wet Soil	W_1	24.57	25.01
Weight of Bowls + Dry Soil	W_2	23.52	23.88
Weight of Water	$W_w = W_1 - W_2$	1.05	1.13
Weight of Dry Soil	$W_s = W_2 - W_c$	13.63	14.59
Moisture Content		7.70%	7.75%
Moisture Content Average		7.72%	

Moisture Content After Test 4kg

Code of Bowls		**7-2A1/4**	**7-2A2/4**
Weight of Empty Bowls	W_c	9.20	8.59
Weight of Bowls + Wet Soil	W_1	36.95	32.30
Weight of Bowls + Dry Soil	W_2	35.21	30.78
Weight of Water	$W_w = W_1 - W_2$	1.74	1.52
Weight of Dry Soil	$W_s = W_2 - W_c$	26.01	22.19
Moisture Content		6.69%	6.85%
Moisture Content Average		6.77%	

DIRECT SHEAR TEST

Variable = Sand + 2 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 128.29 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.88 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	30	1.33	31.781	0.042	0.252
0	50	0.00786	50	2.21	31.779	0.070	0.252
0	75	0.01179	60	2.65	31.778	0.083	0.252
0	100	0.01572	72	3.18	31.777	0.100	0.252
0	125	0.01965	80	3.54	31.776	0.111	0.252
0	150	0.02358	90	3.98	31.774	0.125	0.252
1	175	0.02752	95	4.20	31.773	0.132	0.252
3	200	0.03145	96	4.25	31.772	0.134	0.252
6	225	0.03538	100	4.42	31.771	0.139	0.252
8	250	0.03931	102	4.51	31.769	0.142	0.252
11	275	0.04324	102	4.51	31.768	0.142	0.252
Max Value				**4.51**	**31.781**	**0.142**	**0.252**

Moisture Content Before Test

Code of Bowls		**7-2B1**	**7-2B2**
Weight of Empty Bowls	W_c	9.89	9.29
Weight of Bowls + Wet Soil	W_1	24.57	25.01
Weight of Bowls + Dry Soil	W_2	23.52	23.88
Weight of Water	$W_w = W_1 - W_2$	1.05	1.13
Weight of Dry Soil	$W_s = W_2 - W_c$	13.63	14.59
Moisture Content		7.70%	7.75%
Moisture Content Average		7.72%	

Moisture Content After Test 8kg

Code of Bowls		**7-2A1/8**	**7-2A2/8**
Weight of Empty Bowls	W_c	9.33	8.59
Weight of Bowls + Wet Soil	W_1	40.82	33.56
Weight of Bowls + Dry Soil	W_2	38.90	31.98
Weight of Water	$W_w = W_1 - W_2$	1.92	1.58
Weight of Dry Soil	$W_s = W_2 - W_c$	29.57	23.39
Moisture Content		6.49%	6.76%
Moisture Content Average		6.62%	

DIRECT SHEAR TEST

Variable = Sand + 2 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 125.43 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.63 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	20	0.88	31.781	0.028	0.378
4	50	0.00786	30	1.33	31.779	0.042	0.378
12	75	0.01179	50	2.21	31.778	0.070	0.378
21	100	0.01572	65	2.87	31.777	0.090	0.378
33	125	0.01965	83	3.67	31.776	0.116	0.378
49	150	0.02358	95	4.20	31.774	0.132	0.378
54	175	0.02752	100	4.42	31.773	0.139	0.378
64	200	0.03145	125	5.53	31.772	0.174	0.378
76	225	0.03538	125	5.53	31.771	0.174	0.378
Max Value				**5.53**	**31.781**	**0.174**	**0.378**

Moisture Content Before Test

Code of Bowls		**7-2B1**	**7-2B2**
Weight of Empty Bowls	W_c	9.89	9.29
Weight of Bowls + Wet Soil	W_1	24.57	25.01
Weight of Bowls + Dry Soil	W_2	23.52	23.88
Weight of Water	$W_w = W_1 - W_2$	1.05	1.13
Weight of Dry Soil	$W_s = W_2 - W_c$	13.63	14.59
Moisture Content		7.70%	7.75%
Moisture Content Average		7.72%	

Moisture Content After Test 12kg

Code of Bowls		**7-2A1/12**	**7-2A2/12**
Weight of Empty Bowls	W_c	10.46	10.55
Weight of Bowls + Wet Soil	W_1	34.57	36.22
Weight of Bowls + Dry Soil	W_2	33.13	34.67
Weight of Water	$W_w = W_1 - W_2$	1.44	1.55
Weight of Dry Soil	$W_s = W_2 - W_c$	22.67	24.12
Moisture Content		6.35%	6.43%
Moisture Content Average		6.39%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 125.54 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.63 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
1	25	0.00393	10	0.44	31.781	0.014	0.126
2	50	0.00786	15	0.66	31.779	0.021	0.126
4	75	0.01179	16	0.71	31.778	0.022	0.126
6	100	0.01572	20	0.88	31.777	0.028	0.126
8	125	0.01965	24	1.06	31.776	0.033	0.126
11	150	0.02358	27	1.19	31.774	0.038	0.126
13	175	0.02752	28	1.24	31.773	0.039	0.126
16	200	0.03145	30	1.33	31.772	0.042	0.126
20	225	0.03538	30	1.33	31.771	0.042	0.126
Max Value				**1.33**	**31.781**	**0.042**	**0.126**

Moisture Content Before Test

Code of Bowls		**7-4B1**	**7-4B2**
Weight of Empty Bowls	W_c	9.26	10.71
Weight of Bowls + Wet Soil	W_1	33.42	34.12
Weight of Bowls + Dry Soil	W_2	31.49	32.01
Weight of Water	$W_w = W_1 - W_2$	1.93	2.11
Weight of Dry Soil	$W_s = W_2 - W_c$	22.23	21.30
Moisture Content		8.68%	9.91%
Moisture Content Average		9.29%	

Moisture Content After Test 4kg

Code of Bowls		**7-4A1/4**	**7-4A2/8**
Weight of Empty Bowls	W_c	10.57	10.70
Weight of Bowls + Wet Soil	W_1	38.23	36.54
Weight of Bowls + Dry Soil	W_2	36.24	34.55
Weight of Water	$W_w = W_1 - W_2$	1.99	1.99
Weight of Dry Soil	$W_s = W_2 - W_c$	25.67	23.85
Moisture Content		7.75%	8.34%
Moisture Content Average		8.05%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 119.51 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 119.51 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	10	0.44	31.781	0.014	0.252
1	50	0.00786	42	1.86	31.779	0.058	0.252
4	75	0.01179	53	2.34	31.778	0.074	0.252
5	100	0.01572	60	2.65	31.777	0.083	0.252
8	125	0.01965	65	2.87	31.776	0.090	0.252
10	150	0.02358	68	3.01	31.774	0.095	0.252
14	175	0.02752	72	3.18	31.773	0.100	0.252
15	200	0.03145	76	3.36	31.772	0.106	0.252
17	225	0.03538	80	3.54	31.771	0.111	0.252
18	250	0.03931	80	3.54	31.769	0.111	0.252
21	275	0.04324	80	3.54	31.768	0.111	0.252
Max Value				**3.54**	**31.781**	**0.111**	**0.252**

Moisture Content Before Test

Code of Bowls		**7-4B1**	**7-4B2**
Weight of Empty Bowls	W_c	9.26	10.71
Weight of Bowls + Wet Soil	W_1	33.42	34.12
Weight of Bowls + Dry Soil	W_2	31.49	32.01
Weight of Water	$W_w = W_1 - W_2$	1.93	2.11
Weight of Dry Soil	$W_s = W_2 - W_c$	22.23	21.30
Moisture Content		8.68%	9.91%
Moisture Content Average		9.29%	

Moisture Content After Test 8kg

Code of Bowls		**7-4A1/8**	**7-4A2/8**
Weight of Empty Bowls	W_c	9.29	10.62
Weight of Bowls + Wet Soil	W_1	36.23	37.65
Weight of Bowls + Dry Soil	W_2	34.31	35.74
Weight of Water	$W_w = W_1 - W_2$	1.92	1.91
Weight of Dry Soil	$W_s = W_2 - W_c$	25.02	25.12
Moisture Content		7.67%	7.60%
Moisture Content Average		7.64%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 132.34 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.72 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	25	1.11	31.781	0.035	0.378
0	50	0.00786	35	1.55	31.779	0.049	0.378
0	75	0.01179	48	2.12	31.778	0.067	0.378
0	100	0.01572	60	2.65	31.777	0.083	0.378
0	125	0.01965	70	3.10	31.776	0.097	0.378
0	150	0.02358	78	3.45	31.774	0.109	0.378
1	175	0.02752	85	3.76	31.773	0.118	0.378
3	200	0.03145	90	3.98	31.772	0.125	0.378
5	225	0.03538	95	4.20	31.771	0.132	0.378
8	250	0.03931	100	4.42	31.769	0.139	0.378
11	275	0.04324	102	4.51	31.768	0.142	0.378
12	300	0.04717	104	4.60	31.767	0.145	0.378
16	325	0.05110	106	4.69	31.766	0.148	0.378
20	350	0.05503	110	4.86	31.764	0.153	0.378
23	375	0.05896	110	4.86	31.763	0.153	0.378
26	400	0.06289	110	4.86	31.762	0.153	0.378
Max Value				**4.86**	**31.781**	**0.153**	**0.378**

Moisture Content Before Test

Code of Bowls		**7-4B1**	**7-4B2**
Weight of Empty Bowls	W_c	9.26	10.71
Weight of Bowls + Wet Soil	W_1	33.42	34.12
Weight of Bowls + Dry Soil	W_2	31.49	32.01
Weight of Water	$W_w = W_1 - W_2$	1.93	2.11
Weight of Dry Soil	$W_s = W_2 - W_c$	22.23	21.30
Moisture Content		8.68%	9.91%
Moisture Content Average		9.29%	

Moisture Content After Test 12kg

Code of Bowls		**7-4A1/12**	**7-4A2/12**
Weight of Empty Bowls	W_c	10.43	10.67
Weight of Bowls + Wet Soil	W_1	37.53	38.56
Weight of Bowls + Dry Soil	W_2	35.68	36.70
Weight of Water	$W_w = W_1 - W_2$	1.85	1.86
Weight of Dry Soil	$W_s = W_2 - W_c$	25.25	26.03
Moisture Content		7.33%	7.15%
Moisture Content Average		7.24%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 125.98 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.64 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
1	25	0.00393	22	0.97	31.781	0.031	0.126
5	50	0.00786	30	1.33	31.779	0.042	0.126
9	75	0.01179	34	1.50	31.778	0.047	0.126
15	100	0.01572	40	1.77	31.777	0.056	0.126
18	125	0.01965	45	1.99	31.776	0.063	0.126
23	150	0.02358	46	2.03	31.774	0.064	0.126
28	175	0.02752	46	2.03	31.773	0.064	0.126
33	200	0.03145	46	2.03	31.772	0.064	0.126
Max Value				**2.03**	**31.781**	**0.064**	**0.126**

Moisture Content Before Test

Code of Bowls		**7-6B1**	**7-6B2**
Weight of Empty Bowls	W_c	8.84	10.61
Weight of Bowls + Wet Soil	W_1	38.21	45.79
Weight of Bowls + Dry Soil	W_2	35.96	43.07
Weight of Water	$W_w = W_1 - W_2$	2.25	2.72
Weight of Dry Soil	$W_s = W_2 - W_c$	27.12	32.46
Moisture Content		8.30%	8.38%
Moisture Content Average		8.34%	

Moisture Content After Test 4kg

Code of Bowls		**7-6A1/4**	**7-6A2/4**
Weight of Empty Bowls	W_c	9.78	10.34
Weight of Bowls + Wet Soil	W_1	38.03	36.51
Weight of Bowls + Dry Soil	W_2	35.92	34.67
Weight of Water	$W_w = W_1 - W_2$	2.11	1.84
Weight of Dry Soil	$W_s = W_2 - W_c$	26.14	24.33
Moisture Content		8.07%	7.56%
Moisture Content Average		7.82%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 121.19 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.58 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	30	1.33	31.781	0.042	0.252
0	50	0.00786	40	1.77	31.779	0.056	0.252
-1	75	0.01179	50	2.21	31.778	0.070	0.252
1	100	0.01572	65	2.87	31.777	0.090	0.252
3	125	0.01965	75	3.32	31.776	0.104	0.252
5	150	0.02358	83	3.67	31.774	0.116	0.252
8	175	0.02752	88	3.89	31.773	0.122	0.252
11	200	0.03145	95	4.20	31.772	0.132	0.252
14	225	0.03538	100	4.42	31.771	0.139	0.252
18	250	0.03931	110	4.86	31.769	0.153	0.252
22	275	0.04324	111	4.91	31.768	0.155	0.252
26	300	0.04717	111	4.91	31.767	0.155	0.252
21	325	0.05110	111	4.91	31.766	0.155	0.252
Max Value				**4.91**	**31.781**	**0.155**	**0.252**

Moisture Content Before Test

Code of Bowls		**7-6B1**	**7-6B2**
Weight of Empty Bowls	W_c	8.84	10.61
Weight of Bowls + Wet Soil	W_1	38.21	45.79
Weight of Bowls + Dry Soil	W_2	35.96	43.07
Weight of Water	$W_w = W_1 - W_2$	2.25	2.72
Weight of Dry Soil	$W_s = W_2 - W_c$	27.12	32.46
Moisture Content		8.30%	8.38%
Moisture Content Average		8.34%	

Moisture Content After Test 8kg

Code of Bowls		**7-6A1/8**	**7-6A2/8**
Weight of Empty Bowls	W_c	10.72	9.28
Weight of Bowls + Wet Soil	W_1	31.76	38.72
Weight of Bowls + Dry Soil	W_2	30.22	36.67
Weight of Water	$W_w = W_1 - W_2$	1.54	2.05
Weight of Dry Soil	$W_s = W_2 - W_c$	19.50	27.39
Moisture Content		7.90%	7.48%
Moisture Content Average		7.69%	

DIRECT SHEAR TEST

Variable = Sand + 4 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 143.80 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.87 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	30	1.33	31.781	0.042	0.378
0	50	0.00786	45	1.99	31.779	0.063	0.378
0	75	0.01179	52	2.30	31.778	0.072	0.378
0	100	0.01572	63	2.79	31.777	0.088	0.378
0	125	0.01965	72	3.18	31.776	0.100	0.378
0	150	0.02358	80	3.54	31.774	0.111	0.378
0	175	0.02752	85	3.76	31.773	0.118	0.378
0	200	0.03145	90	3.98	31.772	0.125	0.378
0	225	0.03538	95	4.20	31.771	0.132	0.378
0	250	0.03931	100	4.42	31.769	0.139	0.378
0	275	0.04324	102	4.51	31.768	0.142	0.378
0	300	0.04717	105	4.64	31.767	0.146	0.378
0	325	0.05110	105	4.64	31.766	0.146	0.378
0	350	0.05503	108	4.78	31.764	0.150	0.378
0	375	0.05896	110	4.86	31.763	0.153	0.378
2	400	0.06289	112	4.95	31.762	0.156	0.378
5	425	0.06682	114	5.04	31.761	0.159	0.378
6	450	0.07075	114	5.04	31.759	0.159	0.378
8	475	0.07469	114	5.04	31.758	0.159	0.378
Max Value				**5.04**	**31.781**	**0.159**	**0.378**

Moisture Content Before Test

Code of Bowls		**7-6B1**	**7-6B2**
Weight of Empty Bowls	W_c	8.84	10.61
Weight of Bowls + Wet Soil	W_1	38.21	45.79
Weight of Bowls + Dry Soil	W_2	35.96	43.07
Weight of Water	$W_w = W_1 - W_2$	2.25	2.72
Weight of Dry Soil	$W_s = W_2 - W_c$	27.12	32.46
Moisture Content		8.30%	8.38%
Moisture Content Average		8.34%	

Moisture Content After Test 12kg

Code of Bowls		**7-6A1/12**	**7-6A2/12**
Weight of Empty Bowls	W_c	13.58	13.73
Weight of Bowls + Wet Soil	W_1	42.43	44.67
Weight of Bowls + Dry Soil	W_2	40.36	42.57
Weight of Water	$W_w = W_1 - W_2$	2.07	2.10
Weight of Dry Soil	$W_s = W_2 - W_c$	26.78	28.84
Moisture Content		7.73%	7.28%
Moisture Content Average		7.51%	

DIRECT SHEAR TEST

Variable = Sand + 8 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 130.32 gr

Normal Load = 4 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.69 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
1	25	0.00393	20	0.88	31.781	0.028	0.126
4	50	0.00786	28	1.24	31.779	0.039	0.126
6	75	0.01179	35	1.55	31.778	0.049	0.126
10	100	0.01572	42	1.86	31.777	0.058	0.126
15	125	0.01965	46	2.03	31.776	0.064	0.126
19	150	0.02358	50	2.21	31.774	0.070	0.126
25	175	0.02752	53	2.34	31.773	0.074	0.126
32	200	0.03145	55	2.43	31.772	0.077	0.126
38	225	0.03538	55	2.43	31.771	0.077	0.126
44	250	0.03931	55	2.43	31.769	0.077	0.126
Max Value				**2.43**	**31.781**	**0.077**	**0.126**

Moisture Content Before Test

Code of Bowls		**7-8B1**	**7-8B2**
Weight of Empty Bowls	W_c	10.55	9.28
Weight of Bowls + Wet Soil	W_1	41.35	41.43
Weight of Bowls + Dry Soil	W_2	39.13	38.40
Weight of Water	$W_w = W_1 - W_2$	2.22	3.03
Weight of Dry Soil	$W_s = W_2 - W_c$	28.58	29.12
Moisture Content		7.77%	10.41%
Moisture Content Average		9.09%	

Moisture Content After Test 4kg

Code of Bowls		**7-8A1/4**	**7-8A2/4**
Weight of Empty Bowls	W_c	14.51	9.55
Weight of Bowls + Wet Soil	W_1	38.55	44.72
Weight of Bowls + Dry Soil	W_2	36.78	42.10
Weight of Water	$W_w = W_1 - W_2$	1.77	2.62
Weight of Dry Soil	$W_s = W_2 - W_c$	22.27	32.55
Moisture Content		7.95%	8.05%
Moisture Content Average		8.00%	

DIRECT SHEAR TEST

Variable = Sand + 8 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 118.68 gr

Normal Load = 8 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.54 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
2	25	0.00393	25	1.11	31.781	0.035	0.252
6	50	0.00786	40	1.77	31.779	0.056	0.252
10	75	0.01179	45	1.99	31.778	0.063	0.252
15	100	0.01572	53	2.34	31.777	0.074	0.252
20	125	0.01965	60	2.65	31.776	0.084	0.252
25	150	0.02358	65	2.87	31.774	0.090	0.252
29	175	0.02752	70	3.10	31.773	0.097	0.252
33	200	0.03145	72	3.18	31.772	0.100	0.252
37	225	0.03538	75	3.32	31.771	0.104	0.252
41	250	0.03931	76	3.36	31.769	0.106	0.252
44	275	0.04324	80	3.54	31.768	0.111	0.252
46	300	0.04717	80	3.54	31.767	0.111	0.252
49	325	0.05110	80	3.54	31.766	0.111	0.252
Max Value				**3.54**	**31.781**	**0.111**	**0.252**

Moisture Content Before Test

Code of Bowls		**7-8B1**	**7-8B2**
Weight of Empty Bowls	W_c	10.55	9.28
Weight of Bowls + Wet Soil	W_1	41.35	41.43
Weight of Bowls + Dry Soil	W_2	39.13	38.40
Weight of Water	$W_w = W_1 - W_2$	2.22	3.03
Weight of Dry Soil	$W_s = W_2 - W_c$	28.58	29.12
Moisture Content		7.77%	10.41%
Moisture Content Average		9.09%	

Moisture Content After Test 8kg

Code of Bowls		**7-8A1/8**	**7-8A2/8**
Weight of Empty Bowls	W_c	10.55	9.97
Weight of Bowls + Wet Soil	W_1	40.63	41.63
Weight of Bowls + Dry Soil	W_2	38.45	39.37
Weight of Water	$W_w = W_1 - W_2$	2.18	2.26
Weight of Dry Soil	$W_s = W_2 - W_c$	27.90	29.40
Moisture Content		7.81%	7.69%
Moisture Content Average		7.75%	

DIRECT SHEAR TEST

Variable = Sand + 8 % PU
Curing Time = 7 Day
Date = May , 3rd 2016
Sample Weight = 111.85 gr

Normal Load = 12 kg
Diameter = 6.36 cm
Height = 2.42 cm
Area = 31.75 cm^2
Unit Weight = 1.45 gr/cm^3

Vertical Dial Reading	Δh	Horizontal strain %	Load Ring Dial Reading	Horizontal Shear Force (kg)	Corrected A'	Shear Stress (kg/cm^2)	Normal Stress (kg/cm^2)
0	25	0.00393	25	1.11	31.781	0.035	0.378
-1	50	0.00786	40	1.77	31.779	0.056	0.378
-1	75	0.01179	54	2.39	31.778	0.075	0.378
-1	100	0.01572	65	2.87	31.777	0.090	0.378
-1	125	0.01965	75	3.32	31.776	0.104	0.378
-1	150	0.02358	85	3.76	31.774	0.118	0.378
0	175	0.02752	90	3.98	31.773	0.125	0.378
2	200	0.03145	102	4.51	31.772	0.142	0.378
4	225	0.03538	110	4.86	31.771	0.153	0.378
7	250	0.03931	115	5.09	31.769	0.160	0.378
9	275	0.04324	120	5.31	31.768	0.167	0.378
12	300	0.04717	130	5.75	31.767	0.181	0.378
14	325	0.05110	140	6.19	31.766	0.195	0.378
17	350	0.05503	140	6.19	31.764	0.195	0.378
20	375	0.05896	142	6.28	31.763	0.198	0.378
23	400	0.06289	145	6.41	31.762	0.202	0.378
14	425	0.06682	147	6.50	31.761	0.205	0.378
17	450	0.07075	147	6.50	31.759	0.205	0.378
20	475	0.07469	147	6.50	31.758	0.205	0.378
23	500	0.07862	147	6.50	31.757	0.205	0.378
Max Value				**6.50**	**31.781**	**0.205**	**0.378**

Moisture Content Before Test

Code of Bowls		**7-8B1**	**7-8B2**
Weight of Empty Bowls	W_c	10.55	9.28
Weight of Bowls + Wet Soil	W_1	41.35	41.43
Weight of Bowls + Dry Soil	W_2	39.13	38.40
Weight of Water	$W_w = W_1 - W_2$	2.22	3.03
Weight of Dry Soil	$W_s = W_2 - W_c$	28.58	29.12
Moisture Content		7.77%	10.41%
Moisture Content Average		9.09%	

Moisture Content After Test 12kg

Code of Bowls		**7-8A1/12**	**7-8A2/12**
Weight of Empty Bowls	W_c	8.78	10.61
Weight of Bowls + Wet Soil	W_1	33.63	38.56
Weight of Bowls + Dry Soil	W_2	31.90	36.83
Weight of Water	$W_w = W_1 - W_2$	1.73	1.73
Weight of Dry Soil	$W_s = W_2 - W_c$	23.12	26.22
Moisture Content		7.48%	6.60%
Moisture Content Average		7.04%	