Hydrogen Ionic Stabilization
For Expansive Clay Soils

CONTENTS

What is Clay Set and How Does it Work?

Put simply...Clay Set is a hydrogen ionic soil stabilizer that acts at the molecular level of the clay particle to permanently reduce or eliminate the swelling nature of the clay. (Detailed mechanism is explained at the end of this document). Treatment will reduce the swell potential to a low or insignificant classification and treated soil will be far less permeable to water. Clay Set is not water and can be used even on existing structures to prevent further heaving and pre-construction treatment is very economical and simple.

Although pre-construction treatment with Clay Set is done as easily (if not more easily) than a moisture conditioning operation, the difference in the effectiveness to reduce the swell is significant. Plus...Clay Set is permanent and requires only a single processing no matter the swell potential of the existing soil. On site soil can be used and sites with swelling clays that were once considered too expensive to develop, can now be treated for a fraction of the cost of methods used in the past.

In the table below you can see the results of comparative testing that was performed on soil samples from a KB Home site. The results show the effect that water had to reduce the swells compared to Clay Set. With water alone, the swells remained in the moderate to high classification. The same soil treated with Clay set to the same moisture contents achieved reductions to the low to insignificant classification, well within project specifications.

boring #	depth	Soil Description	MD	DD	Swell %		Passing #200	LL	PL	PI
_7	10	Recompacted Clay+Claystone: 95% @ Optimum	16.8	107.3	+7.4/500		94			
_7	11	Recompacted Clay+Claystone: 95% @ +3%	19.0	107.1	+4.3/500					
_9	0	Recompacted Clay: 95% @ Optimum	17.2	104.1	+7.1/500					
_10-CL	0	Recompacted Clay: 95% @ +1%	18.2	104.1	+5.2/500		92			
_10-CL	1	Recompacted Clay: 95% @ +3%	20.2	104.2	+2.3/500					
_10-CS	10	Recompacted Claystone: 95% @ +1%	18.8	103.2			95			
_10-CS	11	Recompacted Claystone: 95% @ +3%	20.5	103.2						
_Comp-CS	20.1	Recompacted Claystone: 95% @ Optimum	17.8	102.4	+9.1/500					
_Comp-CS	21	Recompacted Claystone: 95% @ +4%	21.4	101.7	+6.6/500					
_TP4 CL	0	LEAN CLAY PROCTOR	14.8	112.7						
_TP4 CL	0.1	LEAN CLAY w/ CLAY SET @ OPTIMUM	15.1	106.9	+0.6/500			40	23	17
_TP4 CL	0.2	LEAN CLAY w/ CLAY SET @ +3%	17.9	107.2	+0.6/500			40	23	17
_TP4/7 CS	0	CLAYSTONE BEDROCK PROCTOR	19.1	106.9						
_TP4/7 CS	0.1	CLAYSTONE BEDROCK W/CLAY SET @ OPTIMUM	19.0	101.7	+2.3/500			43	23	20
_TP4/7 CS	0.2	CLAYSTONE BEDROCK W/CLAY SET @ +3%	22.0	101.8	+0.7/500			43	23	20

The project was performed from December of 2018 through June of 2019. 420,000 cyds of soil were processed successfully using Clay Set. (More data and info on the following pages)

Resilient modulus test results demonstrate a strength increase of 121% over a 21 day period

KB Homes (Sweetgrass Filing 4) | Dacono, CO												
	Test Sequence #	*Confining Pressure*	*Proposed Max. Deviator Stress*	*Applied Max. Deviator Stress*	*Applied Contact Stress*	*Applied Cyclic Stress*	*Recoverable Deformation LVDT #1*	*Recoverable Deformation LVDT #2*	*Average Recoverable Deformation LVDT #1, #2*	*Measured Resilient Strain*	*Resilient Modulus*	*% Mr Increase from Original*
		(psi)	*(psi)*	*(psi)*	*(psi)*	*(psi)*	*(mills)*	*(mills)*	*(mills)*	*(%)*	*(psi)*	
Virgin Soil (Original)	Conditioning:	6	4	4.11	0.38	3.72	-	-	-	-	-	
	1	6	2	2	0.18	1.82	1.5	1.49	1.5	0.019	9,606	
	2	6	4	3.98	0.41	3.57	4.16	4.13	4.15	0.053	6,790	
	3	6	6	6.04	0.64	5.39	8.25	8.24	8.25	0.105	5,151	
	4	6	8	8.07	0.85	7.22	13.6	13.83	13.72	0.174	4,147	
	5	6	10	10.1	1.04	9.06	20.64	20.81	20.73	0.263	3,444	
	6	4	2	2.02	0.23	1.79	1.62	1.64	1.63	0.021	8,659	
	7	4	4	4.01	0.41	3.6	4.65	4.69	4.67	0.059	6,072	
	8	4	6	6	0.61	5.39	8.84	8.95	8.9	0.113	4,779	
	9	4	8	8.04	0.83	7.21	14.16	14.31	14.24	0.181	3,991	
	10	4	10	10.04	1.06	8.98	20.16	20.24	20.2	0.256	3,503	
	11	2	2	2	0.19	1.81	1.71	1.78	1.75	0.022	8,182	
	12	2	4	4.04	0.39	3.65	4.93	5.03	4.98	0.063	5,783	
	13	2	6	6.04	0.62	5.41	9.36	9.48	9.42	0.119	4,530	
	14	2	8	8.02	0.86	7.16	14.64	14.78	14.71	0.187	3,837	
	15	2	10	10.04	1.07	8.97	20.59	20.66	20.63	0.262	3,428	
Soil + ClaySet @ 3 Days	Conditioning:	6	4	4.05	0.41	3.63	-	-	-	-	-	
	1	6	2	1.99	0.22	1.78	1.13	1.13	1.13	0.014	12,838	33.65%
	2	6	4	3.99	0.4	3.59	2.86	2.79	2.83	0.035	10,340	52.28%
	3	6	6	6	0.6	5.41	5.15	5.02	5.09	0.062	8,664	68.20%
	4	6	8	8	0.82	7.18	7.99	7.81	7.9	0.097	7,412	78.73%
	5	6	10	9.99	1.03	8.96	11.45	11.3	11.38	0.14	6,419	86.38%
	6	4	2	2	0.17	1.83	1.23	1.21	1.22	0.015	12,245	41.41%
	7	4	4	3.98	0.38	3.6	3.19	3.13	3.16	0.039	9,271	52.68%
	8	4	6	6	0.63	5.37	5.76	5.67	5.72	0.07	7,657	60.22%
	9	4	8	7.98	0.83	7.15	8.73	8.58	8.66	0.106	6,732	68.68%
	10	4	10	9.99	1.01	8.99	11.96	11.86	11.91	0.146	6,151	75.59%
	11	2	2	1.98	0.22	1.76	1.24	1.22	1.23	0.015	11,653	42.42%
	12	2	4	4	0.42	3.58	3.37	3.3	3.34	0.041	8,747	51.25%
	13	2	6	6.02	0.61	5.41	6.13	6.04	6.09	0.075	7,252	60.09%
	14	2	8	8	0.8	7.2	9.19	9.12	9.16	0.112	6,406	66.95%
	15	2	10	10.03	1.01	9.02	12.6	12.56	12.58	0.154	5,843	70.45%

KB Homes (Sweetgrass Filing 4) | Dacono, CO

	Test Sequence #	Confining Pressure	Proposed Max. Deviator Stress	Applied Max. Deviator Stress	Applied Contact Stress	Applied Cyclic Stress	Recoverable Deformation LVDT #1	Recoverable Deformation LVDT #2	Average Recoverable Deformation LVDT #1, #2	Measured Resilient Strain	Resilient Modulus	% Mr Increase from Original
		(psi)	(psi)	(psi)	(psi)	(psi)	(mills)	(mills)	(mills)	(%)	(psi)	
Soil + ClaySet @ 7 Days	Conditioning:	6	4	4.02	0.42	3.6	-	-	-	-	-	
	1	6	2	2.01	0.21	1.79	1.04	1.02	1.03	0.013	14,184	47.66%
	2	6	4	4.01	0.39	3.62	2.65	2.56	2.61	0.032	11,327	66.82%
	3	6	6	6	0.59	5.42	4.68	4.55	4.62	0.057	9,558	85.56%
	4	6	8	8.01	0.81	7.2	7.24	7.06	7.15	0.088	8,208	97.93%
	5	6	10	9.94	1.03	8.92	10.25	10.05	10.15	0.125	7,162	107.96%
	6	4	2	2.02	0.18	1.84	1.1	1.09	1.1	0.013	13,691	58.11%
	7	4	4	3.99	0.4	3.6	2.93	2.84	2.89	0.035	10,161	67.34%
	8	4	6	6	0.62	5.38	5.27	5.13	5.2	0.064	8,428	76.35%
	9	4	8	8	0.8	7.2	7.95	7.77	7.86	0.096	7,466	87.07%
	10	4	10	9.99	1	9	10.77	10.64	10.71	0.131	6,852	95.60%
	11	2	2	2	0.22	1.78	1.16	1.15	1.16	0.014	12,567	53.59%
	12	2	4	4.01	0.42	3.59	3.11	3.03	3.07	0.038	9,520	64.62%
	13	2	6	6.04	0.6	5.44	5.66	5.52	5.59	0.069	7,928	75.01%
	14	2	8	8.03	0.8	7.23	8.44	8.3	8.37	0.103	7,040	83.48%
	15	2	10	10.03	1.02	9	11.39	11.28	11.34	0.139	6,472	88.80%
Soil + ClaySet @ 21 Days	Conditioning:	6	4	4	0.42	3.59	-	-	-	-	-	
	1	6	2	2.01	0.18	1.82	0.91	0.91	0.91	0.011	16,242	69.08%
	2	6	4	4.02	0.39	3.63	2.36	2.34	2.35	0.029	12,535	84.61%
	3	6	6	6.02	0.61	5.41	4.17	4.15	4.16	0.051	10,571	105.22%
	4	6	8	8.01	0.83	7.19	6.3	6.26	6.28	0.077	9,304	124.35%
	5	6	10	9.98	1.01	8.97	8.73	8.72	8.73	0.107	8,364	142.86%
	6	4	2	2.01	0.21	1.8	0.98	0.97	0.98	0.012	14,996	73.18%
	7	4	4	3.99	0.42	3.57	2.57	2.57	2.57	0.032	11,303	86.15%
	8	4	6	6.01	0.61	5.41	4.56	4.54	4.55	0.056	9,666	102.26%
	9	4	8	8.01	0.78	7.23	6.8	6.75	6.78	0.083	8,679	117.46%
	10	4	10	10.01	0.99	9.02	9.13	9.13	9.13	0.112	8,030	129.23%
	11	2	2	2	0.22	1.78	1.04	1.01	1.03	0.013	14,132	72.72%
	12	2	4	4	0.39	3.61	2.75	2.72	2.74	0.034	10,724	85.44%
	13	2	6	6.01	0.58	5.43	4.84	4.79	4.82	0.059	9,162	102.25%
	14	2	8	8.01	0.81	7.2	7.2	7.18	7.19	0.088	8,142	112.20%
	15	2	10	9.99	1.03	8.96	9.61	9.6	9.61	0.118	7,583	121.21%

Clay Set not only gives superior results in permanently reducing swell and increasing strength in difficult soils, but it also reduces soil suction/capillary action as compared to water alone which means a reduced risk of future movement.

CTL | THOMPSON

January 10, 2020

Century Communities
8390 East Crescent Parkway, Suite 650
Greenwood Village, Colorado 80111

Attention: XXXXXXXXX

Subject: Evaluation of Sub-Excavation Mitigation
Lot 1, Block 2, Interlocken 485, Filing No. 4
Broomfield, Colorado
Project No. DN49,201.001-145-L1

"The Clay Set average swells are lower than water only. The Clay Set addition appears to reduce suction more consistently than water. Since suction was reduced, future reductions in suction would be smaller; this means less potential heave".

We performed a Geotechnical Investigation for the subject Interlocken project and presented results in a report dated February 6, 2019 (Project No. DN49,201.001-115-R2). We found very highly expansive soils and bedrock which are typical for the Interlocken area and discussed foundation alternatives including drilled piers bottomed in bedrock and footing or post-tensioned slabs-on-grade after sub-excavation (a.k.a. "over-excavation") and moisture treatment of compacted fill derived from on-site soils and bedrock. Century is considering the use of Clay Set additive to help mitigate potential swell of the fill. We were asked to design a testing program to evaluate the relative impacts of moisture treatment with and without Clay Set. Information on Clay Set can be reviewed at SoilScientific.com. We were asked to prepare this letter with results of the testing to date from a lay perspective and our opinion of the benefits of use of Clay Set.

The field testing was performed by excavating three large test pits using scrapers and compacting moisture treated fill with and without Clay Set into the pits. At Soil Scientific's suggestion, the moisture added during compaction included water only (no additive), and water combined with Clay Set at ratios of 300 and 200 parts water to 1-part Clay set.

Prior to excavation, we obtained samples of the claystone bedrock in the test area from test pits excavated with a backhoe. The materials obtained from the test pits were returned to our laboratory, combined and then split for testing. The lab samples were prepared to simulate the field treatments described above and tested for potential swell.

We obtained samples of the compacted fill during placement by driving thin-walled brass tubes into the fill; these are referred to as "hand drives." We also obtained samples after the test fills were completed by drilling and sampling using standard local methods. Samples of the undisturbed claystone outside the test fill areas were also obtained by drilling.

Ronald M. McOmber, P.E
CTL│T PROJECT NO. DN49,201-001-145-L1
Supplemental report - 1/10/2020

Pre/Post Swell Data & Project Description
KB Home - Sweetgrass - Filing 4
Dacono, Colorado
January 2019-June 2019
Engineer of Record: Cole Garner

Project Description: The project was a pre-construction treatment of 420,000 cyds of soil. Soil Scientific's Clay Set hydrogen ionic stabilizer was chosen to replace the select fill or deep pier foundation option for the stabilization of sub-grade soils for approximately 30 home lots, streets and flat work. The use of Clay Set allowed construction of the homes with spread footer foundations. Pre-treatment swell testing showed results as high as 9.8% and an average swell of 6%. Average swells after the Clay Set treatment were 0.36%. A 94% decrease in swell potential. A mix ratio of 400 parts water to 1 part Clay Set Concentrate was used to complete the project. Additionally, resilient modulus testing was performed to determine what, if any, strength increase could be expected from treatment with Clay Set. Testing showed a 121% increase in strength over a 21 day period.

An over-excavation operation was performed to a total depth of 18' to allow for 15' of treatment below foundation level. Soils were removed to the 18' level and replaced in loose lifts. Clay Set Solution was applied by water pulls over the top of the loose lifts and a construction disc was used to break down the soil and thoroughly mix the Clay Set with the soils and bring them to the specified moisture content. After the mixing was completed, the lift was compacted with a rubber tire piece of heavy equipment to the specified compaction. Sampling of the lifts was done using hand drives and swell testing was done within 24 hours of treatment. This process was repeated in lifts until all soils were replaced. (very much like a typical moisture conditioning)

Swell testing was performed before and after treatment and at different mix ratios and the results are included below. Resilient modulus testing was also performed. Prior to choosing Clay Set for the project, lab testing was done to compare the effectiveness of the product to water alone using a 300/1 mix of water to Clay Set Concentrate. Those results are shown in the highlighted lines (on page 4 of this document) that accompany the initial boring testing results that precede them. Further testing was performed to evaluate a 400/1 mix ratio as explained in the included letter from Cole Garner and the testing summary is shown on page 7. The results of the swell testing that was done during the project are shown on page 8-10. The results of strength testing are contained on page 11-12. Contact information for Katie Cooley of Cooley Development, Mauricio Barbera of KB Home and Andrew Garner of Cole Garner is included with our reference list.

Pickering, Cole, & Hivner
1070 W. 124 Avenue, Suite 300
Westminster, CO. 80234
Telephone: 303.996.2999

SUMMARY OF LABORATORY RESULTS

ORIGINAL INVESTIGATION

CLIENT KB Home Colorado

PROJECT NAME Sweetgrass Filing No. 4 - Preliminary Geotech

PROJECT NUMBER 12.426.16

PROJECT LOCATION Dacono, Colorado

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
1	4	LEAN CLAY with SAND	21.7	106.8	+0.1/500		77	45	21	24
1	9	CLAYSTONE BEDROCK	22.0	111.4	+3.0/500		83	49	20	29
1	14	CLAYSTONE BEDROCK	10.2	97.5						
1	19	CLAYSTONE BEDROCK	6.0	117.9						
2A	4	FAT CLAY	18.3	106.2	+0.2/500	3200	90	50	20	30
2A	9	CLAYSTONE BEDROCK	16.2	114.6						
2A	14	CLAYSTONE BEDROCK	4.9	97.8	-1.3/1000		79	46	21	25
2A	19	CLAYSTONE BEDROCK	11.9	127.0						
2B	4	FAT CLAY	19.1	106.1	+0.6/500		100	50	20	30
2B	9	CLAYSTONE BEDROCK	13.3	120.5						
2B	14	CLAYSTONE BEDROCK	12.6	124.5						
2B	19	CLAYSTONE BEDROCK	14.7	119.9						
2B	24	CLAYSTONE BEDROCK	17.1	110.1						
2B	34	CLAYSTONE BEDROCK	7.2	125.5						
3	4	LEAN CLAY with SAND	15.9	95.2						
3	9	LEAN CLAY with SAND	24.3	98.6						
3	14	CLAYSTONE BEDROCK	14.7	103.6	+0.8/1000					
3	19	CLAYSTONE BEDROCK	13.9	118.5						
4	4	LEAN to FAT CLAY	20.0	101.9						
4	9	CLAYSTONE BEDROCK	14.1	121.2	+6.0/500					
4	14	CLAYSTONE BEDROCK	11.7	116.0						
4	19	CLAYSTONE BEDROCK	7.8	124.0						
5	2	LEAN CLAY	34.7	96.6	+1.9/200		92	49	20	29
5	4	LEAN CLAY with SAND	15.7	116.4						
5	9	CLAYSTONE BEDROCK	14.3	115.1	+9.8/500					
5	14	CLAYSTONE BEDROCK	12.0	128.0						
5	19	CLAYSTONE BEDROCK	12.8	123.0						
6	4	LEAN to FAT CLAY	23.8	103.8						
6	9	CLAYSTONE BEDROCK	18.7	110.3	+7.5/500					
6	14	CLAYSTONE BEDROCK	10.5	113.7						

LAB SUMMARY - GINT STD US LAB.GDT - 2/17/17 13:35 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2016\12.426.16 SWEETGRASS F4.GPJ

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SUMMARY OF LABORATORY RESULTS

ORIGINAL INVESTIGATION CONTINUED

CLIENT KB Home Colorado

PROJECT NAME Sweetgrass Filing No. 4 - Preliminary Geotech

PROJECT NUMBER 12.426.16

PROJECT LOCATION Dacono, Colorado

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
6	19	CLAYSTONE BEDROCK	11.0	126.7						
7	4	FAT CLAY	17.9	107.3	+3.0/500		97	50	20	30
7	9	CLAYSTONE BEDROCK	21.1	103.3						
7	14	CLAYSTONE BEDROCK	8.5	115.5						
7	19	CLAYSTONE BEDROCK	6.1	93.8						
8	4	LEAN to FAT CLAY	19.2	102.8						
8	9	CLAYSTONE BEDROCK	13.5	120.2	+6.8/500	3800				
8	14	CLAYSTONE BEDROCK	14.0	123.3						
8	19	LIGNITE	36.3	78.9						
9	4	LEAN to FAT CLAY	10.8	111.5						
9	9	CLAYSTONE BEDROCK	16.3	113.7	+7.2/500	1800	98	50	20	30
9	14	CLAYSTONE BEDROCK	16.7	116.1						
9	19	CLAYSTONE BEDROCK	13.6	123.7						
9	24	CLAYSTONE BEDROCK	10.8	125.6						
9	34	CLAYSTONE BEDROCK	6.4	128.0						
10	4	FAT CLAY	18.5	107.5	+6.9/500					
10	9	WEATHERED CLAYSTONE BEDROCK	25.4	99.7						
10	14	WEATHERED CLAYSTONE BEDROCK	17.5	109.6	+8.5/500		100	51	21	30
10	19	CLAYSTONE BEDROCK	18.0	114.9						
10	24	CLAYSTONE BEDROCK	19.9	111.4						
10	34	CLAYSTONE BEDROCK	19.8	110.2						
11	4	FAT CLAY	17.6	108.0	+4.7/500					
11	9	FAT CLAY	17.4	111.1	+5.7/500		99	50	20	30
11	14	WEATHERED CLAYSTONE BEDROCK	19.3	110.4						
11	19	CLAYSTONE BEDROCK	12.6	123.7						
11	24	CLAYSTONE BEDROCK	11.7	127.6						
11	34	CLAYSTONE BEDROCK	13.4	120.6						
TP1	0	LEAN CLAY(CL)					91	47	21	26
TP1	4	CLAYSTONE BEDROCK					96	47	21	26
TP2	0	LEAN CLAY (CL)					92	47	21	26

LAB SUMMARY - GINT STD US LAB.GDT - 2/17/17 13:35 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2016\12.426.16 SWEETGRASS F4.GPJ

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SUMMARY OF LABORATORY RESULTS

ORIGINAL INVESTIGATION CONCLUDED AND CLAY SET VS WATER COMPARISON

CLIENT KB Home Colorado

PROJECT NUMBER 12.426.16

PROJECT NAME Sweetgrass Filing No. 4 - Preliminary Geotech

PROJECT LOCATION Dacono, Colorado

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
TP2	4.5	CLAYSTONE BEDROCK					94	48	21	27
TP3	0	LEAN CLAY(CL)					89	46	21	25
TP3	4.5	CLAYSTONE BEDROCK					96	47	20	27
TP4	0	LEAN CLAY (CL)					92	47	21	26
TP4	5	CLAYSTONE BEDROCK					97	49	20	29
TP5	0	LEAN CLAY(CL)					86	45	20	25
TP5	8	CLAYSTONE BEDROCK					94	45	21	24
TP6	0	LEAN CLAY(CL)					90	47	21	26
TP6	8	CLAYSTONE BEDROCK					94	47	21	26
TP7	0	LEAN CLAY(CL)					88	33	21	12
TP7	7	CLAYSTONE BEDROCK					97	50	20	30
TP8	0	LEAN CLAY with SAND(CL)					80	45	22	23
TP8	4	CLAYSTONE BEDROCK					94	45	21	24
TP9	0	LEAN CLAY with SAND(CL)					76	43	22	21
		SOIL TREATED WITH WATER ONLY								
_7	10	Recompacted Clay+Claystone: 95% @ Optimum	16.8	107.3	+7.4/500		94			
_7	11	Recompacted Clay+Claystone: 95% @ +3%	19.0	107.1	+4.3/500					
_9	0	Recompacted Clay: 95% @ Optimum	17.2	104.1	+7.1/500					
_10-CL	0	Recompacted Clay: 95% @ +1%	18.2	104.1	+5.2/500		92			
_10-CL	1	Recompacted Clay: 95% @ +3%	20.2	104.2	+2.3/500					
_10-CS	10	Recompacted Claystone: 95% @ +1%	18.8	103.2			95			
_10-CS	11	Recompacted Claystone: 95% @ +3%	20.5	103.2						
_Comp-CS	20.1	Recompacted Claystone: 95% @ Optimum	17.8	102.4	+9.1/500					
_Comp-CS	21	Recompacted Claystone: 95% @ +4%	21.4	101.7	+6.6/500					
_TP4 CL	0	LEAN CLAY PROCTOR	14.8	112.7						
_TP4 CL	0.1	LEAN CLAY w/ CLAY SET @ OPTIMUM	15.1	106.9	+0.6/500			40	23	17
_TP4 CL	0.2	LEAN CLAY w/ CLAY SET@ +3%	17.9	107.2	+0.6/500			40	23	17
_TP4/7 CS	0	CLAYSTONE BEDROCK PROCTOR	19.1	106.9						
_TP4/7 CS	0.1	CLAYSTONE BEDROCK w/ CLAY SET @ OPTIMUM	19.0	101.7	+2.3/500			43	23	20
_TP4/7 CS	0.2	CLAYSTONE BEDROCK w/ CLAY SET@ +3%	22.0	101.8	+0.7/500			42	22	20

LAB SUMMARY - GINT STD US LAB.GDT - 2/17/17 13:35 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2016\12.426.16 SWEETGRASS F4.GPJ

Cole Garner Geotechnical
1070 W. 124th Ave, Ste. 300
Westminster, CO 80234
303.996.2999

September 28, 2018

KB Home Colorado, Inc.
7807 East Peakview Avenue, Suite 300
Centennial, CO 80111

Attn: Ms. Katie Cooley

RE: Geotechnical Evaluation of Clayset
Sweetgrass Subdivision - Filing No. 4
Sweetgrass Parkway and Prairie Drive
Dacono, Colorado
CGG Project No: 12.426.16

Dear Ms. Cooley:

Cole Garner Geotech (CGG) has completed laboratory evaluation of Clayset as a soil treatment additive to help reduce the expansive potential of the soils and bedrock present at the site. As discussed in our Preliminary Geotechnical Engineering Report (PGER) for the site, moisture conditioning alone did not appear to be effective for mitigation of the expansive soils/bedrock encountered at the site. As requested, we have completed evaluation of Clayset as an alternative chemical additive.

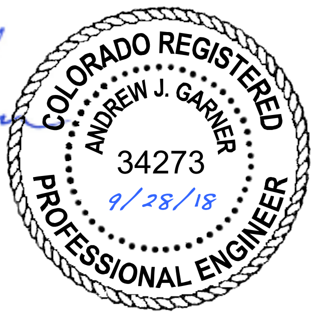
In consultation with Soil Scientific (supplier of Clayset), we evaluated blending Clayset with water at a ratio of 400 parts water to 1 part Clayset. We used this mixture to treat the lean clay overburden soil and the claystone bedrock, separately. Specimens were prepared using this mixture, compacted to about 95 percent compaction at a moisture content of about one percent over optimum (as would be the minimum compaction requirements outlined in our PGER). Specimens were tested for swell consolidation at intervals of one day, 3 days, and seven days after compaction. In addition one specimen of each soil type was compacted seven days after mixing and subjected to swell testing. As shown on attached summary of laboratory testing the clay soils treated with this mixture of Clayset exhibited less than 1 percent swell. Samples of the treated claystone materials exhibited just over 1 percent swell, with the 7-day swell test indicating 1.0 percent swell.

Based on this evaluation, we believe that Clayset, mixed at a ratio of 1 part Clayset to 400 parts water will be sufficient to mitigate the expansive potential of the soil and bedrock materials encountered with Filing 5.

We appreciate the opportunity to provide these additional services and look forward to working with you on this project. If you have any questions or comments regarding this proposal or require additional services, please contact us.

Sincerely,

Cole Garner Geotechnical



Andrew J. Garner, P.E.
Principal, COO

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO 80234
Telephone: 303.996.2999

SUMMARY OF LABORATORY RESULTS

CLIENT KB Home Colorado

PROJECT NAME Sweetgrass Filing No. 4 - Preliminary Geotech

PROJECT NUMBER 12.426.16

PROJECT LOCATION Dacono, Colorado

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
4A	1	LEAN CLAY with CLAYSET - DAY 1	20.2	98.9	-0.3/500					
4A	2	LEAN CLAY with CLAYSET - DAY 3	20.2	98.7	+0.5/500					
4A	3	LEAN CLAY with CLAYSET - DAY 7	20.2	98.5	+0.2/500					
4A	4	LEAN CLAY with CLAYSET COMPACTED - DAY 7	20.2	100.3	+0.1/500					
4A	6	CLAYSTONE with CLAYSET - DAY 1	23.2	95.4	+1.4/500					
4A	7	CLAYSTONE with CLAYSET - DAY 3	23.3	95.3	+1.3/500					
4A	8	CLAYSTONE with CLAYSET - DAY 7	23.5	95.4	+1.0/500					
4A	9	CLAYSTONE with CLAYSET COMPACTED - DAY 7	23.5	97.5	+1.3/500					
4A (Bulk-1)	1	NATIVE LEAN CLAY					91	48	20	28
4A (Bulk-2)	1	NATIVE CLAYSTONE					97	49	20	29

LAB SUMMARY - GINT STD US LAB.GDT - 9/28/18 12:55 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2016\12.426.16 SWEETGRASS F4.GPJ

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO 80234
Telephone: 303.996.2999

SUMMARY OF LABORATORY RESULTS

CLIENT KB Home of Colorado

PROJECT NAME Sweetgrass F4

PROJECT NUMBER 18.23.282

PROJECT LOCATION Dacono, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
4282 L1B8	1	1/4/19 - Test No. 9	25.4	94.2	+0.4/500					
4283 L3B8	1	1/4/19 - Test No. 19	22.5	100.0	+4.4/500					
4289 L4B8	1	1/5/19 - Test No. 21 - Retest of 1/4/19 No. 19	23.4	96.6	+0.8/500					
4294 L5B8	1	1/7/19 - Test No. 36	20.6	101.1	+2.8/500					
4302 L4B8	1	1/8/19 - Test No. 41	25.3	99.7	+0.7/500					
4308 L4B8	1	1/9/19 - Test No. 5	24.9	95.9	+0.9/500					
4315 L1B8	1	1/10/19 - Test No. 9	24.4	98.6	+1.3/500					
4324 L1B8	1	1/14/19 - Test No. 17	29.2	88.0	+0.0/500					
4329 L3B8	1	1/15/19 - Test No. 25	24.4	93.2	+0.1/500					
4340 L4B8	1	1/17/19 - Test No. 34	21.1	106.0	+0.4/500					
4348 L10B8	1	1/18/19 - Test No. 39	18.9	101.9	+1.0/500					
4358 L11B8	1	1/21/19 - Test No. 46	21.3	99.5	+0.6/500					
4365 L8B8	1	1/23/19 - Test No. 57	22.1	102.5	+0.8/500					
4374 L15B8	1	1/24/19 - Test No.65	22.4	102.6	+0.8/500					
4378	1	1/29/19 - No Test Number	21.8	99.8	+0.1/500					
4379	1	1/29/19 - No Test Number	24.4	95.5	-0.7/500					
4382	1	1/31/19 - Test No. 95	19.9	103.6	+1.3/500					
4383	1	1/31/19 - Test No. 87	23.2	98.2	-0.2/500					
4393	1	2/1/19 - Test No. 105	18.7	100.4	-0.3/500					
4402	1	2/1/19 - Test No. 119	23.2	97.6	+0.1/500					
4414	1	2/6/19 - Test No. 130	25.9	96.5	+0.2/500					
4415	1	2/6/19 - Test No. 142	25.9	94.3	+0.3/500					
4429	1	2/6/19 - Test No. 156	26.1	148.2	-0.2/500					
4448	1	2/12/19 - Test No. 170	22.5	99.4	+1.0/500					
4468	1	2/19/19 - Test No. 172	26.1	93.8	-0.1/500					
4483	1	2/19/19 - Test No. 188	22.4	97.4	+0.1/500					
4484	1	2/19/19 - Test No. 201	24.0	95.4	+0.2/500					
4501	1	2/25/19 - Test No. 206	26.6	94.2	+0.8/500					
4504	1	2/28/19 - Test No. 217	22.2	100.1	-0.3/500					
4515	1	2/28/19 - Test No. 251	22.5	96.7	+2.2/500					

LAB SUMMARY - GINT STD US LAB.GDT - 7/10/19 15:05 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS CMT\2018\18.23.282 SWEEGRASS F4.GPJ

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO 80234
Telephone: 303.996.2999

SUMMARY OF LABORATORY RESULTS

CLIENT KB Home of Colorado

PROJECT NAME Sweetgrass F4

PROJECT NUMBER 18.23.282

PROJECT LOCATION Dacono, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
4529	1	3/1/19 - Test No. 247	23.2	94.1	-0.6/500					
4530	1	3/1/19 - Test No. 270	26.0	94.1	+0.1/500					
4539	1	3/8/19 - Test No. 276	26.1	94.0	+0.1/500					
4565	1	3/19/19 - Test No. 276	26.1	96.0	-0.2/500					
4577	1	3/21/19 - Test No. 303	22.9	95.0	+0.1/500					
4578	1	3/21/19 - Test No. 328	21.9	103.0	+1.4/500					
4585	1	3/26/19 - Test No. 338	21.4	96.9	+2.2/500					
4588	1	3/26/19 - Test No. 388	26.6	92.3	-0.1/500					
4592	1	3/26/19 - Test No. 373	21.6	98.4	+0.9/500					
4597	1	3/26/19 - Test No. 382	24.2	91.6	+0.2/500					
4602	1	3/30/19 - Test No. 408	21.9	102.0	+2.3/500					
4619	1	3/30/19 - Test No. 415	25.9	92.8	-0.3/500					
4636	1	4/5/19 - Test No. 439	25.5	97.3	+0.2/500					
4640	1	4/5/19 - Test No. 449	26.1	99.5	+0.1/500					
4644	1	4/8/19 - Test No. 462	22.9	99.0	-0.4/500					
4645	1	4/8/19 - Tet No. 463	20.4	100.7	-0.1/500					
4656	1	4/20/19 - Test No. 464	24.6	93.6	-0.3/500					
4659	1	4/16/19 - Test No. 470	20.0	101.2	+2.8/500					
4670	1	4/19/19 - Test No. 480	29.7	89.1	+0.2/500					
4672	1	4/18/19 - Retest of Test No. 480	22.4	98.8	+1.0/500					
4676	1	4/19/19 - Test No. 483	23.7	97.8	-0.1/500					
4681	1	4/22/19 - Test No. 495	24.5	98.5	+0.1/500					
4682	1	4/22/19 - Test No. 504	25.1	94.4	+0.2/500					
4694	1	4/29/19 - Test No. 510	24.8	98.2	+0.8/500					
4695	1	4/29/19 - Test No. 518	22.8	99.0	+0.2/500					
4705	1	4/27/19 - Test No. 525	26.6	93.6	-0.3/500					
4706	1	4/28/19 - Test No. 536	25.0	96.0	-0.2/500					
4707	1	4/29/19 - Test No. 539	18.2	103.6	-0.3/500					
4712	1	5/4/19 - Test No. 548	26.8	95.5	-0.3/500					
4724	1	5/3/19 - Test No. 570	24.5	95.9	-0.1/500					

LAB SUMMARY - GINT STD US LAB.GDT - 7/10/19 15:05 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS CMT\2018\18.23.282 SWEEGRASS F4.GPJ

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO 80234
Telephone: 303.996.2999

SUMMARY OF LABORATORY RESULTS

CLIENT KB Home of Colorado

PROJECT NAME Sweetgrass F4

PROJECT NUMBER 18.23.282

PROJECT LOCATION Dacono, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
4741	1	5/9/19 - Test No. 601	23.9	99.0	+0.2/500					
4763	1	5/9/19 - Test No. 581	26.6	92.6	-0.2/500					
4794	1	6/1/19 - Test No. 716	26.6	93.5	-0.2/500					
4795	1	6/1/19 - Test No. 731	25.6	93.7	-0.2/500					
4798	1	6/1/19 - Test No. 750	26.5	90.8	+0.1/500					
4802	1	6/1/19 - Test No. 570	25.5	93.1	-0.2/500					

LAB SUMMARY - GINT STD US LAB.GDT - 7/10/19 15:05 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS CMT\2018\18.23.282 SWEEGRASS F4.GPJ

Pre/Post Swell Data and Project Description
Century Communities - Grand Vue
Interlocken - Broomfield, CO
December 2020 - July 2021
Engineer of Record: CTL Thompson

Project description: The project is a pre-construction treatment of 385,000 cyds of expansive clay. Grand Vue will be a multi story building containing apartments and office space. Soil Scientific's Clay Set hydrogen ionic stabilizer was chosen to replace the select fill or deep pier foundation option for the stabilization of subgrade soils. The use of Clay Set allowed construction with spread footer foundations. Pre-treatment swell testing showed results as high as 20.1% and an average swell of 5.3%. Swell results to this point in the Clay Set treatment show an average swell of 0.16%. A 97% decrease.

A mix ratio of 200 parts water to 1 part Clay Set Concentrate was specified for the project.
An over-excavation operation was performed to a total depth of 15' to allow for 12' of treatment. Soils were removed to the 15' level and replaced in loose lifts. Clay Set Solution was applied by water pulls over the top of the loose lifts and a construction disc was used to break down the soil and thoroughly mix the Clay Set with the soils and bring them to the specified moisture content. After the mixing was completed, the lift was compacted with a rubber tire piece of heavy equipment to the specified compaction. Sampling of the lifts was done using hand drives and swell testing was done within 24 hours of treatment. This process was repeated in lifts until all soils were replaced. (very much like a typical moisture conditioning)

Swell testing results from the initial soils report are on page 2 of this document and the post treatment results are on the following pages. The project will be completed in February 2021.

TABLE B - I

SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH	MOISTURE CONTENT	DRY DENSITY	SWELL TEST DATA				SOIL SUCTION VALUE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH	SOLUBLE SULFATE CONTENT	PASSING NO. 200 SIEVE	SOIL TYPE
	(ft)	(%)	(pcf)	SWELL (%)	COMPRESSION (%)	APPLIED PRESSURE (psf)	SWELL PRESSURE (psf)	(pF)	LIQUID LIMIT	PLASTICITY INDEX	(psf)	(%)	(%)	
TH-1	4	14.0	108	6.2		500								FILL, CLAY, SANDY
TH-1	14	19.9	106	3.6		1,800								CLAYSTONE
TH-1	19	16.2	114	2.5		2,400								CLAYSTONE
TH-1	24	13.0	122						48	29	22,300		99	CLAYSTONE
TH-1	0-15								53	35			91	CLAYSTONE
TH-2	9	12.0	120	1.1		1,100								WEATHERED CLAYSTONE
TH-2	19	13.3	119	1.1		2,400								CLAYSTONE
TH-3	4	6.8	126	20.1		500						<0.01		CLAYSTONE
TH-3	9	14.7	118	6.2		1,100								CLAYSTONE
TH-3	14	10.8	125	2.7		1,800								CLAYSTONE
TH-4	4	9.2	118	5.3		500	5,800	4.55						CLAYSTONE
TH-4	9	12.5	126	15.0		1,100	18,000	4.68						CLAYSTONE
TH-4	14	18.5	114	10.5		1,800	27,000	4.46						CLAYSTONE
TH-4	19	13.6	117	7.4		2,400	26,000	4.59						CLAYSTONE
TH-4	24	14.7	113		0.6	3,000		4.55						CLAYSTONE
TH-5	9	15.3	113	5.5		1,100								FILL, CLAY, SANDY
TH-5	14	10.9	120										66	CLAYSTONE
TH-6	4	12.2	110	4.3		500						0.09		FILL, CLAY, SANDY
TH-6	9	15.9	115	4.7		1,100								FILL, CLAY, SANDY
TH-6	19	12.1	117	0.0		2,400								FILL, CLAY, SANDY
TH-7	9	14.8	120	5.6		1,100								CLAYSTONE
TH-7	14	12.8	124	3.0		1,800			54	36			100	CLAYSTONE
TH-7	24	7.1											62	CLAYSTONE/SANDSTONE
TH-8	4	11.2	124	1.6		500								CLAYSTONE
TH-8	14	10.6	130	5.0		1,800								CLAYSTONE
TH-8	24	13.5	119	4.5		3,000								CLAYSTONE
TH-9	4	13.3	116	6.0		500	5,400	3.90						FILL, CLAY, SANDY
TH-9	9	13.5	114	0.0		1,100		3.74						FILL, CLAY, SANDY
TH-9	14	12.7	123	2.1		1,800	7,500	4.13						WEATHERED CLAYSTONE
TH-9	19	14.9	124	2.8		2,400	15,000	4.08						CLAYSTONE
TH-9	24	18.0	114	3.8		3,000	17,000	4.27						CLAYSTONE
TH-10	9	17.3	113	3.5		1,100						<0.01		WEATHERED CLAYSTONE
TH-10	14	11.8	123		0.3	1,800								CLAYSTONE
TH-10	19	11.8	117	0.2		2,400								CLAYSTONE

December 16, 2020

Century Communities/Colorado
8390 East Crescent Parkway
Suite 650
Greenwood Village, Colorado 80111

Attention: Mr. Paul Yourick

Subject: Swell Test Results Sub-excavation and Backfill
Grand Vue at Interlocken
Broomfield, Colorado

Project No. DN49201.001F-310

This letter transmits swell test results from samples obtained during sub-excavation and backfill at Grand Vue at Interlocken. Swell test results are presented in the table below.

Date	Date Tested	Lot/Block	Depth (ft)	Swell* (%)	Moisture Content (%)	Dry Density (pcf)
11/10/20	11/24/20	104/437	11	-0.1	22.1	95
11/18/20	11/19/20	103/429	11	0.1	20.9	100
11/18/20	11/19/20	104/429	13	0.9	19.2	106
11/18/20	11/19/20	102/429	13	0.5	21.1	102
11/18/20	11/19/20	101/429	11	0.4	21.6	100
11/19/20	11/23/20	104/427	14	0.0	19.3	97
11/19/20	11/23/20	103/431	12	-0.6	21.2	95
11/19/20	11/23/20	104/433	14	0.5	19.5	105
11/19/20	11/23/20	105/435	12	0.8	17.6	103
11/20/20	11/24/20	105/431	9	0.3	20.9	107
11/20/20	11/24/20	102/433	10	0.0	21.6	97
11/20/20	11/24/20	106/435	10	0.3	20.4	102
11/23/20	11/30/20	106/427	11	0.7	17.2	109
11/23/20	11/30/20	105/433	10	0.5	20.8	105
11/23/20	11/30/20	106/429	8	0.5	22.3	105
11/23/20	11/30/20	101/435	9	0.4	18.2	111
11/30/20	12/1/20	104/427	12	0.2	21.8	106
11/30/20	12/1/20	106/429	7	0.6	22.7	105
12/2/20	12/3/20	102/429	6	0.1	20.5	108
12/2/20	12/3/20	106/429	6	0.9	20.2	107
12/2/20	12/3/20	105/427	11	0.7	20.1	110
12/3/20	12/4/20	105/429	5	0.6	22.5	103

12/3/20	12/10/20	106/429	4	0.1	20.4	108
12/3/20	12/4/20	105/427	10	1.5	20.9	109
12/3/20	12/4/20	106/427	8	1.4	20.1	107
12/4/20	12/11/20	102/429	2	0.6	16.0	114
12/4/20	12/7/20	105/427	5	-0.7	17.0	101
12/4/20	12/7/20	105/427	6	0.5	20.4	102
12/4/20	12/7/20	102/479	3	0.4	20.4	100
12/7/20	12/8/20	104/433	6	1.3	19.5	106
12/7/20	12/8/20	102/429	2	0.5	17.4	112
12/7/20	12/8/20	103/427	3	1.0	21.3	107
12/8/20	12/9/20	105/437	5	0.3	20.9	107
12/8/20	12/9/20	106/433	0	1	21.8	103
12/8/20	12/10/20	104/435	6	0.5	20.5	108
12/9/20	12/10/20	106/431	1	0.4	18.6	109
12/9/20	12/10/20	104/433	0	0.3	19.5	104

* When wetted under an applied load of about 1,000 psf.

Fill samples exhibited compression to low swell when wetted. If we can be of further assistance, please contact us at your convenience.

CTL | THOMPSON, INC

Alexandra R. Berney, P.E.
Project Engineer

ARB/ss

Swell Testing Data & Project Description
Lincoln Executive Center
Jordan Perlmutter - Owner
Denver Tech Center
March-August 2021
Engineer of Record: Cole Garner

Project Description: Pre-construction treatment of approximately 375,000 cyds of expansive clay for a commercial development of 4 warehouse buildings containing attached office space. Soil Scientific's Clay Set hydrogen ionic stabilizer was chosen to replace the select fill or deep pier foundation option for the stabilization of sub-grade soils for building foundations, slabs, streets and flat work. An over excavation to 10' below foundations and 5' below streets and flat work will be performed. The full project is scheduled to begin in March of 2021. The use of Clay Set allowed construction of the warehouse/office buildings with spread footer foundations and slab on grade.

Pre-treatment swell testing of samples treated with water only showed results as high as 5.2%. Treatment with a 200 parts water mixed with 1 part Clay Set Concentrate (200/1 ratio) showed a reduction in swell to approximately 1%. An 80% decrease in swell potential. It is expected that when the final testing of field treated soil at the project is completed, we will see average swells that are lower than 1% as that is the typical outcome. A mix ratio of 200 parts water to 1 part Clay Set Concentrate will be used to complete the project.

Summary data from preliminary testing that was performed in the lab to compare the use of water alone to the Clay Set Solution is provided below. Swell test results from the initial soils report follows. We are assuming that we are dealing with soils that would exhibit a higher swell than what were shown in the initial report and therefore, are treating accordingly. This is due to the higher surcharge pressures used for the initial testing/report as compared to what the slabs and structure will have in the real world and the fact that post treatment testing will be done using lower surcharge pressures to better mimic real world conditions. This will allow a conservative approach and assure the best long term results for the project. Further information will be provided as the project progresses. The contact information for Andrew Garner of Cole Garner is provided in our references sheet.

Jordon Perlmutter & Co.

Subject: Clay Set Results at Lincoln Executive Center – Centennial, CO

Dear Ms. Langan,

I am writing to thank you and to recommend Soil Scientific's product Clay Set. Jordon Perlmutter & Co. was looking for a solution to develop an industrial site in the Denver Metro area with expansive sandstone/claystone soils that would require export of existing onsite soils and the import of structural fill. Having seen a testimonial on LinkedIn regarding Clay Set and the hydrogen ionic stabilization process we were intrigued by the purported results. Skeptical of the prior findings we performed our own onsite testing using the Clay Set product and found our results equal to, or better than the case studies. Even better, the geotechnical testing results during project construction using Clay Set yielded stellar results by removing nearly all potential swell of the native soils. The elimination of soil export and imported fill saved our company both time and money. I believe the best recommendation in business is a return customer, and we will most certainly be using Clay Set again.

Sincerely,

Brian S. Heinze
Director of Construction & Development
Jordon Perlmutter & Co.

1601 Blake Street • Suite 600 • Denver, Colorado 80202-1329 • (303) 595-9919 • Fax (303) 595-3435
Mailing Address: Post Office Box 480070 • Denver, Colorado 80248-0070
www.jp-co.com

Sample ID and Summary

Boring No.	Bldg No.	Composite Sample Soil Type	Sample Depth	Average Soil Properties of Composite Samples: In-situ Moisture Content (%0	Percent Passing the #200 sieve (%)	Liquid Limit	Plasticity Index	Max. Dry Density (pcf)	Optimum Moisture Content (OMC,%)
101	1	Claystone Bedrock	10 to 20 ft	24.4	94	56	33	91.8	26.1
102	2	Claystone Bedrock	2 to 15 ft	24.6	92	54	32	91.4	26.4
103	3	Claystone Bedrock	5 to 10 ft	17.5	79	53	32	97.2	23.4
104	4	Overburden Clays	5 to 15 ft	18.0	68	39	19	101.6	20.2

Evaluation of Remolded Swell (Water Only, in-situ moisture approximately 2 to 4% below optimum)

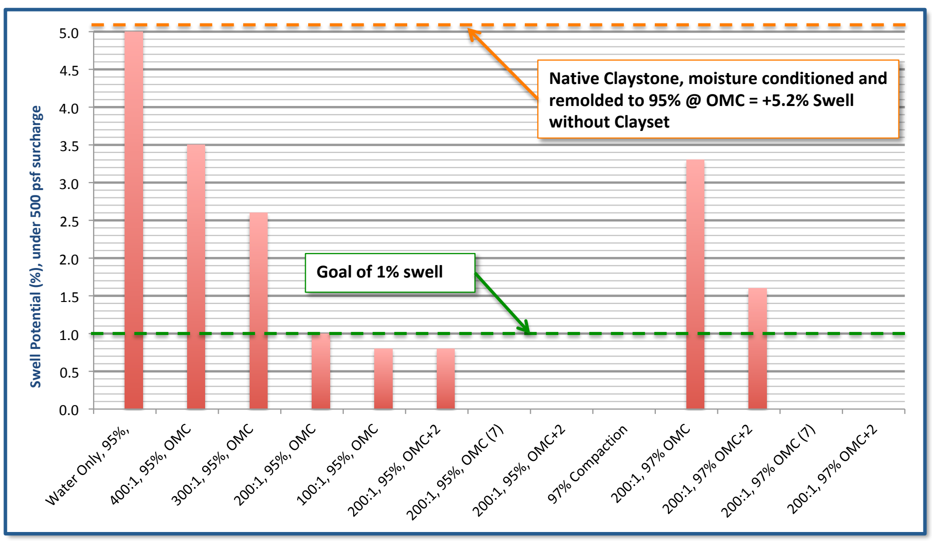
Test ID	Boring No.	Compaction (%)	Moisture Content (%)	Swell Potential, under 500 psf (%)	
A	101	95	OMC	3.7	
B	**102**	**95**	**OMC**	**5.2**	**Identified as worst-case material**
C	103	95	OMC	2.8	
D	104	95	OMC	0.7	

Evaluation of Remolded Swell of Composite Boring 102, added water (to reach OMC) mixed with ClaySet

Test ID	Concentration (Water:ClaySet)	Compaction (%)	Moisture Content (%)	Swell Potential, under 500 psf (%)	NOTES
B-1	400:1	95	OMC	3.5	
B-2	300:1	95	OMC	2.6	
B-3	200:1	95	OMC	1.0	
B-4	100:1	95	OMC	0.8	
B-5	200:1	97	OMC	3.3	Higher compaction at OMC
B-6	200:1	95	OMC with 7-day cure		to test curing at OMC
B-7	200:1	97	OMC with 7-day cure		to test curing on overcompaction scenario at OMC
B-8	200:1	95	OMC + 2%	0.8	to test higher moisture spec
B-9	200:1	97	OMC + 2%	1.6	to test higher moisture and overcompaction scenario
B-10	200:1	95	OMC+2% with 7-day Cure		curing of above
B-11	200:1	97	OMC+2% with 7-day Cure		curing of above

SUMMARY OF CLAYSET TREATMENT

Test Type	Swell (%)
Water Only, 95%, OMC	5.2
400:1, 95%, OMC	3.5
300:1, 95%, OMC	2.6
200:1, 95%, OMC	1.0
100:1, 95%, OMC	0.8
200:1, 95%, OMC+2	0.8
200:1, 95%, OMC (7)	
200:1, 95%, OMC+2 (7)	
97% Compaction	
200:1, 97% OMC	3.3
200:1, 97% OMC+2	1.6
200:1, 97% OMC (7)	
200:1, 97% OMC+2 (7)	



Additional Evaluation, upon request

Concentration (Water:ClaySet)	Compaction (%)	Moisture Content (%)	Swell Potential, under 500 psf (%)	NOTES
100:1	97	OMC		higher compaction
100:1	95	OMC + 2%		higher moisture
100:1	97	OMC + 2%		higher moisture and compaction
300:1	95	OMC with 7-day cure		to evaluate "curing" of compacted mass
300:1	95	OMC +2% with 7-day cure		to evaluate "curing" of compacted mass
300:1	97	OMC with 7-day cure		to evaluate "curing" of compacted mass
300:1	97	OMC +2% with 7-day cure		to evaluate "curing" of compacted mass

GROUND ENGINEERING

Lincoln Executive Center - Building 1

TABLE 1a: SUMMARY OF LABORATORY TEST RESULTS

Sample Location		Natural Moisture Content	Natural Dry Density	Gradation			Atterberg Limits		Swell/Consolidation		Unconfined Compressive Strength		USCS Equivalent Classification	AASHTO Equivalent Classification (Group Index)	Sample Description
Test Hole No.	Depth (feet)	(%)	(pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plasticity Index	Volume Change (%)	Surcharge Pressure (psf)	(psi)	(ksf)			
1	19	18.6	108.0	-	-	66	52	21	0.5	1,375	-	-	s(MH)	A-7-5 (14)	SILTSTONE Bedrock
1	29	19.2	99.9	-	-	78	38	16	-	-	75.4	10.86	(CL)s	A-6 (12)	CLAYSTONE Bedrock
2	7	22.9	101.3	-	-	44	55	22	1.4	250	-	-	SM	A-7-5 (6)	SANDSTONE Bedrock
2	12	16.3	108.3	-	-	79	46	20	-	-	-	-	(CL)s	A-7-6 (17)	CLAYSTONE Bedrock
3	8	27.1	90.0	-	-	59	65	32	1.0	750	-	-	s(MH)	A-7-5 (17)	SILTSTONE Bedrock
3	18	23.8	97.6	-	-	43	67	35	-4.4	2,000	-	-	SM	A-7-5 (10)	SANDSTONE Bedrock
4	3	20.7	104.9	-	-	72	58	27	2.0	250	-	-	(MH)s	A-7-5 (21)	SILTSTONE Bedrock
4	8	21.2	104.1	-	-	73	40	12	-	-	-	-	(ML)s	A-6 (9)	SILTSTONE Bedrock
5	10	20.1	105.0	-	-	72	54	26	-1.2	750	-	-	(CH)s	A-7-6 (19)	CLAYSTONE Bedrock
5	20	21.9	95.2	-	-	63	61	26	-	-	-	-	s(MH)	A-7-5 (16)	SILTSTONE Bedrock
6	2	19.3	102.5	-	-	41	44	14	0.1	250	-	-	SM	A-7-5 (2)	SANDSTONE Bedrock
6	7	23.7	100.5	-	-	85	55	22	-	-	-	-	(MH)s	A-7-5 (22)	SILTSTONE Bedrock
7	4	10.2	108.7	-	-	23	29	7	-	-	-	-	SC	A-2-4 (0)	SANDSTONE Bedrock
7	24	24.3	96.7	-	-	41	47	14	-	-	13.8	1.99	SM	A-7-5 (3)	SANDSTONE Bedrock

GROUND ENGINEERING

Lincoln Executive Center - Building 2

TABLE 1b: SUMMARY OF LABORATORY TEST RESULTS

Sample Location		Natural Moisture Content	Natural Dry Density	Gradation			Atterberg Limits		Swell/Consolidation		Unconfined Compressive Strength		USCS Equivalent Classification	AASHTO Equivalent Classification (Group Index)	Sample Description
Test Hole No.	Depth *(feet)*	*(%)*	*(pcf)*	Gravel *(%)*	Sand *(%)*	Fines *(%)*	Liquid Limit	Plasticity Index	Volume Change *(%)*	Surcharge Pressure *(psf)*	*(psi)*	*(ksf)*			
8	8	22.3	99.8	-	-	74	71	34	0.8	250	-	-	(MH)s	A-7-5 (28)	SILTSTONE Bedrock
8	18	21.2	103.1	-	-	44	45	17	-0.6	1,375	-	-	SM	A-7-6 (4)	SANDSTONE Bedrock
9	2	21.6	98.0	-	-	73	38	10	-	-	-	-	(ML)s	A-4 (7)	SILTSTONE Bedrock
9	22	16.2	105.8	-	-	63	48	19	-	-	47.1	6.78	s(ML)	A-7-6 (11)	SILTSTONE Bedrock
10	5	21.5	88.5	-	-	64	57	26	0.9	625	-	-	s(MH)	A-7-5 (16)	SILTSTONE Bedrock
10	15	15.7	109.9	-	-	72	49	23	-0.5	1,875	-	-	(CL)s	A-7-6 (17)	CLAYSTONE Bedrock
11	4	18.7	106.2	-	-	73	54	27	1.8	750	-	-	(CH)s	A-7-6 (20)	CLAYSTONE Bedrock
12	7	23.7	102.6	-	-	67	48	23	0.6	1,125	-	-	s(CL)	A-7-6 (14)	CLAYSTONE Bedrock
12	27	20.2	*SD*	-	-	62	48	15	-	-	-	-	s(ML)	A-7-5 (9)	SILTSTONE Bedrock
13	3	11.5	112.8	-	-	70	32	9	-	-	-	-	s(CL)	A-4 (5)	Sandy CLAY
13	8	14.2	97.9	-	-	29	*NV*	*NP*	-	-	-	-	SM	A-2-4 (0)	SANDSTONE Bedrock

SD = Sample Disturbed, NV = No value, NP = Non-plastic

GROUND ENGINEERING

Lincoln Executive Center - Building 3

TABLE 1c: SUMMARY OF LABORATORY TEST RESULTS

Sample Location		Natural	Natural	Gradation			Atterberg Limits		Swell/Consolidation		Unconfined Compressive Strength		USCS Equivalent Classification	AASHTO Equivalent Classification (Group Index)	Sample Description
Test Hole No.	Depth (feet)	Moisture Content (%)	Dry Density (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plasticity Index	Volume Change (%)	Surcharge Pressure (psf)	(psi)	(ksf)			
14	4	20.9	96.7	-	-	79	45	15	3.6	500	-	-	(ML)s	A-7-5 (13)	SILTSTONE Bedrock
14	24	17.8	102.6	-	-	37	33	11	-	-	17.9	2.58	SC	A-6 (0)	SANDSTONE Bedrock
15	3	18.1	103.3	-	-	45	38	13	-	-	-	-	SM	A-6 (3)	SANDSTONE Bedrock
15	15	28.1	95.7	-	-	72	43	11	-	-	-	-	(ML)s	A-7-5 (8)	SILTSTONE Bedrock
16	5	19.5	108.3	-	-	60	41	21	-0.9	1,250	-	-	s(CL)	A-7-6 (10)	CLAYSTONE Bedrock
16	10	21.8	103.7	-	-	76	40	18	-0.2	1,825	-	-	(CL)s	A-6 (13)	CLAYSTONE Bedrock
17	7	17.3	110.4	-	-	66	43	18	-	-	-	-	s(CL)	A-7-6 (11)	CLAYSTONE Bedrock
17	17	19.7	97.9	-	-	70	50	20	-	-	25.1	3.61	s(ML)	A-7-5 (14)	SILTSTONE Bedrock
18	4	23.9	98.8	-	-	62	56	24	-	-	67	9.65	s(MH)	A-7-5 (14)	SILTSTONE Bedrock
18	9	19.9	108.3	-	-	76	32	11	-	-	-	-	(CL)s	A-6 (7)	CLAYSTONE Bedrock
19	2	17.9	93.6	-	-	57	54	28	0.0	1,375	-	-	s(CH)	A-7-6 (14)	CLAYSTONE Bedrock

GROUND ENGINEERING

Lincoln Executive Center - Building 4

TABLE 1d: SUMMARY OF LABORATORY TEST RESULTS

Sample Location		Natural Moisture Content	Natural Dry Density	Gradation			Atterberg Limits		Swell/Consolidation		Unconfined Compressive Strength		USCS Equivalent Classification	AASHTO Equivalent Classification (Group Index)	Sample Description
Test Hole No.	Depth (feet)	(%)	(pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plasticity Index	Volume Change (%)	Surcharge Pressure (psf)	(psi)	(ksf)			
20	5	17.4	104.1	-	-	53	44	18	-1.0	1,750	-	-	s(CL)	A-7-6 (7)	CLAYSTONE Bedrock
20	10	24.3	97.2	-	-	59	59	21	-	-	80.6	11.61	s(MH)	A-7-5 (12)	SILTSTONE Bedrock
21	3	9.4	107.3	-	-	51	30	10	-	-	-	-	s(CL)	A-4 (2)	FILL: Sandy CLAY
21	28	21.0	102.9	-	-	62	38	9	-	-	-	-	s(ML)	A-4 (5)	SILTSTONE Bedrock
22	4	7.8	119.8	2	55	43	30	10	-	-	-	-	SC	A-4 (1)	FILL: Clayey SAND
22	14	28.0	89.4	-	-	68	37	16	-1.4	2,000	-	-	s(CL)	A-6 (9)	Sandy CLAY
23	2	18.1	107.4	-	-	70	28	13	-	-	-	-	(CL)s	A-6 (7)	FILL: CLAY with Sand
23	17	19.2	105.1	-	-	36	27	12	-	-	-	-	SC	A-6 (0)	Clayey SAND
24	4	8.3	115.6	-	-	54	31	12	-	-	-	-	s(CL)	A-6 (4)	Sandy CLAY
25	3	22.2	99.2	-	-	97	36	10	-	-	-	-	ML	A-4 (11)	SILT
25	8	17.0	108.8	-	-	62	32	15	-	-	26.8	3.86	s(CL)	A-6 (7)	Sandy CLAY
26	5	18.8	101.0	-	-	81	38	21	-	-	-	-	(CL)s	A-6 (16)	FILL: CLAY with Sand
26	10	26.1	96.4	-	-	96	43	22	-	-	-	-	CL	A-7-6 (23)	CLAY

GROUND ENGINEERING

Lincoln Executive Center - Pavements

TABLE 1e: SUMMARY OF LABORATORY TEST RESULTS

Sample Location		Natural Moisture Content	Natural Dry Density	Gradation			Atterberg Limits		Swell/Consolidation		Unconfined Compressive Strength		USCS Equivalent Classification	AASHTO Equivalent Classification (Group Index)	Sample Description
Test Hole No.	Depth *(feet)*	*(%)*	*(pcf)*	Gravel *(%)*	Sand *(%)*	Fines *(%)*	Liquid Limit	Plasticity Index	Volume Change *(%)*	Surcharge Pressure *(psf)*	*(psi)*	*(ksf)*			
P-1	15	27.4	96.1	-	-	62	62	27	7.4	200	-	-	s(MH)	A-7-5 (16)	SILTSTONE Bedrock
P-2	7	22.2	97.7	-	-	55	55	23	2.8	200	-	-	s(MH)	A-7-5 (11)	SILTSTONE Bedrock
P-3	8	16.7	111.5	-	-	67	46	11	-	-	-	-	s(ML)	A-7-5 (8)	SILTSTONE Bedrock
P-4	12	20.0	106.4	-	-	71	56	25	3.2	200	-	-	(MH)s	A-7-5 (19)	SILTSTONE Bedrock
P-5	3	9.8	112.9	4	27	69	41	18	-	-	-	-	s(CL)	A-7-6 (11)	Sandy CLAY
P-6	4	15.7	106.7	-	-	42	47	18	-	-	-	-	SM	A-7-6 (4)	SANDSTONE Bedrock
P-7	2	13.7	112.0	-	-	57	33	15	-	-	-	-	s(CL)	A-6 (6)	Sandy CLAY
P-8	3	7.2	114.2	-	-	30	30	13	2.9	200	-	-	SC	A-2-6 (0)	FILL: Clayey SAND
P-1 - P-4	0-15	21.4*	98.9*	-	-	74	57	30	-	-	-	-	(CH)s	A-7-6 (23)	CLAY with Sand
P-5 - P-6	1-5	13.9*	113.0*	-	-	61	42	19	-	-	-	-	s(CL)	A-7-6 (10)	Sandy CLAY

** Indicates optimum moisture content and maximum standard Proctor density (ASTM D698)*

CASE HISTORY

DATA SUMMARY OF IONIC CHEMICAL TREATMENT ON LARGE COMMERCIAL BUILDING (4080 BOULDER HIGHWAY, LAS VEGAS, NEVADA)					
LOCATION	DRY DENSITY (PCF)	INITIAL MOISTURE CONTENT (%)	FINAL MOISTURE CONTENT (%)	SWELL (%) FOR UNTREATED SOIL	SWELL (%) FOR TREATED SOIL
4080 Boulder Hwy. N.W. - 2.0 feet	90.6	22.6	36.1	**13**	
4080 Boulder Hwy. N.W. – 2.0 feet	92.1	22.6	25.7		**0**
4080 Boulder Hwy. S.W. – 2.0 feet	94.7	17.4	23.5	**11**	
4080 Boulder Hwy. S.W. – 2.0 feet	96.1	17.6	24.5		**0**
4080 Boulder Hwy. N.E. – 2.0 feet	95.8	10.0	24.8	**15**	
4080 Boulder Hwy. N.E. – 2.0 feet	97.0	10.4	21.4		**1**
4080 Boulder Hwy. C.E. – 2.0 feet	98.2	11.6	23.0	**16**	
4080 Boulder Hwy. C.E. – 2.0 feet	99.0	12.3	16.8		**1**
4080 Boulder Hwy. N.C. – 1.5 feet	106.7	14.0	16.9	**10**	
4080 Boulder Hwy. N.C. – 1.5 feet	107.5	15.5	17.4		**0**

PROGRESSIVE INSURANCE CLAIMS CENTER - LAS VEGAS, NV

The following photos were taken in 2017 and demonstrate that 9 years after construction, the CMU structure has had no issues with movement or cracking, including the slabs, sidewalks and pavements. After speaking with Austin Foote (the facility maintenance manager) in 2019, he confirmed that the building continues to be in perfect condition and is happy to speak with those interested in learning more. You can find his contact information on our list of references.


Clearance 10'-0"
Clearance 12'-0"

<u>Road stabilization and pre-construction treatment</u>



Clay Set can be used to stabilize unfinished road surfaces as well as subgrades. Clay set is mixed into the specified depth of soil, lifts are compacted and the surfaces is rolled smooth to finish. Clay set will improve performance and decrease maintenance requirements.

For new construction projects, the onsite soil is treated with Clay Set to the full depth specified. The soil is removed and replaced in lifts to produce a treatment zone suitable for footer foundations, eliminating the need for select fill, deep pier foundations, etc.

The Clay Set concentrate is mixed into the specified amount of water while the pull or truck is being filled. A metered pump is used to add the correct amount of concentrate through a plastic line running from the pump to the water chute. This is accurate, quick and there is minimal need to the handle the Clay Set concentrate.

The final Clay Set solution is applied to the surface of each lift in the amount and concentration specified for the specific project and soil type. This will vary depending on native soil conditions and swell potentials.

A construction disc or other suitable tiller is then used to thoroughly mix the Clay Set throughout the lift.

Each lift is brought to the specified moisture content (typically optimum to +2%) and % compaction using the Clay Set solution. Compaction can be done with any large wheeled equipment. Less compactive effort will be required because Clay Set will immediately diminish the negative charges of the clay particle, thereby allowing each particle to more easily "come together" to create a strong and stabilized zone of soil.

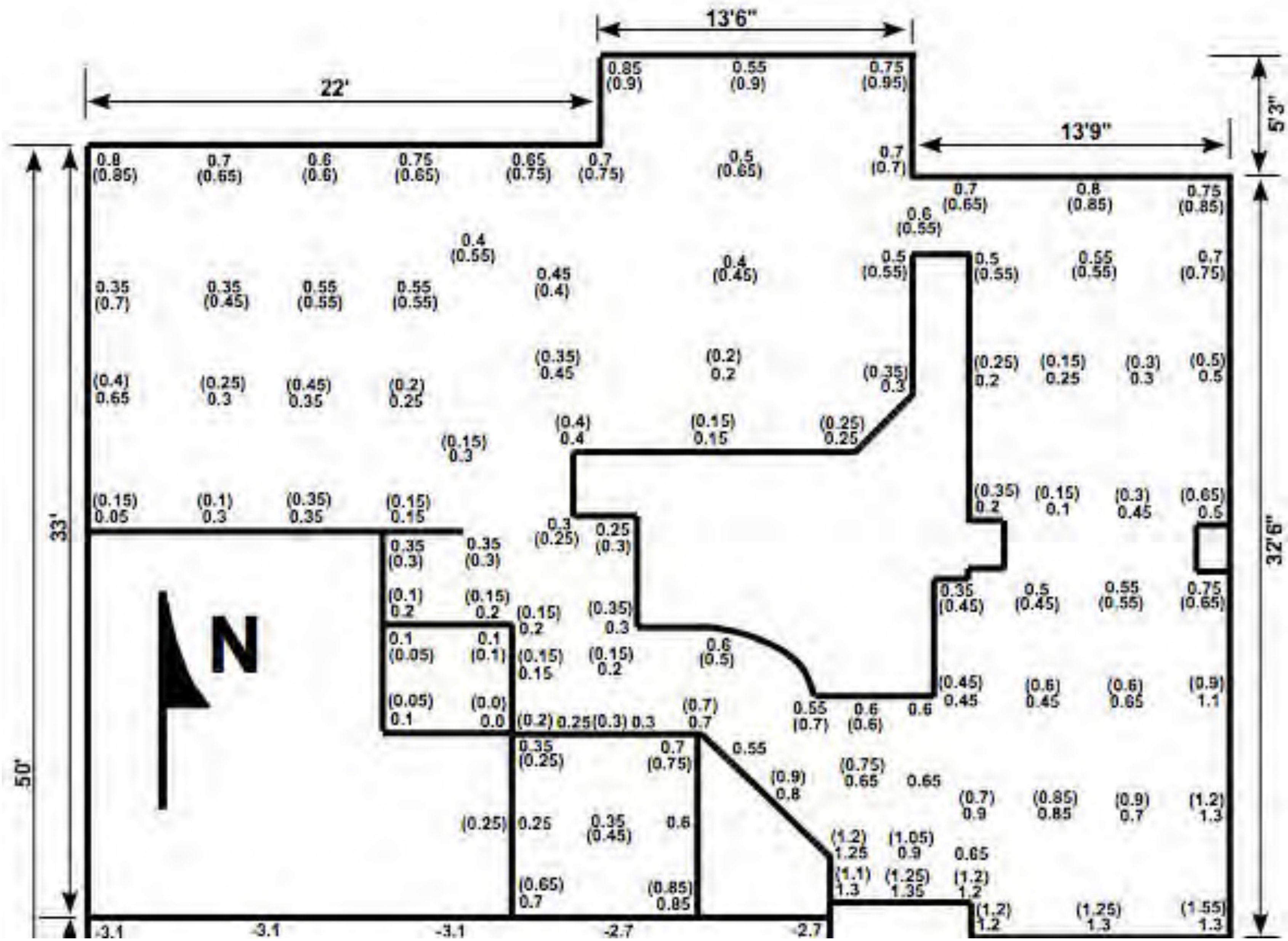
Existing Structures and Limited Access Pre-construction Sites

For existing structures or pre-construction sites with limited access, hand injection can be used. If soil conditions allow, large injection rigs can also be used. The injection pressures vary depending on site soil conditions. Depths of injections can vary from shallow to a maximum depth of 15 feet. Injection is not suitable in very stiff clays.

Existing structures can be safely treated through a careful injection process. The Clay Set is contained on a trailer that is outfitted with pumps. Clay Set is injected to the specified depth a to arrest any further heaving.

On pre-construction sites where access is limited for large equipment, hand injection can also be used. If soil conditions allow, large injection rigs (the same type used for water injection) can be used to treat up to 10,000 SF a day to a depth of 10-12 feet.

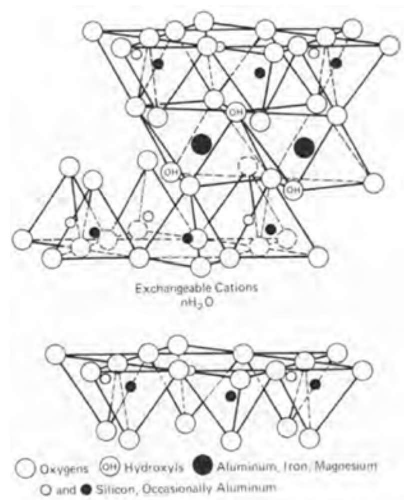
Typical Existing Structure Elevation Reading – Pre: 3/23/08 Post: (9/2/09): When treatment is done on an existing structure, elevations are taken prior to beginning treatment and months after. As is shown in the results below, elevation studies consistently show a lack of movement or even a relaxation of the previously swelled soils.



Details of Clay Set (Hydrogen Ionic Clay Stabilization) Mechanism

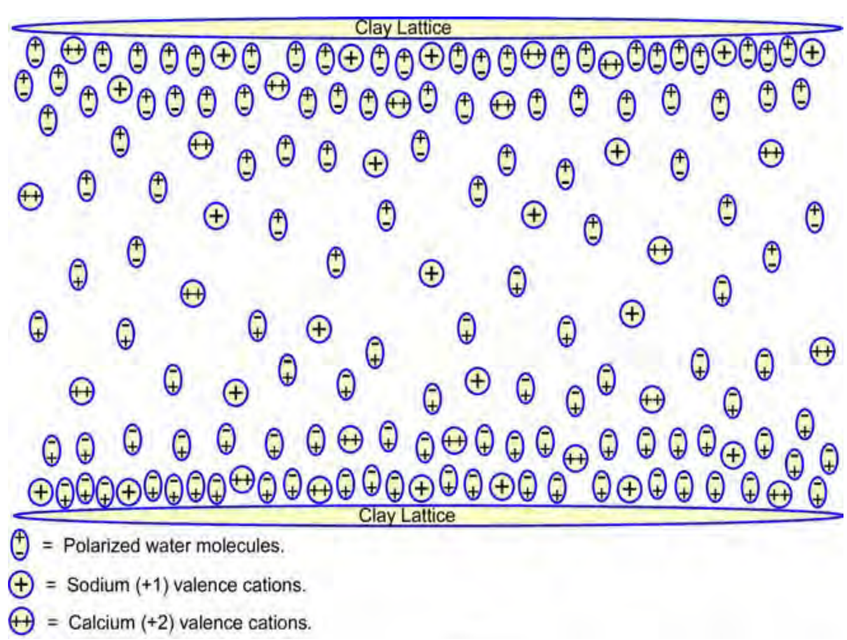
Theory of Expansive Clays

Montmorillonite Clay Lattice Structure



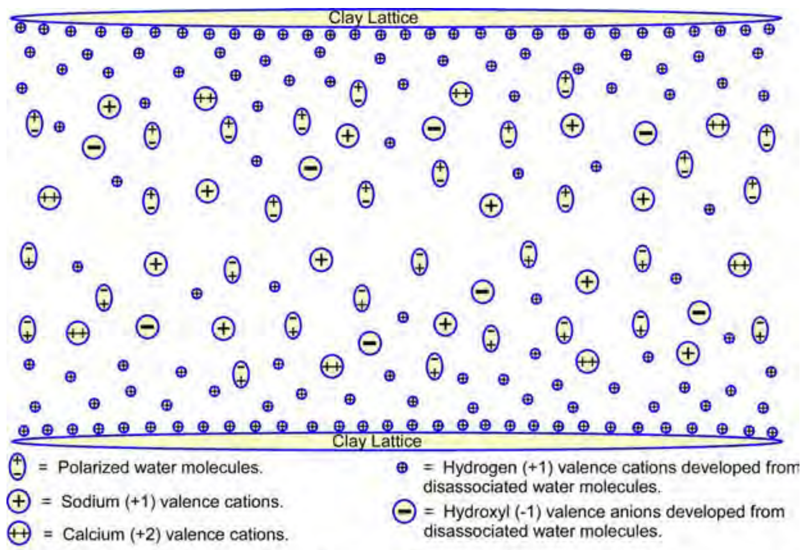
Expansive clay soils can experience significant changes in volume with changes in moisture content. The cause of this expansion potential is due to the electrical charge characteristics of the clay lattice structure. Clay particles are made up of a series of clay lattice structures. The clay lattice structure of the montomorillonite clay is shown above. The montomorillonite clay is a form of smectite clay and is one of the more common high swell clays. As illustrated in the figure above the montomorillonite clay lattice structure is made up of (2) tetrahedral sheets and (1) octahedral sheet. The tetrahedral sheet is made up of a sheet of tetrahedrals with a silica cation in the center surrounded by (4) oxygen's. The octahedral sheet is made up of a sheet of octahedrals with either aluminum, iron, or magnesium at the center surrounded by (6) hydroxyls. Between the clay lattice sheets is a diffuse double layer of polarized water molecules and exchangeable cations.

As a result of missing cations in the tetrahedral and octahedral sheets or the substitution of aluminum for silica in the tetrahedral sheet and iron or magnesium for aluminum in the octahedral sheets produces a negative internal charge. Adding to the internal negative charge of the clay lattice is a negative exterior charge resulting from the geometry of the exterior tetrahedral sheets. The outer exterior of the clay lattice consists of tetrahedral sheets with negatively charged oxygen anions on the outside of the tetrahedral sheets which are on the outside of the clay lattice sheets. The swell potential of a clay is determined by the magnitude of the electrical charge of the clay lattice and the surface area of the clay particle. To offset or neutralize the electrical charge of the clay particles, exchangeable cations and polarized water molecules are attracted around the surfaces of the negatively charged clay particles. The combination of exchangeable cations and polarized water molecules form a layer around the clay particle called the diffuse double layer. The expansion capabilities of the diffuse double layer will determine whether the clay soil has a higher or lower potential for swell.



How Clay Set Works to Stabilize Clay Soils

Treating expansive clay soils with Clay Set significantly reduces the clay soils ability to expand and also reduces their soil suction capabilities. Treatment with Clay Set utilizes chemical soil principles to change the swell/shrink characteristics of the clay soils. The processes that produce these results are referred to as isomorphic substitution and cation exchange which results in a reduction of the internal and external negative charges in the clay lattice. Isomorphic substitution of missing cations in the tetrahedral and octahedral clay lattice sheets reduces the internal negative charges of the clay lattice sheets. Aluminum substitutes for silica in the tetrahedral sheets and iron and magnesium substitutes for aluminum in the octahedral sheets. The external negative charges of the clay lattice are reduced by a chemical process called cation exchange. The Clay Set chemical solution neutralizes the negative charges on the surface of the clay lattice by providing very large amounts of the hydrogen cation in the diffuse double layer that is present between the clay lattices. These hydrogen cations are then attracted to the outer negatively charged surface of the clay lattice, thus neutralizing their negative charge. The diffuse double layer between the clay lattices normally contains polarized water molecules and positive and negative ions. The cation exchange process that occurs is the exchange of the existing large cations that are in the diffuse double layer (primarily sodium and calcium) with the hydrogen cation that is the smallest cation that exists. Due to the very high charge density of very small hydrogen cations (H^{+1}), they can easily exchange with the much larger sodium (Na^{+1}) and calcium (Ca^{+2}) cations and more effectively neutralize the negative charges on the surface of the clay lattices and collapse the diffuse double layer.



As the negative charges of the clay lattice structure are neutralized the swell potential of the clay lattices are reduced significantly. The reduction of negative charges of the clay lattice will allow for attractive forces to become more dominant and repulsive forces less dominant between the clay lattice structures. These increased attractive forces between the clay lattices results in a collapse of the diffuse double layer between the clay lattices with a subsequent tendency for the clay lattices to become more flocculent (edge to face) and less dispersed (face to face). Clay lattices with greater attractive forces will have more flocculent tendencies and will result in significantly lower swell potential and a reduction in soil suction (approximately a ten times reduction in soil suction). The reduction of soil suction will act like a moisture barrier in clay soils that have been treated since the ability for moisture to migrate into clay soils that have been treated with Clay Set is significantly reduced.

Although many scientific studies have been done on ionic chemical stabilization of swelling clay soils, one of the most thorough studies was performed by Dr. Shondeep L. Sarkar and Dr. Bruce E. Herbert with Texas A&M University. It fully explores and explains the mechanism of ionic clay stabilization and the evidence and conclusions help to explain the effects on the clay soils that are routinely seen in the field and in the long term proven results for roads, railroads, parking areas, and structures. A summary of the conclusions from their research is provided below:

- Identifiable smectite peaks were noted to be absent in the Hydrogen Ion Exchange Chemical – treated coarse and fine factions.
- The treatment of clay samples reduced the Zeta potential of the treated sample by 32 % as compared with the untreated clay sample. The Zeta potential is a measure of the negative charge in the clay and on the clay surface. As the Zeta potential decreases it is considered that the double diffuse layer is also reducing.
- Soluble ions analysis of Al and Fe supports the hypothesis that the Hydrogen Ion Exchange Chemical treatment changes the surface chemistry of clays through a complex precipitation-dissolution process; the low pH may be a contributory factor. The treatment of the clay with the Hydrogen Ion Exchange Chemical reduced the soluble Al ions by 43 % and increased the soluble Fe ions by 173 %.
- The Environmental Scanning Electron Microscope examination showed that no morphological changes occur when clay sample is treated with the Hydrogen Ion Exchange Chemical solution, but swelling becomes evident in the counterpart water-treated sample.
- The Transmission Electron Microscope examination revealed that the crystalline electron diffraction pattern of smectite in the treated sample is replaced by diffuse halos, implying a change in the clay structure or a smearing of the smectite particles by an amorphous or non-crystalline material.
- During sample handling and processing, the treated sample was continually recognized as having different behavior compared to the untreated sample. The untreated sample was more "stickier", as opposed to the treated sample that was much more difficult to disperse.
- The dominant conclusion of this study is that soil samples amended with the Hydrogen Ion Exchange Chemical solution exhibit a change in the crystallographic characteristics of the soil, which can be associated with a change in the shrink-swell behavior of smectite.

The question is asked how effective and how permanent is the treatment of the clay soils with Hydrogen Ionic Stabilization? We have accumulated a significant amount of field and laboratory testing and monitoring data that has shown conclusively the successful performance of the Hydrogen Ionic treated clays. With regard to the question of how permanent is the Hydrogen Ionic treatment on clay soils can best be answered by considering the results of the previously described research and our own experiences. We can say that the Hydrogen Ionic treatment of clay soils is permanent. If the crystallographic characteristics of the soil are changed, then we can conclude that the treatment of the clay soils is permanent.