CONCRETE STABILIZATION TECHNOLOGIES, INC.
8500 East Warren Avenue • Denver, CO 80231 • (888) 306-9191 • (303) 306-9099 Fax
WWW.STABLECONCRETE.COM • WWW.CSTSOILS.COM

EcSS 3000™ Preliminary Case Study

Tom Larkin Project – 4975 S. Piper Drive, Erie Colorado

Introduction: Tom Larkin contacted CST Field Consultant, Pam Langan shortly after a presentation she made on treating swelling clays at the Terracon Longmont office. Mr. Larkin was interested in an alternate method to mitigate for swelling soils under and around his new home, at the time in pre-construction. Terracon's original plan specified a 5-Foot over excavation, select fill, and a structural floor, with caisson-supported foundations under the main house. The treatment footprint for the project was approximately 10,000 SF. It included a home with attached garage and airplane hangar.

This project was CST's first in Colorado. As such, Tom was justifiably skeptical about the ability of EcSS 3000™ to reduce swell in the way we stated. He requested references so he could investigate the opinions of others who had previous experience with the use of the product. Pam provided him with a list of references and he proceeded to contact each of them. Meanwhile, Ed Paas of Terracon contacted the engineers in Terracon's Dallas, Texas office to seek their opinions. Each of the references came back with a positive response about EcSS 3000™ and Tom and Terracon were then comfortable enough with the historical performance of the product to move forward. The new plan eliminated over excavation, select fill and a structural floor, and re-engineered the project for a seven-foot deep EcSS 3000™ soil treatment, slab-on-grade floor, plus the original caisson supported foundation.

Larkin's price negotiation included demonstration project pricing. This discount by CST was offset by Larkin's cooperation in documenting the project both now an in the future. This agreement in place, the project was then scheduled. Tom stated that even if CST had charged its regular price, he would have saved over $15,000 compared his previous mitigation plan.

Soil conditions and testing results before and after treatment now illustrate that Larkin's decision was a good one.

Pre-treatment Conditions:

Boring #	Depth	Moisture	Dry Density	Surcharge	Swell %	Blow count
1 - Hangar	2'	7.7	131.5	500 PSF	12.9	50/10
	6'	11.4	-	500 PSF	23.3 PI	50/7
	10'	12.0	123.3	500 PSF	8.0	50/6
	20'	15.3	114.6	1000 PSF	5.6	34/12
2 - Basement	3'	8.9	-	500 PSF	8.9	50/11
	8	9.2	123.4	500 PSF	7.2	50/7
#1 Pre treatment Average:		**11.6%**		**625 PSF**	**8.83%**	**50/8**
#2 Pre treatment Average:		**9.05%**		**500 PSF**	**7.20%**	**50/9**

Pre-Treatment Concerns: The soils were very stiff, dry clay with a very high swell potential. Due to these results and the extremely high penetrometer blow counts there was concern whether CST could physically penetrate the soils. Could our operators effectively permeate the soils with the diluted electrochemical? In addition, because of low moisture content, would the ionic transfer take place so that the specified reduction to a 2% average swell or better (lower) could be reached? To help answer these questions, a CST injection crew went to the site prior to contracting the job and verified that the performance goals could be met, at least in terms of soil penetration and material distribution. The subject pre-contract test was successful. We then began to move forward with the project with a planned 3-pass* operation.

Intermediate Actions: After completing our first 3 pass operation, the soil samples tested confirmed that we had failed to produce the specified results. Because this was CST's first experience with the injection of the chemical, some minor errors occurred. (CST anticipated a learning curve, so a small discount was provided to the customer before starting the project.)

A careful examination of project records ensued. Discussions were held with all parties involved. The ESSL engineers were included. This exchange provided a few important discoveries.

1. Our operators injected diluted material into the soil at too high a pressure. At a 1,200 PSI level, the injection probes pushed the electrochemical too quickly through the soil. This caused a false "refusal" indicator, which erroneously gave the impression that the soil was being permeated and saturated properly. In fact, the material simply "blew through" to adjacent previously-injected holes because of the high pressure. The full distribution of material into the soil – essential to successful treatment – did not occur.
2. Proof of improper distribution was confirmed by low material utilization levels compared to the amount of soil we were treating. We simply had not gotten enough electrochemical into the ground. With EcSS 3000™ it is of the utmost importance that the ratio of material volume to cubic feet of soil be reached. Otherwise, there is not enough ionic transfer within the clay, and the molecular structure of the clay will not be modified enough to lower swell.
3. Some pre-construction calculations were in error. The pre-testing surcharges used in pre-treatment soil tests were higher than normal overburden load amounts. As such, the swell factor is likely higher than indicated. In a lot next door, with similar soil conditions, the swell percentage calculations were slightly higher because the geotech used actual load conditions. In short, we had a higher swell than expected. We had failed to adjust our calculations to account for the amplified surcharge amounts used in the soil tests. A higher swell requires more ionic transfer, and therefore more material.

We subsequently completed a re-injection using a PSI of 500-600. This lower pressure allowed the material to flow naturally into the soils and provided a more even distribution. We also closely monitored electrochemical volume to assure an injection of the proper amount of material into each square foot of area before moving to the next injection point.

Post-Testing – Upon completion of all EcSS 3000™ projects, CST requires independent verification of project success. Initially, CST agrees to the swell percent performance goal set by the customer and their geotechnical or structural engineers. An installation price is then calculated by CST based upon those specifications and existing soil conditions. Three days after the completion of treatment, the customer agrees to obtain soil sample(s) and have them tested to confirm the performance goal has been reached. The average swell is determined by adding the swell percent results at all vertical levels within each boring and then averaging them. CST agrees to re-inject an area not meeting the agreed average swell, and will continue to treat until results are in compliance.

Post-treatment Conditions:

Location	Depth	Moisture	Dry Density	Surcharge	Swell %	Blow Count
Hangar	1'	20%	-	150 PSF	0.90	-
	3'	17%	-	500 PSF	2.30	-
	5'	19%	-	750 PSF	1.40	-
Basement	1'	14%	-	150 PSF	3.90*	-
	3'	16%	-	500 PSF	0.90	-
	5'	18%	-	750 PSF	0.80	-

Hangar average:	**18.66%**	**466 PSF**	**1.53%***
Basement average:	**15.33%**	**466 PSF**	**1.86%**

*The average swell (total the results of all levels tested in a boring and average them) of the soils was below specified number needed to comply with customer specifications. And although the customer was satisfied, CST opted to re-inject the upper level in the basement area to further reduce the 3.9% at the 1-Foot level. This was accomplished with no interference to the project and at no cost to the customer. Although no further tests were completed, we have confidence that the actual average swell of the basement is now closer to the performance goal. This, considering the proven results of the other treatment depths.

Pre and Post-Treatment Swell Differentials

Hangar Area: The *average* swell potential of the soils was reduced 83% from 8.83% to 1.53%

Basement area: The *average* swell potential of the soils was reduced 73% from 7.20% to 1.86% (not including subsequent reductions from treatment at the 1' level)

Overall Project Observations: The project was successful – we reached our performance goals in a predictable manner. Once the problems with the application of the materials were resolved, EcSS 3000™ performed exactly as represented. The geotechs involved in the project were impressed with our ability to reduce the swells in the soils while leaving them in place thereby greatly reducing future risk of settlement due to poor compaction of fill. They were further impressed with the fact that the soils were left in a stable condition that made it possible to move forward with the project without need to wait for the soils to dry or to treat them in some way to stabilize them. They had anticipated the soil post treatment would be like that of a water injected or moisture treated site, but found that it was nothing like that. The geotechs and ESSL considered these soils to be some of the worst they have seen.

The successful treatment of such difficult soils is clear evidence that EcSS 3000 can reduce the swell in expansive soils and offers **the only proven and permanent solution** for expansive soils on the market today!

As seen above, EcSS 3000™ is injected either by hand or by large rigs usually on 3' centers to the specified depth. In a single house pad such as this project, hand injection is used after excavation of the basement and other grades is complete. You can see that other work on the project was progressing without interference by our injection work. EcSS 3000 can also be injected on multiple sites with use of large injection rigs or with mix-in-place equipment for road beds and flatwork.

To learn more about this emerging technology, contact CST's Denver Headquarters at 303-303-9191.