CTL | THOMPSON INCORPORATED

January 10, 2020

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

Attention: Cindy Myers

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

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.

During our previous Geotechnical Investigation, we performed swell tests on numerous samples of weathered and comparatively unweathered claystone samples obtained during drilling. The measured swell after wetting ranged from 0.2 to 20 percent, with an average of 4.8 percent. The samples were wetted under pressures which corresponded to the pressure exerted by overlying soil and bedrock. For samples wetted under 1100 pounds per square foot (psf), the measured swell averaged 5.2 percent, with a maximum of 15 percent.

The laboratory samples and all samples obtained during and after the test fill placement were wetted under an applied pressure of 1000 psf. As with all soil characteristics, the data are variable. Table I summarizes swell test results for the various materials. The data are plotted on Figure 1.

Table I – Summary of Swell Tests

Material	Sample Location	Average Swell (%)	Highest Swell (%)
Native Claystone	Prior Investigation	5.2	15
Native Claystone	Near Test Fills	2.6	7.6
Over-Excavation – Water Only	Test Fill	1.1*	3
Over-Excavation – Clay Set @ 300:1	Test Fill	0.8*	2.1
Over-Excavation – Clay Set @ 200:1	Test Fill	0.7*	2.9

*Average of all hand drive and drilled samples

We also ran soil suction tests on the various material combinations. Soil suction is a measure of the negative pressure (or energy) which binds expansive soils. When water is added, a portion of the negative pressure is released and the soil expands. I often refer to a dry, shriveled sponge which expands when water is added as a visual example. The average measured suction values are summarized on Table 2. The unit of measure (pF) is a logarithmic scale, so a suction value of 4 pF is ten times higher than a value of 3 pF.

Table I – Summary of Suction Tests

Material	Sample Location	Average Suction (pF)
Native Claystone	Prior Investigation	4.3
Native Claystone	Near Test Fills	4.2
Over-Excavation – Water Only	Test Fill	3.8
Over-Excavation – Clay Set @ 300:1	Test Fill	3.8
Over-Excavation – Clay Set @ 200:1	Test Fill	3.7

Local geotechnical engineers have developed nomenclature to describe expansive soils based on swell tests performed by wetting samples under applied pressures of 500 and 1000 psf. Samples which swell less than 2 percent under 1000 psf are described as low swell. The data to date indicate the following:

- All three mitigation approaches (water only, Clay Set at 300:1 and 200:1) reduced swell and suction, and resulted in low swelling fill. 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.

- The suction data are perhaps the best indicator that the 200:1 mixture is (marginally) more effective than 300:1.

We provided heave estimates in our February 2019 report based on an assumed depth of wetting of 24 feet and recommended over-excavation to at least 15 feet below foundations. We estimate the use of Clay Set in the fill will reduce potential heave by about 70 percent compared to no over-excavation. The calculated heave is predominantly due to potential swell of expansive soil and bedrock below the fill. It is not certain wetting will occur below the fill, so the reduction in actual movement may be significantly higher. We believe differential movement will be small.

Soil Scientific provided data from other projects which indicate the addition of Clay Set also increases soil stiffness. This would also help to reduce potential compression (settlement) of the fill. In our February 2019 report, we stated that Century should expect comparatively high maintenance and warranty costs. This statement was focused on surface improvements such as sidewalks, driveways and pavements. We recommended sub-excavation to at least 5 feet below pavements. We estimate over-excavation to 5 feet below pavements with use of Clay Set would reduce potential heave by about 20%. If you elect to over-excavate to 10 feet below pavements, the reduction in potential heave would be about 50%. Sub-excavation fill placed with water alone can soften if drainage is poor, which can result in damage to pavements. The increase in reported soil stiffness associated with addition of Clay Set should reduce the likelihood of pavement damage and increase pavement support.

Given the presence of very highly expansive soils and bedrock at the Interlocken site, the data from this study, and information provided by Soil Scientific we believe addition of Clay Set would be a proactive approach to controlling potential future movements. As with any soil mitigation approach, proper moisture conditioning, mixing and compaction remain crucial to the project performance.

If we can be of further service in discussing the contents of this letter, please call.

Sincerely,

CTL | THOMPSON, INC.

Ronald M. McOmber, P.E.
Chairman, Senior Principal

Ronald M. McOmber
Jan 10 2020

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Enclosure

Via e-mail: Cindy.Myers@centurycommunities.com
pamela.langan@soilscientific.com
InspRep-co@centurycommunities.com

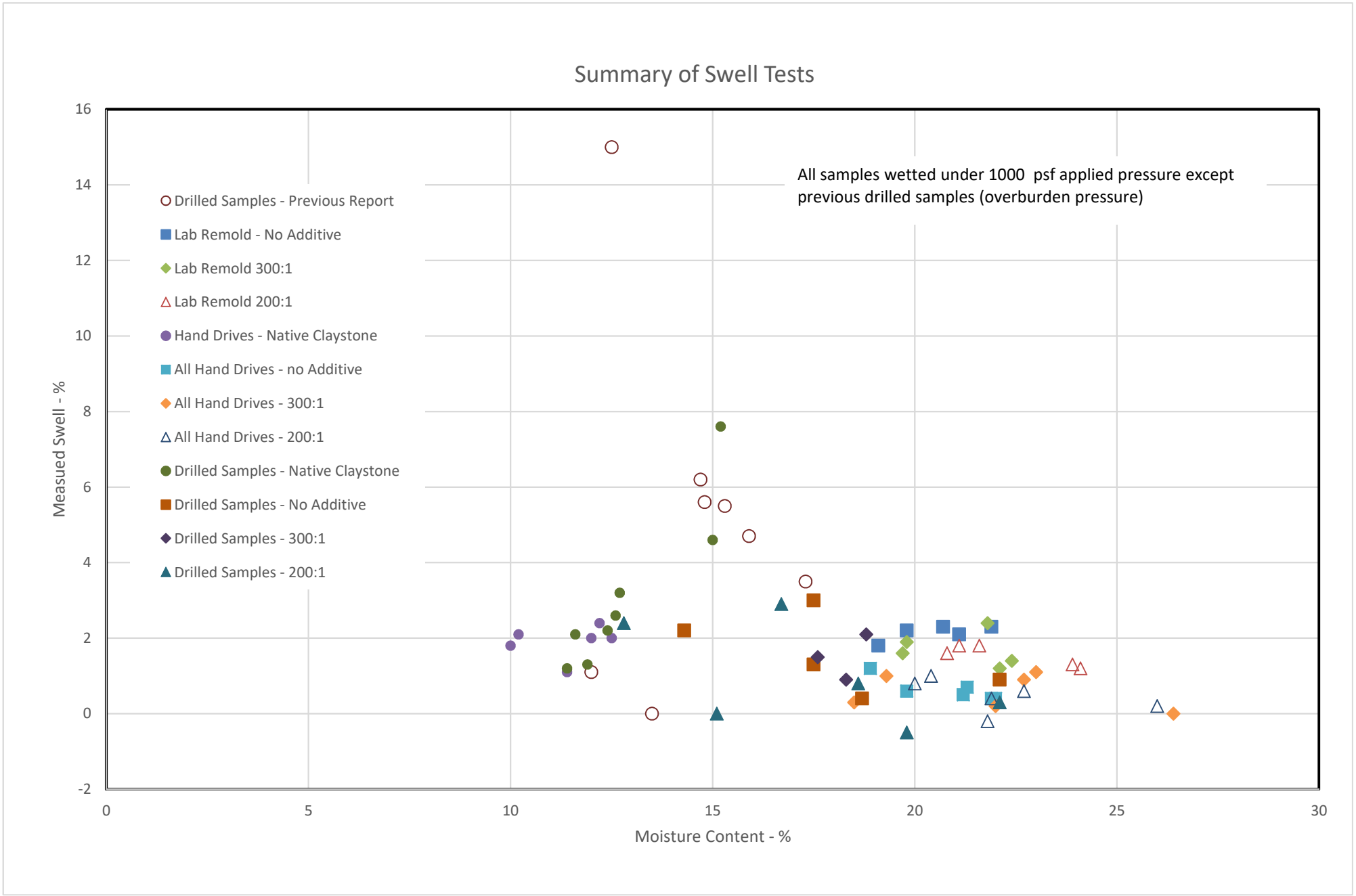

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FIG. 1