February 5, 2019

Provo School District
Attn: Mark Wheeler
280 West 940 North
Provo, Utah 84604

Re: Geotechnical Subsurface Exploration
Timpview High
3570 Timpview Drive
Provo, Utah
CMT Job No. 10466

Mr. Wheeler,

At your request CMT Engineering has performed subsurface explorations and geotechnical engineering testing of samples of the subsurface soils collected at Timpview High School in Provo, Utah. CMT previously monitored settlement at the subject school[1].

Background
We understand that movement/settlement of the building, particularly in the library area, has been occurring for years but more pronounced movement/settlement occurred in the spring of 2017 following a water leak. CMT installed and monitored crack monitors to assess if movement/settlement of the building was ongoing. Readings of the installed crack monitors occurred approximately monthly, and began in November of 2017 and concluded on July 2, 2018. Very little to no movement was noted during the monitoring period.

Subsurface Exploration
To assess the geotechnical properties of the subsurface soils three bore holes were drilled on the exterior of the existing building on January 17, 2019. The bore holes were extended to a depth of approximately 21.5 feet below the existing ground surface at each hole location (see **Figure 1**). Samples of the subsurface soils encountered in the bore holes were collected at varying depths through the hollow stem drill augers. Relatively undisturbed samples of the subsurface soils were obtained by hydraulically pushing a 3-inch diameter (Shelby) tube into the undisturbed soils below the drill augers. Disturbed samples were collected utilizing a standard split spoon sampler. This standard split spoon sampler was driven 18 inches into the soils below the drill augers using a 140 pound hammer free-falling a distance of 30 inches. The number of hammer blows needed for each 6 inch interval was recorded. The sum of the hammer blows for the final 12 inches of penetration is known as a standard penetration test and this ‘blow count’ was recorded on the bore hole logs.

[1] Settlement Monitoring, Timpview High, 3570 Timpview Drive, Provo, Utah, CMT Job No. 10466, November 12, 2018.

The blow count provides a reasonable approximation of the relative density of granular soils, but only a limited indication of the relative consistency of fine grained soils because the consistency of these soils is significantly influenced by the moisture content.

The subsurface soils encountered in the bore holes were logged and described in general accordance with ASTM[2] D-2488. Soil samples were collected as described above, and were classified in the field based upon visual and textural examination. These field classifications were supplemented by subsequent examination and testing of select samples in our laboratory. Logs of the bore holes, including a description of the soil strata encountered, is presented on each individual Bore Hole Log, **Figures 2 through 4**, attached. Sampling information and other pertinent data and observations are also included on the logs. In addition, a Key to Symbols defining the terms and symbols used on the logs is provided as **Figure 5**.

Groundwater was not encountered in the bore holes to the maximum depth explored.

Laboratory Testing

Selected samples of the subsurface soils were subjected to various laboratory tests to assess pertinent engineering properties, as follows:

1. Moisture Content, ASTM D-2216, Percent moisture representative of field conditions
2. Dry Density, ASTM D-2937, Dry unit weight representing field conditions
3. One Dimension Consolidation, ASTM D-2435, Consolidation properties

Laboratory test results are presented on the bore hole logs (**Figures 2 through 4**) and in the Lab Summary Table on the following page:

[2]American Society for Testing and Materials

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LAB SUMMARY TABLE

Bore Hole	Depth (feet)	Soil Class	Sample Type	Moisture Content (%)	Dry Denstiy (pcf)	Collapse (-) or Expansion (+)
B-1	2.5	CL	Shelby	20.2	105.7	
	5	CL	SPT	19.1		
	7.5	CL	SPT	16.5		
	10	CL	Shelby	18.3	96.3	-3.5%
	12.5	CL	Shelby	18.0	109.9	
	15	CL	SPT	18.0		
	20	CL	SPT	25.4		
B-2	2.5	CL	SPT	14.2		
	7.5	CL	SPT	22.3		
	10	CL	SPT	17.7		
	12.5	CL	Shelby	15.9	102.1	-1.0%
	15	CL	SPT	16.9		
	20	CL	SPT	12.0		
B-3	2.5	CL	SPT	18.3		
	5	CL	Shelby	16.4	102.8	
	7.5	CL	Shelby	16.7	106	-1.0%
	10	CL	SPT	19.0		
	12.5	CL	SPT	18.3		
	20	CL	SPT	22.1		

Natural moisture content test results showed some variations with depth. In bore holes B-1 and B-3 we measured moisture contents of samples from 20 feet to be slightly higher than the samples from shallower depths, and in B-2, the elevated moisture was at about 7.5 feet compared to the other depths.

Natural dry density tests showed a little variation as well but none of the samples tested showed significantly low density.

Based upon the consolidation testing, the clay soils at this site are moderately compressible. Given the age of the school, provided subsurface conditions were not altered (i.e. large increase or decrease in moisture content for example) we would expect that consolidation settlement under the loads applied by the foundations would have concluded long ago. To assess moisture sensitivity as part of the consolidation testing, water was added to saturate the samples when loaded to an equivalent pressure of 1,000 psf. This part of the testing indicated a potential for the subsurface soils to experience additional consolidation (collapse) when wetted. Additional consolidation amounts ranged from approximately 1.0% to 3.5%. Collapse amounts of about 1 percent or less are typically considered negligible.

Summary of Findings

Settlement monitoring at the school indicated only slight movements (1 mm or less) during the monitoring period, which could possibly be the result of temperature changes.

Subsurface exploration indicated that the natural subsurface soils are predominately composed of CLAY (CL). Clay soils are compressible when subjected to a load. Consolidation settlement of clay soils occurs generally as water in the soil pores is squeezed out. The structure and mineralogy of clay soils can also influence consolidation behavior. Some clay minerals can absorb significant amounts of water and swell when wetted, sometimes with sufficient pressure to lift floor slabs and even more heavily loaded footings. Clay soils can also form with a porous structure, often visual as 'pinholes' in the soil matrix. These types of clay soils can experience additional consolidation (collapse) when wetted. The amount of additional consolidation settlement would be influenced by several factors such as the load applied to the soil, the thickness of the moisture sensitive layer and its proximity to the bottom of the foundations, and the degree of saturation.

The three samples tested (one from each bore hole) showed moisture sensitivity in the form of additional consolidation settlement when the samples were saturated. The samples from bore holes B-2 at 12.5 feet, and B-3 at 7.5 feet, showed about 1% additional consolidation settlement. For example, if a 5 foot thick layer of this soil were to become saturated and experience an additional 1% consolidation settlement it would be equivalent to approximately ½ inch of additional settlement. This amount of additional differential settlement typically could be tolerated by a well-designed structure.

However, the sample from bore hole B-1 at 10 feet showed approximately 3.5% additional consolidation settlement when the sample was saturated. Using the previous example this would equate to about 2.5 inches of additional consolidation settlement. Differential settlement of this magnitude would typically cause cracking in walls, mis-alignment of door and window frames, etc.

Conclusions

As we understand it, additional differential movement/settlement at the school became more pronounced in the spring of 2017 following a water leak. It is probable that the leaking water saturated a portion of the soils supporting foundations, which appear to have moisture sensitivity, resulting in additional differential consolidation settlement.

Settlement monitoring CMT performed at the school over a period of approximately 9 months in the late fall 2017 through mid-summer 2018 did not indicate that any significant movement was still occurring. However, if foundation soils become wetted again from another water leak, unusual rain event, or snow melt, additional differential movement/settlement could occur.

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Predicting when, where, and how much additional potential differential movement/settlement may occur is not possible due to the many influencing variables as previously discussed.

Reducing the potential for the subsurface soils to become wetted from rain or snow by enclosing the atrium area at the south side of the library for example may help reduce the potential for additional differential movement/settlement in that area, but it is likely not possible to completely prevent additional saturation of the foundation soils, either from surface water or groundwater.

The potential for additional differential movement/settlement could be minimized by installing helical piers which extend to a sufficient depth below potentially moisture sensitive soils, or below a zone likely to become saturated from surface water (likely 15 to 20 feet). The piers could be structurally connected to the affected portions of the foundation to reduce the potential for future movement, and used as a lift point to 'jack' the foundations back to a more level condition. Several local contractors provide these services including, Intermountain Helical Piers, Intermountain Foundation Repair, Hayward Baker, and Goliath Tech.

Closure

We appreciate the opportunity to provide our services on this project. If we can answer any questions or be of further assistance, please call.

Respectfully submitted,
CMT Engineering Laboratories

LICENSED PROFESSIONAL ENGINEER
374995
JEFFREY J. EGBERT
2/5/19
STATE OF UTAH

Jeffrey J. Egbert, P.E., LEED A.P., M. ASCE
Senior Geotechnical Engineer

Timpview High School	CMT ENGINEERING LABORATORIES			Figure:
3570 N. Timpview Dr, Provo	Site Plan	Date:	18-Jan-19	1
		Job #	10466	

Timpview High School

3570 N. Timpview Dr., Provo

Bore Hole Log — B-1

Boring Type: Hollow-Stem Auger
Surface Elev. (approx):
Total Depth: 21.5'
Water Depth: (see Remarks)
Date: 1/17/19
Job #: 10466

Depth (ft)	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0	SOD & TOPSOIL: Clay, roots, organics, moist, dark brown												
	CLAY (CL), moist, brown												
4			1			20.2	106						
	grades with some minor gravel lenses. Fill? stiff		2	4 8 6	14	19.1							
8	very stiff		3	8 13 13	26	16.5							
			4			18.3	96.3						
12			5			18	110						
16	stiff		6	3 4 5	9	18							
20	medium stiff		7	2 2 3	5	25.4							
	END AT 21.5 FEET												
24													
28													

Remarks: Groundwater not encountered during drilling.

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Drilled By: Great Basin Drilling
Logged By: S. Howell

Figure: 2

Timpview High School

Bore Hole Log

B-2

3570 N. Timpview Dr., Provo

Boring Type: Hollow-Stem Auger
Surface Elev. (approx):

Total Depth: 21.5'
Water Depth: (see Remarks)

Date: 1/17/19
Job #: 10466

Depth (ft)	Soil Description		Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0	SOD & TOPSOIL: Clay, roots, organics, moist, dark brown													
	FILL: Gravel													
	CLAY (CL), moist, brown													
	grades with a thin gravel lense	very stiff		8	11 8 8	16	14.2							
4														
				9										
8		medium stiff		10	4 3 4	7	22.3							
				11	2 2 3	5	17.7							
12														
				12			15.9	102						
	SILT (ML) with sand, moist, brown	medium stiff		13	3 2 4	6	16.9							
16														
	Silty SAND (SM), fine grained, moist, light brown													
20		loose		14	3 4 4	8	12							
	END AT 21.5 FEET													
24														
28														

Remarks: Groundwater not encountered during drilling.

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Drilled By: Great Basin Drilling
Logged By: S. Howell

Figure: 3

Timpview High School

3570 N. Timpview Dr., Provo

Bore Hole Log

B-3

Boring Type: Hollow-Stem Auger
Surface Elev. (approx):

Total Depth: 21.5'
Water Depth: (see Remarks)

Date: 1/17/19
Job #: 10466

Depth (ft)	Soil Description	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0	SOD & TOPSOIL: Clay, roots, organics, moist, dark brown											
	CLAY (CL), moist, brown											
	medium stiff	15	3 3 4	7	18.3							
4												
		7.5			16.4	103						
8		10			16.7	106						
		12.5	2 3 4	7	19							
12												
	stiff	15	4 3 5	8	18.3							
16		20										
20		21	4 4 6	10	22.1							
	END AT 21.5 FEET											
24												
28												

Remarks: Groundwater not encountered during drilling.

Drilled By: Great Basin Drilling
Logged By: S. Howell
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Figure: 4

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Timpview High School

Key to Symbols

3570 N. Timpview Dr., Provo

Date: 1/17/19

Job #: 10466

① Depth (ft)	GRAPHIC LOG	Soil Description ③	④ Sample Type	⑤ Sample #	Blows(N) ⑥	⑦ Total	⑧ Moisture (%)	⑨ Dry Density(pcf)	Gradation ⑩ Gravel %	Sand %	Fines %	Atterberg LL	PL	PI

COLUMN DESCRIPTIONS

Depth (ft.): Depth (feet) below the ground surface (including groundwater depth - see water symbol below).

Graphic Log: Graphic depicting type of soil encountered (see below).

Soil Description: Description of soils encountered, including Unified Soil Classification Symbol (see below).

Sample Type: Type of soil sample collected at depth interval shown; sampler symbols are explained below-right.

Sample #: Consecutive numbering of soil samples collected during field exploration.

Blows: Number of blows to advance sampler in 6" increments, using a 140-lb hammer with 30" drop.

Total Blows: Number of blows to advance sampler the 2nd and 3rd 6" increments.

Moisture (%): Water content of soil sample measured in laboratory (percentage of dry weight of sample).

Dry Density (pcf): The dry density of a soil measured in laboratory (pounds per cubic foot).

Gradation: Percentages of Gravel, Sand and Fines (Silt/Clay), obtained from lab test results of soil passing the No. 4 and No. 200 sieves.

Atterberg: Individual descriptions of Atterberg Tests are as follows:

LL = Liquid Limit (%): Water content at which a soil changes from plastic to liquid behavior.

PL = Plastic Limit (%): Water content at which a soil changes from liquid to plastic behavior.

PI = Plasticity Index (%): Range of water content at which a soil exhibits plastic properties (= Liquid Limit - Plastic Limit).

STRATIFICATION	
Description	**Thickness**
Seam	Up to ½ inch
Lense	Up to 12 inches
Layer	Greater than 12 in.
Occasional	1 or less per foot
Frequent	More than 1 per foot

MODIFIERS
Trace
<5%
Some
5-12%
With
> 12%

MOISTURE CONTENT
Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp / moist to the touch, but no visible water.
Saturated: Visible water, usually soil below groundwater.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS SYMBOLS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	GRAVELS The coarse fraction retained on No. 4 sieve.	CLEAN GRAVELS (< 5% fines)	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (≥ 12% fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS The coarse fraction passing through No. 4 sieve.	CLEAN SANDS (< 5% fines)	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (≥ 12% fines)	SM	Silty Sands, Sand-Silt Mixtures
			SC	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	SILTS AND CLAYS Liquid Limit less than 50%		ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with
			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean
			OL	Organic Silts and Organic Silty Clays o f Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	Peat, Humus, Swamp Soils with High Organic Contents

SAMPLER SYMBOLS

- Block Sample
- Bulk/Bag Sample
- Modified California Sampler 3.5" OD, 2.42" ID D&M Sampler
- Rock Core
- Standard Penetration Split Spoon Sampler
- Thin Wall (Shelby Tube)

WATER SYMBOL

- Encountered Water Level
- Measured Water Level

(see Remarks on Logs)

Note: Dual Symbols are used to indicate borderline soil classifications (i.e. GP-GM, SC-SM, etc.).

1. The results of laboratory tests on the samples collected are shown on the logs at the respective sample depths.
2. The subsurface conditions represented on the logs are for the locations specified. Caution should be exercised if interpolating between or extrapolating beyond the exploration locations.
3. The information presented on each log is subject to the limitations, conclusions, and recommendations presented in this report.

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Figure: 5