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Project No. 15-063E
Report No. 1
Project Type 24/33/UU
February 06, 2015

Attention: Ms. Karen Hood, P.E.

Subject: Trench Safety Report
Geotechnical Study for Proposed Sims North WWTP
Waste and Debris Offloading and Disposal Station
9570 Lawndale Street
City of Houston, Texas
WBS No. R-000265-081-4

Dear Madam:

Submitted here are Geotech Engineering and Testing (GET) recommendations on trench safety for the above referenced project. The following is our trench safety recommendations together with the earth pressure diagram for the braced excavations.

General

Occupational Safety and Health Administration (OSHA) has required a trench protective system for trenches deeper than five-ft. Trenches that are deeper than five-ft, should be shored, sheeted, braced or laid back to a stable slope, or some other appropriate means of protection should be provided where workers might be exposed to moving ground or caving. OSHA developed a soil classification system to be used as a guideline in determining protective requirements for trench excavations.

OSHA classification system categorizes the soil and rock in four types based on shear strength and stability. These classifications are summarized in the following report sections.

Stable Rock

means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Type A Soil

means cohesive soils with an unconfined compressive strength of 1.5-ton per square foot (tsf) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam, silty clay loam, sandy clay loam, caliche and hardpan. No soil is Type A if:

- The soil is fissured; or
- The soil is subject to vibration from heavy traffic, pile driving or similar effects; or

- The soil has been previously disturbed; or
- The soil is part of a slope, layered system where the layers dip into the excavation on a slope of 4(h): 1(v) or greater; or
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B Soil

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; or
- Granular cohesionless soils including: angular gravel, silt, silt loam, sandy loam, and in some case, silty clay loam and sandy clay loam; or
- Previously disturbed soils except those which would otherwise be classified as Type C soil; or
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
- Dry rock that is not stable; or
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than 4(h): 1(v), but only if the material would otherwise be classified as Type B.

Type C Soil

- Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
- Granular soils including gravel, sand, and loamy sand; or
- Submerged soil or soil from which water is freely seeping; or
- Submerged rock that is not stable; or
- Materials in a sloped, layered system where the layers dip into the excavation on a slope 4 (h) : 1(v) or steeper.

Under the assumption that appropriate groundwater control measures are carried out, and the groundwater table, if present, is lowered and maintained at least 3 feet below the excavation depths, the stable cohesive soils (CL) & (CH), with unconfined compressive strength greater than 0.5 tsf, are classified as OSHA soil Type "B". The granular soils, which are less stable, are classified as OSHA soil Type "C".

Based on our geotechnical exploration and laboratory test results details of soil classifications at each boring are summarized below:

OSHA SOIL TYPE

Boring No.	Depth Range [1], ft	Soil Type	OSHA Soil Classification
B-1	0 – 2	Lean Clay with Sand (CL)	B
	2 – 8	Fat Clay (CH)	B
	8 – 10	Fat Clay (CH)	C
	10 – 14	Fat Clay with Sand (CH)	C
	14 – 16	Fat Clay with Sand (CH)	B
	16 – 18	Fat Clay with Sand (CH)	C
	18 – 20	Fat Clay with Sand (CH)	B
	20 – 25	Fat Clay with Sand (CH)	C
B-2	0 – 8	Fat Clay (CH)	B
	8 – 18	Fat Clay with Sand (CH)	B
	18 – 23	Fat Clay with Sand (CH)	C
	23 – 25	Fat Clay with Sand (CH)	B
B-3	0 – 2	Lean Clay with Sand (CL)	B
	2 – 4	Fat Clay (CH)	C
	4 – 10	Fat Clay (CH)	B
B-4	0 – 2	Fat Clay (CH)	B
	2 – 4	Fat Clay (CH)	C
	4 – 10	Fat Clay (CH)	B

Note: 1. Refer to each boring log for soils stratigraphy

Stockpiling of excavated materials may not be allowed near the banks of excavated areas. Generally, a distance of one-half the excavation depth on both sides of the trench should be kept clear of any excavated material.

Trenches for the underground utilities should be provided with proper trench support system. The trenches should be provided with a temporary shoring system on excavations deeper than five-ft. The trenches can be made using shored, sheeted and braced, laid back stable slope or other means of appropriate protection system should be provided where workers are exposed to moving ground or caving. The slopes may be constructed in accordance with Table B-1 and shoring may be constructed in accordance with Table C-1.1, Table C-1.2 and Table C-1.3 of 29 CFR Part 1926 of OSHA.

In the event that a trench sheeting is used, the sheeting can be constructed in the form of cantilever sheeting or with bracing. Lateral earth pressures for each method used are summarized on Plate 1. The trenching and shoring operations should follow OSHA Standards. We recommend that a geotechnical engineer monitor all phases of trench excavation and bracing to assure trench safety.

Timber shoring as outlined in 29 CFR Part 1926 of OSHA recommendation may be used in the construction of trench supporting system.

For trench excavation, it is necessary to maintain the stability of the sides and base and not to disturb the soil below the excavation grade. In braced cuts, if the sheeting is terminated at the base of the cut, the bottom of the excavation can become unstable under certain conditions. The stability of the trench bottom is governed by the shear strength of the soils and the differential hydrostatic head. For cuts in cohesive soils (such as lean clay with sand (CL), fat clay (CH) and fat clay with sand (CH)) stability of the bottom can be evaluated in accordance with the procedure outline on Plate 2. Design soil parameters presented on Plate 3 can be used for design.

Groundwater Conditions

Our short-term field exploration along the project alignments indicated that groundwater/perched water was not encountered at the borings. Hence, groundwater dewatering may not be required. However, fluctuation in groundwater can occur as a function of seasonal moisture variation. Dewatering is very important on this project to prevent potential bottom blow up in cohesionless soils. Groundwater control recommendations are presented in the following report sections.

In the event that groundwater is encountered during construction, it is our opinion that groundwater should be lowered to a depth of at least three-ft below the deepest excavation grade in order to provide dry working conditions and firm bedding. Any minor water inflow in cohesive soil layers can probably be removed using a sump-pump or trench sump-pump. Wellpoint system can be used in the area where silt soils are present.

Design of a wellpoint system should consider the amount of groundwater to be lowered and the permeability of the affected soils. The selection and proper implementation of an effective groundwater control system is the responsibility of the contractor. The design of groundwater and surface water should be in accordance with the “City of Houston Specifications, Section 01578 − Control of Ground Water and Surface Water”.

The results of our field exploration and laboratory testing indicate that unsatisfactory soils for excavation, such as firm Lean Clay (CL) and Fat Clay (CH) exist at various depths in the borings at the project site. A summary of the unsatisfactory soils, locations and depths are as follows:

Boring(s)	Depth Range, ft.
B-1	8 to 14 / 16 to 18 / 20 to 25
B-2	18 to 23
B-3 and B-4	2 to 4

If these conditions are encountered during the time of construction, suitable groundwater control measures should be implemented in accordance with the “City of Houston Specifications, Section 01578 – Control of Groundwater and Surface Water”. Furthermore, the contractor may have to over excavate additional 6 inches and remove unstable or unsuitable materials with approval by geotechnical engineer, then place non-woven geotextile follows by compaction of 12-inch of crushed stone or 6-inch of reinforced concrete pad.

Due to potential variability of the on-site soils, unstable trench conditions may exist in the areas where we did not conduct our borings. If these conditions are encountered during the time of construction, a stable trench should be provided to allow proper bedding and installation.

Our recommendation on trench safety at the project site does not address the effects of excavations on existing buildings/facilities at the project site. This study was outside the scope of our work.

We appreciate the opportunity to be of service. Should you have any questions or need additional assistance, please call.

Very truly yours,

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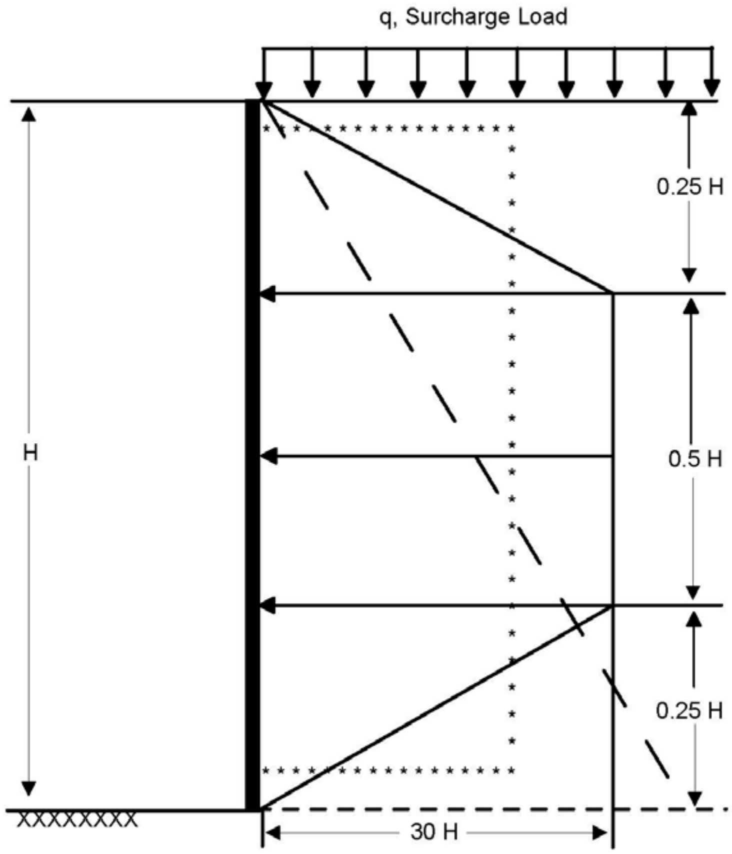
Enclosures: Trench Lateral Earth Pressure Diagrams, Plate 1
Cut in Cohesive Soil, Plate 2
Design Soil Parameters, Plate 3

LATERAL EARTH PRESSURE DIAGRAM



Legend:

———————— Braced Excavation (stiff clays)
* * * * * * * * * * * * * Braced Excavation (sands)
- - - - - - - - - - - - - - - Cantilevered sheeting

Active Pressure:

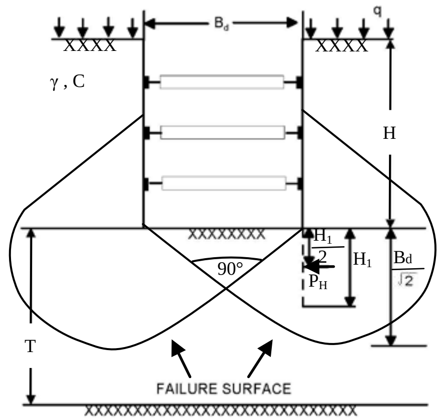
(a) Braced Excavation (stiff clays) = 0.5q + 30H + 62.4H
(b) Braced Excavation (sands) = 0.4q + 18H + 62.4H
(c) Cantilevered sheeting = 0.7q + 42H + 62.4H

where: q = surcharge load, psf: A value of 250 psf can be assumed.
H = wall height, ft.

Notes:

1. The above Active Pressure Equations account for the groundwater at the surface.
2. The final lateral pressures should be reviewed prior to construction.
3. Trench excavation and construction should be observed by a geotechnical engineer.
4. The means and methods for a safe excavation is the responsibility of the contractor.
5. In case of layered soils, active pressure should be calculated based on the dominant or more critical soil conditions.

CUT IN COHESIVE SOIL,
DEPTH OF COHESIVE SOIL UNLINITED ($T > 0.7\ B_d$)
L= LENGTH OF CUT



If sheeting terminates at base of cut:

Safety Factor, $F_s = \dfrac{N_c c}{\gamma H + q}$

N_c = Bearing capacity factor, which depends on dimensions of the excavation:
B_d, L and H (use N_c from graph below)
c = Undrained shear strength of clay in failure zone beneath and surrounding base of cut
γ = Total unit weight of soil
q = Surcharge (assumed q = 250 psf)

If safety factor is less than 1.5, sheeting or soldier piles must be carried below the base of cut to insure stability – (see note)

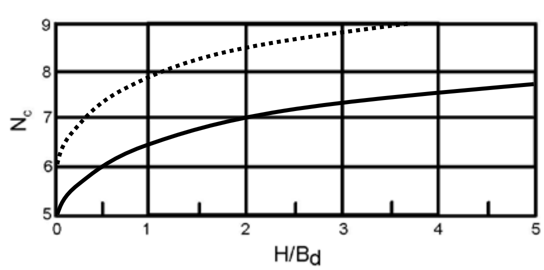
H_1 = Buried length = $\dfrac{B_d}{2} \geq 5$ feet

Note: If soldier piles are used, the center to center spacing should not exceed 3 times the width or diameter of soldier pile.

Force on buried length, P_H:

If $H_1 > \dfrac{2}{3}\dfrac{B_d}{\sqrt{2}}$, $P_H = 0.7\left(\gamma H B_d - 1.4CH - \pi c B_d\right)$ in lbs/linear foot

If $H_1 < \dfrac{2}{3}\dfrac{B_d}{\sqrt{2}}$, $P_H = 1.5 H_1\left(\gamma H - \dfrac{1.4CH}{B_d} - \pi c\right)$ in lbs/linear foot



For Trench Excavations
For Square Pit or Circle Shaft

STABILITY OF BOTTOM FOR BRACED CUT

SOIL DESIGN PARAMETERS

(BASED ON BORING B-1)

Soil Type	Depth Range, ft.	γ, pcf	c, psf	ϕ
LEAN CLAY WITH SAND (CL)	0 – 2	120	2,000	–
FAT CLAY (CH)	2 – 8	120	2,000	–
FAT CLAY (CH)	8 – 10	120	800	–
FAT CLAY WITH SAND (CH)	10 – 12	120	900	–
FAT CLAY WITH SAND (CH)	12 – 14	120	500	–
FAT CLAY WITH SAND (CH)	14 – 16	120	1,700	–
FAT CLAY WITH SAND (CH)	16 – 18	120	900	–
FAT CLAY WITH SAND (CH)	18 – 20	120	1,200	–
FAT CLAY WITH SAND (CH)	20 – 25	120	800	–

(BASED ON BORING B-2)

Soil Type	Depth Range, ft.	γ, pcf	c, psf	ϕ
FAT CLAY (CH)	0 – 8	120	2,000	–
FAT CLAY WITH SAND (CH)	8 – 18	120	2,000	–
FAT CLAY WITH SAND (CH)	18 – 23	120	600	–
FAT CLAY WITH SAND (CH)	23 – 25	120	2,000	–

(BASED ON BORING B-3)

Soil Type	Depth Range, ft.	γ, pcf	c, psf	ϕ
LEAN CLAY WITH SAND (CL)	0 – 2	120	2,000	–
FAT CLAY (CH)	2 – 4	120	900	–
FAT CLAY (CH)	4 – 8	120	2,000	–
FAT CLAY (CH)	8 – 10	120	1,500	–

(BASED ON BORING B-4)

Soil Type	Depth Range, ft.	γ, pcf	c, psf	ϕ
FAT CLAY (CH)	0 – 2	120	1,700	–
FAT CLAY (CH)	2 – 4	120	600	–
FAT CLAY (CH)	4 – 8	120	2,000	–
FAT CLAY (CH)	8 – 10	120	1,200	–