GEOTEST ENGINEERING, INC.

Geotechnical Engineers & Materials Testing

5600 Bintliff Drive Houston, Texas 77036 Telephone: (713) 266-0588
Fax: (713) 266-2977

Job No. 1140195801
Trench Safety Report
April 30, 2014

Mr. Sree Punukula, P.E.
KIT Professionals, Inc.
2000 West Sam Houston Parkway S., Suite 1400
Houston, Texas 77042

Reference: Trench Safety Design Considerations
Minnetex Area and Almeda Genoa Place
Drainage and Paving Improvements
WBS No. M-000289-0002-3
Houston, Texas

Dear Mr. Punukula:

We are pleased to present our geotechnical information for trench safety for the referenced project.

For trench excavation, it is essential to maintain the stability of the sides and base and not to disturb the soil below the excavation grade. This is necessary to prevent any damage to adjacent facilities as a result of either vertical or lateral movements of the soil. In addition, a satisfactory excavation procedure must include an adequate construction dewatering system to lower and maintain the water level at least 3 feet below the lowest excavation grade or a minimum of 5 feet below prevailing level of backfill during backfilling. This will minimize the potential for softening or "boiling" of the base support soil.

Trench Excavation

Based on the information provided by KIT Professionals, Inc., it is understood that the water line, storm sewer and sanitary sewer will be installed by open cut method of construction. The following subsections provide information for the design and construction of the storm sewer and sanitary sewer open cut method of excavations.

Geotechnical Parameters. Based on the soil conditions revealed by the borings GB-1 through GB-21, geotechnical parameters were developed for the design of open cut construction for storm sewer and sanitary sewer installation. The design parameters are provided in Table 1. For design, the groundwater level should be assumed to exist at the ground surface.

Excavation Stability. The open excavation may be shored or laid back to a stable slope or supported by some other equivalent means used to provide safety for workers and adjacent structures, if any. The excavating operations should be in accordance with OSHA Standards, OSHA 2207, Subpart P, latest revision and the City of Houston Standard Specification.

- Excavation Shallower Than 5 Feet - Excavations that are less than 5 feet deep **(critical height)** should be effectively protected when an indication of dangerous ground movement is anticipated.

- Excavations Deeper Than 5 Feet - Excavations that are deeper than 5 feet should be sloped, shored, sheeted, braced or laid back to a stable slope or supported by some other equivalent means or protection such that workers are not exposed to moving ground or cave-ins. The slopes and shoring should be in accordance with the trench safety requirements as per OSHA Standards. The following items provide design criteria for excavation stability.

  (i) OSHA Soil Type. Based on the soil conditions revealed by borings drilled for this study and assumed groundwater level at surface, OSHA soil type "C" should be used for determination of allowable maximum slope and/or the design of shoring along the alignment for full proposed depth of open excavation. For shoring deeper than 20 feet (if needed), an engineering evaluation is required and deeper soil borings will be needed.

  (ii) Excavation Support Earth Pressure. Based on the subsurface conditions indicated by our field investigation and laboratory testing results, excavation support earth pressure diagram is developed and is presented on Figure 1. This pressure diagram can be used for the design of temporary trench bracing. For a trench box, a lateral earth pressure resulting from an equivalent fluid with a unit weight of 92 pcf can be used. The effects of any surcharge loads at the ground surface should be added to the computed lateral earth pressures. A surcharge load, q, will typically result in a lateral load equal to 0.5 q. The above value of equivalent fluid pressure is based on assumption that the groundwater level is near the ground surface, since these conditions may exist after a heavy rain or flooding.

(iii) Bottom Stability. In braced cuts, if tight sheeting is terminated at the base of the cut, the bottom of the excavation can become unstable. The parameters that govern the stability of the excavation base are the soil shear strength and the differential hydrostatic head between the groundwater level within the retained soils and the groundwater level at the interior of the trench excavation. For cut in cohesive soils as predominantly encountered for the proposed excavation depths (8 to 23 feet) in all the borings, the bottom stability can be evaluated as outlined on Figure 2.

Groundwater Control. Excavations for the water line, sanitary sewer and storm sewer may encounter groundwater seepage to varying degrees depending upon the groundwater conditions at the time of construction and the location and depth of the trench. Based on the soil conditions identified in the borings for the proposed water line, sanitary sewer and storm sewer installation, all the excavations (for excavation depths of 8 to 23 feet) will be in cohesive soils. In general for cohesive soils as encountered in all the borings for the excavation depths, the groundwater (if encountered) may be managed by collection in excavation bottom sumps for pumped disposal. It is recommended that the actual groundwater conditions should be verified by the contractor at the time of construction and that groundwater control should be performed in general accordance with the City of Houston Standard Specifications, Section 01578.

We appreciate this opportunity to be of service to you. If you have any questions regarding the report, or if we can be of further service to you, please call us.

Sincerely,
GEOTEST ENGINEERING, INC.
TBPE Registration No. F-410

Naresh Kolli, P.E.
Assistant Project Manager

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Copies Submitted: (2)
Enclosures: Trench Support Earth Pressure – Figure 1
Stability of Bottom for Braced Cut – Figure 2
Geotechnical Design Parameter Summary: Open-cut Excavation – Table 1

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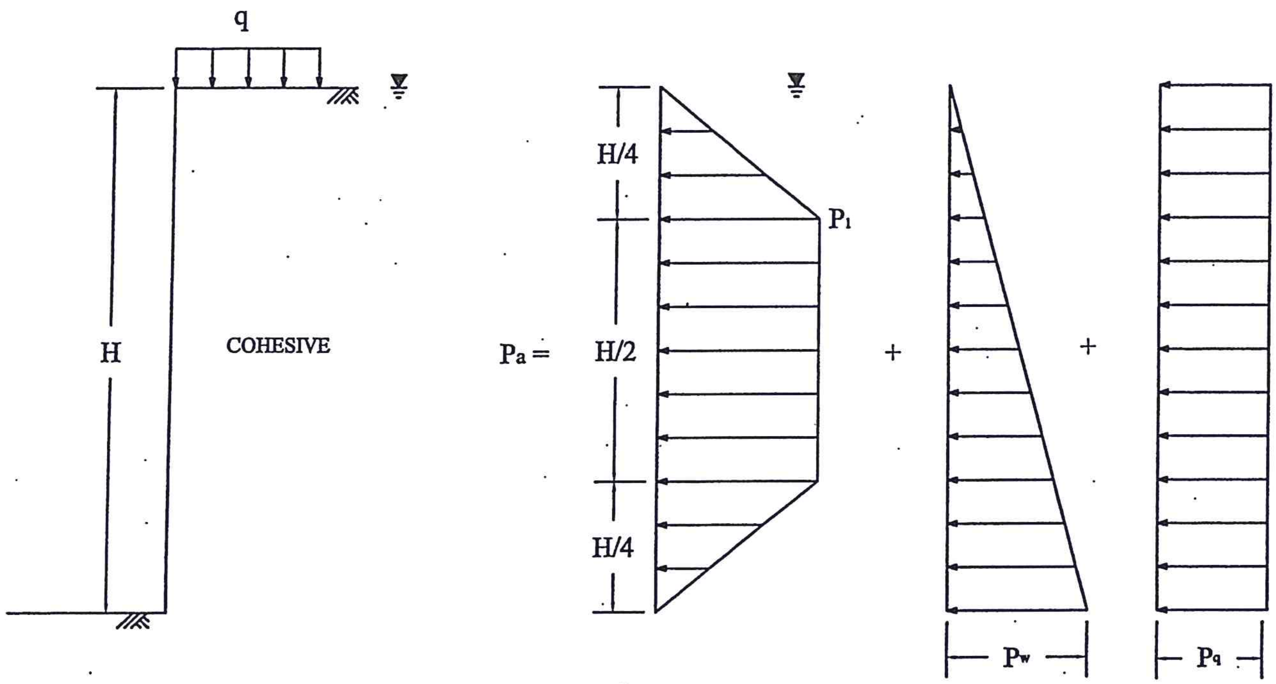

TYPICAL SOIL PARAMETERS

See Table 1 for typical values of soil parameters

BRACED WALL

For $\gamma H/c \leq 4$

$P_1 = 0.3\ \gamma_c'\ H$
$P_w = \gamma_w\ H = 62.4\ H$
$P_q = 0.5\ q$

Where:

- γ_c' = Submerged unit weight of cohesive soil, pcf;
- γ_w = Unit weight of water, pcf;
- q = Surcharge load at surface, psf;
- P_a = Lateral pressure, psf;
- P_1 = Active earth pressure, psf;
- P_q = Horizontal pressure due to surcharge, psf;
- P_w = Hydrostatic pressure due to groundwater, psf;
- H = Depth of braced excavation, feet
- c = Shear strength of cohesion soil, psf;

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL

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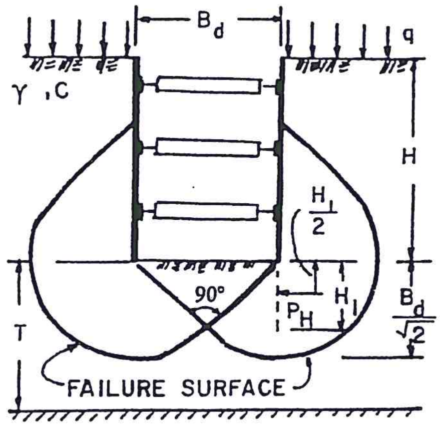
CUT IN COHESIVE SOIL,
DEPTH OF COHESIVE SOIL UNLIMITED ($T > 0.7\ B_d$)
L = LENGTH OF CUT



If sheeting terminates at base of cut:

$$\text{Safety factor, } F_S = \frac{N_C C}{\gamma H + q}$$

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 = Wet unit weight of soil (see Table 1)

q = Surface surcharge (assume q = 500 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)

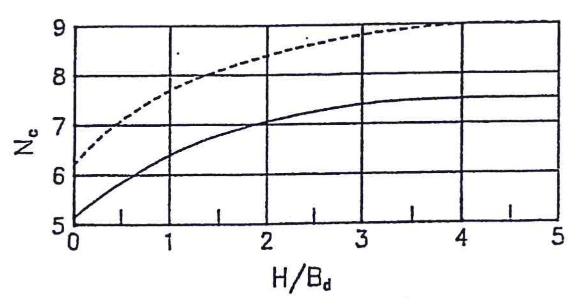
H_1 = Buried length $= \frac{B_d}{2} \geq 5$ feet

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:

$$\text{If } H_1 > \frac{2}{3}\frac{B_d}{\sqrt{2}}, \quad P_H = 0.7\,(\gamma H B_d - 1.4CH - \pi C B_d) \text{ in lbs/ linear foot}$$

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



——— For trench excavations
------ For square pit or circle shaft

STABILITY OF BOTTOM FOR BRACED CUT

TABLE 1

GEOTECHNICAL DESIGN PARAMETER SUMMARY
OPEN-CUT EXCAVATION

Alignments	Boring Nos.	Stratigraphic Unit	Range of Depths, ft	Wet Unit Weight, γ, pcf	Submerged Unit Weight, γ', pcf	Undrained Cohesion, psf	Internal Friction Angle, φ, degree
Water line, Storm Sewer and Sanitary Sewer Along Lincolnshire	GB-1	Cohesive Cohesionless Cohesive	0-2 2-6 6-10 10-16 16-23 23-25	126 125 120 126 104 125	63 63 60 63 52 63	500 1,000 1,500 2,000 -- 2,000	-- -- -- -- 25 --
	GB-2	Cohesive Cohesionless Cohesive	0-2 2-12 12-14 14-17 17-25	123 120 120 106 125	62 60 60 53 63	600 1,800 500 -- 2,800	-- -- -- 25 --
	GB-3 thru GB-5A and GB-16	Cohesive	0-14 14-25 25-31 (GB-16 only)	118 125 125	59 63 63	1,000 1,500 2,000	-- -- --
Water line, Storm Sewer and Sanitary Sewer along Glengarry	GB-6	Cohesive Cohesionless	0-6 6-23.5 23.5-25	128 123 110	64 62 55	1,200 2,200 --	-- -- 30
	GB-7 thru GB-10	Cohesive	0-8 8-16 16-18 18-25	125 130 125 126	63 65 63 63	800 1,600 1,000 1,200	-- -- -- --
	GB-15	Fill Cohesive 	0-6 6-20 20-22 22-30	125 120 125 125	63 60 63 63	1,500 500 2,500 1,200	-- -- -- --
Water line, Storm Sewer and Sanitary Sewer along Allison	GB-11 thru GB-14 and GB-19	Cohesive	0-6 6-10 10-14 14-16 16-20 20-25 25-28 (GB-14 only) 28-30 (GB-14 only)	115 115 120 125 126 125 125 125	58 58 60 63 63 63 63 63	1,500 1,000 1,500 500 1,200 2,200 400 500	-- -- -- -- -- -- --
Water line, Storm Sewer and Sanitary Sewer along Cottingham	GB-14. GB-16 and GB-17	Cohesive	0-12 12-20 20-28 28-31	123 125 126 125	62 63 63 63	1,200 1,800 1,500 500	-- -- -- --
	GB-15	Fill Cohesive 	0-6 6-20 20-22 22-30	125 120 125 125	63 60 63 63	1,500 500 2,500 1,200	-- -- -- --

TABLE 1

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OPEN-CUT EXCAVATION

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Water line, Storm Sewer and along MLK	GB-18	Cohesive	0-8 8-12 12-14 14-32	112 120 125 125	51 60 63 63	3,100 1,200 800 2,000	-- -- -- --
Water line, Storm Sewer and Sanitary Sewer along Hendricksen	GB-5A, GB-10, GB-19 and GB-20	Cohesive	0-8 8-14 14-25	123 130 124	63 65 62	1,000 1,600 1,600	-- -- --
Water line, Storm Sewer and Sanitary Sewer along Lea	GB-2	Cohesive Cohesionless Cohesive	0-2 2-12 12-14 14-17 17-25	123 120 120 106 125	62 60 60 53 63	600 1,800 500 -- 2,800	-- -- -- 25 --
	GB-7 and GB-11	Cohesive	0-6 6-12 12-20 20-25 (GB-7 only)	125 130 125 126	63 65 63 63	1,600 1,000 1,200 2,100	-- -- -- --
	GB-21	Cohesive Cohesionless Cohesive	0-14 14-16 16-18 18-20 20-25	130 125 110 120 125	65 63 55 60 63	2,000 800 -- 500 3,000	-- -- 30 -- --

Note: 1) Fill soils include lean clay with sand and fat clay with wood and shell fragments
2) Cohesive soils include Fat Clay, Fat Clay with sand, Lean Clay, Lean Clay with sand and Sandy Lean Clay.
3) Cohesionless soils include Silty Sand and Sandy Silt.