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Geotechnical Engineers & Materials Testing

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Job No. 1140205501
Trench Safety Report
January 7, 2015

Mr. Chad Nesvadba, P.E.
IDS Engineering Group
13333 Northwest Freeway, Suite 300
Houston, Texas 77040

Reference: **Trench Safety Design Considerations**
City Of Houston Phase II – Design for
Renewal/Replacement of Fir Ridge Lift Station
WBS No. R-000267-0117-3
Houston, Texas

Dear Mr. Nesvadba:

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.

Open-Cut Excavation

Geotechnical Parameters. Based on the soil conditions revealed by the borings, geotechnical parameters were developed for the open cut excavation for the installation of sanitary sewer line or access shafts for pipe and auger method of construction. The geotechnical design parameters are provided in Table 1. For design, the groundwater level should be assumed to exist at the ground surface, since this condition may exist after a heavy rain or flooding.

<u>Excavation Stability</u>. The open excavation for access shaft may be shored, laid back to a stable slope or some other equivalent means used to provide safety for workers and adjacent structures. The excavating and trenching operations should be in accordance with OSHA Standards, OSHA 2207, Subpart P, latest revision and the City of Houston requirements.

- <u>Excavation Shallower Than 5 Feet</u> – Excavations that are less than 5 feet (critical height) deep should be appropriately protected when any indication of hazardous ground movement is anticipated.

- <u>Excavation Deeper Than 5 Feet</u> - 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 per OSHA Standards. The following items provide design criteria for trench stability.

  (i) <u>OSHA's Soil Type.</u> Based on the soil conditions revealed by the borings and the assumed groundwater level at surface, OSHA's soil type "C" should be used for the determination of allowable maximum slope and/or the design of a shoring system. For shoring deeper than 20 feet, an engineering evaluation is required.

  (ii) <u>Excavation Support Earth Pressure.</u> Based on the subsurface conditions indicated by this investigation and laboratory testing results, the excavation support earth pressure diagrams were developed and are presented on Figures 1.1 and 1.2. These pressure diagrams can be used for the design of temporary excavation bracing. For a trench box, a lateral earth pressure resulting from an equivalent fluid with a unit weight of 94 pcf is recommended. The above value of equivalent fluid pressure is based upon an assumption that the groundwater level is near the ground surface, since these conditions may exist after a heavy rain or flooding. Effect of surcharge loads at the ground surface should be added to the computed lateral earth pressure. A surcharge load, q, will typically result in a lateral load equal to 0.5 q.

(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 under certain conditions. This condition is governed by the shear strength of the soils and by the differential hydrostatic head between the groundwater level within the retained soils and the groundwater level at the interior of the trench excavation. For cuts in cohesive soils, as predominantly encountered for the excavation depths of 12 to 20 feet, the stability of the bottom can be evaluated in accordance with the procedure outlined on Figure 2. However, due to the presence of silty sand layer between the depths of 14 and 16 feet in boring FRLS-3, dewatering will be required during the excavation to avoid bottom stability problems.

Ground Water Control. Excavations will encounter groundwater seepage. It is our opinion that in cohesive soils, as predominantly encountered, the groundwater may be collected in excavation bottom sumps for pumped disposal. However, due to the presence of silty sand layer between the depths of 14 and 16 feet in boring FRLS-3, dewatering will be required during the installation of sanitary sewer line. In this area the groundwater may be controlled by using eductor well system if can be successfully lowered 5 feet below the excavation bottom or alternatively installing sheet pile cutoff wall to insure excavation bottom stability.

The contractor should verify the groundwater level at the time of construction and should provide an adequate dewatering system, where required. Dewatering should be carried out in accordance with the City of Houston Standard Specifications, Section 01578, "Control of Ground Water and Surface Water."

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

K. Naresh

Naresh Kolli, P.E.
Assistant Project Manager

STATE OF TEXAS
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Copies Submitted: (2)
Enclosures: Trench Support Earth Pressure – Figures 1.1 and 1.2
Stability of Bottom for Braced Cut – Figure 2
Geotechnical Design Parameter Summary: Open-cut Excavation – Table 1
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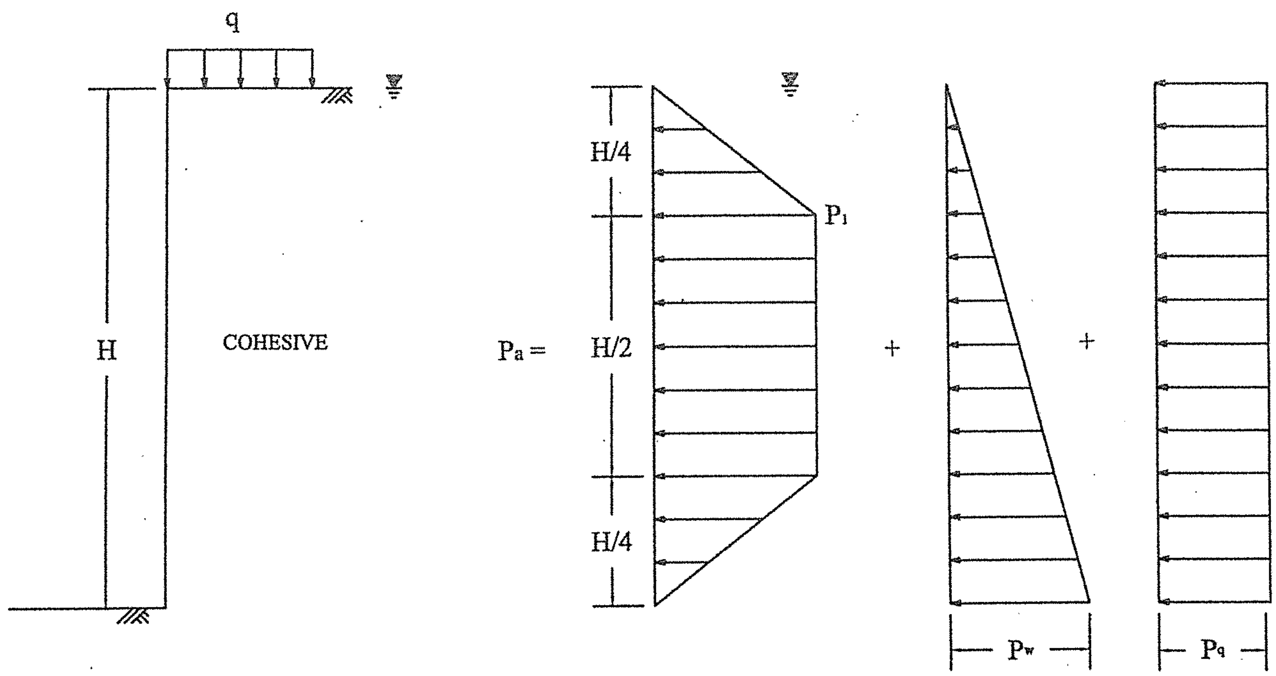

TYPICAL SOIL PARAMETERS

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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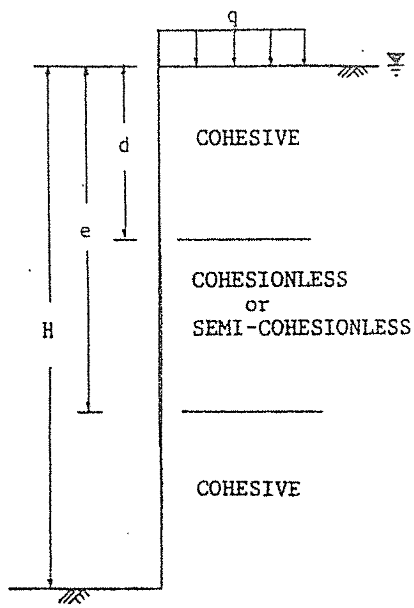
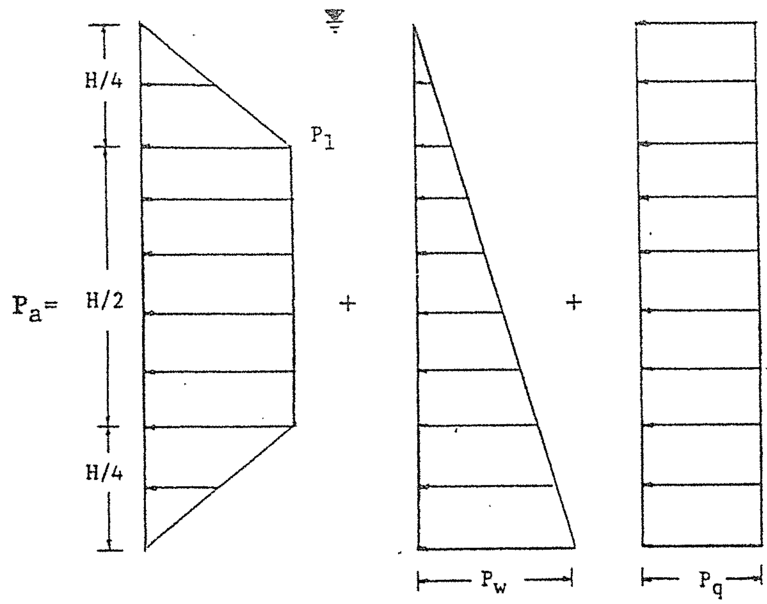


TYPICAL SOIL PARAMETERS



BRACED WALL

See Table 1 for typical values of soil parameters

$P_1 = 0.3\ \gamma'_{avg}\ H$

$P_w = \gamma_w\ H = 62.4\ H$

$P_q = 0.5q$

$$\gamma'_{avg} = \frac{\gamma_c'\ d + \gamma_s'\ (e-d) + \gamma_c'\ (H-e)}{H}$$

$\gamma_w = 62.4$ pcf

Where:

γ_c' = Submerged unit weight of cohesive soil, pcf ;
γ_s' = Submerged unit weight of cohesionless or semi-cohesionless soil, pcf ;
γ_w = Unit weight of water, pcf;
γ'_{avg} = Average submerged unit weight of soil, 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

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL
INTERBEDDED WITH COHESIONLESS OR
SEMI-COHESIONLESS SOIL

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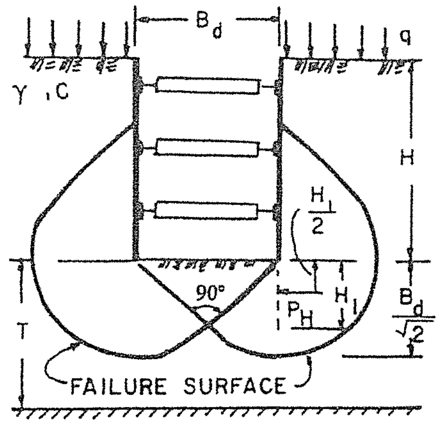
CUT IN COHESIVE SOIL,
DEPTH OF COHESIVE SOIL UNLIMITED ($T > 0.7\ B_d$)
L = LENGTH OF CUT



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 (assumed 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)

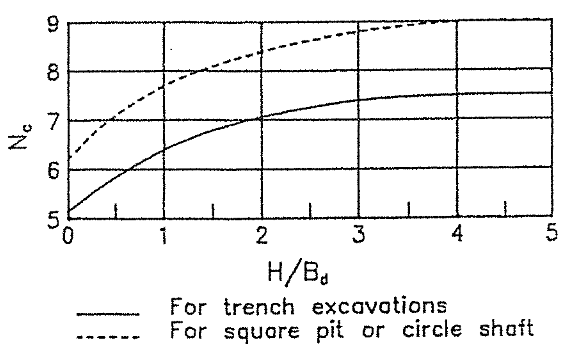
$$H_1 = \text{Buried length} = \frac{B_d}{2} \geq 5 \text{ feet}$$

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:

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

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



STABILITY OF BOTTOM
FOR
BRACED CUT

TABLE 1

GEOTECHNICAL DESIGN PARAMETER SUMMARY
OPEN-CUT EXCAVATION AND ACCESS SHAFTS

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
10 to 15 inch sanitary sewer	FRLS-1	Cohesive	0-6	124	62	2,400	--
			6-8	130	65	2,000	--
			8-14	125	63	1,300	--
			14-27	125	63	1,000	--
	FRLS-2	Cohesive	0-6	127	64	2,800	--
			6-14	128	64	1,500	--
			14-23.5	131	66	600	--
		Cohesionless	23.5-25	106	53	--	30
		Cohesive	25-27	125	63	3,300	--
	FRLS-3	FILL	0-6	126	63	3,000	--
			6-10	126	63	600	--
		Cohesive	10-14	126	63	1,000	--
		Cohesionless	14-16	104	52	--	30
		Cohesive	16-27	120	60	2,000	--

Notes: 1) Cohesive soils include fat clay and lean clay.
2) Cohesionless soils include silty sand.
3) Fill soils include fat clay with sand.