ESTABLISHED 1959

**3143 Yellowstone Blvd., Houston, Texas 77054**
**Tel: (713) 748-3717 Fax: (713) 748-3748**

April 25, 2014
Report No: G14-109

Amani Engineering, Inc.
8313 Southwest Freeway, Suite 350
Houston, Texas 77074

Attention: Mr. Mahesh Dutta, P.E.

Reference: Trench Safety Report
Proposed Neighborhood Sewer Systems Improvements
Sunset Boulevard, University Boulevard and Westheimer Street
WBS No. R-002011-0055-3
Houston, Texas

Dear Mr. Dutta:

Submitted herein are our recommendations for the trench safety for the open cut excavation/trenching/shoring involve in the proposed sanitary sewers replacement. The project entails approximately 9,425 linear feet of new sanitary sewers will be planned along the project alignments in the Sunset Boulevard, University Boulevard and Westheimer Street area.

The proposed sanitary sewers will be 8 to 15 inches in diameter and to be placed at depths ranging from 5 to 14 feet deep while along project alignments. The sewers will be installed using both open cut/trenching and trenchless construction methods. Open cut/trench excavation will be carried out at access pits.

OSHA Classification

Maintaining stability of sidewalls and base of a trench is necessary for the safety of the construction crew working in or near it and for mitigating risks of damages to adjacent structures/facilities due to lateral or vertical movements. At the federal level, Occupational Safety and Health Act (OSHA) requires protective systems for all trenches exceeding 5 feet in depth. Protective systems may be required for trenches shallower then 5 feet in depth if there are indications of potential ground movements. OSHA has developed a soil classification system to be used as a guideline in determining sloping and protective system requirements for trench excavations. This system has set forth a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing degree of stability.

Based on the soil conditions from the borings, the proposed sanitary sewer construction excavation will likely be advanced mostly in stiff to hard clays (with occasional local

stratum of soft to firm clays); however, construction excavation at/near locations of Borings B-1, B-3, B-4 and B-5 will likely or may encounter sands and soft clays between depths of about 8 and 16 feet. ATL recommends classifying the top 5 feet of the onsite clay soils (CL/CH) that are soft to firm as OSHA Soil Type "C", and those that are stiff to hard as OSHA Soil Type "B" for the determination of allowable maximum slope or selection and design of the protective system. All onsite clay soils below a depth of 5 feet shall be classified as OSHA Soil Type "C". Fill soils, sands (SP/SM/SC), silts (ML), silty clays (CL-ML), clay soils containing a significant amount of sand/silt/gravel/calcareous nodules/other granular or low cohesion materials, and any soils subject to hydraulic pressure or vibrations shall be classified as OSHA Soil Type "C".

Excavations

The excavations can be made using open slopes, stepped back to stable slope, vertical cuts supported with shoring, sheet piles or other suitably designed retaining system. The excavation should be performed in accordance with the current OSHA 29 CFR Part 1926 of OSHA (Trench Safety System). For short-term exposure during construction, open slopes in OSHA Type "C" soils should not be steeper than 1(V): 1.5(H). For long-term exposure (greater than 72 hours) during construction, open slopes in OSHA Type "C" soils should not be steeper than 1(V): 2(H). For OSHA Type "B" soils, open slopes is no steeper than 1(V): 1(H) is recommended. We do not recommend using unsupported vertical cuts.

Earth Pressures

For the trench support system, the lateral pressures exerted by surrounding soils are presented in the attached Figures 1 through 3. Temporary earth retaining walls are sometimes designed assuming an equivalent fluid pressure, in such cases, a lateral earth pressure equivalent imposed by a 84 PCF and 102 PCF fluid is recommended for cohesive soils below and above the water table, respectively; in sandy soils, a lateral earth pressure equivalent imposed by a 48 PCF and 85 PCF fluid is recommended for soils below and above the water table, respectively. In general, a surcharge magnitude of q psf will result in lateral earth pressure of 0.5q in cohesive soils and 0.4q in sandy soils. Timber shoring as outlined in 29 CFR Part 1926 of OSHA recommendation may be used in the construction of trench supporting system.

Due to the presence of the roadway adjacent to the proposed construction excavation along the project alignments, the effects of vehicular traffic should be considered in the design of the trench support systems. We recommend that a H20 vehicle loading be considered adjacent to the pit for design purposes, surcharge loading due to construction machinery should be considered. Boussinesq's equation should be used for computing both horizontal and vertical stresses imposed by a surface surcharge load. Stockpiling of excavated material may not be allowed near the excavation. Generally, a distance of one-half the excavation depth on both sides of the trench should be kept clear of any excavated material. If this is not possible due to space limitations then the retaining system design should take into account the surcharge loads.

Bottom Stability

Where granular soils are encountered at trench bottom, dewatering should be performed to lower the groundwater to a depth of at least 3-feet below the excavation bottom. In cohesive soils, the trench bottom stability can be evaluated using the procedure outlined in Section 5.1.2 of ATL Report No. G14-109.

Groundwater Control

Free water was encountered during drilling operation in most borings at a depth ranging from about 12 to 23 feet below existing grade, and between about 9 and 17 feet at the completion of drilling, and between depths of about 7 and 13 feet after 24 hours. Borings GB-2, GB-5, GB-8, GB-12 and GB-18 were converted into piezometers PZ-1 through PZ-5 at the end of drilling. Water level was measured in the piezometers at depths ranging from about 7 to 13 feet after 7 days, and again between about 7.5 and 13.5 feet after 30 days.

Based on the proposed invert elevation and the groundwater information gathered during our field investigation, sanitary sewer construction excavations exceeding about 5 feet in depth will have a possibility of encountering groundwater, especially when the excavations stay open for 24 hours or more. It should be noted that groundwater level will fluctuate with the amount of precipitation and the prevailing environmental conditions prior to and during construction.

The flow of groundwater may vary depending upon depth of construction and weather conditions. A conventional sump and pump arrangement may be used for the trench excavations in cohesive soils to a depth of 15 feet. Below this depth, multi-staged pumps or well points will be required. Where non-cohesive soils are encountered or if the inflow is fast, then dewatering using well points may be necessary. Groundwater control should be in general accordance with the City of Houston Standard Specifications, Section 01578.

More detailed information regarding the soils and groundwater at individual locations can be obtained from our geotechnical report G14-109. We appreciate the opportunity to work with you on this project. Please call should you have any questions or need additional information.

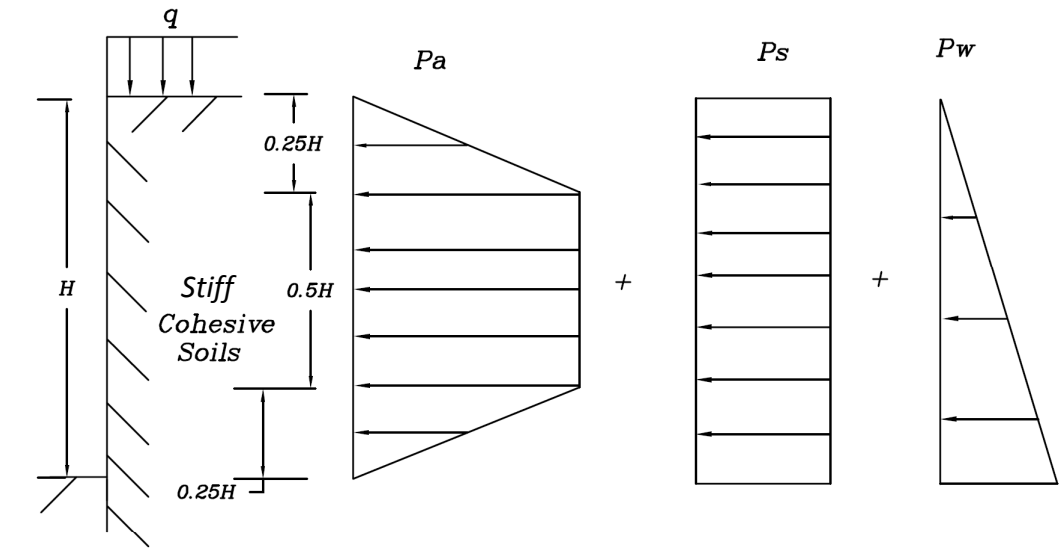
Sincerely,

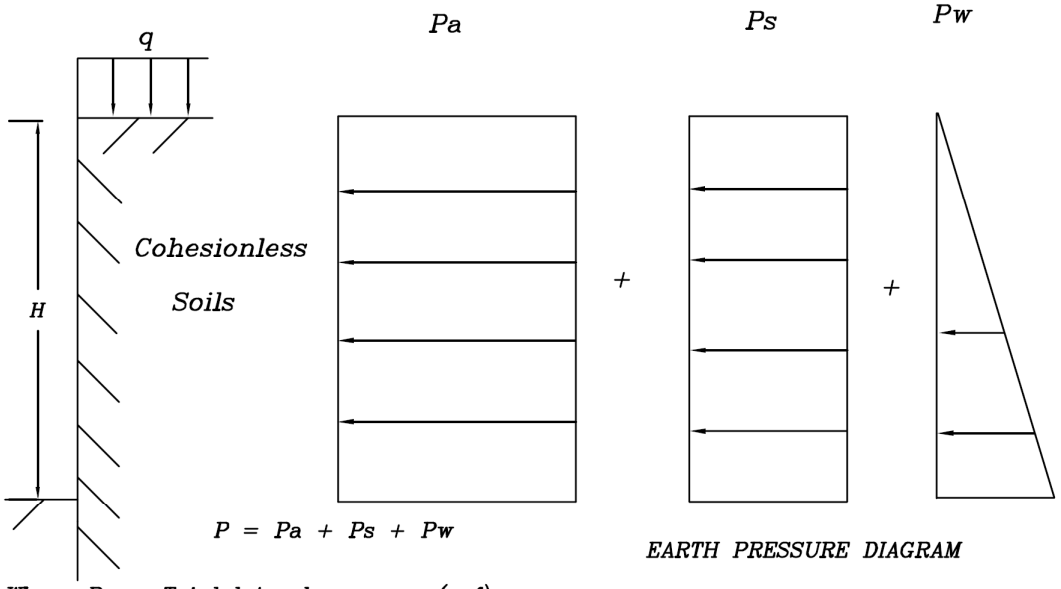
STATE OF TEXAS
PENG SIA TANG
81150
REGISTERED
PROFESSIONAL ENGINEER

4/20/14

Peng Sia Tang, P.E.
Manager, Geotechnical Services

Enclosures: Figures 1 through 3 – Earth Pressure Diagrams




$P = Pa + Ps + Pw$

EARTH PRESSURE DIAGRAM

Where P = Total lateral pressure (psf)

Pa = Active earth pressure(psf) = $K_A \gamma H = 0.4 \gamma H$ for Stiff Clays

= 0.65 $K_A \gamma H$= 0.25$\gamma H$ for cohesionless Sands (0.33 $\gamma H$–for loose sand)

Ps = Lateral pressure due to surcharge load (psf) = 0.5q for Clays

= 0.4q for Sands (0.5q for loose Sands)

Pw = Hydrostatic pressure (psf) = 62.4* water depth

H = Depth of braced excavation (ft)

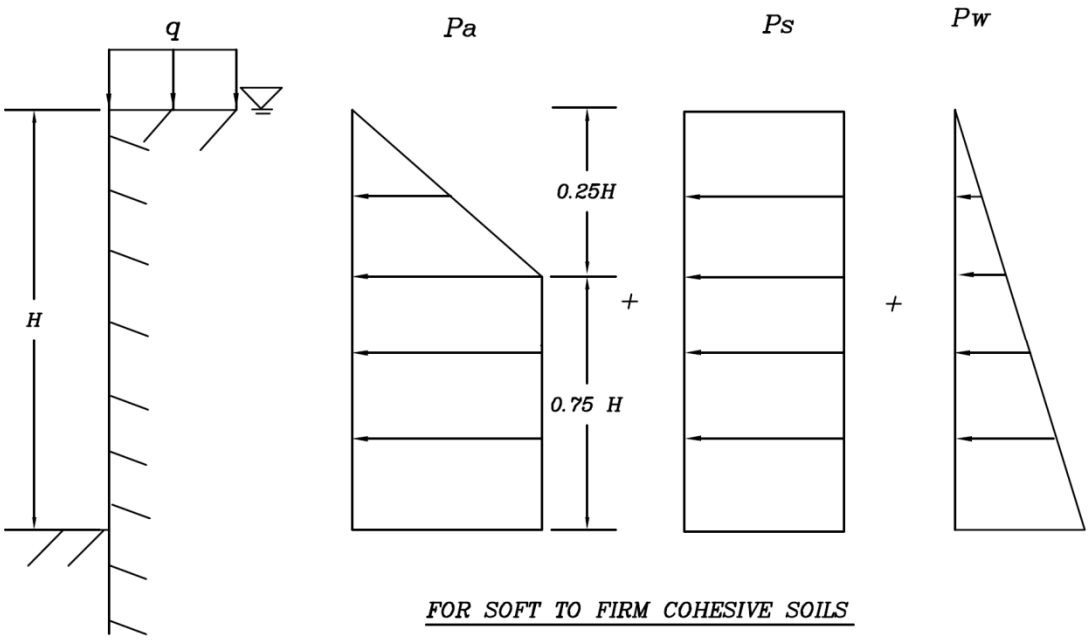
q = Surcharge load (psf) usually taken as 500 psf

$\gamma$ = Submerged density of soils (pcf) = use 60 pcf (use 50 pcf for loose Sands)

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

| | |
|---|---|
| EARTH PRESSURE DIAGRAM | ASSOCIATED TESTING LABAORATORIES, INC.<br>3143 YELLOWSTONE BLVD., HOUSTON, TEXAS<br>TEL: (713) 748-3717 Fax: (713) 748-3748 |
| NEIGHBORHOOD SEWER SYSTEMS IMPROVEMENTS<br>SUNSET BLVD, UNIVERSITY BLVD AND WESTHEIMER ST | WBS No. R-002011-0055-3 |
| | PROJECT NO. : G14-109 / FIGURE 1 |

PST 8/28/12




FOR SOFT TO FIRM COHESIVE SOILS

Where P = Total lateral pressure (psf)

Pa = Active earth pressure(psf) = $1.0K_a\gamma H$ for soft clays

$K_a$ = Active Earth pressure coefficient

$= 1-m\frac{2q_u}{\gamma H} = 1-m\frac{4C}{\gamma H}$ (taking $C=\frac{q_u}{2}$)

Here m=1 for N<4 and m=0.4 for N>5

N= Stability number $=\gamma H/C$

Ps = Lateral pressure due to surcharge load (psf) = $K_a$ for clays

Pw = Hydrostatic pressure (psf) = 62.4* water depth

H = Depth of braced excavation (ft)

q = Surcharge load (psf) usually taken as 500 psf

$\gamma$ = density of soils (pcf) = use 50 pcf below groundwater and 110 pcf above groundwater

$q_u$ = Unconfined compressive strength, psf

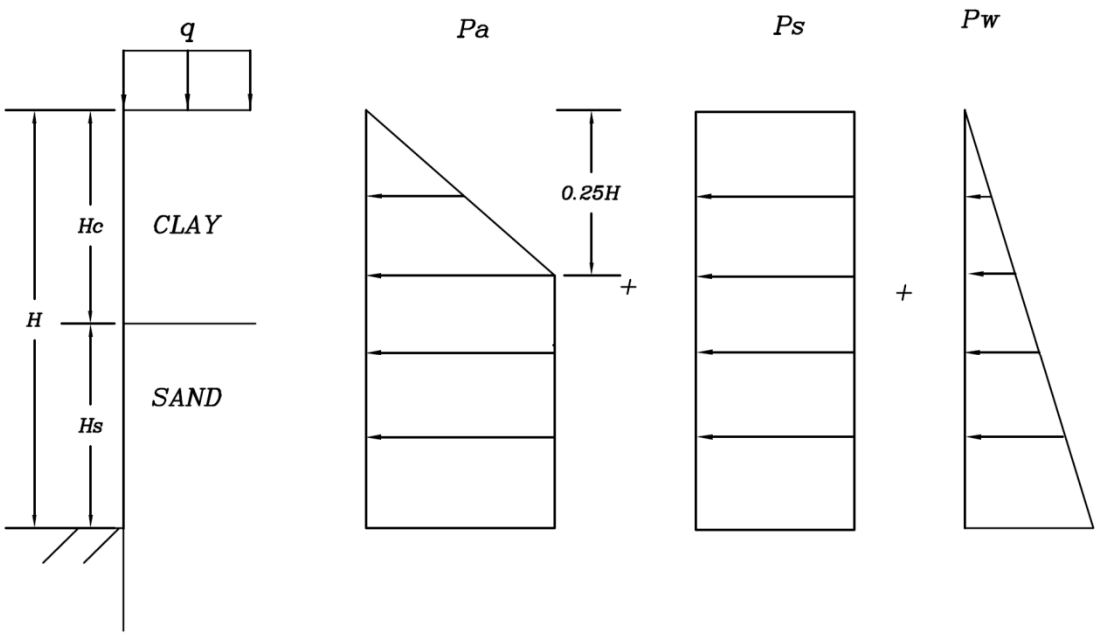
C = Undrained shear strength, psf

Note: Neglect hydrostatic pressure above groundwater level

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

| | |
|---|---|
| EARTH PRESSURE DIAGRAM | ASSOCIATED TESTING LABAORATORIES, INC.<br>3143 YELLOWSTONE BLVD., HOUSTON, TEXAS<br>TEL: (713) 748-3717 Fax: (713) 748-3748 |
| NEIGHBORHOOD SEWER SYSTEMS IMPROVEMENTS<br>SUNSET BLVD, UNIVERSITY BLVD AND WESTHEIMER ST | WBS No. R-002011-0055-3<br>PROJECT NO. : G14-109 \| FIGURE 2 |

PST 8/28/12




$$P = Pa + Ps + Pw$$

Where $P$ = Total lateral pressure (psf)

$Pa$ = Active earth pressure(psf) = $K_A \gamma H = 0.4 \gamma H$

$Ps$ = Lateral pressure due to surcharge load (psf) = $0.5q$

$Pw$ = Hydrostatic pressure (psf) = 62.4* water depth

$H$ = Depth of braced excavation (ft)

$q$ = Surcharge load (psf) usually taken as 500 psf

$\gamma$ = Submerged density of soils (pcf) = use 60 pcf

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

| | |
|---|---|
| EARTH PRESSURE DIAGRAM | ASSOCIATED TESTING LABAORATORIES, INC.<br>3143 YELLOWSTONE BLVD., HOUSTON, TEXAS<br>TEL: (713) 748-3717 Fax: (713) 748-3748 |
| NEIGHBORHOOD SEWER SYSTEMS IMPROVEMENTS<br>SUNSET BLVD, UNIVERSITY BLVD AND WESTHEIMER ST | WBS No. R-002011-0055-3 |
| | PROJECT NO. : G14-109 / FIGURE 3 |

PST 8/28/12