APPENDIX H

RESULTS OF SETTLEMENT ANALYSIS

PROBLEM: Estimate the post and future settlement of of the LEVEE system at PSS-2 , Ansonia/Derby Project .

Project No.: 04019-0001

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Ref: 1. DM 7.1, used for Embankment Loading Influence Chart
2. US ARMY Corps Design Memorandoms.
3. Geotechnical Test Boring data
4. Laboratory Test Data

ANALYSIS:

Subsurface Conditions: Based on review of test borings the following strata are considered in analysis in increasing depth.

GWT Elev. is assumed to be at Elev.+8 based on observation well measurement

Depth to GWT: $Depth_{GWT} := 0$ $Depth_{GWT} = 0$

Impervious Fill : (Elev.+40 to +30) $\gamma_{s1} := 130$ pcf $h_{s1} := 10$

Pervious Fill : (Elev.+30 to +8) $\gamma_{s2} := 140$ pcf $h_{s2} := 22$

Foundation Gravel (Ele +8 to -4) $\gamma_{s3} := 140$ pcf $h_g := 12$

Silty Clay Stratum M: (Elev. -4 to -40) $\gamma_c := 115$ pcf

$i := 1..2$

$h_{c_i} :=$

Thickness of Silty Clay stratum : (subdivided into two layers)

18
18

ft

Approach: Settlement of silty clay layer will be estimated using consolidation theory. Stress distribution is performed using embankment loading procedure

SETTLEMENT ESTIMATE FROM SILTY CLAY LAYERS:

Settlement Parameters for silt layer based on laboratory consolidation testing are as follows:

Coefficient of consolidation: $C_R := 0.141$

Maximum Past Consolidation Stress, TSF: $P_c := 6.4$ Tsf

Coefficient of recompression: $C_r := 0.018$

Coefficient of secondary consolidation: $C_\alpha := 0.0035$

Coefficient of vertical consolidation

$C_v := 22.47 \quad \frac{ft^2}{day}$ average value from PSS-1 & PSS-2 borings laboratory data

- ***Site Loading:***

The depth to the middle of each silty clay layer:

$$Depth_{c_i} := \begin{bmatrix} (h_g) + \frac{h_{c_1}}{2} \\ \left[(h_g) + h_{c_1}\right] + \frac{h_{c_2}}{2} \end{bmatrix}$$

$$Depth_{c_i} = \begin{pmatrix} 21 \\ 39 \end{pmatrix}$$

Influence Factors:

From Levee Embankment :

Use the graph below from DM.7.1 to calculate the IFs.

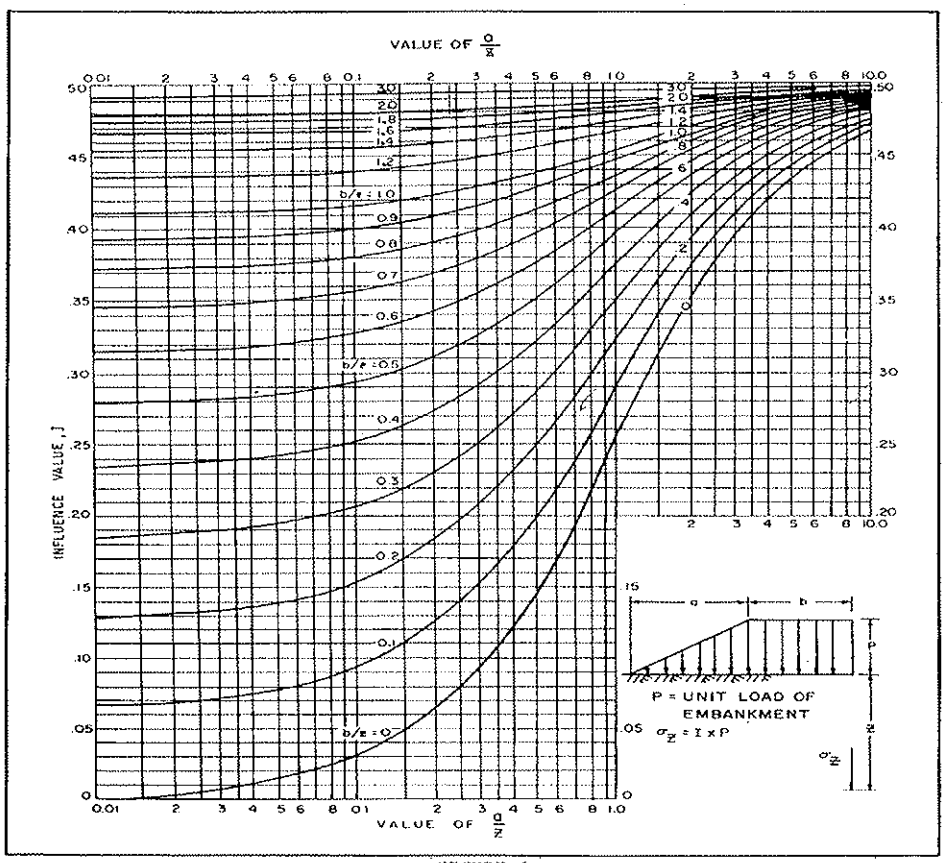

FIGURE 6
Influence Value for Vertical Stress Under Embankment Load of Infinite Length (Boussinesq Case)

At section PSS-2 (River Side)

$a := 81$ ft

$b := 9$ ft

$a_{c_i} := \frac{a}{Depth_{c_i}}$ $b_{c_i} := \frac{b}{Depth_{c_i}}$

$a_{c_i} = \begin{pmatrix} 3.857 \\ 2.077 \end{pmatrix}$ $b_{c_i} = \begin{pmatrix} 0.429 \\ 0.231 \end{pmatrix}$

$IF_{river\_new\_levee_i} :=$

from the graph above:

0.457
0.399

At section PSS-2 (Land Side)

$a2 := 40$ ft

$b2 := 9$ ft

$a2_{c_i} := \frac{a2}{Depth_{c_i}}$ $b2_{c_i} := \frac{b2}{Depth_{c_i}}$

$a2_{c_i} = \begin{pmatrix} 1.905 \\ 1.026 \end{pmatrix}$ $b2_{c_i} = \begin{pmatrix} 0.429 \\ 0.231 \end{pmatrix}$

$IF_{land\_new\_levee_i} :=$

from the graph above:

0.407
0.335

$IF_{new\_levee_i} := IF_{river\_new\_levee_i} + IF_{land\_new\_levee_i}$

$IF_{new\_levee_i} = \begin{pmatrix} 0.864 \\ 0.734 \end{pmatrix}$

Loading:

From Embankment Levee Fill

$\Delta p_{new\_Fill\_levee_i} := (h_{s1}) \cdot IF_{new\_levee_i} \cdot \gamma_{s1} + (h_{s2}) \cdot IF_{new\_levee_i} \cdot \gamma_{s2}$

$\Delta p_{new\_Fill\_levee_i} = \begin{pmatrix} 3.784 \times 10^3 \\ 3.215 \times 10^3 \end{pmatrix}$ psf

PRIMARY SETTLEMENT:

Effective overburden pressure in the middle of each silty clay layer at center of embankment :

$Po_{c_i} := \left[h_g \cdot (\gamma_{s3} - 62.4) + (Depth_{c_i} - h_g) \cdot (\gamma_c - 62.4) \right]$

$Po_{c_i} = \begin{pmatrix} 1404.6 \\ 2351.4 \end{pmatrix}$ psf

Generic Equation for Settlement: $\Delta(Cc, \delta P, Po, H) := Cc\,H \cdot \log\left(\frac{\delta P + Po}{Po}\right)$

Primary Consolidation Settlement:
(since Pc> Po+ δP, used recompression ratio)

$S_{p_i} := \Delta\left(C_r, \Delta p_{new\_Fill\_levee_i}, Po_{c_i}, h_{c_i}\right) \cdot 12$ Silty Clay Layer : $S_{p_i} = \begin{pmatrix} 2.207 \\ 1.455 \end{pmatrix}$ Inches

$\sum_i S_{p_i} = 3.662$

Assuming vertical drainage controls the consolidation within the silty clay layer the required time for 93% consolidation is (sily clay layer is 36 ft thick , assumed two way drinage):

$C_v = 22.47 \quad \frac{ft^2}{day}$

$h_z := \frac{36}{2}$

$t_{93\_ver} := 1 \cdot \frac{(h_z)^2}{C_v}$

$t_{93\_ver} = 14.419$ days

Over the short duration of primary compression, the settlement would occur as the embankment is being built

SECONDARY SETTLEMENT:

Assuming time in years for the future secondary settlement :
(Note : Assumed that the levee was built in 1968, i.e 42 years)

$\zeta := 1..20$

$t_{design_\zeta} :=$

0.2
0.5
1
2
3
4
5
6
7
9
10
20
32
42
52
62
72
82
92
102

years

$$S_{sec_{(\zeta,i)}} := \left(h_{c_i}\right) \cdot \log\left(\frac{t_{design_\zeta}}{\frac{t_{93\_ver}}{30 \cdot 12}}\right) \cdot C_\alpha \cdot 12$$

$$S_{sec_\zeta} := \sum_{i=1}^{2} S_{sec_{(\zeta,i)}}$$

$$\sum_i S_{sec_{(\zeta,i)}} =$$

2.834
3.023
3.17
3.289
3.391
3.556
3.625
4.08
4.389
4.567
4.707
4.823
4.921
5.006
5.082
...

Therefore, the estimated secondary settlement in 42 years is 4.567 inches.

The Estimated future secondary settlement over 30 years is 0.354 inches