Description of a Method of Predicting Fill Settlement Using Voids Ratio

RAY WEBBER, Staff Assistant
Oregon State Highway Department, Salem

This paper contains a simplified explanation of the theory and related computations for estimating fill settlement, using the voids ratio. Included is a problem involving two layers of compressible soil. The problem is solved in a step-by-step method, with comments for each step. Necessary charts and graphs are included for predicting the settlement of a fill.

● MANY highway engineers do not fully understand the principles involved in analyzing the settlement of highway embankments. The primary factor in estimating settlement is based on the amount of water and air which is squeezed or pressed out of the compressible foundation soil by the fill load. The rate of settlement is controlled by the character of the compressible foundation soil and the distance the water and air must travel to escape. Obviously a clay soil will drain water slower than a silty or peaty type soil. Any layers of granular material in the foundation soil will result in accelerating the time of settlement, since the excess water will travel horizontally as well as vertically.

ACCURACY OF ESTIMATE

It must be stressed that computations are correct for each soil test. However, since a soil test may represent many thousands of cubic yards of non-homogenous soil, there results at best an average representation of the soil mass. For highway embankment foundations the condition of average representation by sampling is more pronounced than in the case of structure foundations where the effective mass of foundation soil is much less.

STANDARD FORM OF COMPUTATION

The following data has been selected from the publications of soils authorities. It has been my experience that a continuity of study on this subject involves many references which in turn make it difficult to follow the subject. This probably is the principle reason that many highway engineers are not eager to pursue the subject. A standard procedure generally offers a better understanding of a complex problem.

ESTIMATE OF SETTLEMENT

The computation of the amount of settlement involves the average void ratios of the natural ground before loading with the fill (e_1) and after loading with the fill (e_2) and the thickness of the layer, or:

$$\text{Settlement} = \text{thickness of layer times } \left(\frac{e_1 - e_2}{1 + e_1}\right)$$

ESTIMATE OR THE RATE OF SETTLEMENT

The rate of settlement is determined by the ability of the soil to drain away the excess water and reduce air voids in the soil mass under the pressure caused by the fill load. The basic formula used to estimate the time of settlement (t), is:

$$t = \frac{T\,h^2}{c_V}$$

t = time to settle

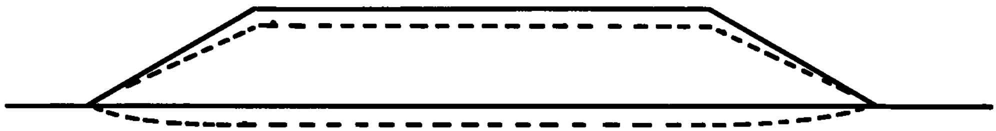
T = Terzaghi time factor (depends on pressure and direction of drainage relationships). Select values from Charts C or D.

h^2 = longest vertical drainage path

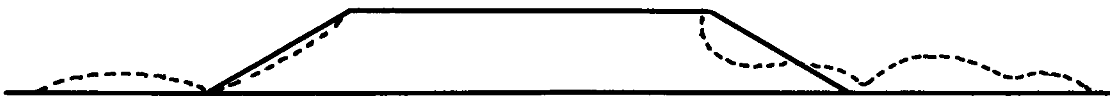
c_V = average coefficient of consolidation

SETTLEMENT COMPARED TO SHEAR FAILURE

A fill settlement should not be confused with the slide or shear type failure. It might be stated that foundation consolidation is contained within the fill section, and the shear type results in action outside of the fill section. Of course, both types of action can occur in the same embankment.



The above section represents settlement on a foundation soil of sufficient strength to support the fill load. In general terms the action is vertical and the amount of settlement depends on the quantity of water and air pressed out of the foundation soil by the weight of the fill.



The above section represents an embankment placed on a foundation soil which is too weak to support the load of the fill. The pressure of the fill acting vertically causes the weak foundation soil to rise or shear outside of the fill section. If the foundation soil is very unstable a slide can develop in the fill section; this condition is indicated on the right side of the above sketch. The condition on the left side prevails when the pressure of the fill exceeds the strength of the foundation soil, but to a lesser degree than that indicated on the right side of the sketch.

SAMPLING

The importance of sampling cannot be over emphasized. There are several factors involved in sampling which can seriously affect the mathematical approach to an estimated settlement of an embankment foundation; chief of which are:

1. The non homogeniety of soils will be a cause of concern. If a layer of clay within a mass of silty type material is selected for testing, the results would be of questionable value; since such material has a definite effect of slow consolidation. Hence the laboratory technician can become a salient factor in the end result of the computations. Also, since the undisturbed sample is very small (generally about 2 in. in diameter x about 1 in. thick) when compared to the volume of foundation soil, the non homogeniety of the soil demands careful selection of the samples.

2. The method of sampling, where it is generally impractical to remove a sample by means of a pit or excavation (most questionable highway embankment foundations being submerged) are subject to serious consideration. At best a so-called undisturbed sample is disturbed, but to a lesser degree if obtained with best design equipment. Usually best samples are obtained by means of samplers using a removable series of rings, inserted into an outer split shell or containing body. Samples are selected by sawing the soil between adjacent rings and inserting the ring and its contained soil directly into the consolidation apparatus.

3. The technique of taking a sample for consolidation testing can produce varied results. In this respect I believe it best that one man be assigned to supervise or take such complex samples. All strata of the foundation soil must be observed and recorded and zones of typical consolidating soils sampled. Layers of granular material within the soil mass must be recorded and the type of material on which the compressible material rests must be identified. Such observations have a direct bearing on the time element computations for estimated settlement, as will be shown later. With a specialist taking all samples (a soils engineer is desired but not required) most con-

sistent results are obtained and more complete data will be obtained.

4. Improper shipping and handling methods can result in altering or even destroying a properly taken sample, again a sampling specialist can take personal care in transporting samples to the laboratory or take proper action in preparing the undisturbed sample for shipment.

Other factors could be described but it is the intention here to bring attention to some of the problems which fundamentally affect the results of computing estimated settlements. Consistent sampling procedures will reduce the judgment and procedural errors or at least bring them to the attention of the soils engineer responsible for making the estimate. It might be said that if highway engineers were aware of this condition a better understanding of the problem would result and an estimate would be more acceptable and understandable to engineers involved.

TESTING AND REPORTING

The laboratory generally reports the void-ratio and the average coefficient of consolidation (c_V) of the sample at increment loads. The applied test loads must exceed the proposed embankment load (wet weight) by at least 25 percent. The height of the intended embankment must be given to the laboratory, this being for purposes of determining the range of pressure to be applied to the sample. Test loads should range from less than 800 lb per sq ft to at least 25 percent greater than the unit weight of the embankment. The specific gravity and natural moisture should be reported. Other tests are helpful such as screen and hydrometer analysis, liquid limit, plasticity index, ignition loss, etc.

EXAMPLE OF COMPUTATIONS (See Fig. 1, Appendix)

With the data from Figure 2, prepare a graph of the logarithm of the applied pressures against the void ratios (P-e curve). This is prepared on semi-log paper; also on the same sheet, plat a graph of the coefficient of consolidation (c_V) against the computed averages of the applied pressures. Figure 3 shows the P-e and c_V curves from the laboratory data of Figure 2.

Line 4

Compute the unit weight of the submerged foundations soils. Figure 2 gives the specific gravity and natural moisture of the samples. With this data using Chart A, the wet weight of soil is determined, by subtracting 62.4 (unit weight of water) the submerged weight of the soil is obtained. Note: in most problems the water level will rise to the ground level upon application of the fill load; this being the case of most fill foundations which cover much more area than bridge foundations, etc.

Line 5

The wet weight of the fill soil per cubic foot is required to compute the total load of the fill. Often this value is approximately 125 pcf, but it can be computed from the dry weight as:

$$\text{wet weight soil} = \text{dry weight} \times \left(\frac{\%\ \text{moisture}}{100} + 1\right)$$

or the wet fill soil may be compacted in the standard mold and its unit weight determined per cubic foot.

Line 6

Highway fill foundations are considered for problem purposes to have the dimensions of a rectangle one side of which is equal to the average width of the fill and the other side is equal to 4 x the depth of the compressible soils. For study purposes this large rectangle is analyzed as a ¼ section, it being the theory that the maximum load is on one corner of a ¼ rectangle. The values A and B represent the dimensions of ¼ of the larger rectangle.

Line 7

This is the average width of the fill or:

$$\frac{\text{top width} + \text{bottom width}}{2}$$

Line 9

The computation for Δp at this point determines the total load per sq ft of the fill at the ground surface.

Lines 10 and 11

Determine the influence coefficient at the mid-point of the layer, or:

$$m = \frac{A}{\text{Depth from ground surface}}$$

$$n = \frac{B}{\text{Depth from ground surface}}$$

With m and n known the influence coefficient is determined from Chart B. This value is used in computing the decrease pressure in the lower regions of the soil mass due to the fill load. See line 13 for use.

Line 12

The average initial static ground pressure within 1st layer is determined, or:

P_1 = Unit weight foundation soil x ½ thickness of layer

This is the theoretical pressure of the natural ground at the mid-point of the layer without the addition of the fill weight. From Figure 3 determine the void ratio for this pressure from the P-e curve of the layer in question and enter in appropriate column as e_1.

Line 13

The effect of the fill pressure at the mid point of the layer is determined. This computation involves the use of the m and n influence coefficient and expansion to cover the 4 corners of the pressure center or:

Δp = 4 x influence coefficient x fill load, (Δp from line 9)

$p_2 = p_1 + \Delta p$ This pressure is the total average pressure acting in the layer and determines the value of e_2 as taken from Figure 3 at the pressure p_2 for the layer in question. At this point it is well to complete $\frac{p_1 + p_2}{2}$ for the average pressure at the mid point of the layer to determine the average coefficient of consolidation (c_v) from Figure 3 for the layer No. 1 of compressible soil; enter value in the appropriate column.

Lines 14 and 15

Determine the m and n values and the corresponding influence coefficient for the bottom of the layer; same procedure as for lines 10 and 11.

Line 16

This computation is the same as for line 13 but is for the bottom of the layer, or:

Δp = 4 x influence coefficient x fill load.

The void ratio is not required at this point; only the average values of e are required to estimate the subsidence.

Lines 17 and 18

Determine values for m and n at the average depth of the layer below ground surface. Same procedure as lines 10 and 11.

Line 19

Compute the natural ground pressure at the middle of the 2nd layer. In this instance it is necessary to compute the total weight per sq ft of the top layer and add to this the average pressure of the 2nd layer. Generally two unit weights of foundation soil are involved necessitating individual computations as:

p_1 = (unit weight of top layer x thickness) + (unit weight of bottom layer x $\frac{1}{2}$ thickness of layer)

For this value of p_1 select the corresponding e_1.

Line 20

Compute the effect of the fill load at the mid point of the 2nd layer. Same procedure as for line 13. Select e_2 for the pressure p_2, ($p_2 = p_1 + \Delta p$); also select c_v for $\frac{1}{2}(p_1+p_2)$ from Figure 3, layer No. 2.

Lines 21 and 22

Determine the m and n values for the bottom of the layer, same procedure as lines 10 and 11.

Line 23

Determine the effect of the fill load at the bottom of the layer, same procedure as line 13. The void ratio is not required at this point.

Line 25

Compute the settlement of each individual layer, from:

$$\text{Settlement} = \text{thickness of layer times } \left(\frac{e_1 - e_2}{1 + e_1}\right)$$

Values of e_1 and e_2 are taken for each layer from the work sheet Figure 1, having been determined from Figure 3 for the pressures p_1 and p_2 at the middle of the layer. The computed settlement of each layer is entered on line 38 under the columns headed by "Settlement" No. 1 layer and No. 2 layer. Further computations involve entering the percent of settlement to complete these columns.

Lines 26 to 29 on right side of work sheet, Figure 1

Charts C and D indicate the effect of time of settlement. It will be noted that the magnitude of the top and bottom pressures affect the T factor. In Cases IV and V the value of u or ratio of top pressure (Δp) to the bottom pressure (Δp) must be determined in order to select the proper T value. After determining the proper case (and value of u if required) enter the corresponding T factor from Charts C or D for the percent consolidation on the work sheet for the individual layers.

ESTIMATE OF TIME OF SETTLEMENT

$$t = \frac{T h^2}{c_v}$$

This formula estimates the time of settlement for the computed percent of settlement, using the applicable T factor; h is the longest vertical path the water must travel to escape from the layer. In the case of a granular bottom under a compressible soil layer, the water travel can be both up and down or the longest vertical path will be $\frac{1}{2}$ the thickness of the layer in question. It will be noted that foundation soils which are free to drain at the top and bottom are identified as Case I of Chart C. If c_v or coefficient of consolidation is given in days the resulting computation for t will be in days.

Complete the work form by computing the t value for all percent indicated in the form and enter the data under the proper column for the individual layers.

PREPARE GRAPH OF SETTLEMENT VS TIME

Following the computations of the amount of settlement and the corresponding time to attain such settlement, prepare a graph on 10 x 10 cross-section paper for each layer using the amount of settlement against the time to attain this settlement (see Fig. 4).

By adding the settlement values of each layer (as graphed) at selected time intervals prepare a graph representing the total settlement of both layers; see Figure 4. This graph can be studied by the engineers who are concerned and be an aid in establishing required quantities to maintain the fill height. It is also very helpful in considering the subsidence during the construction period. Also it will reveal the probability of maintaining a grade line following the construction period.

Once this form and example (Fig. 1) are understood, it will be much easier to refer to the tests prepared by the authorities of the subject. The above example was selected for the purpose of explaining the procedure. If a field problem involves more layers additional sheets may be used for the additional layers.

Some engineers believe that the estimated time of settlement is quicker than the computed value, particularly when there is evidence of varving or layering in the foundation soils. Under such conditions the error, if any, could be attributed to sampling, drill logging the data, etc. If the drill data indicates layers or formations through which the excess water and air can migrate horizontally, a value of ½ the thickness of the layer (longest vertical path for the water to escape) can be used. Using the sample form many layers can be computed by adding more sheets. Of course, intensive sampling might be considered impractical; with this in mind some engineers are dividing the thickness of the compressible layer by 1.5 for anticipated drainage at one surface and by 3.0 if two faces are possible.

ACKNOWLEDGMENT

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Appendix

NOMENCLATURE AND NOTES FOR FIGURES 1-4, CHARTS A AND B AND EXAMPLES I-V

p_1 = Natural ground pressure at mid point of layer.
Δp = Consolidating pressure of fill load.
$p_2 = p_1 + \Delta p$.
$p_1 + p_2 \div 2$ = Average pressure for determining average value of c_V.
e = Void ratio = ratio of the volume of soil solids to the volume of voids.
c_V = Coefficient of consolidation.
m = A $\div$ depth considered.
n = B $\div$ depth considered.
Infl. Coeff. = Factor for computing effect of fill load at various depths.
u = Ratio used in Cases IV and V for determining T factor = Δp top $\div$ Δp bottom.
T Factor = Time factor for determining settlement rate (from Chart C or D).
t = Time of settlement.

Plat P-e curve on semi log paper, using applied pressures and corresponding void ratios, also plat c_V curve using average applied pressures and average coefficient of consolidations.

LINE 4, Using Chart A, determine submerged unit weight of foundation soils.
LINE 5, This is the wet weight of the fill material per cubic foot.
LINE 6, A and B represent the dimensions of ¼ of a theoretical pressure area.
LINE 7, This is the average width of the fill section.
LINE 9, Compute fill pressure at ground surface or; Δp = unit wght. of fill x fill height
LINE 10, m = A $\div$ depth to mid point of layer (from ground surface).
LINE 11, n = B $\div$ depth from ground surface to mid point of layer. With m and n known, select the influence coefficient from Chart B.
LINE 12, p_1 = unit weight of foundation soil x depth to mid point of layer.
LINE 13, Δp = pressure of fill at mid point of layer = 4 x fill load x infl. coeff.
LINES 14, 15, 16, same as Lines 10, 11, 13, except compute for bottom of layer.
LINES 17, 18, 19, 20, same as Lines 10, 11, 12, 13, except for mid point (total dist. from ground surface) of 2nd layer. Note, two unit weights of submerged foundation soil are generally involved.
LINES 21, 22, 23, same as Lines 10, 11, 13, except for bottom of layer.
LINE 25, Settlement = thickness of layer x $e_1 - e_2 \div 1 + e_1$, e_1 and e_2 are taken from the P-e curve for pressures p_1 and p_2 respectively.
LINES 26 and 28, if Case IV or V is involved, compute u = Δp at top $\div$ Δp at bottom of layer. Enter appropriate T factor from Charts C or D in column as indicated. Determine, $t = T \times h^2 \div c_V$, in which h = the longest vertical drainage path. If the bottom layer is granular, h = ½ thickness of layer because water is free to travel in both vertical directions. c_V is selected from the coefficient of consolidation curve at the computed pressure for each layer or $p_1 + p_2 \div 2$.
LINES 29, 38, compute percent settlement of each layer, 100 percent is the values from Line 25. Compute time to settle and enter in appropriate column. If c_V is given in sq ft/day t will be in days, if c_V is given in sq ft/year t will be in years. Prepare a graph of percent settlements against corresponding t for each layer, from this graph accumulate the settlement of both layers at selected periods of t for a graph of total subsidence.

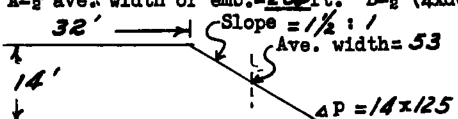
NOTE:

For estimating purposes, it can be considered that foundation materials will be entirely submerged. Generally the effect to the fill pressures will cause water to rise to the original ground line or top of the compressible soil.

OREGON STATE HIGHWAY DEPARTMENT
CONSTRUCTION DIVISION
SOILS SECTION
ESTIMATE OF EMBANKMENT FOUNDATION SETTLEMENT FOR HIGHWAY USE

1 Section________ Highway ________ County ________
2 Station *43+00*, ft. lt. *10* ft. rt. ___, *℄*___. Sampled by *Adamson*
3 Lab. no.______, depth *7* to *8* ft. Lab. no.______, depth *10* to *11* ft.
4 Unit wght of submerged soils; layer #1= *35* pcf; layer #2= *44* pcf.
5 " " " embankment soil (wet wght.) = *125* pcf.
6 A=½ ave. width of emb.= *26.5* ft. B=½ (4xdepth of compressible soils)= *120.0* ft.

7
8
9



Line	Infl. Coeff.	Depth	p_1	Δp	p_2	$\frac{p_1+p_2}{2}$	e	c_v	
9 Δp = 14x125		0.0		1750					
10 m at 4.5 ft.= $\frac{26.5}{4.5}$ = 5.9	0.249								Layer #1 (Compressible soils)
11 n at 4.5 ft.= $\frac{120}{4.5}$ = 26.7									
12 p_1 at 4.5 ft.= 35 x 4.5		4.5	158				e_1=1.62		
13 Δp at 4.5 ft.= 4x1750 x0.249		4.5		1743			e_2=1.42		
14 m at 9 ft.= $\frac{26.5}{9}$ = 2.94					1901	1030		0.95	
15 n at 9 ft.= $\frac{120}{9}$ = 13.33	0.247								
16 Δp at 9 ft.= 4x1750 x 0.247		9.0		1729					
17 m at 34.5 ft.= $\frac{26.5}{34.5}$ = 0.77	0.18								Layer #2 (Compressible soils)
18 n at 34.5 ft.= $\frac{120}{34.5}$ = 3.48									
19 p_1 at 34.5 ft.=(35 x 9)+(25.5 x 44)		34.5	1437				e_1=1.09		
20 Δp at 34.5 ft.= 4x1750x 0.18		34.5		1260					
21 m at 60.0 ft.= $\frac{26.5}{60.0}$ = 0.44	0.12				2697	2067	e_2=1.04	1.16	
22 n at 60.0 ft.= $\frac{120}{60}$ = 2.0									
23 Δp at 60.0 ft. = 4x1750 x 0.12		60.0		840					

24 ← Type of soil; describe, *Clay - Sand*

25 SETTLEMENT; layer #1= *9.0* x $\frac{1.62-1.42}{1+1.62}$ = *0.68* ft; layer #2 = *51.0* x $\frac{1.09-1.04}{1+1.09}$ = *1.22* ft.

26	Settlement		T Factor		t Days	
27 %	#1	#2	#1	#2	#1	#2
28						
29 10	0.07	0.09	0.01	0.01	1	22
30 20	0.14	0.24	0.03	0.02	3	45
31 30	0.20	0.37	0.07	0.04	6	90
32 40	0.27	0.49	0.13	0.09	11	202
33 50	0.34	0.61	0.19	0.15	16	336
34 60	0.41	0.73	0.29	0.23	25	516
35 70	0.48	0.85	0.40	0.39	34	874
36 80	0.54	0.98	0.57	0.51	49	1143
37 90	0.61	1.10	0.85	0.79	72	1771
38 100	0.68	1.22	3.0 ±	3.0 ±	255	6726

Layer #1; u= $\frac{1750}{1729}$ = 1.01 Use Case V

Layer #2; u = $\frac{1729}{840}$ = 2.05 Use Case V

Layer #1; t = $\frac{T \times 9^2}{0.95}$ = T x 85

Layer #2; t = $\frac{T \times 51^2}{1.16}$ = T x 2242

Ray Webber 5/31/56 *C. [illegible] 6-15-56*
Computed by, date, Check by, date

Figure 1.

LABORATORY DATA

LAYER #1	LAYER #2
Depth of sample 7 ft. to 8 ft.	Depth of sample 10 ft. to 11 ft.
Specific gravity 2.58	Specific gravity 2.62
Natural moisture 69.1	Natural moisture 48.5
Ignition loss at 1000° C = 7.9%	Ignition loss at 1000° C = 10.6%
L L = 31, % Silt = 22	L L = 40, % Silt = 30
P I = 0, Pass 200 screen =39%	P I = 0, Pass 200 screen = 45%

Applied Pressure	Voids Ratio	Coeff. of Consol. Sq. Ft. / Day	Applied Pressure	Voids Ratio	Coeff. of Consol. Sq. Ft. / Day
0	1.785		0	1.235	
		0.865			1.853
500	1.584		750	1.284	
		0.797			1.284
1000	1.511		1500	1.079	
		1.034			1.116
2000	1.415		3000	1.027	
		0.872			1.102
4000	1.308		6000	0.968	
500	1.340		750	0.985	
0	1.390		0	1.013	

LOG OF DRILL HOLE

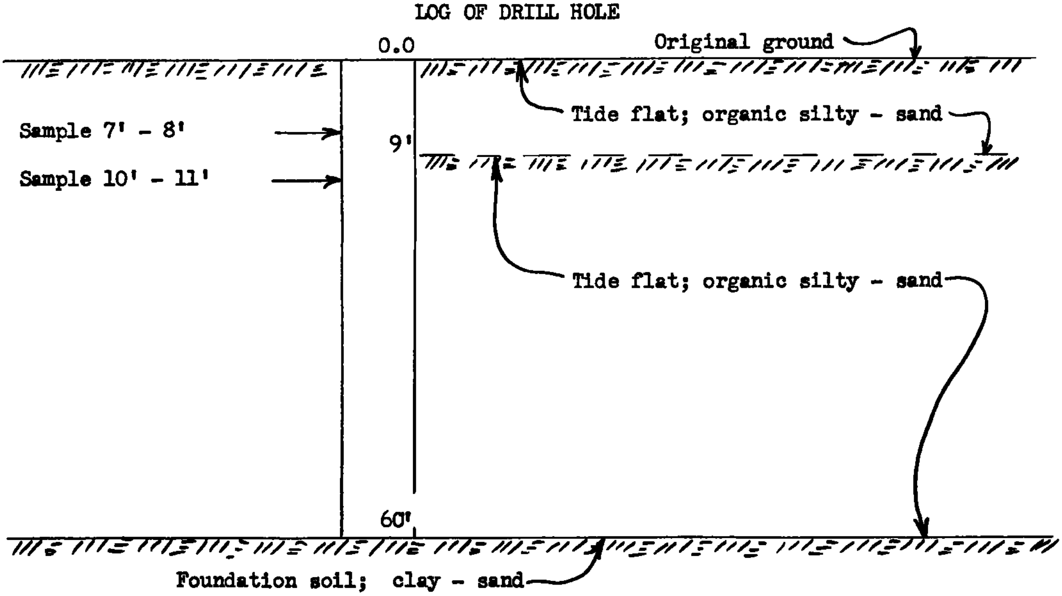


Figure 2.

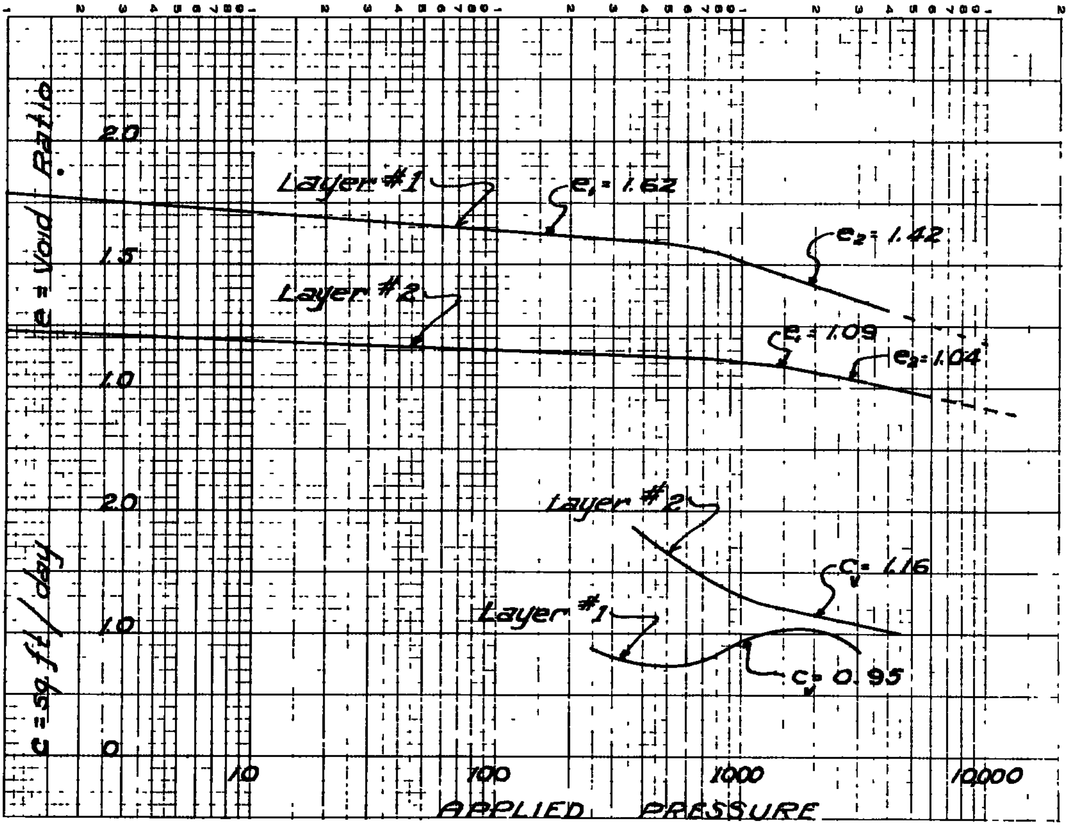


Figure 3.

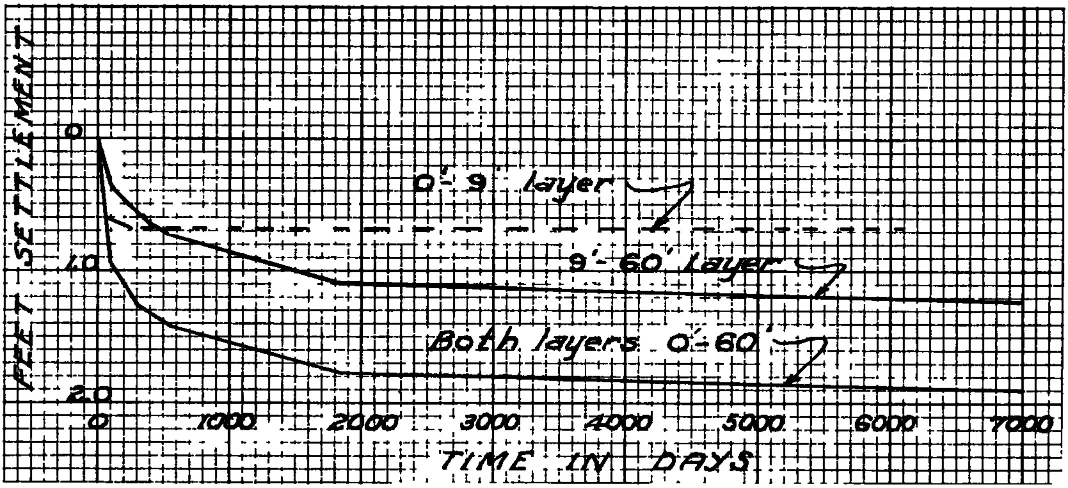


Figure 4.

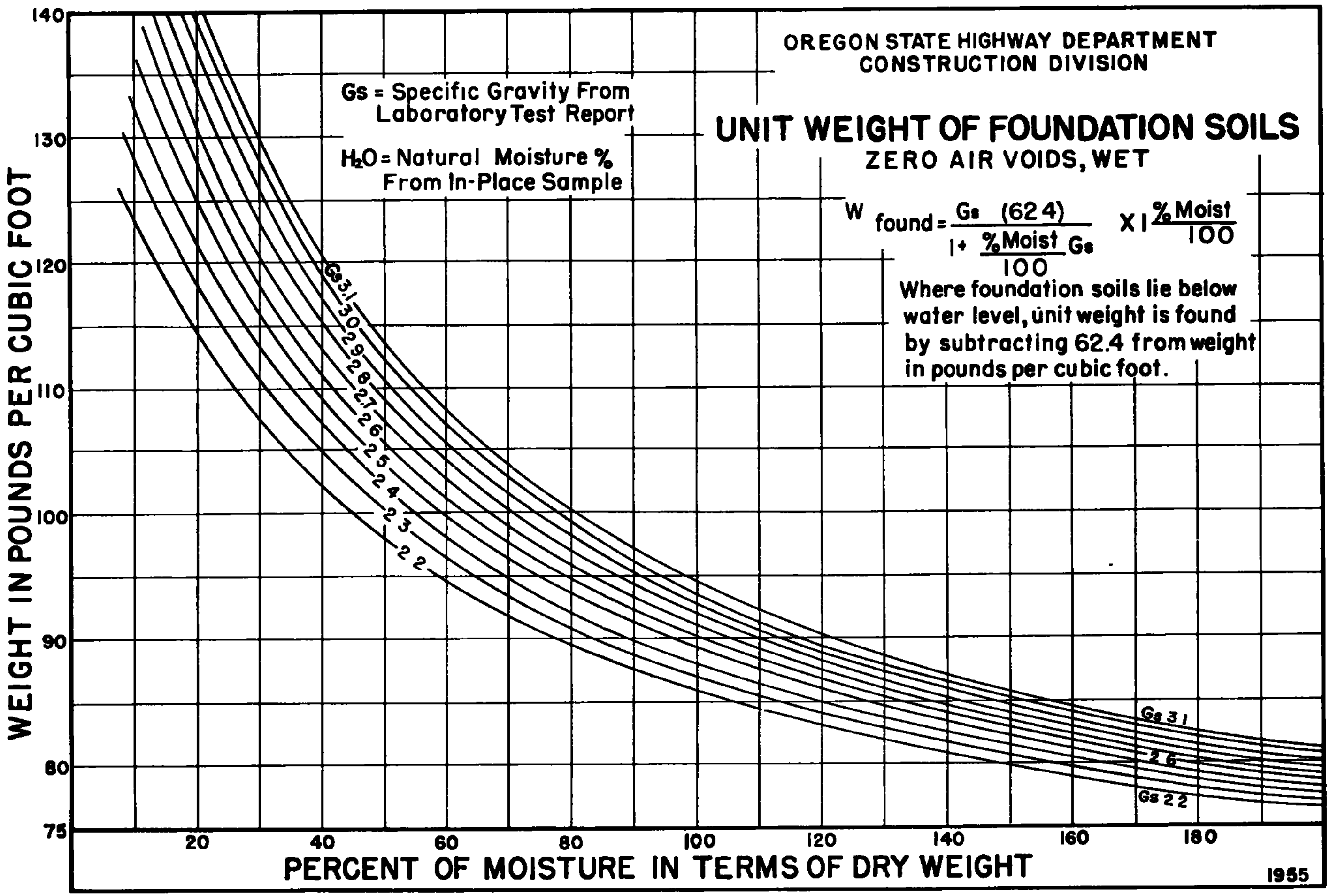

OREGON STATE HIGHWAY DEPARTMENT
CONSTRUCTION DIVISION
UNIT WEIGHT OF FOUNDATION SOILS
ZERO AIR VOIDS, WET
Gs = Specific Gravity From Laboratory Test Report
H2O = Natural Moisture % From In-Place Sample
W found = Gs (62.4) / (1 + %Moist/100 Gs) X 1 %Moist/100
Where foundation soils lie below water level, unit weight is found by subtracting 62.4 from weight in pounds per cubic foot.
WEIGHT IN POUNDS PER CUBIC FOOT
140
130
120
110
100
90
80
75
20
40
60
80
100
120
140
160
180
PERCENT OF MOISTURE IN TERMS OF DRY WEIGHT
Gs 3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
Gs 3.1
2.6
Gs 2.2
1955

Chart A.

NEWMARK CHART FOR VERTICAL STRESSES DUE TO EMBANKMENT LOADS

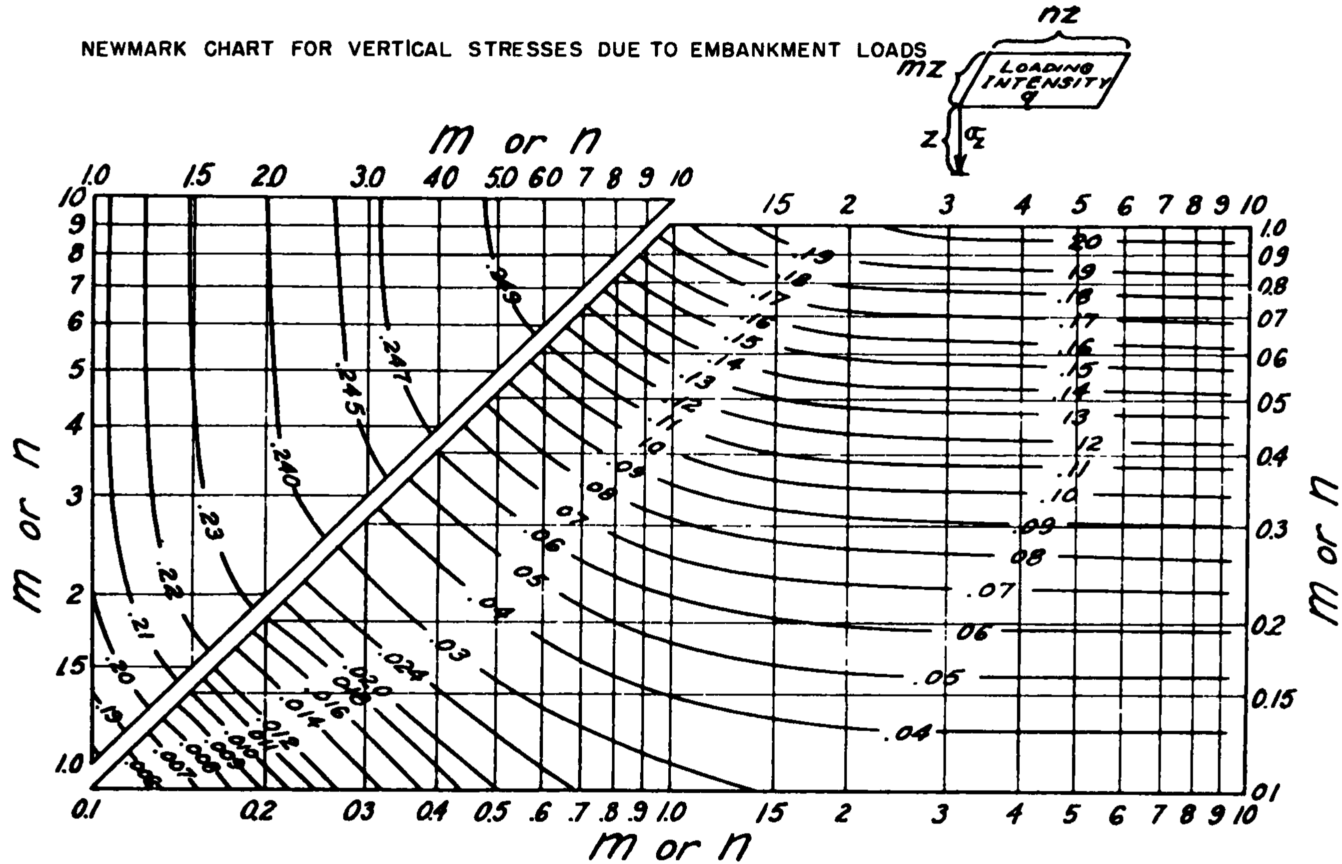
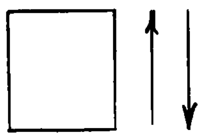


Chart B.

OREGON STATE HIGHWAY DEPARTMENT
CONSTRUCTION DIVISION
SOILS SECTION
FOUNDATION CONSOLIDATION INVESTIGATION

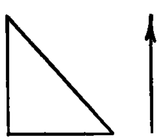
CASE I



Pressure distribution equal with drainage in both directions.

% Cons. =	10	20	30	40	50	60	70	80	90	100
T factor =	.008	.032	.069	.126	.198	.288	.405	.566	.846	3 ±

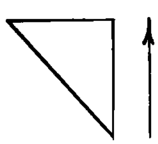
CASE II



Pressure distribution diagram with flow from maximum to zero pressure.

% Cons.	10	20	30	40	50	60	70	80	90	100
T factor	.049	.101	.158	.223	.296	.385	.502	.656	.951	3 ±

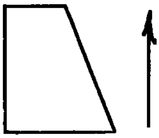
CASE III



Pressure distribution diagram with flow from zero to maximum pressure.

% Cons.	10	20	30	40	50	60	70	80	90	100
T factor	.002	.008	.024	.049	.097	.194	.279	.437	.717	3 ±

Chart C. Internal pressure and drainage relationships for Terzaghi time Factor "T".

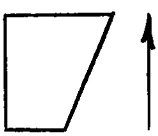


CASE IV

Pressure distribution trapezoid with lesser pressure in direction of flow.

Percent Consolidation	RATIO OF TOP						BOTTOM PRESSURES			
u=	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01
20	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.04	0.04	0.04	0.03
30	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.07	0.07
40	0.22	0.21	0.19	0.18	0.17	0.16	0.15	0.15	0.14	0.13	0.13
50	0.30	0.28	0.27	0.26	0.24	0.23	0.23	0.22	0.21	0.20	0.20
60	0.38	0.37	0.36	0.34	0.33	0.32	0.32	0.31	0.30	0.29	0.29
70	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.43	0.42	0.41	0.40
80	0.66	0.64	0.64	0.62	0.62	0.60	0.60	0.59	0.58	0.57	0.57
90	0.96	0.94	0.92	0.91	0.89	0.88	0.87	0.87	0.86	0.85	0.85
100	3.±	3.±	3.±	3.±	3.±	3.±	3.±	3.±	3.±	3.±	3.±

CASE V



Pressure distribution trapezoid with greater pressure in direction of flow.

Percent Consolidation	RATIO OF TOP						BOTTOM PRESSURES		
u =	1	1.5	2	3	4	5	7	10.0	20.0	100
10	0.008	0.008	.008	.008	.008	.008	.004	.004	.004	.004
20	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	.008
30	0.07	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.02
40	0.13	0.10	0.09	0.09	0.08	0.08	0.07	0.06	0.06	0.05
50	0.19	0.17	0.15	0.15	0.14	0.14	0.13	0.12	0.11	0.10
60	0.29	0.25	0.23	0.22	0.21	0.21	0.21	0.20	0.19	0.17
70	0.40	0.37	0.39	0.34	0.33	0.33	0.32	0.31	0.30	0.28
80	0.57	0.53	0.51	0.49	0.49	0.49	0.48	0.47	0.45	0.44
90	0.85	0.81	0.79	0.78	0.77	0.77	0.76	0.74	0.73	0.72
100	3.±	3.±	3.±	3.±	3.±	3.±	3.±	3.±	3.±	3.±

Chart D. Pressure distribution correction for T (time factor).