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Field Consolidation of a Moderately Organic Hetrogeneous Deposit

P. D. Deo
American Geotechnical & Hydrogeologic Engineers, Novi, Michigan

A. S. Mehta
The Detroit Edison Company, Detroit, Michigan

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P.D. Deo

Director of Engineering, American Geotechnical & Hydrogeologic Engineers, Novi, Michigan

A.S. Mehta

Principal Engineer, The Detroit Edison Company, Detroit, Michigan

SYNOPSIS Very little technical information is available in literature about the compressibility characteristics of peat and organic soils. The problem of estimating consolidation settlements is even more complex for moderately organic hetrogeneous soils, such as mixtures of organic and inorganic soils.

Two known factors affecting compressibility characteristics of organic soils are: natural moisture content and consolidation pressure. From several sites, natural moisture content and compressibility data was collected for organic soils. The data is presented graphically for low and moderate consolidation pressures.

On the basis of the above mentioned data, coefficient of compression index for a moderately organic deposit was estimated. At this site, field consolidation was accomplished by surcharge loading method. Presented are the estimated and observed values of consolidation settlements. For the case history studied, approximately 50 percent of settlement occurred during the first few days.

INTRODUCTION

The organic soils such as peat, marl and organic silts are generally very hetrogeneous. Significant variations in natural moisture content, shear strength and compressibility characteristics are often noted in any two specimens sampled at two different locations only a few inches apart in the same deposit. Since only a limited number of consolidation tests can be performed for an engineering project, it becomes difficult to estimate the average value of compression indices on the basis of consolidation tests. The property that can be determined most easily and with least expense is the natural moisture content of the deposit.

Settlement in organic deposits includes i) primary consolidation ii) secondary consolidation iii) shear strain and iv) loss of organic solids due to decomposition. In interpreting the laboratory time-settlement curves for organic soils, it is generally difficult to separate the primary and secondary consolidation unless pore-pressures are measured during the performance of consolidation tests. Commercial soil laboratories generally do not measure pore-pressures during consolidation tests. It is often customary to use the full settlement of sample during one loading to compute the change in void ratio. This compression generally will include primary consolidation and a good portion of secondary consolidation and shear strain. The shear strain will occur generally for large loads. Therefore, it is reasonable to assume that if a consolidation sample is loaded for at least 24 hours and total compression occurred during this period is used to plot a void ratio - load curve (e - log p curve), the curve will exhibit most of the compression due to the various factors discussed above. Loss of organic solids due to decomposition is neglected.

The low organic soils, such as mixtures of organic and inorganic soils are even more non-uniform than the organic soils. Some data is available on engineering behavior of highly organic soils. However, little or no data is available for slightly or moderately organic deposits.

SETTLEMENT CALCULATIONS

Primary consolidation of a normally consolidated, thin layer can be expressed as:

$$S = \frac{C_c}{1+e_o} \log \frac{P_o + \Delta P}{P_o} H \text{ where------------------(1)}$$

P_o = Initial stress before loading
P_c = Pre-consolidation Pressure
C_c = Coefficient of compression index as determined from Figure 1.
e_o = Initial void ratio
ΔP = Change in stress due to loading
H = Thickness of layer
S = Settlement of the layer
w = Natural Moisture Content

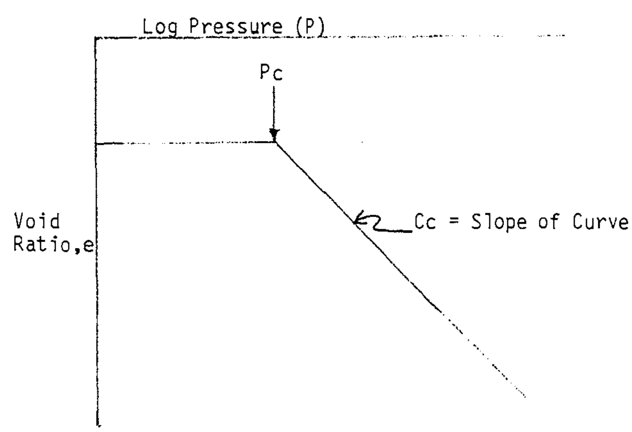

FIGURE 1 - Idealized e - log P curve for a normally consolidated soil.

Figure 1 is an idealized curve showing void ratio - pressure relationship for an undisturbed normally consolidated soil.

It is reasonable to assume that the organic soils will exhibit properties that will be closer to normally consolidated soils.

Secondary consolidation and creep of highly organic soils may be significant. But if settlement readings for laboratory tests are taken for 24 hours or more, the total settlement will include a large portion of secondary consolidation and creep.

For a normally consolidated soil:

$P_o = P_c$

The equation (1) can be integrated for any height of the deposit.

If C_{ct} = Coefficient of total compression index for an organic deposit, C_{ct} is determined from the e - log P curve obtained on the basis of the minimum 24-hour compression reading in a consolidation test as described previously.

The total compression of the organic layer can be expressed as:

$$S = \frac{C_{ct}}{1+e_o} \log \frac{P_o + \Delta P}{P_o} H$$

The equation should be integrated by dividing the deposit into several thin layers.

LABORATORY COMPRESSIBILITY DATA

Laboratory compressibility data was collected for approximately 50 organic deposits from different projects. The data included natural moisture content, coefficient of total compression and initial void ratio of these deposits. Presented on Figure 2 is a plot of C_{ct} versus log w. Presented on Figure 3, is a plot of $C_{ct}/1+e_o$ versus log w. C_{ct}, e_o and w have been explained in the previous section.

It can be seen from figures 2 and 3, that a direct relationship exists between C_{ct} and log w. It appears that the relationship of $C_c/1+e_o$ and log w can be approximated by a straight line. Figures 2 and 3 indicate that the compressibility characteristics of organic soils can be estimated from natural moisture content. No attempt has been made here to develop a unique equation for these relationships. It is recommended that several natural moisture content values be determined for the organic deposit and then the C_c or $C_c/1+e_o$ value estimated from these figures. The exact relationship within the bands on Figures 2 and 3 should be determined on the basis of uniformity of the deposit, type of project and any actual laboratory test performed for the deposit.

A CASE HISTORY

The Detroit Edison Company planned to construct a transformer mat as part of the expansion of an existing switch yard. The transformer had a base area of 12.5 feet square with a total weight of approximately 200,000 pounds giving a contact pressure of approximately 1300 pounds per square foot.

The following represents the generalized subsoil profile at the site.

Depth below ground surface, feet	Soil Description
0.0 - 7.0	Stiff silty clay with traces of crushed limestone, sand and organic matter (Fill)
7.0 - 14.5	Loose to medium compact sand with traces of organic material and shells (moisture content = 20% to 30%)
14.5 - 16.5	Organic silt and peat (Natural moisture content 108%)
16.5 - 30.0	Stiff to very stiff silty and sandy clay
30.0 -	Bedrock

The equipment was considered very sensitive to the settlements and permissible settlement was less than one-quarter of one inch. Due to the site-access problems and presence of other equipments at the site, it was not possible to support the slab on piles or similar deep foundation system. Based on the subsoil conditions, it was estimated that, if the transformer mat is supported on existing soils with no improvement in soil conditions, the resulting settlements will range between 1 and 2 inches.

Accordingly, it was decided to improve the compressibility characteristics of the subsoils by surcharge loading. The loading pattern is shown in Figure 4. It should be noted that there were areas other than the transformer site that were also surcharge-loaded. The maximum height of the surcharge load was 8 feet.

It was estimated that settlement on the order of 1.5 to 2 inches will occur in the area of the transformer pad, which had the highest fill height.

The settlement was monitored by installing settlement plates. A typical settlement plate is illustrated in Figure 5. Two settlement plates were installed at the transformer site and were monitored for a period of approximately 3 months. The data indicated that the settlement at the two locations was 1.56 and 2.40 inches, respectively. The settlement data for the two plates is tabulated below.

Days after placement of Fill,	Settlement of Plate Number 1, inches.	Settlement of Plate Number 2, inches.
1	0.96	0.99
7	1.20	1.32
14	1.34	1.56
21	1.34	1.68
28	1.34	1.80
35	1.56	2.16
49	1.56	2.40
63	1.56	2.40

The actual settlements observed during surcharge loading were slightly larger than those estimated on the basis of figures 2 and 3. It appears that the additional settlement was due to compression of the upper fill. It is interesting to note that approximately 50 percent of settlement occurred during the first day of surcharge fill placement. The difference in the ultimate settlement values and the rate of settlement at the two locations is attributed to the difference in configuration of the fill at the two locations.

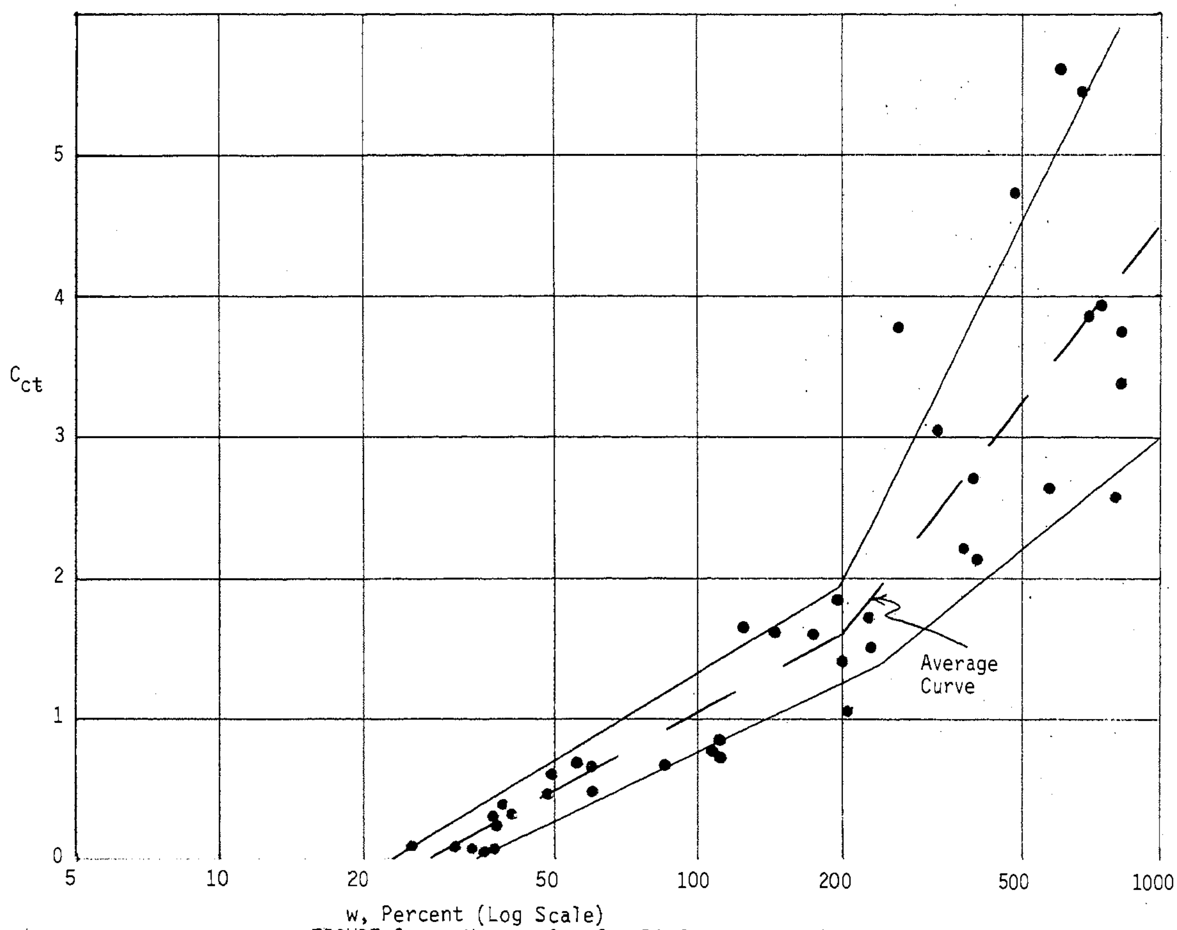

FIGURE 2 - w Versus C_{ct} for Different Organic Deposit

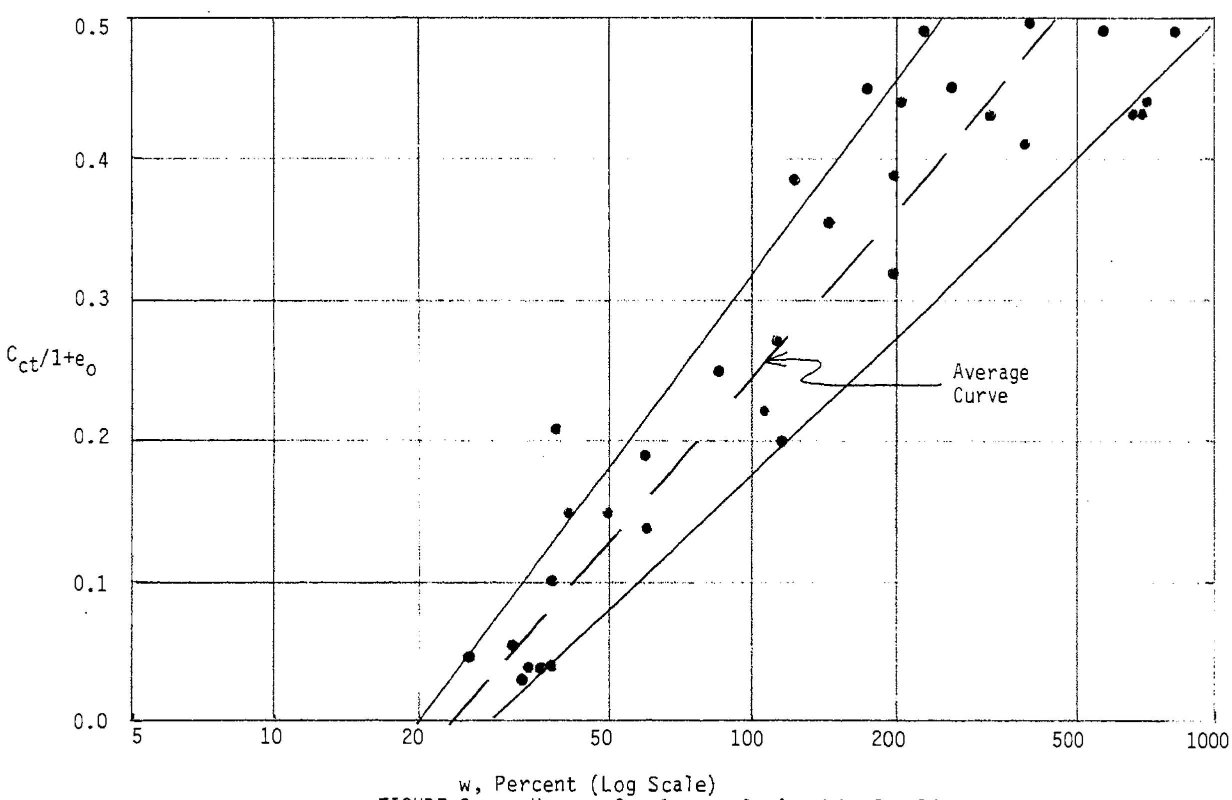

FIGURE 3 - w Versus $C_{ct}/1+e_o$ relationship for Different Organic Deposits

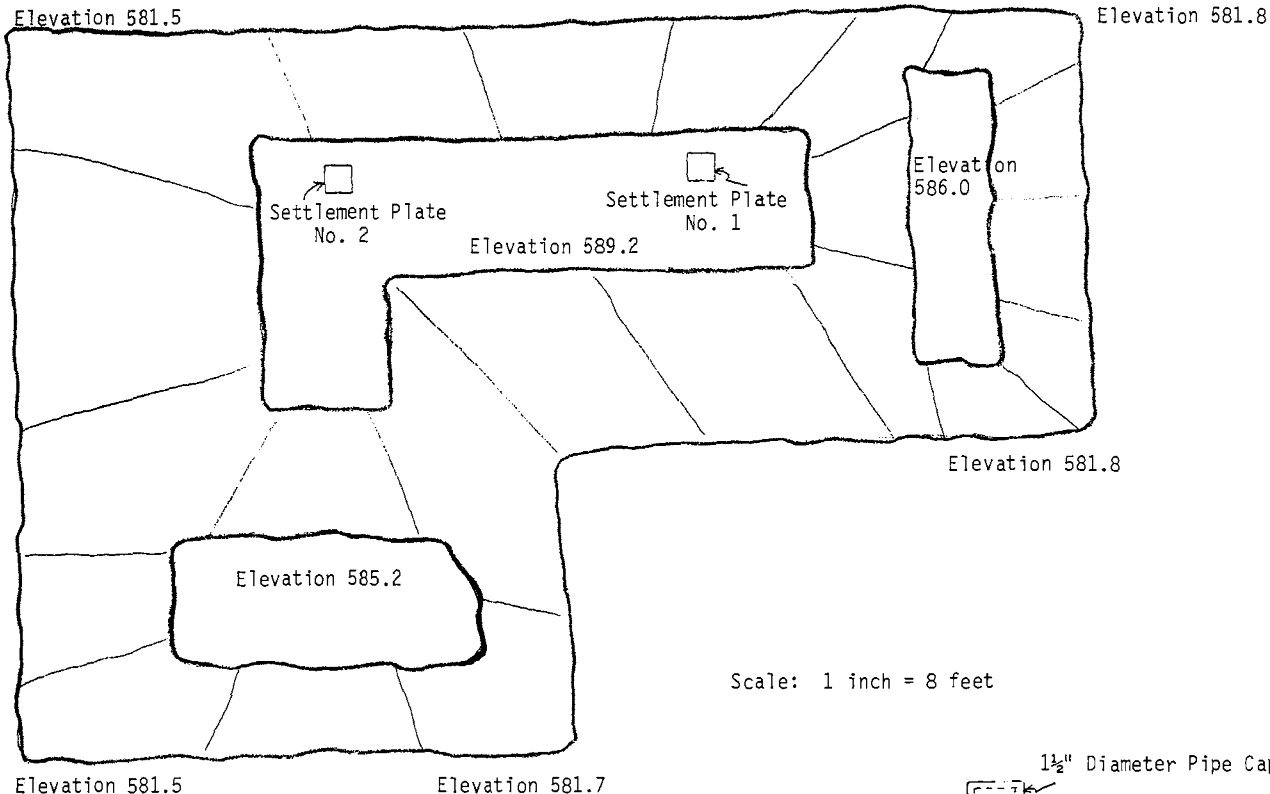

FIGURE 4 - Configuration of Surcharge Loading

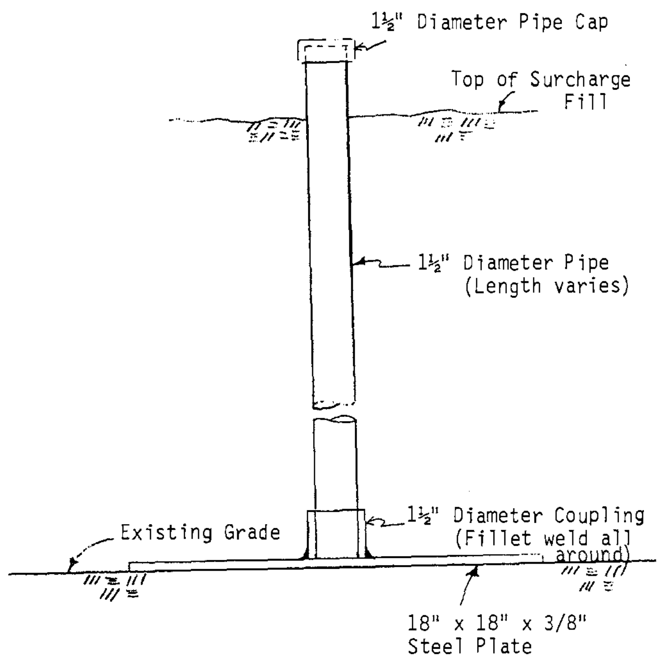

FIGURE 5 - Settlement Plate Details

CONCLUSIONS

A range of coefficient of compression index can be determined on the basis of natural moisture content of organic soils. These values can be used to estimate the settlements of structures supported on these soils. For the case history studied, approximately 50 percent of settlement occurred during the first few days.

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