Factor Influencing Surface Soil Settlement Due to Dewatering

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Abstract: Lowering the water table will affect the surface settlement. In this study, the effects of dewatering on the short-term and long term were investigated. Lowering the water table reduces the moisture content in the top layers and will result in shrinkage.

1. Introduction

Lowering of the groundwater table by dewatering to provide dry conditions during work in large open excavations can lead to land subsidence or soil settlement. Land subsidence is extremely dangerous to structures above the affected water table. Although appropriate precaution is taken dewatering operations, unforeseen events or conditions sometimes occur. When the water table is lowered, the effective load on the subsoil is increased by an amount equal to the difference between the drained and submerged weights of the entire soil mass between the original and the lowered water. This increased overburden pressure causes additional compression and produces a settlement.

Generally, settlement occurs at a faster rate in the sand, but in clay and silt, a much longer period is involved. As a generalization, land subsidence induced by well pumping is explained by groundwater flow and subsidence models. Almost all model have shown compaction by incorporating Terzaghi's one-dimensional compaction principle into the groundwater flow equation. However, because Terzaghi's one-dimensional compaction principle is valid only for a one-dimensional compaction case and was originally concerned with the dissipation of pore water pressure, the Biot theory remains the only suitable fully coupled land subsidence model.

In this paper, an approximate analytical solution for land subsidence induced by the confined clay aquifer consolidation due to single good pumping is shown. The primary consolidation settlement of the confined sand aquifer is determined using the *e*-lg*p* curve method.

2. **Objective**. In this study, the effect of the water drawdown from clay soil is studied. Due to drawdown, the settlement of soil is studied.

3. Methods-

Long Term Settlement- Long term settlement of soil is calculated by using the drawdown profile of the soil. Increase in effective stress is calculated and details. The increase in effective stress is calculated at a reference point, and then the total settlement is calculated. To calculate the settlement, the compression index and -was assumed. The initial void ratio is assumed based on the compression index values to compute the settlement. Different Cc values were assumed for CH and CL soil, and corresponding to(void ratio) values was calculated to form various equations listed in Table1.

Short Term Settlement- Immediate settlement on the soil occurs due to the drawdown of water from the soil. Due to changes in the moisture context, there could be shrinkage in the top layer. Based on the type of soil, there will be shrinkage and also lowering of total stress result in some expansion.

Consolidation Settlement

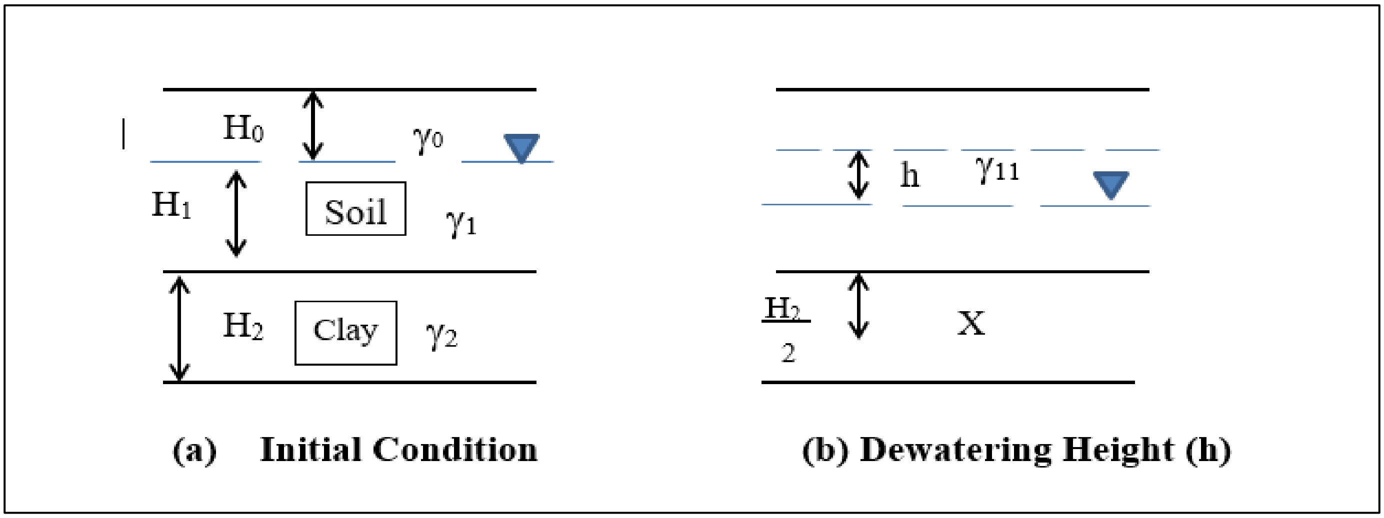

Figure 1 –Initial Condition. **Figure 2-After water Drawdown**

H0=Depth of soil above water level

H1=Depth of soil layer with water table.

H2=Depth of soil layer under consideration

Before Dewatering

$$\sigma_{ax} = H_0\gamma_0 + H_1\gamma_1 + \frac{H_2}{2}\gamma_2 \quad (1)$$

$$U_{ax} = H_1\gamma_w + \frac{H_2}{2}\gamma_w \quad (2)$$

Effective Stress (σ_{bx}” = $(\sigma_{ax} - U_{ax}$))

$$\sigma'_{ax} = H_0\gamma_0 + H_1(\gamma_1 - \gamma_w) + \frac{H_2}{2}(\gamma_2 - \gamma_w) \quad (3)$$

Initial Condition (b)

Total Stress ((σ_{bx})

$$\sigma_{bx} = H_0\gamma_0 + h\gamma_{11} + (H_1 - h)\gamma_1 + \frac{H_2}{2}\gamma_2 \quad (4)$$

Pore water Pressure (Uax)

$$U_{bx} = (H_1 - h)\gamma_w + \frac{H_2}{2}\gamma_w \quad (5)$$

Effective Stress (σ'_{bx} = $(\sigma_{ax} - U_{ax}$))

$$\sigma'_{bx} = \sigma'_{ax} + h(\gamma_w + \gamma_{11} - \gamma_1) \quad (6)$$

$$\textbf{Settlement}\ (S) = C_c \frac{H_2}{(1+e_0)} \log\frac{\sigma'_{bx}}{\sigma'_{ax}}$$

Final settlement is due to change in effective stress in the soil due to water drawdown. Based on equation 6, the final settlement is calculated. To calculate the compression, index several equations have been proposed by researchers and these have been shown in Fig .3.

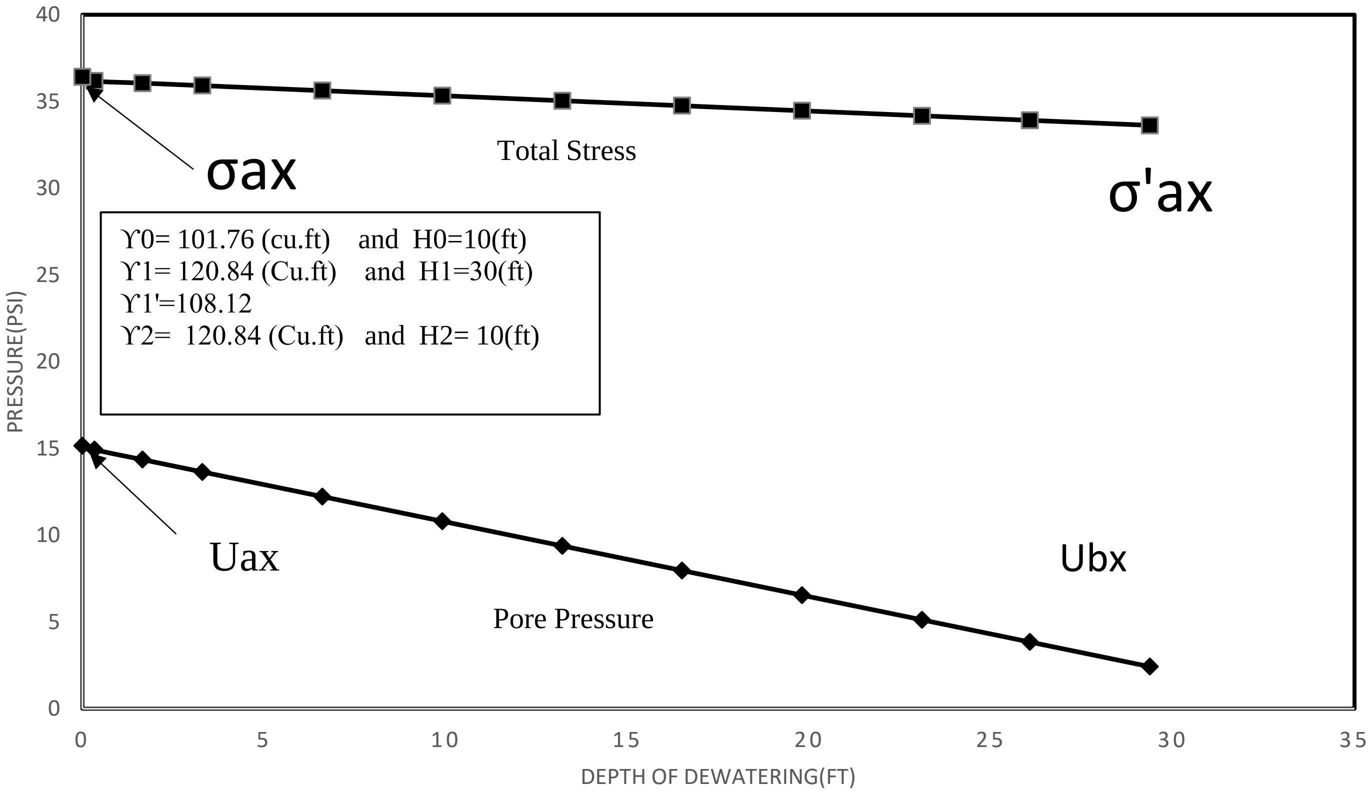

Figure 3-Change of pore pressure and total stress due to water drawdown.

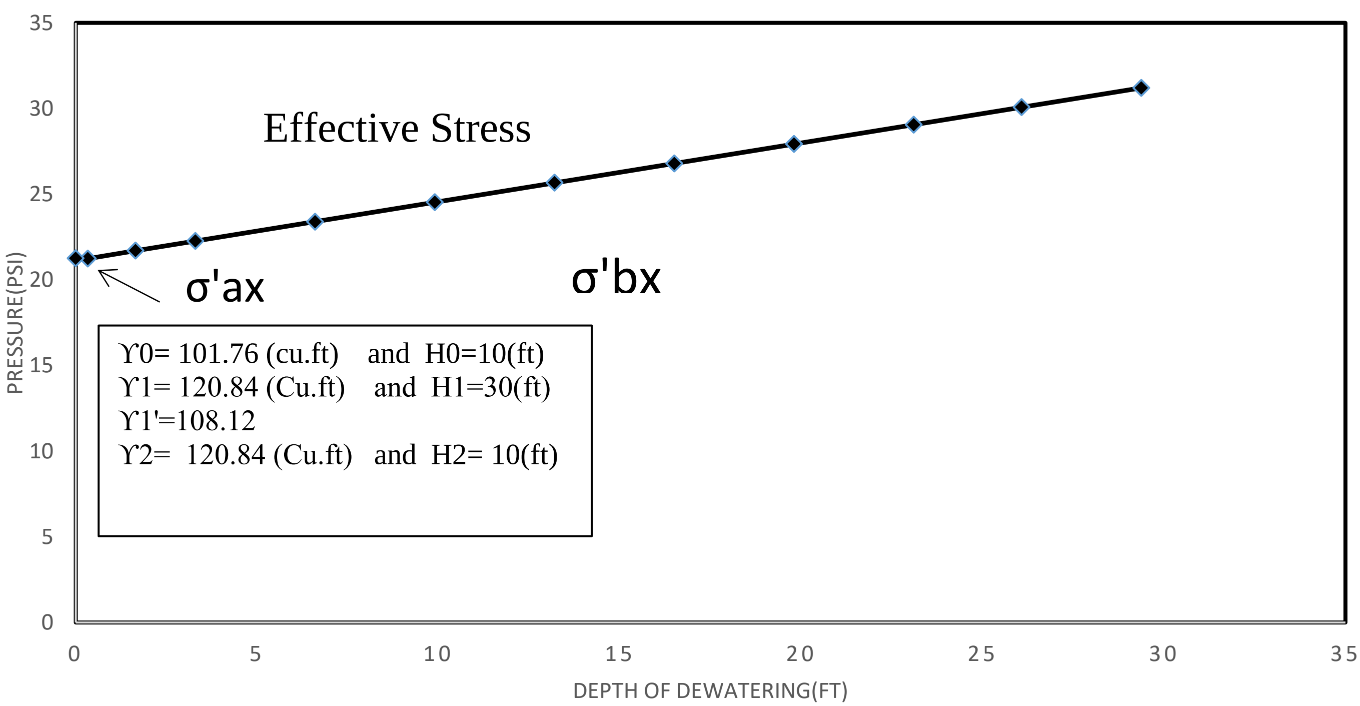

Figure 4-Change in effective stress due to water drawdown.

As water is pumped for the soil, the pore pressure decreases over the influence of drawdown and effective stress is increased due to reduction of water pressure. This reduction in pore pressure and increased effective stress in soil over the drawdown depth causes settlement in soil.

Table 1 Compression Index value from literatures.

	Equation	Soil Type	References
C1	Cc=.54(eo-.35)	All clays	Nishida (1956)
C2	*Cc=.29(eo-.27)*	Inorganic, cohesive soil silt some clay; silty clay; clay	Hough (1957)
C3	Cc=.35(eo-.5)	Organic, fine-grained soil, organic silt, little clay	Hough (1957)
C4	Cc=.43(eo-.25)	Brazilian clay	Cozzolino (1961)
C5	Cc=.75(eo-.5)	Soils with low plasticity	Sowers (1970)
C6	Cc=.289(Avg)	Houston Clays	Vipulanandan(2008) [7]
	e0= Void Ratio and Cc= Compression Index		

In this study, C6 was chosen for computing the settlement of the soil. The e_0 value chosen for the CH soil was 1.3 and 1.7 and for CL soil was 1.1 and 1.9. Using the C2 equation the e0 values were calculated and used in the settlement equation.

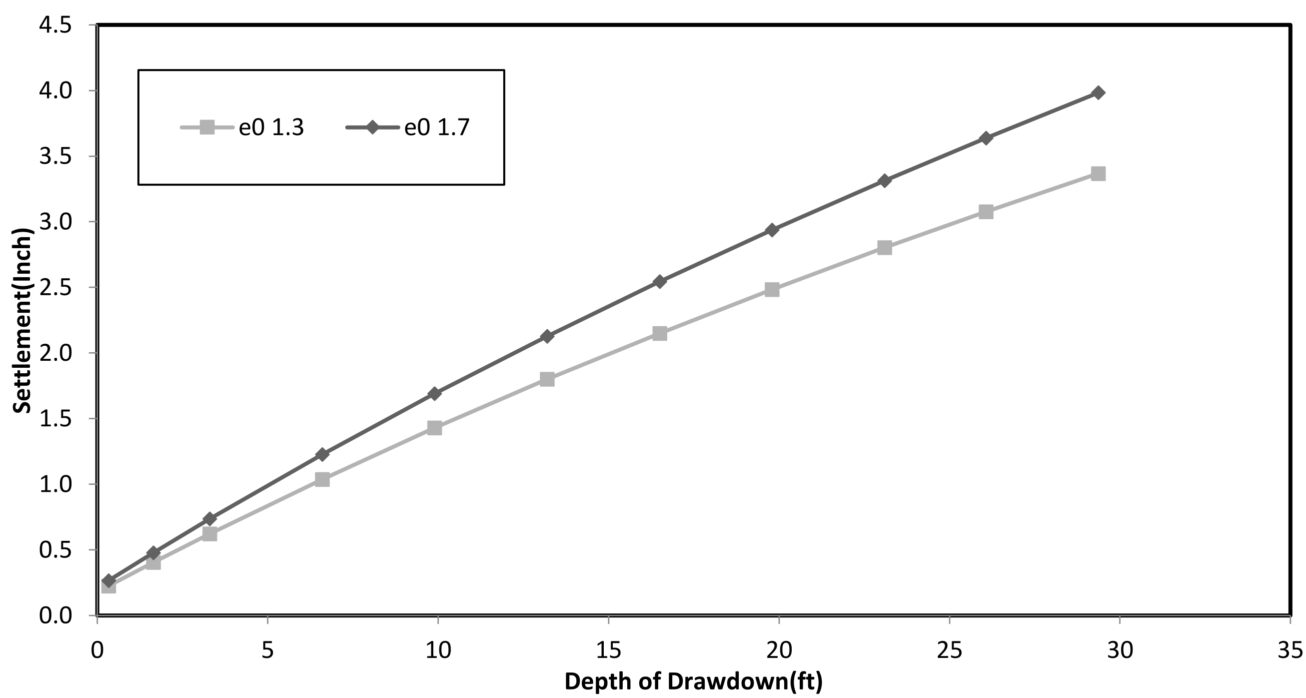

Figure 5 –Drawdown causing settlement after 100 days of pumping at 12l/s in CH soil.

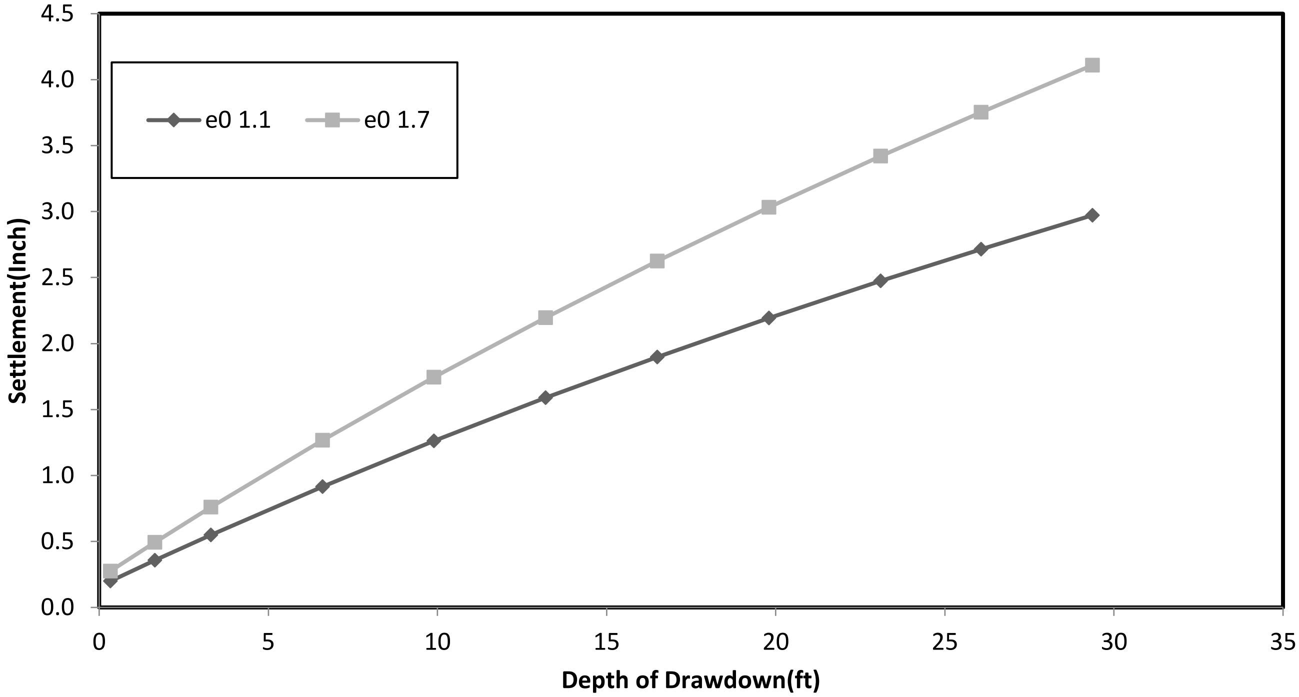

Figure 6 –Drawdown causing settlement after 100 days of pumping at 12l/s in CL soil.

The maximum settlement observed for CH soil is 3.37 inches when the drawdown is 30 ft. In case of CL soil, the maximum settlement observed is 2.97 inches when the drawdown depth is 30ft.

5. Conclusion: Long term settlement of soil can be predicted by using equation (6). The Cc parameter needs to be changed as per index property of clay soil to get the estimated settlement of soil due to dewatering.

6. Acknowledgments:

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7. References

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