Advanced Soil Mechanics
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Lecture – 24
Overall Pore Water Pressure Parameter

Welcome all, so this is the continuation of our previous lecture which is on pore water pressure parameters. We have already seen Skempton's pore water pressure parameter which corresponds to triaxial condition. In this lecture we will see a different way of presenting the pore water pressure parameter and what is known as overall pore pressure parameter B.

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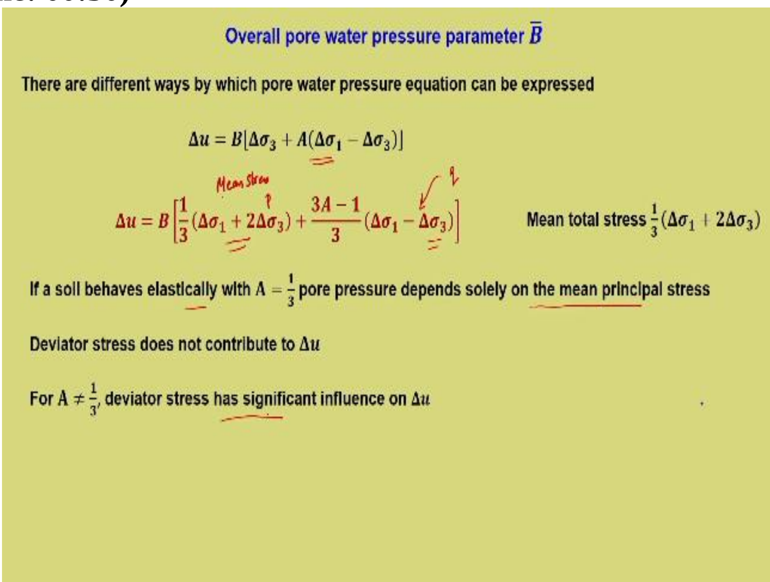

So we will start with the lecture which is overall pore water pressure parameter $\bar{B}$. There are different ways by which pore water pressure equation can be expressed. Now before going to $\bar{B}$ we will see a typical representation of pore water pressure equation this expression of Δu

$$\Delta u = B[\Delta\sigma_3 + \mathrm{A}(\Delta\sigma_1 - \Delta\sigma_3)]$$

is what we have already seen, and understood. Δu expression can also be written in this manner where

$$\Delta u = B\left[\frac{1}{3}(\Delta\sigma_1 + 2\Delta\sigma_3) + \frac{3A-1}{3}(\Delta\sigma_1 - \Delta\sigma_3)\right] \qquad \frac{1}{3}(\Delta\sigma_1 + 2\Delta\sigma_3)$$

This expression $(\Delta\sigma_1 - \Delta\sigma_3)$ we all know it is deviator a stress q which we have seen in the previous lecture. And what is this expression? $\frac{1}{3}(\Delta\sigma_1 + 2\Delta\sigma_3)$ this is nothing but mean stress for triaxial condition. So, the Skempton pore pressure equation can be rewritten in this manner to express it in terms of mean stress and deviator stress.

Now if soil behaves elastically we know that $A = \frac{1}{3}$. So, if you substitute it in $\frac{3A-1}{3}$ then the term $\frac{3A-1}{3}(\Delta\sigma_1 - \Delta\sigma_3)$ becomes 0. So, pore pressure depends solely on the main principle stress only in those circumstances where the soil behaves elastically, deviator stress is not there is no contribution from deviator stress. Now, for all those conditions where $A \neq \frac{1}{3}$deviator stress has significant influence on Δu.

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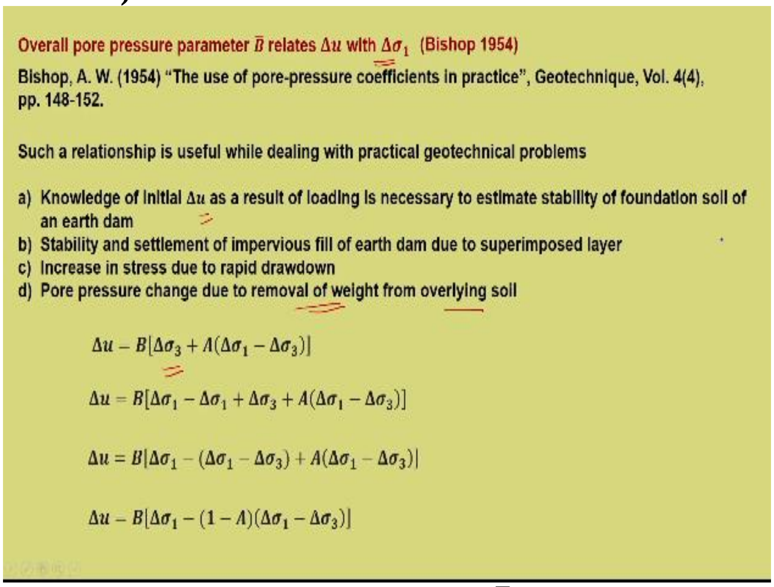

Now, let us see what is overall pore pressure parameter $\bar{B}$ which relates Δu with only $\Delta\sigma_1$. $\Delta\sigma_1$ is normally considered in terms of loading. So, what is the total stress which is acting because of some load external load acting on the soil. So, Bishop in 1954; in this again a classical paper which deals with pore pressure coefficients the use of pore pressure coefficients in practice which is published in geotechnique.

The relationship this $\bar{B}$ this relationship is useful while dealing with practical geotechnical problems. Knowledge of initial Δu as a result of loading is necessary to estimate the stability of foundation soil of an earth dam maybe for drained condition after a pretty long time, what will be the kind of state of the soil for that we need to know what will be the kind of pore depression that gets developed due to loading which is very essential for situations like foundation of soil often earth dam.

Stability and settlement of impervious fill of earth dam due to superimposed layer in staged construction. Increase in stress due to rapid drawdown it is not only that you are adding water to it but when there is immediate release of water from the soil, the effective stress increases. Now, due to this effective stress increase there will be a kind of settlement, so that issue is relevant with rapid drawdown. Now pressure change due to removal of weight from overlying soil.

So, what will be the pore pressure change due to release that is we are removing the weight. So, what happens during that time to pore pressure again we start with the same equation Skempton equation we are doing against some mathematical rearrangement

$$\Delta u = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$$

$$\Delta u = B[\Delta\sigma_3 + \Delta\sigma_1 - \Delta\sigma_1 + A(\Delta\sigma_1 - \Delta\sigma_3)]$$

$$\Delta u = B[\Delta\sigma_1 - (\Delta\sigma_1 - \Delta\sigma_3) + A(\Delta\sigma_1 - \Delta\sigma_3)]$$

$$\Delta u = B[\Delta\sigma_1 - (1 - A)\,(\Delta\sigma_1 - \Delta\sigma_3)]$$

$$\Delta u = B\Delta\sigma_1[1 - (1 - A)\,(1 - \frac{\Delta\sigma_3}{\Delta\sigma_1})]$$

$$\frac{\Delta u}{\Delta\sigma_1} = B\,[1 - (1 - A)\,(1 - \frac{\Delta\sigma_3}{\Delta\sigma_1})]$$

$$\bar{B} = B\,[1 - (1 - A)\,(1 - \frac{\Delta\sigma_3}{\Delta\sigma_1})]$$

Now, $\frac{\Delta u}{\Delta\sigma_1}$ is a function of $\bar{B}$. So once you know $\bar{B}$ we can always calculate what will happen to Δu as a function of $\Delta\sigma_1$.

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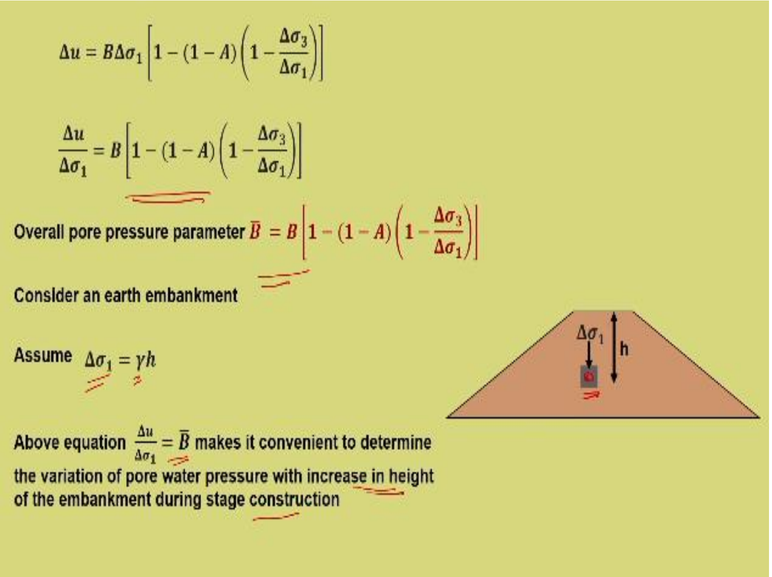

For that to explain this, let us take an example of an earth embankment which is shown here. Now, there is a soil element here which is at a depth of h. So, assume this $\Delta\sigma_1$ it is not assume delta sigma is very much equal to gamma integration where gamma is the unit weight of soil.

Now, what we are assuming is that for about equation $\frac{\Delta u}{\Delta\sigma_1} = \bar{B}$ makes it convenient to determine the variation of pore water pressure with increase in height of the embankment during stage construction. Now, what we are assuming is that the entire loading and the influence that is happening at this particular point is due to the major principle stress $\Delta\sigma_1$.

So, $\Delta\sigma_1$ so, whatever is the change that is happening at this point is entirely due to its geostatic stress which is γ_h. And that is true also because there is no load acting whatever is the superimposed load which is acting at this particular point that can be assumed as the major principle stress $\Delta\sigma_1$ which means to say any kind of loading is represented here in terms of $\Delta\sigma_1$.

So, this assumption is important because then only you can determine the pore pressure as a function of $\Delta\sigma_1$. So, we are concerned about other principle stresses here we are correlating or we are assuming whatever stress change happens that is $\Delta\sigma_1$ only. So, once we know that then the above equation, it makes it very convenient to determine the variation of border pressure happening with loading. Loading means increase in height of the embankment during stage construction.

So that is the beauty of this particular equation pore pressure at any instant of loading that means staged construction can be determined.

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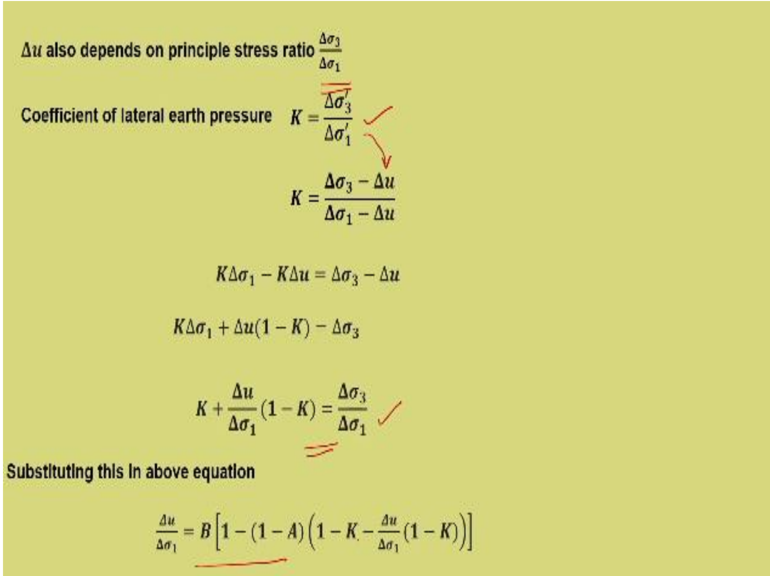

Now but we have seen that in this particular equation Δu also is a function of stress ratio $\frac{\Delta\sigma_3}{\Delta\sigma_1}$ so that also becomes important so, Δu also depends upon the principle stress ratio. Now we know coefficient of lateral earth pressure K is equal to $\frac{\Delta\sigma'_3}{\Delta\sigma'_1}$ so, this is known to us. So K is equal to $\frac{\Delta\sigma_3 - \Delta u}{\Delta\sigma_1 - \Delta u}$ you are just transferring the store total stress condition.

$$K\Delta\sigma_1 - K\Delta u = \Delta\sigma_3 - \Delta u$$

$$K\,\Delta\sigma_1 + \Delta u(1-K) = \Delta\sigma_3$$

$$K + \frac{\Delta u}{\Delta\sigma_1}(1-K) = \frac{\Delta\sigma_3}{\Delta\sigma_1}$$

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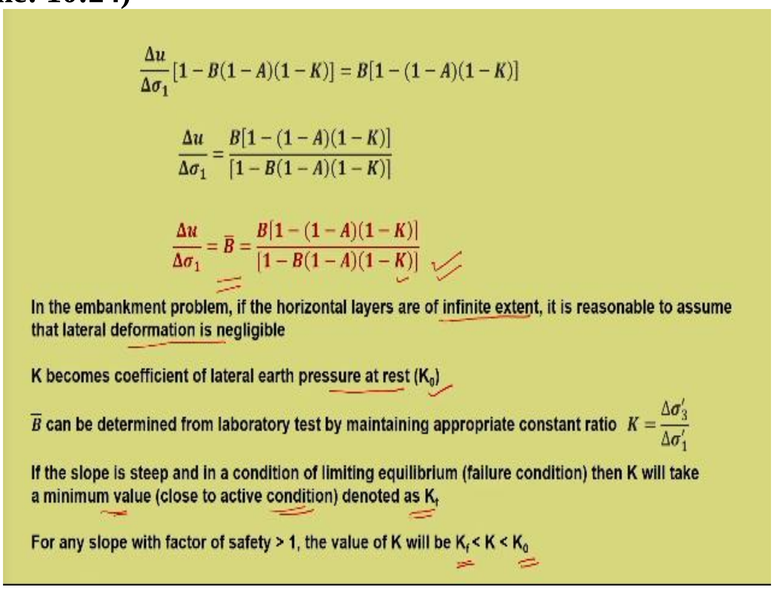

So, if you substitute this for $\frac{\Delta\sigma_3}{\Delta\sigma_1}$. The equation takes the forms like this

$$\frac{\Delta u}{\Delta\sigma_1} = B\,[1-(1-A)\,(1-K+\frac{\Delta u}{\Delta\sigma_1}(1-K))]$$

$$\frac{\Delta u}{\Delta\sigma_1}[B\ - \mathrm{B}(1-A)1-\mathrm{K})]=[(1\text{-K})(1-\mathrm{A})\frac{\Delta \mathrm{U}}{\Delta\sigma_1})]$$

$$\frac{\Delta U}{\Delta\sigma_1} = \frac{\mathrm{B}\ [1-(1-\mathrm{A})\,(1-\mathrm{K})]}{[1-\mathrm{B}(1-\mathrm{A})\,(1-\mathrm{K})]}$$

$$\bar{B} = \frac{\mathrm{B}\ [1-(1-\mathrm{A})\,(1-\mathrm{K})]}{[1-\mathrm{B}(1-\mathrm{A})\,(1-\mathrm{K})]}$$

So, again it is the same overall pore pressure parameter but in a different form in terms of coefficient of lateral pressure.

So, in the embankment problem if the horizontal layers are of infinite extent it is reasonable to assume that the lateral deformation is negligible. If the lateral deformation is negligible, then we can always say this coefficient of earth pressure K is equal to coefficient of lateral earth pressure at rest which is K_o and $\bar{B}$ can be determined from laboratory test by maintaining the appropriate constant ratio $K = \frac{\Delta\sigma_3'}{\Delta\sigma_1'}$ which basically simulates the field condition.

So, one thing is if it is of infinite extent then it can be treated as $K_o$or any other value of K which resembles the field condition. Now if the slope is steep and in a condition of limit equilibrium that is almost the failure condition then K will take a minimum value and which is close to active condition which is denoted as K_f so that K_f can also be simulated. Now, for any slope with factor of safety which is greater than one which is not at failure K value will be in between these 2 bounds that is in between K_f and K_o.

So once we know the appropriate K value that can be determined put into this particular equation and that gives us what will be the pore pressure for any change in loading.

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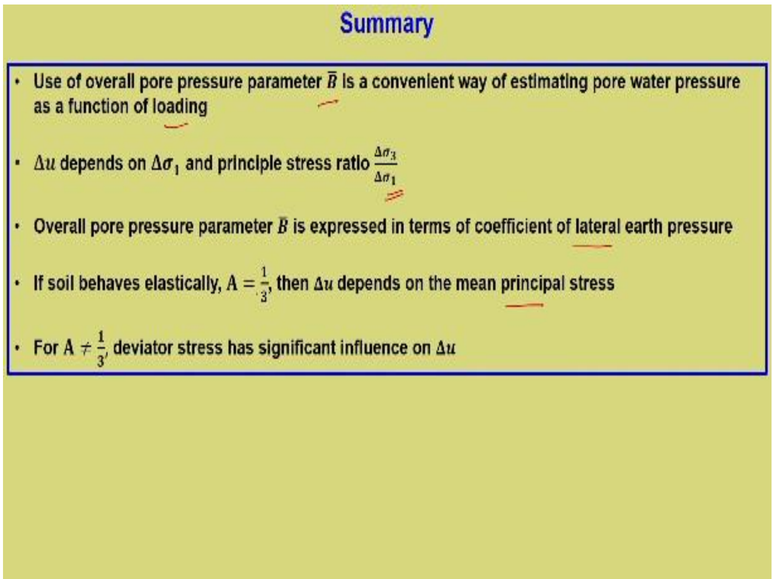

So the summary of overall pore pressure parameter is the use of this parameter $\bar{B}$ is a convenient way of estimating pore pressure as a function of loading in a practical situation. Δu depends on $\Delta\sigma_1$ and the principle stress ratio delta sigma 3 upon $\Delta\sigma_1$. $\bar{B}$ is expressed in terms of coefficient of lateral earth pressure which comes from this. If soil behaves elastically $A = \frac{1}{3}$ then Δu will depend only on the main principles stress.

For $A \neq \frac{1}{3}$ then deviator stress part has a significant influence on Δu. So that is all for today is discussion on pore water pressure. There is one more section left to be discussed in this which we will see in the next lecture. Thank you.