Advanced Soil Mechanics
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Lecture – 26
Pore Water Pressure Estimation

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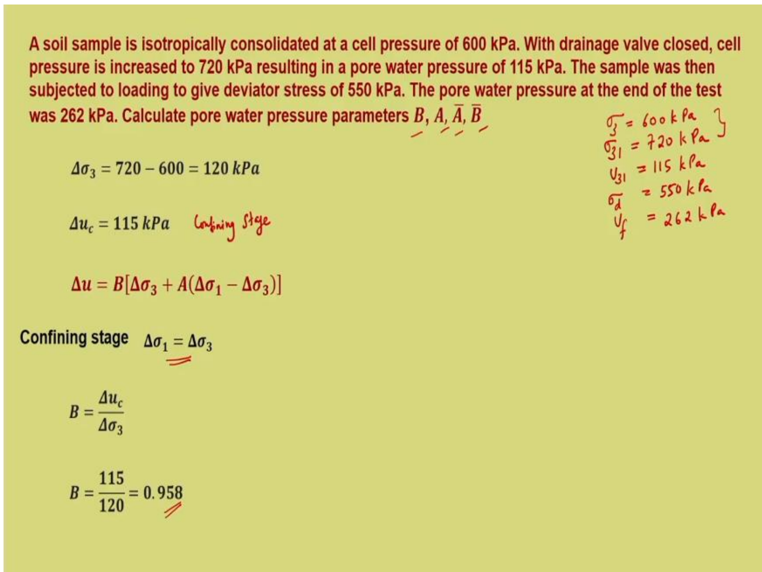

In this lecture, we will try to work out a problem related to water pressure equation. So here the; problem given us a soil is isotropically consolidated at a cell pressure of 600 kPa. So there is cell pressure of $\sigma_3 = 600$ kPa please notes that it is consolidated. So if it is consolidated there will be no pore water pressure, pore water pressure will be equal to 0 we will understand this when we discuss more about the triaxial testing which we will see in the next lecture.

With drainage valve closed, now we have closed the drainage cell pressure is increased to 720 kPa in a pore water pressure and resulting in a pore water pressure of 115 kPa please remember the soil is close to saturation. So there will be changes in pore water pressure and hence after the drainage valve was closed when you increase the cell pressure to 720 kPa's. So then σ_{31} that is the next stage it is 720 kPa.

And this results in pore water pressure $u_{31} = 115$ kPa the sample was then subjected to loading. So without opening the drainage valve the soil is subjected to loading to give a deviator stress of

550 kPa's. So deviator stress $\sigma_d = 550\ kPa$, what is deviator stress? The stress in addition to σ_3 that is deviator stress which is applied axially the pore water pressure at the end of the test was 262 it is a total pore pressure at the end of the test.

So $u_f = 262\ kPa$ please make a note here you need to understand the question very carefully we need to know whether the pore water pressure is in excess of the confining or right from the beginning to the end. So here there is no mention and this clear that pore water pressure at the end of the test means pore water pressure it is total pore water pressure that has accumulated, cumulative pore water pressure or in the soil sample.

So we are asked to determine the pore water pressure parameters B, A, $\bar{A}$ and $\bar{B}$ and this is what we do actually in the laboratory for a given situation or for a given soil at a given depth we will find out using triaxial testing what is it pore water pressure parameters, this pore water pressure parameter values can be used for any other numerical modeling or whatever. So this value can be input.

And when I say parameters mostly I am associating it to the parameter A because B if it is saturated we know it is 1 or depending upon the partial saturation we will know what the value is. So here change in confining stress $\Delta\sigma_3 = 720 - 600$ that is what it is here it is equal to 120 kPa and change in pore water pressure for the confining stage please note this is confining stage is 115 kPa because initially it was 0. Now we can use the pore water pressure equation

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

Now please make a note here nothing has been told about the saturation of the soil samples. So we cannot really assume B = 1 we need to determine it and we have whatever $\Delta\sigma_3$is there and $\Delta\sigma_1 = \Delta\sigma_3$ in the confining stage. So first let us see the confining stage and this condition we know.

So $B = \frac{\Delta u_c}{\Delta\sigma_3}$ and both are known. So substituting $B = \frac{115}{120}$ will get B = 0.958 which is very close to saturation but not equal to 1 and practically in the lab it is difficult to obtain the value 1 it will be close to 1 maybe something from varying from 0.9 of words is all expected for depending upon the type of clays the odd maybe if it is silty, so as it becomes more and more clay it is difficult to achieve B = 1. So anything around close to 1 is considered to be saturated.

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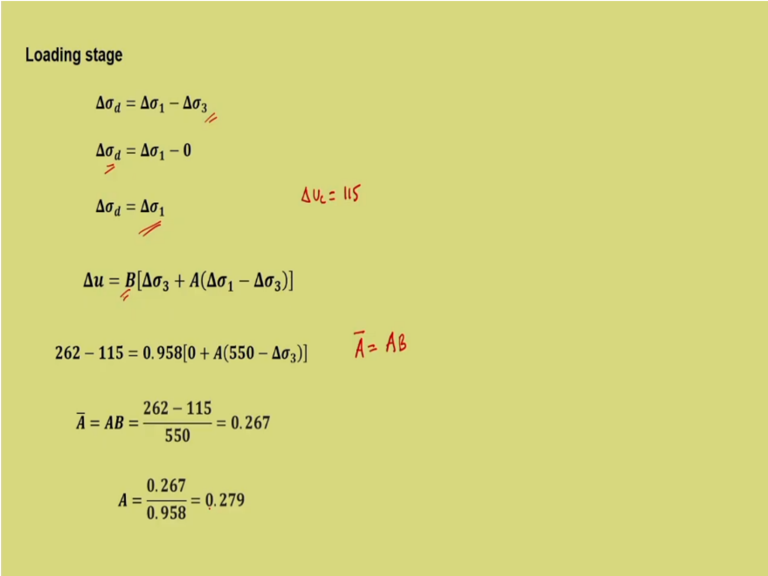

Next is the loading stage. So we have determined B so that B value we have to use B $\neq$ 1 here, $\Delta\sigma_d$ is equal to now this is the loading stage. So we have $\Delta\sigma_d = \Delta\sigma_1 - \Delta\sigma_3$ here $\Delta\sigma_3$ in the loading stage is 0. So because during the application of deviatoric stress there is no change in the confinement it remains same. So $\Delta\sigma_3 = 0$ that gives $\Delta\sigma_d = \Delta\sigma_1$.

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

$$\bar{A} = AB = \frac{262 - 115}{550} = 0.267$$

Again substituting it back we know the value of B $\Delta\sigma_3$ is 0. So that will give $\Delta u = 262 - 115$ please make a note here we are considering only loading states, so we cannot take the cumulative pore water pressure. So we need to detect the confining stage pore water pressure. Now 115 is $\Delta u_c = 115$. So we are trying to minus this from the total pore water pressure, so that you get the pore water pressure corresponding to the deviator stress application

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

$$262 - 115 = 0.958[0 + A(550 - \Delta\sigma_3)].$$

Because whatever is the change in deviator stress that is equal to $\Delta\sigma_1$ so that we have seen here $550 - \Delta\sigma_3$ which is nothing but 0. So here it will be B into A first that is A bar we have seen we already know that A bar = A into B. So here B into A that is $\bar{A}$ that is equal to

$$\bar{A} = AB = \frac{262 - 115}{550} = 0.267$$

And please remember this is due to the understanding that $\Delta\sigma_3 = 0 \; and \; \Delta\sigma_d = \Delta\sigma_1$. So $\bar{A} = 0.267$; so A can be found out by dividing it by B which is equal to

$$A = \frac{0.267}{0.958} = 0.279$$

So we have determined B, Ā A what is left is $\bar{B}$.

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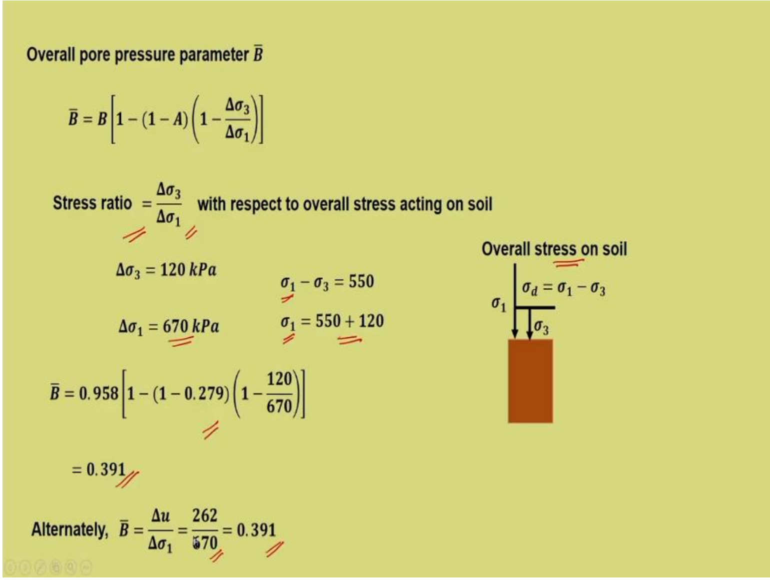

Overall pore pressure parameter $\bar{B}$:

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

This is the stress ratio $\left(\frac{\Delta\sigma_3}{\Delta\sigma_1}\right)$. Now here please do not go by just like that fast stress ratio stress ratio indicates what is the ratio between the total the vertical stress that is major principle stress by or it is between $\frac{\Delta\sigma_3}{\Delta\sigma_1}$. So it is minor principle stress upon major principle stress.

So do not go by delta here because it is the overall stress applied on to the soil in the previous slide we have seen $\Delta\sigma_d = \Delta\sigma_1$ that is only for that deviatoric stress change that is for the loading stage here the stress ratio corresponds to the overall stress that is applied during the whole course of the test. So here we will have σ_3 and σ_1. So what is σ_3? σ_3 is 120 kPa because that is what has been applied.

And σ_1 = 670 kPa in the previous slide it was $\Delta\sigma_1 = \Delta\sigma_d$. So that is why it was 550 here it is the overall stress that is acting which is 670. So that is which comes from here, from the figure representing the forces on the soil element, so σ_3 is there on the soil sample and seen $\sigma_d = \sigma_1 - \sigma_3$. So $\sigma_1 = \sigma_d - \sigma_3$. So that is the overall stress acting on the soil which is used for determining the stress ratio.

So $\sigma_1 - \sigma_3 = 550$, so $\sigma_1 = 550 + 120 = 670$ so I have just forgotten the delta for the time being just for you to understand that it is the overall stress which is acting on the soil sample. So here it is $\Delta\sigma_1 = 670$ which comes from here. So substituting this we will get

$$\bar{B} = 0.958[1 - (1 - 0.279)(1 - \left(\frac{120}{670}\right)]$$

So, $\bar{B} = 0.391$. Alternately you can also determine

$$\bar{B} = \frac{\Delta u}{\Delta\sigma_1} = \frac{262}{670} = 0.391$$

So that is the cumulative change in pore water pressure. So in the previous slide we have splitted it into confining and loading stage but overall pore pressure parameter we will consider the overall pore pressure change which is equal to 262 upon the $\Delta\sigma_1$ here is the total $\Delta\sigma_1$ which is equal to 670. So that will also give the same result 0.391. So either of these equations we can use. So that is all related to pore water pressure equations and it is estimation.

So, this problem we have discussed just to give you a feel of how the estimation of pore water pressure happens and how this can be used further please make a note that this information is very important when you deal with module 3 and module 4. So before going to module 3 and module 4 please revise these portions properly, so that we can use these information in the subsequent modules.

So, we have now completed the discussion on pore water pressure. And in the next lecture onwards we will see the shear stress of soil very specifically which will be more like a bit of reputation from your undergraduate portion but with more interpretation. So that is all for now and we will see in the next lecture. Thank you.