Geotechnical Engineering - II

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Lecture No. 43

Braced Sheet Pile Walls

So, let us talk about some other pressure distributions on the Braced Sheet Pile Wall given by different researchers. So, the first one is sands and we have already discussed about one of the pressure diagrams, which was given by Terzaghi and Peck and this is for dense sands. For loose sands, the pressure diagram looks like this. This is 0.2H, 0.8H and this axis remains same as 0.8 K_a into γ H. This is for loose sands, Terzaghi and Peck.

There is another pressure diagram which has been proposed by Tschebotarioff. These are all empirical pressure diagrams. This is 0.1H, 0.2H, 0.7H and this is 0.8 K_a into γ H. The name of the person who assess with this pressure is Tschebotarioff . This is for sands. And for clays, so, this one is the dense sands.

For clays the pressure diagram is 0.3H, 0.55H and 0.15H and this is (γH- 4c). This is again given by Terzaghi and Peck. However, the pressure distribution given by Tschebotarioff for clays is 0.6H. This is 0.4H. So, this is the pressure diagram. 0.3γH, 0.2γH. This is for temporary support in its stiff clays.

And for permanent support in medium clays these values are 0.75H, 0.25H. This is 0.375H into γ and the whole thing is 0.5Hγ. So, these are the pressure diagrams which have been proposed by different researchers who have worked on this topic. So, hope you can analyze these problems quite easily. The deep cuts which require support are supported by sheet piles and further by installing braces and struts. And then you are supposed to find out the cross section of these braces and struts for that the force is required for the moment you know the force, you know the stresses, you can select the right cross section of the element.

The pressure diagrams are assumed which are known or assumed, superimposed on these structures go for the equivalent beam method and analyse them. So, with this I will finish my discussion on the application of shear strength theory, another application of shear strength theory. Yes, which is the analysis of retaining structures. And the last sub-topic which I would like to discuss would be the slurry trenches. How slurries are used to stabilize the cuts or the trenches which are made particularly in offshore regions.

Particularly wherever you have the soft clays or for geo-environmental applications where you are having the storage of let us say different types of chemicals or different types of industrial sludges, bio-solids and so on. These, I would like to show you a video on how the slurry trenches are being executed in the real-life.

These are also known as soil-bentonite walls. And here you can see a cut is being created or a trench is being created by excavation. And the point is how I am going to stabilize this trench. So, in the background you can see the trench which has been created and this is a thick slurry which could be of bentonite.

Remember we have talked about bentonite slurry being used for stabilization of the cuts. These are mostly used for geo-environmental applications. So, look at this, the way trench has been created and then if you want to stabilize this trench, you have to fill this trench with the slurry of the bentonite.

So, a fluid which is denser than the soil. Applications of this type of development would be let’s say a landfill. If I want to isolate them from the environment so, that the leeches do not come into the nearby area. You create trenches and then fill them up with slurries of bentonite.

Those of you who are interested can watch a few more videos which are available on the YouTube.

So, depending upon the situation, there is another good video of slurry wall. Create a trench by cleaning it. This is the excavation going on. Sometimes they also call them as a cutoff walls.

I can fill on this trench with the cement slurry also. If I want to create a system which is highly impervious or bentonite slurry can also do so, bentonite slurry just for stabilization purpose.

And if you want to create a completely impervious wall which is embedded inside the ground, then in that case is cement slurry, lean concrete can be, or a fly ash mixed with the soil like soil creak can be pumped in. And what we would like to do is, we like to analyse this type of situations that up to what height of the cut of bentonite can be used for stabilizing the cut. This for pumping the slurry. This is the slurry. So, there are several videos of this sort which you can have a look at. Let us come back to the analysis part.

So, suppose we are creating trenches in soils, and we want to stabilize them the way it was shown in the video. So, there are two categories of the problems. One is in trenches in clays and the second one is trenches in sands. So, the statement of the problem is like this. If this is a trench which I have created in a clayey soil of height H, up to what height I should be filling the slurry unit weight of s is the unit weight of a slurry. This becomes H_1. For the maximum possible production what we can do is H_1 can be equal to H also depends upon how much the factor of safety you require against the failure and this situation I like to analyze.

So, you can use again the concept of the trial wedge. The weight is known. The normal stress can be obtained, and this is the shear stress. Pure cohesive material. So, what is this angle? This will be 45°. Now, you can resolve the forces and you can obtain the factor of safety. So, τ is basically C_u undrained cohesion of the soil mass, what are the force coming as far as stabilization is concerned. The force is coming in the form of because this is slurry. So, I can assume that this is the pressure which is imparted which is exerted by the slurry or P only.

So, this is the force diagram. Now, can you show that the factor of safety for this type of a system will be equal to or would be a function of C_u, γ of the soil and γ_s of the slurry and what else, H height of the trench and H_1. So, these are the parameters which can be utilized for designing the whole thing. So, for the sake of simplicity we are doing H_1=H and then can you apply your common sense to find out what will be the factor of safety for this type of the system? This upon (γ_s- γ) into H. True.

$$FS = f(C_u, \gamma, \gamma_s, H, H_1) = \frac{4C_u}{(\gamma - \gamma_s)H}$$

How will you obtain this? Just equilibrate the forces and take the components. So, you have the P_{slurry}, T component, N is not required, N can be eliminated and then another equation comes in the form of W and τ. So, this is the factor of safety of the system when you are going for a slurry trench. I have done a mistake here. This should be γ-γ_s because γ is the unit weight of the soil and γ_s is the slurry. So, γ_s cannot be more than the unit weight of the soil. Thank you.

Now, C_u can be obtained. I know the value of the unit weight of the slurry. The γ is known. So, this is the factor of safety against the failure. So, how will you read this? The more the cohesion factor of safety is more. More the height of the cut or height of the trench, factor of safety is going to be less.

So, truly speaking for the critical situation or the limiting situation this value is equal to 1. So, what we are getting is 4 times C_u equal to (γ- γ_s) into H. This 4 times C_u is an offshoot of 2c, what is 2c? The earth pleasure which is coming in cohesion case. ($K_a\gamma H$-2c$\sqrt{K_a}$). $\sqrt{K_a}$ equal to 1. So, this becomes minus 2c that term is coming over here. Now, this becomes the limiting condition which you will obtain by analysing the free body diagram of this system. Let us try this. This concept can also be extended to the sands. How will you do that?

In case of sands, I will assume that this angle is θ. Rest of the things are same, and this is going to be equal to 45+α/2 let us say because ϕ is not known or ϕ is known. So, ϕ is known, so, we will assume this as ϕ. Now, what I want to do? I want to again compute the factor of safety for a situation when I am retaining sands. So, if you use the same concept of a free body diagram, what I should be getting as factor of safety? 2 times γ into γ_s root of this upon γ minus γ_s into what term, this is something interesting to remember.

$$FS = \frac{2(\gamma.\gamma_s)^{0.5}}{\gamma - \gamma_s}.\tan\phi$$

Say, tanϕ, what is the significance of this, factor safety is equal to 1 that is what is being obtained by this term the deviation of the slurry from the soil mass and then friction angle is the friction angle of the material, so this becomes the sort of penalty term on the friction angle of the soil mass. Try to work it out. These are interesting problems. We know the W. We know the pressure which is coming from the slurry. So, W upon P_f is a sort of a tan(45+θ) term. Yes, and tanα and tanϕ by tanα itself is the type of safety term.

So, these are the good examples of how the simple concepts can be applied to obtain the solution to the most critical but practical problems which we are facing. So, we have discussed a lot of things, particularly related to the application of shear strength theory in the form of earth pressures. These are all applications of the earth pressures which are acting on the system and earth pressure itself is an application of shear strength parameters.

So, interestingly what we have done in this course, so, far is spent enough time in understanding how to obtain the shear strength parameter or the characteristics of the soil mass. We have defined the state of stress in the soil. Using that concept and the shear strength parameters we have obtained the earth pressure which are acting on a system and then we discussed about so many applications.

Rigid earth retaining structures, flexible retaining structures like sheet pile walls and then within the sheet pile walls we have talked about the cantilever sheet piles, we have talked about the bulkheads, we talked about the trenches, bracings, struts and then at the end, how to use slurry to stabilize the trenches. So, with this I am going to close the discussion on earth pressure theory. Thank you.