Geotechnical Engineering - II

Professor D. N. Singh

Department of Civil Engineering

Indian Institute of Technology, Bombay

Lecture No. 38

Sheet Pile Wall Introduction- III

So, now moving on to what type of structures which can be created by using sheet piles. So, the first structure which we will create is a cantilever sheet pile. Because as I described earlier most of these piles are acting like a cantilever, this is the anchorage, and this is the free portion. So, how this looks like as we discussed earlier you take an element of the soil, element of the sheet pile inserts it into the soil. This is the ground surface, and this becomes the, we call it as a dredged level.

Because most of the time sheet piles will be inserted into the existing ground by removing this portion of the soil, so, this becomes the dredged level. This is the ground surface, and this is the dredged or excavated. So, this is a simple cantilever sheet pile. You are retaining a backfill by using a sheet pile. As I said these systems are not for permanent construction, this is just for temporary constructions up to a limited height.

I can complicate the stability problem by introducing the concept of seepage here, which you studied in soil mechanics first course where we studied seepage into the porous media separately. Got this point? So, suppose if I say this is the water table now, what is going to happen? The concept of seepage will come in the picture. These are flow lines this you have studied already and then you can do the equipotential lines also.

So, basically now, you are realizing that what we are doing we are heading towards totality of the situation and the problem. So, immediately a simple problem which was basically a soil-structure interaction has been converted into a soil-structure-water interaction problem. So, we did not want to worry much. What water is going to do? It is going to cause pressure on this sheet pile, clear. We know the pore pressures and each and every point of the sheet pile. We can compute the pore pressure in the form of force. We can include that in this stability analysis as the force component.

You remember another problem which we had done in Geotechnical Engineering- I. There is a ground surface, and the question was how deep I can go without the soil mass caves in. So, you have the sheet pile assembly and then I will do sequential excavation. So, this is gone, this is gone, and the question is how deep I can go so that this is the water table, water table could be different on either side.

So, that the soil here does not cave in. So, we use the concept of effective stresses over here. Remember. We computed the pore water pressures by using the flow nets and the moment you have pore water pressure you can find out the effective stresses and the moment effective stress tends to 0, that is the limiting conditions required for D.

That means, this problem becomes a very interesting problem D is going to be a function of how many parameters. The porosity which is inclusive of void ratio, RD of the soil, γ_d of the soil, the type of the soil, hydraulic head, hydraulic gradient, Δh which is going to cause the instability in the trench correct and length of the flow path. Apart from this anything else.

Now, if you analyse this system in totality, we have to talk about the pressures which are going to act on this. So, that means, now, this problem becomes this depth of excavation plus d. So, I have one more unknown coming over here which is in the form of d where d is the depth of embedment. So, so far, we had analysed this system for seepage induced instability without taking into account the earth pressures which are coming on the system.

Now, we are doing both together. So, we have to use another term as factor safety. For the first time I am introducing this concept and before this we just talked about factor safety when we were discussing the Mohr-Coulomb envelope that how to define the factor of safety associated with the material in terms of shear strength. You can play with this function, and you can solve this. A lot of things have been conveyed in one figure. But now I am realizing I am sure you must be realizing that from theory we are talking about the practice.

Now, look at this how these problems can be amplified or amplified in the sense, suppose if height of retention is more, I am not very happy with whatever H I have created or if height of retention happens to be more than 5 to 7 meters, what I should be doing? The simple logic says put an anchor. So, this becomes an anchored bulkhead. So, this becomes the second type of the

sheet pile. Where what we do is? In this system we will introduce an anchor. So, this is what is known as an anchor or a tie rod and tie rod when connected to an anchor a system.

So, truly speaking this is not an anchor, this is an anchor rod or tie rod this is connected to an anchor, this is the anchor block. This becomes another interesting design problem. What should be the length of the tie rod from the free head at what depth I should be using this tie rod? What should the dimension of the anchor block? How many number of tie rods are required? And what should be their spacing? So, now we are realizing this becoming more intricate design problem.

So, in a 3d system, this is how it will look like, and this is the dredge level this is the ground surface, and all these tie rods are going to be like this of certain length and centre to centre spacing, s. You have done this type of analysis in structure analysis also. Purlins, trusses is it not? A design or purlins, correct? It is very similar now, this face is holding the earth pressure which is coming from left hand side and trying to deflect the ball on the right hand side. This is the problem statement.

So, a simple situation like this has been transformed to anchored bulkhead where these are the tie rods which have been used these tie rods could be made up of steel. these could be wires, or like this could be a wooden block, this could be a concrete block, this could be a steel rod or whatever. Sometimes when you see how this rock fall protection systems are being installed. Typical example is Bombay Pune Express Highway.

So, if this is the slope or a rock mass which is vulnerable to failure and by cutting you have made it let us say very steep. And now we want to stabilize it. So, the best way would be to create a trench over here and put a running anchor and then this anchor is holding the wire mesh and this wire mesh is this is what is known as high energy panels, and they are fitted with anchors or soil nails.

So, these blocks have very different applications. Basically, they provide anchorage to the entire thing. The self-weight of this system made up of steel itself is quite high. So, these anchor systems are very useful this is a similarity.

The third one could be a braced excavation. Struts, by using struts. So, we have the ground surface and then we are installing 2 piles excavate it. In another way what we have done is we are supporting the excavated slopes so that we can go much deeper and then install the struts over here. These are also known as bracings. These are known as bracings or struts, what is their job? Their job is first of all, if you would not have provided the sheet pile, the whole excavation would have caved in.

Now doing this excavation and providing these sheet piles you are stopping it but even if the depths are too high or the soils have different conditions of drainage or let us say type of material which you are retaining is still, they may cave in or they may fail. So, for added precaution, the more you go deeper they put struts.

The question is whether these are compression elements or tension elements? You have to think carefully check it out. I know many of you are very good structural engineers here. Draw the free body diagram and then you will get the answer. What this system is going to supposed to do? So, what is the answer?

These are all tension members it is a paradox. The soil mass along the wall is pushing this system. So, this system has to apply a tension to support that. So, all these are tension elements, they are not compression elements. So, this becomes a typical brace excavation we will be discussing a bit about this in Geotechnical Engineering- I.

Metros are mostly done by using this type of system, you might have to have struts if you go to a metro station the way it is being done, you are excavating out the soil cutting out the rock and then you want to support the walls of the rocks or the soil mass and there you require struts. This could be columns also many times you use the pillars and to support it.

Then there is another structure which is made up of sheet piles this is what I talked about the cofferdams. I have already discussed this, there could be cellular cofferdams also depending upon the requirement. I might be having a cofferdam over here, another cofferdam over here for the ease of construction. It is very difficult to seal the entire soil mass against seepage.

So, imagine if you are constructing this sheet piles, it is not so easy to avoid leakage of water and when leakage of water takes place or seepage takes place. I hope you can realize the fines

which are in the soil mass may also get washed out. These types of failures are very common in coastal regions.

And I have dealt with several cases where we are to show that the fines have washed out and hence the collapse of the cut. So, whatever structures standing over here if the cavity formation occurs the collapse may occur in the due course of time. So, if you want to avoid this type of situations, the first thing is you create either piles or the coffer dams and then connect them in this manner. It becomes a watertight compartment.

So, these are techniques which you need not worry about there are experts who can do this expert execution agencies which may give you a completely watertight system and hence no washing of the fines is going to take place.

There is another category which is known as diaphragms, diaphragm walls. These are very thin structures made up of sheet piles RCC also and the job is to avoid migration of fines. They also look like this. The diaphragm walls will look like this they are interconnected and so on. Made up of the sheet pile, temporary supports. So, anything which is very thin, and you want to retain it from diaphragm walls are being used in the practice.

So, in today's discussion, what I have done is I have given you a brief background about the sheet piles, their types, how to use them for construction purpose, different examples of what type of structures can be created and the philosophy behind using the sheet piles. From next lecture onwards, I will go into the analysis part of it. Watch more videos to understand how these systems are created. Thank you.