Application of Soil Mechanics
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Lecture – 02

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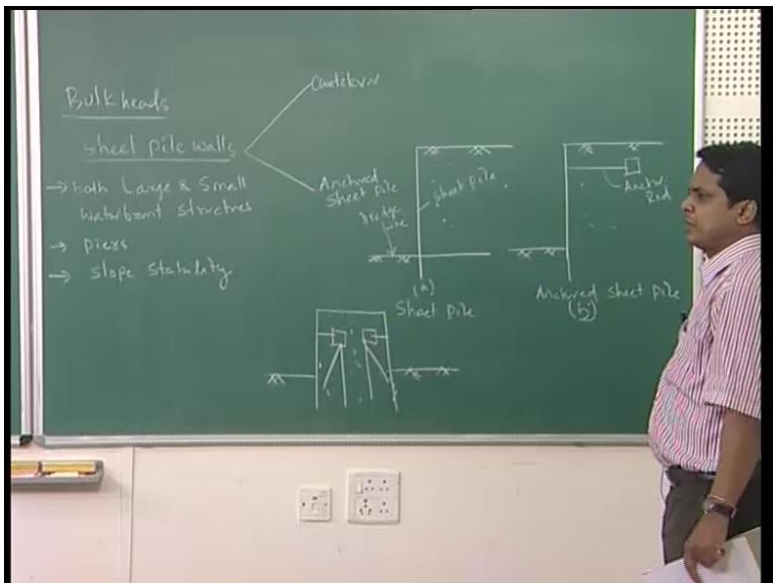

In this section, we will start with this bulkhead. It is nothing but your sheet pile walls, and last class I have finished this some of the sheet pile walls, but cantilever sheet pile wall. In this section, we will see detail classifications, and what is sheet pile wall. Case one sheet piling structure; then case two, anchor rod and this is your anchored sheet pile, this is your sheet pile. Case three will be, this is another example of anchored pile, sheet pile, anchored sheet pile, these are anchor rods. So, where the sheet piles has been used, as I said it is used for both large and small water front structures then it may be used piers, then it may be used for slope stability.

Now if you look at this sheet pile walls, this is basically two types of sheet pile walls; one is your cantilever sheet pile, another is your anchored sheet pile. Sheet pile has been basically classified into two components; one is your cantilevered sheet pile, another is your anchored sheet pile. And the classification where it has been used, it is used both for large and small water front front structures; that means, harbor, dock and harbor structures it has been used. Also it has been used for protection of piers and slope stability.

These are the three examples it has been shown in the figure. First one is only sheet pile; one end of the sheet pile it consist of may be its a water this side or may be empty. Other end is it will retain the soil mass and these line is called dredge line, and the sheet pile is large if sheet pile is large to prevent against bending moment, one end has been connected by means of anchor rod. And this part this arch it has been connected with anchored rod that is why it is called anchored sheet piles. Another example case three if we look at these both the ends it is full of water, so sheet pile walls has been put it. So, with this anchors, so that it allow these ships to be berth in between the sea, so that this is a useful ways of how the sheet pile wall has been used.

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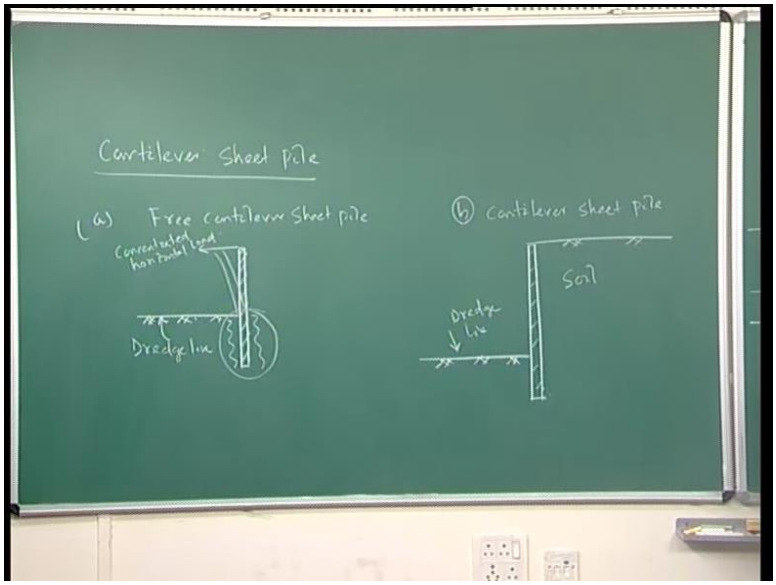

Now, go back to cantilever sheet pile. Cantilever sheet piles has been classified again into two parts; one is your free cantilever sheet pile, and b is your cantilever sheet pile. If you look at your free cantilever sheet pile, why it is called free cantilever sheet pile, this is my sheet pile; this is your dredge line. In case of free cantilever sheet pile, the sheet pile has been acted upon by a concentrated horizontal load at its top and there is no back feel about the dredge line. If will look at the dredge line, there is no back pile, and the free cantilever sheet pile means entirely it derive this stability by means of soil below the dredge line.

Now come back to cantilever sheet pile, in case of cantilever sheet pile, and this is your dredge line. The difference between free cantilever sheet pile and cantilever sheet pile, if

we look at here, both have been acted by horizontal or lateral load. In case of free cantilever pile, there is nothing about the dredge line, neither this side nor this side. It cannot retain soil may be water this side. So, entire stability of the sheet pile has been governed by the soil below the dredge line. So, I push inside this soil entire stability against the lateral load will be taken by the soil below the dredge line that is why it is called free cantilever lever sheet pile; that means, above the dredge line, it is free; one horizontal load lateral load has been acted so that is why it is free.

If you come back to cantilever sheet pile, in case of cantilever sheet pile, this is a dredge line and this is your soil. This is a one side of the cantilever sheet pile, it will retain soil mass that is why it is called cantilever sheet pile, so that means, the entire such stability will be consider the soil here as well as soil below the dredge line considering soil here and here the stability has to be carried out. Remember free cantilever means above the dredge line there is nothing, so it will be acted, it is a free; that means, the entire load will be taken by cantilever action and above the dredge line, it is fully free, so only activated by concentrated horizontal load.

If you look at the cantilever sheet pile, so one side of the cantilever sheet pile soil has to be retain soil has to be retain other side of the dredge line. So, soil also there this stability will be determine from the soils of the one of the meriden and soil below the dredge line. So, this is your cantilever sheet pile that classified into cantilever as well as free cantilever as well as cantilever sheet pile.

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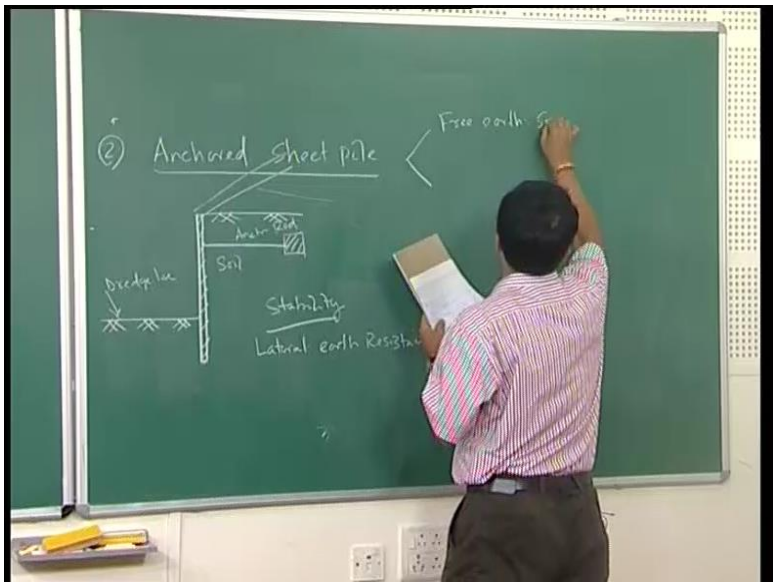

Now, come back to anchored sheet pile, but to in case of anchored sheet pile, if we look here anchored sheet pile, this is your dredge line. Dredge line means this line below this, there is a pool of soil; above this, it may be water. So, will penetrate the sheet pile such a way that it should go inside this soil, it should go inside this soil; that means, below the dredge line will get a stable soil. So, if this sheet pile is large enough, what will happen, excess bending will occur enough. To prevent excess bending at the other end, it is retaining soil mass, so it will be connected at regular interval here if I go this is a cross section, if I go and a with direction, so every per meter width will have to provide this anchor anchor; that means, this is a anchor rod.

So, it will prevent what is the function of the anchor rod once it has been put it here it will prevent the cantilever sheet pile not to bend, but that means, bending will be less as you provide this anchor rod. So, in that case, at regular interval, you can design and you can provide this your anchor rod. So, then cantilever sheet pile may be this length may be you can take larger length of the cantilever sheet pile. So, here stability will be taken care of sheet pile lateral earth resistance. If will look at this how this stability has to be calculated. Once this is a anchored sheet pile, one head, this your dredge line. So, it will be by means of earth pressure, it will be by this soil. And here the pressure taken by the anchored rod both is your governing or criteria for this stability of anchored sheet pile.

Now next page is your how what are the materials of the sheet pile has been used. Then

again anchored sheet pile again classified as two parts, one is your free earth support free earth support, other is your fixed earth fixed earth support, free earth and fixed earth support. If I classify this anchored sheet piles into two types, one is free earth support and other is your free earth support.

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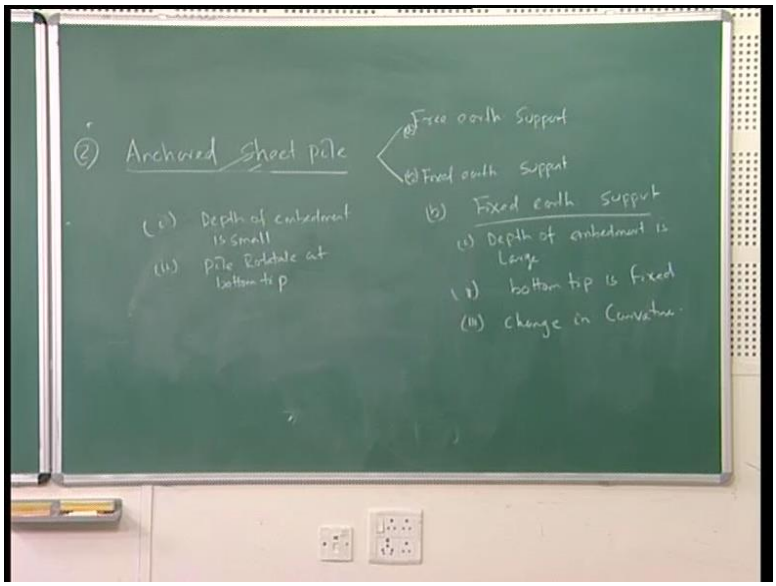

In case of free earth support that means, depth of embedment is small and pile rotate at bottom tip then in case of fixed earth support depth of embedment is large. Bottom tip is fixed, change in curvature. If we look at this both anchored sheet pile free earth support and fixed earth support; in case of free earth support, the depth of embedment is very small. Depth of a embedment means depth of a embedment below the dredge line this is called depth of embedment and it is very small; that means, it allows pile rotate at bottom tip that means, it will rotate at the tip of the bottom it will rotate.

So, but in case of fixed earth support, depth of embedment is very large; that means, depth below the dredge line it will be very large and bottom tip is fixed; that means, the bottom tip it is fix neither it will rotate nor it will movement means there is no movement at the bottom tip. So, what will happen there is a change in curvature there is a change in curvature in the pile. So, once it is fixed, so definitely there will be a change in curvature, this part is fixed change in curvature of the pile. So, this a two distinguish feature, once I said anchored sheet pile this anchored sheet pile may be classified as free earth support as well as fixed earth support.

Once again I am repeating incase of free earth support depth of embedment is very small and pile rotate at the bottom tip. And in case of fixed earth support, depth of embedment is large and bottom tip is fixed bottom tip is fixed; and once bottom tip is fixed, there is change in curvature change in curvature of pile or sheet piles.

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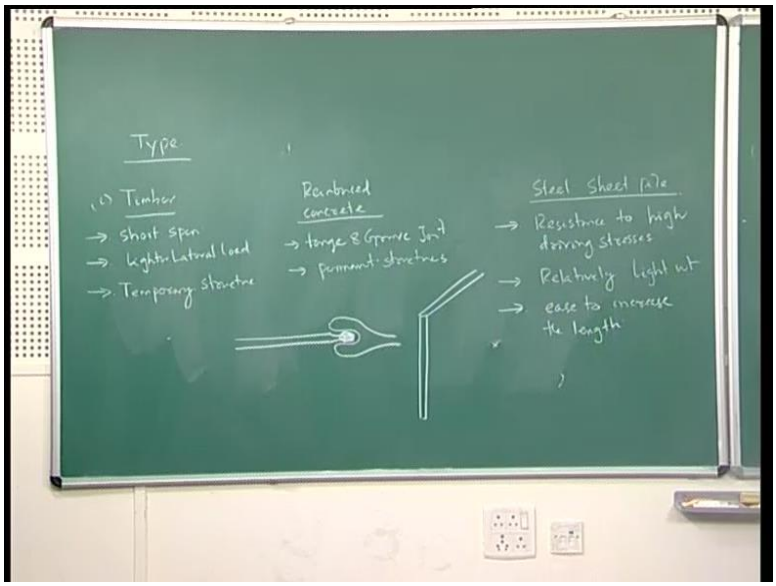

Now what are the materials used, if we look at the what are the materials used. The type of your materials is timber, one is by timber or bamboo you can provide the sheet pile; another one is your reinforced concrete, another is your steel sheet pile. In case of timber, generally once you are using the timber; that means, it is used for short span. Short span means very temporarily the timber has been used, and it can take lighter lateral load, and it has been used for temporary structure. Then in case of reinforced concrete, there is a kind of tunge and groove joint. It has been designed for permanent structures.

Now come back to steel sheet pile. So, it has wide advantage than both these steel sheet pile. So, it is kind of resistance to high driving stresses, relatively light weight then easy to increase the length. So, how it has been connected, if we look at here, one end of the sheet pile wall will be in this way. It is a kind of ball and socket joint means how it has been connected one by one. If we look at these, so this is my one of the sheet pile.

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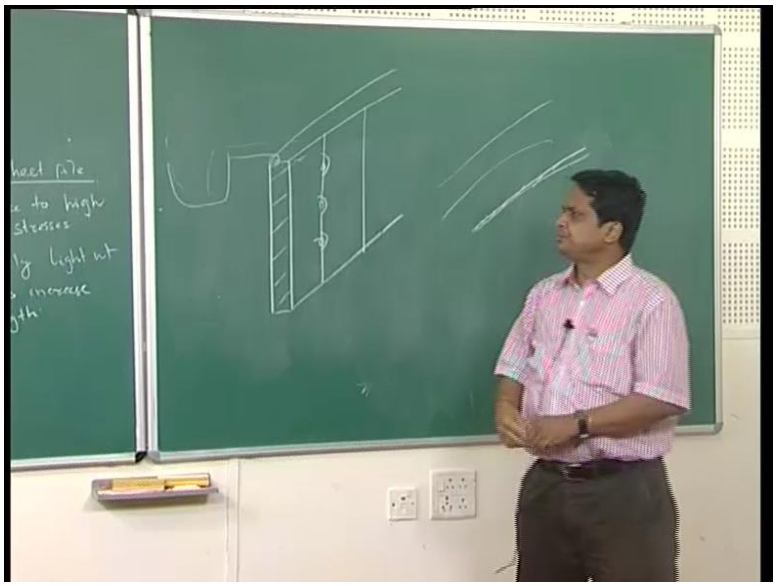

Let me explain here. If you take a bigger section, so this is one part of this may, it will move in this direction in this direction. So, this is a cross sectional view once I am showing only this part; that means, this is a cross sectional view. This sheet piles are not available like as a whole it is not available. These are all kind of a piece by piece it is a available. Once this the piece by piece it is available you have to connect one by one by one. So, how the connection is there, here if I look at the connection here, one end will be like this other end will be like this. One piece of these sheet pile wall will be a ball joint at the regular interval, other piece of these sheet pile will be a socket joint. So, this is a ball and socket joint.

So, in this condition, what happen if you need there is a pressure, it will not disintegrate with each other; it will connect perfectly with each other, so that there will not be any disintegration of the sheet pile walls. If you look at the types there are three types timber reinforced concrete and sheet pile walls.

Come back to timber. Timber generally used particularly in case of village. If we look at here there is a river passing in the village, what happen they provide timber near the river shore near the river shore. So, what will happen providing the timber, so if there is a boat is here people can come. So, this timber has been used particularly for a short span for temporary purpose and maximum lightly lateral load can be taken. Here lateral load how it will be exerted, this lateral load will be exerted by means of ship or boat, because it has

to tied up and people can come out from the boat. So, in incase of this timber lighter lateral road that means, only man made boats can be provide this lighter lateral load. It cannot take heavy lateral loads and it is a temporary structure; that means, two years, three years or maximum for five years kind of things this timber type of material has been provided.

And second part is your reinforced concrete. If you look at this reinforced concrete, it is a large and it is a kind of large structures, and it has been used for particularly permanent. For dock and harbor structures, you need to have this reinforced concrete material over a period of time say twenty twenty-five year or fifty year; in that case reinforced concrete structures you provide permanently, so that one end ship will come, but and people can come out. So, this is also for permanent structures.

And another one is a steel structure steel sheet piles. This steel sheet piles has wide advantage than your timber as well as reinforced steel piles. So, steel sheet piles is resistance, it has a resistance to high driving stresses; that means, it will take more stress in terms of driving you can drive inside, and relatively light weight. You can take it from one end to other end, because it is relatively lightweight and easy to increase the length. What happened RCC is a reinforced concrete structure is a massive one. So, while installation you need lot of manpower, machinery work, but in case of steel sheet pile it is easy you put place one by one then go high. So, the preference wise generally steel sheet piles are preferred rather than reinforced concrete sheet piles. Bamboo or timber it is a short one and short span, for temporary structures generally it has been used. So, these are all three types of material generally used particularly your sheet piles.

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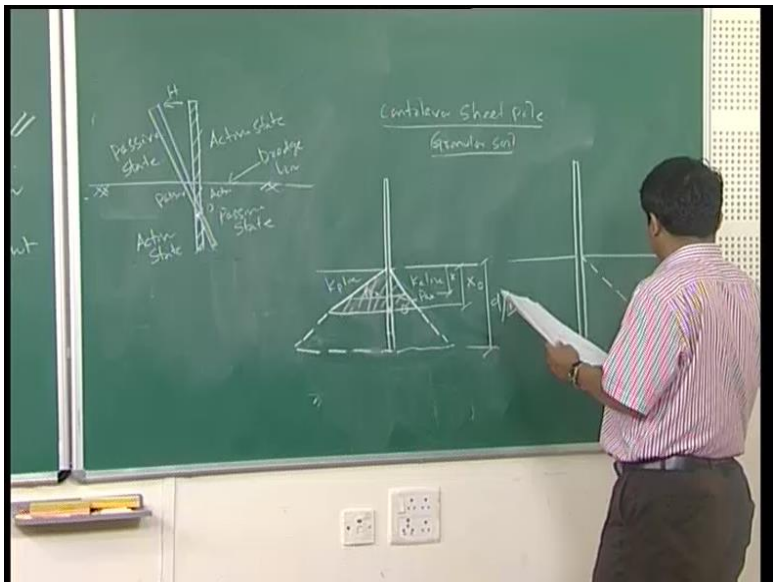

Now come to next part cantilever sheet pile one is your free sheet pile, other is your cantilever sheet pile. Now, as I said last lecture, if this is your cantilever sheet pile for granular soil, we can see the analysis of the stability analysis of will start with this first is your cantilever sheet pile then anchored sheet pile. First is your cantilever sheet pile with your granular soil cantilever last class I started with this cantilever sheet pile. So, in this case for granular soil, there is a point of rotation assumptions also we have discussed earlier. There is a point of rotation, here is your horizontal load, this point of rotation is called pivot point. And once it is moving down, this is your passive resistance, passive state rather you can say that passive state and this part is your active state. Similarly incase of point of rotation, this is your passive state and this is your active state, and this is called dredge line.

So, now we go for analysis step by step. So, let us start with this below the dredge line up to this point 'O' that is called pivot point. How the analysis is there. This is my point 'O' this is a point of rotation. If I remove all point 'O', this is my point of rotations these are the dotted lines; above point of rotation, if we look at the above point of rotation, this is your this state passive, this is your active; that means, pressure above point o this side will be more as compare to this side. Case one what I am doing, I am doing it making this stability analysis step by step for granular soil. This is my pivot point - point O, above these what are the forces coming below this what are the forces coming then will super impose each other then we will find it out what is the capacity.

Because you have to know what is that resistance, then once you know the resistance how much load it can take then it has to be predicted based on that you can say that whether it is a stable are unstable. So, the pivot line if I right it into x 0, and this is your k p line and this is your k a line; that means, active earth pressure line, this is your passive earth pressure line. So, this will be your somewhere else p p x somewhere else it will be your p a x. So, this will be x, and this entire distance up to which it has been driven either small d or capital D, this is depth of embedment below this. So, this is point 'O' - pivot point above the point of rotation.

Similarly, now you come back to below the point of rotation, below the point of rotation where is your passive, this side is your passive; that means, force will be more and this side will be your active. So that means, below the pivot point, this is the point 'O', this is k p line, this is your k a line. Now we will explain in details this physics behind it, it will take time, may be next class.