Soil Mechanics/Geotechnical Engineering 1
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Lecture - 24
Vertical Stress

Once again I welcome you to this soil mechanics lecture, let me continue from my previous lecture. What I have ended last lecture was using bossiness theory and initially I have applied which was originally for, of course load and then I have extended to in uniformly circular loaded circular area, than uniformly rectangular area and if they are in the for uniformly loaded rectangular area that is known as corner formula and if you know the corner formula then by using in several combinations, we can find out stresses at different desired point and how it could be done that I have shown.

Now I will show some of the other aspects like if the foundation shape is irregular, then some time we will not be able to do whatever method we have discussed. So, that is the point I will try to discuss now; that is the method we use for this is new marks influence chart.

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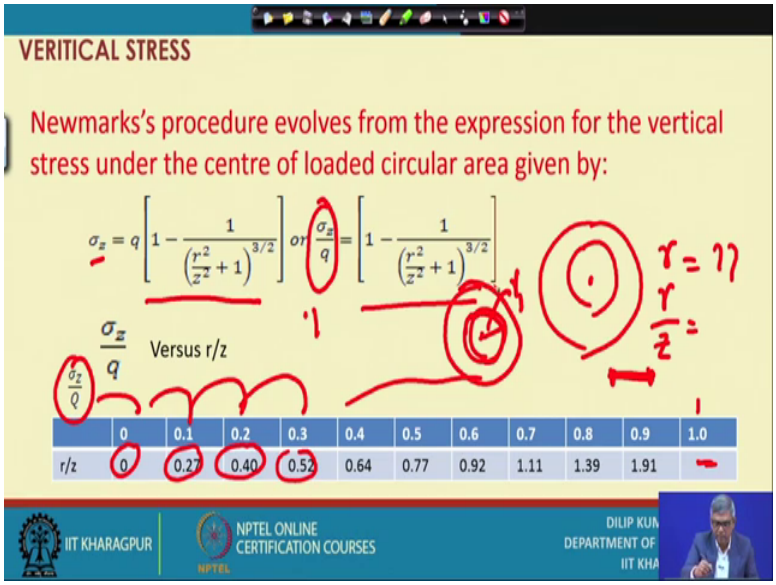

And this for this new marks influence chart whatever already we have done for circular loaded area are integrated and finally you have got a expression sigma z equal to q times 1 minus this term, now I can just simplify sigma z by q and then I can write if this

expression. Now if I want to make sigma z by q is 0.1 0.2 0.3, it means actually whatever sigma z; whatever pressure applied in the surface it is of 10 percent of that 20 percent of that 30 percent of that. So, that value suppose 10 percent of surface stress, if I that is the ratio suppose if it is 0.1 if I consider then it is nothing but 10 percent of the surface loading.

So, what should be the r by z? So, by solving this suppose if I put 0.1 here then I can solve this from this equation what should be the r by z. So, for that actually what I have done here for several values of sigma z by q that is 0 then; obviously, r by z has to be 0 and when it is 0.1 r by z is 0.27, when r by z equal to sorry sigma z by q is 0.2 then r by z is 0.4 similarly sigma z by q is 0.3; that means, 30 percent of the surface load then r by z is 0.52 like that it is going and when it is 100 percent. That means, whatever load you have applied at the surface and same stress will be there, so theoretically r by z will be infinity, so that is the 1. What is the meaning of it actually the meaning of it actually, if I want to make the pressure intensity at a particular depth.

So, different radius of circle I can think of and at the same depth I can find out what could be the pressure. So, by using this actually there is a chart can be prepared that is called new marks chart and principle of new marks chart is suppose you have got r by z different r by z and suppose our intention or main purpose is to find out the stress vertical stress at a depth z, suppose z can be anything suppose 2 meter 4 meter 6 meter 8 meter anything. So, so is this r y z ratio is there, so from there I if I fix is z value suppose 2 meter and that 2 meter distance or depth I will take some of length. Suppose this 2 centimeter 2 mete equals of 2 centimeter then automatically from r by z if I z if y fix, then I will get from they are what is the value of r. So, if I keep z constant throughout z is actually 2, then what I will get for different intensity I will get different r; what is the meaning of it? That means, at 2 meter depth if I want to get 1 for 10 percent of the surface load, then whatever the circular area to be loaded at the surface I will get some value that is suppose r 1 radius.

Now, at same depth if I want to get the pressure of 20 percent, then your circular area are loaded will be different and that will be suppose r 2; suppose let me I will do fresh and the next slide so that means, I can do let me take better 1 fresh page, so suppose I know r by z and r by z actually.

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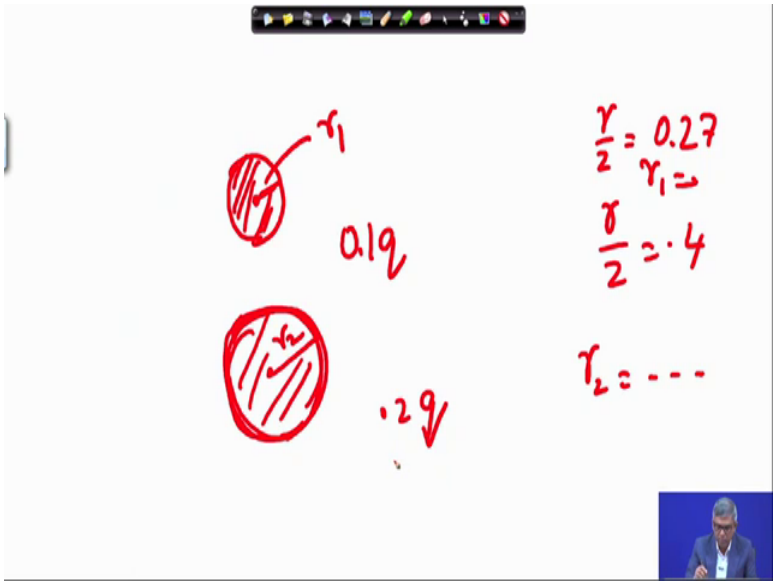

Suppose 2 values r by z equal to if I go back r by z is 0.27 and 0.4 suppose r by z 0.27and r by z equal to 0.4. Now if I fix the depth equal to z 2 meter then r will be some value suppose that is suppose r1; that means, if the circular loaded area is r1 something with radius r 1 and that much load area if loaded with intensity q at 2 meter depth your intensity will be 0.1q. Similarly now if I now do r by z equal to z is the same now if I do same then 0.4 this is the 0.4.

So, r will be equal to that is actually for 20 percent. So, that will give you r 2 equal to sum value, here actually given r 1 corresponding to do here r 2 corresponding there will be getting some other value. Now if I draw another circle with r 2 with radius r 2, what is the meaning of it; that means, that much area if it is loaded uniformly with pressure q, then at same depth 2 meter you will get 0.2 q; now if I do 1 now what I will do I have done point suppose, I will draw now separately I will clean this 1 I will do separately.

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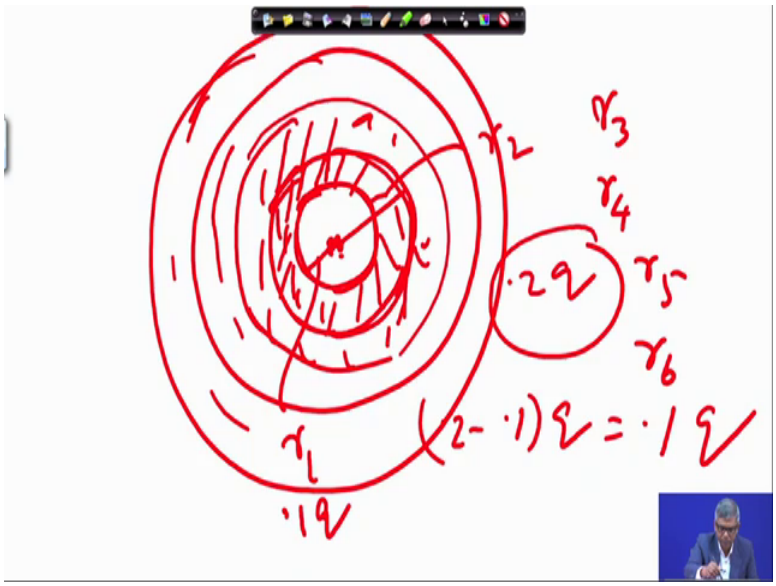

That is suppose this is the radius for 0.2 q this is suppose r 2 for 0.2 q and there is another circle this is suppose with r 1 and that is suppose for 0.1q. Now once I am loading with 0.2 q sorry r 2 with q and you are getting at the centre 0.2 q and once you are applying with r 1 with q loading and you are getting 0.1 q; that means, if I only load this area if I only this load here there area are at same depth will be the stress actually, this was 0.2 q for the whole area and inner area 0.1 q, so difference of this 2; that means, 0.2 minus 0.1 q will be equal to 0.1 q.

So; that means this area is 0.1 q the whole area is a 0.1 q at 0.2 q so; that means, there is differential that between the 2 circle that will be 0.1 q; suppose like that similarly if I now keeping the z same I will do r 3 r 4 r 5 r 6 like that different circle I will draw, if I draw different circle now like this with different areas, then what will happen whatever may be the radius if depth is a constant and corresponding to that if you get the radius, now effect of each annual area at the same depth will be constant that is 0.1q. So, that is the idea will be used for drawing the chart. So that means, we have shown that for 0.1 q 0.2 q 0.3 q 0.4 q like that for corresponding r by z we have got.

Now, I have fix the z then corresponding r 1 r 2 r 3 r 4, if I draw now with that radius r 1 r 2 r 3 r 4 are finally r equal to infinity will be the last circle. So, between the 2 circles the influence at the centre at constant depth 2 meter suppose will be same; that means, each annular area are effect at the centre will be same. So, that is the important

observation to be used for drawing the chart. So, now this is the concept if I use now this is the way you can see it is done already.

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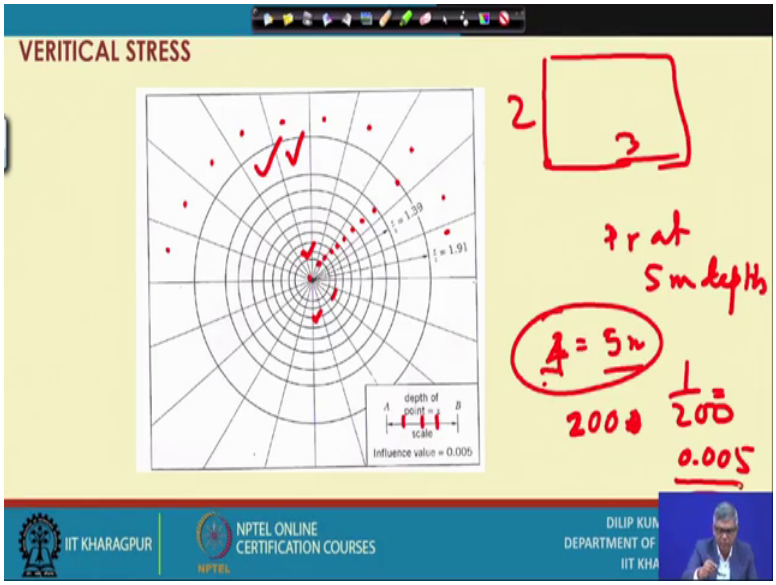

So, suppose this is the 1st circle, then this is the 2nd circle this is the 3rd, circle 4th, 5th, 6th, 7, 8, 9, and 10 circle was infinite; it can be big suppose I am keeping it need not go up to infinity, but from finite depth other part will bigger this. So, now effect of these annular area and effect of this small annular area at the centre will be same, how it is same? See it is from this point this area is far. So, effect is, but area is large, but it is far whereas, this area is small but it is closer. So, because of this because of this affect the net effect will be this 1 and for this 1 will be same, so this way you have drawn so many circles.

Now once again if I this circle if I divide by red divided number of parts draw by drawing radial lines like this. So, you can see you have divided into18 degrees. So, now, when you have divided again we have done 20 radial lines now again those circles also divided to small parts, now the way I have observed that the each annular area is having same effect on the center. Similarly when you divided by the drawing radial line so this part whatever effect will be there, this small part also will be having same effect at the center. So, that is the conclusion from this drawing so that means, now this will be utilized to find out vertical stress at any depth for any shape of foundation type.

So, how to utilize this? So, that is the depth as I have mentioned for drawing these we have to fix the depth. So, for any influence the chart you have to fix the z for and what about z that should be kept along with this chart. So, that is why here actually this line is drawn and that was written this is a z. So, now, what will happen if suppose there is a foundation and I want to find out at 5 meter depth pressure?

So, that depth 5 meter so whatever line length is given here that length will be taken as, so whatever length is given z that will be taken as 5 meter because, I want to find out pressure at 5 meter depth. So, that depth z should be equal to 5 meter so that is the scale now. So, whatever z suppose this was 2 centimeter of 5 centimeter suppose it is 1 to 4 centimeter suppose this length, so 4 centimeter equal to 5 meter that becomes the scale.

So, whatever foundation supposes it is foundation is this much being 2 meter by 3 meter. So, 2 meter by 3 meter foundation now 4 centimeter equal to 5 meter with that scale to be drawn, now suppose I want to find out the pressure at this point. So, that point could be kept here and that scale down the foundation will be put on this diagram keeping the point on the centre, where actually you want to find out the pressure and then it will be cover by some number of blocks and you have to count the number of blocks and each number of the blocks will have same influence and that influence value for this chart is fixed. What is the value? Because you can see initially 10 circles and again circle is divided into 20. So, 10 into 20 200 we have divided. , so sorry 10 into 20 so 200; so that means, this entire circle is divided into 200. So, if I cover the entire circle in the area the value is 200.

So, if I divide if I cover by 1 then it will be value is 1 by 200. So, that is called influence value, so when I cover by 1 only that is called influence value that is 1 by 200 that means 0.005. So, now with that particular scale if I draw the foundation and that foundation I will put in this chart and then I will see how many blocks are covered by that foundation and that number of blocks multiplied by this influence number influence value multiplied by q that gives you the pressure. So, that is the thing I have given a step by step what to do in the next slide.

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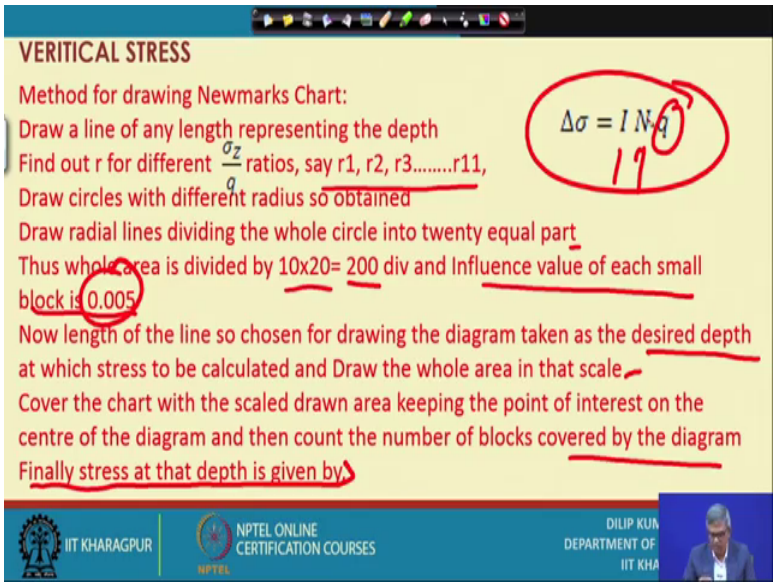

You can see here method for drawing new marks chart, first thing is you have to draw a line of any length representing the depth that is suppose 2 centimeter line suppose I have to do, I have to draw the chart how to fix the length in such a way suppose I only use a 4 size paper, so 9 circles at least it should come within the paper. So, 2 centimeter 3 centimeter anything can be taken and that should be that line also drawn at the side because that is the scale used for drawing the in pressure.

Find out for different sigma z by q ratios say r 1 r 2 r 3 r 1 r 11, like that different radius whatever I have shown that to be calculated, draw circles with different radius so obtained. So, you to draw circles r 1 with r 1 r 2 r 3 and between r 1 and r 2 whatever the circular annular area influence is same as what is between 2 and 3, what is between 3 and 4. So, that that is known I have explained logically, draw radial lines dividing the whole circle into 20 equal part. So, it can be it can be done any number actually. So, we preferably do 20 parts it can be 40 it can be 40 accordingly. We have to find out how many numbers 1 by that numbers will become influence value.

So, here if I do 20 radial lines, then the whole area is divided into 10 into 20 that mean 200 division then influence value of each small block will be 0.005 now length of the line. So, chosen for drawing the diagram taken as the desired depth; that means, what about line shown that should be the depth of the found depth at which actually required to foundation the stress to be calculated and draw the whole area in that scale.

Cover the chart with the scaled drawn area keeping the point of interest on the centre of the diagram and then count the number of blocks covered by the diagram and finally stress at that depth is given by this Delta sigma will be equal to I that is influenced value and n that is number of blocks we will count and q is the intensity which is applied at the surface. So, by that finally will get what is the pressure at particular depth. So, this 1 also schematically this is also explained in the next 1, suppose I will show you another foundation also.

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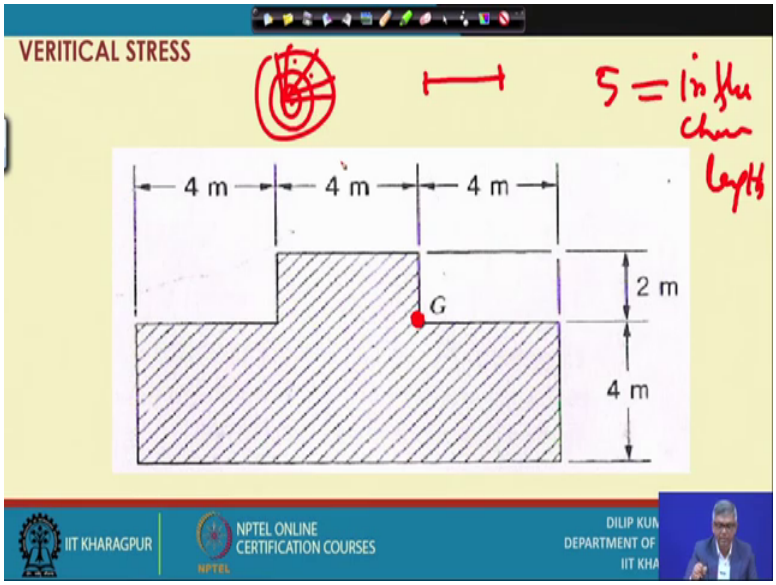

Suppose now this is the foundation and I want to find out that, suppose 4 meter below this. I have to find out the stress, then what I have to do I have to draw the first influence chart and I whatever chosen value used for the chart that actually I have to take as a scale and suppose I have to find out 5 meter below this, I have to find out the stress and so 5 meter become the 5 meter equal to whatever influence chart length, whatever length drawn beside their influence chart there is a line drawn.

So, that long line length actually you have to measure suppose 2 centimeter or 3 centimeter that should be equal to 5 meter. So, now with that scale I have to redraw this foundation. So, that will be of course it will be reduced in size, so all size will be reduced, but will not disturb is orientation on other things only the similar shape, only the it become smaller and since I want to find out pressure at this; as I have mentioned that he have to keep this 1 at the centre of the influence chart and after putting that if you

can count the number all around by that means, in the influence chart. Suppose we have something like this and so when will cover there will be number of blocks will be covered by this. So, you have to count that blocks and if I do that next 1 I will show that.

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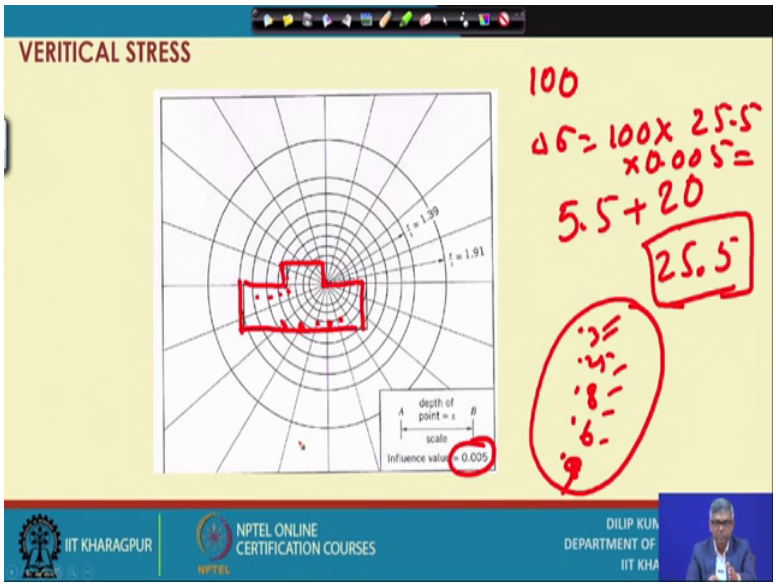

Suppose this is the 1 and this is the influence chart and when the foundation is drawn to a particular scale, then this foundation came here equally we can see and I are we are interested at this point. So, you have put this 1 it centre and then you have done here this there like this and like this; we have drawn sorry this is not the 1 this is line should not be there I will just remove this, so now this is the 1 is covered.

Now, you have to count number of block suppose the whole blocks you have to first count 1 2 3 4 5 6 7 like that we have to count whole block, how many whole blocks covered and then some of the blocks are partially some of this partially covered this block, this block is partially copper covered. So, by just I estimation we can take that as a 0.3 blocks. Similarly this 1 another here another block is covered. So, that is suppose again same may be taken 0.3 or 0.25, like this another block here is covered.

So, by I estimation this can be taken as 0.8 similarly we can see this is another block covered that may be taken as 0.6, this block is taken covered by part it is some 0.8 or 0.9 can be taken; like that whatever fraction blocks are covered that by I estimation can be counted and finally it is added this may come ultimately again 5.5 blocks and there may be another whole blocks maybe 20. That means, you have may be 20 25.5 blocks total

covered by this foundation, then if this is obtained and then I know the influence value it is written in this chart you can see since it is 200 division so it is 0.005. So, if I know the pressure applied on this foundation suppose q is 100, then you can find out your delta sigma will be 100 into 25.5 multiplied by is 0.005.

So, whatever calculation and will come that is the value for this at this point. So, at this and of course 5 meter depth and so now sometime question may arise if I cover keeping this point here, but I will be other way I will put suppose the foundation, suppose I will clean it and suppose I can put the foundation other way suppose this way I am putting and it will cover.

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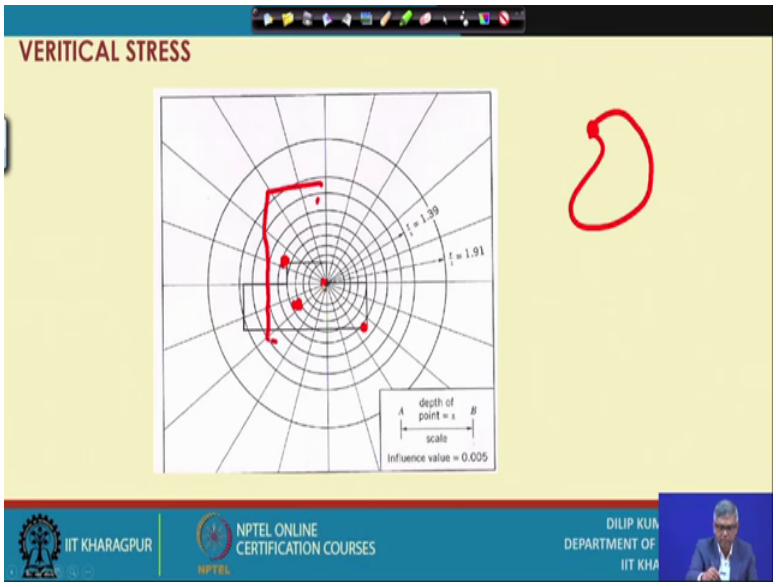

So, whatever way you keep if the interest is fixed then whatever way you orient it will come cover actually same number. So, because of that it is not necessary that this is the only orientation you have to place on the paper, but you can keep any orientation it will ultimately count will be same. So, only thing is you have to know at what point you have to find out the pressure, suppose I want to find out pressure now at this point then I have to see if this point this entire thing and I have to bring this point here automatically this things will be shifted this side at will be cover some other number, so different number will not be same.

So, this point compared to this point, this point pressure may be less. So, accordingly it will number will change. So, you have to so that means was if I want to find out at this

point then again I have to see it entire thing this. So, point I have to keep here and then with respect to this I have to draw the figure this side. So, then again in count the number and then multiplied by I and q then I will get the stress like that any point suppose I want to find out this at this point. So, I have to keep this point here and then I have to cover symmetrically now whatever it is there.

So, like that this is a very universal chart that any shape of foundation suppose, if this is the foundation shape is something like this which is unusual, but suppose I can imagine that is a foundation type this cannot be used by bossiness point formula or bossiness that area integration and point corner formula nothing I can be used here. So, instead of that now if I want to find out pressure at this point what I will do, I will take, I will draw this found at this area in a particular scale and shift here this point and this point I will keep here and then count number of blocks covered and then I will get the sigma z into q into number of block cover multiplied by influence chart will be your pressure at particular depth.

So, this is about influence chart this is very useful when we do not have calculator or computer, people use to enjoy this type of chart; but it has some technique you can see now I will go next.

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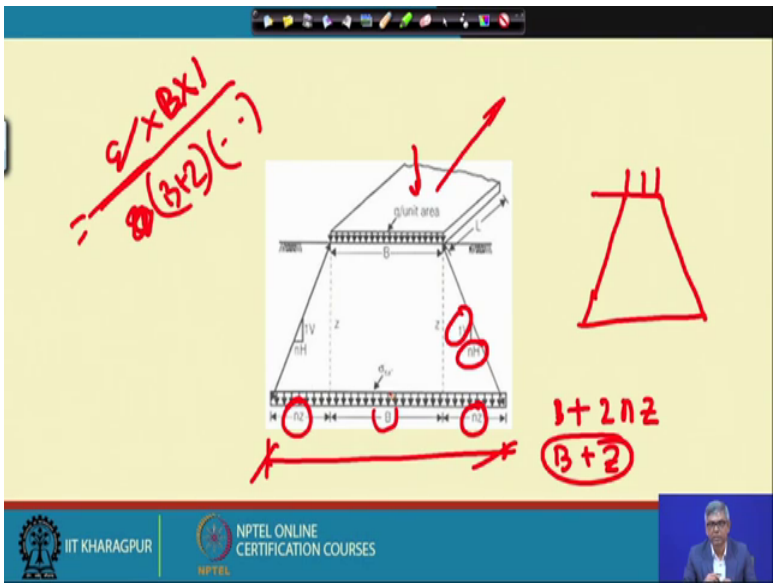

I have now discussed number of things that point load and then you have point load, how to apply different ways that is also we have discussed; then integration corner formula

then you must chart, but in practice what you do. Most of the time so much calculation we sometime when you do and there is a approximate method by which we can do and you can see in this figure, you can see that there is a foundation suppose is shown here and maybe this is extended the side and this is the width and then approximately we can assume that vertical pressure disperse with some particular angle. So, if I apply load here so load will not be vertically you go up to this, so it will be slowly disperse over depth.

So, if I apply load here, this much area it will be disperse over depth like this. So, similarly here so this dispersion when the stronger soil dispersion will be more, but when the soil is weak then dispersion will be less. So, but in most common practical work most of the time in practical work we generally take 1 vertical 2 vertical 1 horizontal, but anything it can be, so that is why I am showing here first generalize 1 vertical image horizontal. So, that is what so in that case that means at any depth, we can imagine they are footing area is increasing here actually it was b now because, of our dispersion I can consider this is the footing width.

So, what is the footing width now? If 1 vertical n h horizontal, if I take n horizontal then what happened it is n time z it will be n time z will be and this will be B projection. So, ultimately your width will be B plus 2 times n Z and now n if it is 0.5 so B plus Z it will be. B plus Z so that means, I can consider the widening of footing suppose at this depth whatever q was there.

So, it is q into multiplied by of footing area length into or B into support unit area I will take that was the load, and at this depth it will be same q this load divided by now area will be changing. So, that if the width will become B plus Z and similarly unit width whatever the correspondingly that will also change. So, that divided by this that will give you whatever pressure intensity was here at this point pressure intensity will be reduced. So, that is the 1 generally we take that is called trapezoidal dispersion we can consider, that is the way simple way sometime we calculate in practice I will show the next slide also.

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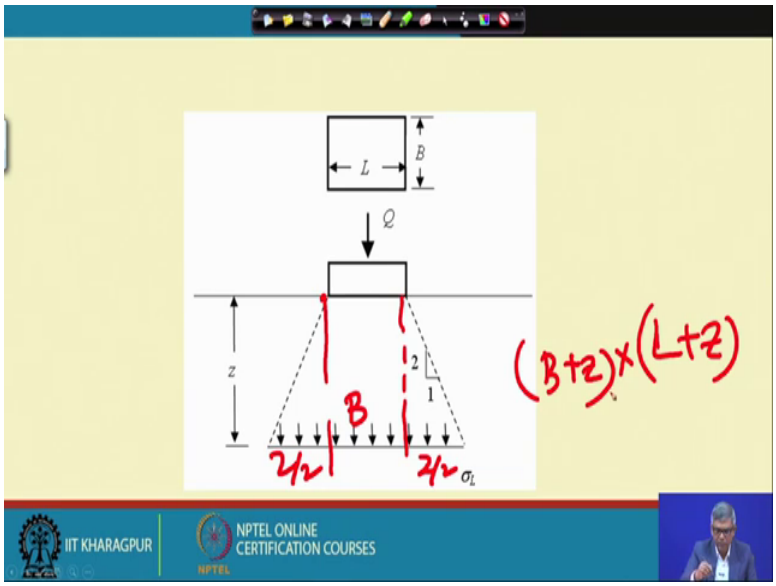

So, this is actually has have told 1 vertical n horizontal here actually 2 horizontal 1 vertical a 2 vertical 1 horizontal this is a standard thing we use, and if you use this then this become B and this become z by 2 z by 2. So, ultimately this width becomes B plus Z. So, if is a rectangular footing B plus Z will be width and say length also will become L plus Z, so at this depth area will be this multiplied by this.

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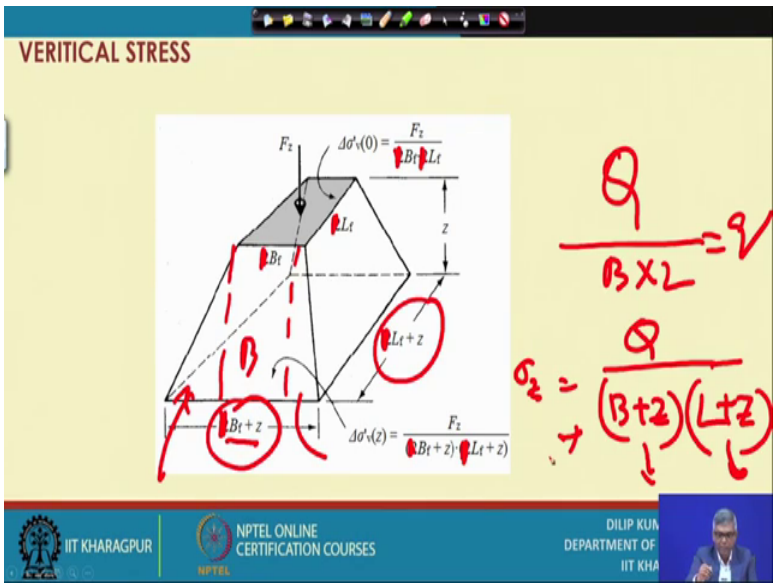

So, this is the 1 in 3 dimensional you try to show here, sometime length people take as a 2 L and 2 B I if I remove this F equal to B by del sigma equal to F by B into L, B

multiplied by L and at this depth in that case if it is B then it will B plus z and this 1 also it will become L plus Z. So, width at this depth will be B plus z at this depth L plus z. So, what will be the pressure at this depth F z B plus z L plus z? So, it was F z initially for at this depth at the surface your 4 suppose Q and then at the surface suppose B into L it was that was a q and now at a depth z sigma z will be Q divided by B plus z into a multiplied by L plus z.

So, if I do this so compared to this width is bigger, so ultimately pressure at this point will be reduced. So, that is the way sometime we calculate approximately pressure at any depth and unlike whatever method we have discussed, but when we have enough time and scope we do that, but most of the approximate calculation or sometime we follow this like trapezoidal distribution.

And as I have mentioned that 1 vertical and n horizontal that is one very generalized way, but most common dispersion we consider 2 vertical 1 horizontal, and if it is done with 2 vertical 1 horizontal; then at a depth z your increased width will be B plus z and increase length will be L plus z; how it is? That if I draw this will be B, and this will be z by 2 this will be z by 2 and so finally this. This is the way we can find out the delta sigma and that is all.

So, I will try to discuss other part, that means how to I have discussed different methods, how to apply these methods for finding out the delta sigma; I will take several problems in the subsequent few lectures.

Thank you.