Soil Dynamic
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Lecture 24
Determination of Dynamic Properties of Soils (Laboratory Tests - Part 4)

Hello friends today I will continue the lecture on determination of dynamic properties of soils using laboratory test already we have seen how to find out the different dynamic properties of soil by conducting resonant column test by conducting cyclic triaxial test.

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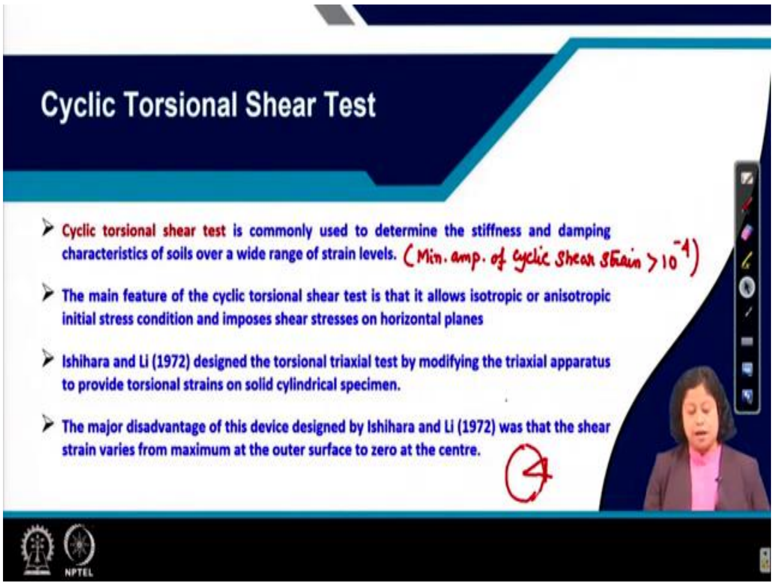

So today we will see how we can find out the dynamic properties of soil by conducting cyclic torsional shear test. Cyclic torsional shear test is one of the high strain laboratory tests conducting which we can determine the dynamic properties of soil. In this context I would like to mention here once again what is high strain test when the cyclic shear strain amplitude is more than 10 to the power minus 4 or I can say the amplitude of the cyclic shear strain is more than 10 to the power minus 2 in percentage then the test is considered as high strain test.

So cyclic torsional shear test is one of such high strain test, this test is commonly used to determine the stiffness and damping ratio of soils over a wide range of strain levels. However, the minimum strain level should be 10 to the power let me write here the minimum strain level that is 10 to the power minus 4, minimum better I just write it as minimum amplitude of cyclic shear strain that is always more than 10 to the power minus 4.

The main feature of the cyclic torsional shear test is that it allows isotropic or anisotropic initial stress condition and imposes shear stresses on the horizontal plane. Ishihara and Li in the year of 1972 design the torsional triaxial test by modifying the triaxial apparatus to provide torsional strains on solid cylindrical soil specimen, the major disadvantage of these device designed by Ishihara and Li was that the shear strain varies from maximum at the outer surface to the zero at the center.

So if I draw the cross sectional area of the cylindrical specimen then in the device which was designed by Ishihara and Li in that device what was happened maximum shear strain was developed at the surface and 0 at the center. So this is the kind of shear strain distribution over the cross sectional area.

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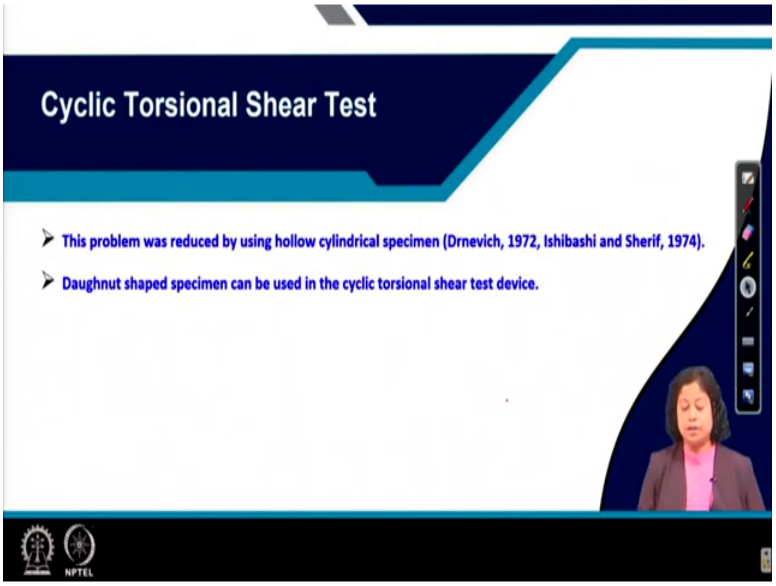

This problem is required to reduce and that was done by using hollow cylindrical specimen which was proposed by different researchers like Drnevich in 1972, then Ishibashi and Sheriff in 1974. So in this case what they have done, doughnut shaped specimen soil specimen was used in the cyclic torsional shear test device.

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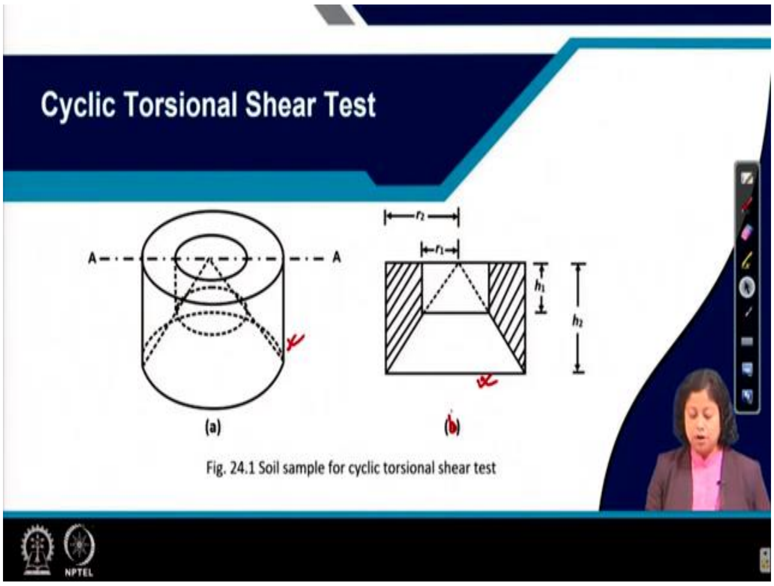

So here you can see that doughnut shape cylindrical soil specimen if we will cut these cylindrical sorry I should not use the word cylindrical hollow specimen then. So this is the portion where we can expect soil material was there I am just erasing. So in this specimen if we will cut it by section A, A then it will look like this one it should be figure b not a. So a gives the full 3D view of the hollow specimen whereas figure b gives the sectional view of the hollow specimen.

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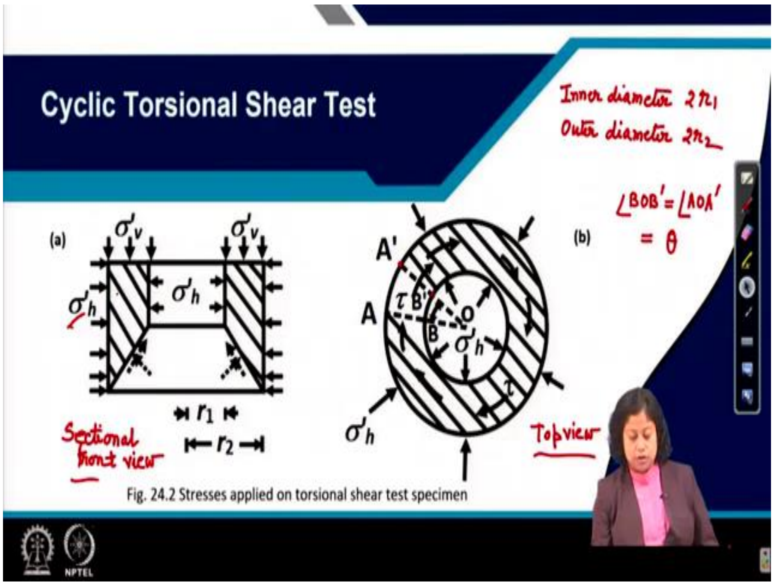

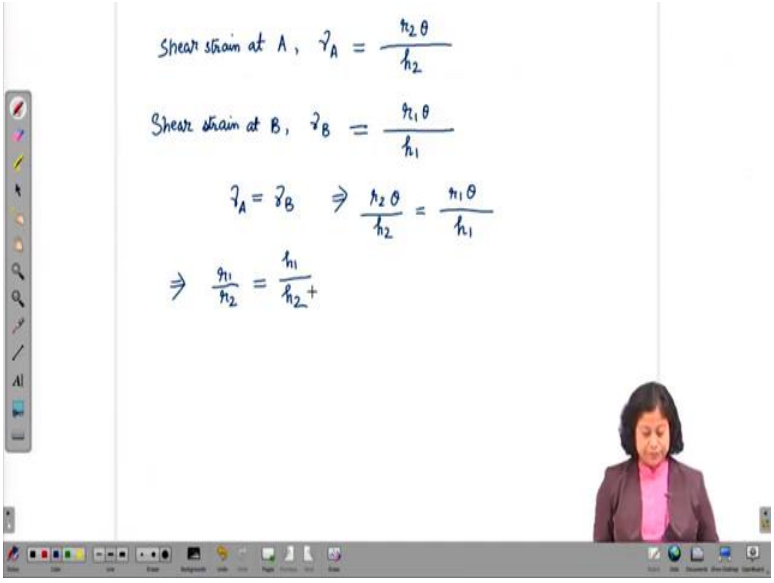

So in this next figure you can see the stresses acting on the specimen. So here you can see vertical stress is sigma dashed v vertical effective stress whereas horizontal effective stresses sigma dashed h. The dimension of the hollow specimen if you see r1 is the inner radius whereas r2 is the outer radius that means it is inner diameter if I will write it here inner diameter that is how much this is 2r1 likewise outer diameter this is 2r2 for the specimen which is shown in this figure.

Now you can see here when tau is applied we can see how shear stresses developed tau is the shear stress on the specimen from the top. So this is the top view and this is the sectional front view. So I can write it here sectional front view, top view and sectional front view.

So now the main features for the main reason I can say for which we have taken or I can say Ishibashi and Sheriff choose these kinds of specimen was that to develop uniform shear strain to the sample that means if you see the point A and B in original position after applying tau when these A B shifted, A B shifted to A dashed B dashed position. So this is B dashed this is A dashed. So originally it was at A and B. Now how much shear strain is developed at A and B if I will go to the board then I can right here as just give me one minute time.

So at A if I will write the shear strain is gamma A then I can write shear strain at A just going back to the original figure that means here shear strain is how much shear strain is here if you think this angle BOB dashed or I can also write it as AOA dashed, if this angle is equal to theta then we can find out the magnitude of gamma A here. So gamma A will be how much? It will be r2 times theta divided by h2 this is the shear strain at A likewise, we can get the shear strain at B also which is gamma B and that is nothing but r1 times theta divided by h1.

Now in order to allow uniform shear strain on the soils specimen what we need to do gamma A is equal to gamma B, if so what we can write here r2 theta divided by h2 which is equal to gamma B. So in place of gamma B I can write r1 theta divided by h1.

So from this what we can see r1 by r2 is equal to h1 divided by h2 that means the ratio of the inner diameter to outer diameter or I can say the ratio of the inner radius to outer radius is equal to the ratio of the height h1 to height h2 that means, for the doughnut shape sample the height at the inner phase is h1 and outer phase it is h2. So that ratio of these two height should be equal to the ratio of the inner to outer radii.

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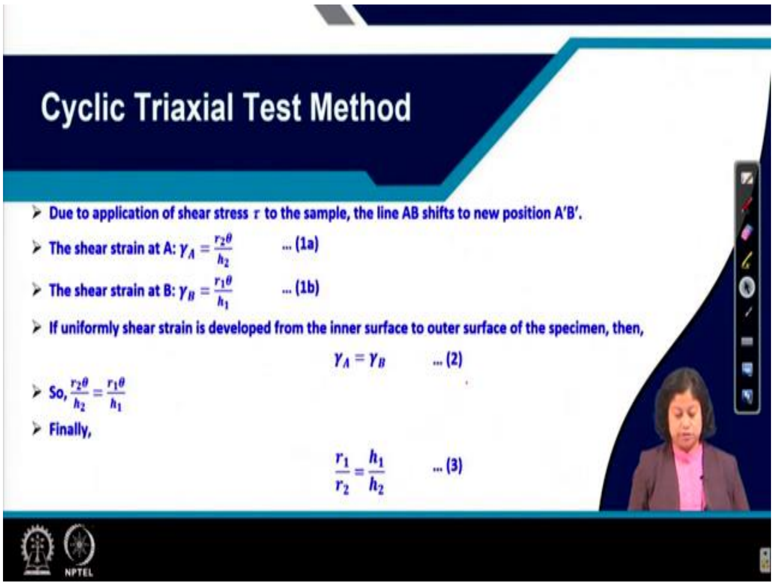

So here you can see the same way I have written that because we are interested to develop the uniform shear strain in the soil specimen. So here gamma A is equal to gamma B that I have already explained. So the same thing is written here and thus finally what we get is r1 by r2 is equal to h1 by h2. Let us give number to all these equations.

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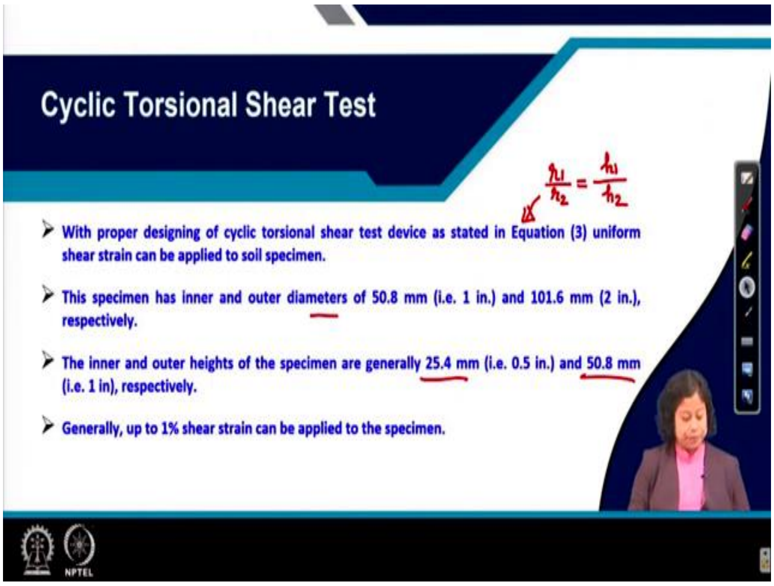

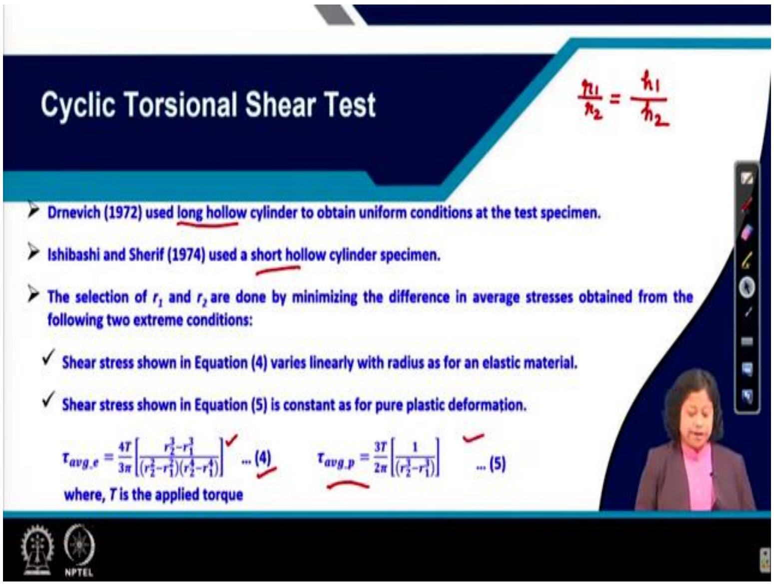

So now we proper designing of cyclic torsional shear test device as stated in equation 3 what is that? That means r1 by r2 is equal to h1 by h2. So satisfying these condition uniform shear strain can be developed or applied to the soil specimen.

Now this specimen has generally inner and outer diameters equal to 50.8 millimeter and 101.6 millimeter respectively. That means inner diameter is 50.8 millimeter and the outer diameter of the specimen is 101.6 millimeter and accordingly the inner and outer height of the specimen can be selected keeping it in mind that the ratio of h1 to h2 should be equal to r1 by r2.

So if you see when inner diameter is 50.8 millimeter and outer diameter is 101.6 millimeter that time r 1 by r2 is 1 by 2, then we need to maintain the same ratio for h1 by h2. Now if h1 is 25.4 millimeter the h2 will be two times of 25.4 millimeter which is 50.8 millimeter. In this case there is another thing that generally up to 1 percent shear strain can be applied to the soil specimen.

Next here we can see the difference in the soil sample used by Drnevich in 1972 and Ishibashi and sheriff in 1974 Drnevich 1972 used long hollow cylinder to obtain the uniform conditions at the test specimen. So here are the main feature is long hollow cylinder whereas Ishibashi and Sheriff 1974 used short hollow cylinder soil specimen. So what is the difference now these long and short hollow?

So in long hollow in both the cases actually the ratio of r1 by r2 is equal to h1 by h2. But when it is long that time the radius of the specimen may not be I am talking about the r2 to may not be equal to h2. However, for short hollow cylinder you can take r2 is equal to h2. So if this way you can make the difference between long hollow cylinder and the short hollow cylinder.

Now how you will select r1 and r2 there is some guideline the selection of r1 and r2 can be done by minimizing the difference in average stress obtained from the following to extreme conditions what are these conditions, first condition saying shear stress shown in equation 4 varies linearly with radius as for an elastic material. So let us see equation 4 and 5 this is equation 4.

Second criteria saying shears stress that means, this one shown in equation 5 is constant for pure plastic deformation. So we have two equations one for the elastic shear stress another four plastic shear stress we can call, now in this equation capital T is the tau applied to the specimen. Now if the difference between the 2 shear stresses mentioned in equation 4 and 5 if this difference will be minimized then we can get that value for the outer radius and inner radius. So one I am repeating once again the selection of r1 and r2 are done by minimizing the difference in average stresses obtained from equation 4 and from equation 5.

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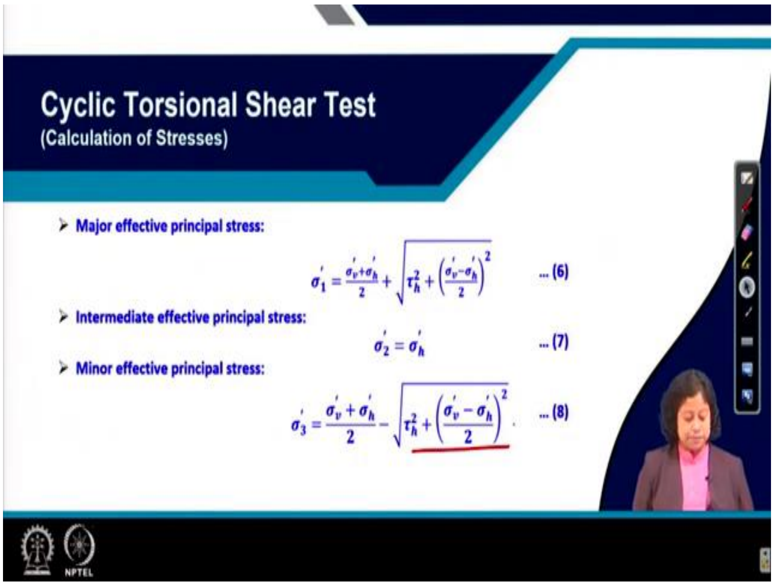

Now with this now we know the amount of the vertical effective stress, horizontal effective stress and shear stress applied or developed in the soil sample. So from that we can calculate the major effective principal stress using this equation. So sigma v dash is vertical effective stress and sigma h sigma dash h is horizontal effective stress tau h is the shear stress, intermediate effective principal stress that is sigma 2 dashed should be equal to sigma dashed h.

And minor effective principal stress which is sigma 3 dashed is equal to sigma v dashed plus sigma h dashed divided by 2 minus square root of tau h squared plus sigma v dashed minus sigma h dashed divided by 2 whole square. So using these 3 equations, we can find out major effective principal stress, intermediate effective principal stress and minor effective principle stress.

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Come to the summary of today's lecture. Today we have discussed the basic criteria for development of uniform shear strain on the soil specimen that is r1 divided by r2 is equal to h1 divided by h2, then we have started the stress calculation, stress calculation means how to calculate major effective principal stress, intermediate effective principal stress and minor effective principal stress.

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Here in this slide you can see the references which I have used for today's class. You can see there are 2 references reference number 3 and 4 are taken from general papers thank you.