Geotechnical Engineering - II

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Lecture No. 14

Shear Strength of Cohesive Soils II

So, for these types of samples normally we do vane shear test. So, somewhere in between 2D and 3D falls the category of a vane shear test. Those of you who have done engineering mechanics properly will realize that it is a good example of the bearings which you talked about.

So, what a vane is like? These types of soils, which are very sensitive, I will bring them, but I cannot take out the sample from the sampler, and what I will be doing is I will be keeping them in a casing or a sampler itself, and then I will lower down a vane, please see the videos, which I have asked you to look into.

So, this is a sort of vane, this could be a laboratory vane, or this could be a, this is a shearing which you are applying or the torque. So, this could be a laboratory vane, or it could be a field vane, most of the bridges in offshore environment are designed by conducting these tests by mounting the setup on a boat or a ship.

So, a good example would be Bandra-Worli Sea Link or MTHL, which is going on right now a huge project in Bombay city. Thousands of vane shear tests have to be done, because there is no point in taking out the sample, samples are very soft. If I draw the free body diagram of this type of system, this is how it is look like. This is the blade of the vane AA and BB, radius is R, length is L sometimes they use *h* also to define this.

The movement is going to occur about this axis by applying a torque. So, draw the free body diagram this you must have done in your Engineering Mechanic's course. This end is resting in the sample this could also rest inside the sample or it could be outside the sample, depends upon the boundary conditions.

So, suppose if I assume a situation where the entire vane is contained in the sample itself, and then I am rotating it, imagine you have a highly viscous fluid like honey and take a spoon and try to rotate it or the way you make coffee. So, you have to stir it, or you have to twist it. So, this is a type of test which is being done over here. I hope you will realize that this is how the cohesion will get mobilized. So, this is the vertical face, this is the cohesion which is getting mobilized do not mistake this as this C_v. So, this will be I will right the vertical, cohesion, units of cohesion are normally kPa or kN/m^2.

Soft sensitive material, so we do not use ϕ over here. What about this point, this is axial rotation. So, I will assume a pressure distribution or the cohesion mobilization in this way. At the centre point, the cohesion will be 0 and this is the distribution of cohesion, horizontal plane on which the cohesion is getting mobilized. So, I will write this as horizontal.

I cannot use the term C_r because C_r we have used for radial consolidation also, cohesion of radial consolidation. Now rest is just simple you have the symmetry about this point. And this is how the cohesion is getting mobilized. So, I hope you can solve this problem very easily. You can obtain this term the total torque required would be,

$$\tau = [(2\pi r).h.C_v.r] \rightarrow \text{Vertical plane}$$

So, this is a component of the torque which is coming due to the mobilisation of cohesion in the vertical plane and plus the horizontal plane. So, there are two triangles now, to solve this problem the way you did in your end bearing cases you are studied in end bearing in the Mechanics course, you must have.

So, this is sort of end bearing if I take a pointed chalk and if I rotate it the cohesion mobilization at the tip is 0. So, this becomes an end bearing in most of the piles, structural piles not the biological piles. So, most of the piles are end bearing systems. So, you go deep inside the ground and tamp them in the hard rock and the entire bridge can be located on the top of it.

So, when you are designing this type of or analysing this type of system, what I have to do is just to clear remind you, if this is the C_{ht}, horizontal cohesion and this is at r, I can go by analogous triangles and this is your C value, C at r and you can derive relationship between,

$$\frac{C_{ht}}{r} = \frac{C}{r_1}$$

Ideally,

$$C_{ht} = C_{vt}$$

Ideally, but for taking into account the heterogeneity and anisotropy of the system of the soils, we have split it in two parts.

So, the way you will write this term is now,

$$\tau = [(2\pi r).h.C_v.r] + 2[\pi r_1^2 C_1 (r_1 dr)(r_1)]$$

So, you can substitute here C1 integrate it and then get the terms that will give you the total value of the torque. What is the advantage of doing this type of test? You are realizing there are two unknowns C_{vt} and this will be C_1, C_1 is a function of C_{ht}. So, C_{vt} and C_{ht} are unknowns. This is the surface area. So, this will be I had written is this correct now, so, this is a surface area r_1.dr. At this given is acting multiplied by (2r/3).

This is the point of application of the total C value C_1. Vertical part is the surface area of the fin or the vane. I have mobilized C value. So, this is 2πrh is the curved surface on which C_v is acting multiplied by r is the moment. From this point if I take moment of this point, this will be this term. 2πrdr. So, this becomes your anulus ring 2πrdr on this C_1 is acting and this is the moment.

Now, what you realize here is that the principal unknowns are C_{vt} and C_{vht}, two unknowns. Now, the question is how we will solve this? So, these types of tests are very trivial in the sense that at the same location you have to do two times the test. So, that you get τ_1 and τ_2. So, if you have two equations minimum then only you can get the value of C_{vt} and C_{vr}.

So, if you perform this test two times you have two equations, you have C_{vt} values C_{vr} value you can solve this. Now, one of the beauty of this systems is that, if I am dealing with let us say a heterogeneous system, suppose there could be a situation where there is a layered soil and I know that this is soil 2 and this is soil 1.

So, problem becomes more complicated now. So, now, you have C_{vt1}, C_{vt2} and this remains your C_{ht}. Now, you require three equations to obtain the heterogeneity of the system. So, depending upon the situation you can perform these tests. Now, there is one parameter which is to be defined here which is known as sensitivity parameter.

Now, this is what is the ratio of the remoulded sample of the soil,

$$\text{Sensitivity } (S) = \left[\frac{\text{Undisturbed shear strength}}{\text{Remoulded shear strength}}\right]$$

This is another classification scheme which is used to deal with the sensitive soils very soft and sensitive soils S parameter is used and typically the value of S is you know and the description, you need not to remember this.

S Value	**Description**
1	Insensitive (OC soils)
1-4	Low sensitive
4-8	Sensitive
8-16	Extra sensitive
>16	Quick

Vehicles sinks not only in the sands, there is a possibility where this may happen in the soft sensitive quick clays also. And there we describe the quicksand condition and remember all this description is for very soft and sensitive clays which are mostly obtained in marine environment.

And I am sure nowadays most of the infrastructure development is happening where in the offshore regions because good land has already been used by your grand grand parents and you are now left with to do with the engineering in such type of deposits which are extremely difficult to understand sample drain.

So, from this point onwards engineering the soft clays starts this will be, please take care of all this. I can give you the concepts. So, now this is correct. So, 2r1 by 3 you are applying the integration from this point to this point. So, the way I have defined this is I am taking only this surface. And I am varying C from this point to this point because there is a discontinuity at this point.