Geotechnical Measurements and Explorations
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Lecture No. # 17

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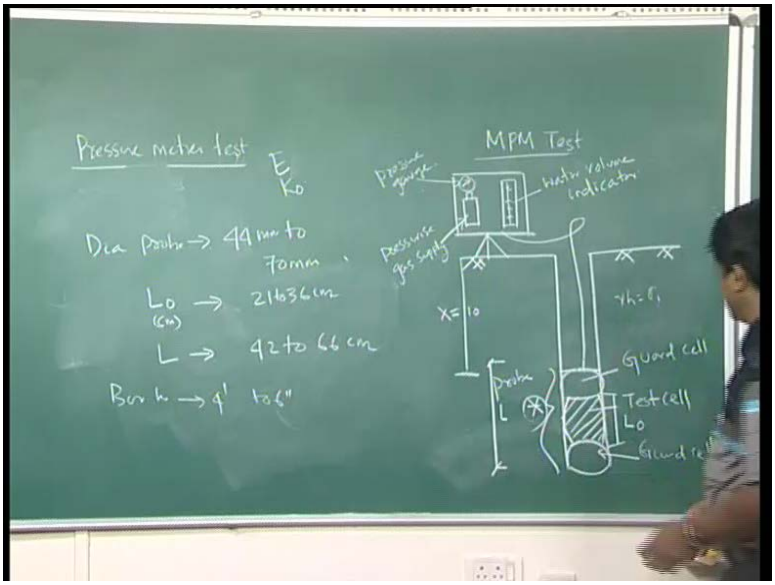

Now, this is all about this pressure meter test. Now, this dimension of this pressure meter test, generally the probe size; diameter of probe varying from 44 mm to 70 mm; then if I say, this is L and L 0, if this is test cell is L 0 and total probe length is L. So L 0 in centimeter, it is varying generally 21 to 36 centimeter; now L is varying between 42 to 66 centimeter; borehole diameter, borehole you can make it 4 inch to 6 inch. Now with this, the pressure meter test as I say, you can calculate is E and K 0, modulus of elasticity and K 0.

Now, can I do this pressure meter test for all kind of soils? In rock, no; in rock, what will happen? No, it cannot either what will happen by means of the philosophy behind it, it will expand, because this test cell will expand, with expansion this soil also expand; that means soil should be, at least soil should be kind of medium to loose not very stiff kind of soil. So if it is stiff or it is rock, what will happen? The test cell, the volume even if it will expand, it cannot expand this stiff or rock. So there are limitations also. To overcome this limitation, there is another test that is called fracture test, hydraulic fracture test, hydraulic fracture test or hydraulic fracture method.

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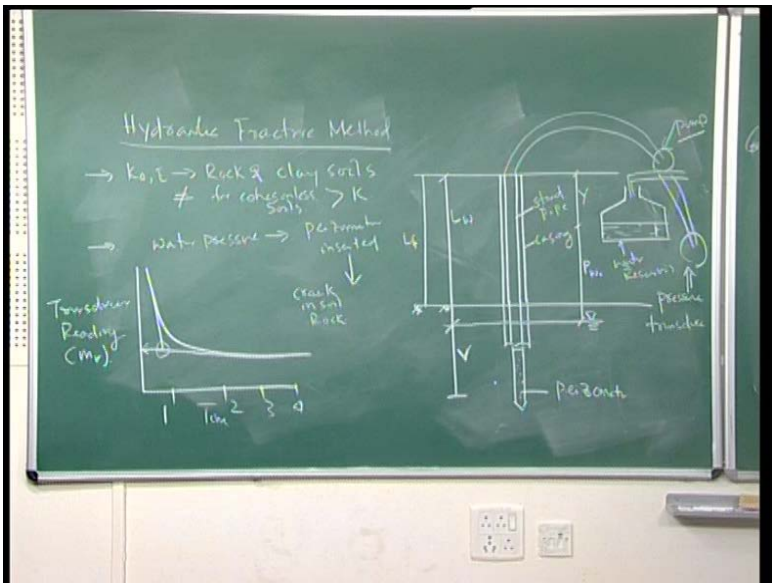

In this, you can find K 0, E for rock and clay soils. But it cannot be used used for cohesion less soils of greater coefficient of permeability. So, basically the concept is under pressure, under water pressure, piezometer inserted inside the borehole, inserted, it will make a crack in soil or rock; that will that will give your value of sigma 3. Now if I draw schematic picture of this hydraulic fracture test. Now, this is first you do the casing, first you do the bore hole, then you insert the casing, this is casing. Then inside casing, insert the standpipe; with this with this standpipe, by means of a probe or maybe connector, by means of probe, insert a piezometer; and this has been connected to (no audio from 06:04 to 06:20) water tank or water reservoir.

So by means of pump arrangement, by means of pump arrangement from water reservoir water pressure is applied to this, suppose at this point sigma 3 has to be calculated or K 0; through piezometer, water pressure, all round water pressure is applied. So once the pressure will increase, increase, and at certain point, there will be crack will develop in the soil or in the rock; the the movement the crack will develop, the pressure will be released; at that point, that is a point of your sigma 3. If I write this is this is my ground surface, and this is termed as L f; then with this water table, this is L w, and reservoir is full, here it is called P wi, and this is height Y. Then volume V is equal to equivalent volume or height in terms of volume of the water. So from this a transducer reading, a transducer, pressure transducer is there, pump is there, and at this point, pressure transducer is there.

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Transducer reading you will get it, because the moment you apply water reservoir; from water reservoir to water pressure to the soil through this piezometer, the moment you will apply the pressure, what will happen? The transducer will give the reading of this pressure. So the pressure will increase, increase, increase, how it looks? Somewhere else, there is no further pressure or maybe first start with this pressure, it will increase, increase, increase, increase at certain point, after certain point there is no more increase, the pressure will remain constant or it may possible that it may decrease. So by means of double tangent, find it out this fracture or pressure pressure corresponding to the your fracture. This is your transducer reading in m v, and this is time, say 1 minute, 2 minute, 3 minute, 4 minute like this, 1, 2, 3, 4.

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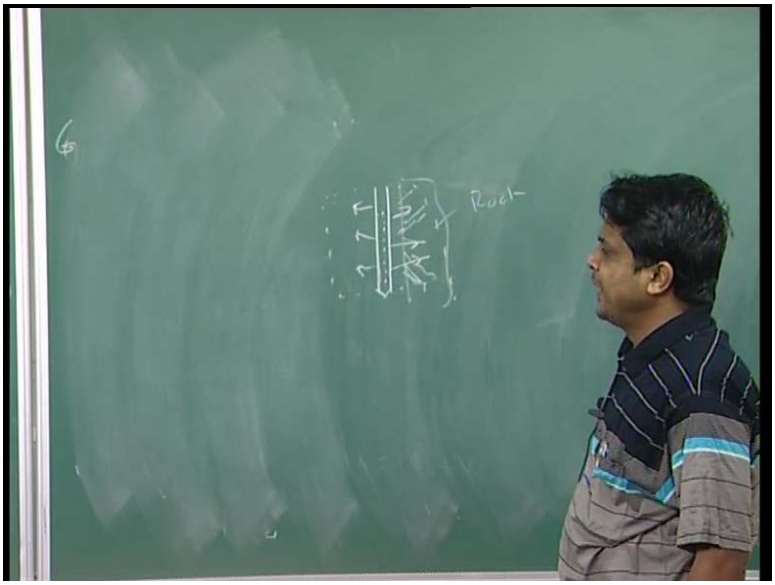

What is the concept here? Suppose suppose this is the piezometer; then this is surrounding soil or maybe rock. Under water pressure you see, then hydraulic pressure will be developed in the piezometer, water pressure, water will try to flow. Laterally, all round it will try to flow, then the pressure will increase; slowly, slowly what will happen? This soil will be this soil will be it will be, lateral deformation will be there, slowly, slowly; the volume change with… No volume means, by means of pressure the lateral deformation will be there. At certain point, you are applying pressure by means of water in through this piezometer, so the pressure is increasing, increasing.

At certain point, this there if there is rock mass, complete rock mass, water inside the void will go, water inside the void of rock will penetrate; so, the pressure will increase. At certain point, the void inside the it will become crack; once there will be crack, so there will at what point you know that crack will be developed in soil or the rock? At that point from pressure transducer, you can observe that it will increase, increase; at certain point it remains constant; no more further change in pressure, in pressure transducer or it may happen, the pressure may fall, it may happen the pressure pressure may fall. So that point where it remains constant at that point that is your fracture point or it it relates to your sigma 3.

So you know, what is this height, this height, total height? Where you are finding out your K 0 or E may be at this point. So with gamma, you can calculate you can calculate what is your sigma 1? Once you know sigma 1 and sigma 3, you can calculate K 0. How to calculate E? E is nothing but your stress versus strain, so stress how much applied with strain? You can find it out E.

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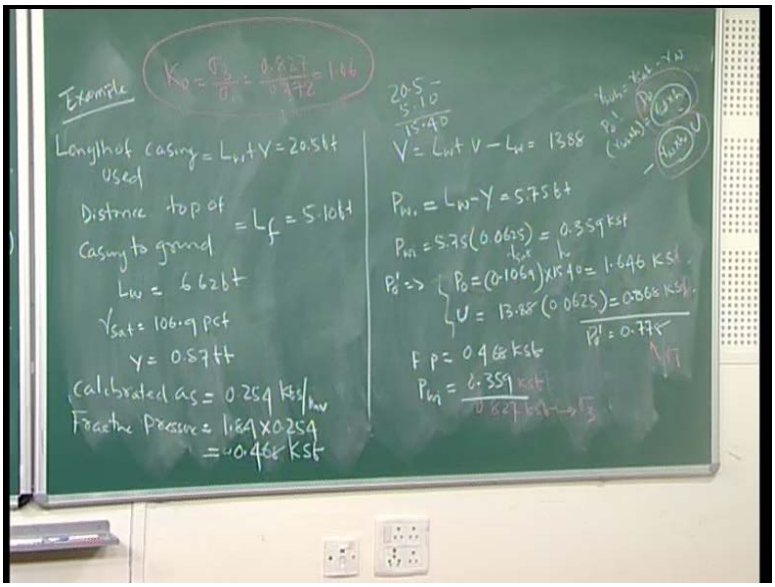

Now we will solve one example, hydraulic fracture method. So, what are the given data? Given data is your length of casing used, which is equal to L w plus V 20.5 feet. Then distance top of casing to ground, which is equal to L f 5.10 feet. Distance L w it is given 6.62 feet. Saturated unit weight of soil, assuming ground water level at the ground surface, so it will be gamma saturated unit weight of soil, assuming water table is at

ground surface, which is equal to 106.9 pascal per cubic feet. Y, Y this water means water reservoir, where you keep this water reservoir with this distance from here, you can find it out Y. Y is given 0.87 feet. So, this pressure transducer calibrated as it is given from this pressure transducer, it is coming out to be 1.84, it is this point is coming 1.84 mv. So pressure transducer calibrated as 0.254 kbs per mv.

Now it has been asked, find K 0? Length of the casing used that means length of the casing means, total casing up to here, the casing has been made, it is L f, L w plus V, L w plus V is given; distance top of casing to ground distance top of casing to ground, from here to ground L f is given, five point, L w also it is given 6.62 feet the probe, gamma saturated is given, and water reservoir, the height of the water reservoir from this casing, Y is given; then find this K 0.

Now with this help of this, V is equal to L w plus V minus minus L w which is equal to 13.88, pressure because of P wi - L w minus Y, L w pressure generated because of water reservoir, so L w minus Y, this height water reservoir is there. So pressure height is equal to 5.75 feet. Now total pressure you can if this is a pressure height, pressure is equal to 5.75 into gamma w, which is equal to 0.0625, which is equal to 0.359 ksf kbs per square feet. Now P 0 prime - effective over burden pressure, calculate, so P 0 you will get it; gamma is equal to, what is your gamma? Gamma is equal to 106.9 106.9. So, it will be 0.1069 it is pascal per cubic feet, it has been converted to kbs into 15.40, where this 15.40 will come into picture. This is the height, total height 15.40 is coming, this is the total height 15.40 is coming, if you take it L w, what is the value of L w? L w is given 6.62 feet; L w plus V is your 20.5 feet, and minus L f, where is your L f? Minus L f 20.5 minus 5.1, so it will be 15.4. At this height, at this point, you are measuring below the ground surface; you are supposed to measure K 0.

Now what is this height? The L w plus V minus L f this is my height from this ground level, so it is coming 20.5 20.5 it will be, it is coming 20.5 minus 5.10, it is coming 15.4. So this is my gamma and this is H. So from there, you are going to get 1.646 kbs per square feet. Now pour water pressure generated or may be developed, because of water pressure, so this will be 13.88 into 0.0625; probe height total probe height, this your from here the water will be there, and this will be the water. So this volume V equivalent to probe height, which is nothing but is your 13.88; 13.88 into unit weight of water, this is unit weight of water. So which is equal to your 0.868 kbs per square feet and P 0 prime is

equal to 0.778, this is your effective over burden pressure. I calculate total, total minus pour water pressure, so this is effective.

With this calibrated as with this pressure transducer calibration, it is observed that the fracture point observed is 1.84 mv; the calibration is given 2.54 kbs per square feet by mv that means the pressure will be fracture pressure is is equal to 1.84 into 0.254, which is equal to 0.468 kbs per square feet. Now with this fracture pressure, so your fracture pressure is given 0.468 kbs per square feet, and P wi P wi water pressure, this is your fracture pressure, this is your water pressure; water pressure is equal to 0.359, so total pressure is equal to your 0.827 kbs per square feet, so this is nothing but your sigma 3 and this is nothing but your sigma 1. Now you can easily calculate K 0 is equal to sigma 3 by sigma 1, which is equal to 0.827 by your sigma 1 prime or which is equal to 0.778, which is equal to 1.06.

So, if you look at here, if you look at here, in hydraulic fracture method one example is given; details of length of casing pipe and height of this water reservoir Y is given and L w plus V is given, from there you can find it out height equivalent to your piezometric height you can find, and water pressure you can find it out, because of your water reservoir, water pressure height, from there water pressure you can find it out, and P 0 you can calculate P 0, gamma h; gamma is saturated unit weight it is given 106 pascal per cubic feet, it has been converted to kbs per cubic feet which is 0.1069, this is your saturated unit weight. Now h from this ground surface, if you look at here, this h is nothing but this, because your this is your ground surface, below this, this height this height is your h.

Now L w plus V is given, and L f is given, L w plus V minus Lf, this is your soil height, where you want to find it out K 0. From here this h has come from here is 15.4 feet this is your 15.4 feet which is coming 1.646 kbs per square square feet square feet square feet. Now how much effective, because this is water table is at this point, so total minus this pour water pressure, so 13.88 height, this is your height and unit weight of water. If you look at here, how I calculated gamma submerged is equal to gamma saturated minus gamma w. Now, this will be P 0 prime, which is equal to gamma submerged into h, which is equal to gamma saturated into h, this is your P 0 minus gamma w into h, this is your U, this is your U.

Now this P 0 and U in terms of U, I have calculated; so if you look at here P 0 is here calculated and U calculated. So, this if I deduct it, from there effective stress you can get it 0.778. Then another point is given; from fracture pressure or may be pressure transducer, from pressure transducer, this has been given, this graph has been given with increase in pressure with time, this profile has been given; with this help of graph, with this help of this graph draw a tangent initial part and draw a tangent bottom part, find it out, where the change in pressure? What will happen? Pressure increase, increase, increase, increase, upto certain point, it starts either decreasing or it remains constant. So this point is nothing but is your fracture point; so that gives from this graph 1.84 mv. Now this calibration calibration curve it says 0.254 kbs per square feet per mv; so for 1.84 mv, what is your fracture pressure? It is 0.468; this is your fracture pressure, fracture pressure generated generated by water pressure; that means you have to consider water pressure also.

So, fracture pressure is there, water pressure is your 0.359 kbs per square feet, so total you are getting; because of fracture pressure because of water pressure 0.827 that is nothing but is your sigma 3. So you know sigma 3, you know sigma 1, so sigma 3 by sigma 1 if you get it, you will find it out your K 0 that is your 1.06. Where this K 0 has to be used? As I said earlier, this K 0 nothing but earth pressure at rest, earth pressure at rest.

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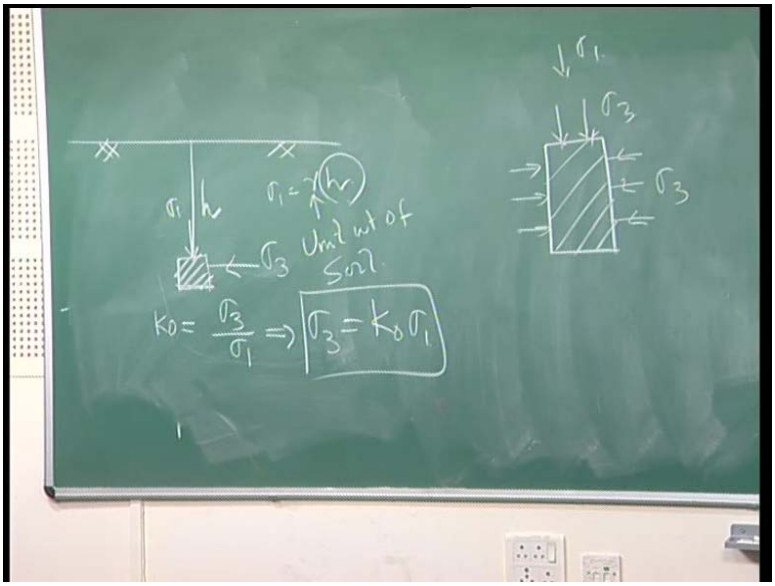

Now if you take a soil sample here say at a height h, this soil sample is there; it has been collected from this ground surface. Now, you you should know to simulate in the laboratory, to simulate in the laboratory say triaxial test, you should know, what is the value of sigma 1, and what is the value of sigma 3, what is the value of sigma 3? So this sigma 1 and sigma 3, if I if you look at here, the triaxial testing procedures, in triaxial test, what will happen? This soil sample placed inside the triaxial chamber. So, initially you apply confining pressure, all round confining pressure of sigma 3. Then after consolidation is over, you apply shearing with increasing value of sigma 1, apply it. So, from where you will get this sigma 3? Sigma 1 I can calculate gamma into h, this is unit weight of soil, and this is the height considered means, where this soil has been taken; sigma 1 you can calculate.

Now next parameter, how do I know this sigma 3? Sigma 3 is nothing but if you go there K 0 is equal to sigma 3 by sigma 1, then you can find it out sigma 3 is equal to K 0 into sigma 1. Now if you know K 0, if you know K 0, then only you can find it out sigma 3; if you do not know K 0, from where you will get it sigma 3? So that means you K 0 earth pressure at rest in insitu; so that is why this field test is required. Similarly for rock, if it is a soil, suppose there is a rock, similarly for triaxial test, to know this C and phi parameter, to know the phi parameter, soil as well as rock, so you have to go for your triaxial test, you you have to find it out, what is the over burden pressure sigma 1, also you have to set, what is the value of sigma 3; in that case you need to know, what is the value of K 0? If you have your test, field test if you know the K 0, then you can find it out easily, what is the value of sigma 3?

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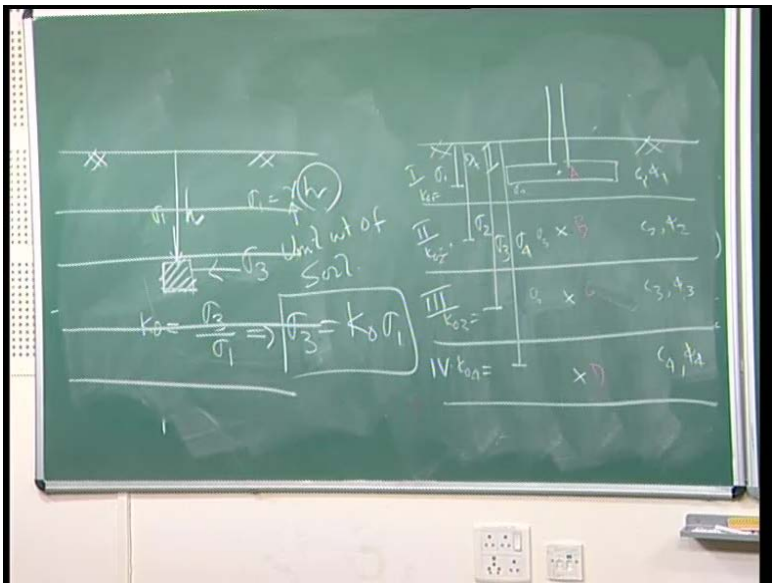

Now let us say this is my ground profile, ground surface; or I can draw once again this ground surface, let us say this is layer 1, layer 2, layer 3, layer 4. Now a footing has to be constructed or stayed in this soil profile; so I do not know, where this footing to be placed. You have to calculate the strength parameter of each layer; C, phi, C 1, phi 1, C 2 phi 2, C 3, phi 3, C 4 phi 4. Now for each layer, each layer by means of boring, by means of boring you have collected undisturbed sample at this middle, at this middle of this, you collected undisturbed samples. Now for each layer, you know what is the value of sigma 1? Then what is the value of sigma 2? Then what is the value of sigma 3? Then what is the value of sigma 4? What I mean, if you do not do K 0, if you do not do hydraulic fracture test or maybe pressure meter test, you cannot find it out K 0. So, once you know the K 0 value of each layer, so layer 1 - K 0 1 is this, layer 2 - K 0 2 is equal to this, K 0 3 is equal to this, K 0 4 is equal to this.

Once you know K 0 value for each layer, then with knowing with known value of sigma 1, sigma 2, sigma 3 and sigma 4, you can easily calculate, what is the value of sigma 3 here, sigma 3 here, sigma 3 here, sigma 3 here. Once you know the sigma 3, then whatever the soil sample you collect from the field at this point, suppose say this is the soil sample at this point say A, B, C and D; then easily you can conduct means triaxial test in the laboratory to find it out the parameter C and phi, C 1 phi 1, C 2 phi 2, C 3 phi 3, C 4 phi 4.

So, this is basically the requirement, directly this requirement for field explorations may be to know the engineering properties. And it has advantage that you will get whatever the K 0 value that to be in the insitu conditions; without disturbing this soil sample inside the ground, you are finding the K 0 value. Then then once you get K 0 value, rest problem will be solved. So these are the two methods, hydraulic fracture as well as pressure meter method. Generally in India, pressure meter method has been applied means, widely used; but hydraulic fracture method has been used, where these rock mass is there, because pressure meter you cannot do this test in rock mass; rock mass, this hydraulic fracture method has been used.