Geotechnical Measurements and Explorations

Prof. NiharRanjanPatra

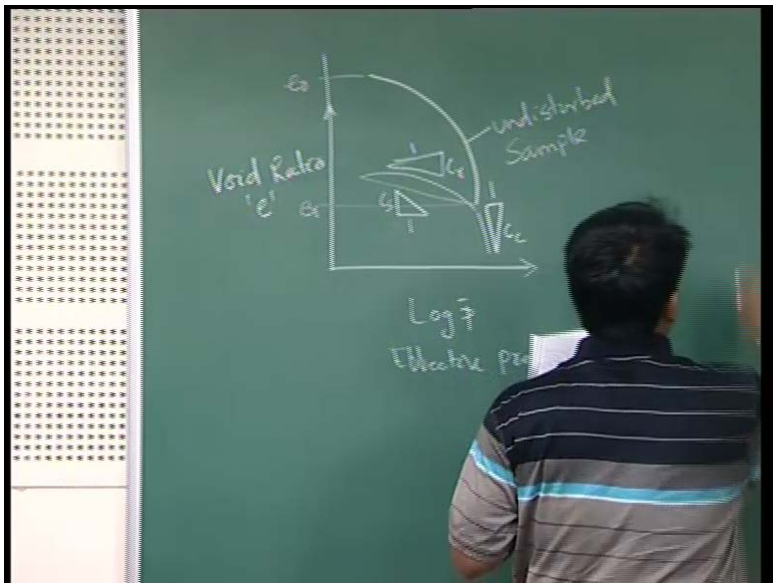
Department of Civil Engineering

Indian Institute of Technology, Kanpur

Module No. # 01

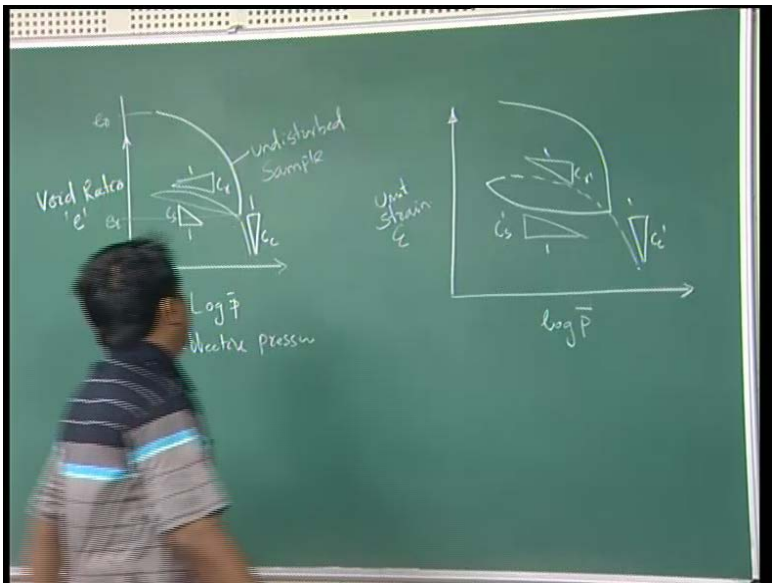
Lecture No. # 02

(Refer Slide Time: 00:20)



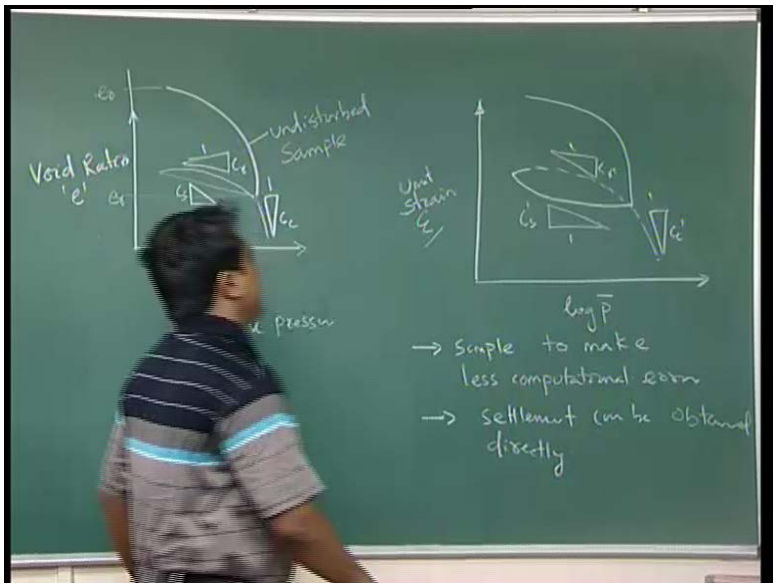
These are the two standard curves you can say; one is e versus log p, e is void ratio and this is log p or effective pressure. So, the curve is coming so now if I extend, this is my e zero and this point will be e r, this is c c one, cs then one and this is one c r.

(Refer Slide Time: 01:52)



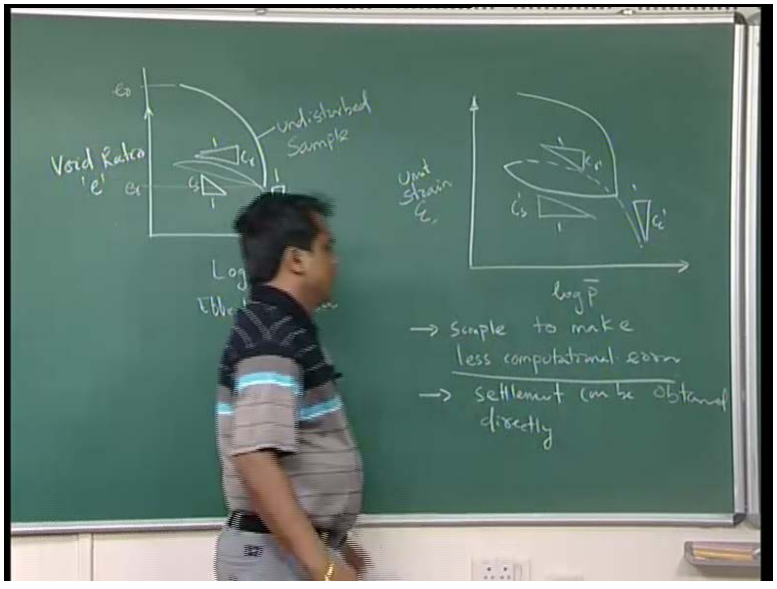
You can plot it, consolidation curve either void ratio versus effective stress or unit strain from where you can get c r prime and this is your c c prime one. Now, yesterday means last class we have covered this c c. cc is your compression index. Two curves you can plot it generate for your finding out c cc r and c s what is c c? c c is your compression index and c s is your swelling index swelling index c r is your recompression index. Either you plot it void ratio e versus log p or unit strain unit strain versus log p. There is a advantage if you plot it you need strain versus log e curve. The advantage is like you can you can you can make this e versus log p you can plot always convenient it it is it is a simpler.

(Refer Slide Time: 03:33)



It is simple then to make simple to make, less computational error and another one is you can get directly settlement. Settlement can be obtained directly from this odometer test or the consolidation test you can go for void ratio e versus log p or unit strain. How do you get the unit strain? It depends upon this displacement of this dial gauge from this displacement you can get your strain. If you plot this strain versus log p or effective stress this is easy, there is a chance that with this plot there might be a possibility that computational error will occur.

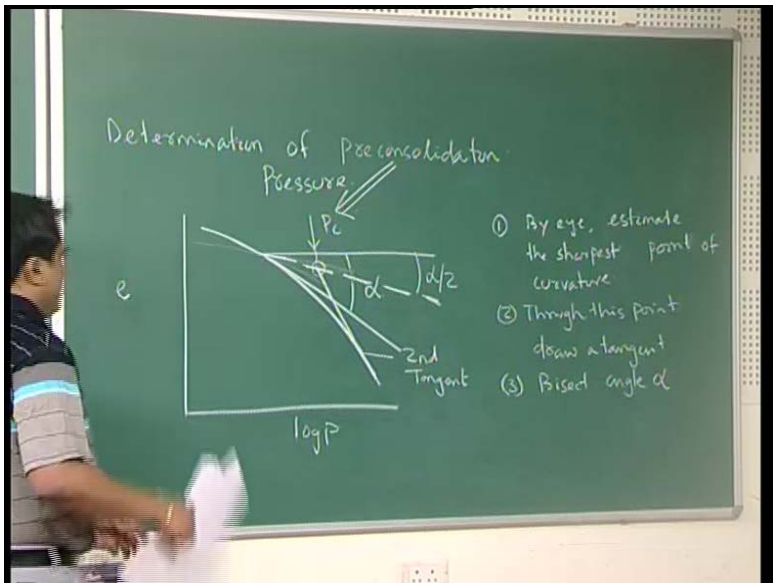
(Refer Slide Time: 04:43)



But, in this plot, the simple means less computational error may occur. Also settlement can be obtained directly from this plot. Now, our next step is these are all your undisturbed sample from this field there is a error between field and lab once you are doing laboratory test, oedometer test because of over burden pressure lost as well as your other constants. So, there are certain correction has to be applied with your e versus log p.

Before I go for certain corrections for e versus log p how to find it out pre consolidation pressure? Based on the pre consolidation pressure you can say that soil is over consolidated or consolidated or may be normally consolidated.

(Refer Slide Time: 05:34)



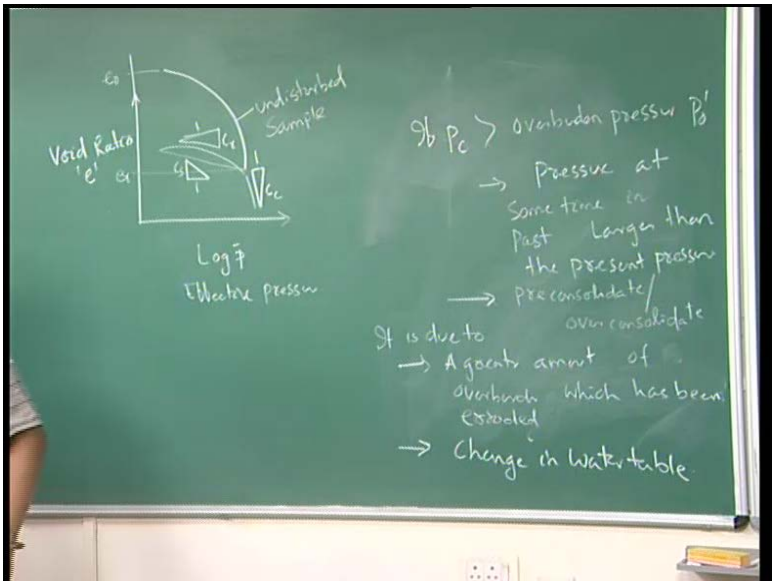
Now, determination of of pre consolidation pressure, look at this curve. This is typical e versus log p.

So in e versus log p you will get a curve like this. So step one step one by your i, by i estimate estimate the sharpest point of curvature. That means by i by i estimate your sharpest point of curvature, from there draw a tangent draw a tangent second step is through this point, draw a tangent. Now this point is it as a beginner, it will take time. Once you practice, then you can easily identify where the sharpest point of this curvature. Once you identify the sharpest point of the curvature then through this point you draw a tangent, this is a tangent and with this a horizontal line is drawn, with this point a horizontal line is drawn and this will generate an angle say alpha.

Now, third point is bisect angle alpha. Now this angle you just bisect. It has been bisected so it will be alpha by two. Now, with this from this curve from this curve e versus log p, identify bottom part of this curve where you can draw a tangent such that it become straight line or may be a there is no more variation or no more change in curve with this or may be curvature changes, with this you extend so that with this tangent this is second tangent. Now, you are getting point, this point is your p c. So p c is nothing but, your pre consolidation pressure. This point is your p c that means once again I am repeating draw e versus log p, then by your i this curve identify, estimate where the sharpest point of the curvature is. It may be like this sometimes it may be like this sometimes it may be like this.

So in this point you once you identify by eye contact the sharpest point with that point draw a tangent. So a tangent has been drawn with that point. Then with that point through this point draw a tangent through this point also draw a line. Then generate generate angle alpha once angel alpha is been generated bisect this angle alpha means alpha by two and this bisect line has been dotted here by means of dotted lines. Bisect line has been plotted here by means of a dotted lines. Then at the bottom of this curve, identify draw a tangent bottom of this curve from this where there is no more change in curvature. Then where it intersects, that point gives your p c or pre consolidation pressure. What does it mean with this p c or pre consolidation pressure? It will indicate whether soil is over consolidated or may be normally consolidated.

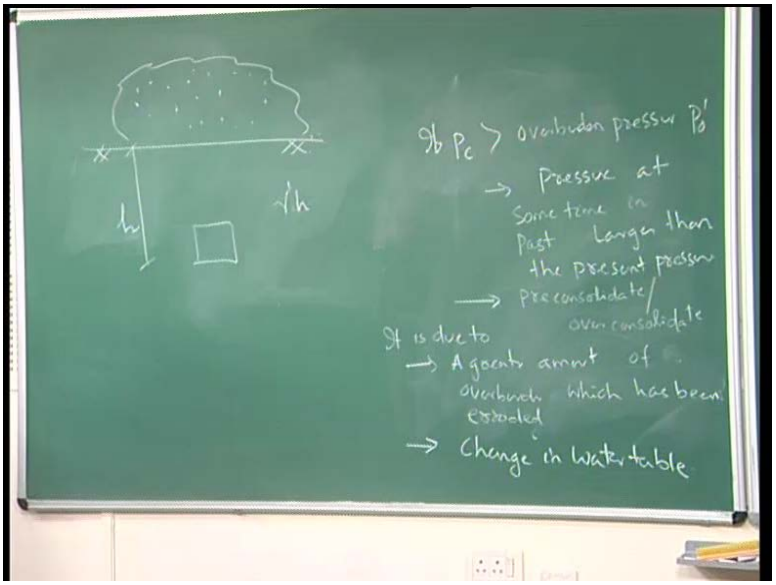
(Refer Slide Time: 10:37)



Now you can say that if p c obtained from this curve is greater than over burden pressure or p zero prime then what will happen? If p c is greater that in-situ over burden pressure then what does it mean? That means pressure at sometime in past is or may be larger than the present pressure. Then in that case, soil is said to be, soil is pre consolidated consolidated or over consolidated. It is due to a greater amount of over burden which has been eroded. Then change in water table.

Now whatever we are getting here, p c pre consolidation pressure, if pre consolidation pressure is greater than your over burden pressure what is this over burden pressure?

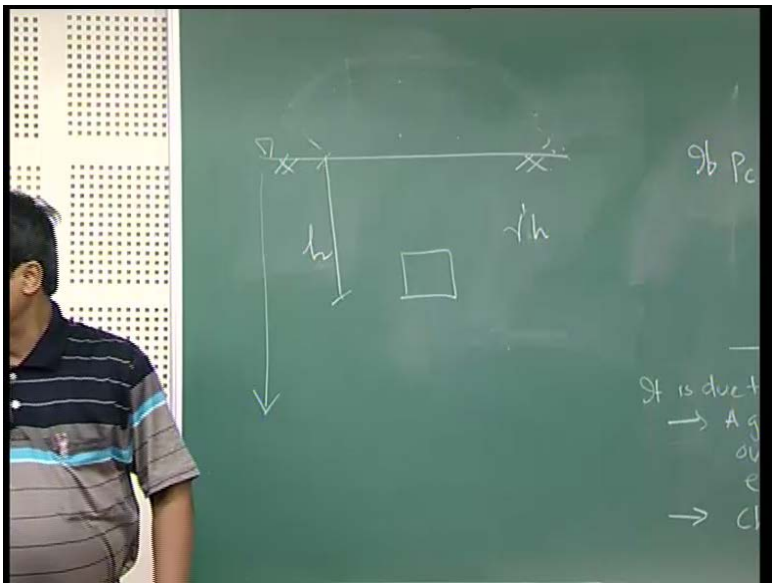
(Refer Slide Time: 13:01)



Suppose we collect suppose we collect soil sample below the ground surface at a depth say h. With this h what is your over burden pressure? Over burden pressure is your gamma prime gamma prime h. So, in that case whatever we are getting pre consolidation pressure from consolidation curve if it is greater than over burden pressure that means what does it mean? Why it is greater than?

That means in past recent past pressure at some time look at here in recent past pressure at sometime is larger than the present pressure. Whatever pressure present here means till today earlier the pressure on this ground was larger. it It was due to because this over burden which has been earlier it may possible in the past there are some searchers it was existed. May be due to rain or may be due to manmade may be due to certain things it has been eroded away.

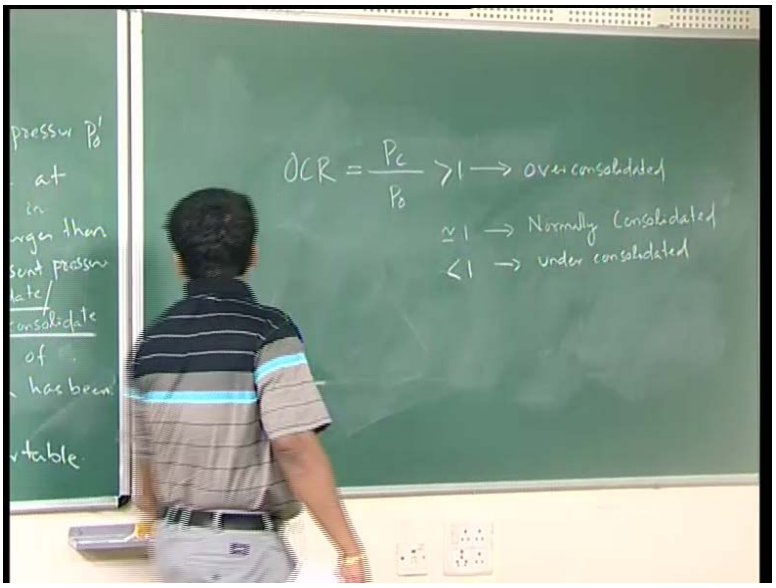
(Refer Slide Time: 14:08)



That means it has been removed or it has gone.

Then second part is your due to suppose water table is always there at may be in the ground surface due to this rise in temperature the water table goes down, down, down. So, change in water table also it causes pre consolidation pressure greater than your over burden pressure. In that case in that case we say either it is a pre consolidated or over consolidated soil. Pre consolidated means it has been consolidated earlier or over consolidated means it has been consolidated earlier. That means the pressure earlier was much more than the present pressure that is your gamma prime into h.

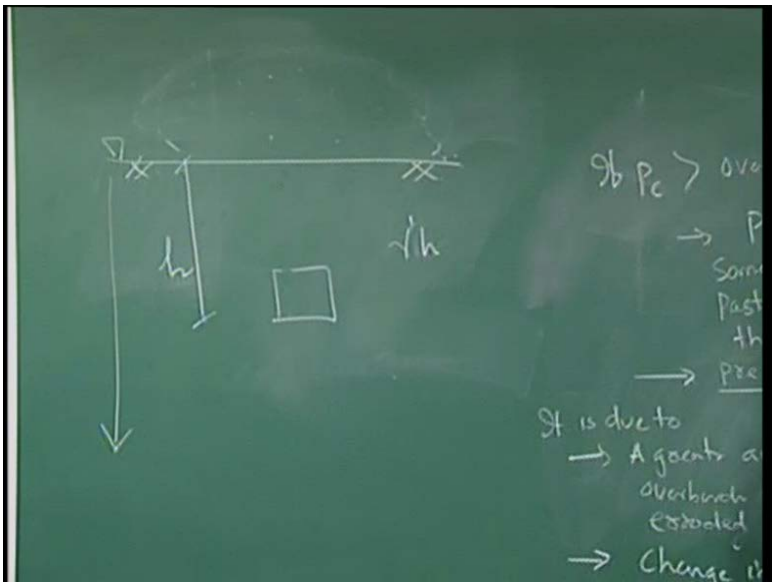
(Refer Slide Time: 14:58)



Now there is another term it is called o c r. That is called over consolidation ratio. OCR is over consolidation ratio it is nothing but, p c pre consolidation pressure by p zero. That is your over burden pressure. If it is greater than one then it is called over consolidated. Then if it is one that means it is called normally consolidated. If it is less than one this is called under consolidated. Now over consolidation definition I have explained right now.

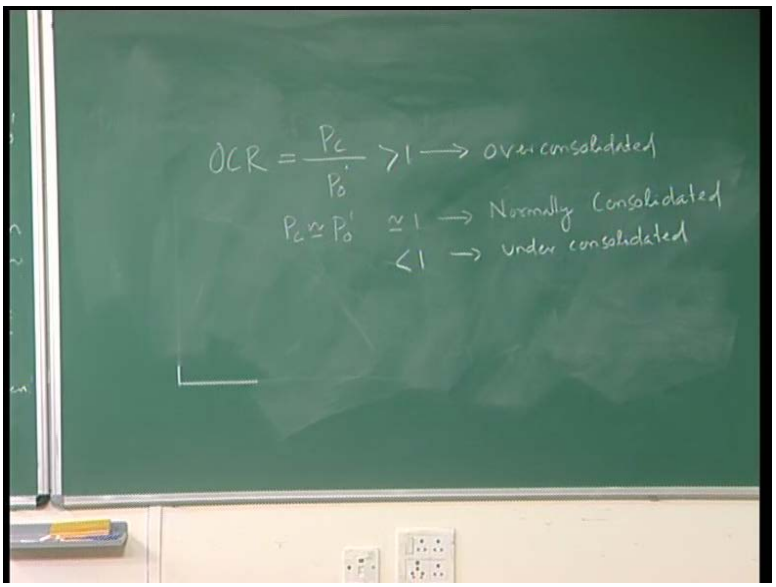
Now, normally consolidated; that means in recent past whatever pressure above the soil mass was there right now the pressure is same.

(Refer Slide Time: 16:20)



In that case it is called that means p c is equal to p zero.

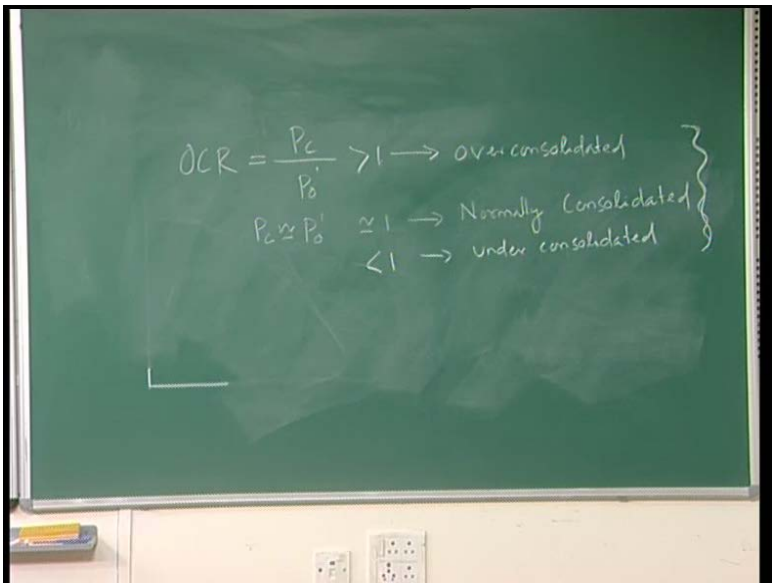
(Refer Slide Time: 16:24)



In that case pre consolidation pressure is equal to over burden pressure. So, p c is equal to p zero. So, in that case it is normally consolidated that mean the consolidation process has been started. It is normally consolidated. In over consolidation or pre consolidation means the consolidation process already started in the past, it was already consolidated so it is just continuing.

Now, if p c is less that p zero what does it mean? That means it is under consolidated, that means pressure in past was less than whatever pressure over burden pressure now. That means the consolidation process has not been started yet.

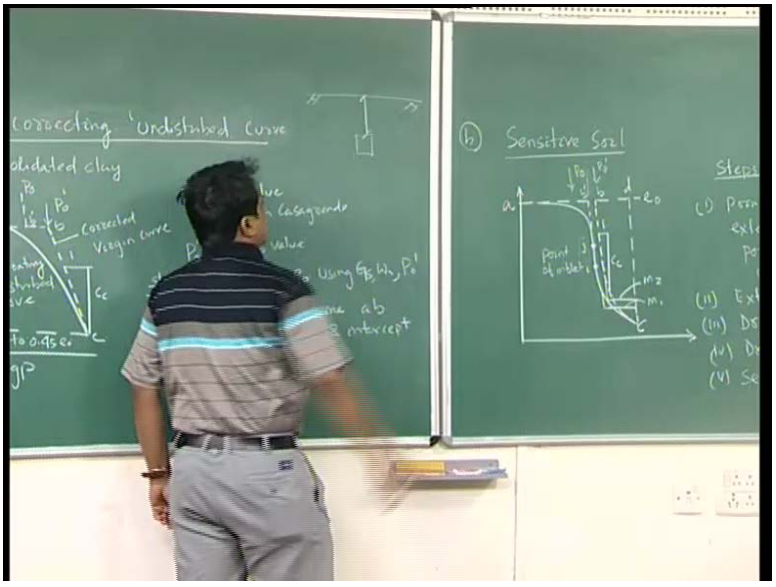
(Refer Slide Time: 17:17)



These three terms will be used throughout this course; over consolidated, normally consolidated and under consolidated. So, this clarifies at what condition it is over consolidated and what condition it is normally consolidated and what condition it is under consolidated.

Now whatever we are getting undisturbed soil sample in the field; the moment we bring this undisturbed soil sample from field to lab, so this over burden has lost.

(Refer Slide Time: 17:55)

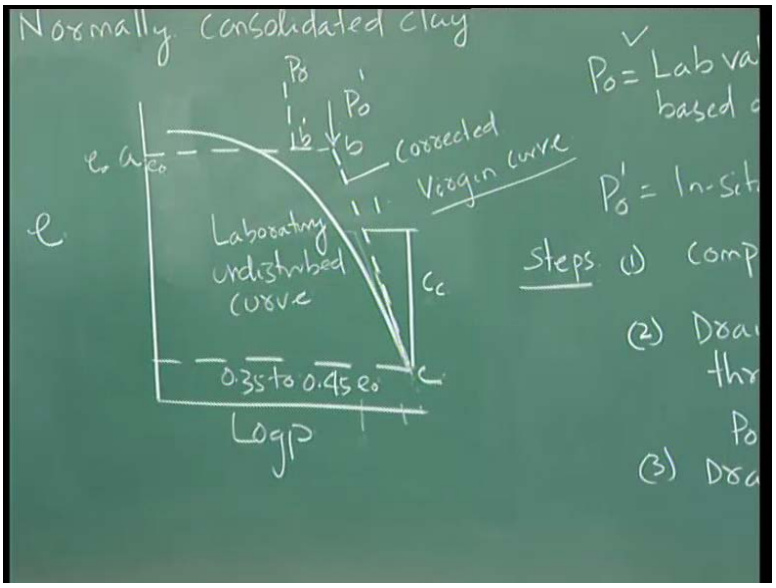


As I said earlier, once you collect the soil from undisturbed soil from the field. The moment I collect the soil take out from the field to the lab, that means this major prime of this over burden pressure has left. Means it has completely gone as well as this pressure, confining pressure also it has sometimes it lost, sometimes it is there.

So to simulate means the moment you bring it bring it back to lab then you go for consolidation test. Whatever the curve you are getting in the laboratory consolidation curve that is not truly representating your consolidation curve of field. So to do it certain corrections are required. So that is why I write it here steps in correcting undisturbed curve. Now, there are three conditions; three three parts if I divide it one is normally consolidated clay other is your sensitive soil another one is your over consolidated clay. In case of normally consolidated clay if you look at here e versus log p curve. Now in this e versus log p curve this is the curve this is the curve you are getting in the laboratory. This is laboratory undisturbed curve but, that does not mean that it will represent true curve of this field. That means certain corrections are required.

Now p zero means lab value, lab value based on your casagrande then p zero prime is your in-situ over burden pressure. Now, with this with this step one first find it out initial void ratio e zero. I have written the all the steps. Compute e zero using g natural moisture content and over burden pressure. Using g natural moisture content, w n is your natural n means natural, w is your moisture content natural moisture content and over burden pressure.

(Refer Slide Time: 20:15)



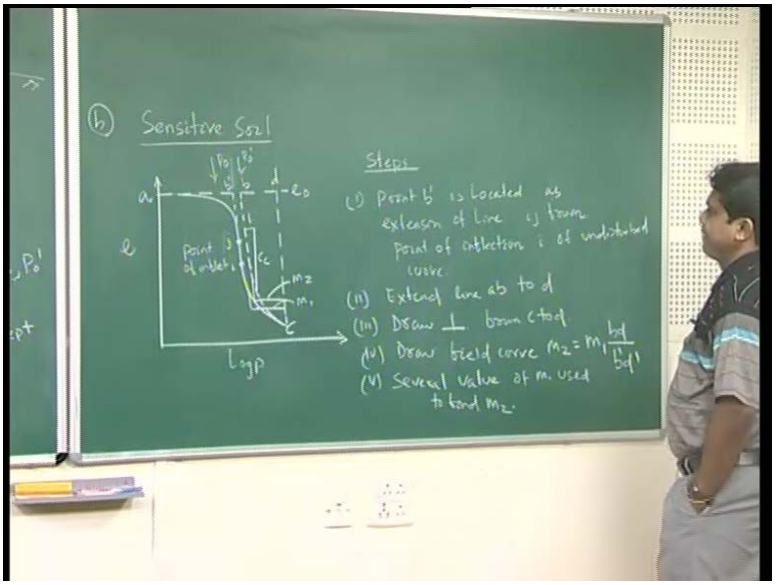
Once you get e e zero; that means this is my e zero. From e zero, that is your point a. Point a is your e zero draw a line a b through e zero. This is e zero draw a line a b. Then you identify this is a log p curve. You identify where is the pressure equal to your p zero. P zero is your lab value based of casagrande. So this point is your p zero so this point is your b prime.

Now this a b you extend it, a b line you just extend it. Now, from this third part is from the bottom of the curve draw a tangent where this curvature is not varying much or it is straight line. From this point draw a tangent and extend this line and this tangent has been extended so it intersects a b prime at point b. So, your b and c this is your corrected virgin curve for field corrected virgin curve for field and whatever you are getting c c this is your true c c representing your field condition. But, whatever you are getting here earlier that is your c c related to your laboratory test. So, be careful once you get it get it done in the laboratory curve the corrections for normally consolidated clay is required. So the steps are like this first identify once again I am repeating, first identify e zero means first calculate e zero. e zero is initial void ratio using g w n and p zero prime w n is your natural moisture content whatever you get it in the field conditions. Then from point e zero draw a line a b. From point e zero draw a line a b and you identify where is you p zero in log p so that b point you can get it. You are getting e zero as a point and b point automatically where p zero is there, pressure in the lab you can get it here. So a b join the a b and extend and from point c draw a tangent that is the bottom part, draw a

tangent and extend it. From point c the tangent extended where it intersect a b prime. At point b this is your b and c is your corrected virgin curve and from the slope you can find it out c c, coefficient of curvature representating your field conditions.

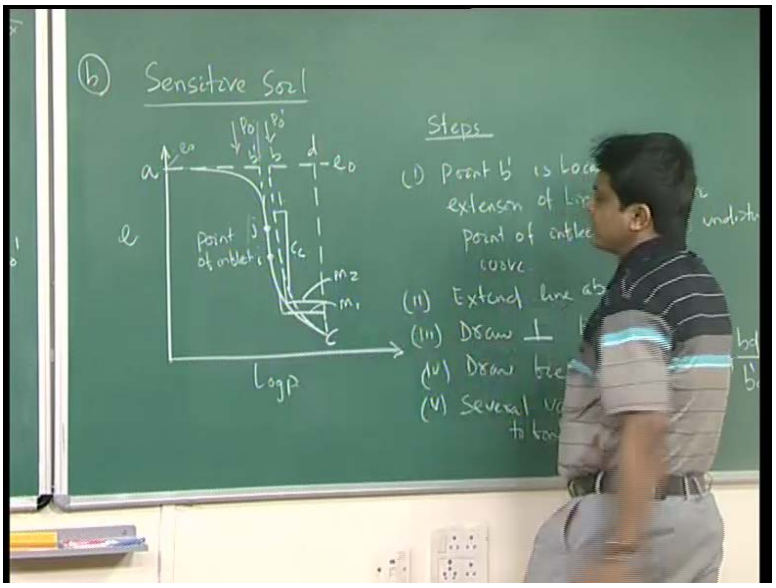
Now second there are three cases as I say. One is normally consolidated clay other is your sensitive soil, another is your over consolidated. In case of sensitive soil so first identify what is your b prime is located as extension of if you look at the point one.

(Refer Slide Time: 23:39)



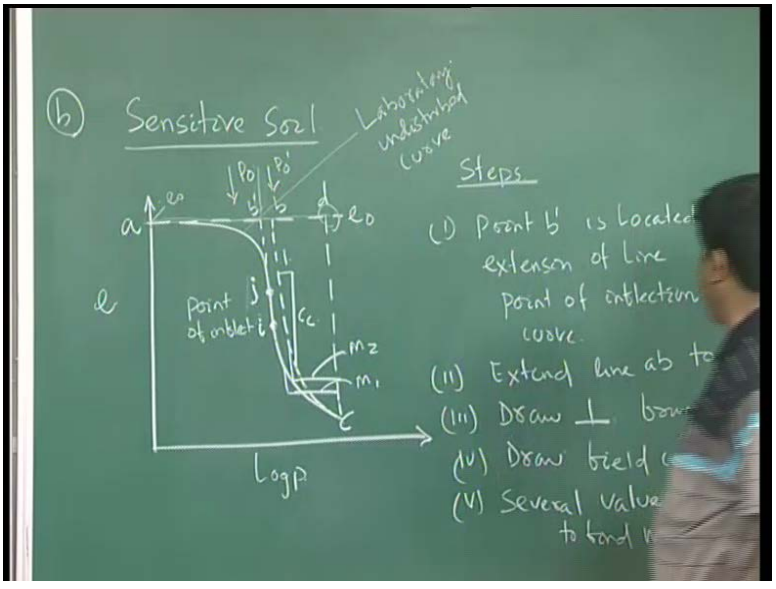
Step one means you draw this is your e versus log p e versus log p draw the curve. So, it has been drawn then point b prime.

(Refer Slide Time: 23:53)



If you look at here the b prime has been located first same step, first you identify first calculate e zero. With this e zero find it out suppose this is my e zero this is your point a then the curve generally sensitive soil, the curve will go in this way all of sudden it will point of inflection. Then it will again asymptotic asymptotic towards log p. So, point b prime is located as extension of line i j. I have taken two points in the point of inflection that is one is i, this is i, other is your j. i and j, point b prime is located as extension of line i j from point of inflection i of d undisturbed curve.

(Refer Slide Time: 24:48)

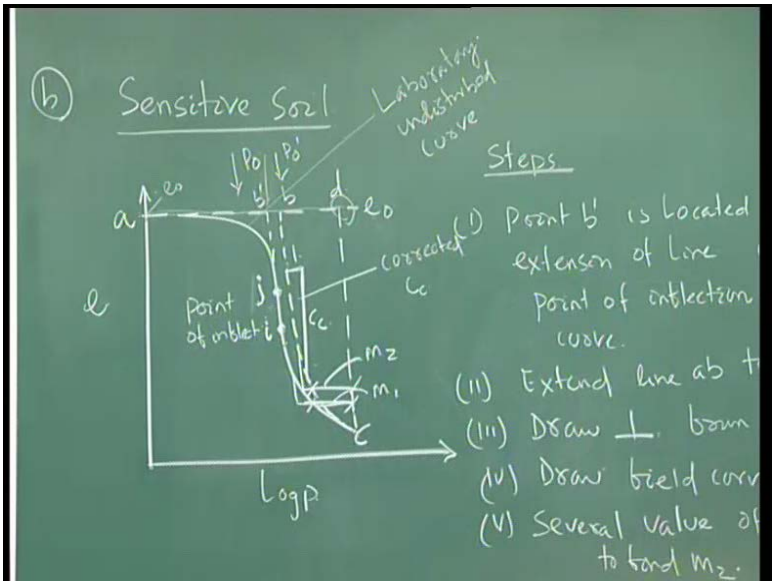


This is your undisturbed curve from laboratory undisturbed curve. You can say laboratory undisturbed curve.

Now you identify where is your point of inflection. First point is, first step is calculate e zero, mark point a, from e zero mark point a. Then second step is identify the point of inflection say i and j. With this i j draw a tangent or draw a line, extend line, line of extension from i j where it intersect with this line e zero line. This is called e zero line parallel to log p. With this e zero line where it intersect. Then extend line a b to d once it intersect with this you are getting line a b. So, extend it a b to d how you are extending to d. From this point c draw a line perpendicular, draw perpendicular from point c it goes here where it intersect a b and here this is your point d. Now you draw the field curve. This is your particularly this is your laboratory curve. Draw the field curve m two is equal to that means m one b d by b prime and d prime. This is my m two, m two is coming from m one is here to here m two is here to here. That means this dotted line is my corrected virgin curve and this is your m one means, this is your laboratory curve so m two you can find it out m one into b d b d by b prime d prime.

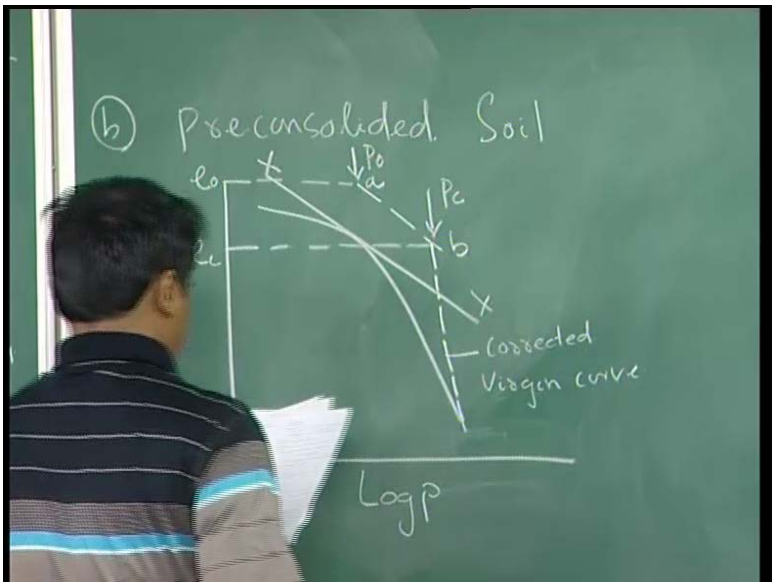
So for different sets of values of m two, you can get sets of m one. Once you get m one value, this corrected curve can be drawn. Once you get corrected curve then you can find it out this slope. From this slope you can get c c or coefficient of curvature.

(Refer Slide Time: 27:27)



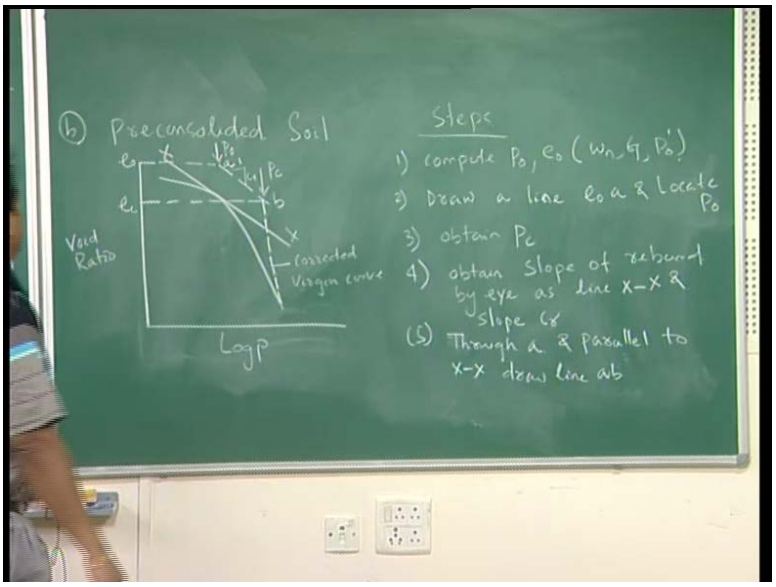
This is your corrected c c this is yourcorrected c c. Now, these are all two another one is for, last part is your that is your c, this is your b part is over. Now c part is your, there are three particularly we have drawn three cases; one is normally consolidated other is sensitive soil.

(Refer Slide Time: 28:01)



Third is your re consolidated soil. Now in this case of pre consolidated soil, just draw your e versus log p. This is my e zero, this is e c, this is the p c and it is p zero and this is a and this is p.

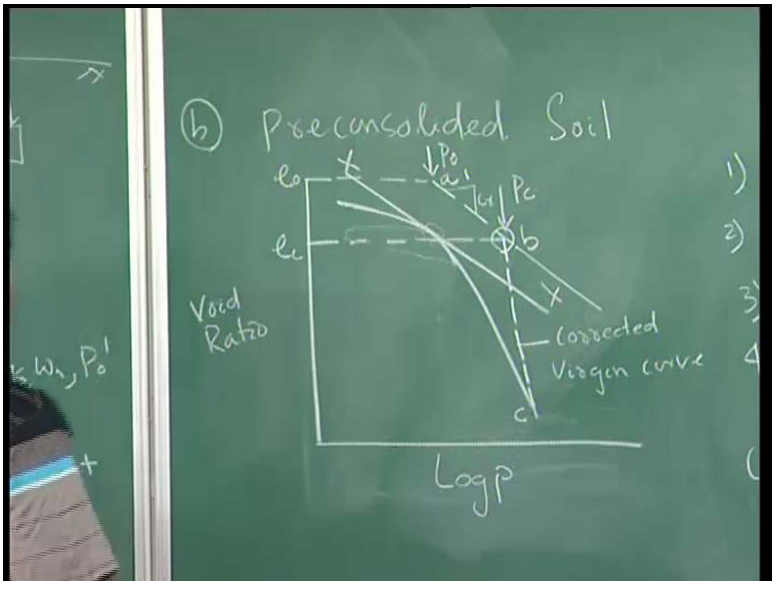
(Refer Slide Time: 29:46)



Steps: Compute p zero and e, e zero p zero by means of cassagrande method, e zero from natural moisture content g and from over burden pressure, draw a line, locate p zero, p c. Obtain slope of rebound by i as line xx and slope c r through a and parallel to x x draw line a b.

Now, for pre consolidated soil draw the laboratory curve, undisturbed curve from your consolidation. Then steps are as usual compute p zero and e zero. e zero you can get it from natural moisture content from g and p zero prime I say here, then draw a line e zero a. This is your line e zero line draw with this. Then locate p zero then locate p zero from here where is the p zero is there. This is your e zero a line you can get it, then find it out p c by means of casagrande method then obtain slope of rebound by i. If you look at here slope of rebound means this is going this curve and all of sudden coming down. Now if I unload it, it will then load it, it will rebound. So, this point will be your slope of rebound by i by i you identify where is your slope of rebound. As a line x x, draw a line x x with that point and through a, once you draw the line x x point a is already there e zero a with corresponding to p zero with a with a parallel to x x draw another line. So it may go somewhere else.

(Refer Slide Time: 33:35)



Now at point c at point c draw a tangent and extend it. Where it will intersect line from a to parallel to x x at point b at point b. That means c b c b represented corrected virgin curve of field condition. This is your virgin curve for laboratory condition, this is your

corrected virgin curve in case of field condition. You see here you can find it out also c c with your laboratory undisturbed curve but, a correction is required. Similarly, because over burden has lost here similarly, in case of pre consolidated soil you can get it correction curve from b c.

So these are the three particularly three cases we consider the correction to be required. One is normally consolidated clay, second one is your sensitive soils, third one is your pre consolidated soil. This is your c once you know the corrections you can apply and find it out what is your corrected virgin curve. Once you get corrected virgin curve b c c has to be used for other calculations like foundation design and in soil mechanics point of view not b c c laboratory undisturbed curve from here you will get whatever c c it has not to be used. Rather than this curve will be corrected and whatever c c you will get it you will find it out this c c is your corrected c c and it can be used for settlement calculations.

That is it for today's lecture. Thank you.