Geotechnical Measurements and Explorations

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Module No. # 01

Lecture No. # 03

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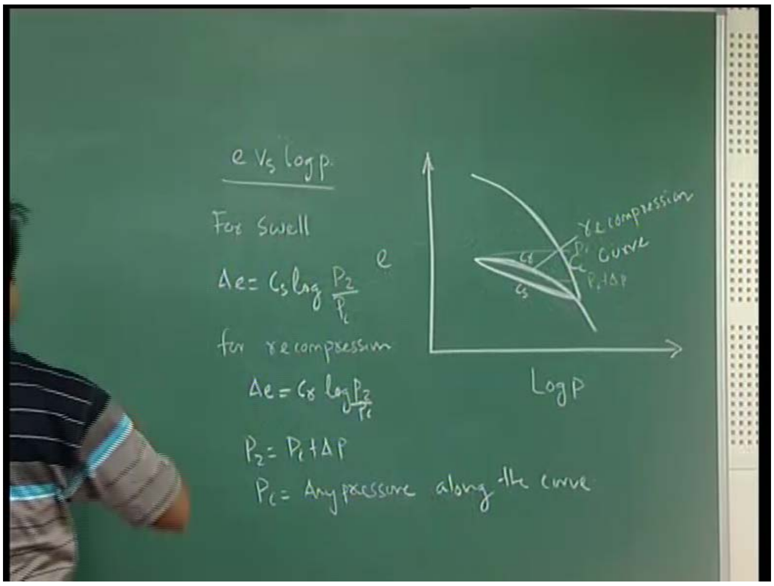

Now we start with this e versus log p again. So this as I explained earlier; this is your compression curve, this is your swelling curve and this is your recompression curve. For swell if interested to find it out what is the swell? For swell change in void ratio delta is your c s log p two by p I. For recompression curve; this is your recompression curve for recompression curve delta e is equal to c r log p two by p I c r is your recompression index so p two is equal to p I plus delta p p I is your any pressure along the curve. If you look at here p I is your any pressure, this is my p I and this is your p p I plus delta p. p I is your any pressure along this curve.

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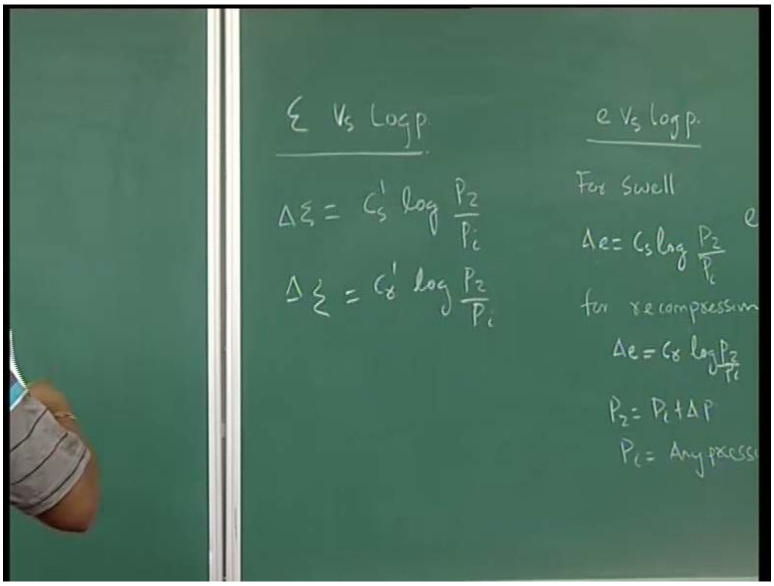

Now similarly, if this curve is there for strain versus log p then what parameter you are going to get? In terms of change in strain particularly swelling c s prime log p two by p I. Similarly, for recompression it is c r prime log p two by p i.

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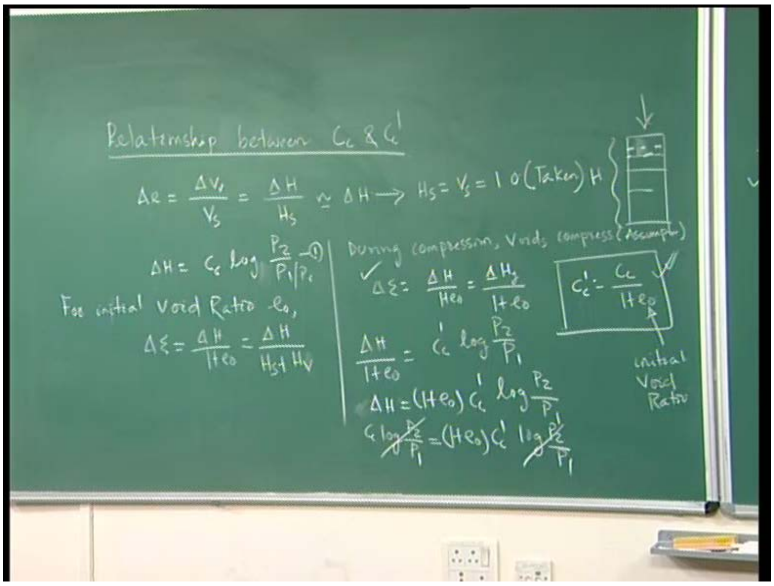

Now, come back to what is the relationship between relationship between c c and c prime. c c compression index and c c compression index prime; now as you know the void ratio delta e, change in void ratio or void ratio you can say volume of voids by by definition volume of voids by volume of solids. So, it is delta v volume of voids change in volume of voids change in void ratio is equal to change in void ratio is equal to change in volume of voids divided by volume of solids which is equal to delta h by h s.

H s is nothing but, your height of soil and delta is is your change in void. How do you find it out? Change in void; it will as the sample compress. As the sample compress by means of consolidation test what will happen in the compression? Expulsion of air and water will occur. Once expulsion of air and water will occur so suppose sample is initial height is h, now it has been compressed during consolidation. So voids will go, means air and water will go out. So slowly, slowly sample will change its positions that means delta is is your change in length or change in height change in height divided by is your height of solid. Height of solid is your volume of solid. So, this is equal to delta h. That means this condition when it is applicable? When h s is equal to v s is equal to one that means we assume that maximum it will change in height will occur so that after that no further change in volume or no further change in height. That means if I take h s means height of solid and volume of solid is equal to one. This is assumed or may be taken then is your change in void ratio is equal to change in is your height or change in your strain.

Then delta h c c log ten p two by p one or p I whatever you say for for this compression curve delta e is equal to c c log ten p two by p I whatever. So, p two by p I, now as delta e is equal to delta h now delta h I put it here c c log ten p two by p one and p i. Now, for initial void ratio e zero; e zero change in strain delta h by one plus e zero which is equal to delta h by h s plus h v height of solid plus height of volume. Now, during compression only voids compress. This is our assumption in one dimensional consolidation theory. We assume that during compression that means it is one in one direction suppose this a z direction may be y may be x in one direction particularly in vertical direction it compresses. Once one direction it compresses, the assumption is it only compresses voids. That is it it only compresses the voids. This is your assumptions.

Now, change in strain delta h by one plus e zero which is equal to delta h g by one plus e zero. Now, delta h by one plus e zero is equal to c c prime log p two by p one. This is your change in strain, this is your change in strain if I plot instead of e if I plot strain per log p strain per log p, so this c c from here we are supposed to get c c, it will become c c prime. Now, this is your change in strain is your delta h by one plus e zero which is equal to c c prime log p two by p one. Now delta h by one plus e zero if you look at here, it is coming delta h is equal to one plus e zero c c prime log p two by p one. Now, delta h is nothing but, if I write it here equation one delta h is nothing but, c c c c log p two by p one which is equal to one plus e zero c c prime log p two by p one. Now, if you cut it means cancel all equal terms both the sides. Now, c c prime is equal to c c by one plus e zero. That means compression index what you get by plotting change in strain with your log p by plotting strain or e versus log p? Suppose you are plotting e versus log p; the compression index curve it is giving you c c. If I plot strain versus log p the compression index curve will give me c c prime.

Now what is the relation between c c and c c prime? If somebody wanted to change from change in strain versus log p two e versus log p, that means compression index c c prime due to strain versus log p is equal to c c compression index, you are getting from e versus log p divided by one plus e zero. e zero is nothing but, it is your initial void ratio. This relationship if you know from there if you know h you can find it out e, if I know c c I can find it out c c prime. Suppose there is a curve has been plotted e versus log p, so once you get e versus log p from there you can get it c c because from this slope of this curve you can get c c compression index. Once you get c c then you can get what is your compression index for a curve change in strain or strain versus log p. From this relation you can get it c c prime.

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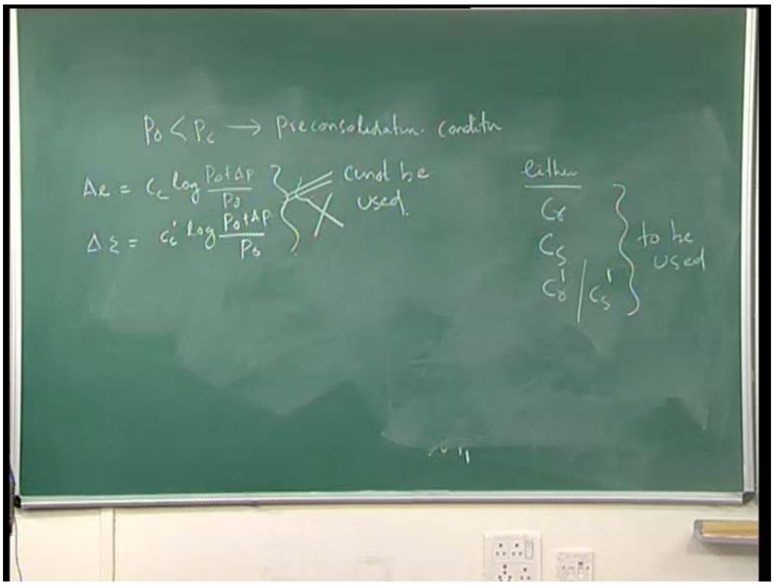

Now move to when p zero less than p c. That means this condition is called for pre consolidation pressure, pre consolidation condition. In this case in this case these two equations change in void ratio c c log p zero plus delta p by p zero or change in strain c c prime log p zero plus delta p by p zero. These two equations cannot be used for pre consolidation conditions. To find it out change in void ratio or change in strain by means of conventional formula. This is a conventional formula. It cannot be used the condition where p zero is less than p c. That means in case of pre consolidation conditions these two cannot be used. Now for these conditions for these conditions either c r c s c r prime or c s prime to be used. Why? Because this pre consolidation condition means earlier whatever pressure is there it is less than your p c. This pressure has been eroded away that means the pre consolidation conditions has been from recent past it is continuing. So, in this conditions settlement can be calculated in two stages.

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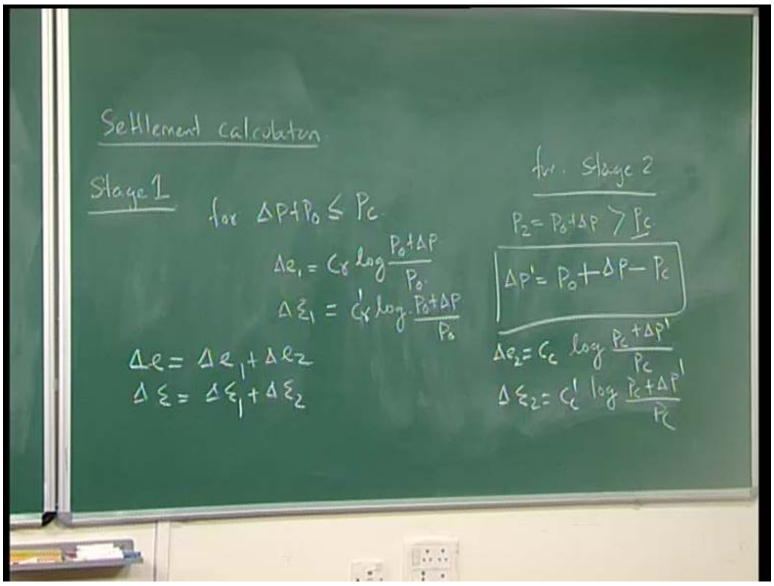

Stage one; for delta p plus p zero less than equal to pre consolidation pressure, p c is your pre consolidation pressure then, delta e one is equal to c r log p zero plus delta p by p zero. Then delta e one is equal to c c log e zero plus delta p by p zero. For stage two that means, increase in delta p plus p zero. That means this is your over burden pressure, increase in stress and the present stress if less than your pre consolidation may or consolidation pressure p c then, delta e and delta xi means change in void ratio and change in strain in terms of c r and c r prime to be calculated. So here, recompression curve here recompression curve for strain.

For stage two; suppose say p two is equal to p zero plus delta p greater than p c that means, stage one p zero plus delta p less than p c. p c is your pre consolidation pressure. If stage two p zero plus delta p is greater than p c that means pre consolidation pressure, in that case you can find it out delta p prime is equal to p zero plus delta p minus p c. As it is greater than your pre consolidation pressure that means, increase in stress because of this is p zero plus delta p minus p c. So now, we can find it out delta e two is equal to c c. In this case it will come c c log p c plus delta p prime by p c and delta xi two is equal to c c prime log p c plus delta p prime by p c. Now the total change, if I say total change in void ratio because of condition one, stage one and stage two what will happen? So in this case, delta e is equal to delta e one plus delta e two delta xi, that means change in strain is equal to delta xi one plus delta xi two. Now, look at a in figure this is this is this is what I have written in terms of calculation point of view.

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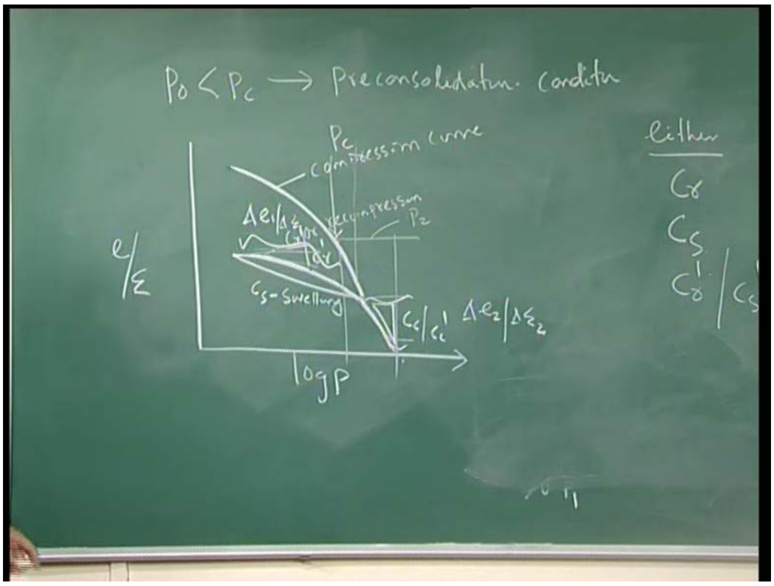

If you want to understand then draw e versus log p. Stage one; in stage one if you look at here, we are using recompression index. If this is my once again I am saying this is compression curve, this is c s or swelling, this is c r or recompression. Now, p zero is less than pc that means pre consolidation condition. That means the consolidation has already been done in the past recent past that means stage one whatever I am applying increase in pressure plus whatever the pressure is there is less than p c. That means already this compression part is over, means already the compression or may be consolidation has been occurred in recent past. That is the physical significance.

Now, we are here when delta p and p c is less than p c. That means once I am applying delta p, because the condition is p zero is less than p c. That is your pre consolidation condition. In pre consolidation condition means, as I explained last class this is your pre consolidation condition. Means already consolidation occurred in recent past that means this part is already over. Consolidation occurs in the recent part past that means the compression part is already over. Now, once you applied increase in stress delta p that means we are here we are applying increase in stress delta p. So, that means it is nothing but, you are using your recompression curve c r or recompression curve from here you can get your recompression index by means of your slope. You can get it from slope re compression index. So, that is why for stage one increase in, means change in void ratio you can find it out c r, change in strain you can find it out c r prime.

Now for stage two; the moment you say that what will happen? The moment you say that p zero plus delta p is greater than p c suppose p c is lying somewhere else here. Pre consolidation pressure is lying somewhere else here. Now, you are saying stage two p two is equal to p zero plus delta p greater than p c that means p zero plus delta p greater than p c means, pre consolidation pressure means it will cover up reconsolidation means recompression curve and again it will come back to your compression curve. It will again come back to your compression curve or slope so this is nothing but, your c c or c c prime. So, that means for stage two if p two is equal to p zero plus delta p greater than p c that means p c is here. Whatever I am applying delta p increase in stress is more than p c that means this curves here, it will start from here.

In this case you find it out how much is your increase in pressure, how much is your increase in pressure delta p prime. That means initial pressure initial over burden zero whatever you applied increase in stress delta p minus pre consolidation pressure, your pre consolidation pressure is your minus here. That means whatever is here from here to here in terms of you can say from here to here, this is your p two after p c. So, from there delta p increase in stress you find it out. Once the p two has been applied the curve from recompression, it comes to again compression it comes to again compression. From this compression curve you can find it out c c or c c prime by slope. So, you can get change in void ratio or change in strain in this conditions. That means here to here you are getting delta e one or delta xi one. From here to here you are getting delta e two or delta xi two. That means total change in void ratio or total change in strain you can find it out delta e one plus delta e two or total change in strain delta xi one plus delta xi two. For stage one and stage two. Now, move to, this is all about your c c this is all about your c c.

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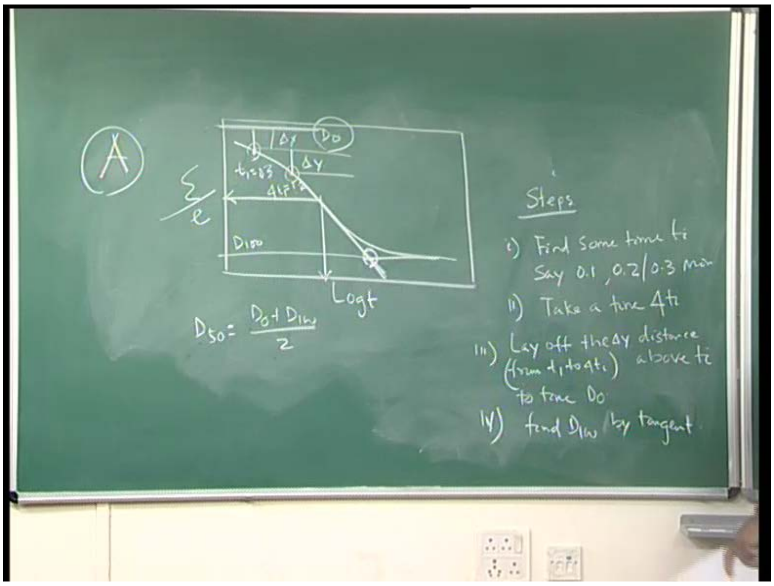

Now, we are moving to c v, time of interest interest for computing for computing c v. One is your log t plot, log t plot b is your root two root time plot. So, case one; a strain versus log t. This is called logarithmic time plot. This one so plot it. Now what are the steps? Find sometime t I say 0.1 0.2 or 0.3 minute. Then second step is your take a time four t I. Now, I take certain time let us say arbitrarily say t one is equal to 0.3 minute, then find it out what is your four t I. Suppose four t I is here, suppose t one is 0.3 minute, four t I means four into 0.3. So, 1.2 minutes. So this is your four t one is equal to 1.2. Now, find it out what is your lay off this delta y. Now, this delta y between t one and four t one it should be lay off above t one. So, this is your delta y to get e zero or d zero. This is my d zero. Now, d hundred to be you can get it draw a tangent of from this part of this where the curvature and the bottom of your where it is asymptotic towards your time curve wherever the intercept is there, you will get d hundred. This is your initial reading d zero. So, from there you can find it out d fifty is equal to d zero plus d hundred by two.

Now third step is your lay off. The delta y distance from t one to four t one above t I to find d zero, find d hundred by tangent. Now, if it is not a strain versus log t; it may be a e versus also log t. Void ratio versus also log t. In case of void ratio versus log d this will be your e zero, d zero means initial. General trend of this curve is like this. Once again I am repeating these steps. So, arbitrarily you choose any time. Suppose t I I can say choose .1 .2 .3. In this case my first part is your t one, first you have to find it out d zero where is your d zero? Locate. First time I have arbitrarily chosen say t one is equal to 0.3 minute.

Now, with this t one find it out four t one. That means where it locate four t one is locating here. That is your one point two minutes. Now lay off this from t one to four t one how much is your this? This is your delta y with this delta y from t one you canput it above the t one. So, this delta y I put it here so whatever we are getting from here this is my initial d zero or e zero sometimes it is called, if it is e versus log t plot you can find it out d zero point here. D hundred point you can get it you draw a tangent from here and the bottom part where it is asymptotic towards your time axis where it intercept that is your d hundred. Now from this d zero to d hundred you can get d fifty that is that means d zero plus d hundred by two that is your d fifty. That means this is my d fifty or t fifty. D is nothing but, you can say that d fifty is your up to the degree of consolidation, fifty percent degree of consolidation. This is your zero degree of consolidation. This is your hundred degree of consolidation. From there you can get time t fifty for fifty percent of consolidation. Now come back to second method root two time plot b.

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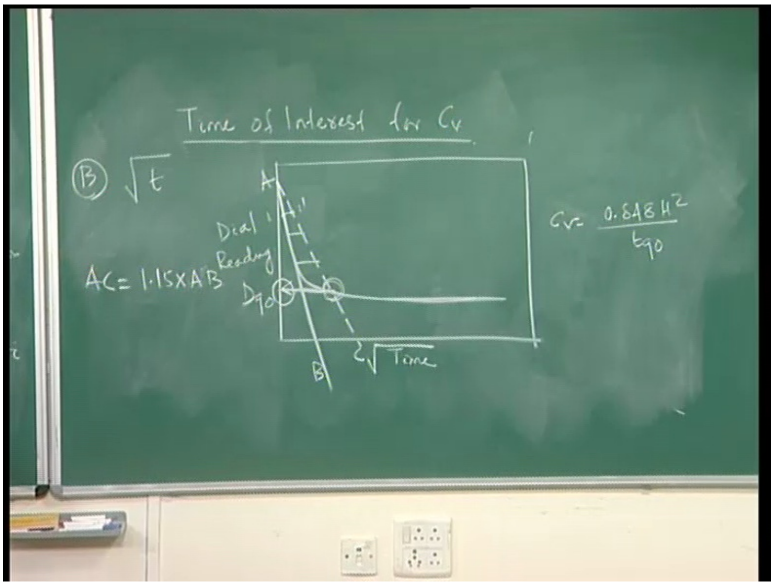

Now, plot this curve say dial reading dial reading whatever from consolidation, dial (( )) reading versus time time interval in terms of root root time, you draw the curve this is your curve general trend is like this. Now, initial part draw a tangent from the initial part where it curve generally starts with moving straight line draw a tangent. From this initial part and extend it.

With this tangent draw whatever line mark it a b. Now with this line a b you can extrapolate a c. Suppose this coordinate is how much? This is your coordinate from there. Suppose this is your a one. So, this coordinate will be a one prime. So, it will be exactly 1.15 times of a b, 1.15 times of a b. Now, each coordinate you mark it, each coordinate you find it out and plot a c. a c is nothing but, your 1.15 times of a b. The a c where it intersect your consolidation curve that is your dial gauge reading versus time. This part it it intercepts at this position from here. You extend this gives your ninety percent degree of consolidation, ninety percent degree of, that is your d 90 ninety percent degree of consolidation. Now, once you get d ninety or d fifty then, from here once you get d ninety you can find it out c v is equal to 0.848 by t ninety. For this case for here you can find it out c v is equal to 0.197h square by t 50.

These are the two methods used particularly to find it out c v. These two methods called time of interest. What time of interest you are, you want degree of consolidation should be ninety percent or you want a degree of consolidation at fifty percent? What would be your coefficient of consolidation c v? So, these are the all two time plots; one is your logarithmic time other is your root two time.

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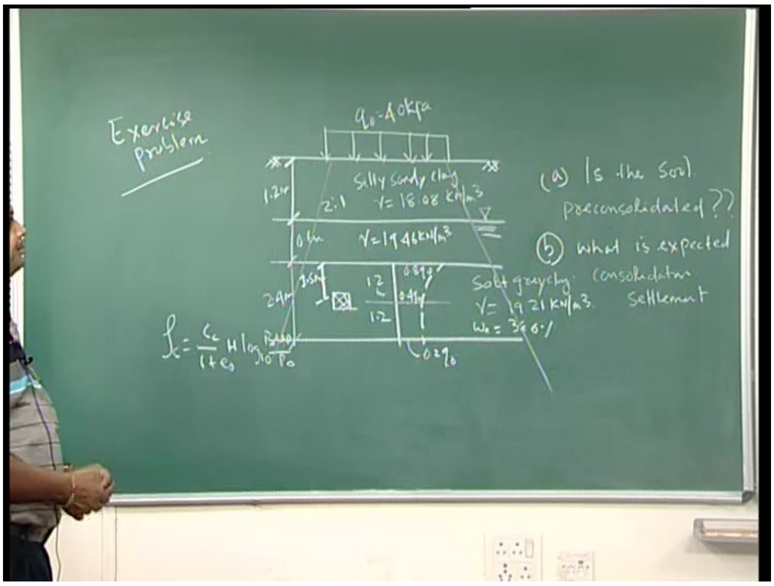

Now one exercise problem I am giving. Silty sand this is a field problem, silty sandy clay, gamma is equal to 18.08 kilo Newton per meter and water table is located below 1.2 meter of the ground surface. This is your water table located below 1.2 meter here gamma is equal to 19.46 kilo Newton per meter and soil is expected to take out from the ground surface. So, this distance is say 1.5 meter. Now, this is your 1.2 meter. This is your 1.2 meter and this is 0.8 q0, 0.4 q0 and 0.2 q0 and this is soft gray clay, gamma is equal to 19.21 kilo Newton per meter cube. Natural moisture content is equal to 30.0 percent. Now, this is your field condition where the surcharge is forty k p a. Initially this is a silty sand clay first 1.2 meter, 10.6 meter below 1.2 meter this is water table and the soil is gamma is 19.46. This soil is also silty sand below 1.8 meter soft grey clay is there and with this below 1.8 meter another 1.5 meter soil sample has been collected for your consolidation laboratory, from field.

Now the question is; there are two questions. One is your is the soil pre consolidated? Now b is equal to second part, what is expected consolidation settlement? Now this is your consolidation pressure or this is this is varying from 0.89 q, 0.49 q, 0.29 q0. From these, there are two two two questions; one is your is the soil pre consolidated, that means you have to check whether p zero is less than p c, pre consolidation pressure or if it is less than then it will be pre consolidated.

Second part what is your expected consolidation settlement in this layer? Expected consolidation settlement in this layer means consolidation settlement c c by one plus e zero h log ten p zero plus delta p by p zero. Find it out p zero. Stress at this distance because gamma into gamma is your 18.08 into 1.2 gamma into 0.6 gamma into this. Delta p increase in stress because of your forty k p a. That you can find it out by means of I am giving this is hint. This is an exercise problem because your fear external load forty k p a increase in stress, you can find it out by means of two is to one method. Two is to one distribution method at this layer what is your increase in stress delta p you can get it and c c one plus e zero natural moisture content is given and from there you can find it out e zero and c c you can assume it. There are correlations. Next class I will say different correlations of c c available for soft clay, c c is equal to 0.07 into one minus e zero. From there you can find it out c c. With this hint please complete this problem. Thank you