Soil Mechanics/Geotechnical Engineering I
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Lecture - 07
Three - phase diagram (Contd.)

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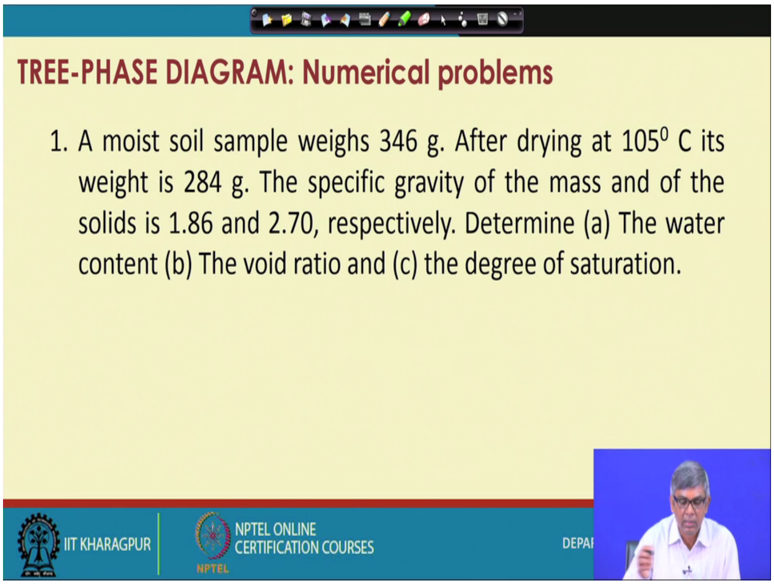

So, in the previous lecture whatever relationship we have developed those things some application we will see now solving a few problems, first let me see the first problem, it is a moist soil sample weighing a weight 346 gram, after drying at 105 degree centigrade it is weight is 240 gram. The specific gravity of the mass and of the solid is 1.86 and 2.70 respectively. Determine the water content, b the void ratio and c the degree of saturation this problem we will try to see the solution.

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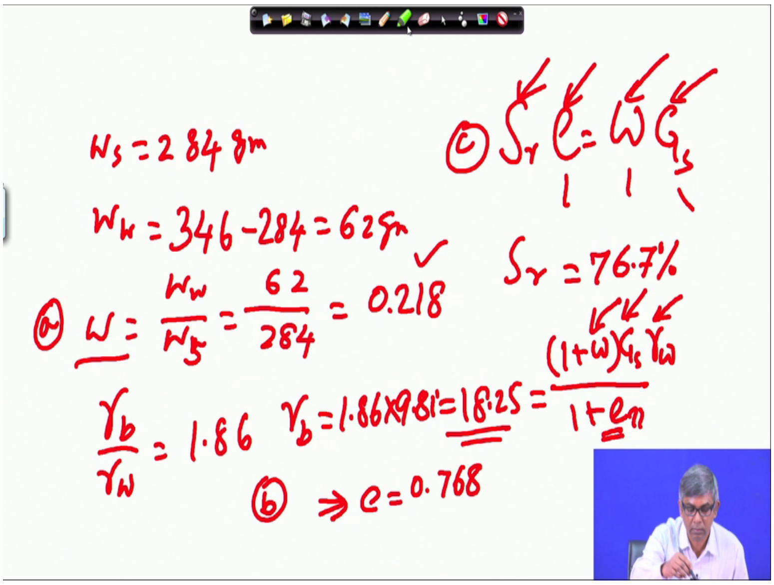

First of all we have got W S equal to 284 grams, and W W become 346 minus 284, so that gives you 62 grams. And then water content by dividation W W by W S that become your 62 by 284, so that become 0.218. And now gamma b by gamma w is given as one point bulk unit of it is given 1.86, so gamma b that means gamma b equal to 1.86 into 9.81, so this value become 18.25. And we know the expression for gamma bulk in terms of water content 1 plus W into G S into gamma W divided by 1 plus e and this is actually your values given 18.25.

So, from here W is known this 1, G S can be assumed 2.7, gamma W is 9.81 and then only unknown is this one this only unknown. So, from here I can find out e equal to 0.768 and this become part a, this become part b and part c actually we have another relationship S r into e equal to W into G this is degree of saturation, this is void ratio, this is water content this is specific gravity, so we know these then your degree of saturation S r substituting all values it comes 76.6 percent, so this is the a first step application of whatever formula whatever you have derived that relationship what is the definition bulk density, then water content, then degree of saturation, then void ratio all definition and their values their relationship is used in solving this problem.

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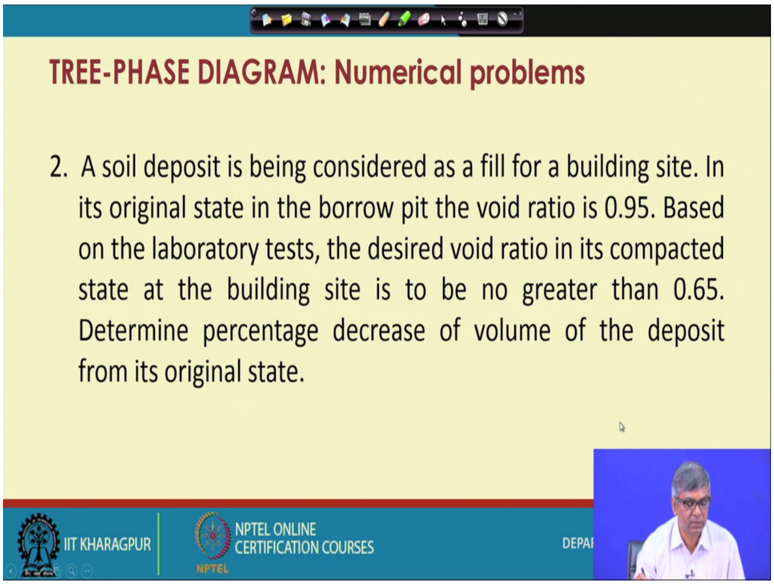

So, now I am going to the second problem, a soil deposit is being considered as a fill for a building site in it is original state in the borrow feet in it is original state in the borrow feet the void ratio is 0.95 based on the laboratory test that desired void ratio in it is compacted state at the building side is to be no greater than 0.65, then determine percentage decrease of volume of the deposit from it is original state, so that means at the borrow site void ratio is 0.95 and at the compacted site your void ratio is required 0.65, what is the meaning actually that means volume will be reduced void will be removed.

So it will be more compact so that you have to find out now that that calculation we will try to see, we will see that calculation is a borrow pit one is, there is a borrow pit or borrow site and I can say another compacted site and then in that case it is void ratio at borrow pit is given eb is equal to given 0.95 and compacted side that the void ratio will be 0.65 so ec compact constructed site compacted site it is 0.65. Then by definition actually we know V equal to V S into 1 plus e, it is nothing but V S plus V S into e, V S into e is nothing, but V b, so V S plus V b actually total void actually V S plus V b, so I can write V S into 1 plus e in this form.

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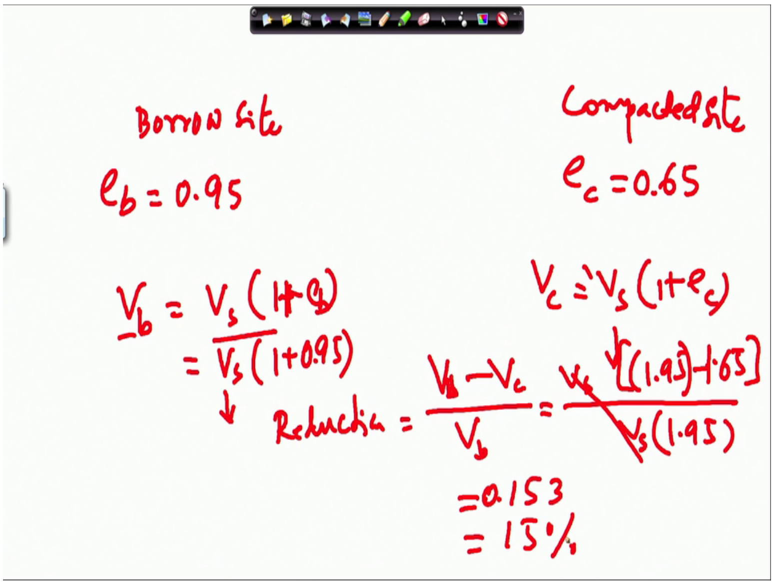

So, I say V b equal to this and similarly then I can write V S into 1 plus 0.95 and here I can write V c is equal to V S into 1 plus ec and this is eb. Now the this V S and this V S this 2 V S actually in two condition V S will not change, because of the compaction of the soil your because of the compaction of the soil void will be reduced but solid volume will not change, so that is the assumption if you make then the two cases actually V b and V c so this is the V S I can find out, so reduction in volume reduction will be equal to borrow site was more V b minus compacted site volume become less divided by V b.

If I do this then it become this is 1.95 V S into 1.95 minus 1.65 divided by V S into 1.95, so this V S get cancels, so 1.95 plus minus this is minus 1.95 minus .65, 1.95 minus .65 by divided by 1.95 this if you do then this gives you 0.153, that means it is nothing but 15 percent. That means from a site where void ratio is 0.95 and if you take a borrow material and compact in the site with void ratio equal to 0.65, then that may how much volume actually will reduce it will reduced by 15 percent, 15.3 percent in fact, so this is our second application.

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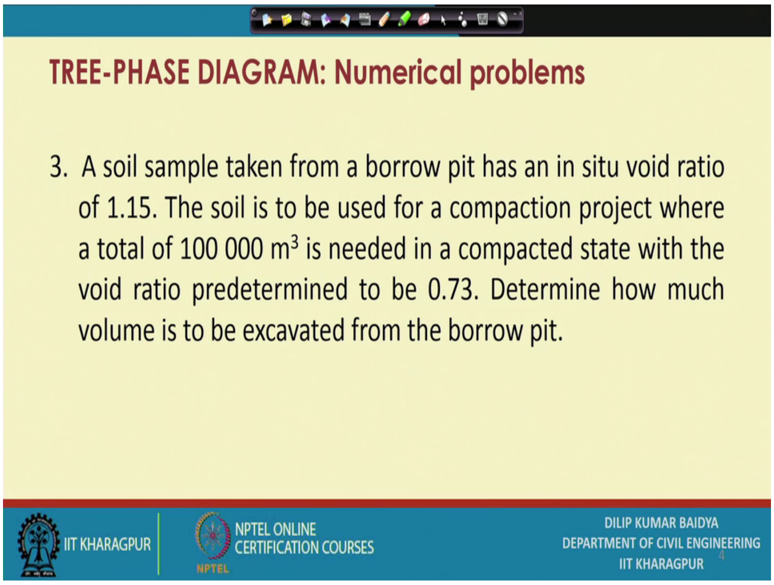

Next problem suppose, third problem again similar a soil sample taken from a borrow pit has an in situ void ratio of 1.15 the soil is to be used for a compaction project where a total of 100 1000 meter cube is needed in a compact it is a state with the void ratio predetermined to be .73, determine how much volume is to be excavated from the borrow pit.

So the compacted volume is known 100 1000 meter cube and compacted state what is the void ratio that is also known .73 and from a borrow site we will be taking the soil and that soil is having void ratios 1.15, so if I want to if I set want to satisfy this if I want to do construction satisfying this condition that means 100 1000 meter cube of compacted site to be produced how much soil I have to take from the borrow site that is the problem we have to do, so for this let me take this one and you can see.

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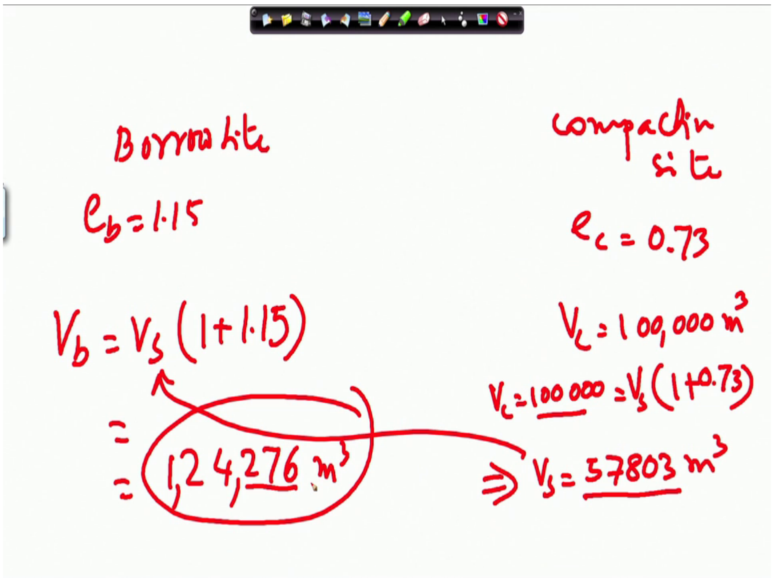

Ah the again similarly borrow site and compaction site I can divide in two part and here actually eb is given 1.15 and here it is given ec is given 0.73 and here actually additionally what I have got I have got compacted volume is 100 1000 meter cube, now this V C equal to a 100 1000 equal to is not this is the volume nothing, but V S into 1 plus 0.73, so from here I get soil is present in that much of volume so V S will get from here 57803 meter cube so that means the 100 1000 meter cube of solid soil bulk soil we have only 57803 meter cube of solid and remaining actually voids.

Now, I have to find out as I have mentioned in the previous problem that when the same soil has been used and compact, then your compact compaction all you are removing the voids not remove not reducing the solids so solid will be remain unchanged if that is the condition is taken now I can consider V b equal to V S into 1 plus 1.5 that is the void ratio of the site, so if I substitute this V S here then I will get this V b equal to 124276 meter cube of water that means, for 100 1000 meter cube of compaction if I want to make then I have to how much I have to do, I have to bring from the borrow site 124276 meter cube, so obviously when it is loose the volume will be more that more volume will be put in the site and then compact then you will get the actual volume, so this is the third application.

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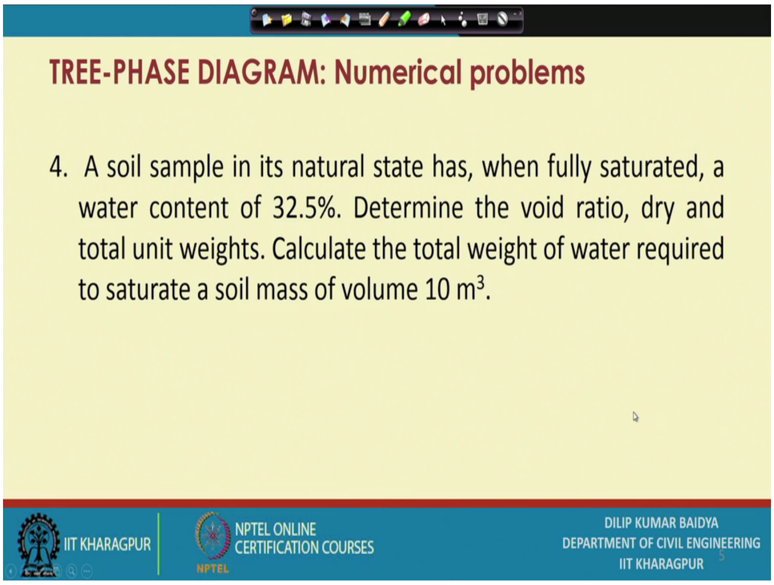

Now, I have to I will go to fourth application, the soil sample in it is natural state has when fully saturated water content of 32.5 percent and determine the void ratio dry and total unit weights, calculate the total weight of water required to saturate a soil mass of volume 10 meter cube so this is the thing only water content is given at saturate condition, so that means two things are given and G S can be assumed which is not given most of the time it will be given and since it is not given I can assume as 2.70.

So, only here I have got water content at saturated condition, saturated condition of S r equal to 1 and W equal to 32.5 percent additionally I can assume G S equal to 2.7 and then by knowing that I have to find out the rest of the things. So I have to calculate total weight I have to find out the void ratio, dry and total unit weight first void ratio, then dry and total unit weight and then total weight of water required to saturate a soil mass of 10 meter cube, so this one we will try to find out and you can see this.

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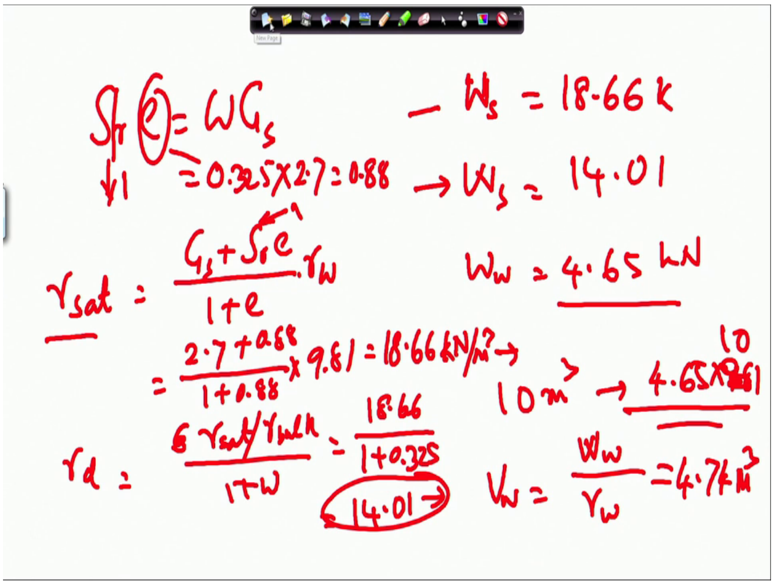

We know the relationship S r into e w into G S and this is S r value is 1, so ultimately I will get directly e equal to water content into G S so water quantity is 32.5, so this is nothing but 0.325 into G S is 2.7 so this become your 0.88, so I have got e this is 1 so I have got e equal to 0.88. Now I have to find out saturated weight, unit weight and dry unit weight so gamma sat equal to G S plus S r into e by 1 plus e into gamma W, since right from beginning it is known that S r equal to this is 1.

So, G S plus e by 1 plus e that means 2.7 plus your e is actually I have got now 0.88 divided by 1 plus 0.88 into 9.81, so if I do this value will get 18.66 kilo newton per meter cube, anytime unit is very important without unit these are all meaningless. Similarly I can I have we have derived gamma d will be equal to gamma sorry gamma sat or gamma bulk or gamma bulk divided by 1 plus W, so we have got 18.6 so divided by 1 plus W that is 1 plus 0.325 so this gives you 14.01.

And next I have got dry unit weight, I have got bulk unit weight so fine to find out the third fourth condition so that means I if I take 1 meter cube of soil then what is the saturated weight, that means W saturated W saturated for 1 meter cube is 18.66 kilo newton and W S which is nothing but 14.01, so saturated weight is dry weight is this that means W W that means only water will be this minus this and that will be equal to 4.65 kilometer, so weight of water in 1 meter cube of soil is 4.65 millimeter so 10 meter cube of soil if you take then how much will be there 4.65 sorry it was.

So from here I can directly get multiplied by 10, 4.65 into 9.81 no 10. So, this is 10 this volume this weight I can get and if I want to find out V W that weight, that is W W divided by gamma W if I do I will get the value so that will be actually 4.74 meter cube, so that means these are the four parts are done. So that means if I know the water content or saturated condition then I can find out using those relationship I can find out other important thing.

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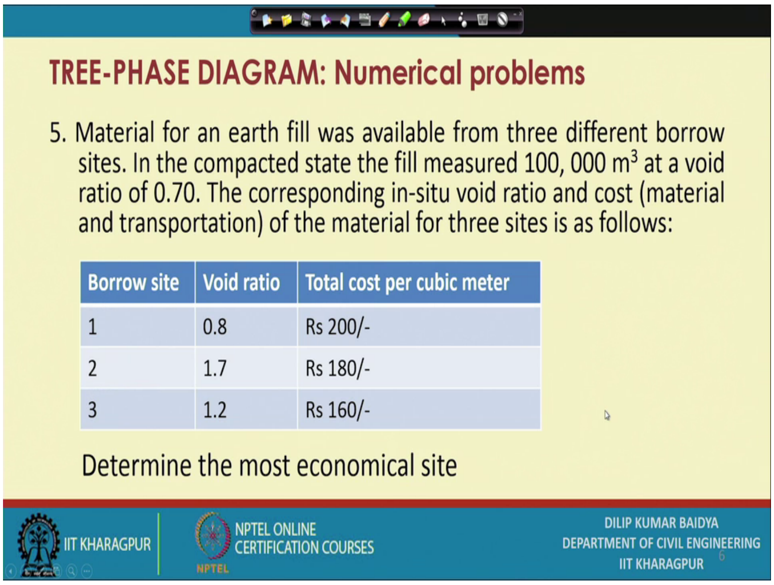

So this is the application number 5 and you can see now this problem is given three sites actually chosen for a construction to take the borrow material for not earth fill was available from three different borrow sites. In the compacted state the field measure 100 meter cube at a void ratio of .7 that means compacted that the compacted site your void ratio requirement is .7 and total volume requirement is 100 1000 meter cube.

The corresponding in situ void ratio and cost of material and transportation together of the material for three sites are given like this, so site one actually void ratio in situ void ratio is .8 and cost for transportation and all those together material is 200 per meter cube, similarly for site two it is void ratio was 1.7 and cost for transportation and material 180 rupees per meter cube and site three void ratio was 1.2 and the cost for material and transportation was 160 rupees per meter cube .

Now, we have to find out the we have three sites their cost and all those thing are known and conditions are known, we have to find out now which site is the most economical.

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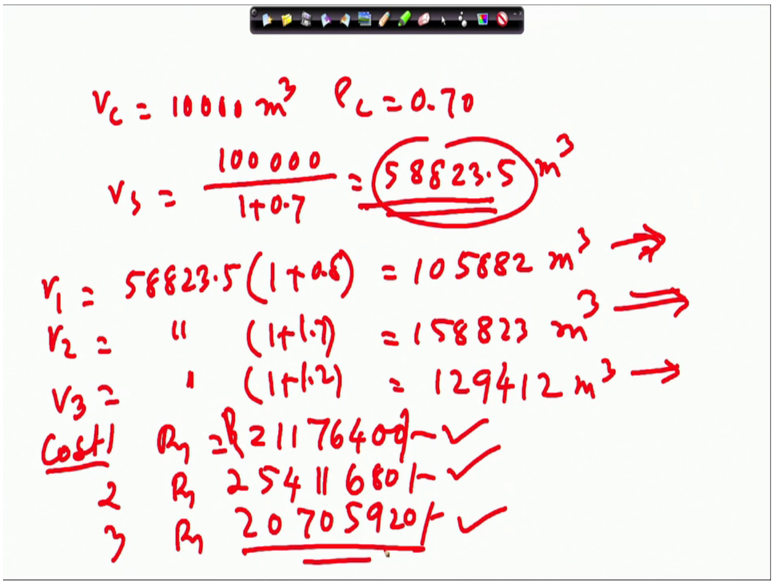

So, for these let us do, you know that actually construction site V S was 100 1000 meter cube and your ec equal to 0.7 and then I can find out from here V S equal to 100 1000 divided by 1 plus 0.7 so that gives you 58823.5 meter cube. That means out of 100 1000 meter cube of soil compacted soil, the solid will be this much and this amount of solid should be there in each of the sites.

So, in that case then I can calculate now V 1 how much volume if I want to take from site one then what is the volume required from that it should be 58823.5 into 1 plus 0.8 which is void ratio of site one, so this gives you 105882 meter cube, similarly I can get V 2 will be equal to this will give you this into 1 plus 1.7, this gives you 158 and 823 meter cube and then V 3 will be equal to this into 1 plus 1.2 this gives you 129412 meter cube. So, from different sites actually if I choose then a different quantity will be required so this from site say this of quantity from second site this much quantity from third site if I go this much quantity will be required.

Now, the cost of material and transportation is given, so I can multiply by that volume cost one will get will be rupees this volume multiplied by 180 around 200 actually that is actually gives you 2117640 this much rupees, from site two this will be rupees 25411680 and from site three it will be rupees 20705920 so that means if I take select the site one this much cost, if I select site two this much cost, if I select site three this one is the cost.

So, which one is the lowest this is the lowest so we should choose site c as the borrow site because that will be the more economical, so this is the application or 5 th application now I will do one more 6 th application.

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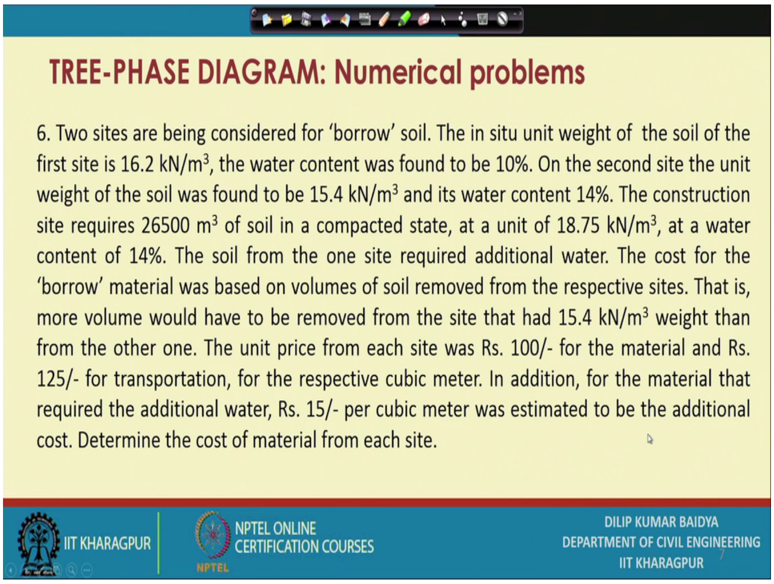

So, this is the problem actually again two sites are being considered for borrow soil the in situ unit weight of the soil of the first site is 16.2 kilometer per meter cube, water content is 10 percent. On the second site again same unit weight is 15.4 and water content it is only 14 percent which is more. The construction site requires 26500 meter cube of soil in the compacted state at a unit or unit weight of 18.75 and water quality of 14 percent the soil from the one site require additional water that means where water quantity is less than the first site water is required.

The cost for the borrow material was based on value of soil removed from the respective site that is the more volume we have to be removed from the site that have 15.4 kilometer per meter cube weight than the from the other one, the unit price from each site was 100 for the material and rupees 125 for transportation for the respective cubic meter and in addition for the material that required the additional water that required rupees 15 per cubic meter estimated and so determine the cost of material from each site.

So, that way two sites one site will be water content is less other site will be water content is slightly more and second site whatever water content is required and it is there that is the water content is equal to the compacted side there is no need to add water or remove water, but first site since it is a 10 percent but actual condition is required 14 percent so you need to add some amount of water. Now from this two sites when soil is taken and constructed and they are respective void ratio also is given and if I text from the site one or site two their material per cubic meter cost is given and transportation cost also given and where water is required that is per meter cube of soil how much additional cost for water that is also given.

So, based on that sometime instead of that way how much quantity of water is required and unit price of water also given but this problem based on solid value approximate cost of water is given, so we have to find out the volume of soil from both sites and then you estimate the then you have to estimate the cost.

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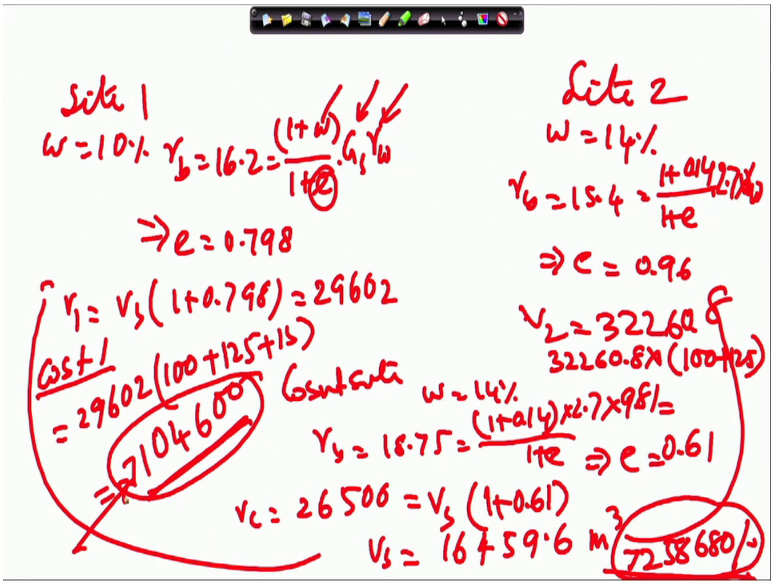

And you can see now I can consider site one site one and now I can say site two, site one W equal to 10 percent and gamma b gamma bulk equal to 16.2 equal to 1 plus W by 1 plus e into G S gamma W. So, this since water content is given I am using this problem I am not using S r into e because I have this 1 and G S can be assumed gamma W is known so only unknown is e from here I can find out e value equal to 0.798 and then your site two again water content is given 14 percent and gamma b is given 15.4 which is equal to 1 plus 0.14 divided by 1 plus e into 2.7 into gamma W, this gives you e is equal to 0.96 and construction site construction site we have actually water content W equal to 14 percent and your gamma b is equal to 18.75 equal to 1 plus 0.14 into 2.7 into 9.81

divided by 1 plus e so this gives you e is equal to 0.61. And we know the volume so construct constructed volume is actually 26500 that will be equal to V S into 1 plus 0.61 so from here I will get V S is equal to 16459.6 meter cube, so as we have discussed previous problem also this V S will be from here is whatever amount of soil you take V S must be this much V S also must be this much from this site so if you know the V S now, if I text soil from site one v 1 will be V S into 1 plus 0.798 so that become your that become your volume and this is 29602 and here actually this V 2 will become 32260.8.

Now, I can find out the cost from site one that will be equal to 29602 multiplied by cost per material is 100 plus transportation 125 plus water 15, because first site water is required so that become the cost if that will be 7104600 is the cost for this site, similarly if I go for this site this cost will be again this site if I do if I take this site that cost will be again the volume is this multiply this 3260.8 into 100 plus 125 that gives you equal to 7258680.

So, this is 71 and this is 72, so this is big value and so this difference so this that means this site become your cheaper so that means, out of whatever condition is described in these two sites and what is the condition described in the construction site and if I do this calculation based on this calculation what I am getting I am getting the site one as the most economic site because out of two so this is the one preferred ok. So, I think I could whatever we have derived before with this 5 problems I can I could show the application of them ok.