Concrete Technology
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Lecture - 17
Mix Design of Concrete: ACI 211 Method

Welcome to module 4 lecture 4 of concrete technology and today we shall be discussing ACI 211 Method; Mix Design of Concrete. So, we have earlier discussed the Indian code 10262 Method and then having discussed the department of environment British practice which is quite close to the Indian method. Now, we can look into ACI 211 Method.

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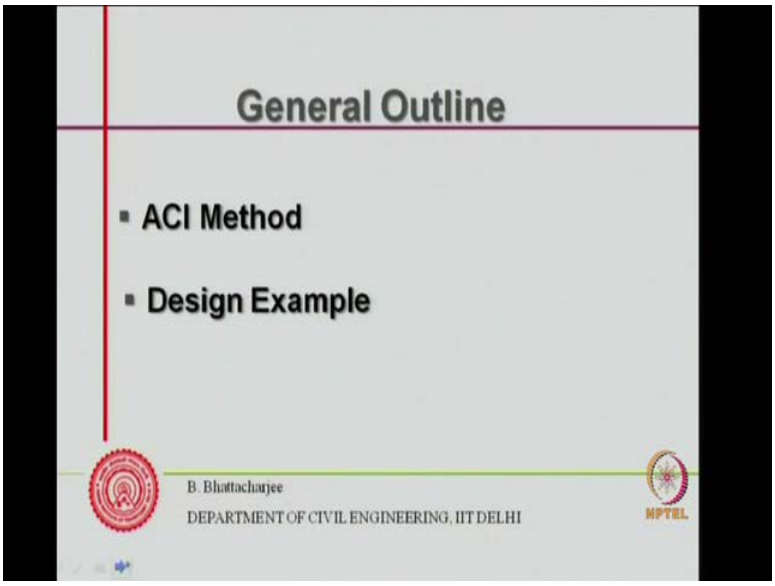

So, generally we will discuss this and some example we will take. Now, of course all though I am writing this is step 1. If you look at ACI 211 report, the step 1 is stated to be the determination of slum; and step 2 is given as determination of maximum size of aggregate. Now, these 2 are similar to the earlier method, and if we are doing it by Indian method or in India using a ACI method. Then, we shall be actually using the highest method or highest 4562 thousand guide line; for specifying the slump or fixing the slump and fixing the nominal maximum size of aggregate.

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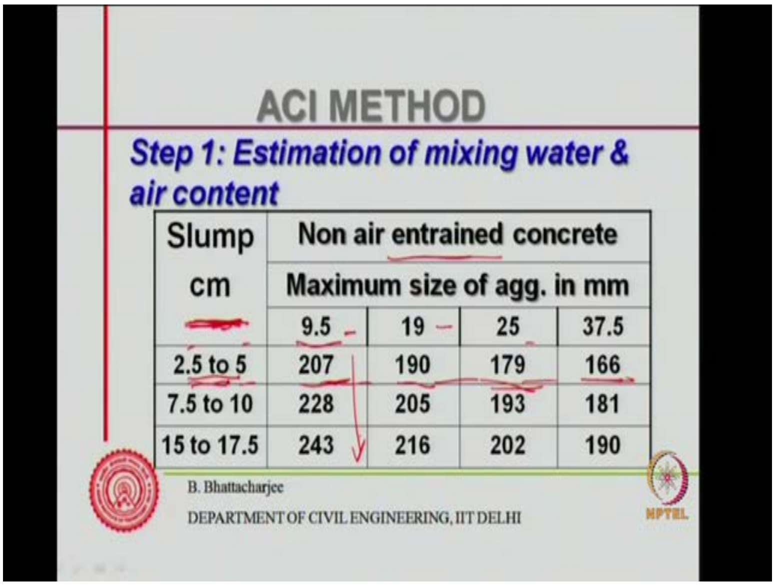

Having done that next is the step 1 part of it which will be you know actually step 3 in the ACI Method or else ACI report to 211, but here I am calling them as step 1. So, that it is actually estimation of mixing water estimation of mixing water. And, that we do from a table which is given below; that we do from a table which is given below.

This table has got 2 parts; first part is related to first part is related to determine you know the mixing water and second part gives the amount of air entrainment. So, you determine air content amount of air content. So, determine a amount of air content and mixing water together from 2 table; 1 is for non air entrained concrete, another is for air entrain concrete. For example, this table if you look at it the amount of water depends on slump; this is of course you have taken in centimeter I mean 1 inch, 2 inch.

So, corresponding to this in fact ACI 211 gives you now SI everything in SI unit as well together with the u s customer unit. So, slump we have written in centimeter and maximum size of aggregate corresponding to this amount of water for non air entrained concrete is given. And, you can recollect in both the other methods we discussed earlier; the max the amount of water has been a function of the MSA the required work ability in terms of slump and BV etcetera and also of course, shape of the aggregate. So, here it is given in terms of the MSA and non air entrained concrete and air entrained concrete will have some amount of difference in water requirement.

That is because air entrainment although its main purpose it is related to fix; though resistance improves the work ability somehow makes it plastic, makes the concrete little bit more plastic. Therefore, you know more flow able; therefore water required somewhat different. So, non air entrained concrete this are the values given for slump from 2.5 to 5 centimeter, there is 25 mm to 50 mm. And, as your aggregate size increases you can see that water content reduces. And, as your slump increases, water content increases again. So, it is a principal is same, idea is same after all use the same kind of concrete only and water content is what you can find out in the beginning.

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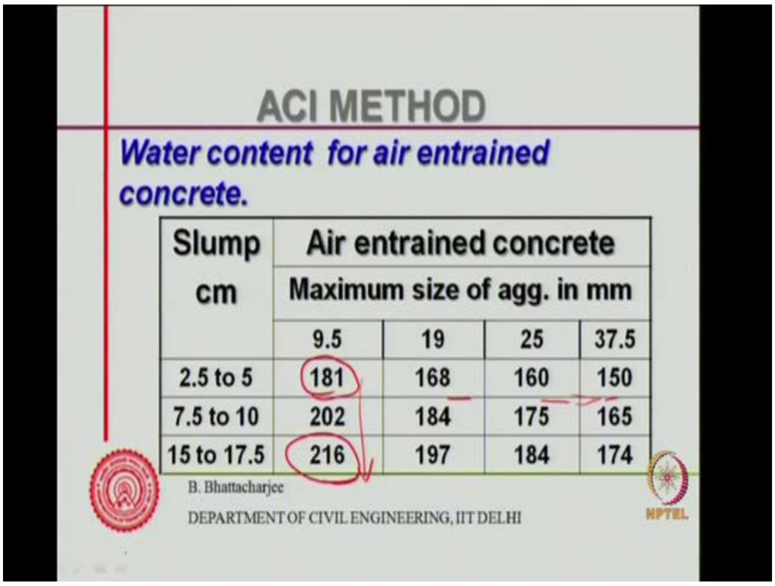

For air entrained concrete this values water content or somewhat less because as I said air entrainend tend to improve the work ability. Therefore, if you see this 181 for air entrained concrete, for non air entrained concrete the same value is for non air entrained concrete same value has 207. So, the what you know water content for air entrained concrete is much less. And, as we increase your slump, water content increase this was 243 for non air entrained concrete, for air entrained concrete this is 216; and as it go along this direction it reduces. So, this is the first step if you know the slump I say then this will be the first step. So, you determine your water content for the given MSA and given slump.

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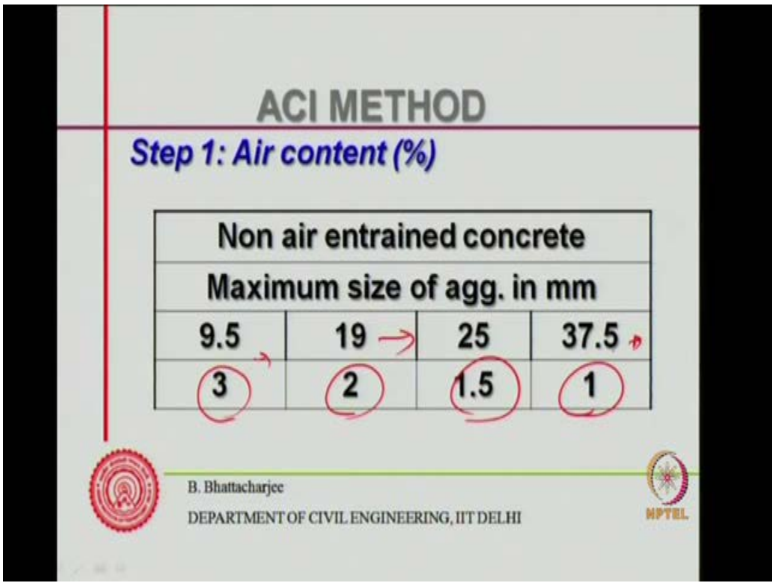

Then, air content corresponding air contents are given. For non air entrained concrete typically you can take the air entrained air content in percentage percentage as 3 percent of the total volume 2 percent, 1.5 percent and 1 percent; for MSA increasing from 9.5 mm size to 37.5 mm size. That means, high better the higher the you know bigger the MSA more the MSA packing is better. So, your air content reduces down paste would be reducing. So, air content actually reduces down and that is what is given for non air entrained concrete.

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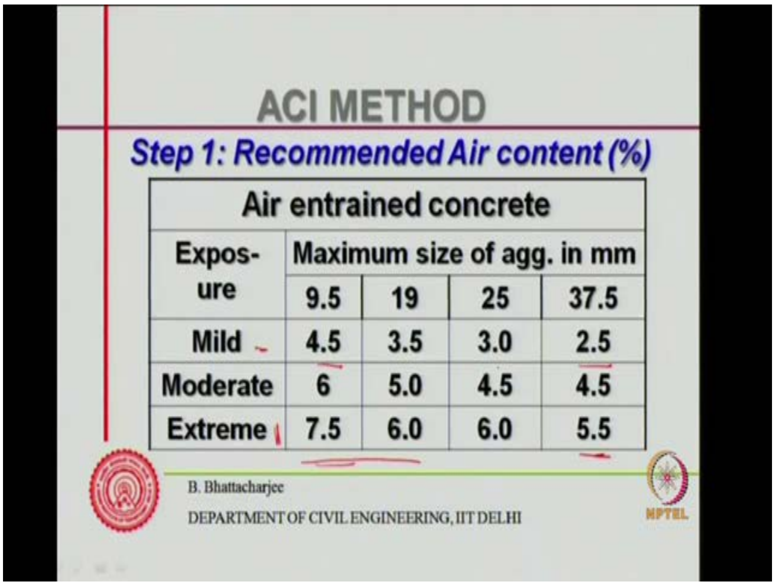

For air entrained concrete however this will be much higher. And, that would depend upon that would be much higher; and that depend upon on the dosage of the air entrainment. Now, this is suggested that minimum air content, recommended air content for different exposal condition. For extreme exposal condition you know this air entrainment should be 7.5 to 5.5 depending upon the MSA; and for mild expose it is 4.5 to 2.5. So, your dosage of air entraining agent should be such that it gives you much higher. You know at this this recommended air content when it is expose to extreme frizzed condition, mild condition as defined by the code. So, mild, moderate and extreme situation as defined by the code as defined by the code. So, this is air entrained air content.

Now, so for as we determine the water content. Air content does not have direct you know implications at the moments, but water content has the direction implication at the moment you know to calculate out the other to calculate out the other component in the mix proposition of other component in the mix proposition of other component in the mix. So, having the determine the water content; the next step would be to determine the water to cement or water to cement (( )) material. Now, American method of course, uses 28 cylinder compressive strength rather than the cube strength it uses 28 cylinder compressive strength.

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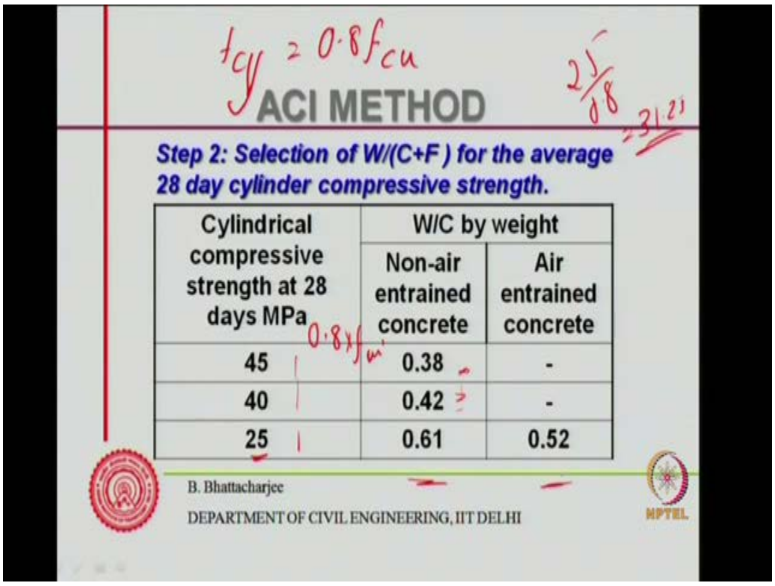

And, therefore the recommended water is given. For every cylindrical compressive strength at 20 days in terms of a M P a corresponding water by water to cement ratio by mass is given in terms of you know for non air entrained concrete. So, this is given in a table. So, you can distinguish actually from the other 2 method. First of all in Indian method it is suggested you take it from experience or the durability requirement. In the British D O E method strength verses water cement ratio scarps are given. So, you pick up one of the scarps; here the recommended water cement ratio is given in terms of table. So, from the table you pick up for air entrained concrete and non air entrained concrete.

So, depending upon the strength in fact here is only a part of the table, the complete table will have more data. So, cylinder strength is average cylinder strength is given. This is actually averaged strength averaged strength averaged 28 day cylinder composite strength average; which is something similar to our target mean strength expect for the fact that it is actually cylinder strength; it is actually cylinder strength and perhaps we have not discussed this so far. But when you discuss about strength or factors affecting strength of concrete; we will be seen that the specimen shape; especially in terms of l by d ratio has got an effect on the strength. So, cylinder strength cylinder strength this is about you know 0.8 times f cube strength f c u.

So, f c u why if I call it cylinder strength is equals to 0.8 f c u. In other words the cube strength is higher than the cylinder strength. So, to any work using this let us say like in India where we generally used cubes there. If it is an m 25 rate of concrete than cylinder strength will be 25 multiplied by 0.8 which will be actually 20 or if it is you know if it is 25 here correspondingly 25 divided by 0.8 will be 31.25 whatever it is. Somewhere for 25 will correspond to m 30 grade concrete you know closed to that. So, this is this is while adapting the adaptation you know the for a adapting this in Indian scenario in Indian condition. You have to convert them to or convert cube strength to the cylinder strength. So, correspondingly you can choose the water cement ratio given their water cement ratio given their for non air entrained concrete and for air entrained concrete.

Largely of course, in India we do not use a air entrained concrete expect for Himalaya region. Where air entrained if it come mass because there is a problem of freeze though action in; you know the deterioration due to freeze though action is possible in the Himalaya cold region. Otherwise generally non air entrained concrete is what we should be using. So, here the water cement ratio is straight forward obtain from the table. We obtains it from the table straight forward; water cement ratio is obtained from the table. But what is average strength?

You see when it when we are talking of IS Method we talked of target mean strength F M which was f c k that is your grade strength characteristic grade strength plus 1.65 sigma. We are always talking about 28 days strength only and age is not varying. So, we were talking of target mean strength. Here, the strength represents something similar; average strength something represents something similar. So, these are essentially the average strength and corresponding water cement ratio you can determine. Now, how do we determine this average strength?

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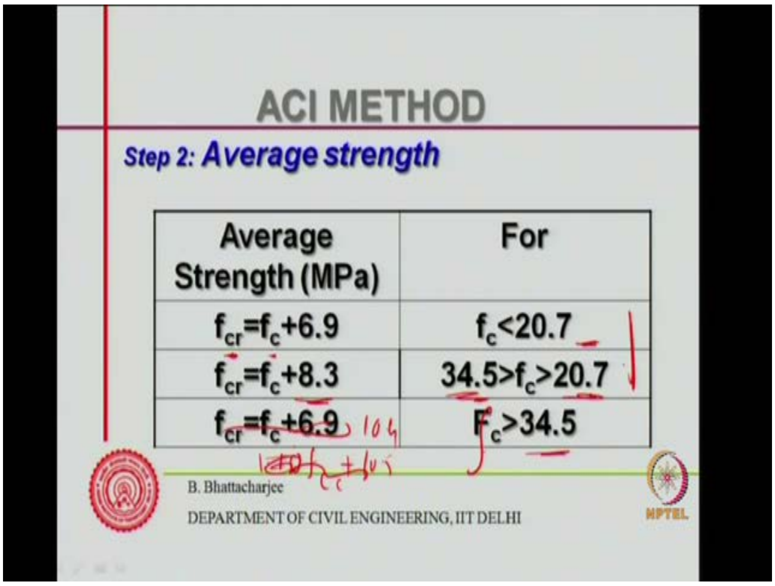

Well, this is slightly different then the other code. First of all it says that you from 30 consecutive results you can determine the standard deviations. From 30 consecutive result you can determine the standard deviation. And, if it is not available then you take the average strength of f c r as f c plus 6.9 f c plus 6.9; when the cylinder strength great cylinder strength is characteristic cylinder strength is less than 20.7. If it is more than 20.7 and less than 34.5 then you at 8.3. And, if it is greater than 34.5 then you had this given as 1.1 f c Plus 10.5. So, the value is different this is not correct. The value is different I think we have the formulas separately. So, this is f c plus 10.9 not 1.1 f c plus 10.9. So, anyway this is f c greater than 34.5 you have you have the average strength more than you know more than added by some number. So, basically specifies basically specifies what should be the what should be the strength depending upon what should be the strength depending upon what is the cylinder strength?

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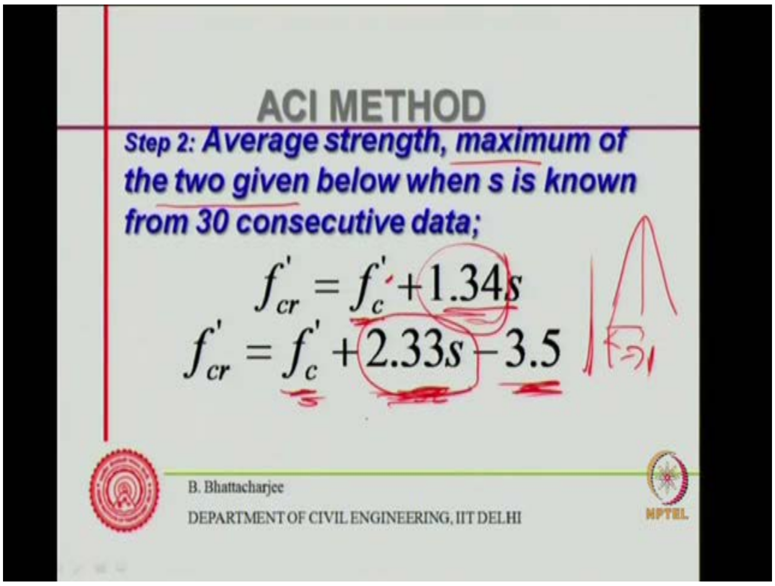

So, average strength if you do not know the standard deviation, but when you know the standard deviation when you know the standard deviation; the deviation from 30 consecutive data or you know or you know it from 2 sets of 15 consecutive data. So, that you can find it out as a under root of s 1 square plus s 2 square; s can be s square can be written as s 1 square plus s 2 square. So, s 2 15 set of data if available. So, that s is known to you; so when you know s. You will find out the strength as maximum of the 2 given below that means this either of this or this. So, when nothing is known you find out from the table when nothing is known you find out from the table. When it is known then you find out from this 2 formulas of equation whichever is greater maximum; maximum of the 2 given below that is this is your cylinder strength plus 1.34 standard deviation.

And, all this plus 2.233 s minus 3.5 actually minimum acceptable strength minimum acceptable strength is f c dash minus 3.5. So, minimum plus 2.33 f c is a average strength. So, average strength is minimum strength plus 2.33 s that is you know it is again from that is normal distribution curve. So, 2.33 s to cover specific percentile. So, is the case we had 1.65 to cover 95 percentile; that means only 5 percent that means 5 percent would be strength less than this. Here, this value is somewhat different because it is not 5 percent and this minimum strength is stated to be this. So, minimum strength plus 2.33 s should be the average strength; this is again with certain confidence limit. So, which ever gives you higher based on this, whichever gives you higher, you choose the 1 whichever gives you higher.

So, that you choose or you choose from the table that was that is given simply in terms of f c dash plus some value. So, that is how you choose your average strength and then go to the table and find out the water cement ratio. So, you find out the water cement ratio. So, where you can find out the water cement ratio and we have also found out the water content. So, for this you know it is all again I repeat its for the cylinder strength. So, average cylinder strength is known and therefore, correspondingly found out the water cement ratio. And when I found the water cement ratio also the water content I should be able to find out the cement content. So, cement content should be find out. But before that to mention that s can also be obtain from 2 data sets having 15 data each as s 1 square plus s 2 square is equals to s square. So, that is how it can be found out that is how it can be found out.

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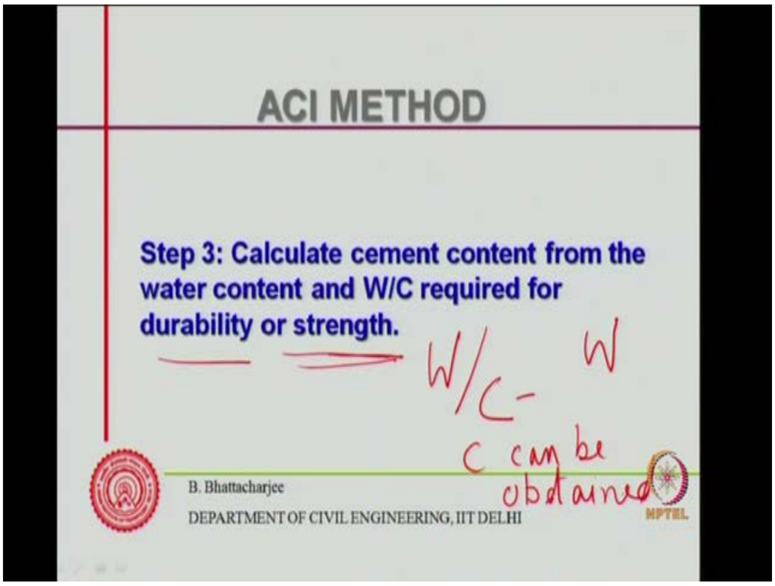

So, the next would be calculate cement content from the water content and water cement ratio required for durability or strength. Well, durability again controls water cement ratio is controlled you have a maximum limit of water cement ratio you have a maximum limit of water cement ratio. So, therefore durability is again controlled durability controls the water cement ratio. So, you have maximum water cement ratio and from the strength consideration you found out the water cement ratio. So, whichever is lower you choose that water cement ratio. And, based on the you find out the cement content because you know w by c, you know w. You can find out c, c can be obtained c can be obtained.

So, you see this has got some sort of similarity up to the stage with the methods that we have looked into r d r as well. There is D I E method also does the same thing; first finds out the strength water cement ratio from strength. And, water content from workability MSA and this whether a crushed or natural aggregate from that kind of other words shape of the aggregate. So, you find out the water content and once water cement ratio and water content is also known c can be obtained. Now, here differs here a same method differs; as you can see it differs ACI Method would differ from r d r method; D I E Methods used wet density concept while IS method while IS method used some total of volume must be equals to 1 meter cube So, conservation of volume principal; wet density is also similar.

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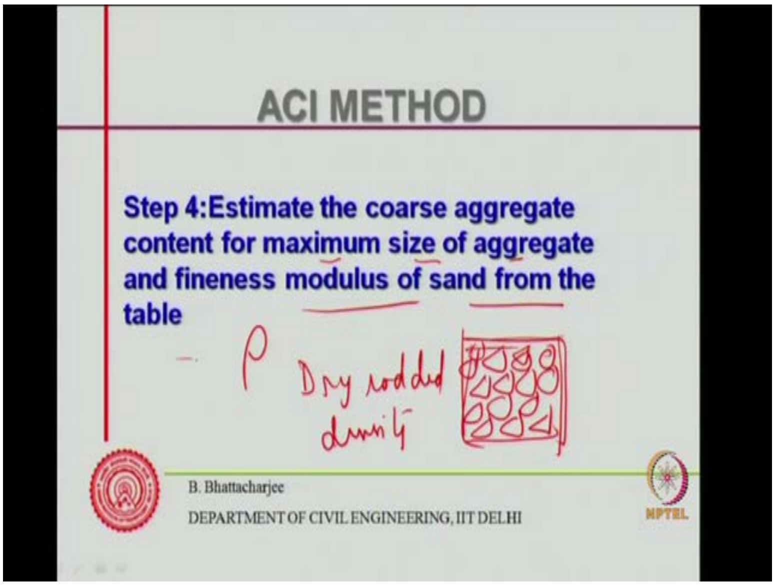

But here what is done is you find out the dry rodded density of the aggregate dry rodded density of the aggregate. That means, what you do? You have you pick the aggregates course aggregate in 3 layers aggregate in 3 layers. And, find out because volume of this is known, how much is the mass? This volume you can find out first by filling it water volume of the container. Then, put the aggregate then put the aggregate and find out how much is the mass of the aggregate?

So, if you know this mass they know this will be dry rodded density density dry rodded density. So, you know the dry rodded density dry rodded density and dry rodded density of this is known that is mass unit volume is known unit volume is known. And if I know the volume occupied by the aggregate volume occupied by the aggregate in the overall volume; then this is multiplied by this dry rodded density that will give me the amount of course aggregate present amount of course aggregate present in the overall concrete system. So, estimate the course aggregate content for maximum size of aggregate and fineness modulus from the table.

This the course aggregate content in volume metric course aggregate content of proportional to the content of aggregate content. And, fractions that we can find out we will just find it out just now. From the next table we will look into the table, but before that adjust make you know I would like you to recollect. When we discussed about aggregate remember we talked about fineness modulus. The fineness modulus is average it is a average sip size in some form that is what we have seen. So, fineness modulus defines the fineness of the sand fineness of the sand if you can recollect fines of the sand is got defined by fineness modulus.

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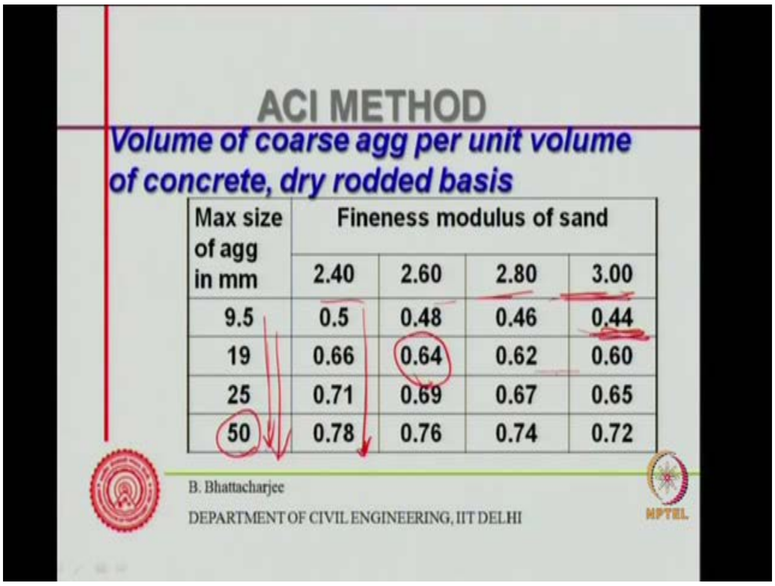

Max size of agg in mm	Fineness modulus of sand			
	2.40	2.60	2.80	3.00
9.5	0.5	0.48	0.46	0.44
19	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
50	0.78	0.76	0.74	0.72

So, in the next table we will come back to this one again if required fineness. If you see volume of course, aggregate parented volume of concrete on dry rodded base is is given as by this. So, you have as your maximum size of aggregate increases here we have taken also for 50, 37.5 and 50 and there are large numbers are available. This is the fineness modulus of the aggregate the impressing along this direction and this is my MSA increasing. So, total aggregate content increases in other words your send content to decrease as I have more sizes. As I MSA increases totally aggregate content increase because send content would reduce, because it will have a better packing. So, sent content would reduce and this is related to the fineness modulus of the sand fineness modulus of the sand. As a fineness modulus increases the (( )) proportional of the sand again would reduce because this is something to do with the overall gray ring overall packing of the system overall packing of the system.

Because higher the fineness modulus it means you go to quarters you go to the quarters size overall size will be quarter. Which means you have got a better grading of the sand itself send them. So, suspect better and they have different size more larger size is also available in them. So, they occupy more volume than the pack better. And, therefore you know the I mean the pack they do pack by overall packing is better. So, sand volume reduces along or course aggregate volume reduces as I go along this direction. In fact sand volume increases volume, overall proportion of the sand actually overall proportion of the sand increases, overall proportion of the sand or sand volume increases. Because course aggregate proportional is reducing, because sand itself got a better packing and more there is larger size is also there.

So, it fix it into overall grading better the space here would be filled in by less sand. So, that why you find that fineness modulus with higher the fineness modulus of sand. This is decreasing and as we increase a MSA this volume aggregate volume aggregate increase. So, the proportion of the aggregate volume is given by this one this particular table. So supposing you find out that this is 0.64 and you know the dry rodded dry rodded density dry rodded density of the course aggregate multiplied by this to get the mass of the course aggregate that is present.

It means that in your total aggregate 64 percent 64 percent will be the aggregate volume aggregate volume 64 will be the aggregate volume; rest of the volume would be volume of the course aggregate this much rest of the volume would be the paste and the mortar all together. So, 64 percent would be occupy volume would be occupy by our 65 percent of the mass would be occupied by the dry rodded density; gives you the mass per unit volume. You know 64 percent of that would be occupying and the total space in concrete rest all will be filling. So, in 1 meter cube you know dry rodded density gives you how much solid aggregate would have gone it will multiplied it will multiplied; by this fraction. That much will be the aggregate content in the course aggregate content in the concrete.

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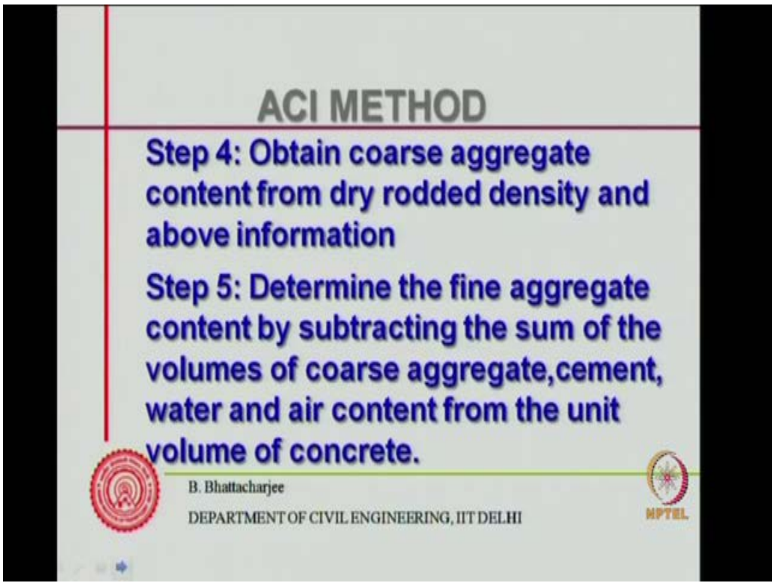

So, obtain course aggregate content dry rodded density and above information that percentage that you have got. And, then determine the fine aggregate content by subtracting the sum of the volume. So, course aggregate cement, water and air content from the unit volume concrete. So, than again it uses a conservation of volume concept. And, you can determine the total determine the fine aggregate content and thus how you got the proportion. So, you have got the proportion.

So, we can look into now example. Similar, example as we have done earlier. Well, Indian M25 will not be correct statement I will say 25 is cylinder strength. So, this is not 25 25 MP a cylinder strength cement of course, we are using OPC for the simple case of an example. If it is M25 this would have been 20 MP a cylinder strength 20 MP a cylinder strength; but we are not using that in fact ours is highest strength. So, 25 MP a cylinder strength corresponding concrete strength would be you know cube strength would be 25 divided by 0.8 would make it 31.25.

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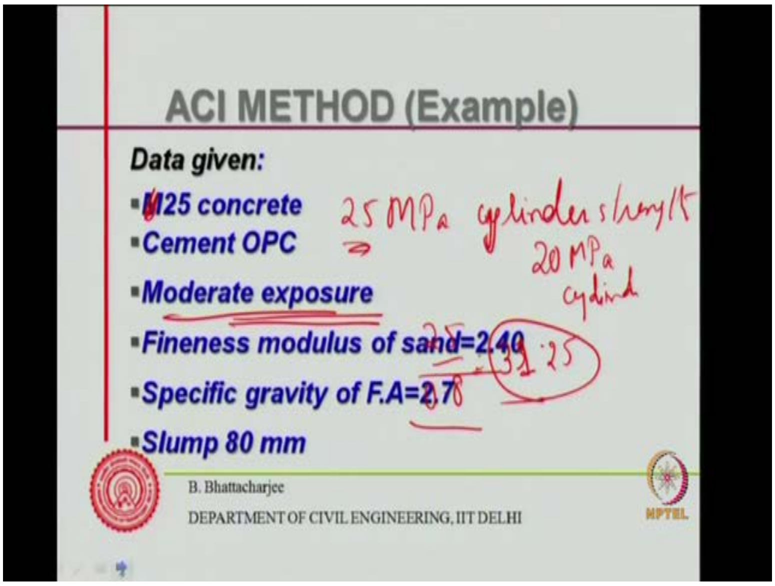

So, somewhere around 30 grade of concrete is if the cylinder strength is 25 MP a something close to 30 MP a concrete; that is what we looking at. And, moderate exposure of the cement ratio etcetera, etcetera. Now, if are adopting in Indian situation you can take this water cement ratio permissible by Indian court only. And, finest modulus of the sand is taken ads 2.40 which is required and in this case. The specific gravity of fine aggregate is 2.7 slump is same what we are taking as 80 mm same as before.

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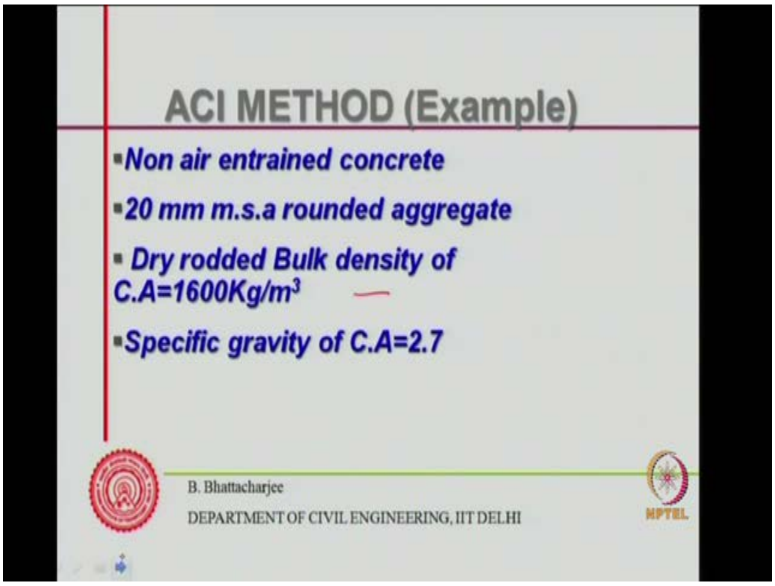

Non air entrained concrete we are using because again we are only looking at the Indian scenario. And, we have chosen 20 mm say rounded aggregate as we have done before. Dry rodded bulk density of course, aggregate is 1600 kg per meter cube. So, this is to be measured in 3 layers. You actually measure this in 3 layers at them in 3 layers and in a standard manner. And measure the container volume by water displacement method. Then, measures the mass of the aggregate that is gone in to the container. Since, you know the volume and the mass. Therefore, you can find out the Dry rodded bulk density of the course aggregate which is 1600 kg per meter cube; which is there say as example 1600 kg per meter cube. Specific gravity of the course aggregate is also against 2.7.

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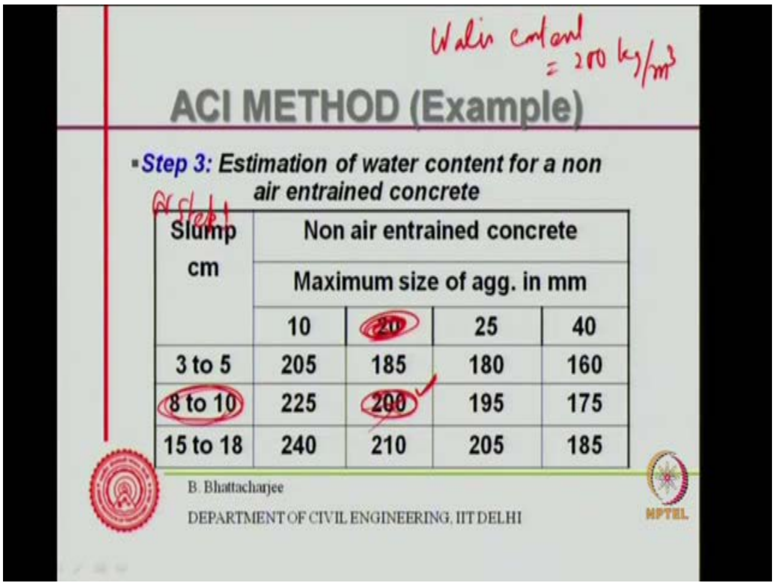

So, first step you would have been step 3 because as I said step 3 would have been Step 3 in the code, but we are considering a step 1. So, this is step 3 or step 1 actually. I will say step 1 from a or non air entrained concrete we have to estimate the water content and this is the table. Now, I may say my msa 20, my slump is 8 to 10 centimeter 80 mm. Therefore, my water is 200. So, this is my water content is 200 kg per meter cube. So, that is the first step corresponding air content of course, we know for 20 mm m s a just see them that that is c for 25.

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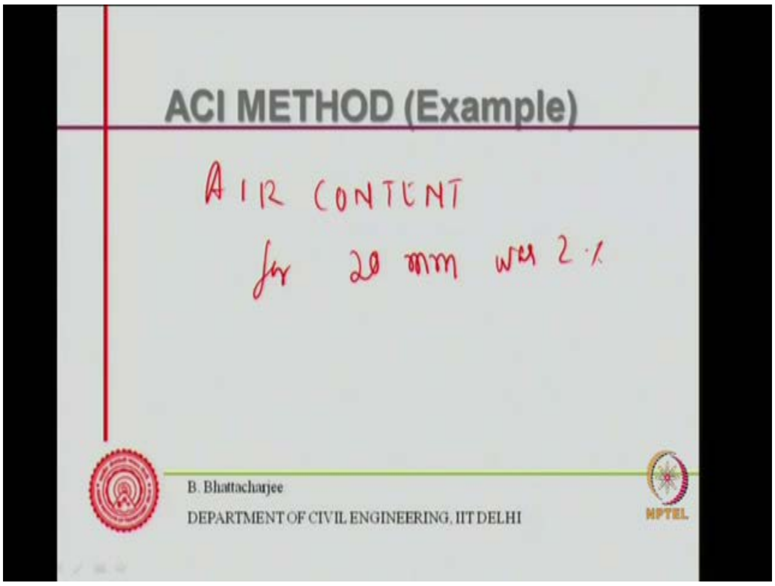

So, air content would be air content air content for 20 mm m s a if you recollect was 2 percent, 1 percent was 40 mm aggregate and 2 percent for this. So, this is the other information that we have obtained.

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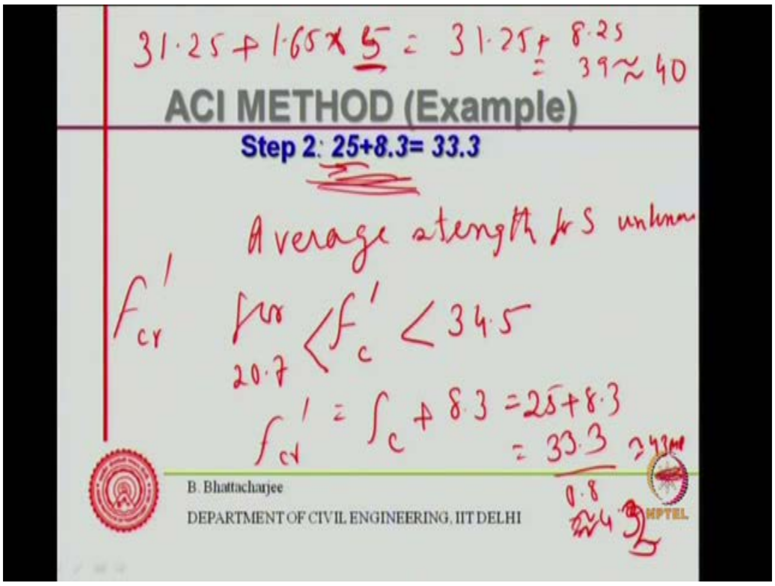

And, then next step is 8.3 because you see supposing I do not have standard deviation known. So, we said average strength average strength if it no standard deviation is known average strength. When s is known for s is unknown for for fc dash less than 34.5 greater than 20.7 is equals to fc average strength fcr dash. So, fcr dash is equals to fc plus

8.3. So, this is 25 25 plus 8.3 is equals to 33.3. And, if I compare this cylinder strength this cylinder strength and if we compare with this is the cylinder strength; the average cylinder strength divided by 0.8. And, I will get 4 and may be 4.2 approximately 4.3 and 42 and 43 and about 43 mp a that will be a cube strength.

Now, my concrete was 31.25 some grade plus 1.65 into the standard deviation of about 4 or 5 if I take it I think 5 by our code. So, you will have 31.25 plus if I take 5 as a standard deviation. So, this will have another 8.25 or something. So, this will be around 39.5 or 40 let us say is close to 40. So, you see this is talking slightly higher if we look from Indian strength point of view is slightly higher. This is value is slightly higher this value is slightly higher.

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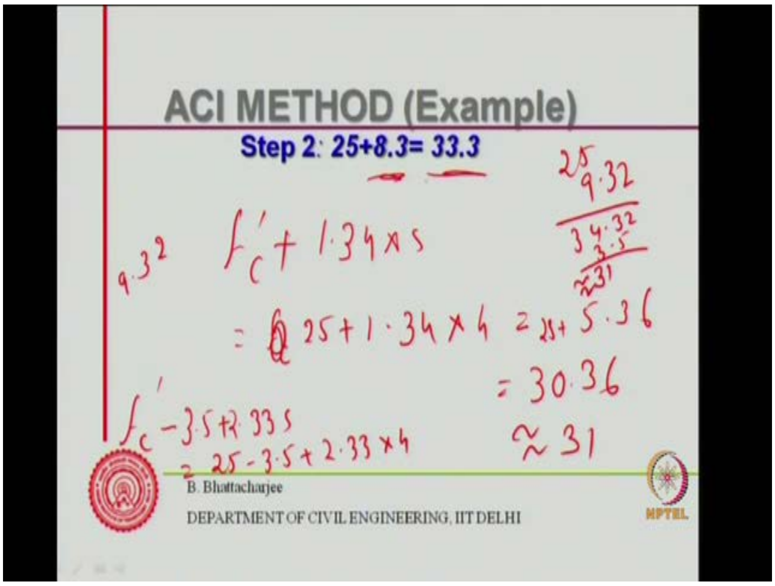

However, step 2 is because this is a unknown. So, that is why taking slightly higher, but standard deviation becomes known. Then, this should become lower with the standard deviation becomes known this will become lowest; because we said that it will be fc dash plus 1.34 into s. Now, s would be smaller here; let us say s is 4. So, if it is 4 then fc dash is 25 plus 1.34 into 4 and this will be equals to plus 25. So, this will be 30 plus 36 I will take it as 31 or I will take it as fc dash minus 3.5 plus 2.33 s. So, if s is 4 this value will becomes 25 minus 3.5 plus 2.33 into 4 and which will give you 9.32. So, 25 plus 9.32 is Minus 3.5. So, approximately it will be 31. So, this will give me 31. So, both ways I am getting actually maximum of the 2 both ways I am getting actually 31. So, it will be 31 if the standard deviation is known and if it is not known it would have 33.3. So, average strength would be 33.3. So, 1 has to decide seems we said that there is no standard deviation is not known. So, we will be designing for 39, 33, 33.3 and correspondingly I must find out.

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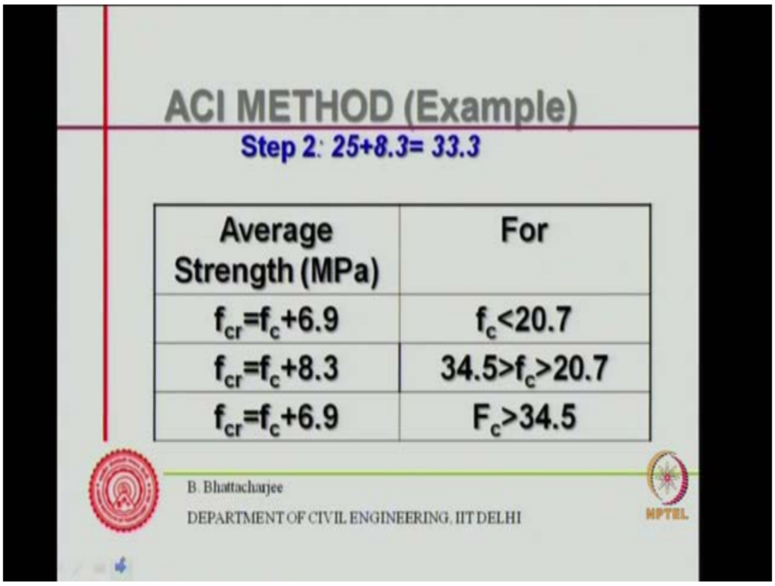

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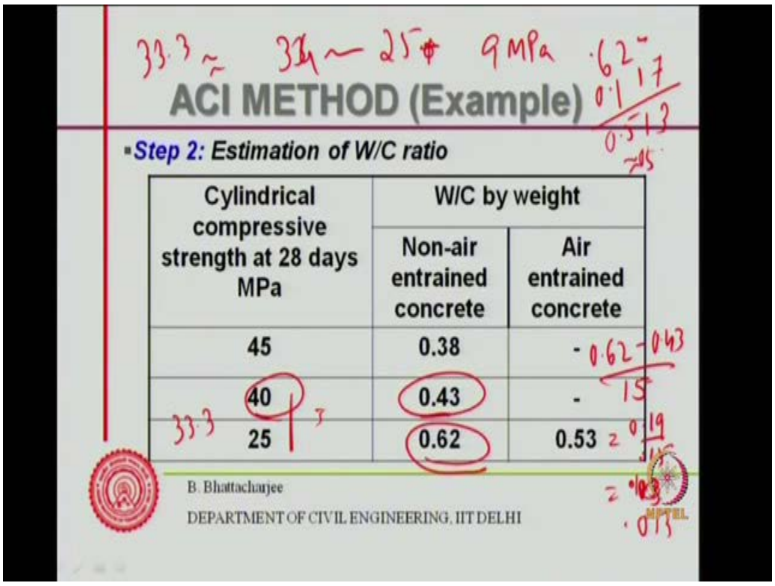

So, this is this is thing and correspondingly I must finds out water cement ratio from the table. So, from 25 it is 0.62, for 40 it is 0.43; and in between value are also given which we have taken by this all value is 33.3. And, corresponding to this so this is divided by

15. So, 0.62 minus 0.43 divided by 15 divided by you know 25 plus 15. So, per MP a per M P a it would be 0.19 divided by 0.15. So, which will come out to be roughly 1.3 per MP a. So, 25 plus 33.3 or 34 let us say 34 minus because 33.3 it was which we will approximately 34 minus 25; which would mean that the 9 M P a or 9 MP a water cement ratio has to be reduced into point. So, 0.13 this is 15. So, 15.0.013 0.13 per MP a, for 10 MP a it will be 0.13 of or 9 MPa somewhat around point. So, 0.62 minus 9 MP a it will be 0.62 minus 0.117; and this will come out to be 31 and 0.5. So, it will be 0.51. So, you take as a 0.51 or 0.5 we take it as a 0.51 or 0.5. So, one can interpolate if it is not available, but however actual table gives you a number of values in between.

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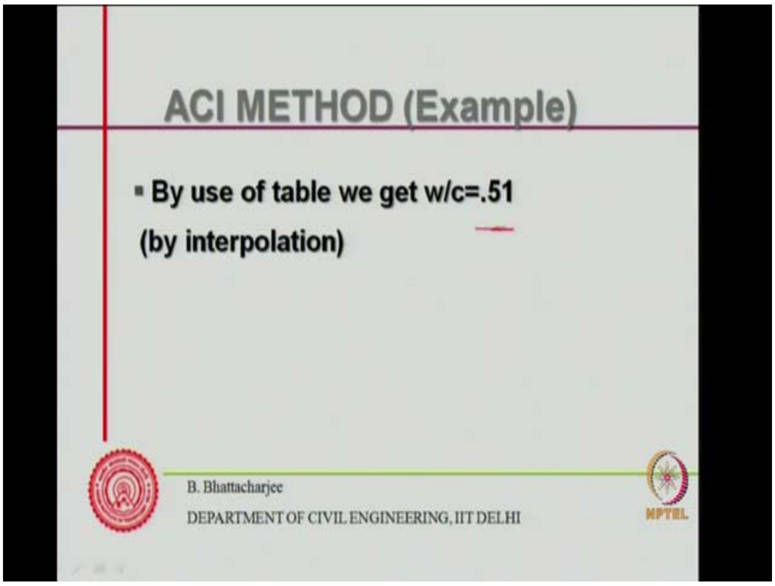

So, we assume in the our case we assume as water content. Let us say 0.51 by use of table by interpolation we can get the water cement ratio as 0.51. Now, we can find out the cement content the water content was 200. If I take it as 0.5 approximately to is of calculation. This will be 400 kg I just taken it easy. And let us say my water cement ratio specified for durability is 0.5. So, I take it as 0.5, cement content is 400 kg. And I have to check whether it is more than that is required for durability which is actually more. Because for this consider this condition we have see IS 456 2000 gives much lesser cement. So, 400 kg of cement 200 kg of water is what we have got so for.

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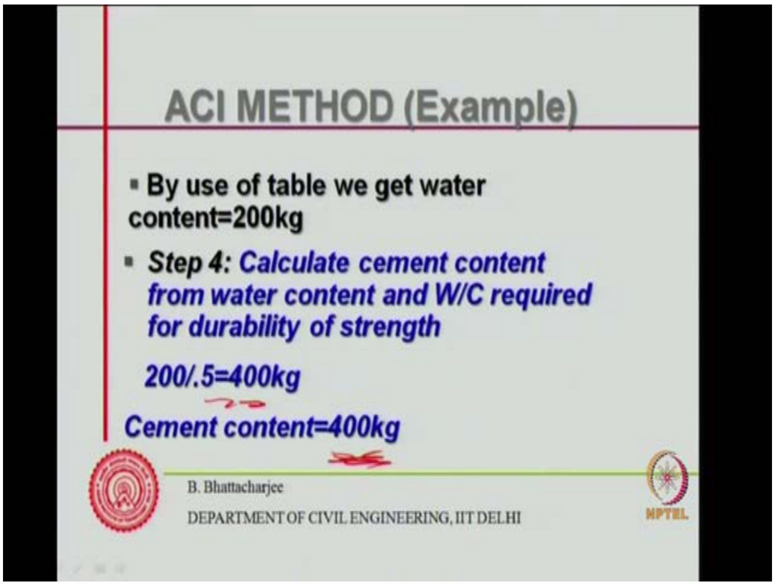

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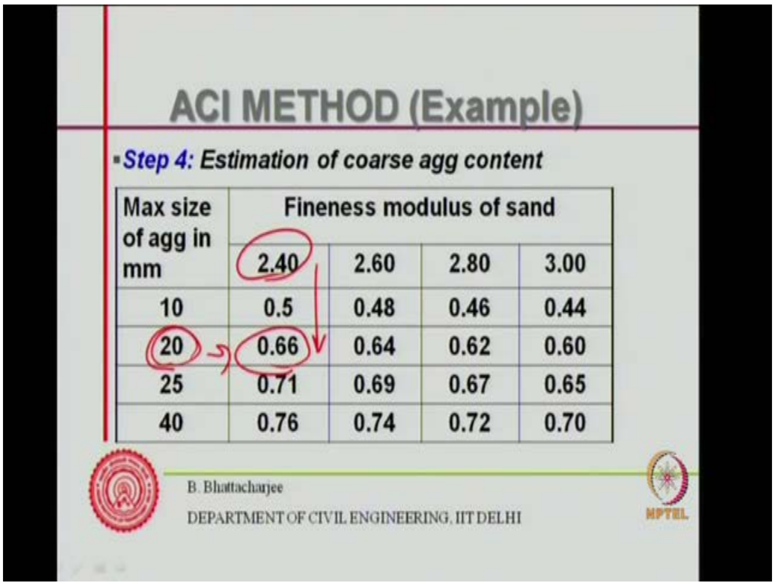

Max size of agg in mm	Fineness modulus of sand			
	2.40	2.60	2.80	3.00
10	0.5	0.48	0.46	0.44
20	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
40	0.76	0.74	0.72	0.70

The next step would be to estimation of course aggregate content. And, this is from this particular table and we had 20 mm msa, sorry maximum size of aggregate is 20 mm. And, fineness modulus is 240. So, therefore 0.66 is the coarse aggregate content 0.66 is the coarse aggregate content.

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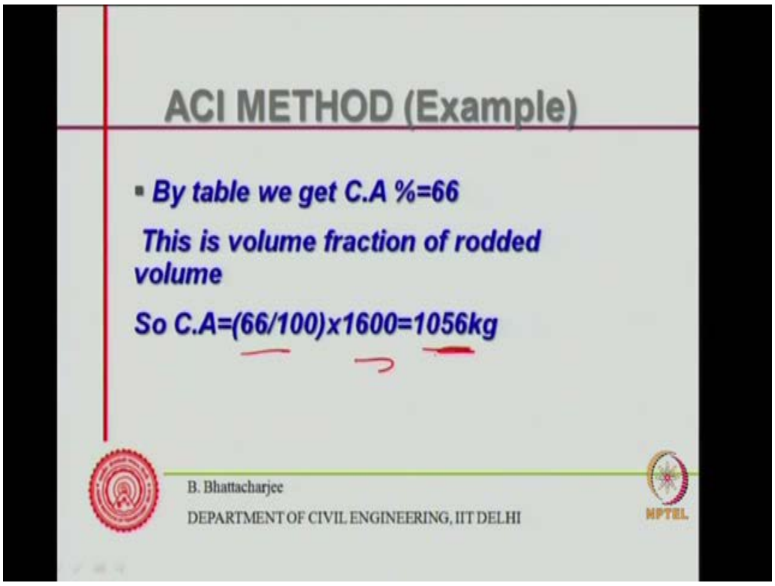

And, with this now I can find out the volume of you know volume fractions specification; dry rodded 66 percent multiplied by so this a quantity of coarse aggregate that should be there. You know in 1 meter cube actually 600 kg of coarse aggregate goes, but the volume that would be occupied by the coarse aggregate. In bulk is the 66 percent of the total concrete that is what it is saying. 66 percent of the total concrete volume aggregate total concrete volume will be occupied by the course aggregate. So, rest of the 0.44 percent would be occupied by of course the other materials which will contain also some amount of air.

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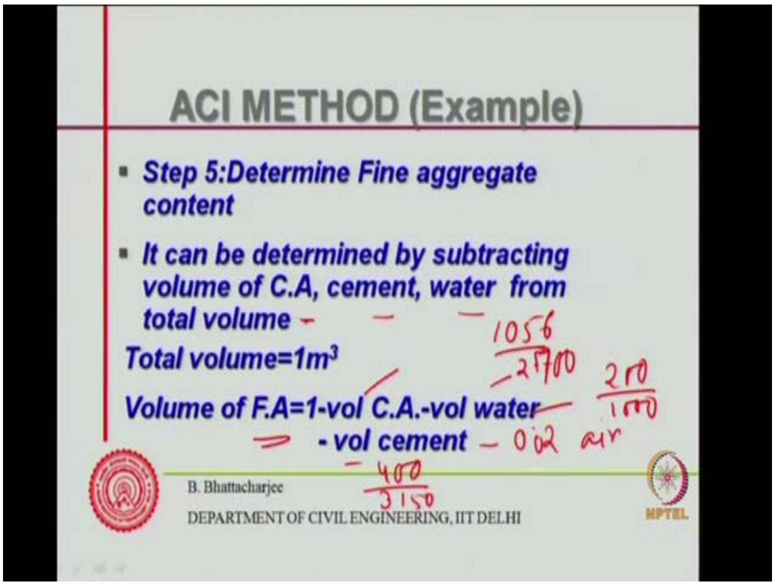

So, coarse aggregate content straight away you get it you get it. You know course aggregate content in 1 meter cube 66 percent of the material cube is actually occupied by course aggregate in bulk in bulk. And, therefore, I multiplied by bulk density; which means that there are force inside and rest of the material will be other material.

Fine aggregate content now I can determine by subtracting by the volume of coarse aggregate, cement, water and of course, air volume also from the total volume. So, total volume 1 meter cube minus actually 2 percent I should subtract. So, actually I have an equation 1 minus and volume of cement also 2 percent air volume air volume is 0.02. So, this has to be subtracted. Now, volume of course aggregate volume of water volume of course aggregate is given as 1056 divided by 2700; volume of water will be 200 divided by 1000 and volume of cement will be 400 divided by 3150. Therefore, volume of Fine aggregate you can find out volume of fine aggregate you can find out.

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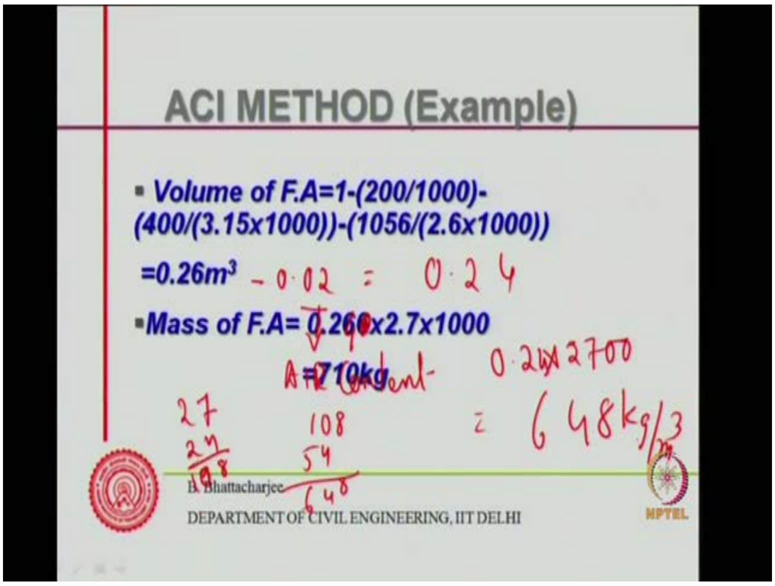

And, this will come out to be point this minus 0.02 to also should be there because of the air content air content and this will be 0.24. So, 0.24 is the volume 0.24 multiplied by 2700 will give you the fine aggregate content. So, this is 2700 will give you Fine aggregate content and this you found out comes out to be this is Fine aggregate is 2.24 because 2 percent air content has to be subtracted. So, this value will come out to be 27 into 24 is 64 this is how much 27 into 24 so 648. So, I get Fine aggregate content will be 648 fine aggregate will be 648 not 700, but it will be 648 kg per meter cube.

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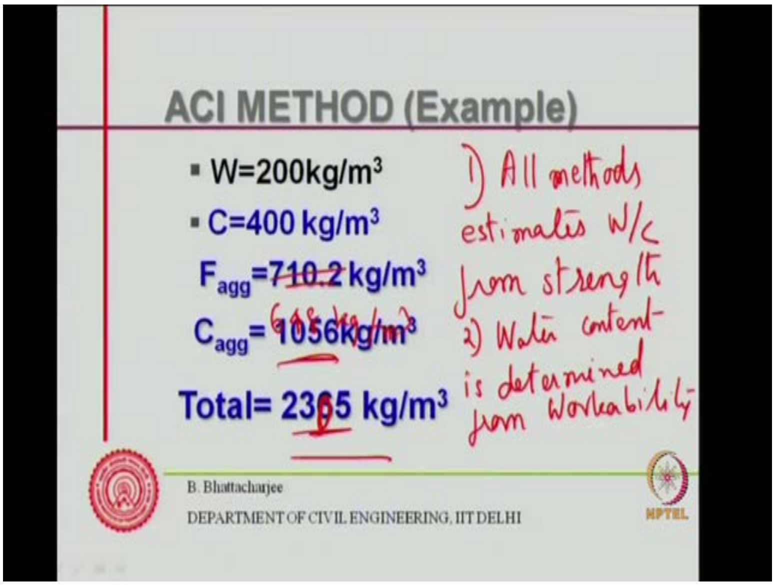

So, if I put it together so if I put it together from ACI Method I will get water 200 kg, cement 400 kg. This is this is incorrect this will be 648 kg per meter cube and I will have coarse aggregate 1056 kg. So, total sum of course, there will be some change in this there will be list thus 2 percent because there is someone talk about 60 kg. So, this will be around 2305 kg per meter cube. So, this is how we can obtain the obtain the proportion through ACI Method. So, if we now compare this 2 different methods, 3 different methods. Step 1 I mean you can generalize one thing can generalize all methods all methods estimates water to cement ratio from strength. That we said in the first day; water content is determined from work ability aggregate work ability is determined from work ability and msa and shape of aggregate.

So, W you determine from msa slump and shape; water cement ratio from strength strength. Then, Cement content calculated only if next thing you should determine the course aggregate to fine aggregate ratio; that is determined differently by different methods. So, you know most of the methods determines water cement ratio from strength, water content from msa slump, shape of the aggregate, cement content then you can calculate out. And, course to find ratio calculated differently by different method.

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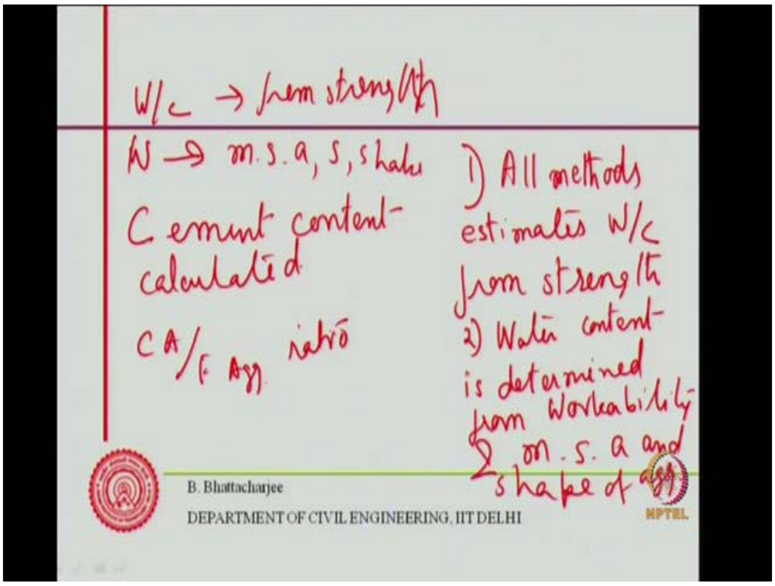

So, the diagram that we show in the very first class related to the general mix design procedure. That that is why it is you know that is it follows; actually strength is a function of water cement ratio. So, durability requirement you know based on the chemical exposure durability requirement; determine the water cement ratio and strength also governs the water cement ratio.

So, whichever is lower we choose that water cement ratio while work ability is governed while work ability is governed by the paste content. And, which also depends upon the packing characteristics of coarse aggregate and fine aggregate system. So, it will depend upon the maximum size of aggregate, shape of the aggregate and water content therefore determined based on the slump based on slump. And, maximums size nominal size of aggregate and shape of the aggregate etcetera, etcetera. So, one of these are known cement content is calculated and up to this although 3 methods which discussed by large saying in some form or other.

Now, once you know the water content and cement content. You can water content and water cement ratio you can calculate out cement content. Now, 3 methods differ in Indian code you have got the proportion of Fine aggregate also specified. In the total aggregate proportion of the Fine aggregates are specified; in D I E method proportion of total aggregate first you find out the total aggregate from total aggregate by density card.

And, since you know the wet density, total aggregate content you can find out by subtracting the course aggregate a subtracting cement and the water.

In ACI method then you first find out the quantity proportion of coarse aggregate in volume proportion course aggregate in the total concrete. And, then multiply this by the dry rodded density that will give you the amount of aggregate. In Indian method you find out from the conservation of volume equation. Because you know the cement content, you know the water content, proportion of fines as known to you from table proportion of fine to the total aggregate of proportion. Of course, in the coarse aggregate in the total aggregate volume that is known to you. And, therefore, fines and course you can find out by setting simply 2 equations. So, by enlarge principles of all this methods this 2 methods. 3 methods are same except for the last stage of it, but in all cases as we mentioned already here it is the trial mixture it is only the first mix you can get it.

The reliability of strength water cement ratio tables as given in ACI is not I mean there reliability in Indian scenario. They may not be applicable simply Indian scenario; because as you recall strength is a function of water cement ratio when all of things remain same. Now, aggregate type the cement properties cement itself they would be different you know from country to country. So, this is it will there be there can be infinite possibility of strength water cement ratio relationship. Because from abroad also from seen there are 2 constants. And, this constituents constants could would actually determine the actual strength water cement ratio relationship and this constant depends upon the aggregate type, cement type etcetera etcetera. So, directly directives of ACI water cement ratio relationship may not be the best thing to be.

The other problem of course, as will see is not problem, but the other care one must take is the a c I method actually uses cylinder strength. So, 1 has to be careful about using ACI Method when adopting an Indian scenario. We have take the cubes strength to in equivalent cylindrical strength roughly you taken 80 percent this is the other issue. So, keeping this to point together 1 can actually adopted any other methods in Indian scenario, but that gives you only the first trial; water cement ratio is most important. Therefore, Indian code current code of 2009 10262 definitely puts the water cement ratio should be determine from experience. It does not give you any kind of fix guideline which both the other methods do. So, when adopting either d u e method or ACI method one must chose the water cement ratio perhaps with your experience.

You know rather than rather than trying to chose it from table a such, but in any case they can they all save as the starting point. You have to do trial makes and find out the strength slump or specified properties from the mix that you have obtained; and then do the modification. And, then of course site modification to us moisture content etcetera are definitely required. Lastly, you have to actually do trial and monitor the strength also trial to start with. And, once you started casting you have to monitor the strength also and modify the mix.

So, mix proportion is not a static thing it is actually dynamic thing and continuously it must be monitored and the mix proportion will have to be modified. So, it is to be understood that once you have got mix design done write in the beginning that is not the end of it. And it cannot used again and again without modifying and monitoring the same. So, for modifying you monitor the practice of having a specified mix proportion and use it for while is not correct. So, 1 has to monitor it and modified continuously, anyway so this note of summarizing this with 3 method.

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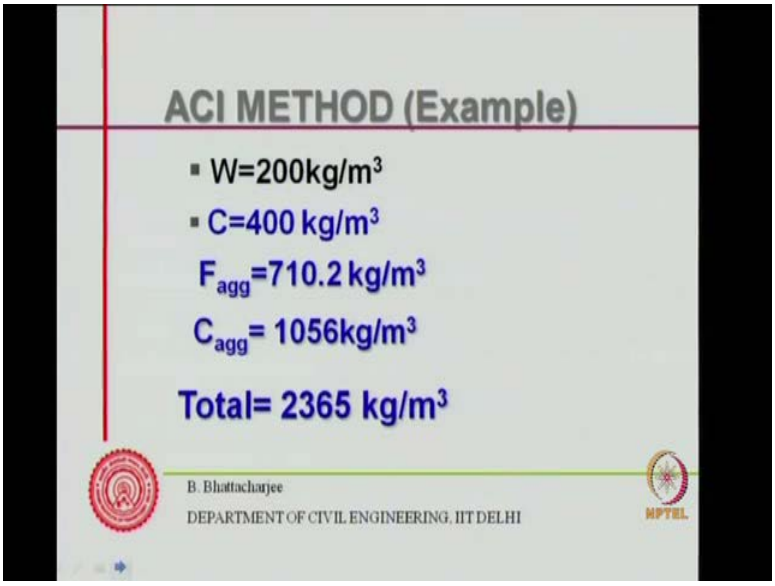

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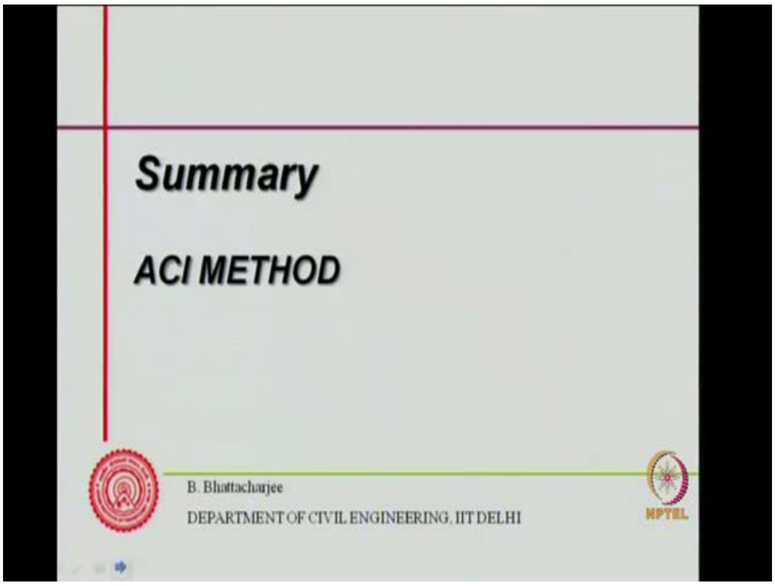

We would like to conclude our discussion that you have seen that these are the 4 proportion we have already seen. And, we can we can summarize that today we have discuss the ACI method. Earlier is discussed d y due and Indian method and we have also discussed somewhat about the comparison of these 3 methods. And, where you know I mean how can you adopt them in Indian scenario. I think this we will conclude.

Thank you very much.