Fire Protection, Services and Maintenance Management of Building
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Lecture - 51
Core Strength test

So, continuing from where we have stopped; we talked about just introduce the Core Test.

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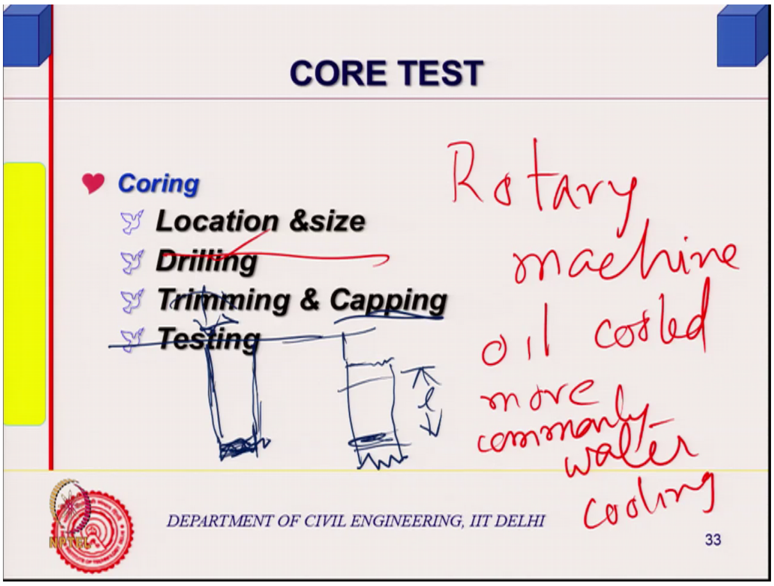

Let us see what is the core test, first of all we go to drill, drill the samples from the concrete so coring is a process. So, it is rotary drill, usually rotary drill what you use right, and can be oil cooled or water cooled. It could be oil cooled or what because you need cooling, you need cooling. So, coring can be oil cooled or water cooled, you know.

So, rotary drilling machine; rotary machine could be oil cooled, more commonly oil cooled. Now, if it is if you want to do chemical testing water cooling has a, you know, you have to you cannot use distilled water for cooling purpose. So, this can water cooling can add contaminant. So, you have to see that if your doing chemical testing, water cooling. So, you have to see that if you are doing some chemical testing or something of that kind preferably with inert coolant one should be doing, which you did not contaminate the concrete. Then important is the location and size. Now size must be first size; size must be representative of the concrete, because concrete is homogeneous at a macro level; more you go finer it becomes heterogeneous.

And for example, in centimetre level, 1 centimetre level in fact, it is a heterogeneous, because you can have aggregate size is larger than 1 centimetre. Then motor and aggregate is from some parent rock. So, that will have it is own in homogeneity whatever is there, but that is relatively less in homogeneous or heterogeneous; is heterogeneous rock should be heterogeneous at still micro level, the grains and so on impurities or what you call you know, the constituent chemicals in the grains. It might vary from point to point etcetera etcetera.

So, that would bring in some in homogeneity; in concrete additionally the motor is there. Motor itself if you look at it, if you consider sand particle, then it will be at a fraction of a millimetre level you know, 0.8 millimetre or so. If the sand sizes are 475 micron to you know, 475 micron to we consider it up to 2 point is, you know, 470, sorry, 475 mm to75 micron that is what we consider as sand. So, 477 you know, 5 mm you know, close to 5 mm and smaller. So, 1 millimetre level, sand sizes are of that 0.8, 0.9 average 0.8, 0.9 or 1 millimetre that is order would be there.

So, there again it is heterogeneous the sand and the hard and phase. And at the phase level again it is heterogeneous. So, again I am not going to that part again microstructure level. So, if you are taking a core, you are looking at the macro property. Compressive strength is a macro level property as you understand. Therefore, you should take such size which is representative of the concrete is a whole and you can treat it as a micro concrete. So, in that case size is I will just tell you size will be related to the it is diameter or minimum dimension.

Location as I already told you earlier. You do not take from a vulnerable location; which will cause more damage to it right. So, that is what it is drilling I have already told you drilling is rotary drilling. Now, when you drill actually you drill from the top side, right you drill from the, you know, will be drilling possibly from the top side. You will be drilling from the top side right this is what it is top or surface from the surface vertical also it can drill. So, what you do is, you drill it something like this right. And there will be some undulation here, you have drill drilled it I mean drill it something like this is usually.

Then what you do? You put simply share it off by putting some sort of a you know, giving some sort of pressure like this or moment or something of that kind. You put a put a wedge or even a screw driver does the job and just brake it. So, when you share it you will have this undulated so. In fact, the piece you that get, you get may not be very polished at the surface but surely will be somewhat undulated the bottom.

So, what you do? You trim it, then you trim it here, and trim might trim it up the also. So, this is called trimming so, after drilling trimming. And there has to be a minimum size, because as you would see a little bit more, the measured strength is a function of this l and if this is d function of l by d.

So, below a point of length being too small compared to d result should, you know you would get a variable results I mean you do not want that way, we will see what it is. So, it actually sometime if the size is small you might have to do a little bit of capping, to bring it to the appropriate size. But then it has to be done in a standard manner. So, that is called capping we will discuss some of them.

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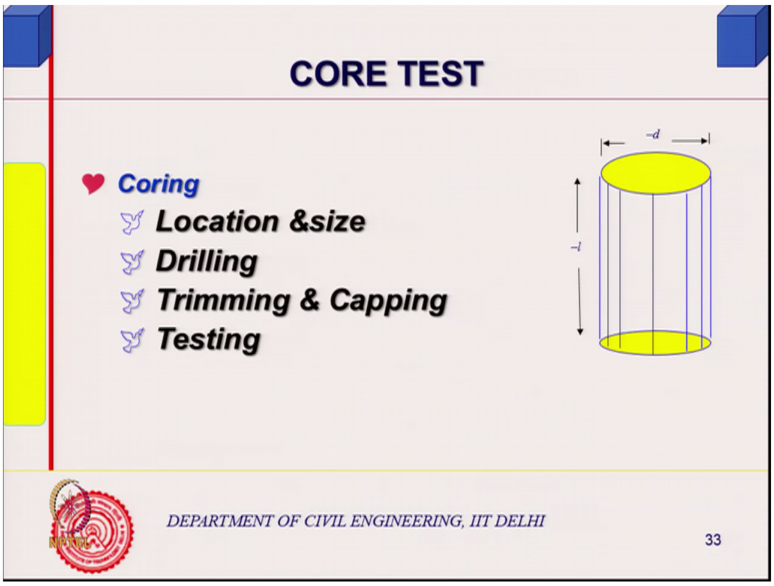

Then standard testing as normally we do for any other compressive uni-axial compressive strength test we will do the testing. And this is what a core will look like after trimming l by d.

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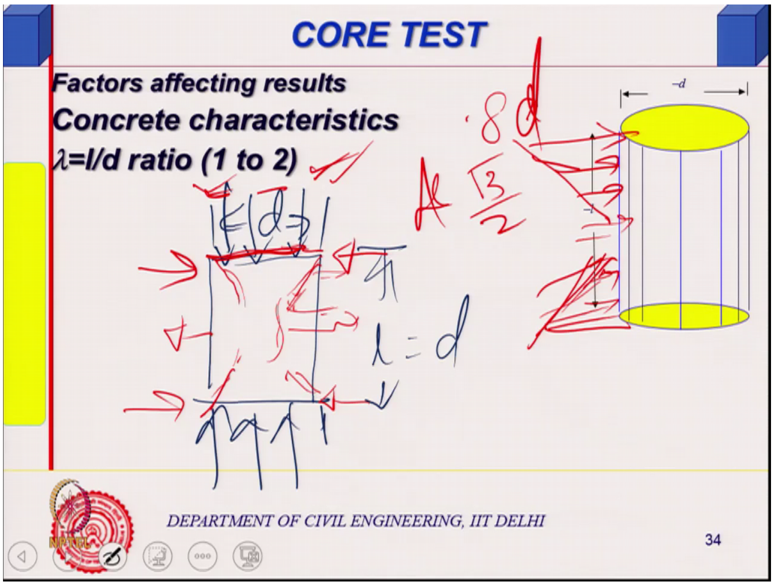

So, l is the length, d is the diameter and you know, factors you have seen factors affect the result is l by d right. Obviously concrete characteristics will effect, but l by d, l by d ratio is important. Now why l by d ratio is important? You know, the strength of cube is more than that of the cylinder, strength of cube because the reason is when you are testing uniaxially a cylinder let us say l; which is equals to d and this is equals to d.

So, you are applying compressive force like this from both sides. There is the basic; you know there is the basic tendency of this material would be due to poissons effect, tendency of the metal would be to expand laterally. And now since these materials are basically bonded granular material, you have pieces of rocks or stones or aggregate whatever we call it, and they are mechanically bonded, not really chemical bonding mechanical bonded with the phase system hard and phase system.

Right within the phased of course, there has van der Waals kind of bond. So, that I have not come to, but these are weak bonds; whatever bond between aggregate very feudality if it is chemical bond. If it is only some specific type of aggregate volcanic source, aggregate which series volcanic you know, some sort of chemical bond very rarely it can have, mostly it is mechanical bonding.

So, if they are very weak in tension, you can push them all they can stand a lot load, but you try to pull them they separate out. So, what happens is this is much less this load carrying capacity or strength along this direction is much less tensile compared to this. So, you will have cracks of this kind.

You know cube or cylinder failure you will see cracks of this kind, but what happens is when it is trying to expand, the machine plate shear do not allow expansion. So, there is the frictional force like this, frictional force like this right. So, this is what we call as platen effect, this is what we call as platen effect. And this fictional force actually causes a biaxial affect, biaxial or triaxial effect in a way you know, this sort of.

So, when you have a situation you are pushing from all sides or you know 2 sides you are pushing right, you are trying to push from this side, it cannot expand. As a result, you find in the failure is failure you know, pattern is something like this in case of l equals to d or cube.

So, it is not l by d is usually 1 or 2, you can see that it is always dimension is very small compare compared to that required for buckling. Buckling occurs at l by d equals to short column you might be knowing, you know, much larger l by d value. So, this is not buckling, this is essentially because of what is called platen effect right. So, platen effect causes failure.

So, if your this you know, this effect the if you see knit stress would be then there will be some compressive stress, there will be some compressive stress from both the sides. And depending upon it is length there will be a zone where there will be no compressive frictional forces due to, you know compressive force due to friction of this plates.

Plates offers friction it does not allowed to expand, but that vanishes of beyond certain point. And this is around, you know, root 3 by 2 around you know, root 3 by 2 some something of this order. Root 3 by 2 one can show this forces. So, when you have l by d is equals to 2 this effect will not be there.

Because this is the how much is this 0.8 or something. So, 0.8 l or some such thing 0.88 d so, this effect is up to 0.8 d or something of that kind. So, if you have some value of d, I mean length greater than some value of multi, you know, 1.6 d or something you do not have this effect.

So, strength therefore, is a function of l by d. So, l by d generally recommended is 1 to 2. And correspondingly depending upon now if it is less than 1, then it tends to become too small, and effects the much more prominent. So, if the most standard cube test I mean, as core test when you do l by d is restricted to 1 or 2.

So, if you are getting less than 1, then you trim it off input some capping material. Otherwise, try to keep it l by d equals to 1 and do it uncapped testing uncap testing is the best, but not more than 2 again. If it is 2 although there is there is no benefit, because I mean there is no change l by d effect really goes, but core restricted to l by d equal to 2. Because this is ease of calculation and things like that.

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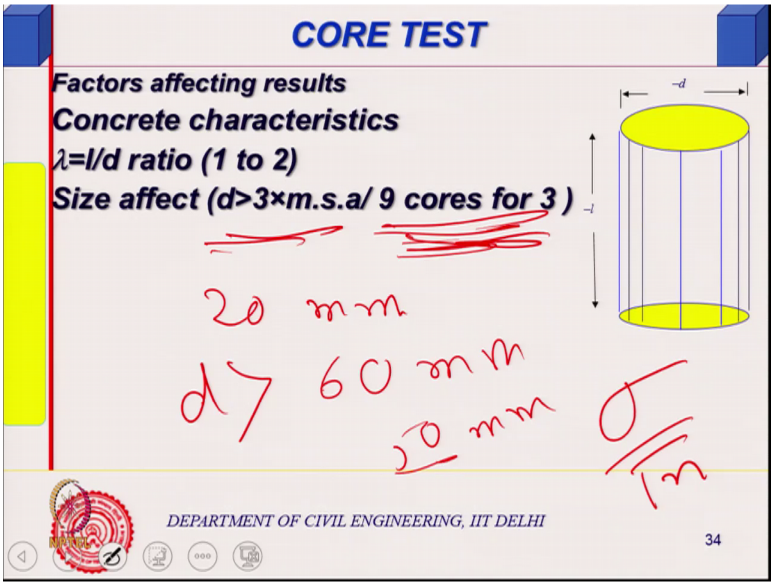

So, l by d has an effect, l by d has an has effect on the strength, size affect as I said so, minimum d is should be 3 times the m s a. Minimum d should be 3 times the m s a, right? Because then if it is nano size maximum size of aggregate. Supposing you was using 20 mm aggregate that is d should be greater than 60 mm. Then you are getting a representative concrete sample, aggregates and motor everything will be inclusive so, it is representative. If you test smaller than that size, then variation will be large.

For example, instead of this if you take 50 mm core, then you might have somewhere more motor less aggregate for may be more aggregate plus motor. So, standard deviation will be larger. So, in such cases what is suggested that if you are testing small size core, you might test 9 core instead of testing 3 cores with a appropriate size.

So, test now because you go to take care of the standard deviation which will be some higher. Remember, accuracy is sigma under root n so, you to go to increase it with that order. Because this is a function of you know, the number of samples required will be to maintain same, accuracy number of samples required will be square, you know, it is n square.

So, n increases, n is equal to square of the error. So, if I keep the same n would be e square error squares keep the same e I need to 3 core it will become 9 core and so on. So, this is what it says to maintain so, you a standard deviation actually tend to increase to take care of that kind of situation this is being done. So, size is like that, size is like that.

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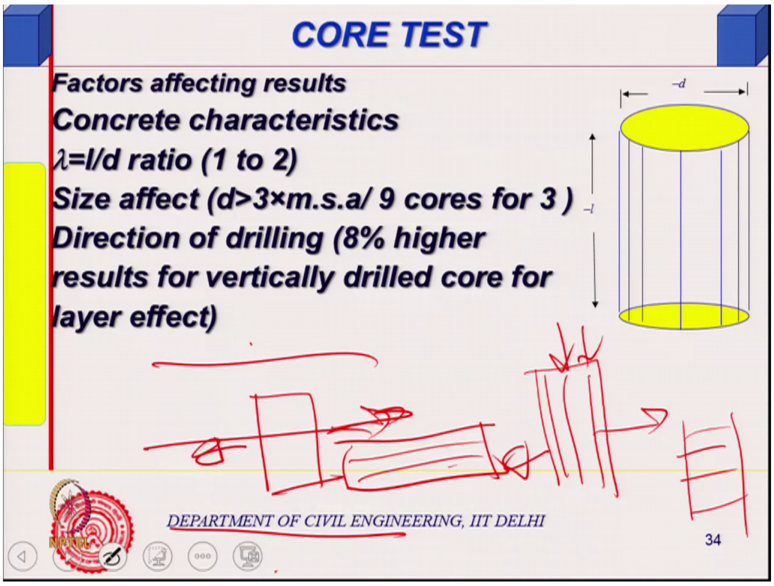

This not really the size effect one understands in fractures. So, the another things that direction of drilling, because casting is done in this manner from bottom to top. So, if you drill along this direction there will be a layer effect because failure is poissons effect along the transverse direction. So, this should be like that right layer effect. So, 8 percent higher results for vertically drilled core for layer effect. So, you know, the basically the strength I mean you have a correction factor, we will see that correction factor. There is the correction factor variation is around 8 percent.

If you test it like this, drill is drill the you know, layer is something of this kind, then you will be testing with the layer in this manner. Horizontally drilled core layers will be parallel to the direction of the load, right. So, this is how this is how actually it will separate out, because failure is because of the transverse tension due to poissons effect. While you have you are drilled, you know, vertically drilled core the layer will be like this. So, results differ by around 8 percent, results differ by around 8 percent right.

So, vertically drilled cores shows slightly higher results so, correction factor is applied which will actually multiplying factor is you know, there is a multiplying factor. We will see that how will do it. So, these are the other issues these are the other issues related to coring and you one must know those.

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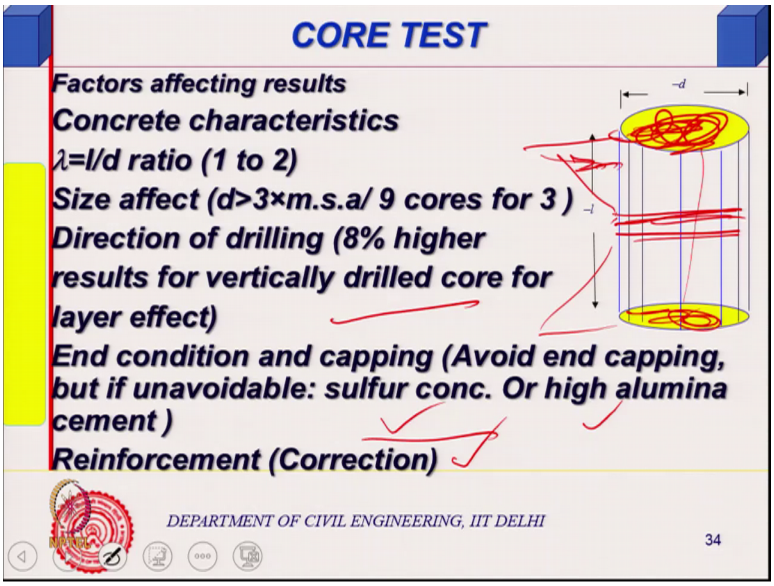

Now I s core does not take this effect. So, end condition and capping, avoid capping because as I said, when you put cap here some material, supposing I put rubber, I put Teflon or a rubber, which allows expansion easily right. So, the frictional force which was resulting from the machine plates now can get reduced. So, it will fail at dual load, you know, I said that platen effect causes kind of a bi you know, biaxial stresses from the other direction as well confinement sort of thing right, and this confinement reduces as I go down below.

So, supposing I put down rubber, rubber will also expand with the plate. So, the confinement effect will get reduced. So, capping material has got an influence of the strength result with that. So, that is why it is standardized with sulphur concrete or high alumina cement, not any other cement or anything because you it is meant for comparing the results and there is a multiplying factor everywhere.

So, basically standard capping materials should be used. Because it differs strength measure strength depends upon the capping material. If I have a very rigid material which does not allow you know, which does not expand itself, rather it opposes the expansion of the concrete much, then you might find you know, there is the confinement affect is more, then you might find a find a higher strength.

If the confinement effect is less you get lower strength s, it is related to that. So, capping material has been standardized. So, what you do is, everything else is standardaized except for the material that you have taken from the site and obviously, if there is a reinforcement present something like this.

Because it will not present along this direction, you are not going to drill a longer reinforcement that is very unlikely. It will be present it is like to do present somewhere in between because while you are doing vertical downward a reinforcement might have come. Better to avoid them, but supposing if it is a come, then you can actually apply correction you can apply a correction. So, that is what it is.

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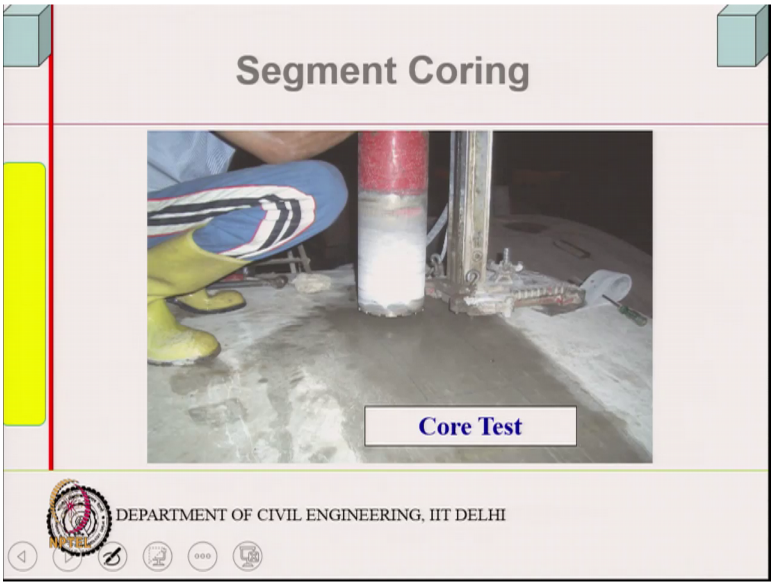

Now, you can see this is the drilling machine, this is the drilling you know, this is the drilling machine the coring is done. So, with a rotary drill this is a bit diamond bit.

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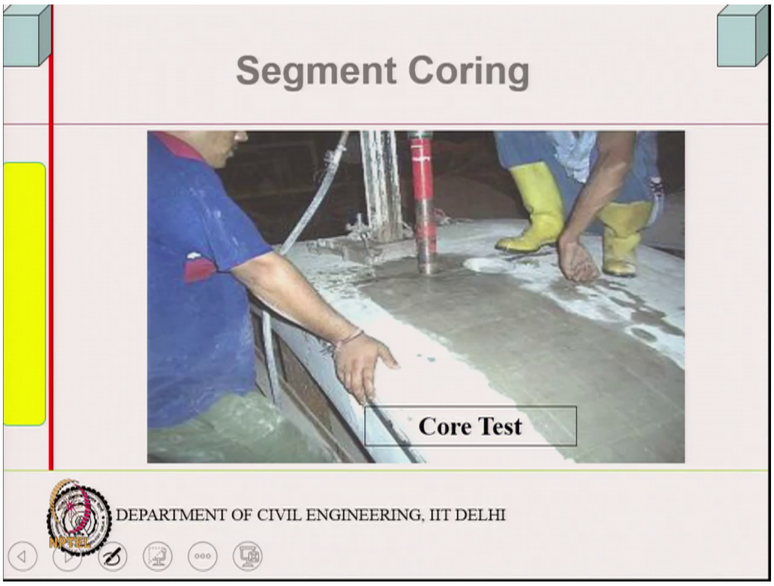

So, that is actually drilling and that is how it is taken out, that is how it is taken out right.

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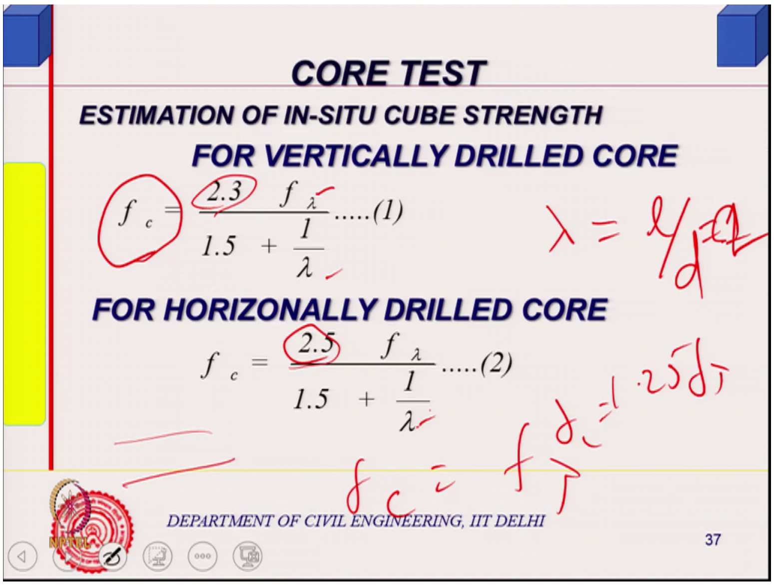

And this is the, you know, estimation of in-situ strength. What you measure is a strength of the sample, from that I should be able to predict the in-situ strength or equivalent cube strength.

For example, if I have a supposing I assume a hypothetical cube there. What will be it is strength? Hypothetical cube what will; that will I call as a in-situ strength because in-situ strength is different than standard cube strength in the laboratory. Which I prepare in the standard manner in the laboratory, cure it in a standard manner in the laboratory test it after a fixed date 20 days or whatever it is. This strength is different than in-situ strength in-situ. So, we call it in-situ cube strength what we get is in-situ cube strength. Right now, is core gives you a way I will come to that, but before that this is from, you know UK.

So, this is a this is a they have done lot of testing for example, you can take core and for the same concrete you take cubes also, right? Cure them in the same manner put it by side by side, well your you know, beam you cast, beam cure it, and put some make some cube, cure them in side by side compaction procedure more or less try to keep same, not the standard compaction try to keep. You know, some people have done this kind of test and empirical equations they have come out with. So, for vertically drilled core what they have found is, f lambda is the measured strength, f lambda is the measured strength and lambda is what? L by d, lambda is l by d.

So, f lambda is a measured strength and the in-situ cube strength f c will be given by 2.3 f lambda divided by 1.5 plus 1 by lambda. So, let us say lambda is equals to, let us come so, this is vertically drilled core. Horizontally drilled core, these value is something like this. In other words, what it is saying is if you have a horizontally drilled core, if you have a horizontally drilled core let us say lambda equals to 1 lambda equals to 1; in that case, this value will be f c will be equals to f lambda only. Because this will be 1 this is 1. So, this is 1, 2.5 will cancel out. So, it is f lambda f c is f lambda.

So, as long as you are it is taking effect factor, you know, factor this factor is taking in to account what factor? The l by d affect it is taking and then; obviously, the core size has to be large that means, the diameter must be greater than 3 times the maximum size of aggregate, and l by d is lie between 1 to 2. And if it is 2 we can see that this will be 1.25 f lambda, f c is equal to 1.25. Because still in standard cylinder, you know, l by d is 2. So, if it is 2, l by d equals to 2, then you get standard cylinder strength.

If it is l l by d is equal to 1, you get standard, you know, size cube size cube strength. So, that is what it is saying. so, this is how it is. Now, this factors are different for vertically drilled core and horizontally drilled core. If it is vertically drilled core, right the multiplying factor there is a this factor is reduced down; that means, you are divided it by some value, while horizontally drilled core is as good as a standard cube. Because casting of the cubes are done you know, casting of the cubes are done bottom to top again, casting of the cube is done. So, concrete is also done in the same manner.

So, this is related to the sort of situations, right. Then if you are horizontally drilling it, if you are horizontally drilling it actually horizontally drilling it just a minute, I supposed is correct vertically and horizontally drilled core.

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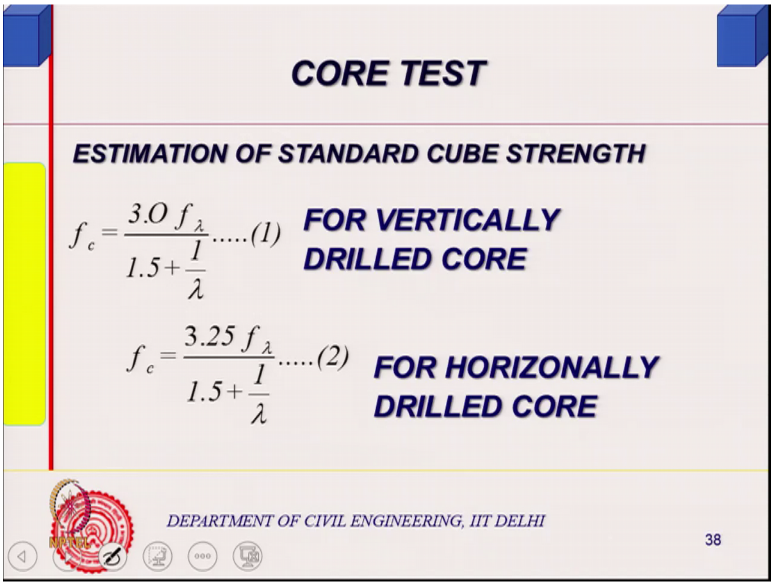

Vertically drilled core is this, and horizontally drilled core is something like this. So, this is this layer effects are taken into account there. The multiplying factor is there is a fractional, you know, this is around 0.8 times, 8 percent difference. So, you can see that 2.5 into 0.92 or so will give you 2.3. So, that affect is taken into account for vertically drilled core and horizontally drilled core.

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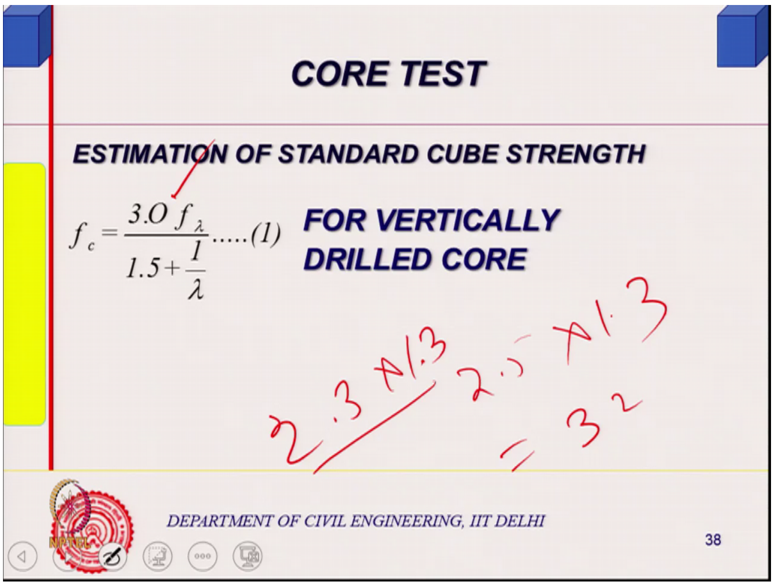

Then you have got, they suggest that if you have a standard core, you want to find out standard cube strength, one suggestion is that multiplied by 1.3, but that is not the best way so, 30 percent increase. So, 3 2.5 into 3 1.3 you get something like 3.25 close to this, and 2.3 into 1.3 you get around 3. So, for vertically drilled core this is this for horizontal drilled core this scenario.

So, in standard cube to but this is not to be used much. Now this is one suggestion one can use this, but this is not really better ways are there which we will discuss. So, this is how you can find out from British considerations; while if you look at Indian scenario, they also British (Refer Time: 22:56) British code was using this formula. And they have also given a correction for reinforcement.

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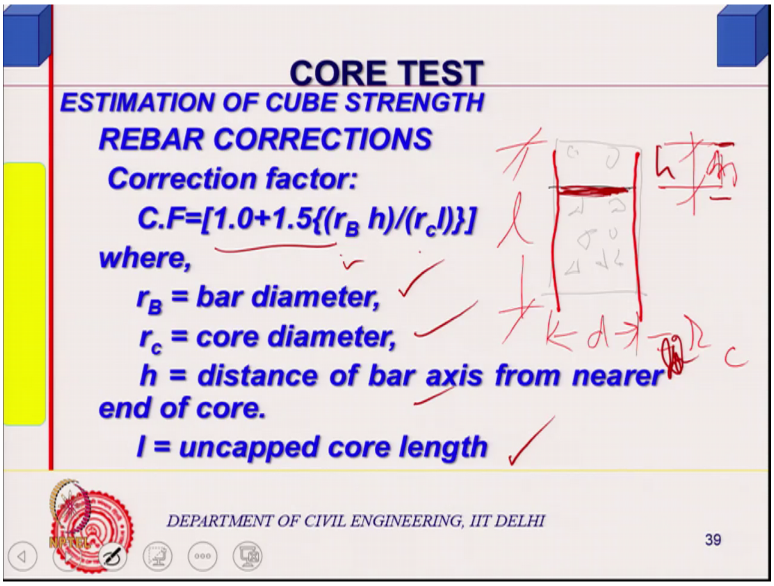

So, reinforcement correction is given like this. You have say, this is your core, l is there, d is there and you have a reinforcement, you have a reinforcement here; which is at a distance h from the nearest place this is h. So, this distance is h from the nearest place.

And bar diameter you know so, r c is the this is d so, twice r c. So, r B is the bar sorry, this is the bar this is r c this is a core diameter. So, core diameter is r c bar diameter is r B, the correction factor is 1.0 1.5 r B into h divided by r c into l. So, this ratio r B into h by r c by l into 1.5 that is the correct (Refer Time: 23:57), what happens whenever reinforcement, it will fail at a lower load. Because that interface will come into, you know, and reinforcement is usually perpendicular to the direction of the loading right.

And it will split, you know, moving from the fraction will occur is it reduces down the measure strain.

So, you have a multiplying factor which is more than 1. So, this is the correction and if you have several reinforcement this will be summed up simply; 1.5 sigma as many suppose in 2 bars are there. So, find out r B into h for first bar divided by r c into l plus for the second bar whose diameter could be different. So, this is the correction factor right. So, l is the uncapped core length, h is distance of the bar axis from nearest nearer end and etcetera, etcetera. So, this is the correction.

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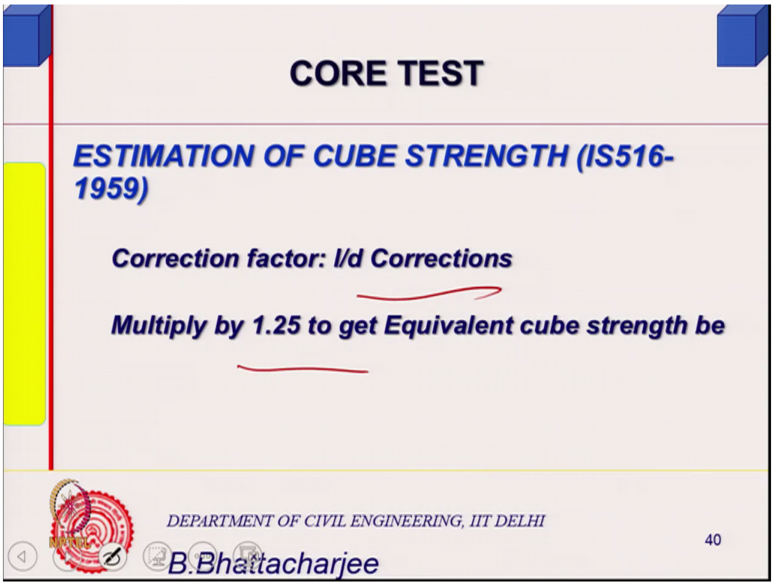

Now, if you see in India this is what it is. IS45 46 what is gives you? It gives a correction for l by d, and using this l by d correction you find out equivalent cylinder strength. Then it says that whatever strength you have got multiplied this by 1.25 to get equivalent cube strength. So, first find out the equivalent cylinder strength. How do you find out? Using this of a curve, there is a curve given in the core l by d.

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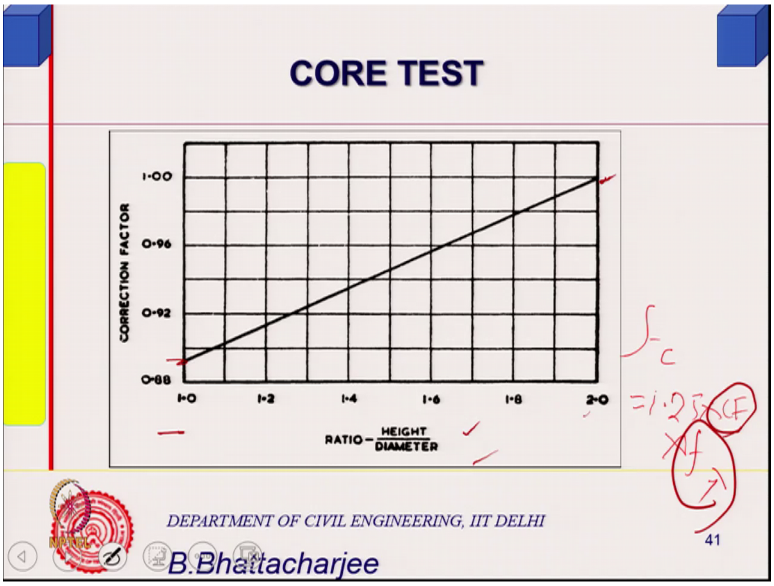

So, l by d equals to 2 this value is 1; that means, you have finding same as cylinder strength. L by d is equals to 1, multiplying factor is 0.88. So, you first you find out the equivalent cylinder strength. So, this is a correction factor which you find out from big for u r l by d for u r l by d, find out what is the correction factor.

Then this multiplied by the measured strength f lambda into 1.25 will give you the equivalent in-situ cube strength. So, first multiplied by correction factor the strength that you have got that is load divided by area and all that. Multiplied by the correction factor then multiplied by 1.25. So, that you do not take account of layer effect on those kind of thing any further.

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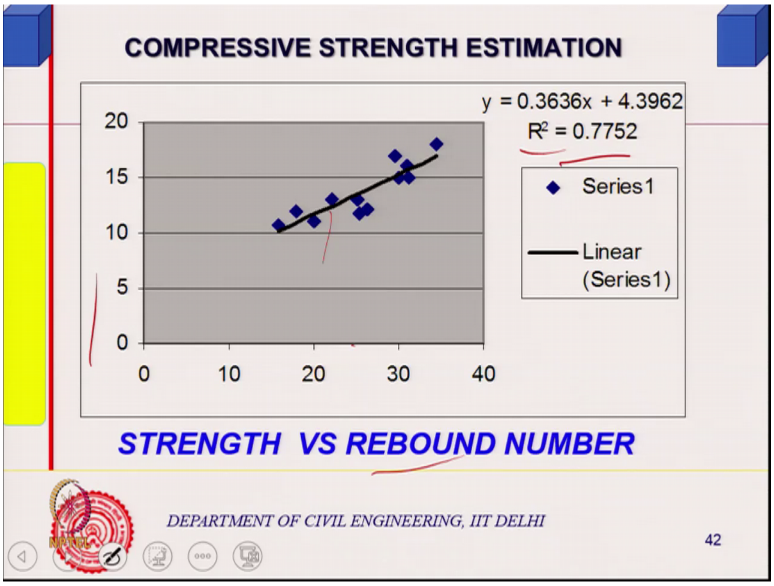

Now, if you have a correlation, you know such core test you can perform on in-situ test you can perform. But then it is done (Refer Time: 26:20). So, you do not perform too many core test you do at some places minimal you require. You know, depending upon what is your objective. Now you want to find out strength of let us say concrete columns in a large building. You cannot go on testing too many cores. So, what you can do is to increase you know, you can you can do core test limited, and correspondingly low those locations you find out the rebound number.

But before that you do a ultrasound, ultrasonic pulse velocity test, and ensure that your concrete is not has got sufficiently sound concrete, right. Right velocity is more than 3 kilometre per second will again discuss this in interpretation. Once this is sound concrete internal core is, then you can take rebound number to predict the strength. So, to establish such a correlation, you need some limited core test to be done.

So, such a correlation will be something like this. Say, compressive strength estimations, this is the, this is actually x axis is rebound number. X axis is rebound number, x axis is rebound number this side is the strength. And then you have limited number of coring has been done, you can see that correlation do not come extraordinarily good. But if you have more number of samples by the correlation improves yeah, it can be better. But now this is here about I think some 5 plus 10 plus 12, 13 results.

So, if you have more, but then you do lot, what you do lot more coring actually. So, you can establish this kind of correlation, and then from rebound number value predict the strength using this correlation so do an extensive rebound hammer test. All over the place you will get several values and correspondingly from this you estimate using this kind of equation you use the use you know, use find out the estimate the strength. The strength variation will be plus minus 20 percent. Error will be easily, you know, like a it is suggested, that error can be observed from plus minus 20 percent. So, if you say f c k is equals to 20, it can be anything from 16 to 24, it can be anything from 16 to 24 right.

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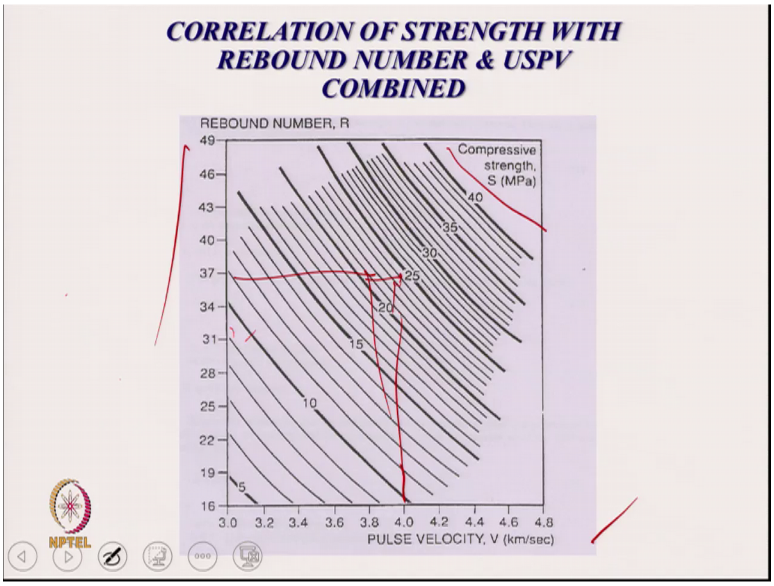

So, that is what we do estimate the strength using core test. Now you can actually in precast if you were a casting yard, somewhere like railway sleeper. Or something like, you know, electric pole and you have a precast unit. And you want to test them, then you can establish a multiple regression or correlation, you know, you can actually use both rebound hammer and ultrasound ultrasonic pulse velocity test and establish correlation curves. For example, this side is pulse velocity this side is rebound number right, and these are the strength connective lines.

So, this is 40 MPa, this is 15 MPa and so on. So, you can actually have 2 variable. You know, regression lines generated and then you can use them in quality control. So, for example, if your rebound pulse velocity is 4, and rebound number is 37 from this kind of graph the strength is likely to be in-situ strength whether, you know, actual strength is likely to be closed to 25 MPa also. But this I mean this values are not universal, we have to find out for specific concrete. So, you can actually establish your quality control system using this.