Concrete Engineering and Technology
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Lecture - 36
Some additional topics

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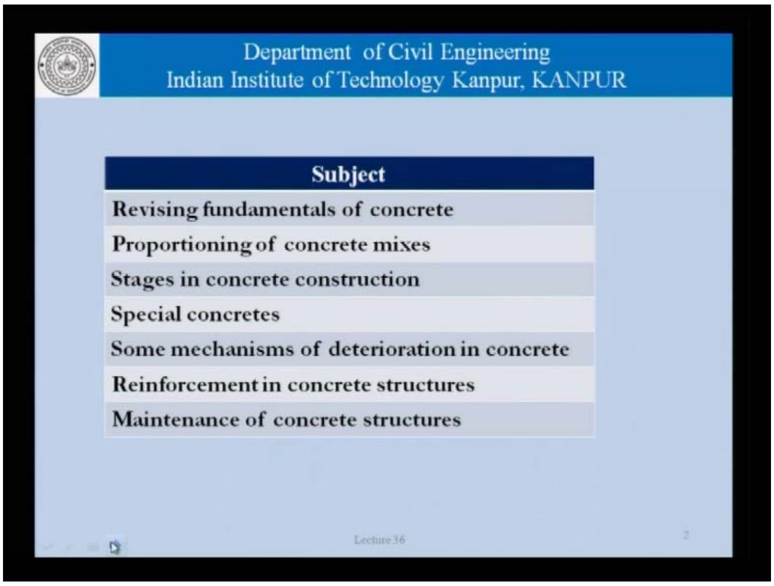

Welcome to another lecture in this module, on Concrete Engineering and Technology, where we are talking about different aspects relating to concrete construction, the material proportioning, maintenance of concrete structures and so on and so forth.

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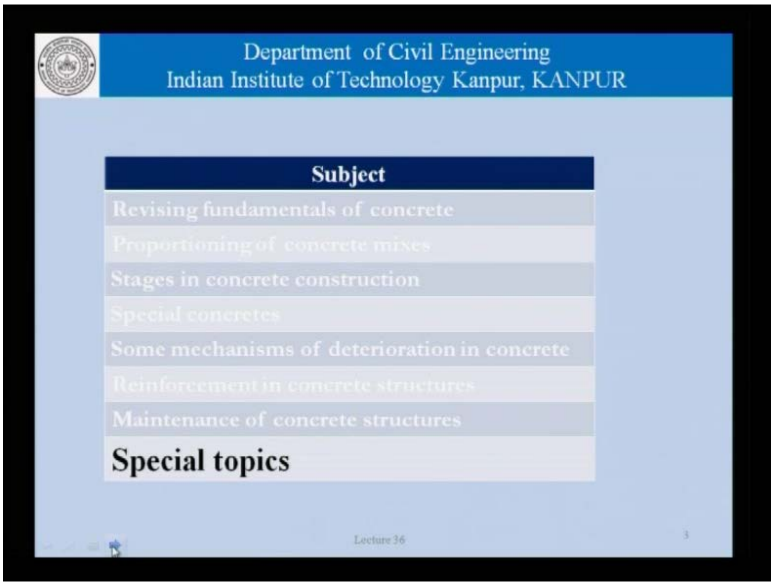

Now, apart from these subjects, which have been covered in the different lectures that we have had in this module, there are a few things, which were not mentioned perhaps when, we were talking about those aspects, and I would like to definitely share some of those things with you. So, today's lecture, we will talk about a couple of more or less divergent issue, some of which have been covered in previous discussions, and you will have to relate them to those topics, after we have gone through the whole lecture.

Now, the first thing that comes to my mind, which we did not spend too much time on, was mixing of concrete. A concrete is a mixture of cement, coarse aggregate, fine aggregate and water and if we want to use chemical and mineral admixtures. But the whole trick depends on, how does the concrete mix or how is the concrete mixed, we have to get a uniform mix, a homogeneous mix and there are different ways of doing it.

For example, as far as the process is concerned, mixing is the process of combining the constituents, water, cement, aggregates that is, coarse and fine, and admixtures to obtain a homogeneous uniform mass and that is what we call, concrete. Now, in case, the concrete is not homogeneous, we can have difficulties in terms of, the potential strength may not be achieved, on account of inadequate hydration. So, we are talking of potential strength here because, at the end of it, when we mix the concrete and we allow it to hydrate with curing and so on.

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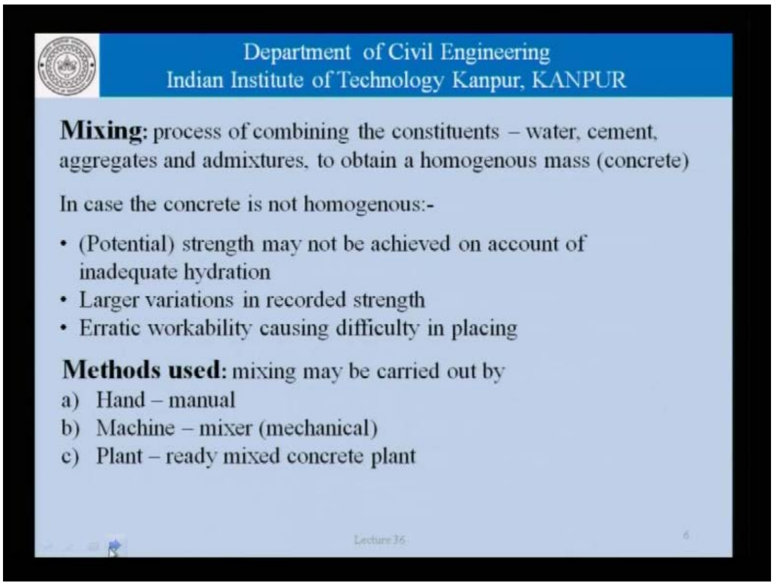

There is a strength that, it can achieve, there is a strength, beyond which a particular mix depending on its proportions, will not gain the strength. Now, if the mix is not homogenously mixed, it is not properly mixed, even that potential strength may not be reached. We can expect larger variations in the recorded strength because, different parts of the concrete will have ingredients, which are different and therefore, we can expect different strength.

So, this gives rise to a greater variation in the compressive strength that, we will get as far as the cubes is concerned, and also lead to a difference in the quality of concrete actually used in the construction. One must remember that, at the end of it, testing cubes is only a part of the quality control exercise. The real thing is that, the entire structure or whatever is designed to be, of a particular grade of concrete and so on, should all have the same properties.

And that is obviously, something that is going to be compromised, if the concrete is not properly mixed. We could have erratic workability causing difficulty in placing because obviously, if the concrete has not been mixed properly, different parts of concrete or different batches of concrete would have been mixed differently, leading to different properties of the fresh concrete. And that would give an erratic behavior as far as the workability of concrete is concerned, and the same thing can be said about the air content.

So, basically improper mixing will affect the properties of fresh as well as hardened concrete and that is something, which we want to avoid. And therefore, we must pay close attention to achieving a uniform homogeneous mass at the end of the mixing process. Now, how can the concrete be mixed, it can be mixed by hand, which is manual or it can be mixed in a mixer, which will basically a machine or sometimes that is mixed in a plant.

Now, the difference between the concrete mixed in a mixer, in the plant, the way i intended is the following. When we do experiments in the laboratory, whether it is for academic purposes, for research purposes or for that matter to cry and find out the most appropriate mix, for a particular construction project and that time we use a mixer. But, that is not the same thing as using the actual mixer, which is going to be used for mixing the concrete, which is going to be used for the project.

Now, the question is, whether the concrete mixed in a mixer, in the laboratory and the concrete mixed using a mixer, in a ready mixed concrete plant, will the properties of these concretes be different. And that is the kind of question, which we need to answer, when we are talking of when we are talking about mechanized construction where, we are talking about drawing a protocols for quality control of concrete construction, in a mechanized environment.

So, we should know, what are the kind of factors or parameters that, effect the concrete quality and pay attention to minimizing any such effects so that, as far as possible, the concrete that we get is uniform and homogeneous. Of course, as far as hand mixing is concerned or mixing by hand or manually that is a completely different method and can be used only for very, very small construction projects.

Now, this picture here shows the concrete being mixed by hand and the person is using basically, a shovel to keep mixing the concrete, till in his judgment, the concrete attains a homogeneous look. This is an example of a mixer that we sometimes use in the lab for laboratory scale studies; this here is a plant operation for producing a ready mix concrete. So, the difference between the mixer that is used in a plant and the mixer that is used in the laboratory is primarily in terms of the size of the mixer and obviously, also the kind of mixing method that is used, as we will see shortly.

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Another kind of mixing that goes on in concrete construction and we must be aware of that is when the concrete is being transported from the batching plant to the construction site and that mixing is in advertent, because the intension of that process in an agitator truck is not really to mix the concrete unless is so designed but basically to keep the concrete agitated and ensure that the concrete does not set.

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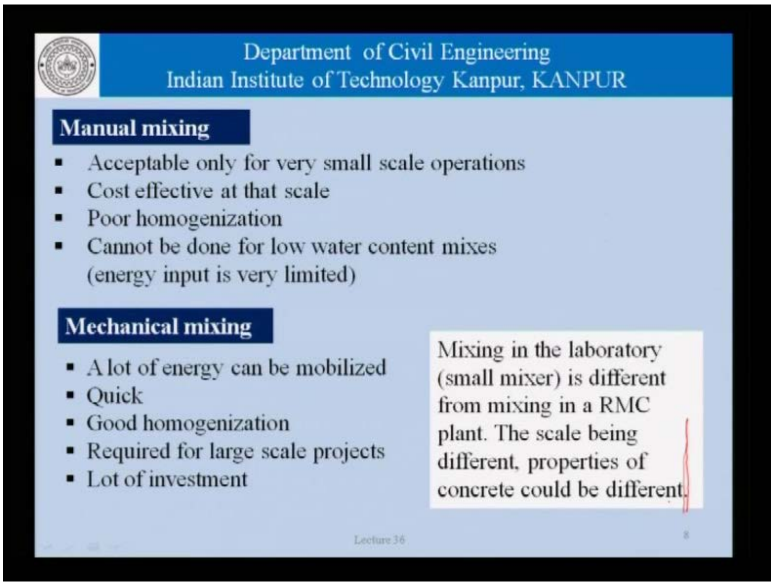

Now, let us talk little bit about the manual mixing, it is obviously acceptable only for very small scale operation is where, it is simply impossible to get ready mix concrete or to setup a plant for carrying out the operation or even smaller in the sense that we do not even want to bring a mixer to site. It is cost effective at that scale, because if we insist that for those kinds of operations involving say 10 liters or 15 liters of concrete, we need to have a mixer, there it might become very expensive.

But that something which the engineer has to decide, because there is a compromise involved as far as the quality is concerned. So, if the decision is made that well, quality must be retained or must be maintained at all cost then, regardless of the cost, hand mixing may be not allowed. Of course, the way hand mixing or manual mixing operates, we can only expect poor homogenization, we cannot expect a very homogeneous mix at the end of a hand mix process.

The whole process as far as hand mixing is concerned, is matter of fact, cannot be done for low water content mixes. The concretes in that case, are so stiff that, it simply beyond the power of an individual, to be able to mix the concrete and by that token, when we are doing the manual mixing in concrete, we invariably land up using a large amount of water. In contrast to that, as far as mechanical mixing or mixing using mixers is concerned, it is obvious that, we can mobilize a lot of energy.

Therefore, the concrete that we get is quickly obtain that is, the mixing process takes a lot less time, the homogenization is good and it is an absolute requirement as far as large scale projects are concerned. But it requires a lot of investment that, if you setting up a plant then, obviously, there is a whole lot of logistics, there is a lot of investment to be done, before the concrete is starts to be produced. As I stated earlier, mixing in the laboratory, when a small mixture is used, is different from mixing in a RMC plant, the ready mix concrete plant. And the scale being different, the properties could be different and this is something, which one needs to investigate from a research point of view as well as from an engineering perspective.

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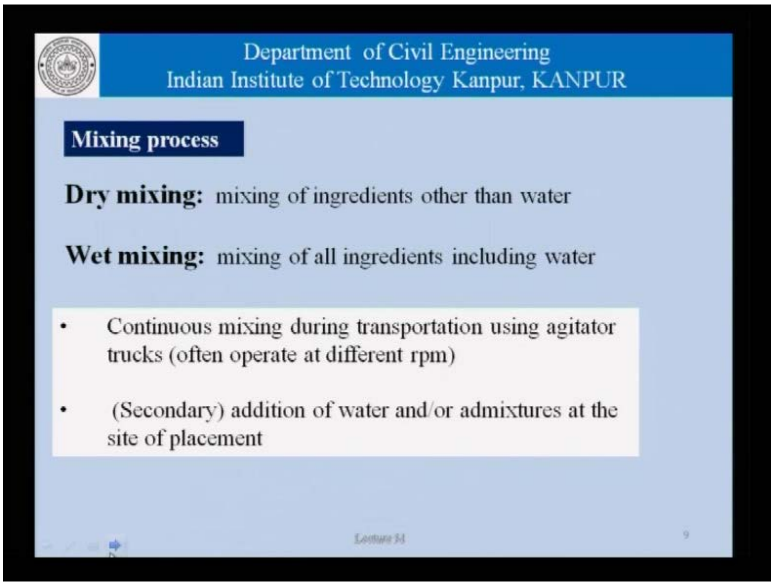

As far as the mixing process now is concerned, we can talk in terms of keyword such as dry mixing that is, mixing of ingredients other than water. That is to say that, we just mix cement, sand and coarse aggregate first and then, is and then, adds water which is called wet mixing. We could always do the process all together, when all the ingredients are put into place and the mixing starts. Recall that, while discussing shotcrete, we talked about a wet process and a dry process as far as shotcreting is concerned.

So, in shotcreting, largely the mixing is dry, in the dry process of shotcreting, the mixing process really dry and no effort is really made to mix the concrete with water, which is just added at the nozzle before the concrete is actually sprayed from the nozzle, on to the surface where, it is being applied. As against that, as far as the wet process of shotcreting is concerned, it is a regularly wet mixed concrete, which is being transported through the nozzle to the site of application.

Now, sometimes, in order to ensure proper mixing, since there are no standards to evaluate, whether the concrete has been actually mixed to the extent that, it has become homogeneous specifications, may talk in terms of a minimum mixing time. Now, the minimum mixing time is therefore, broken up into the time when, the ingredients start getting loaded on to the mixer and finally, the concrete is poured out of the mixer.

It is not necessary really that, all that mixing time is required and therefore, one might like to study the actual concrete being used at different mixing times, if the cycle time involved is at a premium. While mixing, another keyword that comes in is the fact that, there is continuous mixing during transportation using agitator trucks, which often operate at different RPM. So, there can be requirements, which say that, well while the concrete is being transported, it should be churned at least at a certain rpm.

We cannot have a very low RPM and at the same time it cannot be very high, we can at the same time talk in terms of a situation where, the concrete will be vigorously mixed, just before it is placed at site that is, it would be gradually mixed while it is being transported. But once the concrete agitated truck reaches the concrete placement site, it will be vigorously mixed for a period of say, 15 seconds or 30 seconds in order to, ensure that, if at all there has been a problem during the gradual mixing process or the agitation process that is, taken care of, by this vigorous mixing.

Related to this issue is one of, secondary addition of water and or admixture at the site of placement usually, all the ingredients need to be mixed at the plant and the concrete is transported in a manner that, it is simply ready to place. In certain cases, however, it might be required that, some water or some admixture is used or is added to the concrete, juts before it is placed. An example in this context could be, if we want to use accelerators now, there is no way, we would like to use an accelerator at the plant because of, the uncertainties involved in the transportation time.

However, at the site of placement, we may like to use the accelerator because, at that time, it is known that, well now, we are ready to place the concrete and once placed in position, we want the strength development to be accelerated. So, in these kind of cases, when we are talking in terms of secondary addition of water and admixtures, or admixtures.

Then, one has to be very careful in designing the entire mixing process, as to what kind of additions will take place at the plant, what kind of additions will take place at the site because, related to this discussion of designing the mixing process, is the issue of quality control. The moment we say that, only a part of the water will be added at the plant and the remaining water with the admixture and so on will be added at the site, we have the problem that, what kind of quality control values, we will use when, we are accepting the concrete from the plant and taking it to site. So, these are some of the difficulties, which we must keep in mind, when we design the mixing process for a specific project.

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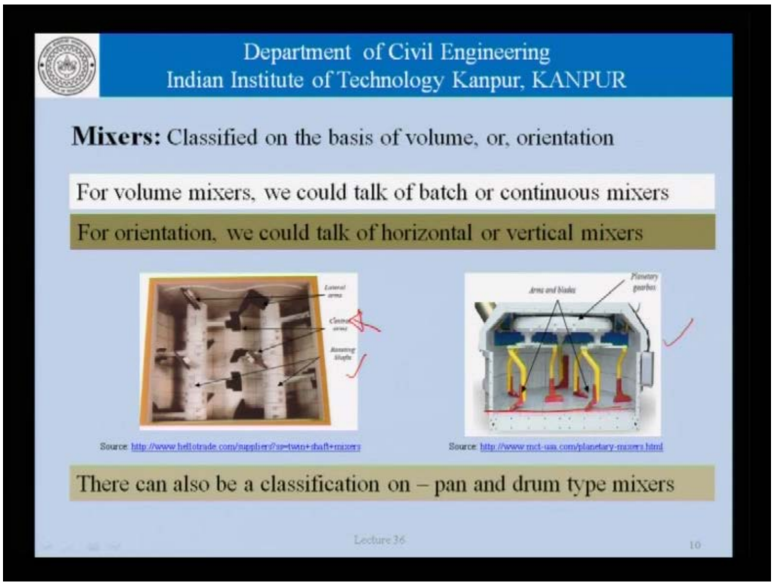

Now, let us talk a little bit about the mixers, which can be classified on the basis of volume or orientations for volume mixers, we can talk in terms of batch or continuous mixers. Batch mixers means, there is a fixed batch or a fixed volume, which can be mixed, and which could be mixed in that mixer at one time. It could be 1 cubic meter, 5 cubic meter, 10 cubic meters whatever it is or it could be a continuous process where, all the ingredients are being fed into the mixer and we have a continuous supply of concrete at the other end.

As far as orientation is concerned, we could talk in terms of vertical or a horizontal mixers depending on, what is the orientation of the axis, about which the blades of the mixer are rotating. This here for example, shows a vertical mixer where, the blades are operating where the blades are rotating about a vertical axis this here is a horizontal mixer where, the blades will rotate about a horizontal axis. We can also talk in terms of different mixers being classified, in terms of whether they are pan mixers or they are drum type mixers.

This here, is a pan mixer where, one surface, on which the concrete is being mixed in the mixer or one surface of the mixer is flat, drum type mixers are those where, the concrete is really mixed in a drum and this mixer here for example, is just one of the examples of drum type mixers.

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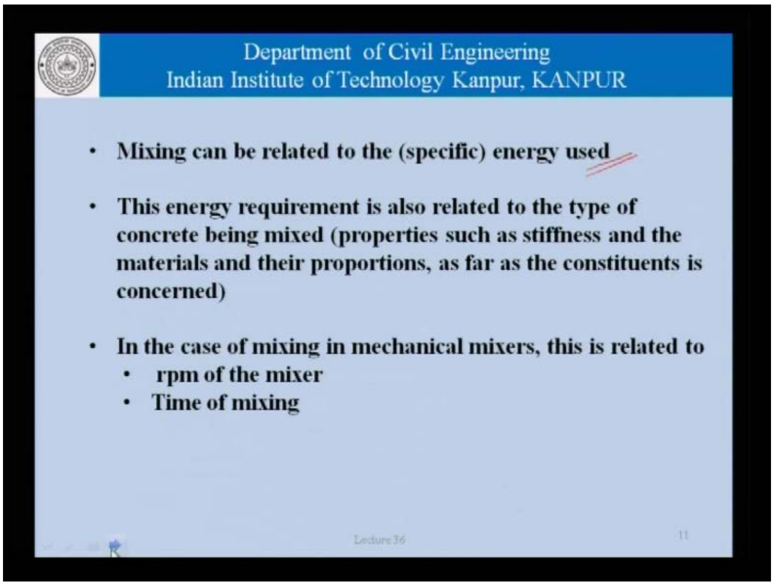

Now, coming to the kind of parameters, that affect the mixing process, one could be energy or specific energy that is, the amount of energy that is used per unit mass of the concrete being mixed. And this parameter, if we could quantify this, would be very different for manual mixing or for mechanical mixing. As far as mechanical mixing again, how much energy we need in order to produce a concrete, which is uniform homogenous.

We must remember that, this energy is related to the type of concrete being mixed in terms of its properties for example, whether the concrete that, we are mixing is stiff. And the materials in that proportions, whether we are using round aggregates or crust stone aggregates, whether we are using a certain chemical admixture or not and so on. So, the amount of energy that is required to produce a concrete, which is acceptable, depends not only on the type of mixer, the RPM, the time that is, involved but, also the ingredients that, we are using and their proportions.

As I said, in the case of mechanical mixers in the case of mechanical mixers, the energy is also related to the RPM or the revolutions per minute of the mixer, if the mixer rotates more rapidly or less or less rapidly and so on, and also the time of mixing. So, indeed since energy that we are using to mix the concrete, is such an elusive property, it is easiest to talk in terms of a minimum mixing time as far as, the specification is concerned.

If I was asked that, given this mixer, how should be go about operating it, in order to produce a uniform concrete, I would say, well let us mix the concrete for 2 minutes. Because, that is something, which is easiest to measure, in the absence of a direct measurement of the homogeneous nature or the uniformity of concrete, this discussion of energy being related to the property that we want. In this case, the mixing energy to the workability in the air content and making sure that the concrete is homogenous, this discussion is pretty similar in the case of compaction of concrete.

We can compact concrete manually but temping with rods and that is, what we do for example, in the slump test or when we are measuring the air content similarly, we compact the concrete using internal of form vibrators. And there also, it is the nature of the vibrator as well as the time of vibration, which is important other than the nature of the concrete that is, being vibrated to the level of final compaction. So, this is something which, as concrete engineers of the 21 st century, you must remember.

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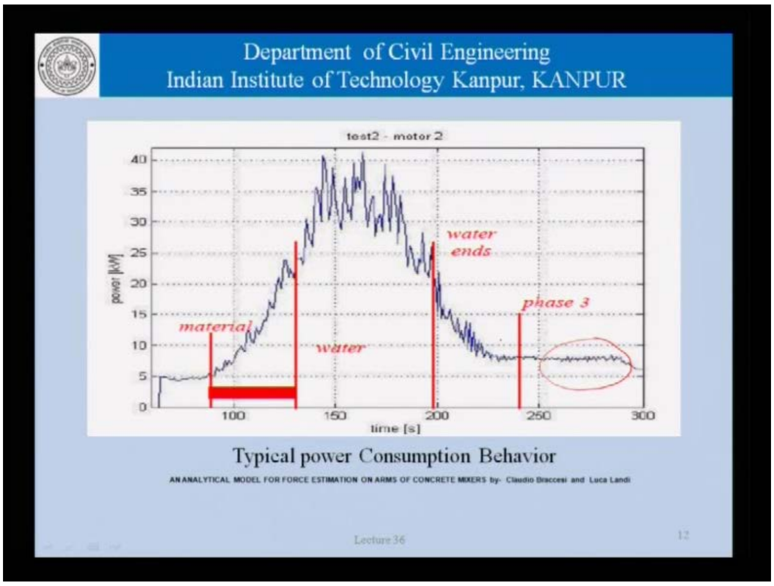

This here is a typical power consumption behavior observed in a test where, the power consumption is monitored over a period of let us say, 5 minutes, while the mixing is being done and different ingredients are being added. So, I do not have any reason to explain this graph in very great detail except that, one must remember that, this is the kind of work that, one needs to do, if we are trying to evaluate a particular mixer.

If a particular mixer has to be evaluated then, we have to find out what is the kind of consumption of power that it has, how much time does it take to reach a situation where, the power consumption becomes stable, where we can say that, the concrete has become uniform.

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Enough about the mixing of concrete, I think, I have given enough pointers for you, to be able to do some self-study and understand the mixing process a little better. Now, let us take a look at some of the other small bits of information, interesting applications and so on, for some of the other topics that, we have already covered. Now, the first in this series is self-compacting concrete, we have already talked about self-compacting concrete in detail, the mix proportions, the kind of test that, we need to carry out and so on.

So, what we will do today is just see some of the applications, which we missed out the last time here, is a test being done for self-compacting concrete, as against conventional concrete. So, this here is conventional concrete and this is the self-compacting concrete and this is the fill box test. And we can see that, when concrete is poured into this box using this funnel here, conventional concrete does not even conventional concrete cannot negotiate these pipes, which have been put in place to stimulate the reinforcement that, concrete has to go through.

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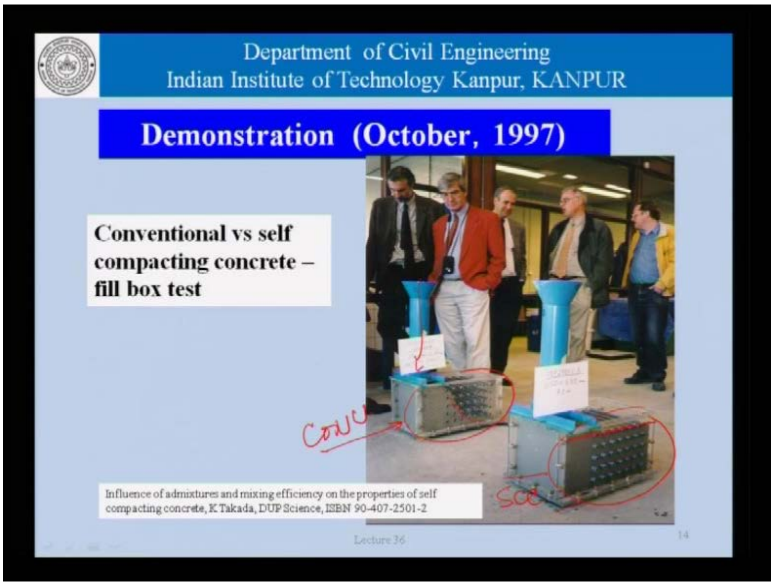

Compared to that, if we use a self-compacting concrete mix, more or less the surface that we get is horizontal except that, it is not truly horizontal. And the level or the extent, to which the surface deviates from the horizontal, is actually a measure of the self-compactability of that concrete.

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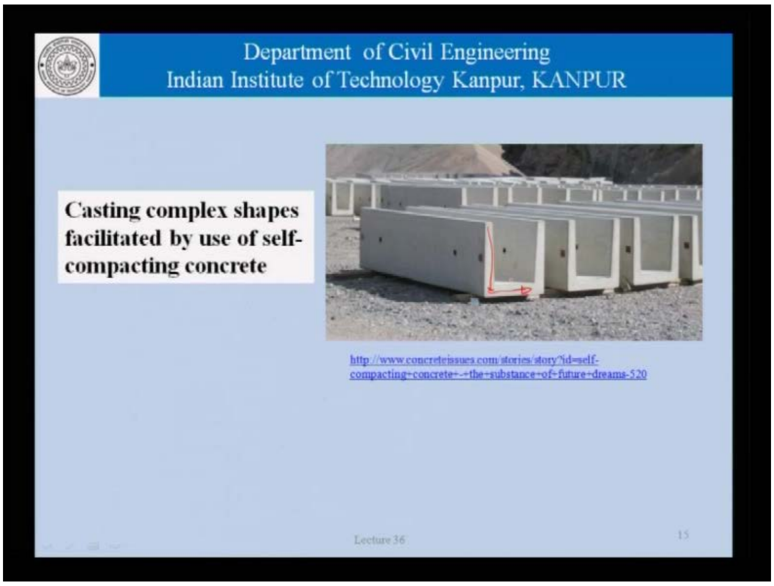

Now, as far as, self-compacting concrete application is concerned, these here are complex shapes, which have been cast, and which casting has been facilitated by the use of self-compacting concrete. Now, in a shape of this nature, if we were to use conventional concrete, there are different ways of doing it. But, we will always have some kind of construction joints because, you must remember that, all these legs whether it is these two verticals or it is this horizontal, that will also have reinforcement.

Couple with the fact that, if we pour concrete here and expect it to flow in this direction that is, asking conventional concrete too much, that simply does not happen. Moving the concrete with a vibrator or facilitating the movement of concrete by a vibrator or a needle that also, is not a very good idea. So, examples of this nature show us, how self-compacting concrete help us produce precast elements, which could be of more complicated shapes without necessarily having construction joints.

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This picture here, shows the use of self-compacting concrete in the precast industry, there is concrete members, as can be seen here are being cast using concrete with very little intervention manually and these people here are just doing some preliminary or some simple leveling operations. So, that is another application of self-compacting concrete or how self-compacting concrete mix the life easier as far as the concrete engineer is concerned.

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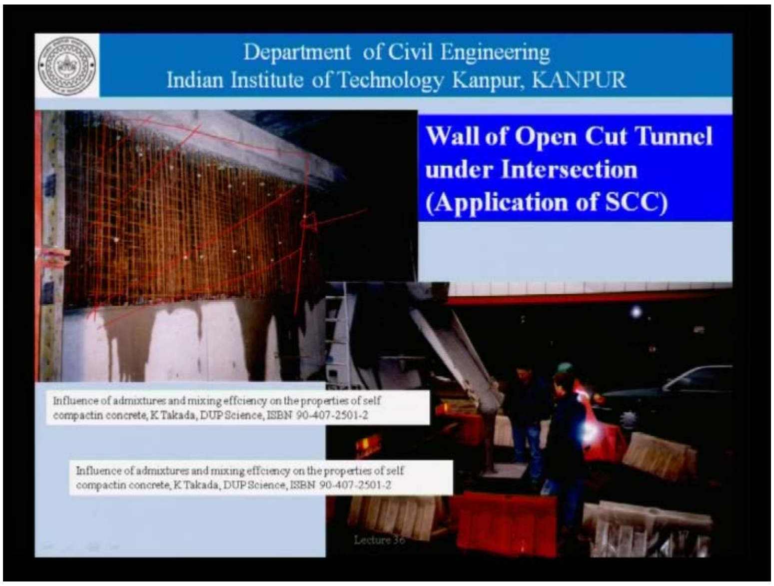

These pictures here are that of, an application of self-compacting concrete where, the concrete had to be poured in a portion like this. Now, you can imagine that, if conventional concrete was to be poured then, it will be difficult to ensure the kind of joint that, we want at the top even, if we were to even if it was possible to pour the concrete into this congested reinforcement for a certain height. If it is self-compacting concrete of course, then, all that needs to be done is, to cover this entire portion, which shuttering and pour the concrete from one end and the wall is completed.

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This here is another example of application of a self-compacting concrete in the renovation of the royal theatre at Hauge, in the Netherlands. I must say that, Netherlands was one of the countries, which in the late 90's was at the forefront of the development of self-compacting concretes and it's application in different projects. So, at the end of it, use of self-compacting concrete simply means, pouring the concrete in the literal sense of the world and it makes the construction more easy and fast.

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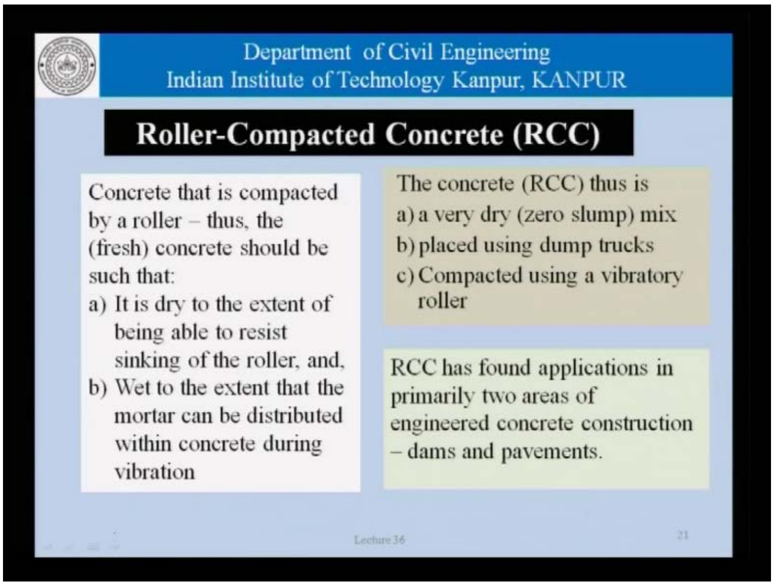

Now, coming out of self-compacting concrete and moving towards roller compacted concrete, we had talked that, concrete in roller compacted concrete is compacted using vibratory rollers. And in that case, the concrete should be dry to the extent that, it is able to resist the sinking of the roller and wet to the extent that, the mortar can be distributed within the concrete during vibration.

And as a result, we wanted very dry that is, zero slump kind of concrete placed using dump trucks and so on. And found applications in two areas largely, one was dams, gravity dams particularly, and the other was pavements.

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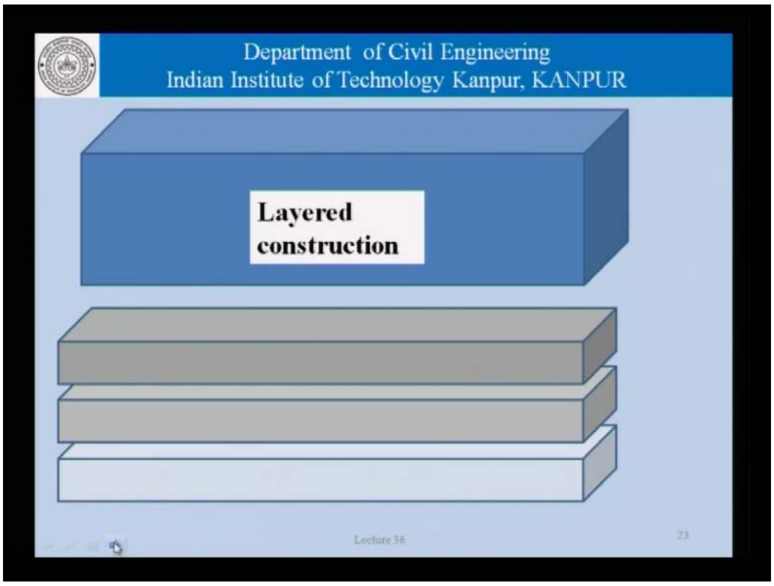

As far as a diagram is concerned, if you want to construct this block, we had talked about normal construction using these three blocks. And then, we had talked about roller compacted concrete where, we are talking about layered construction where, this layer is placed first on top of that, this layer and finally, this layer.

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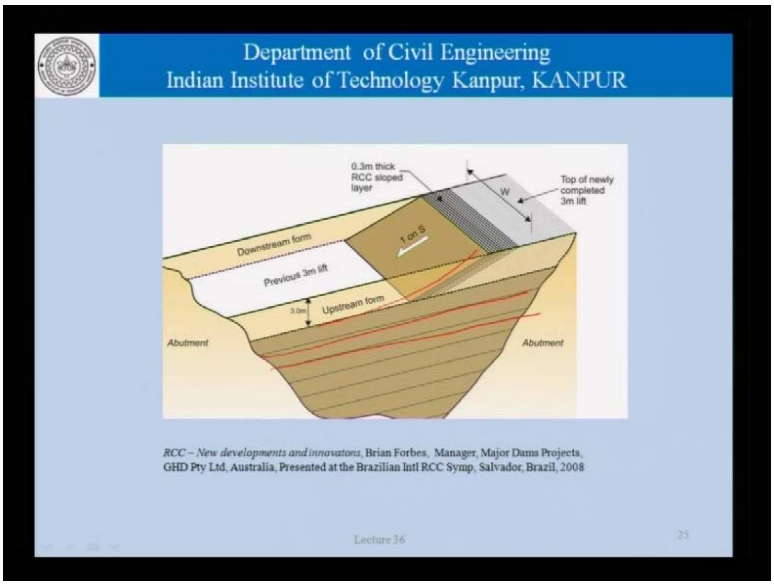

So, Now, an interesting innovation beyond this point is a construction, which is of this nature where, instead of the layers being truly horizontal, somebody comes up with the idea that, let us cast concrete, which is also having a slope.

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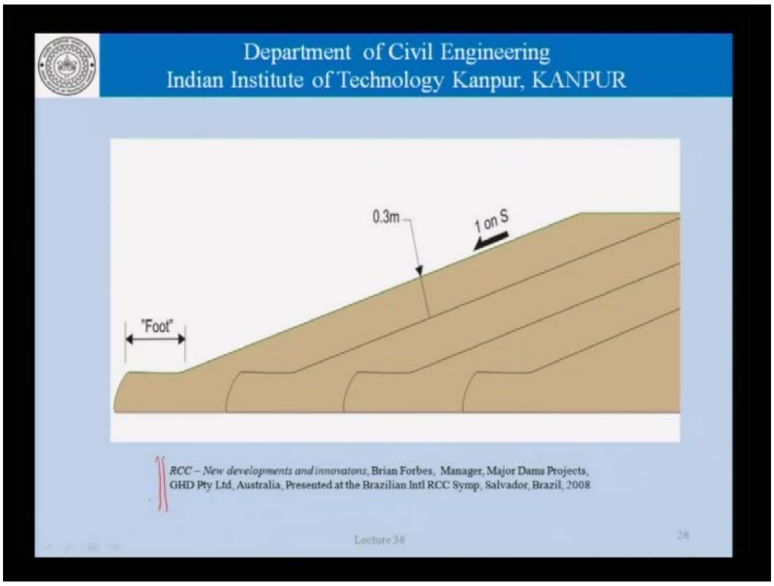

So, the layers are not truly horizontal but, we try to construct layers, which are of this geometry now, this speeds up the construction quite a lot, as was reported in this paper. So, the idea of showing this innovation here, is to show that, innovation never stops, we have to continue to innovate, we have to continue to look at ways and means where, the method that, we are using can be better utilized, can be more effectively utilized, to reach the purpose that we want to achieve.

After all, why did we go into roller compacted concrete, why do we want to go into layered construction compared to block construction, there are certain fit falls though of course, there are certain advantages and that is why, we want to do it. Is there a way of improving the productivity further and this here, is a classic example where, the productivity or the construction rate is improved, if we innovate and we try to have the casting being done in layers, which are sloping. In another application, we are talked about mass concrete and we are talked about monitoring the temperature in the mass concrete.

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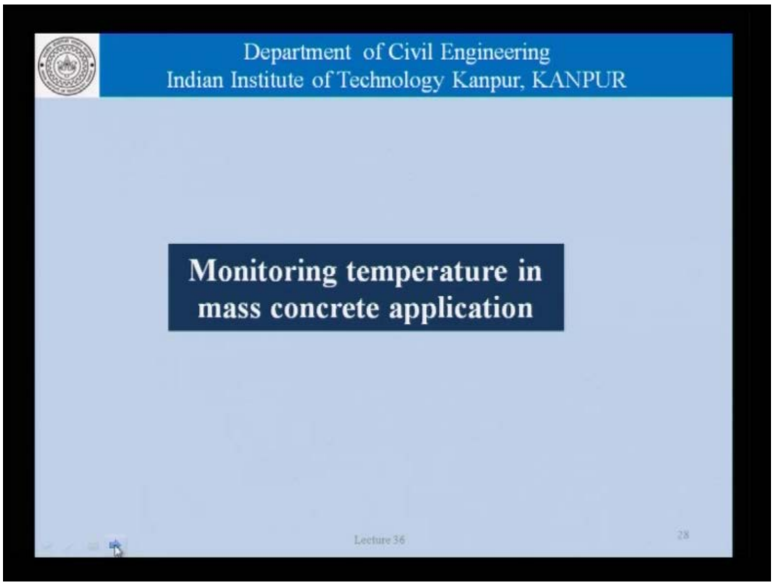

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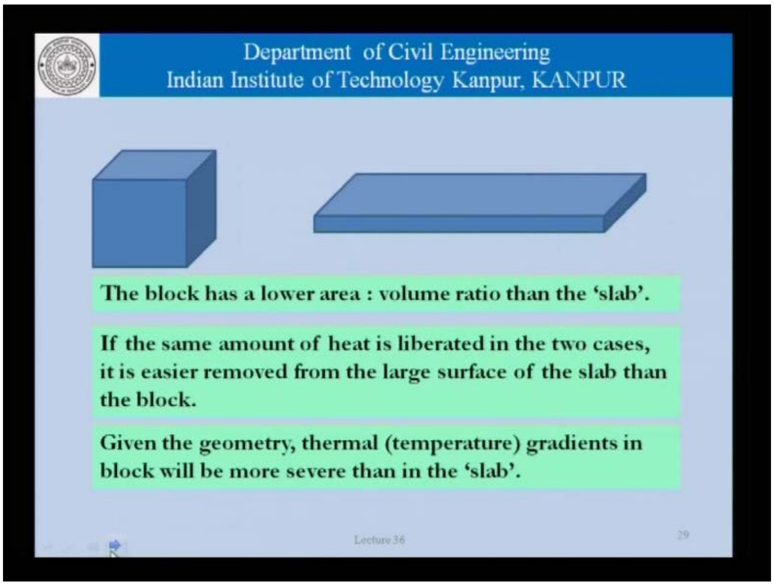

Here also, let me recall that, the block and the slab if you compare, the surface area of the slab is much more and therefore, the dissipation of heat takes place more easily in a slab than in a block. And as a result of that, if the same amount of heat is liberated in the two pores, one in a block and another in a slab, it is more easily dissipated from a slab than a block.

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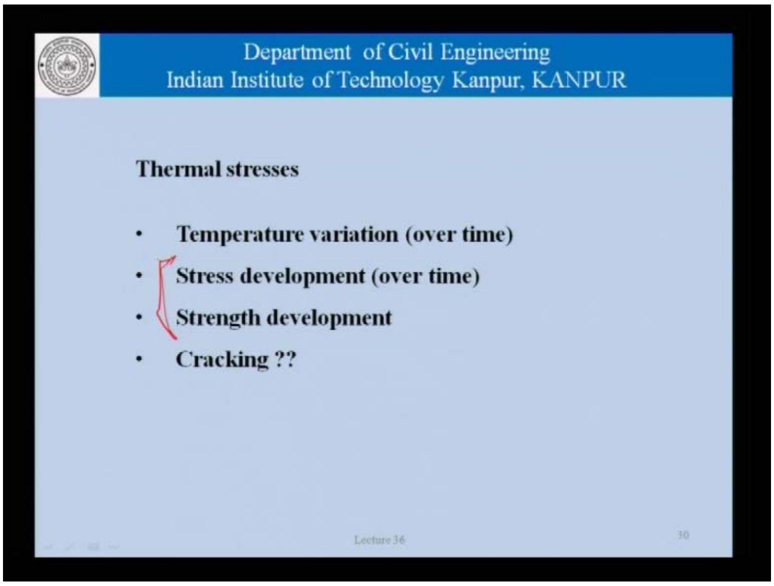

Now, this is the crux of the discussion as far as mass concrete is concerned, as far as thermal stresses are concerned and that is something, which we have talked about in greater detail, earlier. We have talked about the temperature variations over time where, the temperature in the concrete block changes, on account of the continued hydration and the release of the heat of hydration and the extent of temperature rise, depends on the difference between the temperature, depends on the difference of the heat that is generated and the heat that is dissipated by way of radiation, convection and so on.

And then, we have said that, if the temperature differences or the thermal radiance build up, we also have a stress buildup in the concrete. And that stress development again occurs over time, as more and more thermal radiance develop in the part of the in parts of the concrete where, hydration is going on. At the same time, that is the strength development going on and what we have concerned about is cracking. Now, cracking we had discussed would be related to some kind of a stress to the strength develop.

So, if the strength that has been developed at a particular point and time, is such the rate can withstand the stress, we will not have cracks but, if the strength is lower than the stress developed then, we will have cracks.

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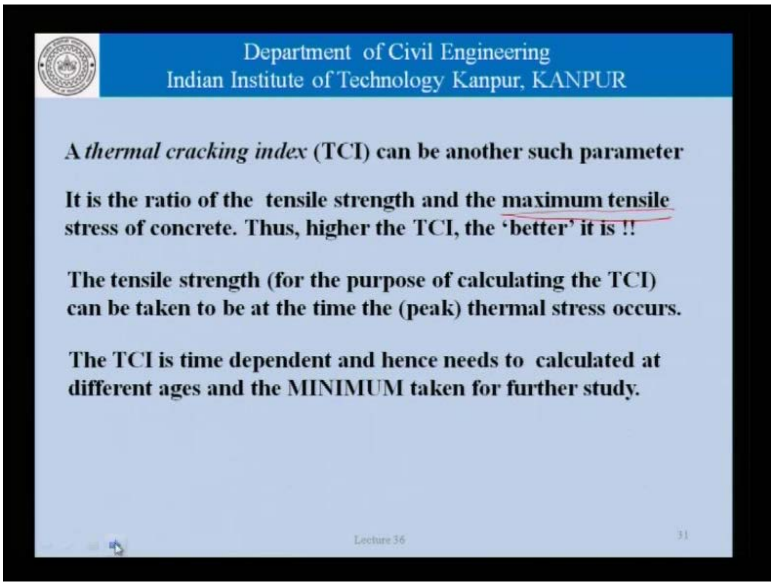

And that is the kind of discussion, that we said, gives us a parameter call, the thermal cracking index, which is the ratio of the tensile strength and the maximum tensile stress of concrete. And this maximum tensile stress is the key operator because, the tensile stress itself varies over time of course, like we had discussed just now. Higher the thermal cracking index, the better it is because, it tells us that, we have more strength than the stress, which is being developed and indeed as far as the tensile strength is concerned.

It should be taken at the time, when we are talking about the peak thermal stress, there is no point in taking the design tensile strength of concrete, which will be achieved after 28 days or 56 days. And then, trying to determine whether or not, a particular concrete will crack, if the peak tensile stress is being developed at 7 days or 8 days or 4 days. Indeed the TCI time dependent and hence, in other words, the thermal cracking index is depending on time and hence, needs to be calculated at different ages and the minimum should be taken for further studies.

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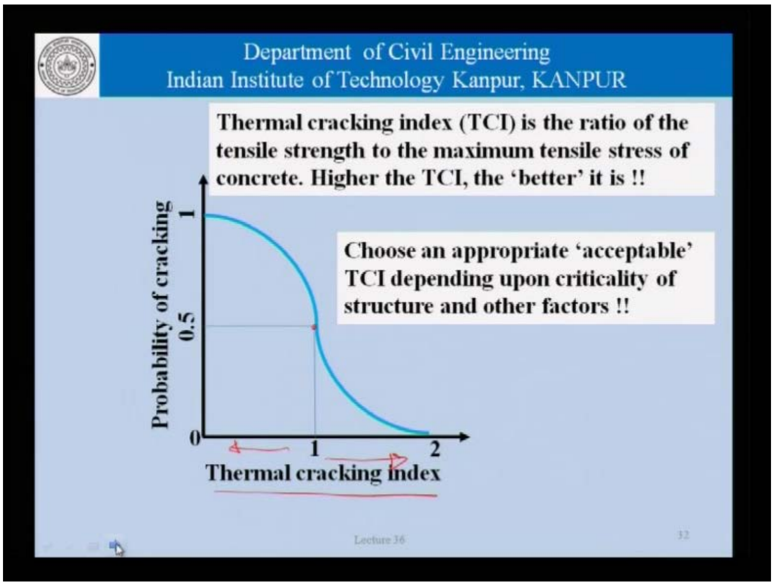

So, this is all that we had done, we had talked in terms of a probability of cracking and thermal cracking index. If the thermal cracking index is 1 that is, the peak stress that is developed and the strength developed is the same then, we really do not know sometimes it may crack, sometimes it may not. And therefore, the probability of cracking has been given as 0.5 whereas, if we move towards a higher number here, we have more strength than the stress developed and that is why, the probability of cracking goes down.

And similarly, if the cracking index is lower than 1 well then, it is simply means that, we do not have adequate strength and the probability of thermal stress induced cracking occurring is very large.

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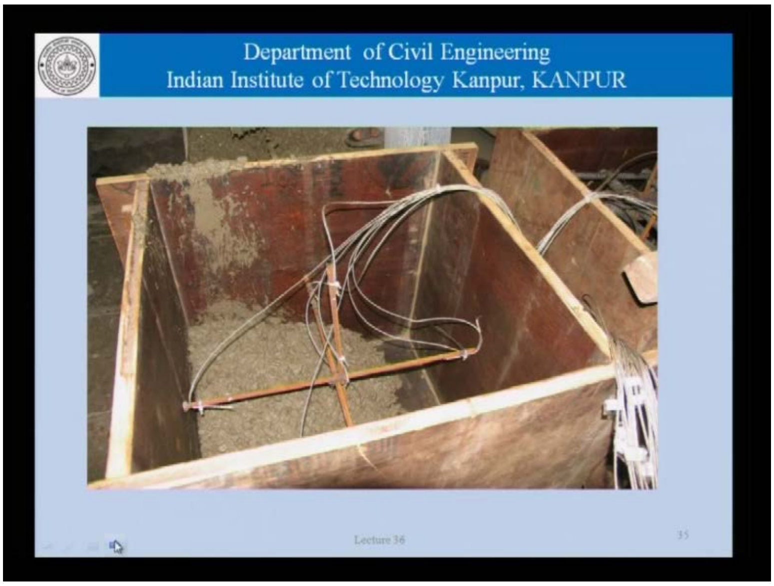

Now, this is something, which we have done earlier, what we had also covered briefly was experiments where, the temperatures in the concrete blocks was being monitored.

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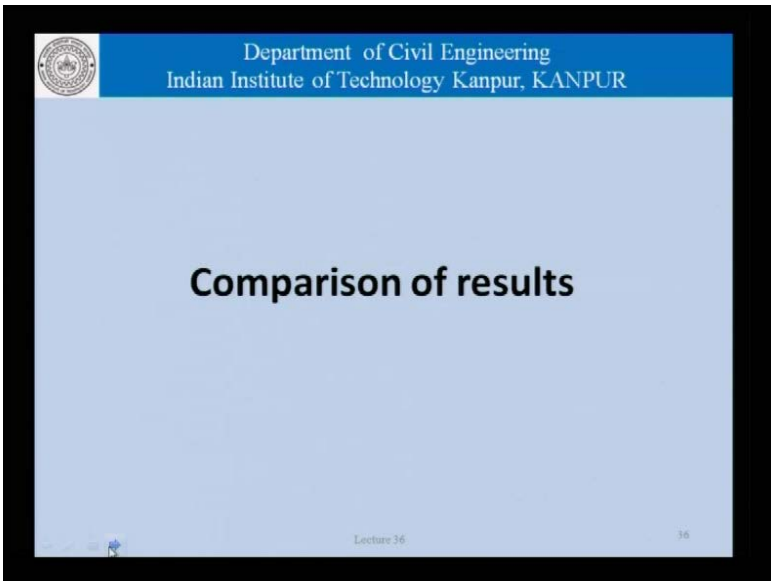

And using analytical tools, the monitor temperature, the actual temperature in these blocks was compared with that predicted using all kinds of heat equations. The equations that help us understand the rate of heat liberation the rate of heat liberation, the rates at which the heats are transported through the concrete and the rates, at which it is dissipated into the atmosphere. So, once we do all that mathematical modeling, at the end of it, the temperatures that we get from simulations should match with the temperatures, that are obtained in the block.

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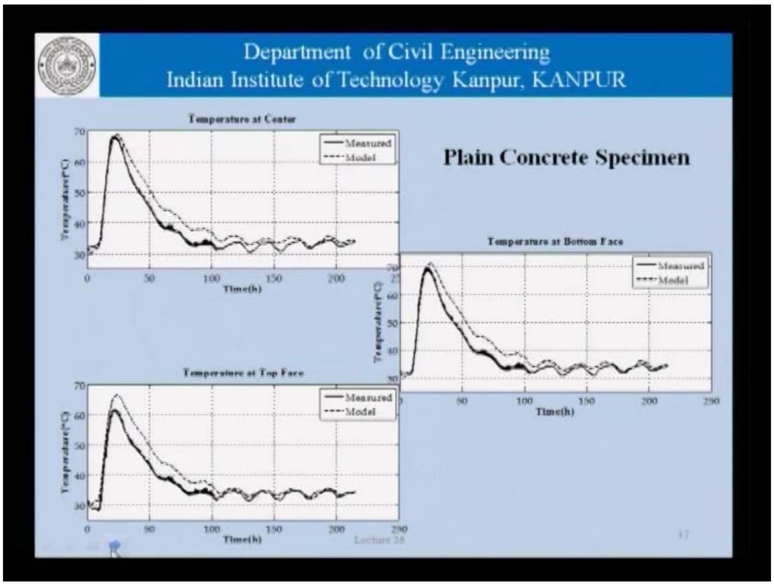

Now, this is something, which was talked about and we found that, well within a certain boundary of error or a certain limit as far as the differences are concerned, the temperatures are more or less similar, at least the profiles are similar and the extent, to which the temperatures differ is largely within acceptable band.

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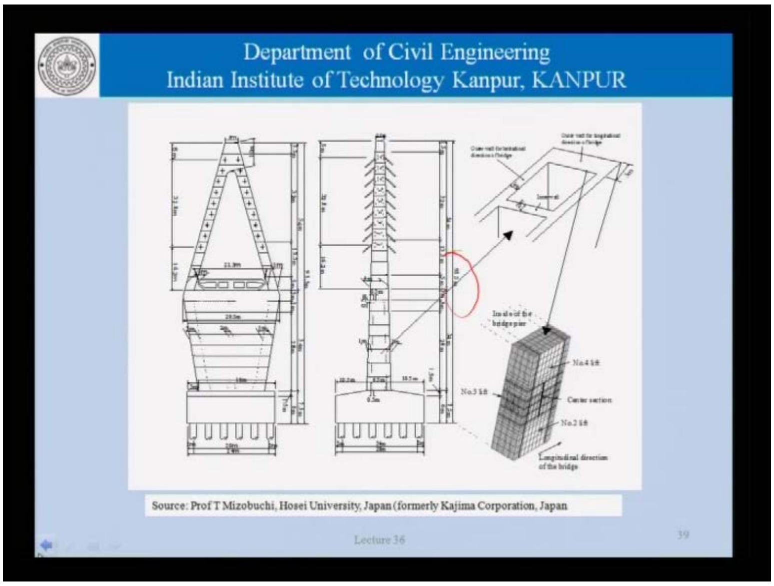

Now, the point is, whether this kind of discussion also translates into a validation in field studies and that is something, which we had just not, which we had not covered last time. And i can share with you this example where, a large concrete power in a bridge, the temperature was monitored in about a 96 meter high tower and the concrete was being placed, temperatures sensors were placed at different points in the tower. And the temperatures of concrete at those locations, was measured and also simulated using the kind of studies that we talked about just now.

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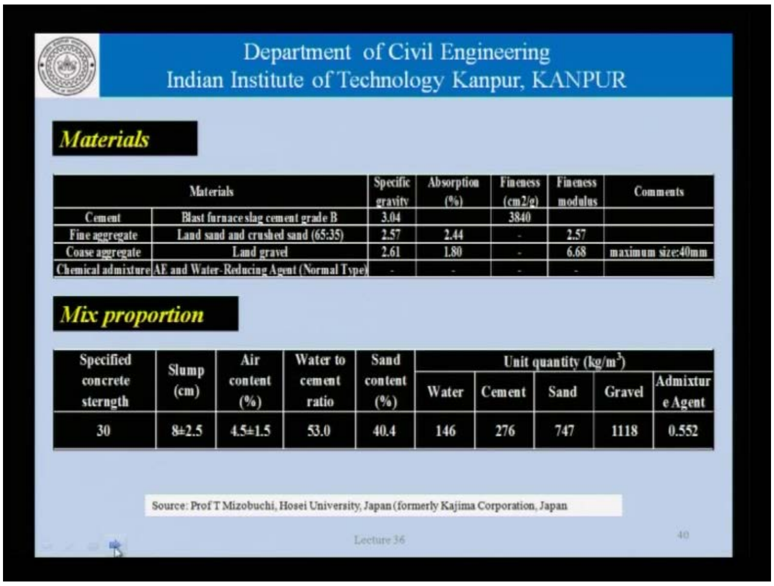

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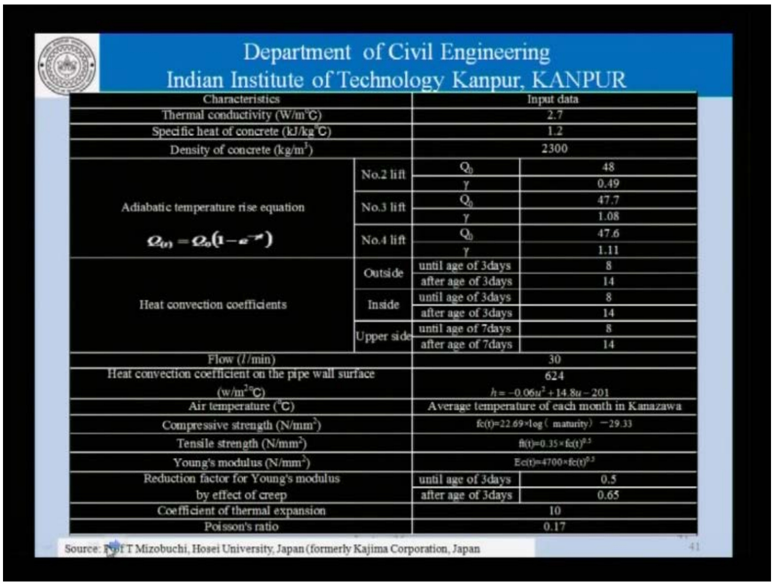

What we needed was, the details about the materials being used, a proportions that are used and all kind of modelling equations, as far as adiabatic temperature rise is concerned, the heat convention coefficients, the flows and all that kind. We needed the details for the materials that are being used in terms of the cement, coarse aggregate, fine aggregate, chemical admixtures. We need at the proportions, in which they were mixed and also, we needed to model the thermal conductivity, the specific heat and the density of concrete.

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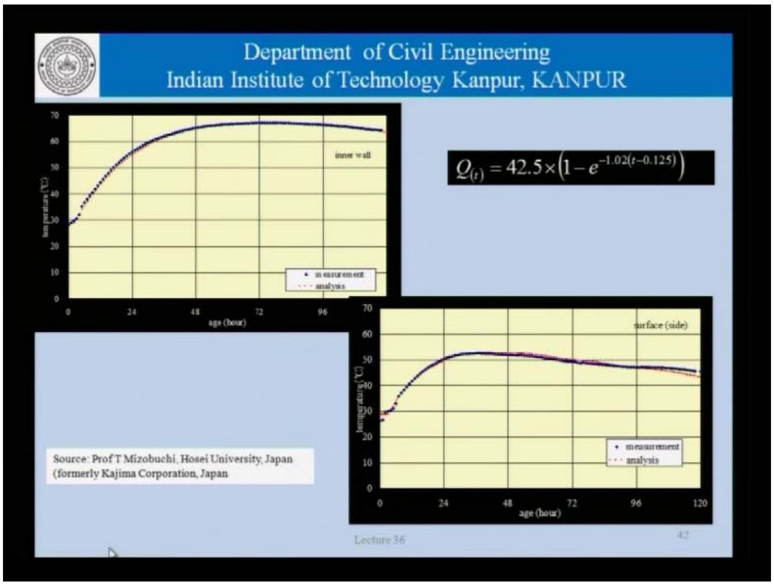

We needed to have an adiabatic temperature rise equation, which had to be created from laboratory studies, we needed heat convection coefficients and the different constant. And based on that, if we measure the temperatures, that are obtained in the inner wall or the surface and so on, those temperatures are simply very close to the actual temperatures that are monitored. So, it is not really just an exercise of mathematics that, we tried to carry out and estimate the temperatures. But we must, but in order for that exercise to be meaningful, those temperatures have to match, with the once actually monitored, not only in laboratory studies but, also in the field and that is where, the real challenge for a civil engineer lives.

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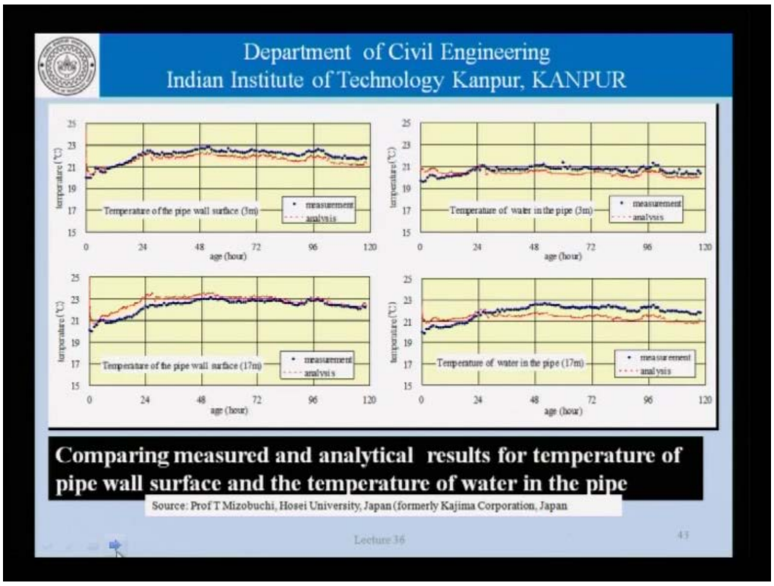

In this study was further continued where, the concrete in the site was cooled with water using pipe cooling and there also the results were acceptably close. These picture shows that, there is a limit to the extent, to which scientific models or mathematical models can be relied upon to actually represent physical phenomenon, we do not still know enough about a lot of physical phenomenon. And therefore, the models that, we use are idealizations and that is something, which we must remember as far as concrete engineering is concerned, in all aspects of the subject, whether it is mass concrete, whether it is flowing concrete, whether it is the rheology, whether it is durability, whether it is porosity and permeability and so on, and so forth.

Now, let us spend some time on nondestructive testing of concrete, this subject is well has been dealt with earlier, except there are that time, we had talked in terms of mostly laboratory tests. Today the discussion will be largely focused on, better understanding the permeability of concrete in situ that is, in an actual structure. As we have stated several times for a concrete structure, if we have a concrete structure like this where, the environment is on one side and the reinforcement is sitting here then, it is of great significance for us, to understand and study the properties of the covered concrete.

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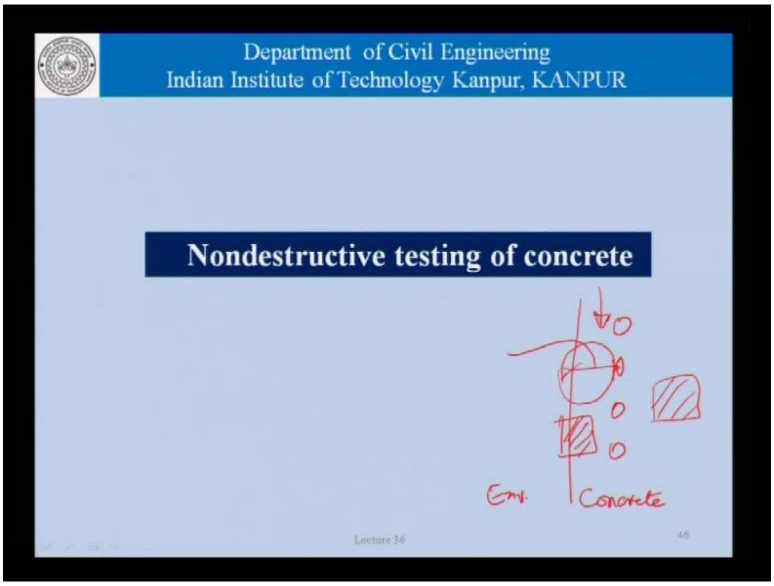

And insitu measurements like the once that, we will talk about today are largely confined to better understanding and measuring the properties, in situ of this cover concrete. Even though, the word cover concrete is hardly used and we say it is concrete but, we must remember, as far as a rigorous treatment is concerned, when we carry out a test in this part of the concrete, this part of the concrete is not really the same as the main body concrete.

It may be the same from the point of view of constitution, it may be the same from the point of view of the fact that, the same concrete was brought in an agitator truck and used to cast this member. But, as far as the placing conditions are concerned, the concrete here, in the cover region has had to flow through the reinforcement and therefore, there is reason to believe that the properties of this concrete could be different.

Having said all that at the end of it, it is the cover concrete and the properties of the cover concrete; that are very, very important as far as, durability studies are concerned. And therefore, considerable effort as far as research is concerned, has been directed towards understanding these properties.

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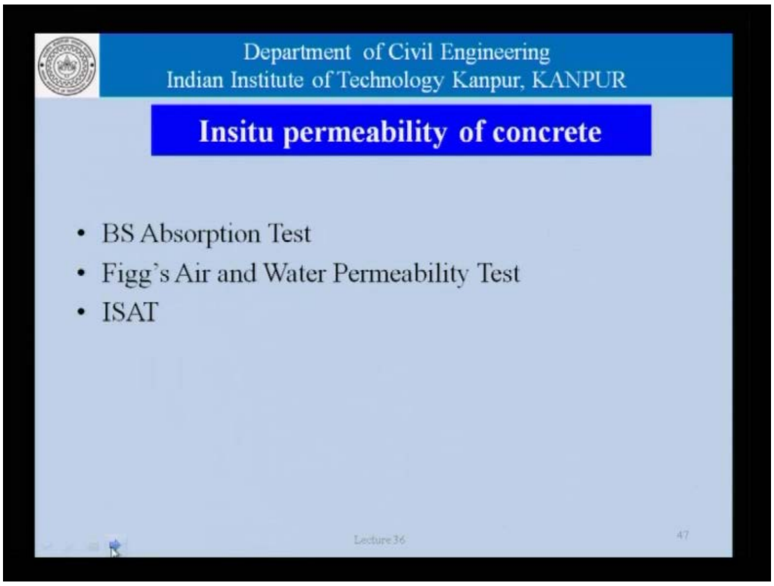

Now, as far as insitu properties is concerned, there is a british stand out on the absorption test, there is a figg's air and permeability test and there is the ISAT that is, the initial surface absorption test. Now, these three are only examples of, some of the test that have emerged in the last about 20, 25 years, to help us evaluate the properties of surface concrete.

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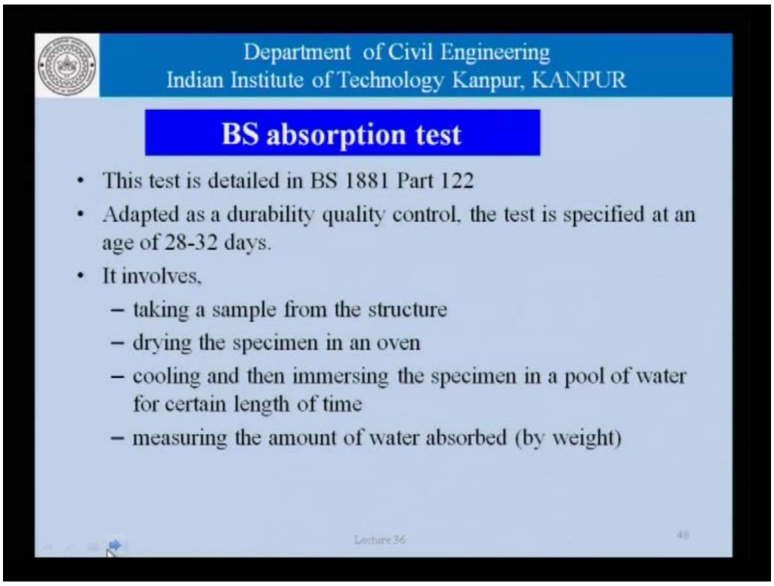

As far as BS absorption test is concerned, it is adopted as a durability quality control and is specify to be carried at nature flexi 28 to 32 days. It involves taking the sample from the structure, drying the specimen in an oven, cooling and then, immersing the specimen in a pool of water, for certain length of time and measuring the amount of water, that are absorbed by weight.

As i have stated several times in the course of this discussion, concrete engineering has to be such or the practices in concrete engineering, have to be such that, the tests are simple to carry out. They are robust and can be carried out with as little expertise as possible, given the nature of the construction industry where, very often the people that we are dealing with, may not be very sophisticated.

The level of education may be just marginal and that something, which code writers, specification writers and so on, have to keep in mind, when we try to draw tests, write down specifications for quality control and so on. So, if you look at this test for example, it is an extremely simple test and says that, well a concrete which is more porous, will observe more water that is it.

Now, the test has to be carried out understand at conditions and that is why, we need to have specifications or the test method must clearly state, what is the size of the specimen to be taken, what is the temperature at which it has to be conditioned and so on, what is the length of time over which it has to be soaked in water, what kind of readings have to be taken and all that.

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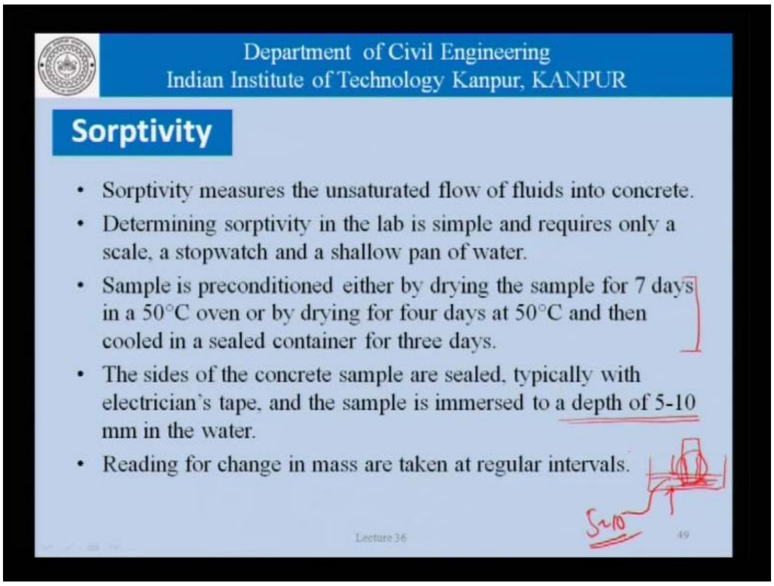

Another word or another test, which we see sometimes in literature is that called sorptivity now, sorptivity measures the unsaturated flow of fluids into concrete and there are papers and books, that deal with the subject. Determining sorptivity in the lab is simple and requires only a scale, a stopwatch and a shallow pan of water. The sample is preconditioned either by drying the sample for 7 days and about 50 degrees oven or by drying for 4 days at 50 degree c and then, cooling it in a sealed container for 3 days.

Now, these numbers are all optional in the sense that, only if we are trying to carry out a test under standard conditions, we need to follow this. If the test is being carried out for research purposes or for making a qualitative assessment of one concrete versus another, any of these conditions can obviously be relaxed. The size of the concrete sample are sealed, typically with electricians tape and the sample is immersed to a depth of 5 to 10 millimeters in water.

The difference between the sorptivity test and the BS absorption test lies in this depth of immersion in water. In the british absorption test, the entire specimen is immersed in water whereas, in this case, it is immersed only to a 5 to 10 mm depth. So, basically, what is done in this test is, we have a pan, we fill it with water and we immerse a concrete specimen like this and this depth of immersion here. This is kept over 5 to 10 millimeters and we try to see, how much water goes into this specimen through capillary action.

So, the capillary action part is true even, in the british absorption test but, in this case, we might have the situations where, there is more water rising into the specimen from the sides than from the inside. So, these are some of the aspects that, we must be aware of, when we are carrying out these tests and trying to use them as tools for quality control.

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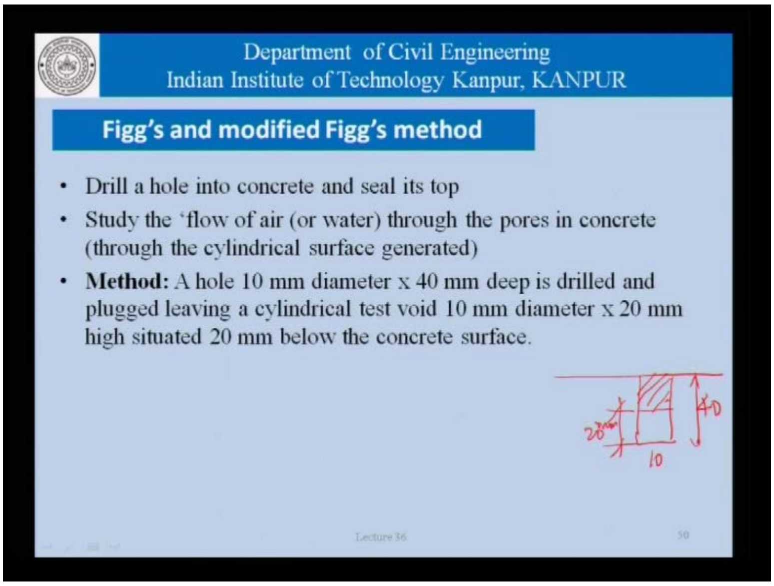

As far as the figg's and modified figg's operators concerned, this is another interesting test where, at whole is drilled into the concrete and sealed at the top. And we want to study the flow of air or water through pores of concrete, through the cylindrical surface that is generated. The method really involves drawing drilling at 10 mm diameter in 40 mm deep hole and then, plugging it leaving a cylindrical test void of 10 mm by 20 mm.

So, basically, if we have a concrete surface, we make a hole, which is measuring 10 mm in diameter and 40 mm in depth, out of which, we seal this part here. So that, this cylindrical surface that is generated, that has a depth of 20 millimeters left for us. This here is a schematic representation of the test where, this is the total depth of the hole and this is the depth that, we are talking about as far as the actual surface, through which the permeation of air or water will occur. What we try to do is, to fill this portion with water or pressurize it with air and we see, how easy it is for water or air to permeate through this surface.

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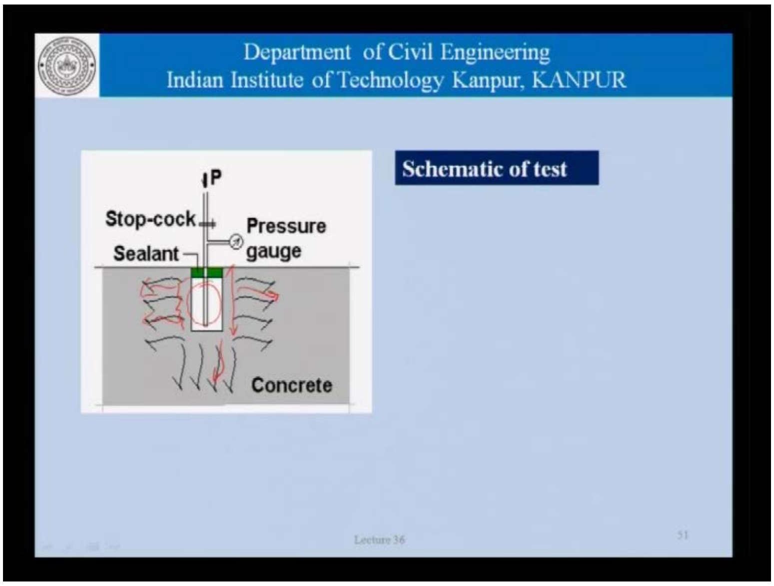

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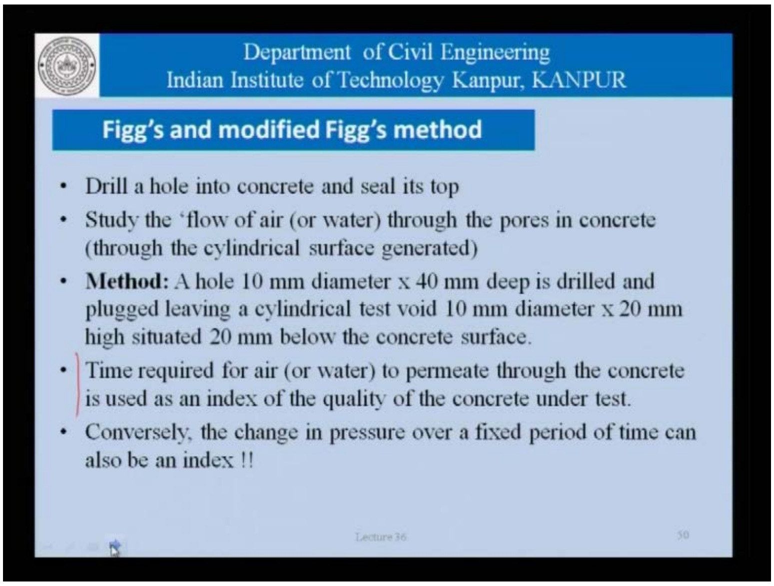

Now, in this test setup obviously, there are two things that can be measured, one is the time that is, required for air or water to permeate through the concrete. And use that as an index of the quality of concrete under test or conversely, we could measure the change in pressure over a fixed period of time and use that as an index.

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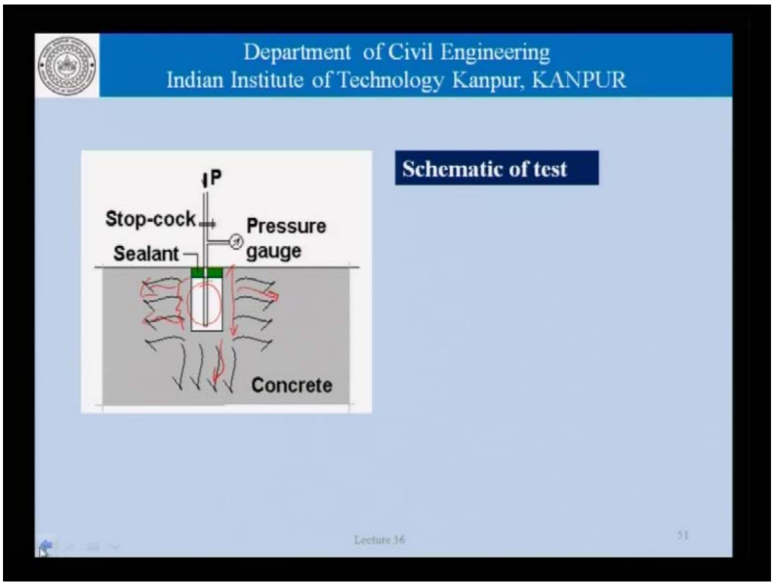

So, this here, is the principle of the figg's and the modified figg's method for the measurement or estimation of permeability of surface concrete.

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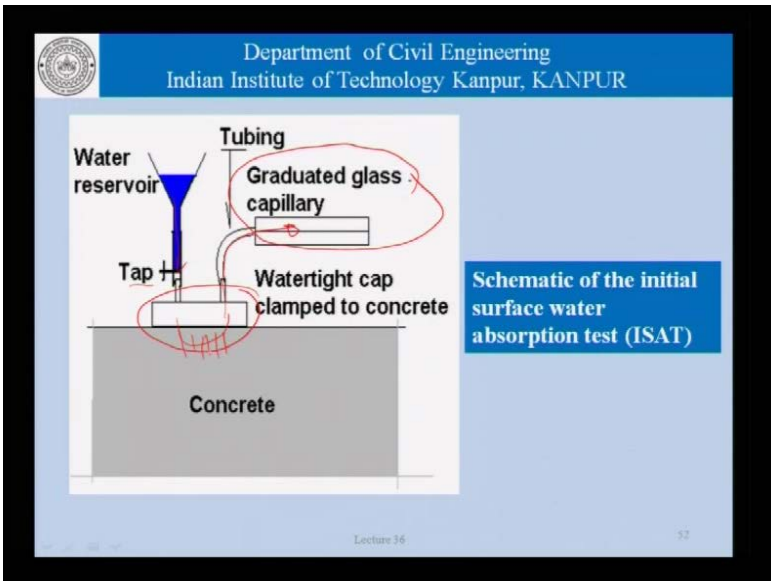

Now, coming to the last test that, we are talking about is that of ISAT or the initial surface absorption test and in this case, we fix this plate on to the surface of the concrete, connected to water reservoir. And we have a graduated glass capillary here and once, we open the tap here, we see how much water rises into this capillary tube. And that is a measure of, how much water this concrete is absorbing and this measurements, helps us evaluate the concrete that we are talking about.

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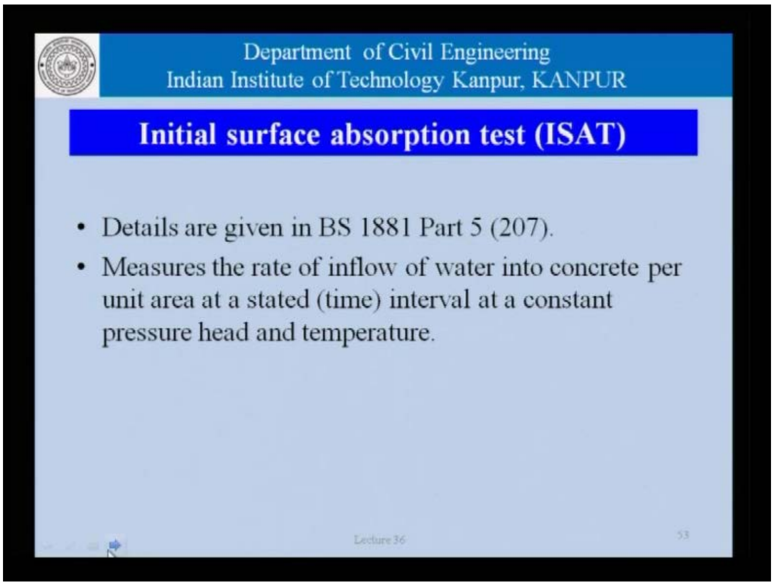

So, as far as the method is concerned, it basically measures the rate of inflow of water into concrete per unit area, in a stated time interval at a constant pressure head.

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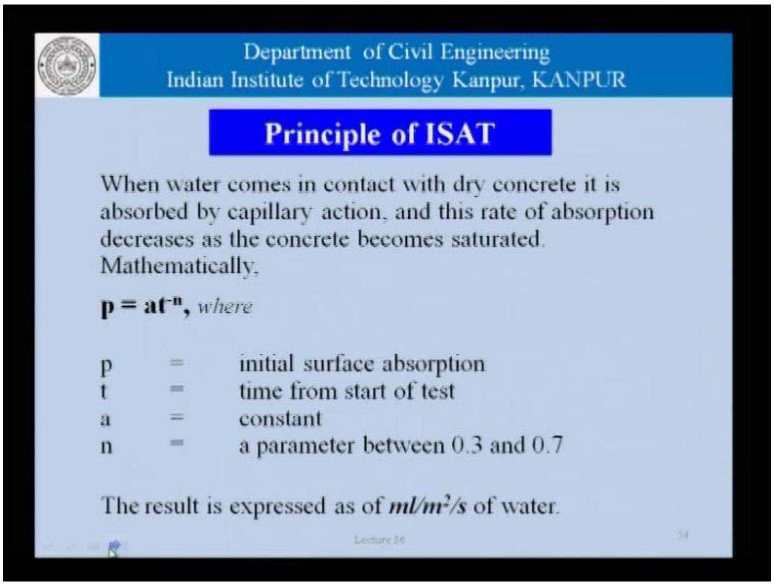

And the principle really is that, water when it comes in contact with dry concrete, it is absorbed by capillary action and this rate of absorption decreases, as the concrete becomes more saturated. And mathematically speaking here in equation, which is of the nature that is given here where, p is equal to a times t to the power of minus n where, p is the initial surface absorption, t is the time from the start of the test, a is the constant and n is the parameter, which has been found to vary between 0.3 and 0.7, for most concretes. And once we do all this, we have a result, which is express in terms of milliliters per square meter per second of water absorbed.

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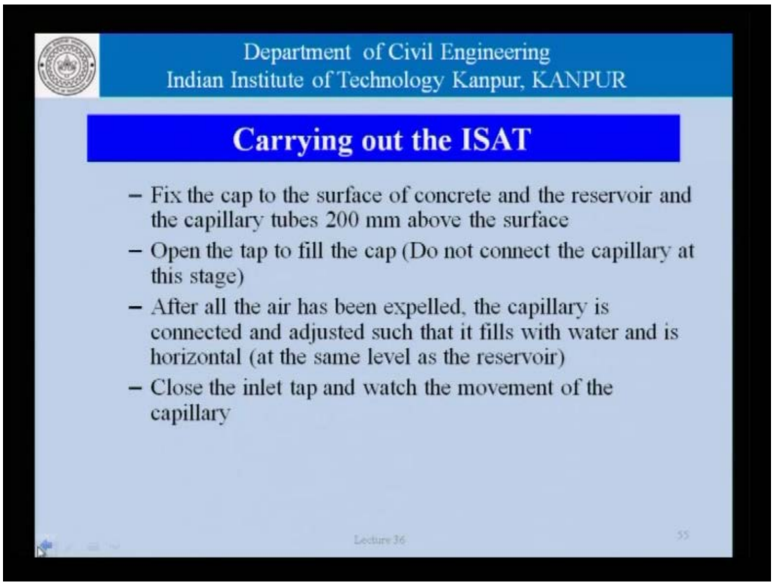

And when we are carrying out these tests, these are the steps that are involved in the process.

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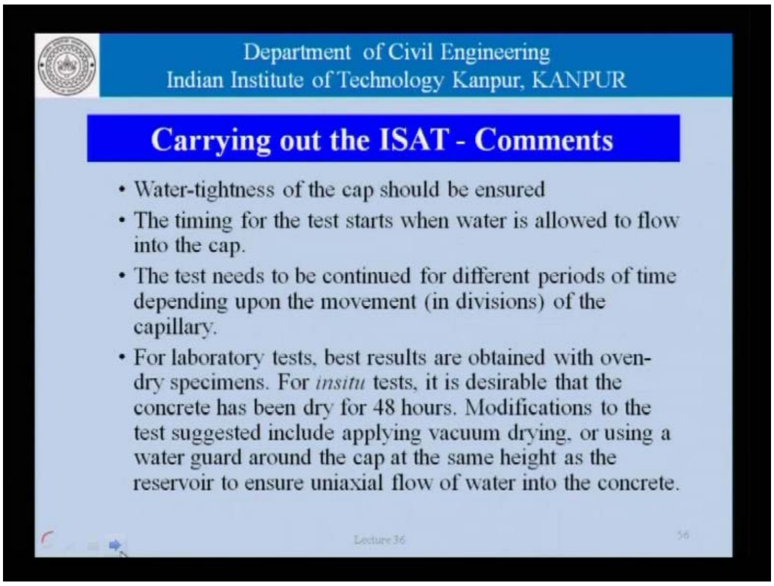

And finally, as far as comments on this test is concerned, we must ensure that the water tight we must ensure that, the cap that we uses indeed, water tight. And the timing for the test starts, when the water is allowed to flow into the cap and the test needs to be continued for different periods of time, depending upon the movement, in divisions of the capillary that, we are talking about.

So, in this case is well, we can talk in terms of quality, on the basis of the divisions, that the water moves in the capillary tube in a given time or the time that it takes for the water to move through a certain number of capillary divisions. So, depending on our convenience, we can use one or both of these measures, for laboratory test, the best results are obtained using oven dry specimens.

For insitu test, it is desirable, that the concrete has been dry for 48 hours and modifications to the test suggested include applying some kind of vacuum drying on the surface or using a water guard around the cap, at the same height to ensure uniaxial flow of water into the concrete.

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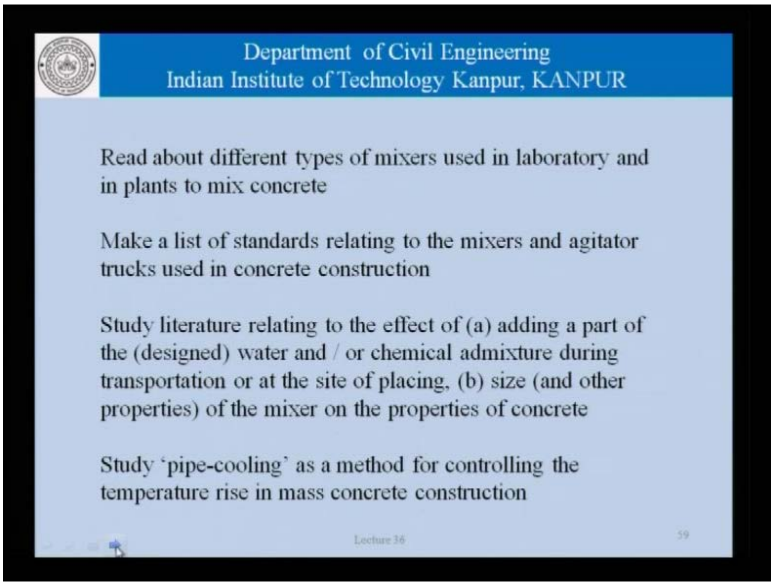

Now, with this, we come to an end of the discussion today and we will quickly run through some of the questions especially, for the mixing part, because that something, which we have not talked about earlier. You could read about the different types of mixers used in the laboratory and in plants, the ready mix concrete plants, which are used for mixing concrete.

We could make a list of standards relating to the mixers and the agitator trucks used in concrete construction, as to what are the specifications that govern then, in the first place. We could study literature, relating to the effect of adding a part of the designed water that is what we were talking about in terms of what we talked of in terms of supplementary addition of water at the site, whether its water or chemical admixtures during transportation or at the site of placing, or we could study literature, which relates the size another properties of the mixer to the property in the concrete that is obtained.

And one question for the mass concrete part, study the pipe cooling as a method for controlling the temperature rise, in concrete construction especially, basically, mass concrete construction.

Thank you.