Admixtures and Special Concretes

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Lecture -25

Chemical Admixtures: Other specialty admixtures

Effects on dosage of inhibitor:

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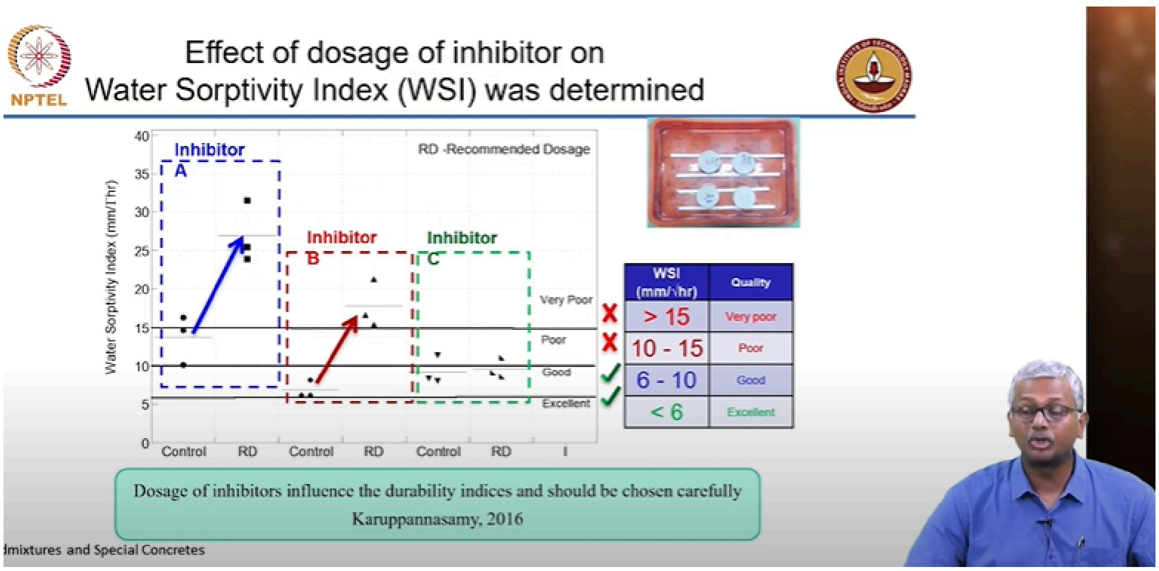

I just wanted to come back to corrosion inhibitors to show you some additional data. I had talked about how usage of chemical admixtures can lead to side effects which has to be properly designed for. We talked about some idea about how strength can sometimes be affected if you are overdosing the corrosion inhibitor. This is another data from our laboratory studies where the durability indices were affected by the presence of certain types of inhibitors. So here there are 3 different types of inhibitors that have been looked at and you can clearly see that compared to the control values of water sorptivity.

So water sorptivity essentially is a test where you take slices of concrete, expose the area, you dry the slices so that they will be able to take in water by capillary absorption then you put them on a water tray so that water is basically imbibed by capillary absorption. So the more permeable or more porous the material is, the faster it will imbibe the moisture and if the pores are connected the capillary absorption is going to be significantly higher and that is what is seen in this case is that when you go from a control to an inhibitor system you are increasing the water sorptivity index. There is more water absorption happening. Depending upon the type of inhibitor the effects could be quite different. So what this simply goes to show is you need to assess the impact on concrete properties before you can suitably use any inhibitor inside concrete.

Coming to inhibitors in general there is, I have not covered that in detail but there are two ways in which the inhibitor can be used. One is of course as an admixture. The other way is also to use it as a surface applied inhibitor. Now what you do in this case is the inhibitor chemical is basically either sprayed on the surface or applied by a brush and it diffuses towards the reinforcing steel after application. So the molecules of the inhibitor diffuse from the surface to the level of the reinforcing steel. So there has to be a sufficient enough gradient to cause this diffusion to actually happen. This is of course not a mechanism that will work in all circumstances. You need to ensure that the concrete is sufficiently saturated otherwise this diffusion is not going to happen easily. If it is dry concrete there is no reason why your surface applied inhibitors will actually penetrate to the level of your reinforcing steel. So surface applied inhibitors also can be used for structures that have already been constructed without the use of a corrosion inhibitor. But for new structures it is generally recommended that we go for an admixed corrosion inhibitor rather than a surface applied inhibitor. So you have to be careful about what type of chemical you are going to be using in your system.

Mechanism of shrinkage reducing admixtures:

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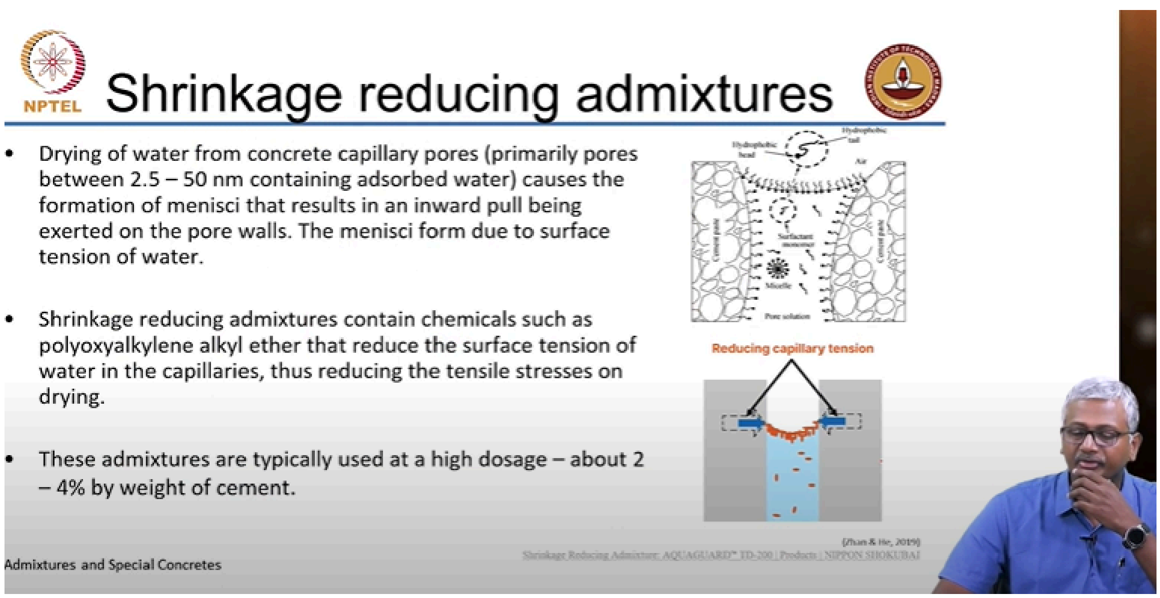

We were also talking about the mechanism of action of shrinkage reducing admixtures. The meniscus that is formed because of the drying of the water leads to increased capillary stresses in your cement paste that is surrounding the pore and the presence of the surface active chemical that is your shrinkage reducing agent cuts down the surface tension or reduces surface tension of the water which essentially ends up reducing the capillary tension felt in the paste surrounding the pore.

So because you are reducing that capillary tension you are reducing the chances of shrinkage cracking happening in your system. These chemicals need to be present throughout the microstructure of your concrete. They need to be present entirely in all your pores to actually have a much more uniform effect that is why we use very high dosages 2 to 4% which makes the overall application of these admixtures quite expensive in concrete.

Styrene butadiene latex:

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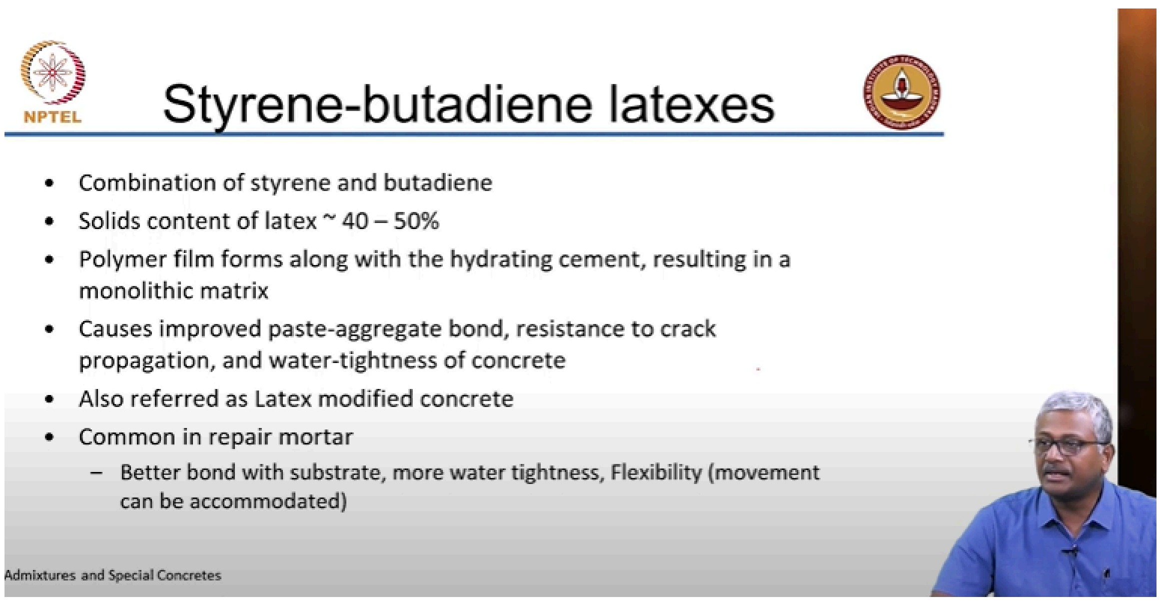

Other specialty chemical is styrene butadiene latex. Latex is what kind of material? It is basically rubber. Styrene butadiene are types of compounds that are typically found in rubber. So latex what do you think you will add rubber? for essentially to introduce some more flexibility in your system. Flexibility in concrete also implies better crack resistance. So styrene butadiene latex is with the solids content about 40 to 50% that means the remaining part is water. They are basically emulsions of these styrene butadiene molecules in water. So these are added along with the concrete and the monomeric styrene butadiene essentially forms a polymeric film. As the cement is hydrating you also have this polymerization of the rubber that leads to the formation of a polymer film along with the hydrated cement products. Now the formation of this polymer film helps to actually improve the paste aggregate bond. It improves resistance to crack propagation because it makes your system a lot more flexible, able to accommodate movements much better. Interestingly it also improves the water tightness of concrete. For a long time people were using polymer modified or latex modified concrete for bridge deck overlays that was one of the common strategies for use of latex modified concrete. So in the deck slabs of bridge decks on top of that you have an overlay, a thin overlay which can be added on the top to essentially impart some durability characteristics to your concrete. Here what you needed essentially was a system that is more impermeable to moisture and moisture obviously carries other active ingredients that may affect the concrete. So because of that you can introduce extra durability in your system by having an overlay that has latex modified concrete.

And in repair mortar when we use prepackaged material for repair mortars it is a very common thing to find these styrene butadiene latexes as parts of the formulation of the repair mortars. So in repair mortar typically you get these bagged products, products which are already pre-mixed in a bag and all you need to do at the site is simply add water. In some other instances there are two part chemicals that are available. So one is the bagged dry mortar and the second part is the water along with this latex and any other admixtures that are dissolved in the water then on site you need to have a mixer in which you put the dry and the wet part together, mix it and then apply it as a repair mortar. What should be the strategies characteristic of the repair mortar? One obviously is the bond with the substrate. You need to have a good bond with the substrate. You need to have good water tightness. Compatibility is important because the rate of movement to temperature of the repair material and the substrate could be quite different. You need to have that compatibility maintained. Secondly the substrate is already shrunk. When you are doing a patch repair the substrate may have already shrunk. So when you put the repair mortar in place if the mortar shrinks more it will simply get delaminated, de-bonded. This is a common thing that we observe when these contractors come and simply slap up some cement mortar and put it as a patching material very soon it simply falls off because it de-bonds from the substrate. It shrinks more than the substrate and so it just falls off.

Secondly if there are temperature related movements, temperature or moisture related movements of the material of the underlying substrate if the repair mortar is not flexible enough to undertake those movements there will again be a debonding. So because of all that flexibility as well as shrinkage compensation is very important. Shrinkage for a repair mortar shrinkage compensation is also very important. That means the system should not shrink too much so that it de-bonds. But shrinkage compensation is not provided by latex. Shrinkage compensation is provided by either using a shrinkage reducer or using a cement that expands during hydration so that overall shrinkage is reduced significantly. So we can also get that system with an expansive cement, expansive cement admixture.

Other Specialty admixtures:

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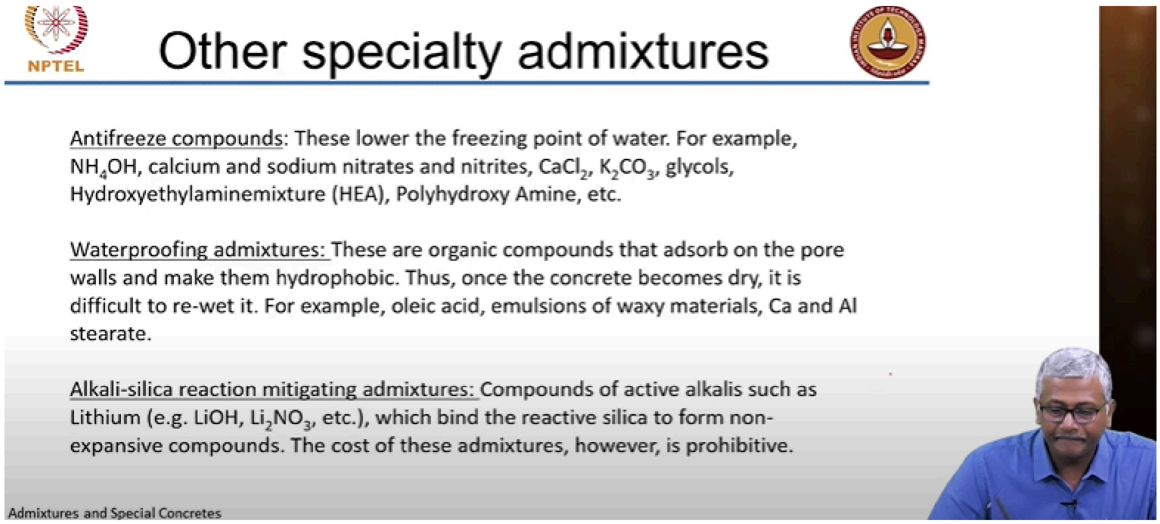

Now there are other specialty admixtures about which not much has been looked at in detail with respect to research because these are not used in all circumstances but they have their place in concrete technology. One is antifreeze compounds when you are doing concreting in extremely freezing conditions. If you have temperatures of less than 0 operating at the time of your construction generally you would not undertake construction in those temperatures. However if there is a chance that your concrete may be subjected to sub-zero temperatures you can add chemicals that can lower the freezing point of water. Essentially you do not want the water inside concrete to freeze. You want water inside concrete to be available for the reaction of the cement. And these are typically your nitrates and nitrites which are similar to your accelerating chemicals. You can also have ammonium hydroxide, calcium chloride, potassium carbonate, glycols and so on. Now the interesting part about using glycols or the other organic chemicals is that they also function very well as shrinkage reducing chemicals. So sometimes you can again get multifunctionality from these chemicals.

Waterproofing admixtures, now this is a whole range of chemicals that are available in the industry. The construction chemical manufacturers who sell waterproofing agents make you believe that whatever be the quality of the concrete you have put this material in and it will become magic that is all wrong obviously. Good engineering is the top solution to any water related problems. First is you need to engineer the material or engineer the structure properly. If water is there you want to cause the water to flow out of the building that is basically pure engineering. Your slope should be properly done. Second, concrete quality has to be good. The use of waterproofing chemicals can only make good concrete better. It cannot make poor concrete into good concrete that is not going to happen. So engineering, material and only then the waterproofing agent. So waterproofing agents are essentially those that can adsorb onto the pore walls and make them hydrophobic. So it is like using wax. So you put wax on top of a car and what happens when you pour water slides off. It does not stick to the surface. Same thing you are making a surface hydrophobic. So once concrete dries you cannot wet it again because the water does not have a chance to get in since pore walls are hydrophobic. Of course waxy materials could also be used, emulsions can be used. Calcium and aluminum stearate are very commonly used for waterproofing agents. It turns out that many of your integrals we also call them integral waterproofing compounds. Just so that we can distinguish this from the range of waterproofing treatments that it can give to the surface you would have seen in many projects that they give a layer on top like on terraces now you have these waterproofing layers of polyurethane foam. You sometimes give acrylic based systems to cover the surface with a membrane. All those are essentially externally applied waterproofing treatments. Silane siloxane coatings all of these are externally applied treatments. Those are not to be confused with chemical admixtures because chemical admixtures are added into the concrete mixture. So that is why they are called integral waterproofing compounds and that is where all these materials like waxy materials calcium aluminum stearate all are used into the concrete mixture to produce this resistance.

There is also another series of materials called crystalline water proofers. Crystalline water proofers are a very interesting concept. So at least the claims are quite interesting. The people who make these crystalline water proofers say that when concrete gets hardened these compounds that are added as crystalline water proofers basically crystallize inside the pores and fill up the pores so that your concrete does not have any open porosity through which water can enter. Another interesting claim is that when concrete actually cracks these compounds crystallize inside the cracks and then still prevent water from coming in. Unfortunately the evidence that we produce in the lab is not always backed up by this claim or this claim is not backed up by the evidence that is there in the lab. Although under some controlled conditions these companies that are manufacturing these chemicals are able to get their products certified and these days in many of the infrastructure projects it is quite common to see in your formulation the use of a crystalline waterproofing agent.

There are companies like Penetron for instance that is one of the common chemicals or Xypex that is the other one. And many of you if you have read literature on concrete research you would have seen that very many people are also putting in bacteria into concrete. They call it bacterial concrete. The idea is that bacteria under certain conditions if you provide the right nutrients in the presence of calcium bearing compounds can actually precipitate calcite or calcium carbonate. So bacterial concrete is another claim because it is okay to have this bacterial mixture put in from the external surface if a crack appears. If you fill up the crack with this bacterial system to precipitate the calcite in the crack externally that makes some sense.

But a lot of the claims are that we put these bacteria along with the nutrients inside the concrete as an admixture when the crack appears; these will start filling up the crack with calcite. Again that is a claim which is very difficult to actually perfectly test and certify because we do not know what is going to happen inside the concrete. How long are these going to be stable in the alkaline environment? In crack concrete applying a crack filling solution from outside is a completely different concept and there a lot of success has been achieved with the bacterial concreting systems also. But all of these things you have to take with a pinch of salt, examine the evidence and ensure that you are able to completely satisfy yourself that these are actually doing the job that they are purported to do. So read the literature, understand mechanisms and only then make a judgment whether it is good enough for your project to be actually using these compounds or not.

Bacterial concrete is a big topic of research all across the world. A lot of people are working on it. We are getting scared of viruses. Imagine putting bacteria and getting near bacteria. I would not want to do that myself. Then the other common durability problem that you have in concrete is alkali silica reaction. Now of course we will discuss this more when we come to mineral admixtures. But then you can also have chemical additives in your concrete that can take care to some extent to reduce the expansion in alkali silica reaction. This happens when your aggregate is reactive.

If you have reactive siliceous aggregate, certain forms of sedimentary rocks are highly reactive; certain igneous rocks could also have some reactivity if the silica is amorphous. In such instances when your alkali content of the cement is high you can lead to the formation of expansive gel which leads to cracking. Again we look at this mechanism a little bit more when we talk about mineral additives. But if you use a lithium based salt, lithium hydroxide or lithium nitrate and so on these react with the silica much before your alkalis from the cement which are what type of alkalis. Sodium or potassium. If you have lithium compounds present they bind the silica into non-expansive products. But if sodium or potassium are there they bind silica and they form these expansive gels which basically create pressures in your concrete and lead it to crack. So lithium based admixtures could be used to mitigate alkali silica reaction but they are very expensive. A much simpler and robust strategy to protect against ASR is to simply use mineral admixtures like fly ash or slag or silica fume. They are much more effective in controlling alkali silica reactivity. We will talk about that in more detail when we actually get to mineral admixtures.