Admixtures and Special Concretes

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Lecture -35

Mineral Admixtures: Fly ash - Part 3: Effects on fresh concrete

Recap:

We were talking about fly ash primarily with respect to its collection and the differences in the composition between type C and type F fly ashes. We also looked at the specific types of coal from which after burning fly ash can be obtained and the quality and the composition of fly ash obviously depends on the type of coal which is being burnt. And we also discussed the fact that in cement, sorry in thermal power plants because of a shortage of coal you can get coal from multiple sources because of which you do not really have a control on what type of coal you have and essentially what type of fly ash gets produced from it. So cement companies that actually end up collecting this fly ash for producing blended cement have to work around the fact that it may be a type C or a type F fly ash and because of that the properties could be variable in a blended cement. Hence the control that needs to be exercised while actually producing the blended cement is much more.

It is not the same as obviously using it in a concrete mixture directly. In that case the fly ash is collected and brought to a ready-mixed concrete plant and that is where it gets used. There you can control the concrete characteristics. So there are several different ways of looking at it. Now between type C and type F fly ashes we saw that while there is not much difference in the particle size and morphology there is obviously the difference in the calcium content that leads to different kinds of performances from them.

Type F fly ash has essentially a pozzolanic performance whereas type C can exhibit some cementitious nature also. In that it can undergo the reaction on its own. Even in the absence of lime there can be some reaction because of the higher calcium oxide content. Obviously if the calcium oxide content is not high enough you may not get that reaction you may still need to provide sufficient quantities of lime.

We also looked at some other aspects of the composition of fly ashes that needs to be restricted primarily. And we were then talking about again a larger study done in the US where they compared several different types of fly ashes and looked at the composition

characteristics. It is clearly seen that as the calcium oxide content increases the sum total of the other three oxides is going down and again the density also seems to decrease with lowering the amount of calcium oxide or increasing the amount of the silica and alumina. So alkali content also seems to depend significantly on the ashes that have greater impurities have greater alkali content. Class C fly ash is known to be from a coal that has greater amount of impurities so it ends up having a higher alkali load as compared to type F fly ash. We were looking at this structure. There are solid spheres of silica which are the reactive silica but then they can also be these gas filled spheres which are much larger which can contain some of these solid spheres inside. Once the surface glass of these larger spheres breaks it releases the smaller spheres which can be then used for reactivity. You could also have gas filled spheres that are very small in size which we call as cenospheres which are essentially used as lightweight aggregate. You could also use cenospheres as light weight aggregate but all this means that you need to then collect the fly ash and do classification we call that classification.

Classification means not classification with respect to composition classifying fly ash is a means of processing in which you are controlling the particle sizes. You control particle sizes or you are controlling particle densities. So low density material primarily composed of the cenospheres can be extracted in this fashion and cenospheres are available as lightweight aggregate today. We also looked at the difference between collected and processed fly ash and we saw that in process fly ash there is a much greater fraction of smaller particles which leads to much better reactivity in the system. Now the problem obviously is process fly ash will add to the cost of the material. If you go to the western countries you get fly ash just like you get cement as a process material in bags and because of that you need to pay a price for the fly ash. In India a lot of the fly ash that is available for use in concrete directly is made available by suppliers who go and collect the ash from thermal power plants and they supply directly to the RMCs without any processing.

In such cases your extent of variability you can expect is going to be much more. So because of this obviously there is a problem in people's trust with respect to the use of fly ash because it is not really a controlled commodity when it comes to using it as a mineral but when you use it as a Portland pozzolan cement you do not seem to have that kind of a disadvantage.

Issues of Fly ash:

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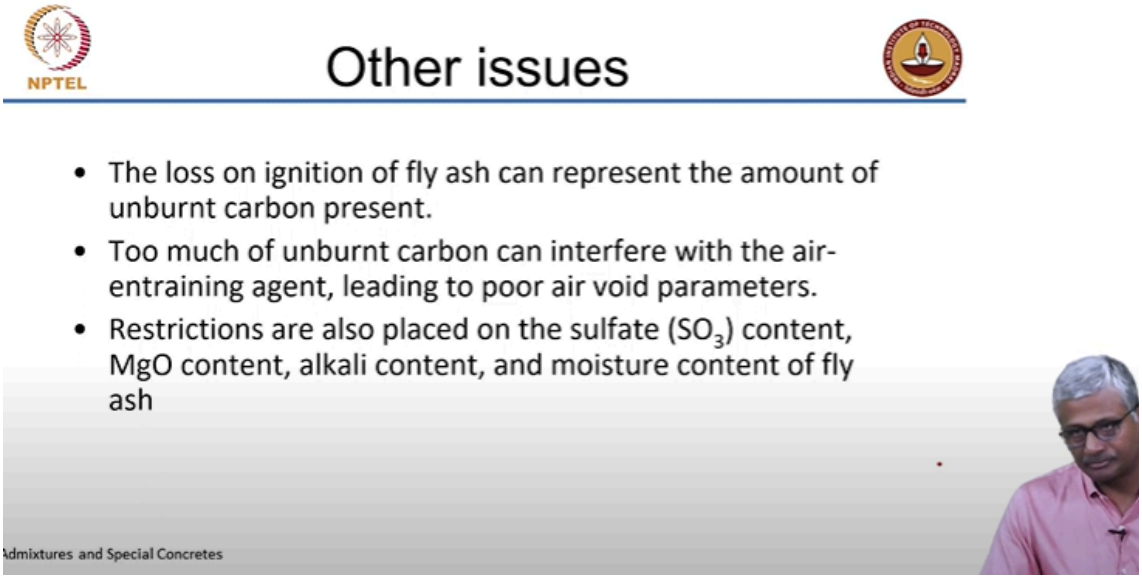

Now unburned carbon could be there in fly ash for obvious reasons because you are burning coal to get the fly ash, lighter particles of coal can fly off along with the fly ash and get collected along with the fly ash and that probably leads the fly ash to have a distinctly blackish coloration and this unburned carbon needs to get removed or it needs to be within a certain range. If you do not do that it can interfere with air void parameters leading to poor performance of the air entraining agent. As I said, too much unburned carbon can interfere with air void parameters leading to poor performance of the air entraining agent. Generally more air entrainer may be required to produce the same extent of air because of all of these issues there is also a loss in strength associated with excess carbon in your system and your discoloration. Carbon is very light. So when you actually place the concrete this carbon can come up to the surface and cause a discoloration on the surface and that is not something that is generally accepted from a quality perspective.

Some of you have been on site so how do you check the quality of concrete? What are the specific parameters you look for? All that is fine after you pour the concrete and the formwork and you remove the formwork. What are some aspects of concrete quality that you look for No again bleeding is in the fresh state I am talking about hardened state honeycombing you look for honeycombing what else? Efflorescence, why would efflorescence happen in plain concrete? Maybe there are some additional salts in your water that may come up to the surface and would have dried there causing some coloration or some patches on the surface. What else? Again this could be one of the

reasons lighter ingredients like carbon for instance are coming up to the surface and causing discoloration also on the surface.

Is there a desired color of the concrete? In quality control do you also look at the color of the concrete? You expect concrete to be metallic grey but on site do you make a distinction based on the color? Mostly not. But imagine if you are constructing a very large wall and there are major changes in your color as you go along the quality is not really being met you have a problem. You may have seen this in several applications even in columns when you have successive lifts made for the same column there is a minor variation in color and that really puts off the entire appearance of the column. And these days a lot of projects are moving towards a struck finish that means form finish. When you remove the formwork no more finishing no plastering nothing. Concrete has to appear good like that. Or in other words we call it fair faced concrete. So there you are not going to be putting any paint on top of the concrete you are not putting any extra coverings or coatings or plaster because of this such things can really affect the quality of your concrete.

Now the only thing is of course we check performance in terms of strength or durability we don't really have a clear assessment of quality. We don't gauge structural performance in terms of quality. Honeycombing is an obvious issue obviously you can see it but color changes which could also indicate some change in quality are not really paid much attention to because in most cases we do some surfacing on top of the concrete.

You put plastering, is plastering really necessary on concrete? Yes, why? Concrete is supposed to look good on its own. Why should you need plastering to make it aesthetically good? So you are saying that if you don't do plastering the surface of concrete may have voids. So if you do a proper concreting process do you need plaster? Actually not, actually you don't need plastering on concrete at all.

What do they need to do to put plaster on top of concrete? They need to roughen the surface so that plaster bonds to the concrete and for that they use a chisel and hack the surface. So you are actually damaging your concrete by doing that. It is a very poor practice. I don't know how it stayed for so long in the industry.

It is extremely poor practice to do hacking on the surface of the concrete to put plaster. Of course it increases the bond strength of the plaster with the concrete but you are damaging cover concrete. Please remember cover concrete is a key to durability of concrete. You are hacking, hacking will create cracks and that will lead to durability problems. Plaster is not going to protect against durability problems. Why? Because plaster is much more porous as compared to concrete. Plaster is extremely porous when you compare it to concrete. The porosity of plaster even if it is of the same grade, mortar will have more air in it and that is why it will have more porosity as compared to

concrete. So the porosity of the plaster is going to be much more than that of concrete. It will lack a water sink. It will absorb the water and slowly the water will make it into the concrete through the channels. Now of course when you have a case like this where you have discoloration of the surface of the concrete. In such cases the plaster may help but it may help only aesthetically. It is not going to affect the quality of your concrete or it is not actually improving the quality of your concrete.

The other reasons could be if you are using formwork that has been already subjected to several cycles of use and reuse especially if it is a wooden formwork, it would have started warping and because of that the shape or the finish on the surface of the concrete is sometimes affected. In such cases plastering helps to ensure that you have a perfect orthogonality between the faces of the column or whatever structural member you are making. But again it is undesirable. Imagine the time and cost that is spent on plastering in buildings. It is absolutely a waste if you are trying to do plastering for concrete surfaces. Plastering for brick or masonry block surfaces is reasonably justified because you want to have a smooth surface on which you can do painting and other finishing. But plastering on concrete is simply unjustified.

If you have an opportunity in your job sites to stop that. That would be the first practice to stop plastering of concrete surfaces. So that is very important. I also call it 3D printing. Using plaster to wipe out blemishes in the surface of concrete and give it a perfect shape essentially that is man made 3D printing. We will take a look later at the robotic 3D printing that has completely different applications but this is our first instance of 3D printing where workers 3D print to the surface. But that is totally unnecessary when it comes to concrete.

So apart from carbon which can lead to these surface blemishes and also interfere with your performance of the concrete, you have to obviously restrict the sulphate content. In concrete again you need to be careful as to how much sulphate loading the fly ash is bringing in because this sulphate will contribute to the other issues that you may have related to sulphates in concrete like sulphate attack. Internal sulphate attack or delayed retrogate formation could also be a possibility sometimes when excess sulphate is brought in.

Magnesium oxide content, why? Because it causes unsoundness. Then alkali content. Alkali content is obviously important because too much alkali would lead to alkali aggregate reaction in case aggregates are reactive. But even in that case, even if the alkali content is high in your mineral additives, much of this alkali gets bound by the mineral additives and is not available to react with the aggregate. Even if the alkali is brought in by mineral additives, it is still not really a big problem because a lot of this alkali does not get available for the aggregate to react. That means when I start making blended cement, I can now relax my alkali content limits to some extent. I will talk about that

again when we discuss silica fume and slag and the effect on ASR. Moisture content obviously is important from the point of view of understanding in a stockpile or in a silo containing fly ash, what is the moisture content so that you can take that into account when you decide on the mix water for your concrete. This is only applicable when fly ash is directly used as a mineral additive.

Effects on fresh concrete:

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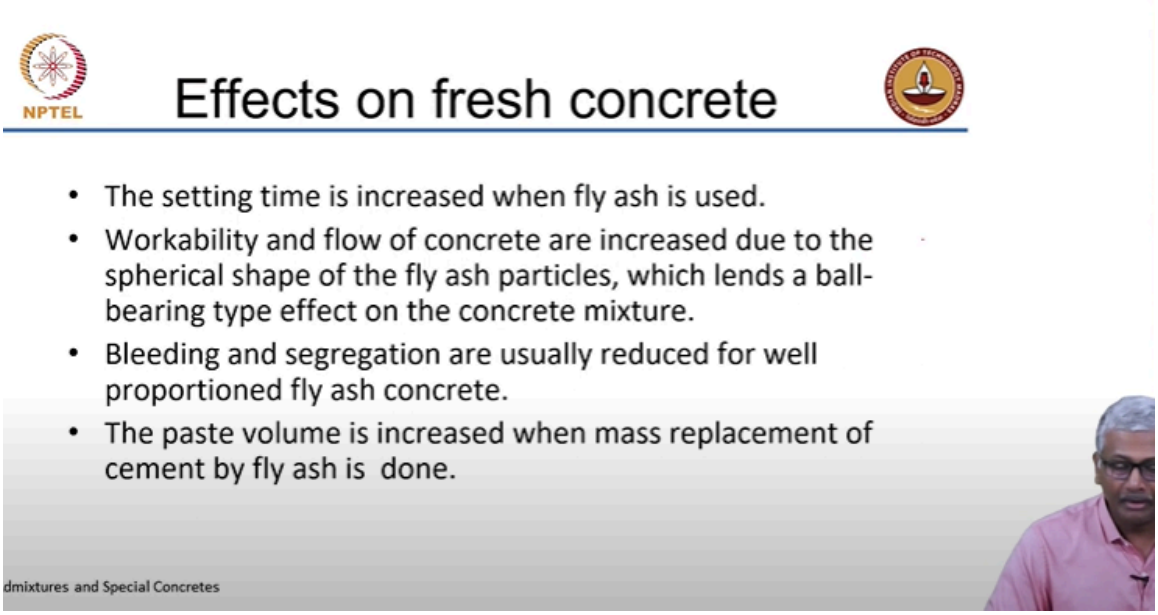

Now fly ash reacts slowly, so setting time is going to increase. Workability and flow of concrete are expected to be increased because of the spherical nature of the fly ash particles and just like air voids, the spherical nature of fly ash particles lends a ball bearing type effect that increases the flow ability of the system. .

Bleeding and segregation generally will be reduced. Why should bleeding and segregation get reduced when fly ash is used? You have finer particles and you have a greater volume of powder because you are replacing cement by a less dense material, so you have a greater volume of powder. More fines are there in your system which will prevent water from rising up to the surface and bleeding. So paste volume is definitely getting increased when replacement of cement by mass is done.

I talked about this earlier that you could also replace by volume in which case you preserve the volume of the powder, but here when you replace by mass which is the conventionally followed mechanism of mix design, you are going to be leading to an increase in paste volume and that may have effects on other properties. Dimensional stability primarily, creep and shrinkage, you can expect that there is some increase in

creep and shrinkage because of the paste volume, but data does not show conclusively that that is the case

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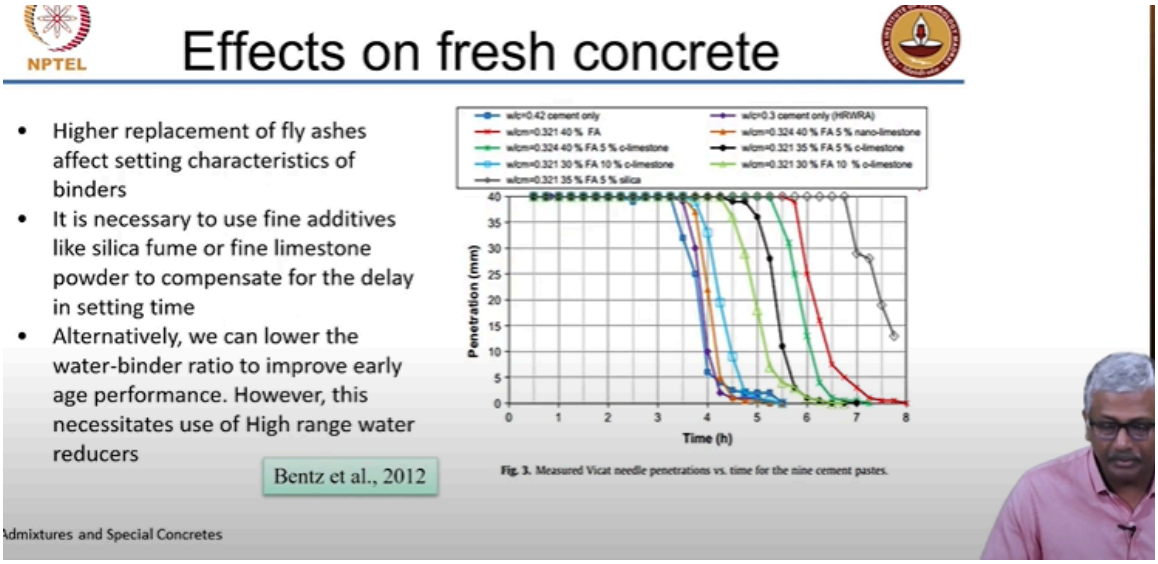

Now setting time with fly ash concrete is definitely slowed down as compared to plain cement concrete, but what it turns out is that if you start adding some fine additives like silica fume or fine limestone to the system, it compensates for the delay in setting time to a large extent. So there is some advantage in doing a ternary blended system which has limestone as an additive in addition to the fly ash in the cementitious system and that will sort of help compensate for the delay in setting that happens due to fly ash.

Now why is the delay in setting a problem on a job site? Particular form work is delayed so that reduces the productivity of your system. What problems can come? Let us say you have a slab and this concrete is not setting for a long time. What kind of problems can happen in a slab because of the slow setting of concrete?

Similarly your bleeding is reduced, slab surface is exposed during the first day so it can lead to plastic shrinkage problems. If the concrete is not setting fast enough the water inside the concrete now has an opportunity to start drying out and when that happens if the water from the surface dries out whereas the bulk of the concrete underneath is not drying it is going to restrain the top surface from contracting because of shrinkage and that restraint will lead to cracking. So in concrete mixes which are highly flowable first of all and which have significant bits of fly ash in it that will lead to delayed setting and such delayed setting can make the concrete susceptible to plastic shrinkage cracking. So that is a very important consideration. Most mineral additives will lend concrete more susceptible to plastic shrinkage cracking, not just fly ash most mineral additives will do that. .