Building Materials and Construction
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Module - 5
Lecture - 3
Fresh Concrete: Role of Admixtures

So far we have looked into concrete without any admixtures, we just looked into basic concrete with cement water fine aggregate that is usually, the sand and coarse aggregate, but modern concrete cannot be thought of anything without kind of admixtures particularly the one which modifies the workability or consistency of concrete also we have mineral mixtures which I have mentioned earlier. So, they have some role as far as improving the workability of concrete is concerned some of them. So, in this module 5 lecture 3, we will look into fresh concrete and role of various admixtures.

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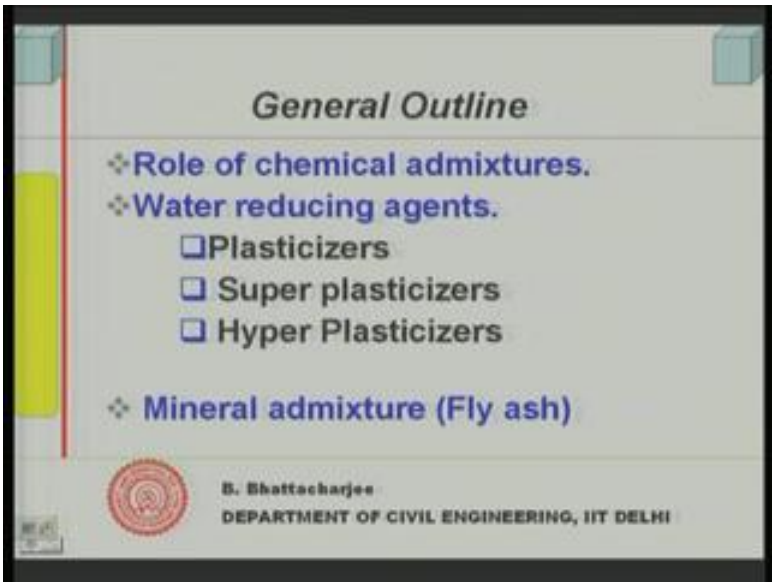

So; obviously, as I just mentioned our discussion will be first on chemical admixtures and this includes what are called water reducing agents by large. We will discuss only we will discuss on water reducing agents. There are other kind of chemical admixtures they do modify the properties of concrete and we will define what admixtures are. Then, in this water reducing agents there are 3 varieties plasticizers super plasticizers and hyper plasticizers. We will discuss about them all and, then we will talk about mineral

admixtures mainly fly ash which has a strong influence on the workability of concrete right.

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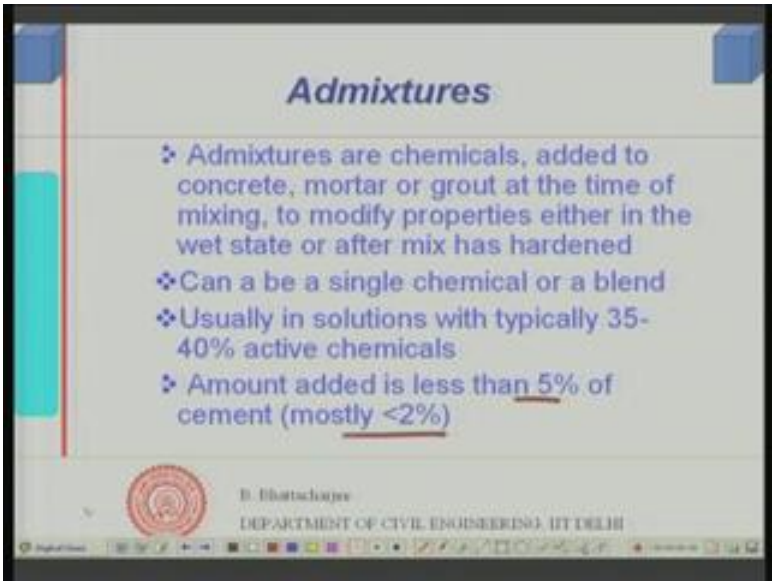

Let us define first admixtures, since we have started with admixtures define lets define admixtures. Admixtures are chemicals they, could be minerals as well as we are calling of mineral admixtures, they are added to mortar or grout at the time of mixing to modify properties either in the wet state or after the mix is hardened. So, this is the general definition of admixtures of course, today what we are looking at we are concerned more with this 1, we know we are concerned today we are concerned more with this 1 this particular type wet which, modifies the concrete in wet state right, so alright.

So, that is what the definition of admixtures are it can be a single chemical or it can be a blend of various chemicals. Usually, they are in solutions forms usually water based typically 35 to 40 percent active chemicals 35 to 40 percent active chemicals and the amount added very small usually, less than 5 percent mostly less than 2 percent very small quantity 2 percent by mass of the cement itself very small quantity is added you know mostly, less than 2 percent by mass of the cement itself. So, very little very little quantity we add, but they modify the property.

So, that is the basic definition of admixtures and we can use some of the admixture which will actually improve the fresh concrete properties consistency of workability of the concrete and that is what we look into in details today. There are other kinds of

admixtures namely, let us say accelerators which, will accelerate the strength gain process of the concrete a retarder which slows down the process of hydration as, I just mentioned this sometime and several others which are relevant to our discussion.

So, some of them I might mention at some point you know, in our discussion today, but mainly our focus would be on water deducing admixtures a little bit of history is important this has come much later than the concrete.

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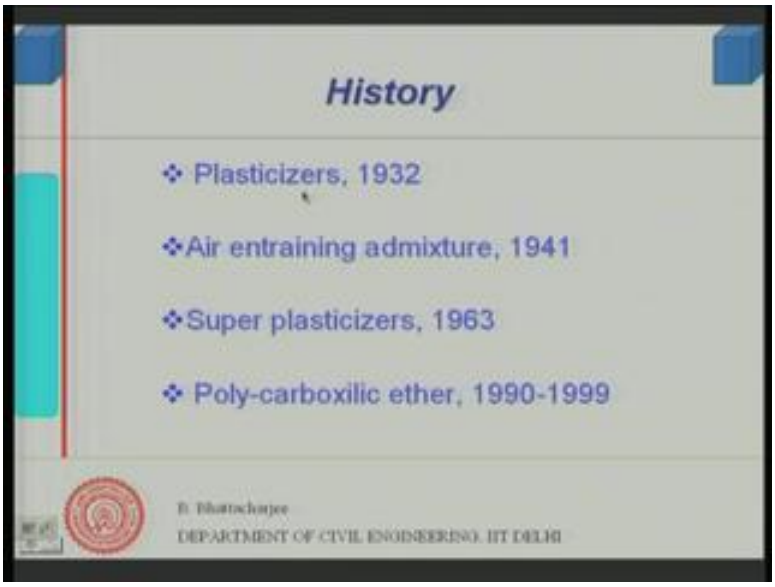

But today of course, most of the concrete you cannot think of concrete. Because, some form of admixtures are added 1 variety which, we will discuss called plasticizers actually came in 1932, then there are something called air entraining admixtures will also mention again, about this today they came in 1941.

Then, super plasticizers similar variety improved variety that came, in 1963 and, then this is some variety this is already there at that point. But, today it is in a modern format has come possibly 1 can call it as a hyper plasticizer and it is developed in 1990 to 1999. So, that is the kind of history that is there right.

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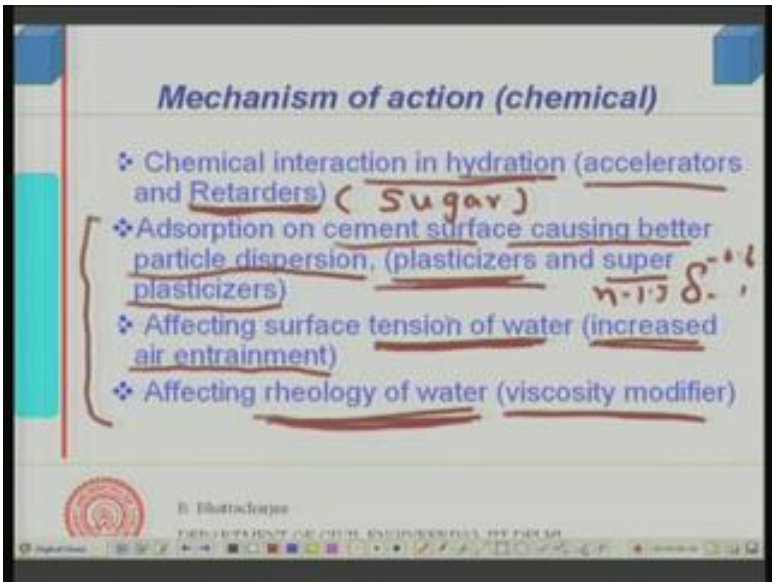

So, let us see now discuss in general little bit about various kind of admixtures they, can be discussed in terms of the mechanism of the reactions all admixtures do not act in the same manner all admixtures do not act in the same manner right.

So, let us discuss then in the light of the reaction. So, first of all there are certain admixtures which interacts in the process of hydration, they are accelerators and retarders they are accelerators and retarders, I mentioned accelerators and accelerator accelerates the strength gain alright calcium chloride is 1 of them. But, we will not discuss much about this, but retarder has something to do with phase state also lets discuss a little bit about this retarders actually slows down the hydration process.

Now, sugar is 1 of the retarder sugar is 1 of the retarder okay sugar is 1 of the retarder, if you add sugar to the concrete it actually interferes, with the hydration process and slows down the hydration process. So, this can be used where you want to delay the setting this can be used where you want to delay the setting there are many other chemical retarders are there which, comes from may come from even sugar or some sort of sugar you know presence of sugar. So, this retarders actually reduces down slows down the rate of hydration.

Therefore, supposing you want to delay the setting process retarders are used you know practical example: is would be in a ready mix concrete truck you can use the retarder. So, that it does not set while traveling in addition to agiting you can also use the retarder.

Similar other place where, you expect that your yours know compaction time required would be relatively more the time required when you can or placing time would be relatively more you have to long hall or something like that kind you can use a retarder. So, retarders are 1 which actually, retards the setting process although they may not necessarily affect the later on strength development characteristics.

So, this is 1 they actually interfere with the hydration process you know interacts, with the hydration process and change the hydration process. The second variety is surface acting type we looked this into more detail and they generally, cause particle dispersion and that is what we are going to look into plasticizers and super plasticizers etcetera. They essentially absorbed the surface of the cement particle or cementitious particle and cause actually, dispersion of the particle and as we have seen earlier this dispersion of the particles means the distance between the particles are increasing.

So, when distance between the particle increases delta, if you remember from our last lecture delta function you know delta minus 0.6 equals to 1.3 delta minus you know something like that you remember. So, if you increase delta the dispersion of the particles the viscosity will reduce and this reduction of viscosity means; that it will give some sort of mobility. So, viscosity reducing actually affects that cause dispersion, which in turn would reduce visocity of the cement paste system.

So, right this is the plasticizer and super plasticizer does that kind of thing allows bubble formation you know they allow air entrainment. So, this also we will mention today because this 3 relates the fresh concrete.

So, a increased air entrainment is required for some this you know some specific purposes I will discuss this sometime later on in this lecture itself, but this means that actually you are affecting the surface tension of the water from bubbles. So, this admixtures actually affect the surface tension of the water to form bubbles and that is how they form bubbles and this bubbles in turn helps in workability, but they do much more for free thaw against you know durability they do they improve the durability against freeze thaw action.

So, that is important they improve the durability against freeze thaw action now some can increase the viscosity of water. If you add certain type of hyper plasticizer certain hyper plasticizer over certain dose to increase the mobility, you increase the mobility

alright, but this might lead to actually bleeding or separation of the water or segregation of the water from the rest of the material, you know you have caused such dispersion that lot of water became free the water itself, might move away remain you know go away alone leaving the rest of the part.

So, this is a kind of segregation that is bleeding if you want to reduce that bleeding and at the same time you want lot of dispersion to reduce. This bleeding what you add is called viscosity modifier and this actually, changes the viscosity of the water. So, this affects the rheology of the water viscosity modifier. So, viscosity modifier are essentially used in self compacting concrete not in ordinary concrete. So, we will not have much discussion on that, but at the moment lets discuss about this the viscosity modifier actually, increases the viscosity of water.

Therefore, deduces bleeding tendency or segregation tendency of self compacting concrete discussion, will mainly focus on this we will also discuss something on this, in terms of chemical admixtures, but then of course, will go to mineral admixtures right. So, that is the first stage.

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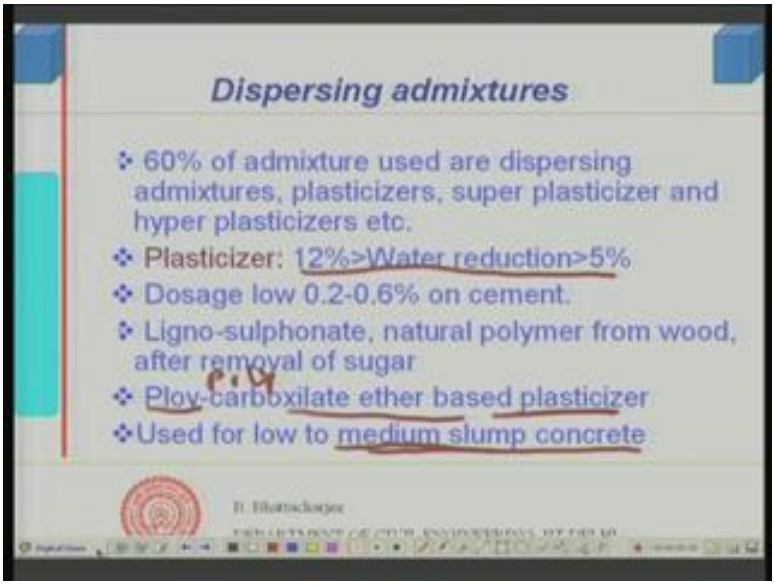

So, we are focusing our discussion on dispersing admixtures as you can see 60 percent of the consumption of admixtures, in the world actually 60 percent is the dispersing admixtures. That is majority of the admixtures are used for plasticizing or improving the workability of concrete or improving the workability of concrete just to little bit

digressing from here, I did not mention about many other admixtures like corrosion inhibitors and several other admixtures are there, because that is not part of the fresh concrete discussion.

But, if we have time we will discuss them at appropriate time, but here we are only concentrating on to mainly on to dispersing admixtures or whatever, modifies the fresh concrete properties right. So, coming back to this plasticizers super plasticizers and hyper plasticizer all of them are dispersing admixtures. They are all dispersing admixtures, in other words they, cause dispersion of the particle and we know why they, you know how do they actually, disperse some of the particle what it will do it will essentially, it would essentially cause reduction of the viscosity of the cement system.

It will cement paste system cement paste system therefore, flow ability of the flow ability of the cement paste would improve, and that in terms would improve the flow ability or deformability of the whole concrete system and therefore, improves the workability. So, that is the plasticizer effect. So, first variety in this 1 we call as plasticizer and this plasticizer is the 1 that was the earliest developed earliest you know, plasticizer was the ones which was developed earlier.

They can reduce the water by about 5 to 12 percent while these are also called water reducing agent in American terminologies generally these are called WRC water reducing agents WRC water reducing agent WRC is the water reducing agent. So, it can reduce the water 5 percent to 12 percent; that means you can have a reduction of water, between 5 to 12 percent and you will get the same consistency of the concrete when you use this from about 0.2, 0.6 percent as a percentage of cement.

So, when you use very small quantity 0.2 to 2.6 percent of this plasticizer of this chemical admixture as a percentage of cement 0.2 to 0.6 you can reduce the water requirement for the same viscosity or consistency of the cement by 5 to about 12 percent because this causes dispersion of the cement. So, therefore, dispersion of the cement which earlier you are getting through the water well, you can put much less water and get the same dispersion that is the idea.

So, that is what it is dosage are 0.2 to 0.6 percent and ensure dispersion right; what are these materials the materials originally, they were ligno sulphonate natural polymer from wood after removal of sugar why remove sugar sugar will otherwise cause retardation if

you do not remove sugar sugar will cause retardation. So, this we remove because it will cause retardation. So, basically it is wood has got lignin actually, cellulose fiber embedded in lignin. So, it is the lignin material the paper industry actually when it uses you know some of these materials can come from paper industry.

So, this lignin is sulphonated its actually natural polymer from wood and sugar is removed the ligno suophate is obtained. So, this is the original kind of very early plasticizers, which were there and today, also majority of the plasticizers raw material is this you know this is modified based on this the product is formed and plasticizers are usually formed. The other could be poly carboxylic ether other could be poly carboxylic ether based plasticizer that was also quite early, carboxylic acid has got COH oxilates poly.

This is poly this should be poly poly carboxilate poly carboxilate ether based plasticizer. So, the acid reacting with alcohol gives you ethers. So, this poly carboxilate based plasticizers they are the other 1's.

This 1's are used for low to medium slump concrete and their water reduction is limited to 5 to 12 percent water reduction is limited to 5 to 12 percent. So, they are used for medium to low slump concrete low to medium slump concrete. As opposed to this we have something called super plasticizers.

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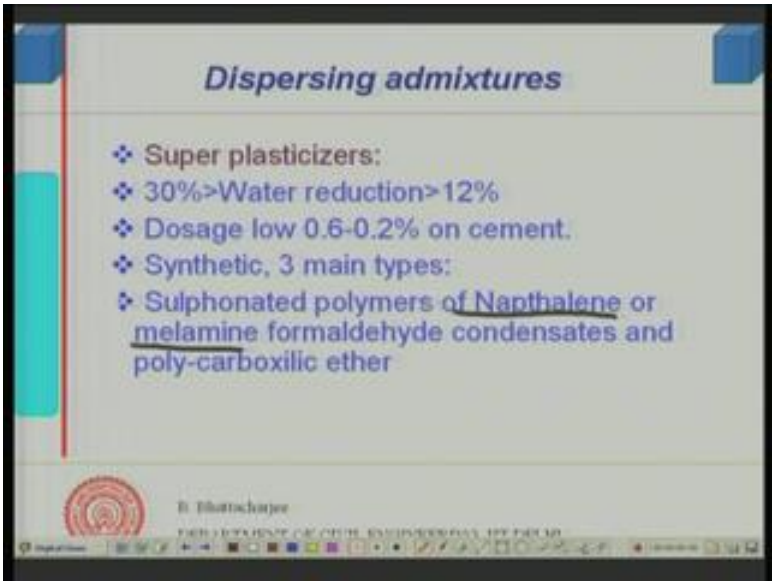

Now, this super plasticizers were developed later in 1963 as we mentioned and they are super plasticizers. So, with reference to plasticizers they can actually, reduce the water much more as you can see from 12 to 32 percent and eventually their doses are also higher 0.6 to about 2 percent not 0.2 percent.

But, this is 6 to about point you know 6 to about 2 percent this is not point. This is 6 to 2 percent 0.6 to 2 percent on cement. So, water reduction is from 12 percent to 30 percent and earlier you have seen that was 5 to 12 percent this reduces much more. So, super plasticizers require more dosage, but at the same time reduce the water more; that means, they can disperse the cement particle more. So, you have to add less water for the same dispersion.

So, you get similar consistency with much less water they are synthetic and there are 3 main types sulphonated polymers first 1 is the sulphonated polymers of naphthalene second 1 is melamine naphthalene or melamine. You know naphthalene formaldehyde condensates or melamine formaldehyde condensates. So, they are the 3 main types 1 is the naphthalene polymers of naphthalene formaldehyde condensates second one is melamine formaldehyde condensates and third variety is the poly carboxylic ether type. So, the super plasticizers are based on this naphthalene formaldehyde or melamine formaldehyde condensates condensates and poly poly carboxylic ether right.

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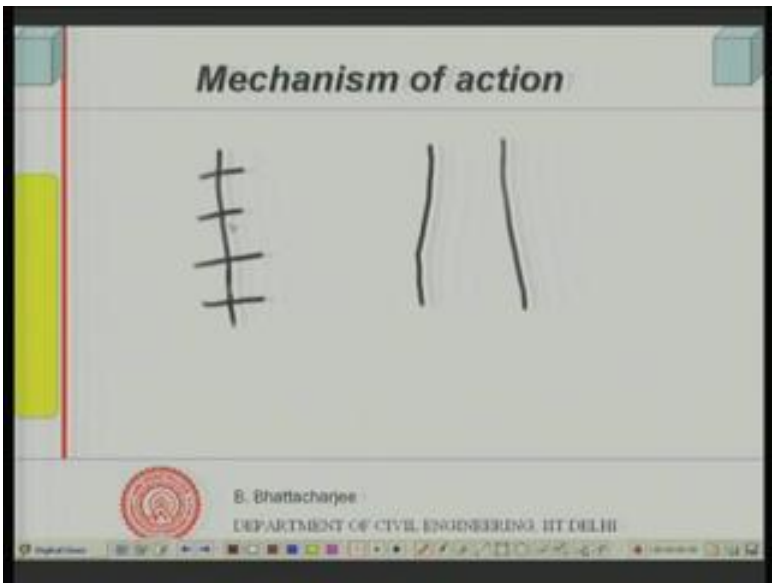

They actually, reduce the water much you have seen and their dosage also high. Hyper plasticizer is mainly based on poly carboxylic ether type and they do this action is much higher much higher which is a recent development. And much higher because all these are basically enough thing, but long change polymeric molecules and they get absorbed at the surface as usual look through the mechanism and causes a kind of charges.

Now, if you have surface, if you have chains and then branches also the poly carboxylic ether type have similar branches and which further can cause more dispersion, you know the super plasticizers have simple long chains, but the poly carboxylic type has got branches as well. So, therefore, they can actually cause lot more dispersion and thereby they can act much more. So, they can be more much more active than the melamine formaldehyde condensates or naphthalene formaldehyde condensate type right. And that is what the result in hyper plasticizers is…

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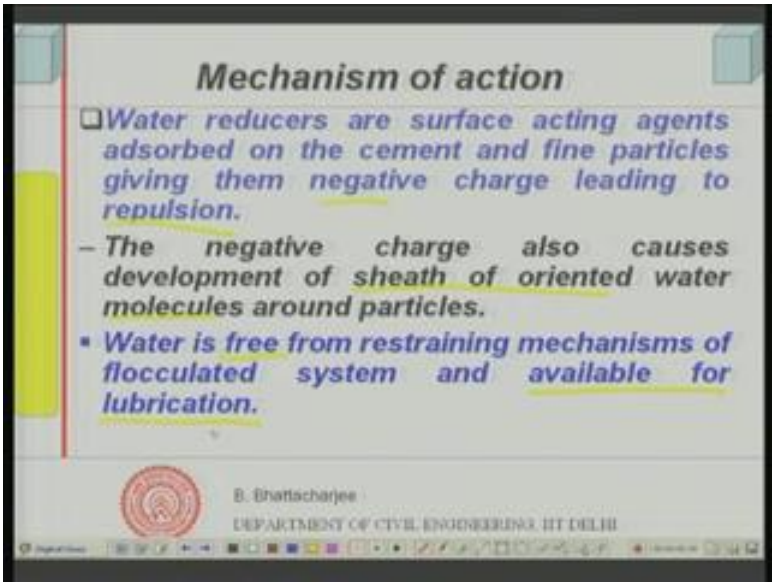

Let us see, through the mechanism of direction water reducing agents or water reducers are as or plasticizers and super plasticizers and hyper plasticizers. They are all water reducers in general terms, they are actually surface acting agents.

They are surface acting agents and they get adsorbed on the cement and fine particles that is fly ash silica fume etcetera. And they do give negative charge leading to repulsion of this particle. So, this particles they get adsorbed at the top of the surface and once they are adsorbed they give make them negative charge and thereby since, this particles are all

getting negatively charged they are repelled by each other and therefore, the dispersion is attained in this manner. Earlier by addition of water you are actually causing dispersion of this particle.

Now, by addition of less water actually we are able to disperse this particle because they are negatively charged because they are negatively charged. Second action is of course, the negative charge also causes development of sheath of oriented molecules around the particles. This is because; we know that water is a polar liquid you know the water has got a dipole moment. In H2o the centre of positive charges and the negative charges that do not coincide.

So, since they do not coincide it has it is a polar liquid and it can get attached to the negative, you know oriented around that negative charge formed, and therefore causes development of sheath of oriented water molecules causes development of sheath of oriented water molecules. And you know this results in some of the water being some of the water being getting released you know, from restraining mechanism when happens you know mechanisms of flocculated system.

So, when you do not add the plasticizers cements are flocculated and they, restrain the water, because water is no longer oriented and they sought of it is not free, it is not very easy to move and some water gets freed, because they are now oriented and because the restraining mechanism of flocculated system is no longer available, it is all dispersed and this water which is addition of water is available is free for lubrication.

So, therefore, it releases the water not by 1 means, but by more than 1 means; first of all negative charges is a you know this adsorbed and negative charges causes repulsion, then sheath of oriented water molecules resulting in resulting in free water and that would actually be available for lubrication. This is the mechanism how does this. So, plasticizer and super plasticizer acts. So, the 1 which are more effective in getting adsorbed at the surface they act more. So, super plasticizers acts more than the plasticizer and hyper plasticizer can cause more dispersion resulting in you know resulting is more effective means.

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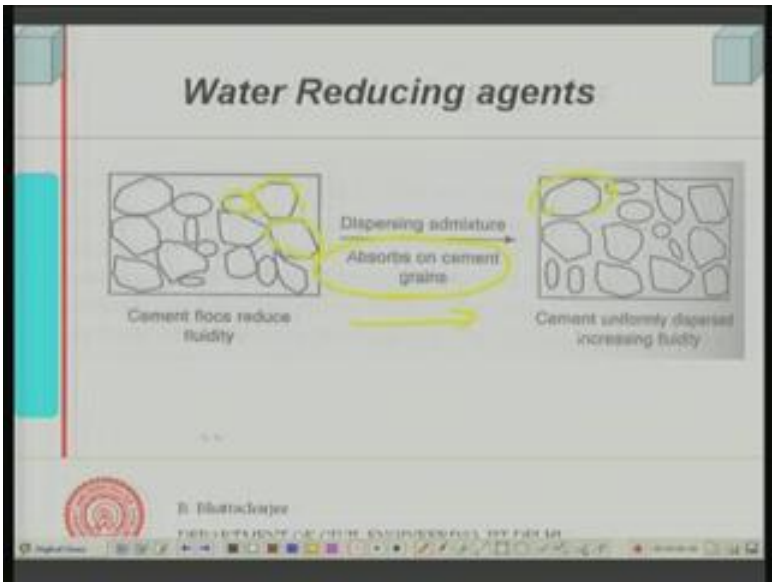

This diagram perhaps would give us the idea how do they, act this diagram will give us the idea how do they act. This is the you can see the cement flocs, which gas got less you know the fluidity is relatively less they, are all together the particle. So, when you add dispersing admixtures this get adsorbed at the cement grains and the cement particles are now individually, separated because they are not together like clay particles which are charged cement particles are such fine particles.

So, they have the tendency to get flocculated and this dispersing particle once they get adsorbed at the surface of each of this particles, they get adsorbed at the surface of the each of the particle they cause dispersion not only that as we have said the water molecule will get oriented around. This particle from a sheath of oriented water molecule and thereby, releases some of those water for which was available, which was not available earlier. Now, becomes available for lubrication and thereby actually required for same plasticity same plastic condition or same consistency.

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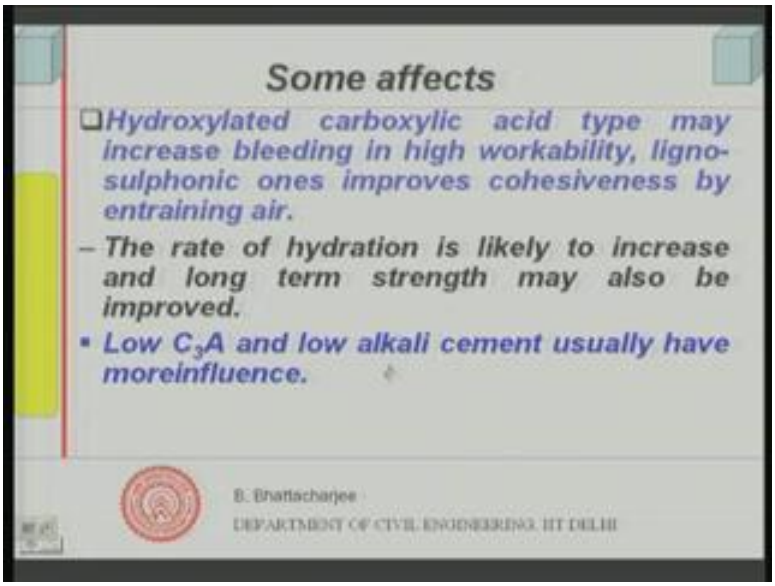

So, let us follow it up, let us look into some other effect. As I mentioned that hydroxylated carboxylic type, they are the 1 actually which are which can be more effective. They can be more effective very effective and when you use in large doses can lead to bleeding especially, when you have high workability concrete in case of basically self compacting concrete right. And what you do in such case then you use the viscosity modifier, I mentioned earlier which would thicken the water. If some sought of thickening agent water thickening agent actually some sought of water thickening which would thicken the water.

Now, this can also be done I mean; 1 way to improve the viscosity you know getting the viscosity modifying effect reduce down the segregation is to use very fine cementy other cementitious material, in self compacting concrete, but that is any way not our discussion at the moment. So, this can happen, but then you can use a viscosity modifier. Lingo sulphonic acid ones of course, improves the cohesiveness by entraining air not all of the plasticizers and super plasticizers actually entrains air.

But, lingo sulphonic based the 1 based on lingo sulphonic acid can improve the cohesiveness of the system as well. Secondary effect and its positives in some cases or most of the cases as usual see is that rate of hydration can be increased particularly, with some super plasticizers, because now you have got better dispersion particles are all separated. So, therefore, the hydration rate will be higher you know the hydration takes

place from surface. So, hydration rate will be higher that is what we have seen in case of expanding cluster model we were looking earlier.

So, therefore, hydration rate can be increased, because this it will have more uniform structure also since, the particles are separated off they are dispersed they are not close together they are dispersed there is a distance between them. So, uniform hydration is possible product formed will be uniform rather than a clock system where, particles are you know the hydration product would have come something like this, but here it will be more uniform distribution of the hydration product.

It will be surely improving the long term strength long strength will be improved significantly. And this is what is seen in case of high performance concrete that is happens in case of super plasticizer well. Some cases low C 3 12 A and low alkali content cement have more influence on strength you know, for a strength is concerned low C 3 12 A and low alkali cements have better influence on strain right. So, let us see how do we how can you use them.

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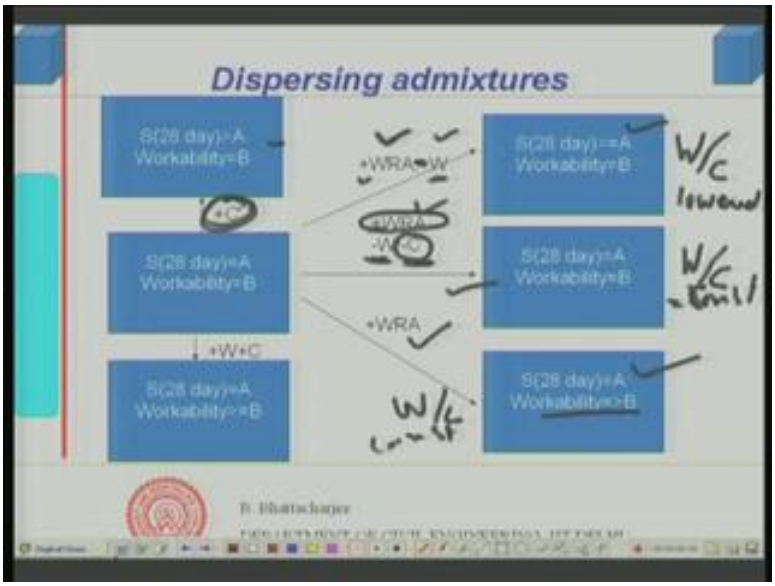

First of all supposing, I have a concrete S I am denoting here for strength and its strength is equal to A and let us say workability is B. Now, I want to increase its let us say: strength reducing the workability what will I do I will reduce down the water cement ratio. So, if I want to reduce down the water cement ratio I will add cement. So, if I add cement then what will happen my strength will increase as can be seen the strength will

increase as can be seen that the strength is now, greater, but the workability has remained same, because I have kept the water same the paste will have little bit less consistency, but generally would not affect because water you know the water cement ratio usually, in concrete is relatively high in normal strength concrete we are talking of and therefore, may not affect the workability significantly.

So, it will remain same although the water you know the paste paste content has increased and slightly drier paste, but the paste itself will be consistent enough because water cement ratio, I will be talking of normal strength concrete and water cement ratio is sufficiently high to make the cement paste consistent. So, workability will remain same workability will nearly remain same, but my strength will increase. Supposing I want to get a second effect and I did not add any admixture to this.

Now, I want to get a secondary effect I want to increase the workability as well as maintain the strength same I increase the I want to increase the workability and maintain the strength same, then what I will do I will add some water, but I will add cement. So, that my workability has increased, but the workability has increased, but strength has remained same, because I have added water cement in such a manner that water cement ratio has remained same. So, I have added some water added some cement strength is same.

Now, these same effects I can get now with plasticizer or super plasticizer let us see how. Now, supposing I add water reducing agent that is plasticizer plus water, with this concrete then I have added water reducing agent plus you know, water reducing agent, but actually the cement is not necessary water reducing agent I have added water reducing agent, but I did not add the cement on to it water reducing agent there is no need for adding water I just add water reducing agent.

I will get you know I will I have added water reducing agent and then what it will do, if I want to keep my workability same I will actually, reduce my water it should be minus w I will reduce some of my water. So, I have added water reducing agent I will subtract some water. Now, since my w by c has to be same then I can subtract some cement. So, in this 1 actually, I will subtract water reducing agent just simply if I just add WRA I will get water can be water can be water can be reduced keeping if I keep the cement then my strength will increase.

So, I just water WRA I reduce my water a little bit keeping the cement content same. So, do not reduce the same content keep the you know water cement ratio same. So, water cement ratio itself, is this just add WRA reduce a little bit of water keep the cement same C is constant keep cement same. So, W by C will be lower it will be lower. So, strength will increase. So, 1 way is to add WRA reduce water keep the W by C same and or W by C will increase increasing the strength. Second way would be supposing same effect I am trying to get.

So, whatever is doing S is getting 28 days higher workability is same by adding cement, but here I did not add cement instead, I added WRA and just reduce the water. So, cement I did not add and if the cost of this WRA is less then I will get a saving compared to the added cement then I will get a saving. So, I can add WRA reduce the WRA a little bit keep the cement then I will have my increase in strength workability will remain same. Second case could be I add WRA minus W minus C I will maintain the strength same workability same.

Because, if I add WRA I can reduce the W reduce the water to maintain same workability I can reduce some cement. So, such that W by C is constant in this case then I will get same strength. So, you see by adding WRA by I can actually save on cement for same strength and same workability. Now, supposing I find saving in cement the reduction in cement cost of the cement is less than; I mean; more than the cost of the saving that, I am getting in cement by reducing cement is more than the cost of the WRA then this would be economical.

So, I can use it in this manner as well third way I can use it is actually by adding WRA and doing nothing. So, if I add WRA my water content will remain same cement remains same. So, my strength will remain same, but my workability will increase. So, adding WRA ensures that just adding WRA my strength will remain same, because I am maintaining the water by C is same constant water by C is constant, but workability will increase workability will increase, because I have added WRA.

So, same thing I can do it in different manner you see by adding WRA and subtracting W by adding RA by adding WRA and subtracting WRA keeping the cement same my water to cement ratio would be lowered lowered. So, strength increases. So, the same strength increase whichever is getting through adding cement. Now, I can do it by adding

water reducing agent and reducing water reducing water. Now, this cost of this if this saving you know the cost of this and cost of this, I can compare if this is cheaper I can follow this.

If I want to maintain the same strength and same workability I can reduce the water I can reduce the water cement ratio, but W by C I keep it constant simply saying constant I keep it constant I keep it constant. So, W by C I keep it constant W by C I keep constant. So, I reduce W I reduce W by C as well, but add WRA now saving that I am getting by using the cement, if that is more compared to the cost of the WRA which is added in very small percentages, then I am getting a benefit using super plasticizer or plasticizer you know usually, there is a usually there is a benefit of doing that because this cost would be relatively small.

A third case would be simply increase the workability do not change anything keep w by C constant and workability and water WRA will increase the workability. So, increasing workability is possible we have mentioned by increasing water earlier, but if I add WRA then this way also it is possible. So, this is one way of action you know this is the ways of actions of water reducing agents.

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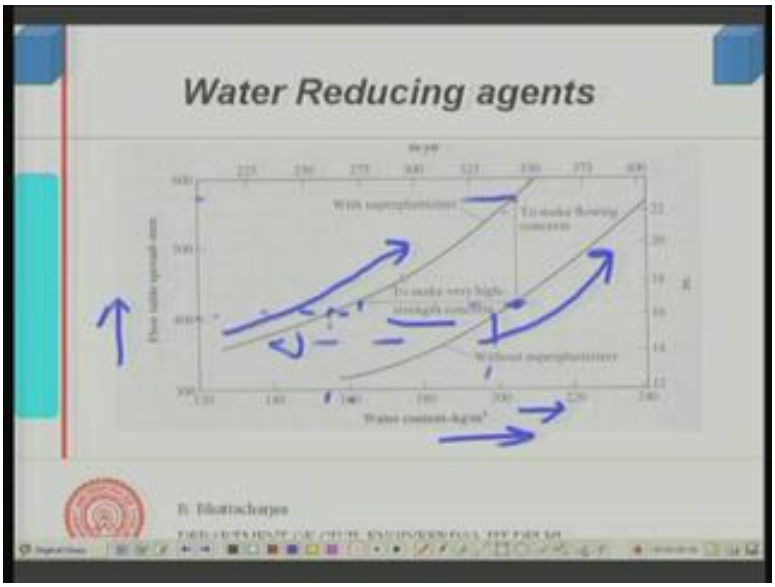

This diagram will show some same thing again in a little bit more detail this axis is water content this axis is flow table spread, which is a measure of workability or consistency of

concrete or even paste or whatever, it is usually this is for concrete this particular case is for concrete.

So, if you have as I go on increasing water without super plasticizer this is the curve which super plasticizer this is the curve, I require a much less water you can see much less water I need much less water. So, this curve shows with super plasticizer and without super plasticizer. There is a water reduction same flow, I am getting flow is constant same 400 flow this much of water I need here and in this case I am needing this much of water. So, there is a significant reduction in water. So, what do I do same thing same action I said.

Supposing, I was getting supposing I go simply along this direction, I will reduce my water if I keep the cement same, I will increase the strength of the concrete like I mentioned earlier. If I keep my water same then it will increase simply the flow it will increase simply the flow. So, if I increase the water same and go upward just use the WRA it will increase my flow. So, both actions I can have I can increase my flow just by adding, I can increase my you know I can make strong very high, because I can reduce down the water, if I use the cement keep the cement same strength would be increasing.

So, same action what I mentioned earlier this diagram also shows the water reduction and we will conclude to the same thing that I can by using efficiently or economically I can use water reducing agents or high range water reducing agent. These are called you know the water reducing agent and high range water reducing agent that is plasticizer and super plasticizer, I can utilize them. First of all if I just add them without changing anything then my flow will increase.

If I add them and reduce the water reduce the cement as well, then I will save on my money on cement, because water reducing agent might cost less keep the strength same workability same third way could be reduce the water, but do not change the cement, then water cement ratio will reduce significantly for the same workability strength can be increased. So, that is the advantages of plasticizer super plasticizer.

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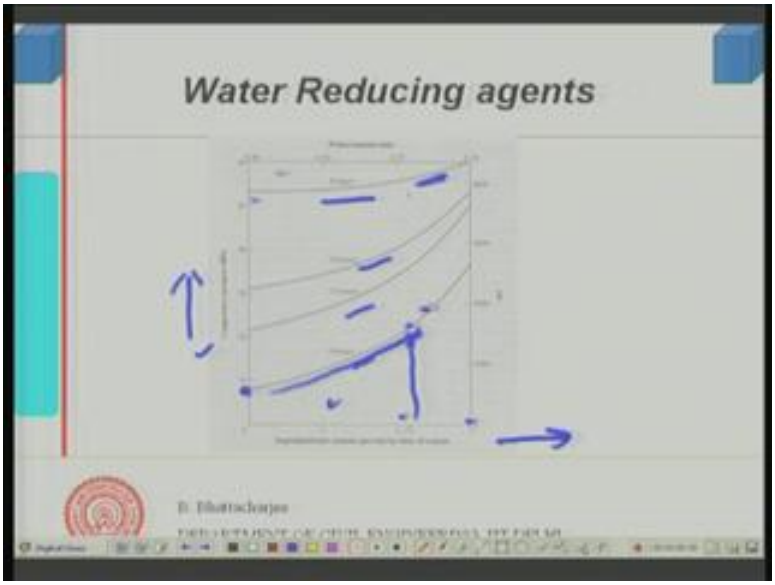

Now, I was mentioning about dispersion strength dispersion strength improvement of the super plasticizer. This diagram shows you that you see this shows the super plasticizer dosage, which are about 12 percent etcetera 3 12 percent and if you look at the composite strength in MPA of concrete, then this is at you know 8 hours 12 hours 24 hours and 28 days. Now, if you see that early strength if you use the increase the super plasticizer dosage early strength increases.

So, at 8 hour strength without super plasticizer and with super plasticizer its much higher that is, because the dispersion caused by the super plasticizer has actually resulted in improvement in hydration and this is also seen in 20 days strength as well. So, there is an because of the uniform structure is formed there is better dispersion no flocculation of cement and cement hydrates uniformly throughout the structure of the concrete throughout the matrix of the concrete or over all in the overall concrete therefore, you find that 20 days strength even 20 days strength this is the improvement.

This is much more pronounced at lower strength at 8 hours this is much more pronounced without super plasticizers and with super plasticizer 2 or 3 12 percent dosage the strength difference is pretty high. This difference of course, we dosage, but still it is there somewhat. So, it gives you a uniform well dispersed uniform structure of the cement paste in the concrete and therefore, it shows an improvement in the strength characteristics of the concrete even for 20 days strength as well. So, that is all about plasticizer super plasticizer and hyper plasticizer that is water reducing agent high range water reducing agent etcetera and very high range water reducing agent.

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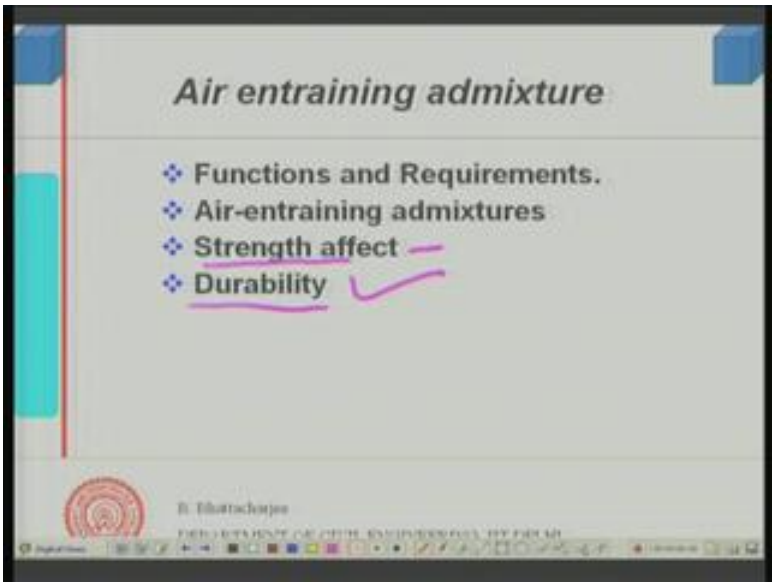

Now, the other kinds of admixtures which are also affect some amount of workability are the air entraining admixtures well. If you look at air entraining admixtures their main function is against freezing and thawing they show good durability performance against freezing and thawing. Air entraining agent essentially, improves the surface changes of surface tension of the water and thereby creates air bubbles.

They are very fine closed air bubble systems distributed throughout the concrete structure. They are uniformly distributed throughout the cement paste or the concrete structure and when freezing and thawing takes place initially they are air filled, but in case of freezing what happens; there is an excess pressure in water filled pores because of the freezing, because ice or you know occupies more volume water when frozen occupies more volume than the liquid water. So, it exerts pressure.

So, originally added air filled space their surface their boundaries get ruptured and excess pressure is released, because the water can flow into those pores. Some of the pores will be actually converted into open pores closed pores due to entrainment will be converted into open pores, in 1 year next year more and next year more and so on. So, now number of freeze thaw cycles they can actually withstand is more compared to non air entrained concrete well. That is the main reason why they are added, but any way that is not part of our discussion at the moment.

But, they also do they improve the workability they also improve the workability somewhat. So, the air entraining mixtures improve the workability, they would reduce down the strength a little by putting air bubbles uniformly dispersed, they actually improves the deformable deformability capability and mobility and thereby they improve the workability, but durability is our main concern in this kind of in this kind of structure you know, in this kind of admixtures that is what I mentioned strength will be reduced somewhat.

The strength would be reduced somewhat, because you are going to introduce new pores into the system. However, you do not mind sacrificing the strength at the cost of the because you know you get the improvement in durability at the cost of little bit of strength. So, we do not mind, but our fringe benefit is of course, it improves the workability as well it improves the workability as well.

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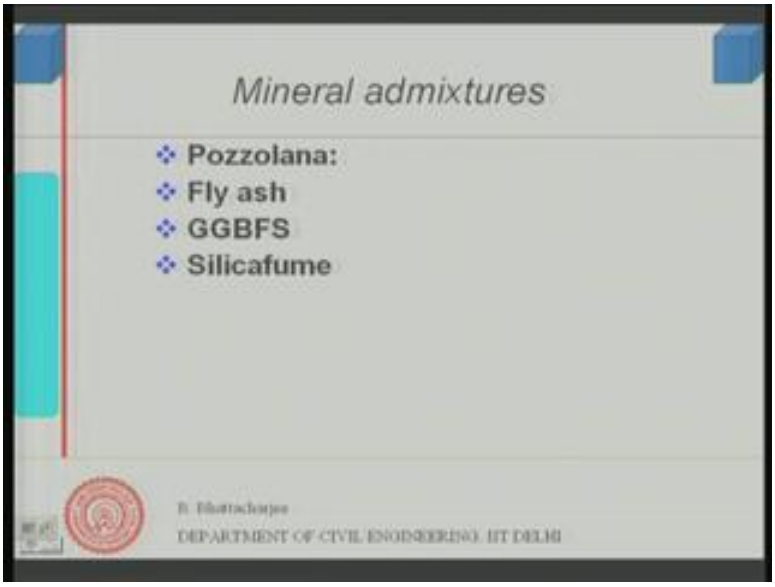

So, that is what is air entraining admixture is about let us look into now the mineral admixtures well. We have already mentioned that mineral admixtures are pozzolana some pozzolana. So, they are added in cementitious material in cement and we have already mentioned something like fly ash is 1 of them, I defined fly ash is sometime, but fly ash has got a strong effect as far as workability is concerned and also other other other mineral admixtures are generated ground generated blast furnace slags, which I mentioned some time then; I have also mentioned about silicafume sometime earlier.

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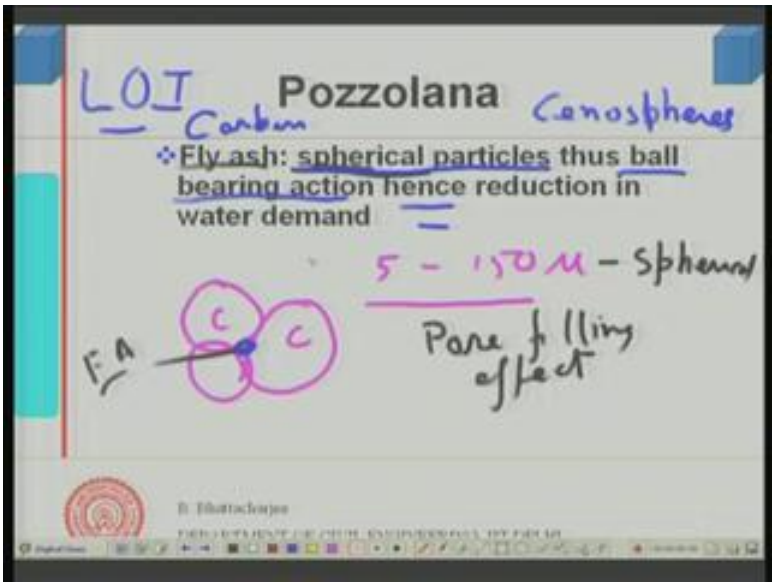

Now, this admixtures do have they have some effect as far as fresh concrete is concerned. Now how, so you look into 1 by 1 is fly ash. Now, fly ash I mentioned the particle size is very small 5 to 150 micron 5 to 150 micron. So, they are very fine particle and this particle to certain extent are like, I mean; to certain extent although final ones will still go in you know show this effect more. They this are my cement particles these are cement particles fly ash particle can go inside. So, these are fly ash particles.

So, you will have some sort of pore filling effect pore filling effect would be obtained from fly ash particles. So, this fly ash particles can fill in the pores you know this is 1 aspect. Now, if they can fill in the pores thereby packing characteristics of the cementitious system itself, is improving and you will require possibly less water to fill in the voids space within the cementitious particle, but some water goes in wetting them also because they would should be dispersed.

But, more importantly these particles are spherical in nature these particles are spherical, in nature the shape the fly ash particles are spherical shape they are spherical shape you know fly ash particles are spherical shape they are spherical shape. So, their particles spherical particles, I mean; under electron microscopy electron microscope 1 could see the fly ash particles are spherical. Some very few particles in them are called cenospheres some very small particles, in the you know called cenospheres which are actually hollowspheres.

Some of them are available in the cement particle, but why a large fly ash particles are you know spherical in nature of course, 1 must satisfy the requirement or the specifications appropriate specification and should have definitely less loss on ignition because loss on ignition corresponds to presence of carbon loss on ignition presence of carbon. So, if you have high loss on ignition it means that you have sufficient you know if you have high carbon content which will actually, they are these are not spherical particle.

They are actually flaty sort of flat particle which will absorb a lot of water and the water demand actually will increase with water demand actually increases with this sort of particle. So, carbon content should be low in case of fly ash. So, if your fly ash is good; that means, it is fine particles very relatively fine it can go into the pores and it has got spherical particles sufficient. This spherical particle tends to give what is called ball bearing action. You know this spherical if it is spherical in nature.

This can other particles can roll over it packs better gives a better packing and other particles can roll over it and this results in results in reduction of water. So, this causes reduction in water demand. In fact, it has been seen that fly ash significantly reduces the water demand for same flow. So, for the same flow water demand is reduced when you pack fly ash particles.

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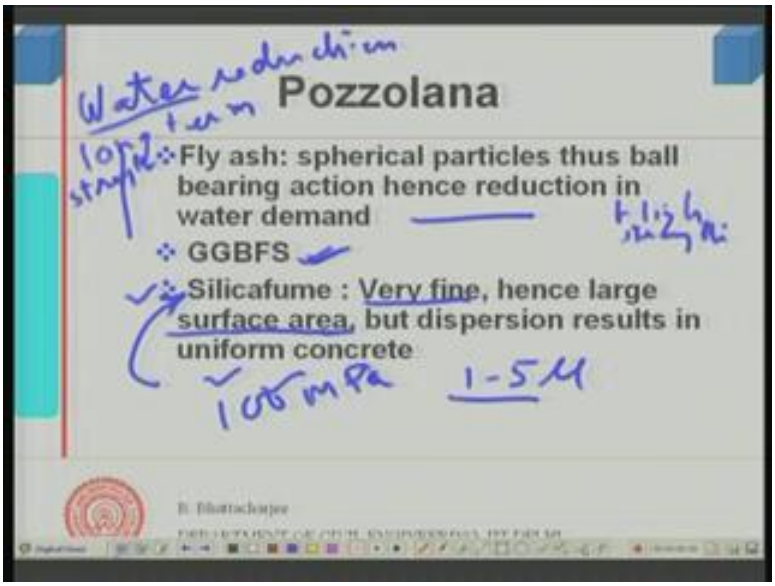

So, 2 issues 1 main thing it does is it gives pore filling effect and also it gives you also the fly ash also gives you pore filling effect and also it gives you through spherical particles gives you ball bearing action and therefore, there is a reduction in the there is a reduction in the water demand of the concrete when you add fly ash most of the code recognizes this some values I will show you GGBFS of course, they are not GGBFS effects is not known to be. So, much as spherical in nature, but they are too did these 2 are also very fine.

So, they can improve the cohesiveness of the concrete in general 1 thing here on thing you must understand coming back to the fly ash that fly ash reduces the water alright, but it depends you know it improves it gives you a cohesive mixture. And this will also give you a cohesive mixture, but you may not get the same slump although cohesion or consistency may be same for the same for the concrete even though, you may have a lower slump, in this case a little bit lower usually 25 millimeter lower slump is tolerated when you add fly ash together to the concrete anyway, we will come back to this when you look into the table of water reduction. GGBFS on the other hand is is not spherical in nature.

So, this ball bearing action that you get in case of fly ash is perhaps is not available, but it can still make it cohesive. Silicafume this is very fine and if you remember this was from 1 to 5 micron size this is usually the size will range 1 to 5 micron deflocculated 1

has to be there although larger size, you can have you have larger size then; there is a problem, but if you have fine size usually of this sizes this has got very large surface area, but very large surface area. So, the water requirement this may not reduce itself, but this material is seldom used without super plasticizers.

So, silicafume is used together with the super plasticizer and usually for very high strength or very high strength concrete. So, you know using fly ash since you can reduce water using this 1 can reduce water. So, water reduction is possible water reduction is possible and there is a gain in long term strength is also possible long strength gain long term strength. So, you can get somewhat high strength concrete high strength concrete is possible high strength concrete is possible upto certain level.

But, very high strength concrete or you know high strength concrete on the higher side 100 MPA concrete 100 MPA concretes are obtained through this. And this is with usually, with low water cement ratio water cement ratio is usually low and you definitely use this super plasticizer. So, when you are using super plasticizer and silicafume together doses are super plasticizer required is high, because when everybody using plasticizer or super plasticizer, with this material super plasticizer or plasticizer with this materials.

Then, super plasticizer or plasticizer with this material then they cause dispersion of this materials as well. Silicafume very being very fine and it has got large surface area usual water requirement is more. But, we do not use them alone without super plasticizers and when you use super plasticizers doses required are more, but then it forms very uniformly dispersed concrete system very you know highly dispersed concrete well dispersed concrete system; that means, you will have cement particles like this.

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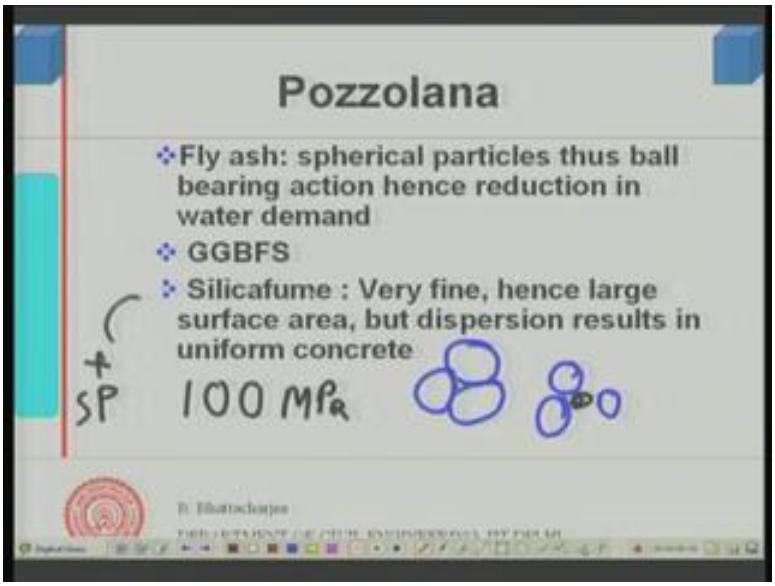

You will have cement particles like this. And which are themselves will get dispersed in some manner by the plasticizer and this silicafume particles will actually, be actually be forming you know it will be actually be within the interstitial space between them. So, you have a actually, well dispersed uniform system when you use both silicafume and super plasticizer together resulting in high strength concrete. So, for very high strength concrete over 100 MPA concrete silica fume plus super plasticizer is the actually material.

So, silicafume has such it will not have you know sought of influence strongly it does not it is not a water reducing agent unlike fly ash it has got some sought of water reducing capability also it does not have. So, much, but it is used together in very high strength concrete and usually in low water cement ratio concrete with super plasticizer and there this dispersion, it consumes more dosage of super plasticizer, but disperse also more and therefore can give you uniform concrete.

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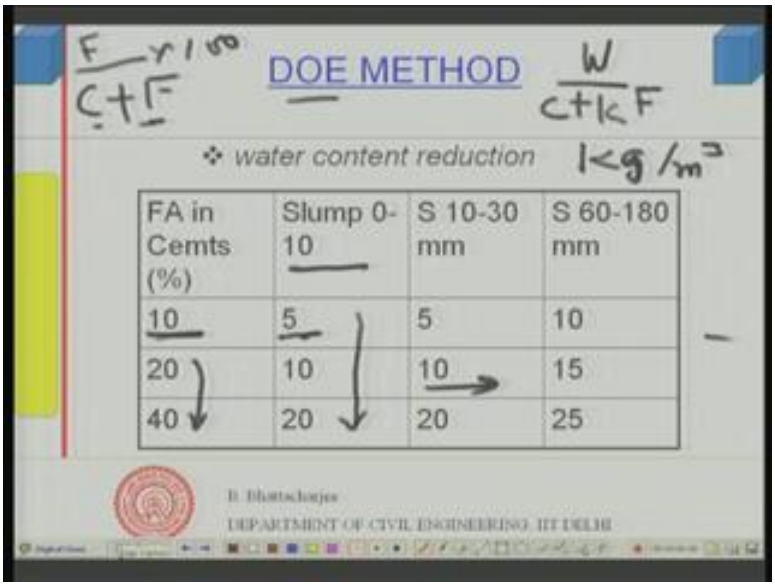

Now, water content reduction is some example of water content reduction due to fly ashes water content reduction due to fly ashes supposing you know this comes from the department of environment British practice the mix design method. So, in this mix design method it gives you mix design procedure involving fly ash also. Now, it gives you a table part of the table is actually, reproduced here where it shows you supposing the percentage of the cement percentage of fly ash FA in cementitious means; C plus F where C stands for the cement F stands for the fly ash.

So, F divided by C plus F into 100 that is the percentage in cementitious if this is 10 percent and if your slump is 0 to 10 then this would you can reduce the water content, in the concrete you can reduce by 5 kg per meter cube. This is in kg per meter cube 5 kg per meter cube; that means, originally if you have something like 100 kg per meter cube. Now, you can make it as 100 and ninety 5 kg per meter cube. Slump from 10 to 30 mm also slump from 10 to 30 mm also you can have 5 kg reduction whereas, there are in between others 30 to 60 and which the part of the table that is not shown here.

Here also you can have when it is 60 to 180 the reduction possible is 10 kg per meter cube. So, at higher slump the water reduction is higher. Higher the slump water reduction is higher for the same higher content and as you go on increasing the fly ash content, you

can see the water reduction increases, because more the fly ash more. It can actually allow for the ball bearing action and pore filling effect.

Similarly, this again as you go along this direction there is an increase. So, you can significantly reduce the water demand by adding fly ash and this is utilized in the mix design. So, add fly ash you can reduce down the water and therefore, if you want to get the same strength you can reduce down the cement also of course, this is not. So, simple this is slightly more modified because in case of fly ash it is the strength is function of C plus K F which we will discuss some time later on unlike W by c alone.

So therefore, you can reduce down the water to some extent and cement consumption also can increase and you have to redesign the mix completely to get the full beneficial of it. So, fly ash can reduce the water significantly fly ash can reduce the water significantly right and give you a plasticizing effect right.

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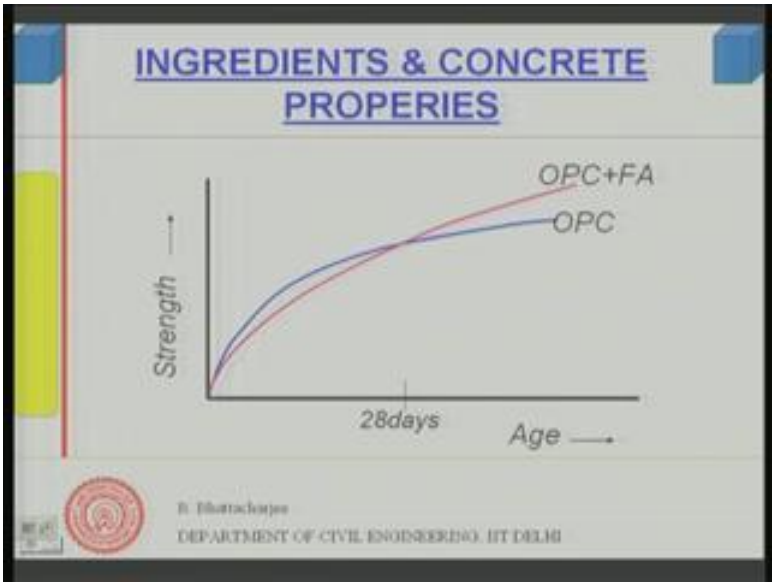

But, few things must be remembered here few things must be remembered here. This we know the strength increase we have already seen this strength increment with fly ash 28 days strength can be same and long term strength is beneficial.

But, what we have seen today as far as the workability is concerned fly ash reduces the water demand, but one thing must be remembered as, I mentioned earlier that all the fly

ash reduces the water demand. If you are doing slump, you will find that it might show those otherwise other consistency measure it might.

So, same effort required to compact it might still be same, but it might show somewhat lesser slump because the pore filling the pores are also filled filled by, in the cement system is also filled somewhat by fly ash and it is more cohesive in nature does not show. So, much of relatively same amount of slump as without fly ash concrete, so as 25 millimeter reduction in slump is allowed.

So, for example, if a concrete without slump is without fly ash is showing 100 mm slump concrete with slump with fly ash if it shows even 75 mm slump they might be treated nearly same consistency, because of the cohesiveness that the fly ash allows right. So, by using mineral admixtures, we can reduce down the we can improve the by using the mineral admixtures we can improve the workability in other words, we can have reduced water demand.

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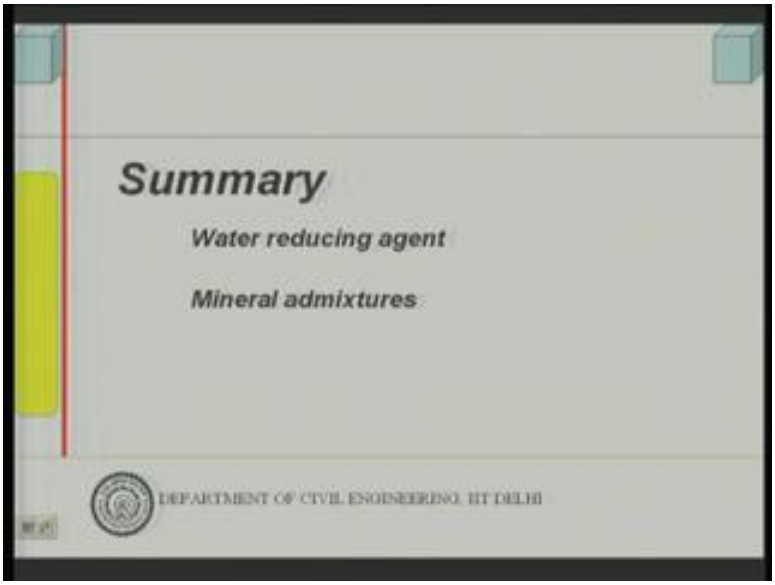

And we have also seen that by adding water reducing we can have significant reduction in water demand. Air entraining mixtures their purpose is of course, to provide better durability against freeze thaw action, but they do reduce down the water demand somewhat importantly when you both of them you use together the water reducing agent and the mineral admixtures you can have lot more choice available. Simple water

reducing agent we have seen the choices are available is limited either; I can have same strength same workability with lesser cost.

Because water reducing by using a water reducing agent, I can reduce down possibly cement and thereby it can be economic sometime. It can be economic to water reducing agent or I can increase the strength by reducing the water keeping the cement same or I can increase simply the workability. So, this 12 options were available, when we were using only water reducing agent, but if I use water reducing agent and silicafume or I mean fly ash together it can it can open up lot more possibilities I mean you know. So, reduction, in the cement can be still higher by using fly ash because it further gives you a reduction in water and also can show you a improvement in the long term strength.

So, combination of this type of admixtures can give you large amount of benefit. Something more in our summary is also, we discussed a little bit about viscosity modifier which actually thickens the water sought of improves the viscosity and reduces down the segregation and also you discussed about something about the retarders, which would actually slow down the process of hydration and thereby allow the placement of the concrete over a longer period of time.

So, these are the kind of advantages you get in case of plasticizers super plasticizer hyper plasticizer and other admixtures mineral admixtures, but 1.0 which I have not mentioned and I would like to mention in the end is that all plasticizers and super plasticizers are not compatible with all system while, you might find it reduces the water 1 might actually delay the setting process significantly, there can be side effects from super plasticizers or plasticizers especially when added in excessive dose.

So, dosage should be within the limit specified by the manufacture and their compatibility should be tested that they do not cause any reduction, in the you know any elongation, in the setting time not do they cause any kind of segregation, in terms of bleeding etcetera. Or any other secondary side effects that is there in the concrete. So, this is the most important 1 you must test for the compatibility of the plasticizer whenever, you are using a plasticizer or super plasticizer which is compatible with 1 cement may not be exactly compatible with another cement.

So, while using them and this has to be done by trial and error. They are using mix design also by trial and error and I think with this, we can say conclude the discussion on

the admixtures and concrete and thank you for hearing, next we shall discuss about segregation and bleeding in fresh concrete.

Thank you.