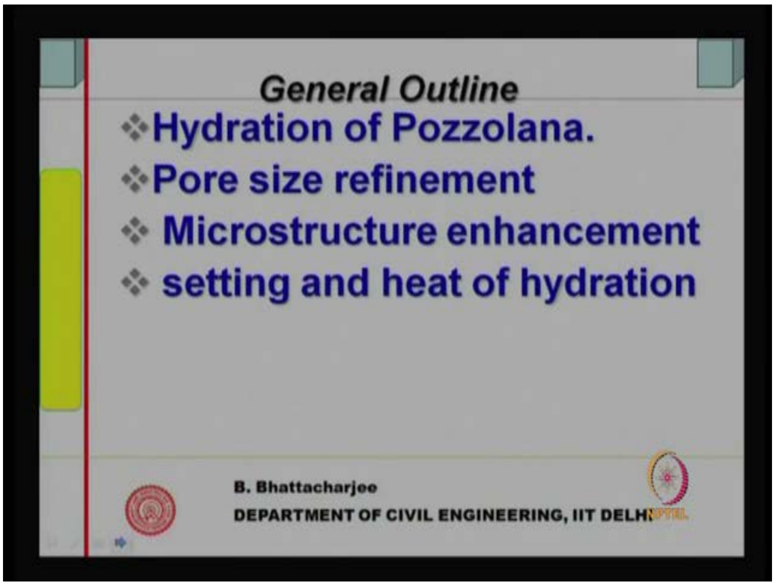
Concrete Technology

Prof. B.Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology Delhi

Lecture - 12
Mineral Admixtures

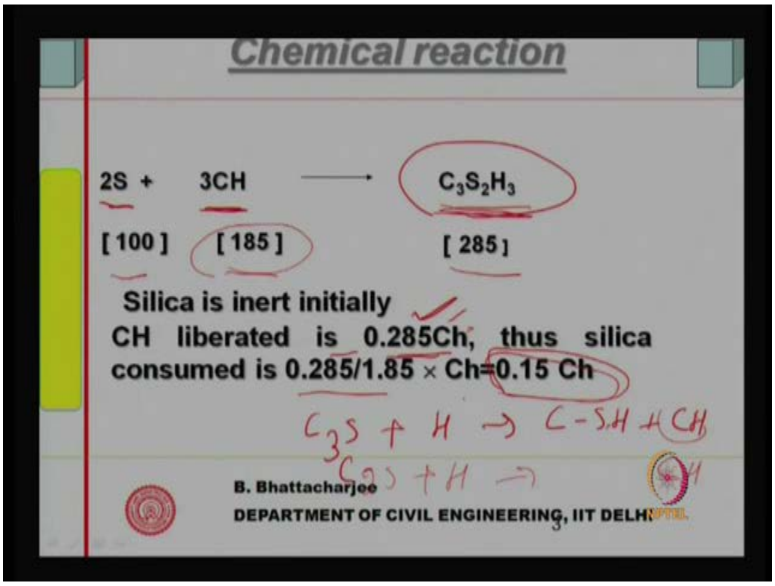
Welcome to module 3 lecture 4 we looked into mineral admixtures, some of them in the last class namely flyash ground granulated blast furnace slag, rice husk ash and silica fume also we had some discussion on metakaolin and pulverized fuel ash.

(Refer Slide Time: 01:23)



In general, we looked into the characterization and basic particle size distribution and some essential properties of those materials individually. Now, this lecture we shall be looking into their how do they react because we define them as pozzolana as a class many of them of course, you can have non pozzolonic mineral and mixtures, as well we will have short discussion on those something like lime stone powder some of them are inert but, here of course, right now we will concentrate on pozzalana so how do they react hydration of pozzolana we will look into, we look into the way they refine the pore size of the cement hydrates and improvement in the micro structures that they bring in they bring about in cement paste in mortar or concrete and then setting and hydration of this material their water demand in the fresh state etcetera.

(Refer Slide Time: 02:18)

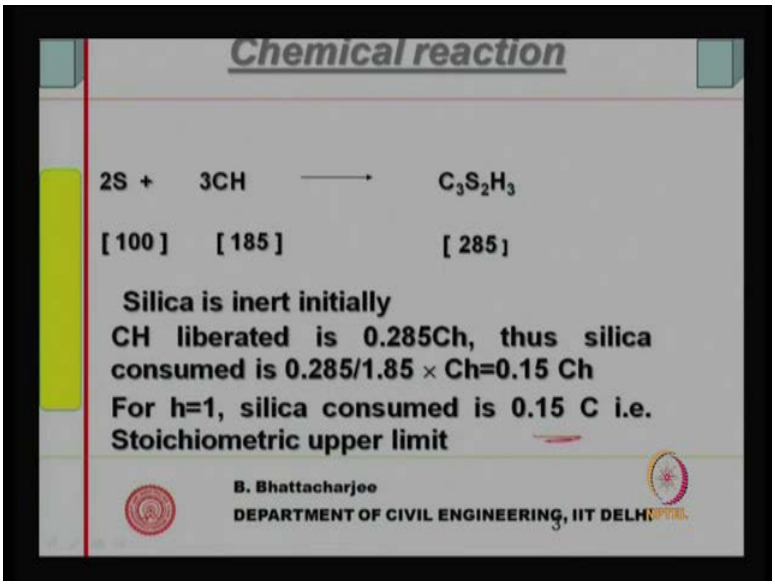


So, chemical reaction are something like this is one of the possible reaction chemical reaction of this material the silica component of it mainly the silica component of it the silica the silica reacts with silica reacts with calcium hydroxide to form the calcium silicate hydrate may be hundreds grams of silica may be reacts about 185 grams of calcium hydroxide to produce 285 grams of calcium silicate hydrate well this is one of the reactions.

There are several others proposed reactions possible reaction suggested in literature but, this being the simplest we can understand something like this must be happening but, finally, the product formed is calcium silicate hydrate may not have been having exactly this formula some of the formula but, generally calcium silicate hydrates are formed this silica is inert initially in cement when you add with cement initially the silica is inert, if you directly of course, mix with lime then the reaction can follow with lime itself but, if you recall that you see this lime reactivity test used lime together with silica and the de molding time was about 48 hours which means the reaction do not occur very rapidly in this particular you know reaction for this particular reaction silica and lime and it takes about 10 days of hydration before we do the actually test.

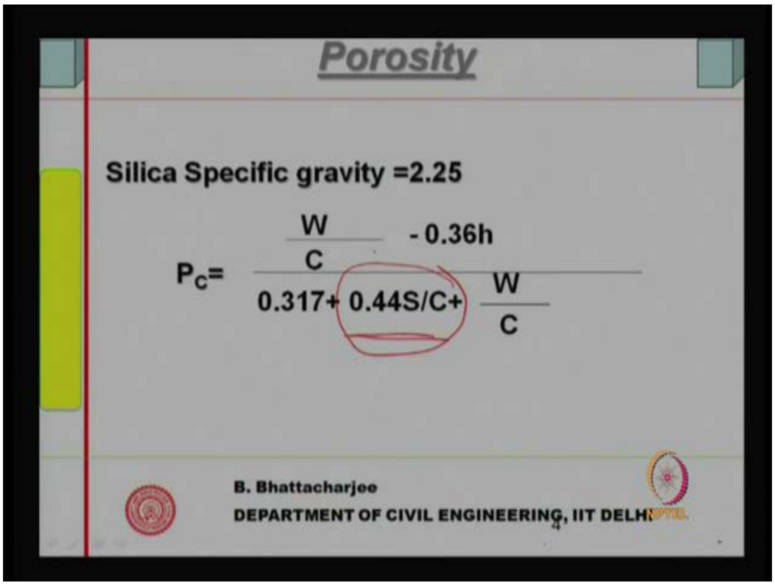
So, the reaction process itself is relatively slow but, when you add it together with the cement then cement does not have lime directly but, when it reacts with water the C 3 S and C 2 S they produce the lime so lime is not available initially therefore, silica will remain inert all right so calcium hydroxide when liberated right and one can actually calculate out it will be 0.285 Ch because we know the stoichiometry of cement reaction C 3 S reacting with water it forms a you know Ch s of some form plus of course, CH that we know.

(Refer Slide Time: 05:51)



And similarly, C 2 S also C 2 S also produces C2 S C 2 S also produces Ch and this we know stoichiometry we know from the stoichiometry we can calculate out that calcium hydroxide liberated is 0.285Ch is the amount of cement; h is the degree of hydration, thus silica consumed would be about 0.15 Ch because for two 285 Ch Ch liberated is 285 the silica is 185 lime is you know lime divided by the final product is of this order and it will be one can find out that is about the 0.15 percent of the Ch will be the silica consumed. So, one can actually find out how much percentage of silica is consumed so it is about 15 percent of the cement that is hydrated right that is what it is so if h is equal to 1 it is 0.15 C that is stoichiometric upper limit.

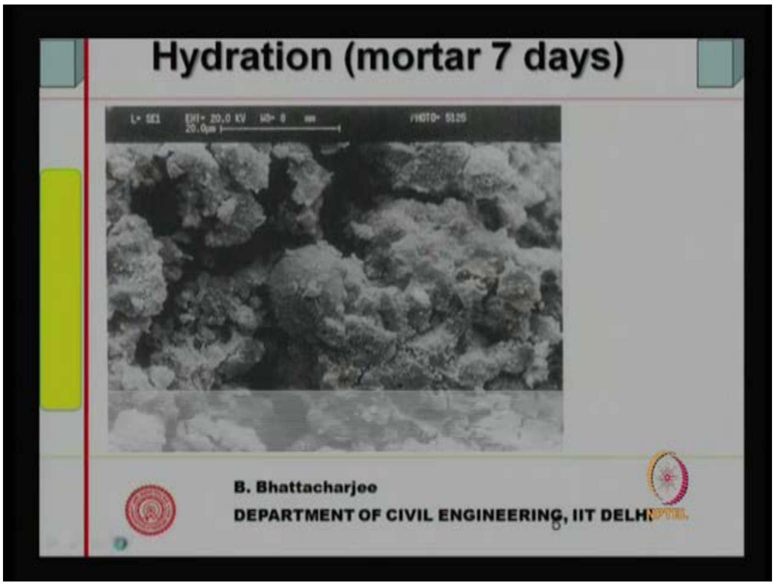
(Refer Slide Time: 06:30)



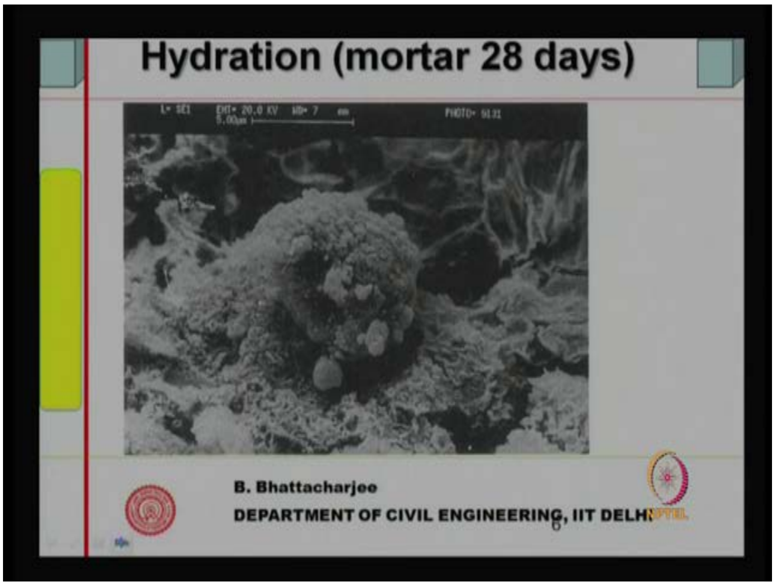
The maximum 15 percent of the you know cement reacts 0.15 C is the maximum silica that can be consumed by cement pure silica 15 percent by mass of the cement that can react with the cement at full hydration if it is partial hydrated lime liberated will be less and it will be even less also and one can actually calculate out how much maximum silica it can consume thus stands out to be 15 percent the specific gravity is 2.25 and one can actually using same kind of powers model as we have done for cement one can possibly show that the capillary porosity will be given by W C minus 0.36h and this was already there if you recall in case of cement alone but, when you have silica fume.

One can see that it will come as 0.44S divided by C where S is the silica and C is the S is the silica that is reacted and C is the cement. So, this term increases this term remains same this is the space occupied you know space left unoccupied by the water field space water field space which remains unoccupied after hydration product has come so one can see that actually capillary porosity will be lower because this value is higher the denominator is higher and therefore, capillary porosity reduces in case of capillary porosity reduces in case of silica or any pozzolan a consumed by the cement. So there is a reduction in capillary porosity.

(Refer Slide Time: 08:23)

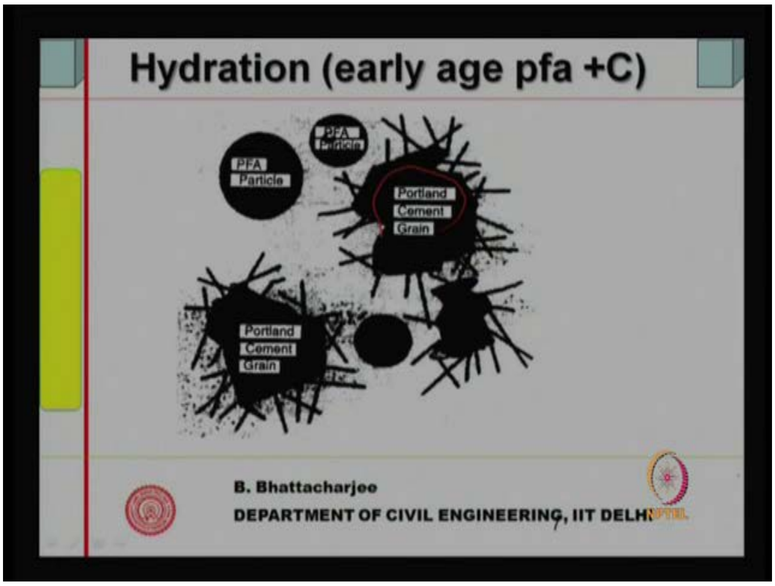


(Refer Slide Time: 08:47)



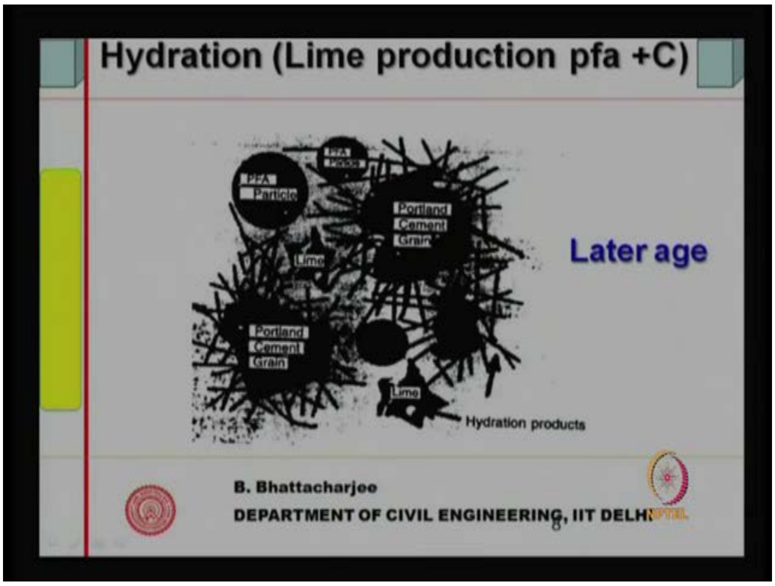
That one can calculate out this comes out to be this one can do this exercise this is not very complex, but then this is you know one of the reactions actually this is still this is not you know the exceptancy of this has to be seen because the reactions are not really fully known things like that however one thing we understand from this exercise that capillary porosity will reduce. If one looks at the scanning electron micro graphs right a hydration of the seven days one could see that the spherical flyash particle this is within the mortar spherical flyash particles has produced a number of C h S and they look like cotton like things the number of C h S has been produced and this is what one can see from scanning electron micro graphs and similar more such hydrate should be seen more such hydrate should be seen in the 28 days. So, when 28 days more hydrates are hydrates are formed 7 will be very little, but 28 days you will see lot of hydration product actually the C h S formation if you distinguish from 7 to 28 days 7 days much lesser of this would be there and 28 days you will find more of this hydration product that is accumulated.

(Refer Slide Time: 09:26)

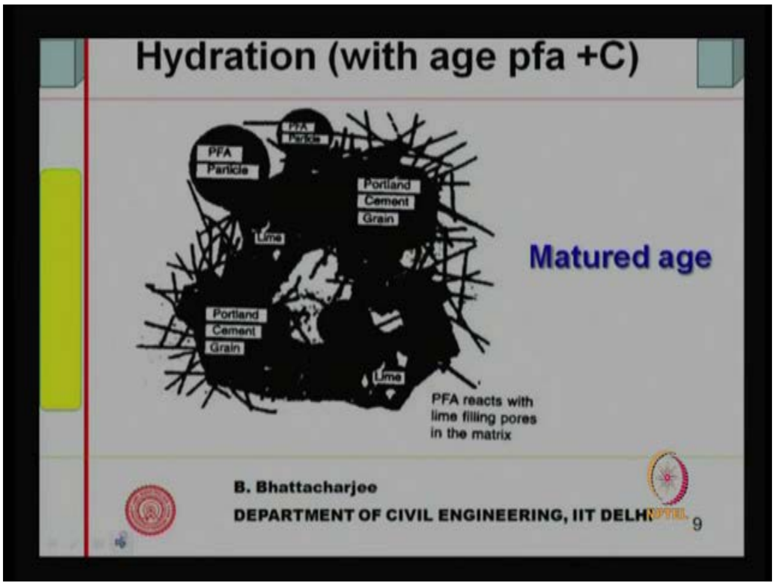


So, little actually 7 days is not much is seen, but 28 days you see lot of hydration product with p f a this is a model for example, you have a Portland cement grain let us say and the Ch S right at a early age the Ch S has come out Ch S that structure has produced which we have seen earlier when you looked at cement hydration process this is the pulverized flow ash which is generally that has flyash or similar things which are generally spherical and they are there in the initial stage so this Ch S has formed and calcium hydroxide will be now liberated initial age there is not much of consumption is p f a.

(Refer Slide Time: 10:05)

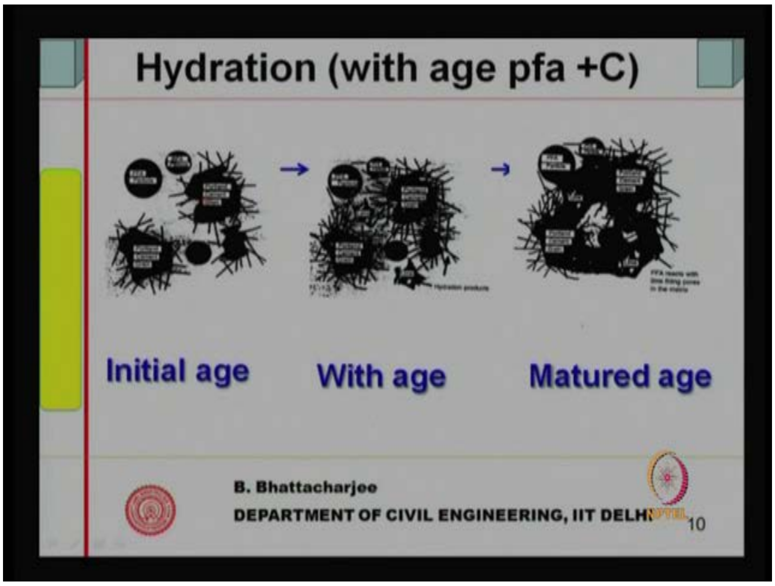


(Refer Slide Time: 10:34)

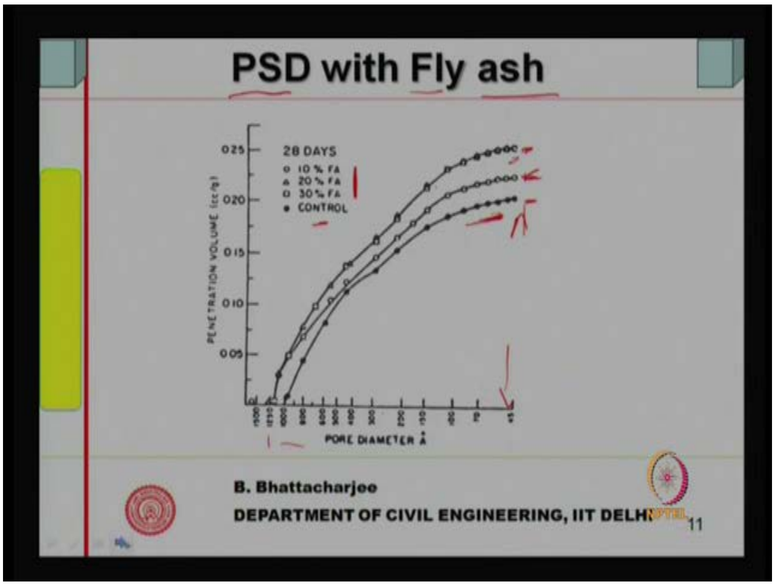


But, in the later age if you see lot of this would get consumed and more of this hydration production. So, lime would be liberated in later age lime will be liberated and this spheres are still intact not really much but, the lime has come and lot of C h Shas actually produced. So, Portland cement grain now is become much larger with its hydration product surrounding it and the lime being there in the solution and in matured age this lime will start consuming this pfa hence spherical pfa particle will get further consumed and reduce down the porosity capillary force present in the capillary force present in the cement hydrate system capillary force present in the you know hydrated cement system right.

(Refer Slide Time: 10:56)



(Refer Slide Time: 11:35)

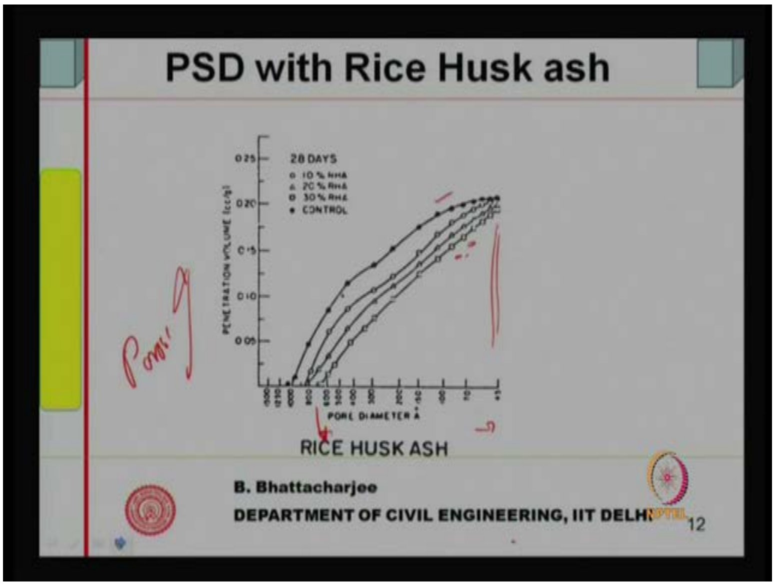


So, this if we look at it sequentially first stage is followed by next stage the lot of just initial hydration has occurred initial hydration has occurred followed by the hydration product surrounding the surrounding the cement particle the lime is also there and then in matured age it will come out some of this will react and all of them would actually you know constitute the solid phase which will bring down or lower down the capillary porosity.

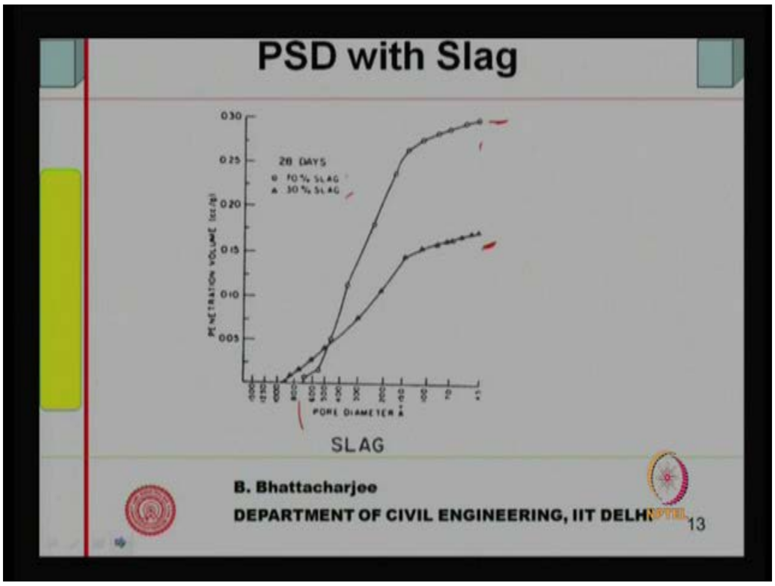
So, this is the model excepted for any kind of any one of this material and if you look at the pore size distribution PSD with flyash this is what has been tested by people PSD then you see 28 days with different percentage of flyash has been seen control is here so control is the circular quantity here the right control is somewhere here and if you see the control it has got penetration I mean control control control will have sorry the control will have this case there are three percentages shown in fact this is 10 percent p f a is this particular one.

So you have got penetration volume penetration volume at 28 days penetration volume more volume penetrates as well as 10 percent is concerned the this one is triangle with 20 percent pfa 10 percent pfa 20 percent pfa more volume more of volume you know force should be larger force and larger force and with 30 percent pfa 30 percent pfa is also somewhere close to this so 10 percent, 30 percent 20 percent and 30 percent is somewhere here and 10 percent is somewhere there, control is somewhere there.

(Refer Slide Time: 13:13)



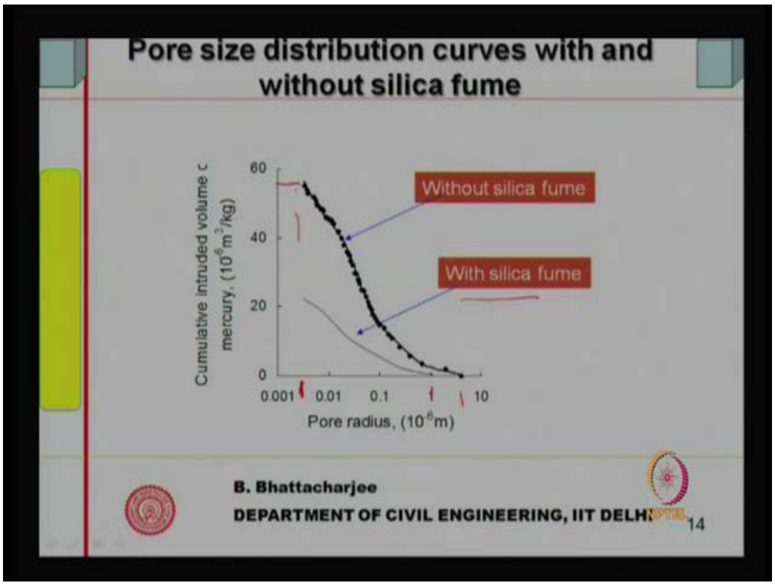
(Refer Slide Time: 13:44)



So, it shows control shows lesser porosity in fact initial 28 days for particular results and let see what happens in the long run with rice husk ash this shows with rice husk ash the control is higher this shows better results this is with 30 percent rice husk ash which shows much lower porosity over all because this is a measure of the porosity this is measure of in way porosity more the volume more is the porosity less so therefore, this is less porosity and particular sizes are also final. So, rice husk ash seems to perform better than fly as that 28 days and if you look at slag with 70 percent slag and 30 percent slag so 70 percent slag is somewhere here higher porosity is 30 percent slag seems to perform better, but 70 percent slag shows a lesser pore sizes reduces or the porosity seems to be some what higher.

So, some ideas of the pore size distribution measured with the mercury into the porosimetry is shown some idea about could mercury into porosimetry is shown right some idea about mercury porosimetry mercury into porosimetry is shown in this results in this results right. So, what we have observed is that fine pozzolana such as rice husk ash reduces the porosity more and refines the porosity more by 28 days whereas, if you look at slag higher percentage of slag do not refine in you know it always refines the pore all right but total porosity is still more compared to let us say 30 percent slag, whereas flyash 10, 20, 30 percent they do not you know the pore refinement is relatively not much compared to without pfa up to 28 days.

(Refer Slide Time: 15:04)

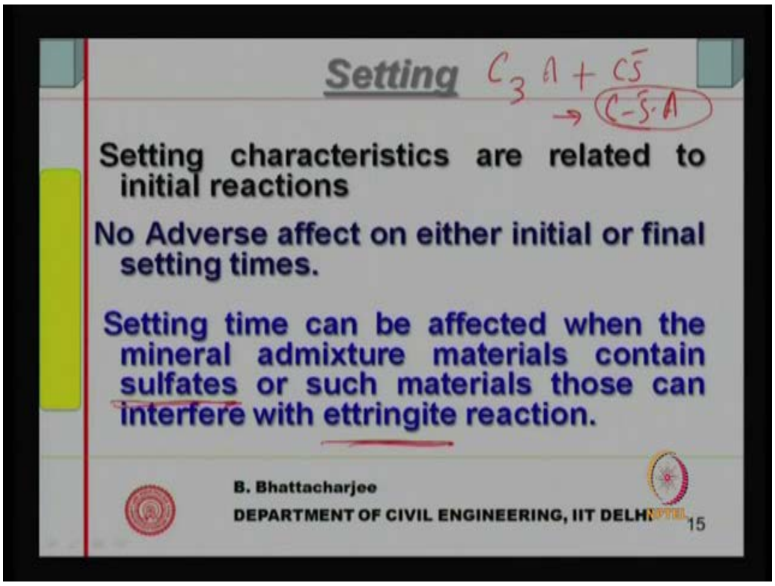


Let us follow it up pore size distribution curve with and without silica fume. Now, if you have silica fume then there is a significant change because this is the really fine, it is very fine without silica fume the pore size distribution is something like this and with the silica fume the pore size distribution is the next one as shown. So, you can see that the pore size distribution sizes becomes smaller with silica fume and without silica fume sizes are less refinedand the volume of the pores are also more volume of the pores are also more.

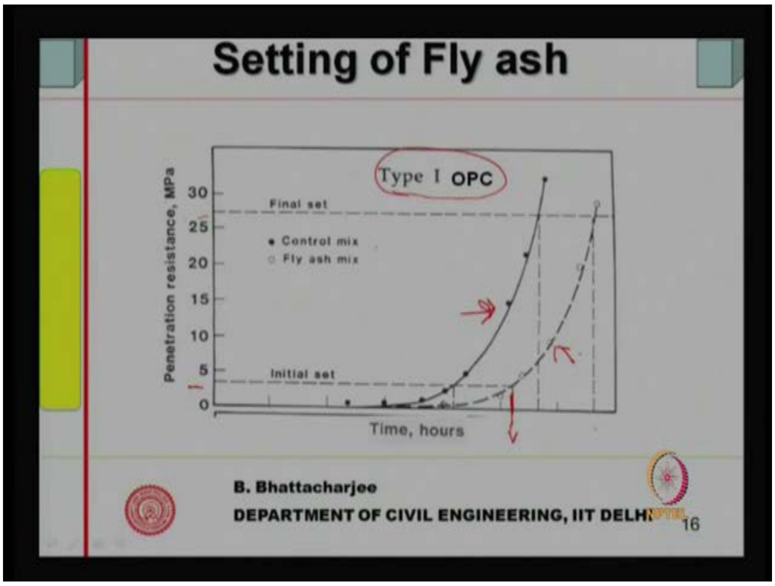
So, fine pozzolana, very fine pozzolana they would actually refine the pore andrefine the pore you know make the sizes finer and also they would reduce all the porosity whereas relatively poresur pozzolana like flyash it does reduce you know it would reduce this effect much less by say about 28 days, but in the long run perhaps it would be you know it would be reducing the capillary porosity to much larger extent.

If you see the setting characteristics setting characteristics are related to initial reactions and generally no adverse effect on either initial or final setting times as been observed with any one of those material hardly any effect has been seen on either initial or final setting time. Setting time can be effected when the mineral admixture materials contains sulfates. This because sulfates is a first reaction C 3 A reacting with CS bar that is the first reaction to form ettringite calcium sulfa alluminate you know calcium sulfa alluminate. Now, this is calcium sulfa alluminate at the you know this ettringites are if there are sulfates this can create some problem and this can interfere with ettringite reaction.

(Refer Slide Time: 16:08)



(Refer Slide Time: 17:09)

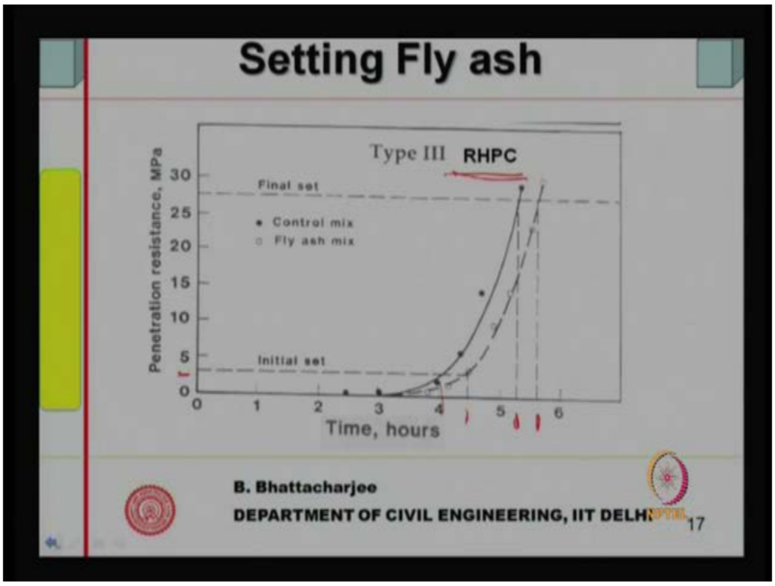


But, usually this is not a very common phenomena they do not adversely affect the initial and final setting, some results of flyash setting of flyash you know the flyash is available for example, if one does a wall penetration test. Now, in ball penetration test what you do is the effort required a ball to penetrate is standard ball to penetrate in the concrete is measured and if it is above let us say if it is more than let us say this corresponds to 3.5

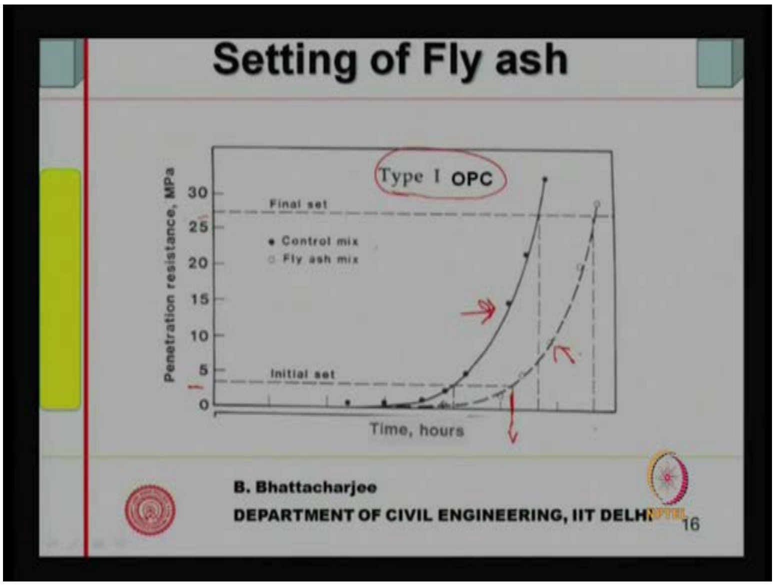
MPa than it is in 3.5 MPa for it corresponds to initial setting time, final setting time corresponds to 27 MPa. So, if you look at that this is control mix that is no flyash this one has no flyash, this is with flyash.

So, what is observed is that initial settings time has been delayed by flyash is for a some cement was type 1 OPC that is a Portland Cement and this was some type C flyash. So, some cases it can delay the initial setting time and the final setting time also can be delayed a little bit, but this is not very significant you know it is not of very significant importance it is only seen in some cases most of the cases setting time is not affected adversely. In other words initial setting time is not shortened not reduced by addition of mineral admixtures like fly pozzolana's, pulverized fuel ash or you know just flyash as they are or silica fume, but final setting time in few cases can get elongated, but usually does not get extended beyond 10 hours so not much adverse effect is seen as for a setting is concerned.

(Refer Slide Time: 18:55)



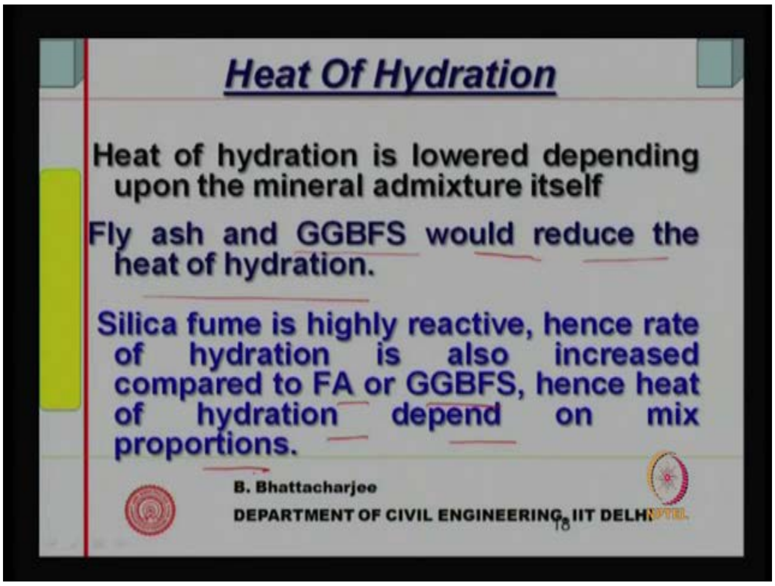
(Refer Slide Time: 18:55)



This is with rapid hardening cement that means now the cement has changed and rapid hardening cement itself against the strength is very fast and if you can see the time is still within 6 hours although without without the without the you know without the flyash it is about 5 hours do not really go beyond 10 hours and initial setting time is there of course, there is an increase without the initial setting time would have been five hours, but this is about four and a half hours so not much change and similarly, in the previous case if you can see this also do not go beyond 10 hours in any case.

So, in the time frame they do not make time change they do not make a great change or adverse affect so everything is within 10 hours of the final setting time within 10 hours and initial setting time is not less than 30 minutes. So, they do not shorten the initial setting time and do not elongate the final setting time to much to go beyond 10 hours because normal cement final setting time much less than 10 hours so that is why they do not effect setting time adversely.

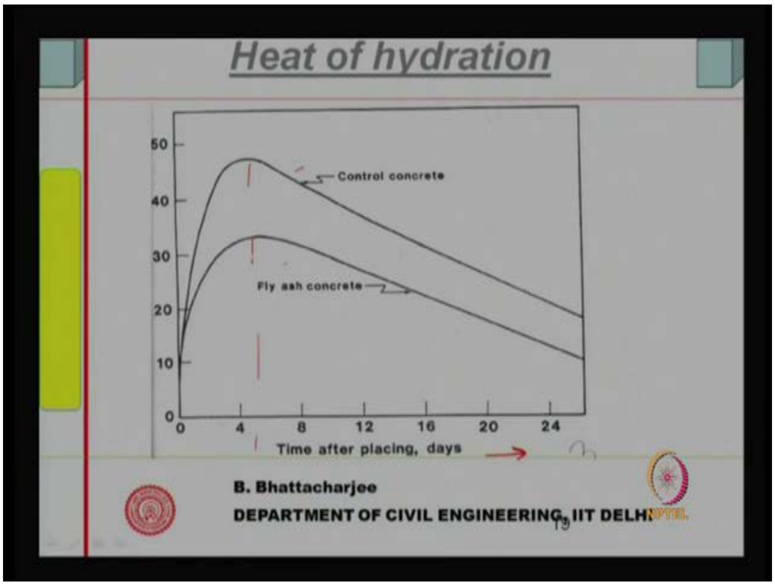
(Refer Slide Time: 20:05)



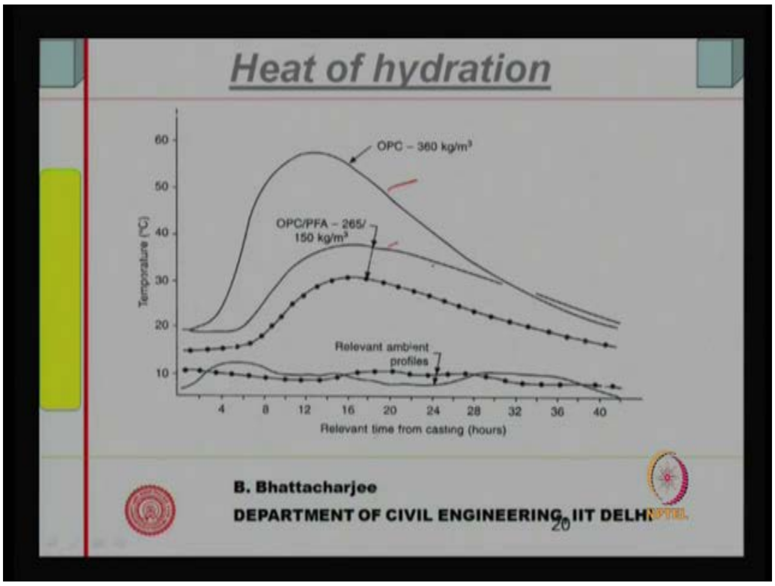
The other issue is heat of hydration heat of hydration is lowered depending upon the mineral admixture itself for example, flyash would lower it significantly it will lower it significantly and it is one of the places where it is used you know flyash is used one purpose of using flyash is to reduce down the heat of hydration both flyash and GGBFS would reduce the heat of hydration they reduce the heat of hydration because they do not react very fast there are two effects one is dilution effect because if you have cementitious stored consider total cementitious material have it been alone cement alone then it would have reacted and produced heat of hydration, but now part of the cement has been replaced by the pozzolana itself like flyash. So, therefore the dilution effect so heat of hydration in the initial phases will only be contributed by cement right and that is why heat hydration gets reduced flyash reacts relatively at a slow pace generates rate of it generates therefore, is reduced down and it is spreaded over a longer period of time so effect is much less.

So, both GGBFS and fly as reduce the heat of hydration that is what we have seen. Silica fume is highly reactive hence rate of hydration is also increased compared to FA or GGBFS, hence heat of heat of hydration depend on mixed proportion, if you have high cement obviously, it will try to produce more heat and it also depends upon how much is your C 3 A with the C 3 A is a major contributor to heat of hydration. It is major contribution it is major and maximum it produces maximum heat of hydration, that is what we have seen.

(Refer Slide Time: 21:57)

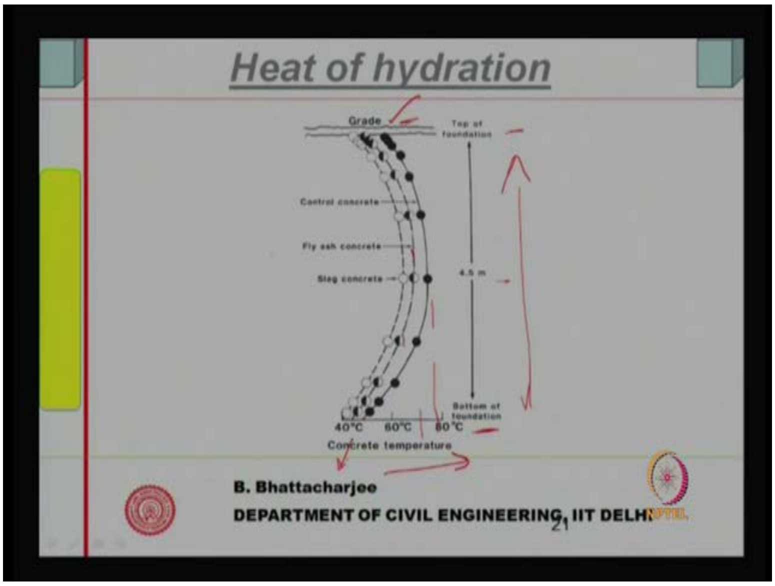


(Refer Slide Time: 22:19)



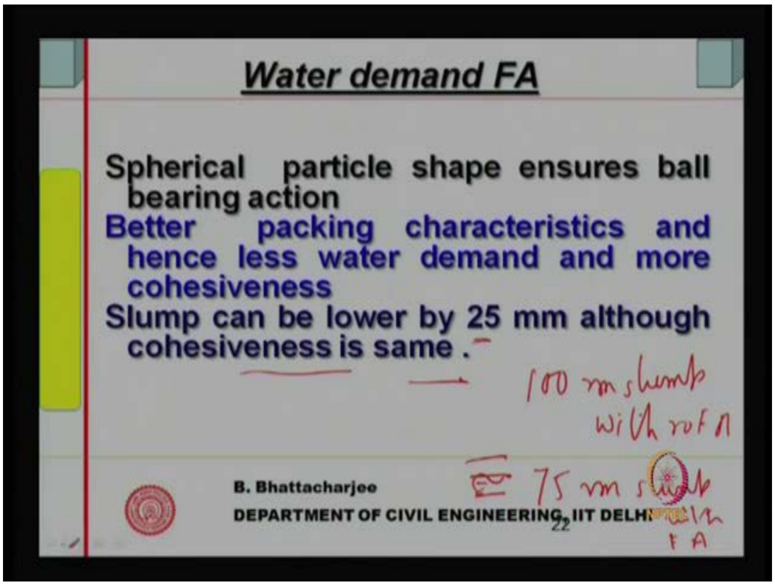
So, some comparative diagram we can look into heat of hydration for example, flyash concrete control mix if you see time of placing in days versus the heat of hydration then control concrete produces more heat this produces as the same time, but the amount of heat produces much less this must be in Joules per k g so this is much less so heat of hydration produced is much less and its temperature sorry the previous one is also less temperature this should be in temperature rise temperature rise showing. So, temperature rise much slower with flyash and here also the temperature with OPC 360 k g this is OPC 265 OPC 265 k g right OPC 265 by 150 this is this one is OPC 265 by PFA 150 k g right so this is the this is one and this is ambient condition is somewhere here relevant ambient and condition is somewhere.

(Refer Slide Time: 23:23)



So this is 265 OPC this is OPC 265 plus 150 k g of you know this is flyash is 150 and ambient condition is here ambient profile the relevant ambient profile in two cases this is what is shown. So, actually temperature rise is much less when you use flyash and this diagram also shows the same thing for example, this is the top surface of a you know grade level top of a foundation.

(Refer Slide Time: 24:34)



So it is a rough thick rough 4.5 meter thick rough 4.5 meter thick rough bottom of the foundation is here in this direction is the temperature. Now, flyash concrete has got the maximum temperature somewhere here at a center whereas this one is controlled without flyash with a much higher temperature and slag concrete is still lower than the flyash concrete.

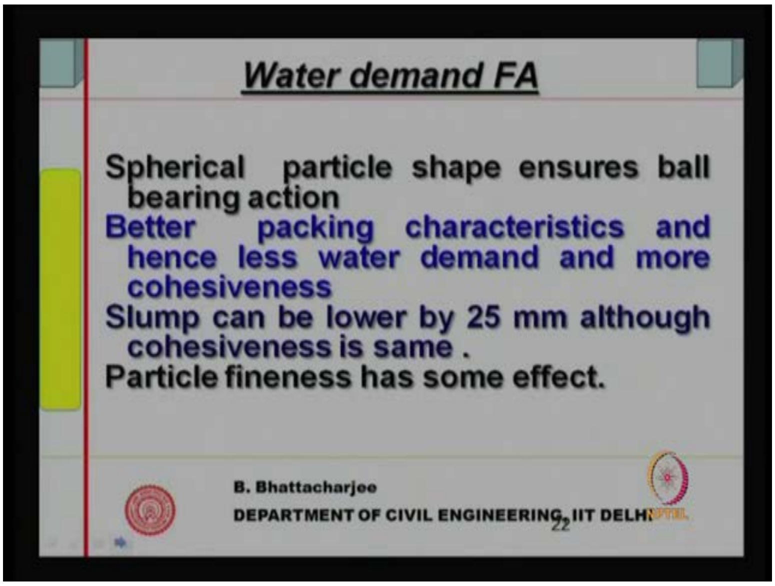
So, generate temperature at the center is maximum because this equation will take place from here this equation will also takes place through the ground, but center temperature rises maximum and in this particular experimental results as is shown the slag shows the least temperature followed by flyash and control concrete shows the maximum temperature control concrete shows the maximum temperature. So, as you can see that they really reduce down the heat of hydration both slag as well as flyash both can reduce down the heat of hydration, setting not adversely effected but, heat of hydration is reduced by use of this particular water demand plus c because do the effect of water capability water demand right.

So now when it is spherical particle like flyash they ensures better packing of the cementitious system and also you know there also there something like they ensure there is some amount of ball bearing effect that means on circular spherical particle all other particle can move very easily on top it can go lower so this called ball bearing action and this material flyash can exhibit this ball bearing action because there are space pack you know they are very spherical better packing characteristics enhance less water demand.

So, water demand reduces because of better packing and also ball bearing action so they make the concrete somewhat flow able to make the concrete somewhat flow able concrete concrete on water somewhat flow able. So, in a way water demand reduces with flyash water demand reduces with flyash slump can be although lower if you get 100 mm slump without flyash that is equivalent to about 75 mm slump with flyers the cohesion is similar the consistency would be similar you know wall ability that is your effort for compaction will be similar however the slump can be slightly less because they are sticky little bit sticky with you know similar consistency.

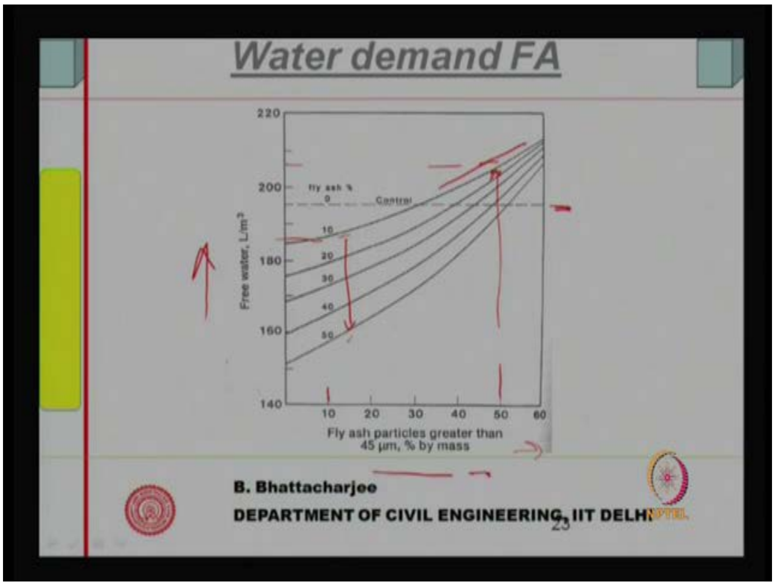
So, as a result it has been observed the slight slump can be lowered although cohesiveness is same so 100 mm slump with no FA is equivalent to equivalent to 75 mm slump with FA. So, therefore 25 mm slump reduction would have occurred although water you know we find that cohesiveness is same.

(Refer Slide Time: 26:53)



Particle fineness will have effect finer the particle or finer particle is more the water demand would change accordingly in fact below 45micron what are the characteristics of way of measuring the flyash as a percentage of particle passing through 45 micron or percentage of particle retained on 45 micron, if it is more passing through is more that is a better flyash because that is finer and finer flyash performs better right spherical particle content has also some effect more the spherical content it is been seen that water demand reduces because ball bearing action is more attacking characteristics would be better and therefore, less water is required to fill in the pore space within the cementitious material to make it consistent so consistency standard consistency if you have similar thing it will conceive the amount of water required will be less when you us flyash with more spherical particle and more fine particle.

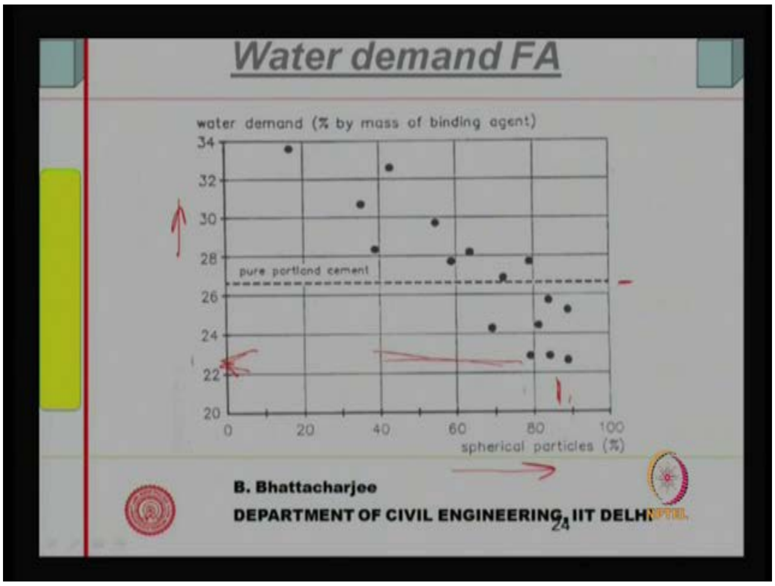
(Refer Slide Time: 27:58)



Let us see some diagrams are available if you look at this diagram this is zero flyash control flyash particles greater than 45 micron by mass so if you increase the particles more than 45 micron free water required in liter per meter cube of concrete you can see that this increases if 10 percent flyash if you have 10 percent flyash and 10 percent is 10 percent is particle greater than 45 micron water demand is somewhere around hundred and ninety liters right but, same when you have particle retained on or poresur then,you know porsur then 45 micron is more about fifty percent than your water demand will increase.

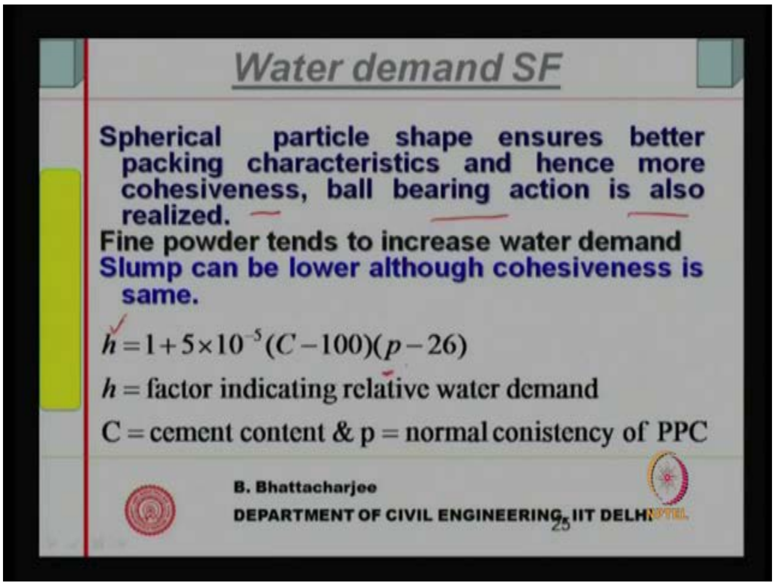
So, finer the particle or particle passing through 45 micron if it is more retained is less you know retained more means porer more water demand passing more is less water and this effect tends to water demand stands to reduce when we use more and more more and more flyash and it just goes on more flyash less is the water demand, fine flyash less is a water demand.

(Refer Slide Time: 29:39)



So, therefore this seems to be that is you know this seems to simply increase up to fifty percent if you look at it you know water demand seems to reduce with the flyash and it also seems to reduce with the flyash particle being finer particularly passing through the forty five micron if it is more that is better this is proportion of spherical particle. Now, you know this is clear Portland cement no flyash this is the proportion of spherical particle and this is the water demand by the mass of binding agent to give you same kind of consistency both cases same consistency.

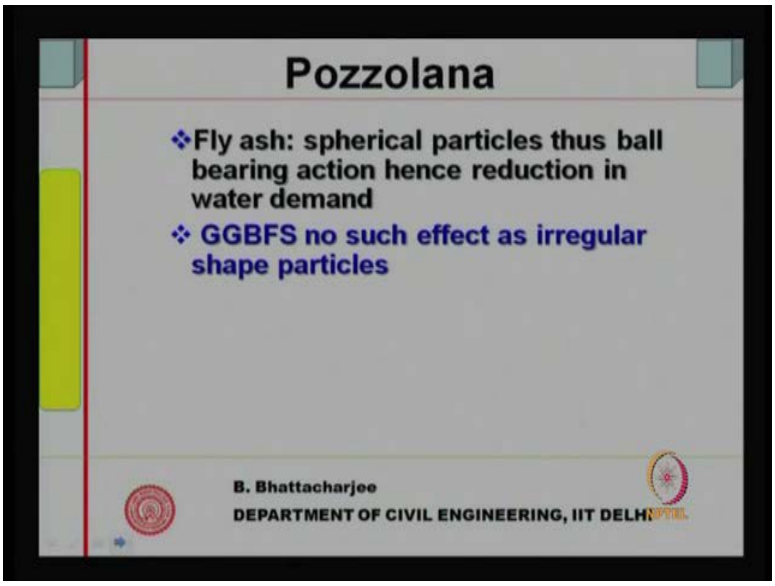
(Refer Slide Time: 30:43)



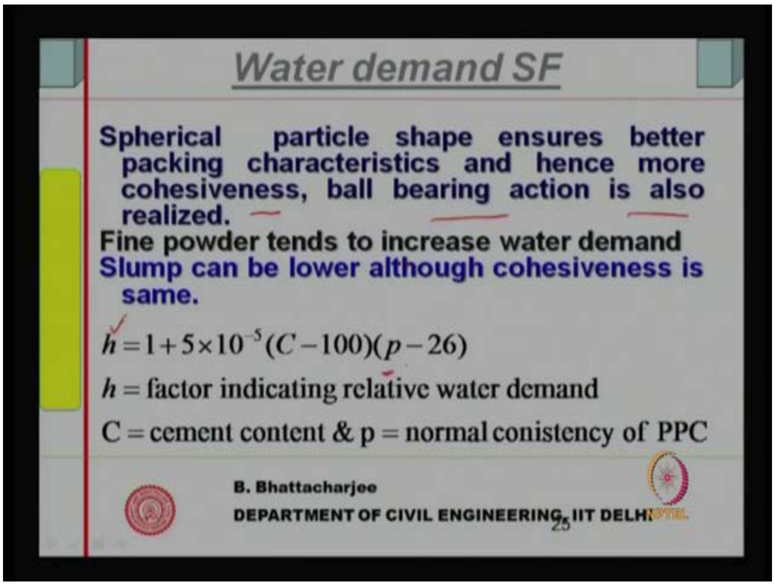
So, more the spherical particle water demand is much less you know same kind of consistency for example, if you have got eighty ninety percent of spherical particle you need only twenty two percent of water to give you a standard consistency sort of thing whereas, if it is only twenty percent spherical you will need thirty to thirty three control is of course, somewhere here control is somewhere here so higher particle spherical particle is more the spherical particle lesser will be the water demand lesser will be the water demand right lesser will be the water demand. So, this is how flyash effect the water demand if it is silica fume they are of course spherical in shape and they do ensure better packing hence more cohesiveness ball bearing action is also realized, but they have very fine size and with their large size single large size is being more they themselves may require a little bit of more water for wetting.

So, packing this both this effects act together slump can be lower although cohesiveness is similar quite lower like flyash itself and you have relative water demand does an expression like this where h is a for this kind of material pozzolonic material where h is a factor indicating relative water demand if it is all cement hundred percent cement you know hundred percent cement this h factor is not there but, this is this term will be simply one C put C is equals to hundred this term is one this term is one right C is the cement content pin percent so normal consistency of PPC.

(Refer Slide Time: 32:17)



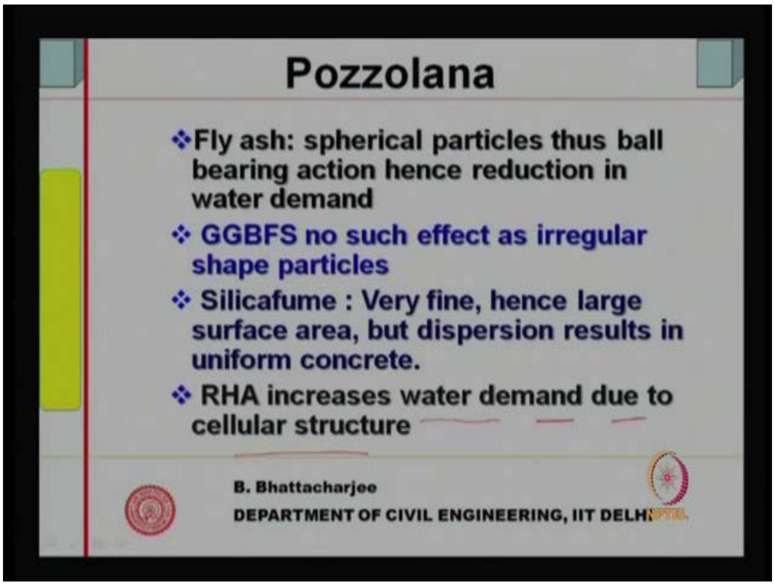
(Refer Slide Time: 30:43)



So, if you have normal consistency of PPC minus twenty six that is with the age is a factor indicating the relative water demand if the consistency is low less water demand will reduce down in case of material like silica. Hence, reduction in water demand that is what we have seen GGBFS has no such effect because it is irregular in shape GGBFS there is no such effect because it is irregular in shape so if you know in the previous expression if the standard consistency of the standard consistency of the PPC is less than 26 or it is 26 if is26than this term zero if it is less than 26 than you will get a reduction in the water demand but, if it is more than 26 you may not get so for PPC the P depends upon what is the value of P standard consistency of PPC if it is better than 26 this is an empirical equation.

Something of this kind can be understand that if you have PPC Portland pozzolana cement and this was directly adding flyash directly getting flyash always reduces the water demand PPC if there is some amount of grinding so it will depend upon the standard consistency of PPC that you know obtain if you have less consistency of the PPC you will get less you know water demand will be lower and this is an empirically equation it is related to 26 percent standard consistency.

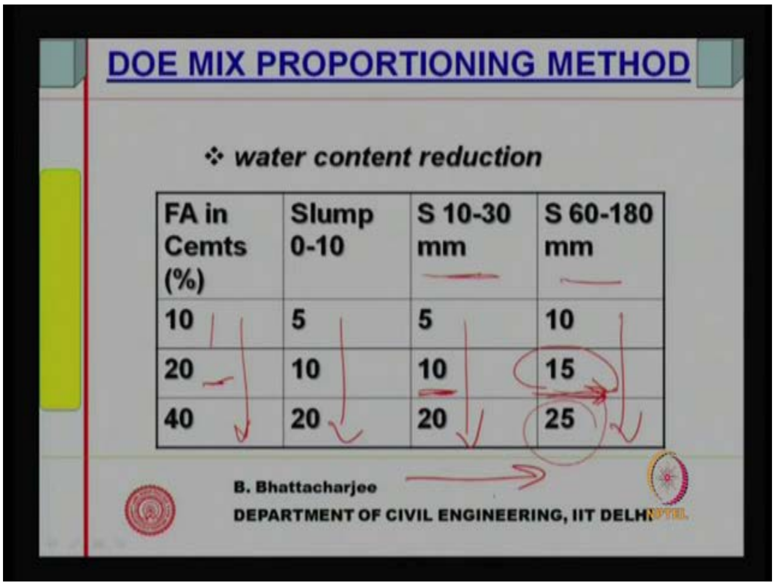
(Refer Slide Time: 34:08)



Now, over all if you can sum it up flyash spherical particle thus ball bearing action hence generally reduction in water demand PPC or slag cement will have somewhat different you know properties or different performance in this terms but flyash when you add to the concrete directly as mineral admixtures you will get it something like this GGBFS no such as effect you will get because they are irregular in shape and therefore, you won't get reduction in water demand silica fume very fine and large surface area, but dispersion results in uniform concrete.

So therefore, flyash is the one which is almost you know reduces down the water demand almost act like plasticizers I mean not to that extend but, something plasticizing or water reducing effect is very much there and rice husk ash has a other kind of problem because it has got a cellular structure rice husk ash has got cellular structure therefore, water demand is increased due to cellular structure so it increases causes it increase in water demand rice husk ash causes increase in water demand due to cellular structure.

(Refer Slide Time: 34:48)



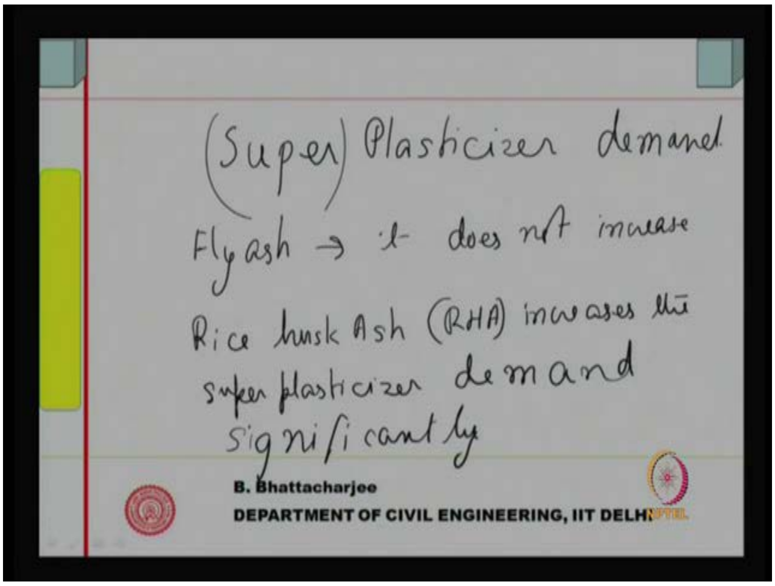
Mixes and methods actually allow for reduction in water remove water content if your using flyash for example, in a slump range of 10 to 30. If you use flyash 20 percent the water demand can be reduced by 10 k g per meter cube according to the British practice of department of you know DOE British practice so in this one you can reduce down therefore, it is an mixture if you are using flyash from outside and depending upon percentage of flyash you can reduce the water demand depending upon the slump original slump of the concrete.

So if you look at higher the slump the reduction is more so control concrete has more slump or range of slump is more you can reduce the water more more the flyash you can reduce down more see it is increasing along this direction increasing along this direction and increasing along this direction so water demand can be reduced if you are using flyash because it has got some plasticizing effect but, it will also depend upon the type of flyash if you have 45 percentage passing through 45 microns and how much.

(Refer Slide Time: 36:07)

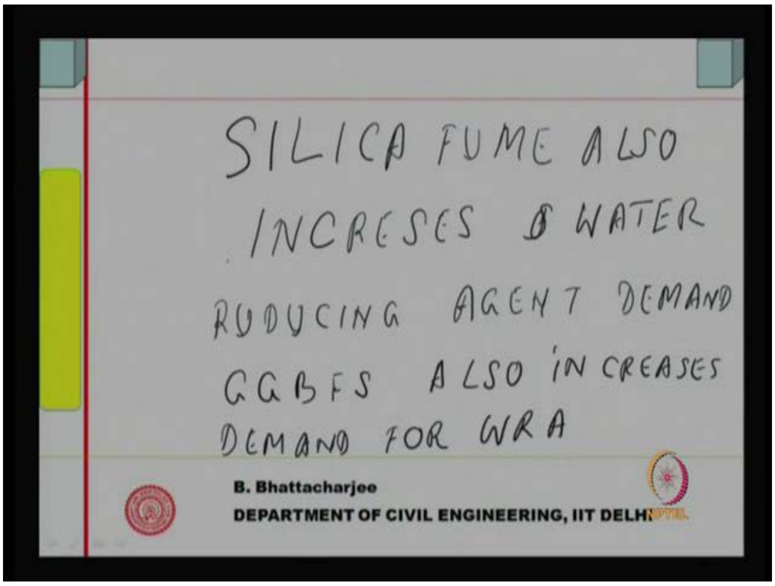
Spherical particles is there this is an important ask again no such things are seen from GGBFS or no such things are seen from GGBFS or no such things are seen from GGBFS or you know in fact its GGBFS will give you opposite action it is you know it is does not gives you an opposite action and it causes increase in the increase in the water demand in fact because of its irregular and angular shape silica fume as you have seen it reduces down so therefore, when it there is nothing like that no codes allow you to change now one issue which we have not discussed. So, far is issue of one issue we have not discussed so far is an issue of super plasticizer demand.

(Refer Slide Time: 37:02)



Super plasticizer or plasticizer what are plasticizer you know or super plasticizer demand in case of fresh concrete so when you have flyash it does not increase rise husk ash increases the super plasticizer demand.

(Refer Slide Time: 38:20)



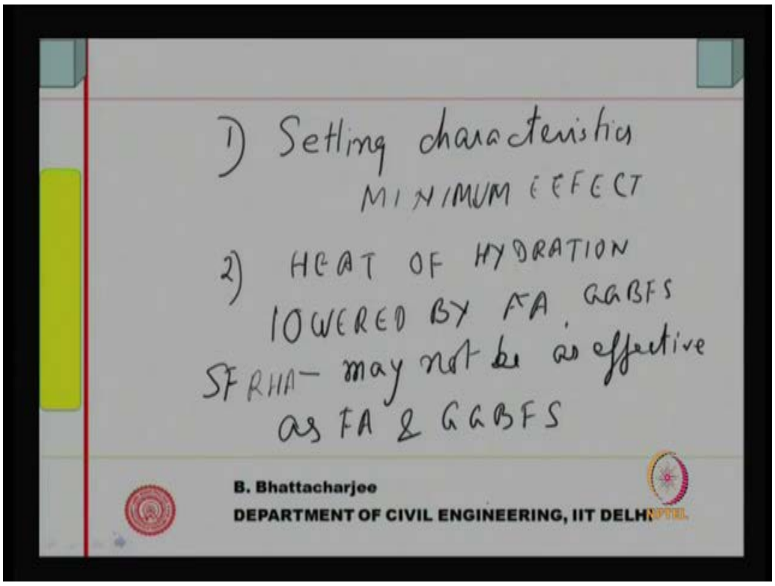
Significantly, silica fume silica fume silica fume on the other hand silica fume on the other hand silica fume also increases you know water reducing agent water using agent demand and GGBFS also increases demand for water deducing agent.

Now, rice husk can increase it to such a large extent that rice husk ash can increase this demand to such a larger extent that it may not be feasible to use this material because there are negative effects of using excess water reducing agent in fact it can effect the setting characteristics significantly if you are over dosing it so this is this is the problem compatibility of rice husk ash should the super plasticizer is a problem because it is cellular in nature and therefore, it has got very large surface area you can recall the blames surface was very very high in case of rice husk ash compared to even silica fume.

So, you have got when you have got very large surface area specific surface this results in this usually results in adsorption of large quantity of water reducing agent so demand for water reducing agent increases significantly when you are using rice husk ash in the extreme and flyash is on the other extreme which actually reduces down the water demand so they have a plasticizing effect so if you use super plasticizer that such kind of problem do not come with it silica fume although makes the cement based material or concrete system more cohesive.

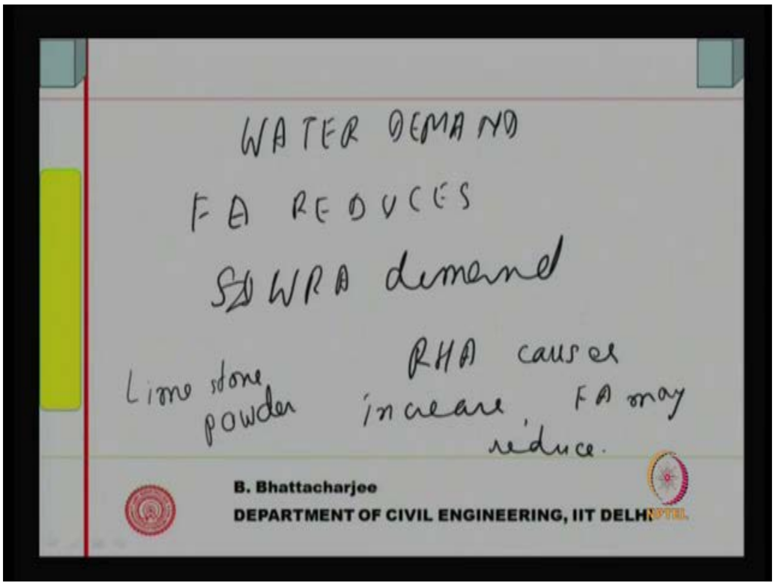
Since with since its surface area is very large because of its fine size silica fume also tends to increase the silica fume also tends to increase the super plasticizer demand so normally one has to look at the compatibility issue of super plasticizer with the silica fume and the cement system in fact as you go on increasing the proportion of the silica fume the demand for super plasticizer increases even more and thereby you know the dosage required increases so optimal dosage is usually you know is much higher quite often can be quite high in case of rice husk ash and it is that is why it creates a little bit of problem while.

(Refer Slide Time: 42:08)



Using them right so this as far as their behavior in fresh concrete is concerned so what we have seen is number one we have seen that to start with they do not effect the setting characteristics setting characteristics minimum effect heat of hydration lowered by flyash and GGBFS but, may not be may not be.

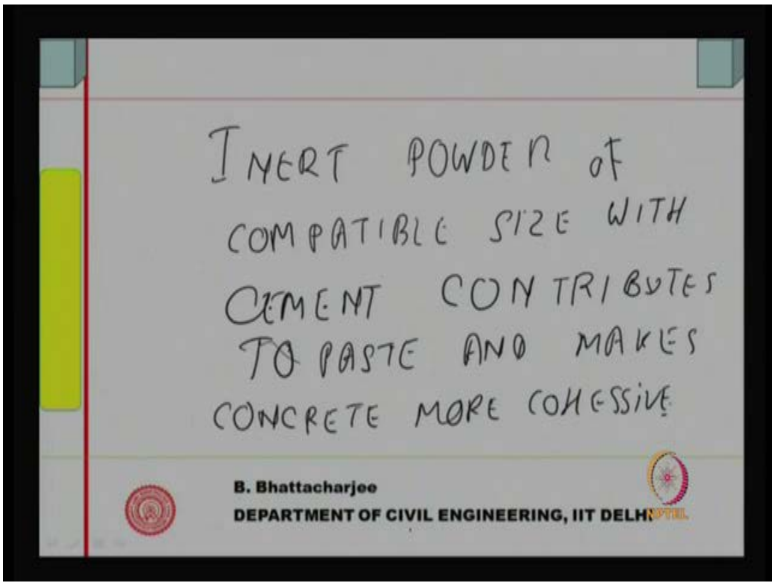
(Refer Slide Time: 43:33)



SF silica fume and RHA may not be as effective as flyash and GGBFS the next would be this is the this is the this is the these are the two main initial you know important characteristics of the fresh state the next would be reduction in water demand what we have seen water demand flyash reduces super plasticizer demand or plasticizer demand I mean water reducing agent demand demand rice husk causes increase.

Flyash may cause reduction may reduce so if I if I sort of reduction scale if I want to put them in a kind of scale flyash should be one which shows much better performance of the fresh state or enhances the performance of the cement based material in fresh state compared to let us say you know other mineral mixtures inert mineral admixtures such as you know lime stone powder lime stone powder or similar sort of thing essentially contributes to the paste of the system now if we can recall you know it is paste content.

(Refer Slide Time: 45:33)



Paste you know sometime I just stated discuss that in case of in case of concrete system paste is respected to fill in all the voids in the mortar and mortar is respected to fill in all the voids in the aggregate system so inert powder contribute to the paste and the paste it is required that the paste should be flowing paste should be flowing so inert powders they will always contribute to the play inert inert powder of cementitious size of cement size let us say of compatible size with cement compatible size you know with cement.

Contributes to paste and makes concrete more cohesive if it is pozzolonic if it is pozzolonic material then also they because of their sizes which is compatible with the cement or you know nearly cement size they can pack well within the cement system therefore, they also contribute to the paste now this has got you know in modern two types of concrete this has got high relevance for example, pump able concrete were you want more cohesion.

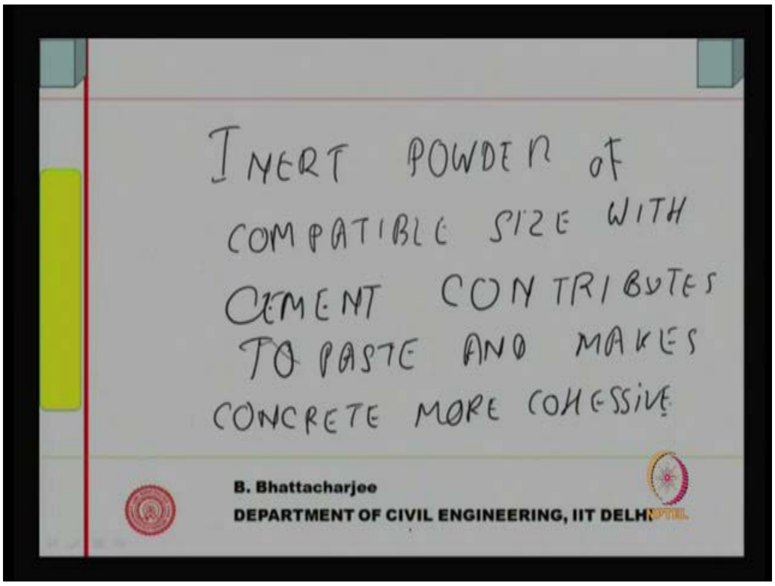
Such that water you know the slump required the something order of the one twenty cube orone 50 millimeter so when in case of pumpable concrete flyash increases the cohesion of the mix and water cannot get out of the concrete system when under you know its subjected to pumping otherwise the water also got the tendency to go out of the system leaving the solids behind this cannot occur if I have sufficient fines in the system therefore, in pumpable concrete it is necessary that I have sufficient paste content to fill in all the voids in the mortar and slightly more and the paste should be such that it can actually holds the water together and generate a fine slurry at the pipe pipe concrete inter face so that pumping becomes possible friction becomes less.

Now, such situation for pumping addition of flyash is almost may are necessity or very fine powder of the similar kind is almost a necessity you know it helps very much in a second modern concrete it will they comes very useful is self-compacting concrete were the paste content is much higher and when you talk about self-compacting concrete will be talking about this issue all again the self-compacting concrete you need lot more paste now you cannot add on cement the cement will contribute to shrinkage there will be other secondary effects heat of hydration so therefore, one would use inert powder or pozzolonic material like flyash so flyash while in self-compacting concrete or pumpable concrete or high slump concrete where you need high amount of paste you need more amount of paste and flowing paste.

Addition of this mineral admixture is all most a necessity so this two places where they again positively which right now we have discuss in details when we talk of pump ability we will be coming back to it again and similarly, when we talk of self-compacting concrete we look it look at this one again we look into the same thing so as per fresh stage is concerned fresh stage is concerned this two materials are this materials flyash act most positively rice husk ash of course, do not have act so positively it is it will be the other end and other materials likes GGBFS and silica fume also do not contribute very positively to a water reduction etcetera right so this is this is generally performance of this material in fresh state this is the generally performance of mineral admixtures their effect on.

Fresh state but, what about early strength gain when it comes to early strength gain we have seen the reaction rate of flyash is slow silica fume is itself is so fine that it can filling the pore within the cement system right in the beginning. So you get what you known pore filling effect there are by right from the beginning you might see there is increase in strength enhancement early strength there is no problem. Where is as if you look at flyash three will be some problem related to early strength gain as this flyash reaction starts only after liberation of sufficient amount of calcium hydroxide so when in together cement use flyash early strength gain is usually less compared to no flyash.

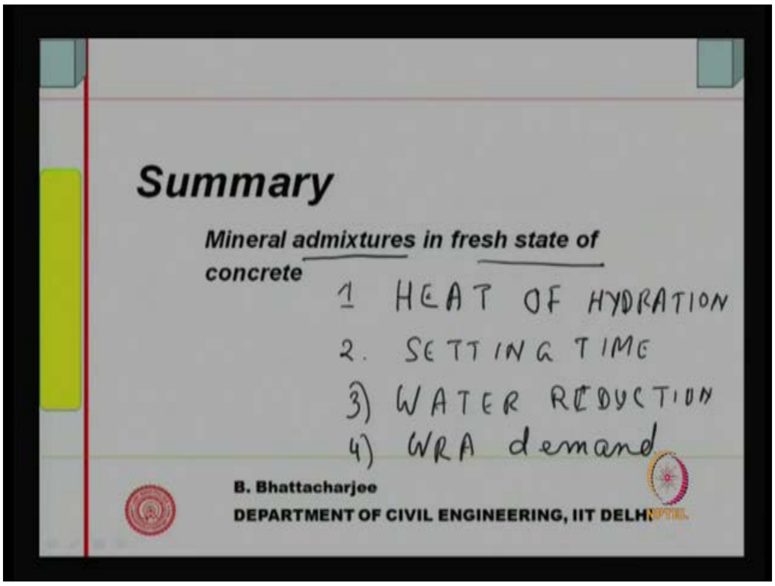
(Refer Slide Time: 45:33)



Whereas silica fume this not the problem and GGBFS also similarly, if you use GGBFS which can be used in relatively more quantity then the flyash early strength gain is not you know you do not get the early strength gain whereas long term strength would be fine. So, you have reduction in heat of hydration and at the same time the moment you have the reduction in heat of hydration because the reaction rate being slow and reaction initiation time being longer as calcium hydroxide libration has to take place so a initial you know initial strength gain is relatively less in such material but, heat of hydration is also low whereas, those material which will have high early you know do not have that much problem. In terms of initial strength gain will also will not be very much effective in reducing heat of hydration so silica fume in that sense is not as effective as flyash in reducing the heat of hydration but, if you know the effect on initial strength gain is also lower in this kind of material.

So, I think this would end of discussion on fresh concrete and initial stage of strength development in the long run in the long run all this material then to show better strength and durability characteristics because of pore filling effect because of the secondary reaction secondary hydration reaction which takes place overall longer period of time that would tend to you know improve the micro structure in terms of that would tend to increase the micro structure in terms of its soundness that is reduction in porosity is a main issue and therefore the strength gain we see.

(Refer Slide Time: 53:37)



Strength gain in the long run is more than the normal strength concrete that is for same 28 days strength you will find that the flyash concrete having same 28 days strength long term strength will be higher so is the case with silica fume but, silica fume can give in early strength you know gain or at least maintain the same early strength GGBFS also is similar in this 28 days strength being similar you might find long term strength is betterthis issue we will look into the next lecture. So to conclude this lecture we can see that we have looked into the effect of mineral admixtures in fresh state of concrete in terms of heat of hydration, setting time, water reduction and water reducing agent demand, right and we just also just talked a little bit on strength gain which we will be doing in the next class in more details in the long term strength gain and their effect on hardened concrete system. So, with this we can conclude this lecture.

Thank you very much.