**Concrete Technology**
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**Lecture - 11**
**Mineral Admixtures**

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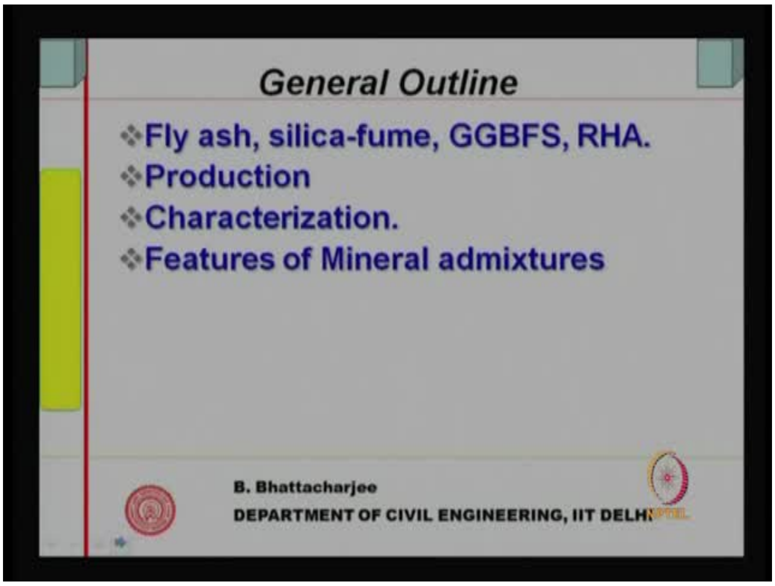


Now, we shall be looking into mineral admixture, so module three lecture three deals with mineral admixtures.

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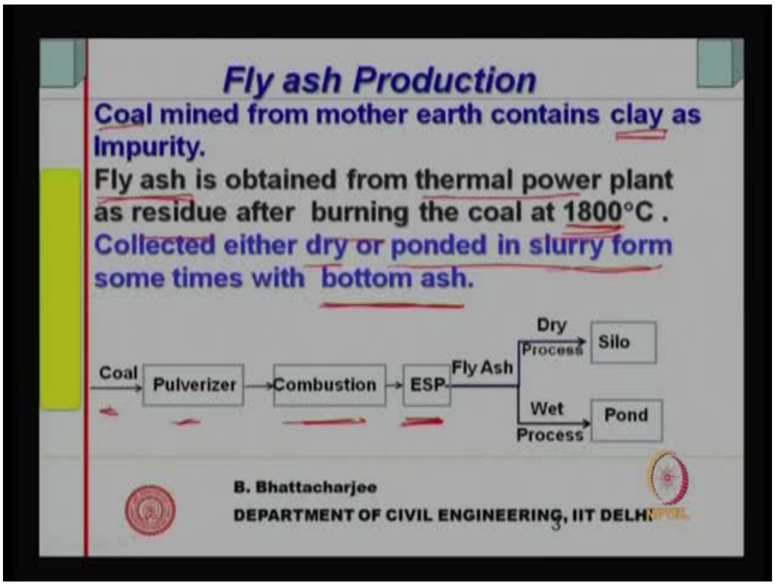

So, general outline of our discussion would be something like fly ash, silica fume, ground regulated blast furniture slag, rises cash, etcetera. These are all mineral admixtures, their production, characterization and some features of the mineral admixtures.

So, that is what we look in to this lecture 3. Now, let us see what is fly ash? Coal is mined from mother earth and it contains clay as impurity. Now, is it thermal power plant want this coal to produce energy, which is used to generate steam and finally to run the steam turbine to generate electricity. The fly ash obtained from thermal power plant finenessses obtained, actually fly ash is obtained from thermal power plant, because this coal is burnt and it contains clay.

So, when coal is grinded and burnt to produce energy at about 1800 centi grade, the residue left after burning is fly ash. The residue left after burning is fly ash, in other words it is something to do with the clay ash itself. Now, this is collected either in dry or in a you know slurry form. So, collected dry or a some sort of slurry form and a small portion of this ash as we call it goes down, which we call as bottom ash.

In fact, the ash that is generated it is a clay which is heated up together with the coal produces this ash, which flies away and some portion of ash goes to the bottom of the furnace that we call at call as bottom ash. So, we have fly ash and bottom ash. Fly ash generally goes above collected through the chimney, collected through electro static precipitator and then bottom ash remain at the bottom. So, let us see the process that coal which is actually pulverizer or made into fine powders, then these combustion occurs in furnace.

From the combustion, this the flow gases will go through the chimney and this is actually this goes through what is called electro static precipitator because fly ash being fine particle they would have otherwise gone to the atmosphere, but generally considered as hazard from environmental point of view, health point of view. So, you do not want fly ash to go to the atmosphere and deposit in neighbor hoods or elsewhere. It is kind of flying fine dust, very fine particle, so not desirable that they get spread everywhere. Therefore, there collected in the chimney itself using what is called electro static precipitators. They are nothing but electrically charged plates through which the flue gases passes.

Since, this fine particle forming colloidal solution in the air is colloidal solution in the air since this is a you know colloidal solution in the air they are charged particles. So, this charged particles essentially when they come across those electro static precipitators which have electrically charged plate actually are precipitated and they are then collected, then they are collected. So, they are collected in electro static precipitator and followed by electro static precipitated followed by fly ash production. This fly ash can be handled dry or wet process can be handled wet.

So, why in wet process what you can do; you actually mix up this ash with water and usually with the bottom ash usually with the bottom ash forming to a slurry and this slurry is transported and stored in a pound. In case of, dry process they are handled dry and taken directly to the silo, wet process put it into the pound wet process put it in to the pound. So, this is how fly ash is produced, this is how fly ash is produced. It comes from the mother earth along with the coal, the coal gets burned into carbon dioxide etcetera, etcetera, but the silica or the clay particle they form the ash.

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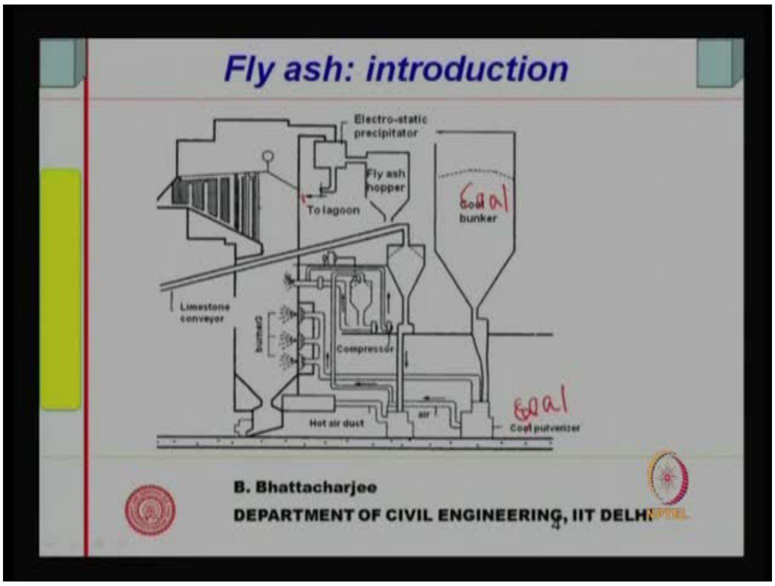


So, that is what it is, that is fly ash. Now, this shows the fly ash production again. You see this is the coal bunker, this is not cool this is coal bunker actually coal bunker this coal bunker coal bunker from where it comes to the pulverizer pulverizer this is coal by pulvirizer coal not c double o l, coal pulvirizer. And then from this you know this pulverized coal is put it in to the burning process or furnace where from the flue gases will generate, air compressed air is also passed in through this.

You know this is put into the burner and this burner would pass through the electro static, you know one gases will pass through the electro static precipitator and finally the ash is collected from electro static precipitator, this ash is collected. If they are handled dry they will go to the fly ash hopper and if they are handled wet they will go to the lagoon or the pound mixed up with possibly bottom ash.

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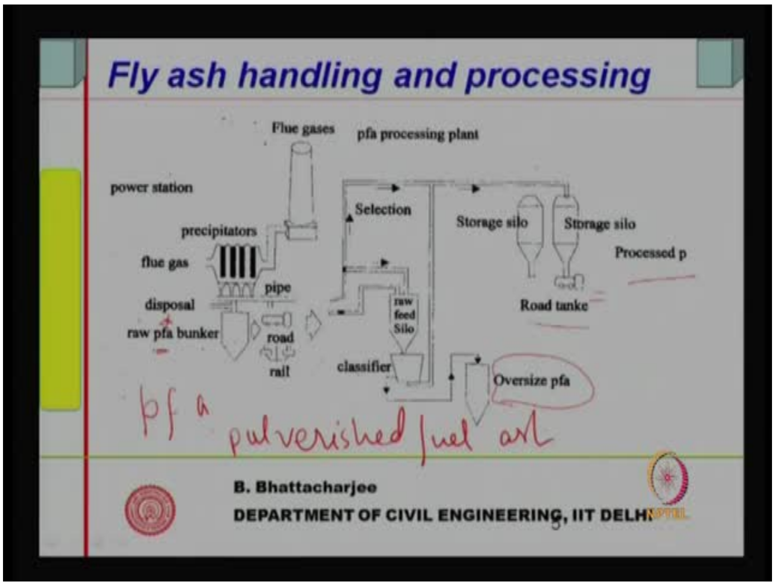


So, this is what is fly ash production? Schematically, if you look at it again to understand the fly ash as material you see pulverized this is this is you know this is first of all this is the flue you know this is this is this is basically the flux or rail or roads. Basically, production from the power station this is the precipitator and from the precipitator the some of them might go to disposal. Some might be stored in raw pulverized fuel ash bunker, p f a stands for pulverized fuel ash bunker and then they can be transported somewhere.

So, this is from the chimney, the flue gas though the precipitator this is fly ash are collected and transported and then you can put it into a classifier. Therefore, if you put in a classifier; sizes difference size deflection can be separated, some at straight to be taken to the storage silos and may be transported through road tanker to various kind of process. And here the oversize ones can be collected.

So, you can process the fly ash somewhat, whatever fly ash you get from the chimney, electro static precipitator they can be directly stored somewhere in silos or they can be passed to a classifier where the is rise over sized or large sized ones they are separated out. Fine ones take a handle separately stored in a possibly silo and then of course transported by rate road or rail or whatever is required.

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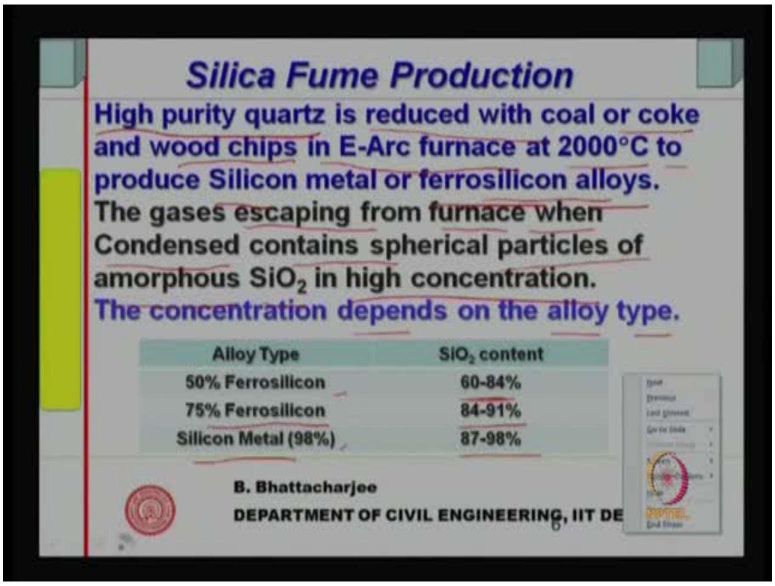


So, this is how fly ash is produced in handled. If you look at the next one, another of mineral admixtures material; it is silica fume. So, fly ash is one of the mineral ad mixtures, silica fume is another mineral admixtures. Now, silica fume is produced in silicon industry. Basically, you see silicon and ferrosilicon alloys in in their production uses high purity quartz. And this is reduced with coal or coke and wood change chips basically with carbon this reduced to produce Si. So, these are reduced actually in electrical arcs or furnace at around 2000 degree centi grade to produce silicon metal or ferrosilicon alloys. The semiconductor industry uses this material silicon and ferrosilicon.

So, whichever industry uses silicon and ferrosilicon in their production essentially quartz is reduced that is SiO2would be reduced to Si, and we in presence of you known using carbon or coke or coal or whatever it is in the electric art arc furnace. Now, in this process some gases escapes and this gases escaping from the furnace when condensed contains spherical particles of amorphous SiO2 in high very concentration.

And this concentration of coals depends upon the alloy type. For example, if you have 50 percent ferrosilicon then you will have SiO2 content in the condensed silica 60 to 84 percent. For 75 percent ferrosilicon this will be 84 to 91 percent and for silicon metal 98 percent pure, you will have 87 percent to 98 percent of silica content in the condensed silica fume. So, this condenses silica fume is reach in silica its reach in silica and that is how it is produced, that is how it is produced.

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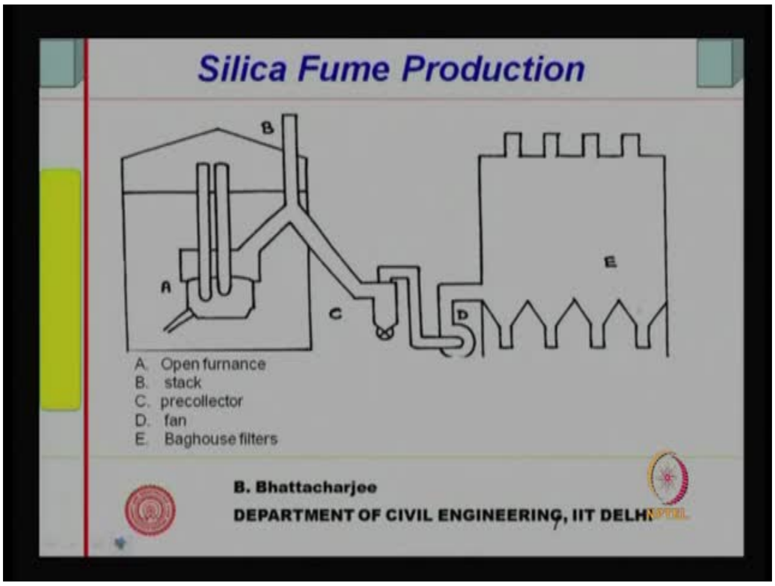


The schematic diagram will look like this; where A is the open furnace, B is the stack, C is the precollector and D of course is the fan, E is the baghouse filters. So, open furnace from where this stack the gases goes some about it is collected. Condensed silica fume comes this way, the fume goes out and the condensed silica fume comes this way. It is collected, precollector is here after there to the fan this is you know actually collected baghouse and filters, that is how it is collected. So, silica fume is other mineral admixtures; fly ash is one of them, silica fume is other of them.

Then we have got granulated bluss ground bluss furnace slag. Now, if the two material are the two extremes. Fly ash almost you get you know, it is it is actually if you do not collect it it almost environmental hazard and therefore this is you know available practically free of cost with transportation cost because the thermal power plant or the power industry finds it difficult to dispose it off.

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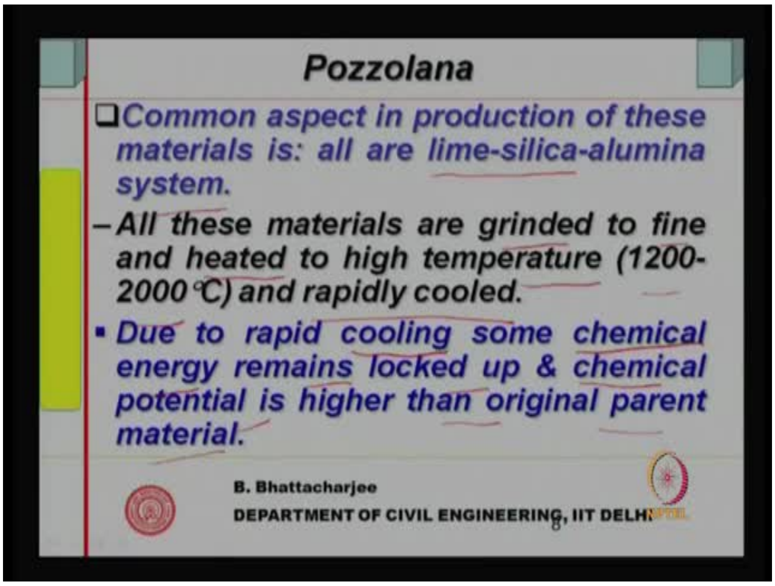


It is generally environmental concern, therefore the power industry would like that as much of as much of is it is utilized elsewhere. And they do not rep to pond because you cannot go on ponding or making what is called mounts out of them. In either case you need land and you cannot go on acquiring the land again and again.

So, for them disposal is a problem therefore, it is available practically free of cost. Whereas, condensed of silica fume it is not produced in all the countries. And therefore, it is produced only in some limited countries. Needs not much processing, only little bit of processing in terms of condensation, etcetera, but its cost is generally high in many countries. In India of course, it is about 7 to 8 times costlier mostly. It is now often it is costlier 7 to 8 times than the that of cement. Fly ash on the other hand is practically available free of cost with transportation cost. These materials they have a commonalities, all contain silica which can react.

All you know they are common aspect of this material is all comes from lime silica alumina system; they have silica and alumina. Second aspect common to this materials are they are grinded to fine and then heated to high temperature. You know, 1200 to 2000 degree centi grade and they are rapidly cooled; both silica fume as well as fly ash. Now, due to this rapid cooling some chemical energy remains logged up as chemical potential.

Some chemical energy remains logged up, therefore the chemical potential is higher than original current material. Both this cases you see in case of fly ash the coal has been heated and in case of quartz in case of silica fume quartz also has been heated. Both are heated, contain silica and some alumni of course, alumni in case of fly ash. In case of, silica fume these are other materials are very less. It is usually the silica; SiO2 content is very, very high.

So, both have been heated and cooled rapidly so that it could not reach to its naturally stable state. They are generally not crystalline, they are largely amorphous and they can react in a conducive condition. Some time the clay impurity may contain a little bit of lime also in case of fly ash. So, that is why the lime silica alumni system, they all belong to lime silica alumni system.

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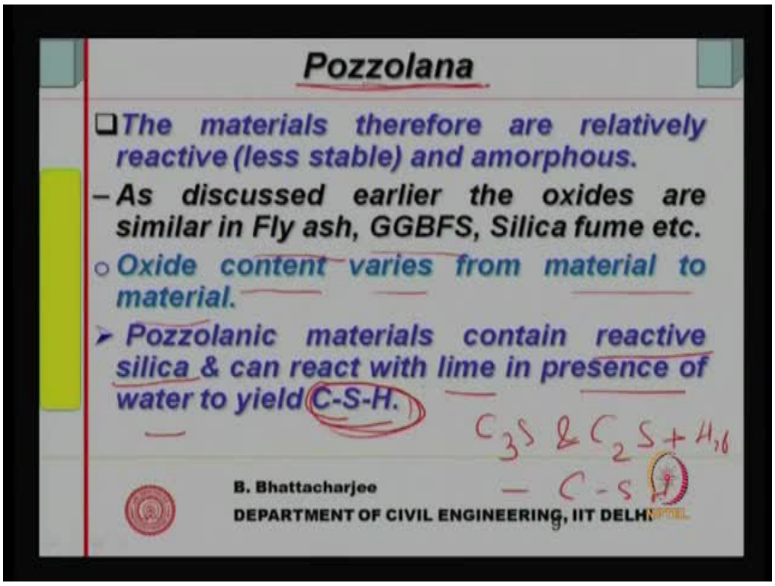


Therefore, these all as I said they relatively unstable because they are heated and then cooled rapidly. So, oxides that are present would be SiO2, Al2 O3, some cases little bit of calcium oxide and some other pieces it will be more. For example, in this case is of course is high, but I have not come to the production of the this as yet. So, this case is calcium oxide is high and some fly ash has got high lime content. So, the oxides are similar, almost similar as cement clinkerm ordinary port line cement kink clinker, but the proportional are different. This class of materials we call as pozzolana, that is why the title pozzolana we have seen and I will just explain what pozzolana is little bit later.

Oxide content of course varies from material to material, that means SiO2 content in case of silica fume is very high. It is not so high in case of fly ash and even steel less in granulated ground blast furnaces slag, rice husk ash cose again high we shall see that later on. Now, pozollanic material has the characteristics that they contain reactive silica as I said because the silica which has been heated up and cooled rapidly is in amorphous, relatively unstable form and can react with lime in presence of water to yield same product as cement hydration. We have seen when cement reacts with water C3S and C2S reacts with water plus water you know they give rise to C-S-H.

Now, lime you see is in this case of ordinary portland cement clinker, lime and silica or mixed together. They are heated calcine to obtain the opstic clinker, but here is a reactive silica and reactive lime you take, mix them together in presence of water, they will be reacting and produce the same sort of product C-S-H. So, this reaction reaction of lime with silica in presence of water is called pozollanic reaction. So, the material which exhibit pozollanic reaction is call them as pozzolana. Many most of the many mineral not many most of the mineral and mixtures and which, we use in concrete are basically pozollanic in pozollanic in nature.

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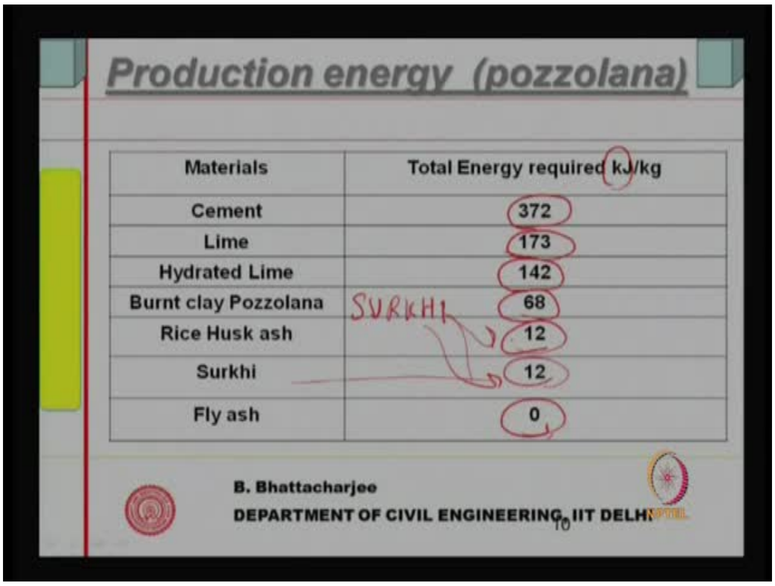


If you see the energy cement kilo joules per k g, in case of cement it is 372. Lime if you want to produce it will consume 173 kilo joules per k g, fly ash none, hydrated lime 1.42 and burnt clay pozzolana because you burnt clay for example, meta kaolin. When you take kaolin at kevline clay and calcine or heated up to about 780 degree 18 800 degree centigrade cool it rapidly you get burnt clay pozzolana or surkhi is also a burnt clay pozzolana obtain from brick. And you know when you making brick we have clay which we mould into bricks and when we heat up the fine powders as a dust which comes on bottom of the kelin, it is nothing but clay heated up to 12, 1300 degree centi grade and cooled rapidly.

Surkhi is also a pozolana, Surkhi as we call it. So, Surkhi could be one of them. This once and this one has also some energy required to produce rice husk ash about 12 k g per k, you know Surkhi is already shown here 12. So, they need much less than it much less actually. So, this produces energy least energy is consumed in the use of production is fly ash. Cement of course uses maximum, regulated blast furnace slag has got somewhat higher value, some silica few more course will have some slightly more than this.

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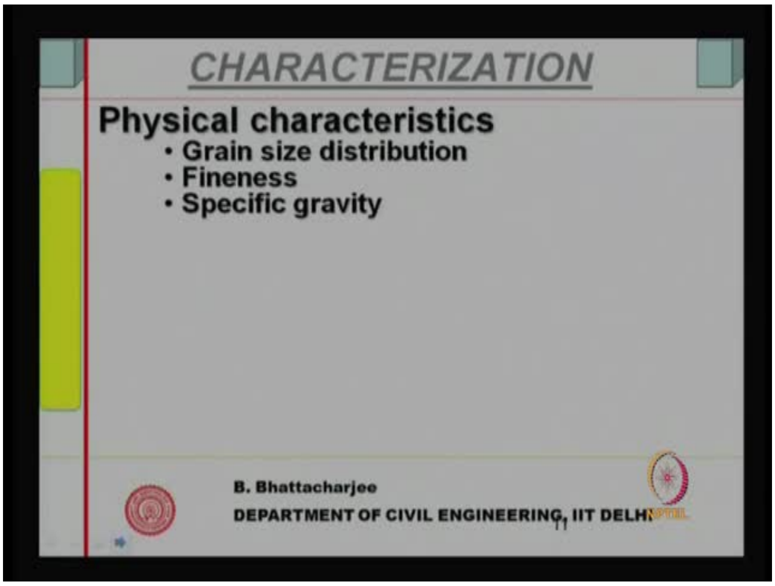


So, energy used is this. Now, let me just explain before I go to this, let me just explain before characterization.

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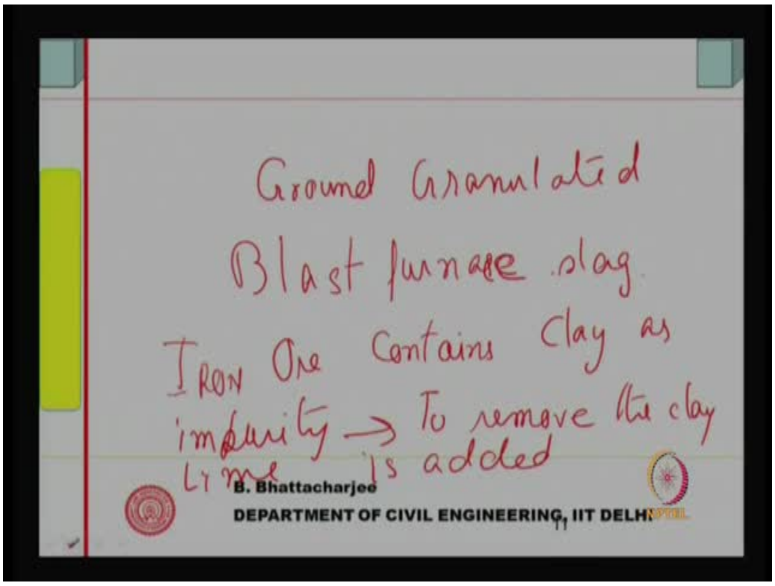


Let me just explain how do you get ground granulated blast furnace slag. You see generally iron ore contains iron ore contains clay as impurity. To remove the clay lime is added, lime is added. This lime forms the this lime forms the slag, this lime forms the slag. So, lime is added.

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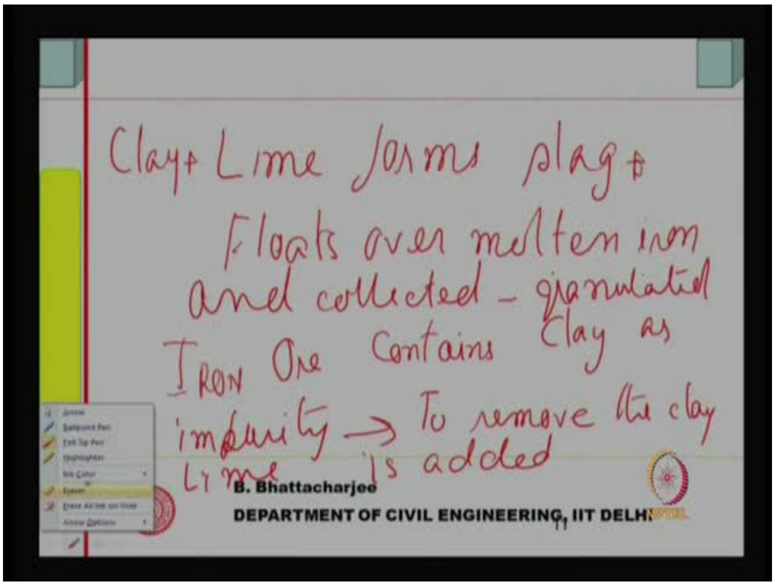


Now, lime forms lime forms slag. You know lime form slag together with slag lime form slag lime clay and lime form slag, which normally floats over molten iron, floats over molten iron and collected, granulated and grinded.

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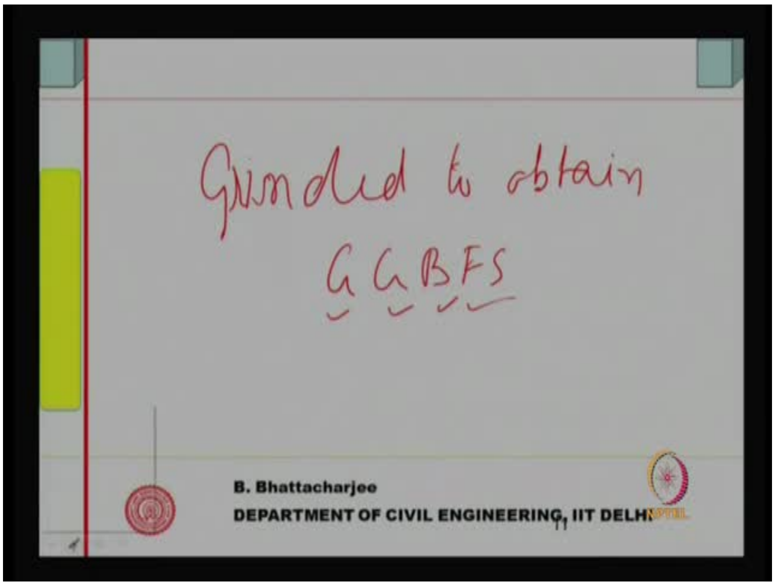


And grinded granulated and grinded to obtain G G B F S; ground granulated blast furnaces slag. Rice husk ash is obtain from rice hush burning rice husk and slightly the burning rice husk and slightly processing the same, slightly processing the same. So, all this materials there obtain by burning some sort of silica alumina system at high temperature and rapidly cooling them rapidly cooling them rapidly cooling them rapidly.

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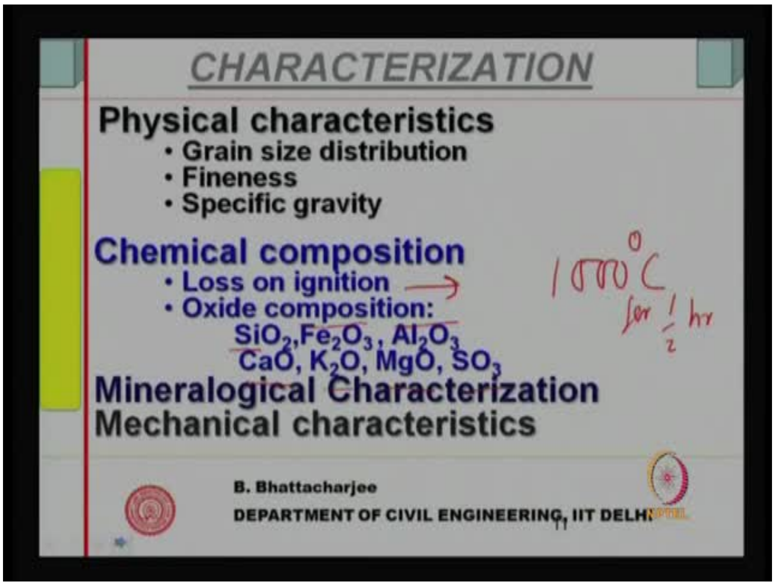


Characterization of this material; you have physical characteristics. First thing we look at grain size distribution, particle size distribution, fineness and also specific gravity. Now, grain size distribution is important because you know if you have more of the fine materials, if the particle sizes are finer they can react at faster rate. Therefore, fineness you know distribution is one thing and over all fineness is also an important aspect. So, fineness finer the material is it will react more.

Specific gravity is important because that will tell us how much is volume is there, occupy. Then we have chemical composition. We look at oxide compositions, so oxide composition like SiO2 content Fe2 O3. So, you know silica, iron oxide, ferric oxide, aluminum oxide, lime and kelcally magnesium oxide, SO3 etcetera, etcetera. Loss on ignition is an important issue, loss on important ignition is an important issue, this is determined by heating it up to 1000 degree centigrade 1000 degree centi grade and for keep it for half an hour for half an hour for half an hour.

Keep it for, heat it up to 1000 degree plus 50 degree centi grade around the temperature. Keep it for half an hour, what will happen all the unbound carbon represent will actually get converted into carbon dioxide and go away, but there will be some amount of moisture loss also. Any unoxidized material may also oxidized. So, there will be net change of mass. Obviously, it will be usually inter you know usually the loss because carbon unburnt carbon depending upon of course unburnt carbon. So, loss on ignition actually is a measure of how much carbonaceous material, unburnt carbon is available. And this is an important parameter because more of it makes it detrimental for use in cement based material or concrete section.

So, chemical composition we look at this to important thing. Mineralogical characterization, largely this material should be amorphous, but there are some amount of mineral present. Of course, that you know percentage of amorphous material is most important. More of it better it is, but still we look at the mineralogical composition if there is any whatever the mineral present there we might look into by x ray deflection.

Then of course, mechanical characteristics that is most important. So, you look into mechanical characteristics, that is something like how a mechanical characteristics are something like how how much strength potential they have with us with cement or we say with lime. So, these are some mechanical characterization, we look into some of them.

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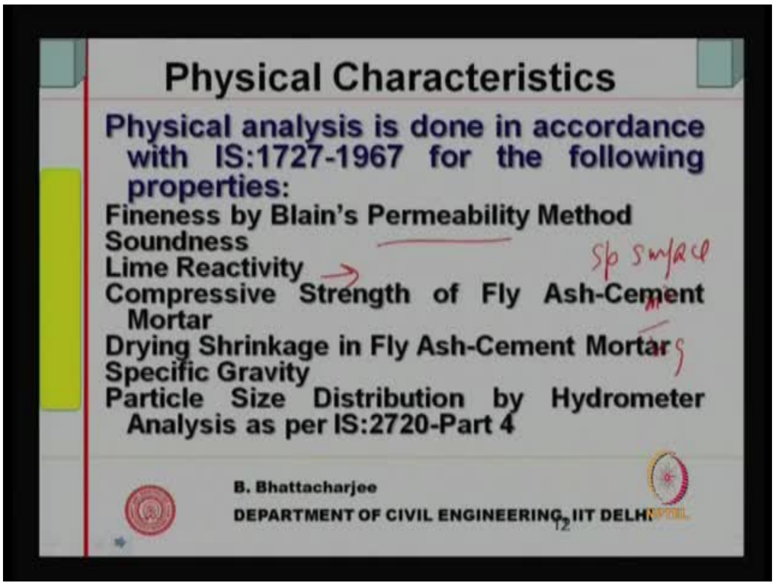


So, let us see physical characteristics. This is of course, in Indian scenario, the code that is available is IS 1727-1967 and following properties we can test. Fineness is measured by what is called Blains permeability method. I think we discuss this when we are talking of cement. You know fineness of cement is also measured by Blains permeability method. And if you recall we have a standard packing of the particulate system with a given porosity and we achieved this with a plunger and in an in a given container. We pack it fixed mass of the material and pack it in a given manner so that we get nearly same porosity.

And then we measure what is called air permeability, in other words for a constant head drop the time required you know flow for the flow how much is the time required for a constant head drop. That we find out and from this time we can find out specific surface. Specific surface is related to the air permeability. So, you can find out the specific surface and there is formula available. So, Blains fineness gives us basically specific surface in terms of like cement you know meters square per kg or centimeter square per gram etcetera etcetera. So, fineness is measured by this.

We measure soundness like we do for cement, is there any volume changes with certain reaction? Lime reactivity is an important test whereby we measure in fact the pozzolanacity. What we do is we make cubes with lime pozzolana and sand. These cubes are prepared in a standard manner 5 centimeter by 5 centimeter by 5 centimeter cube.

They are prepared in a standard manner. Basically, the amount of water is fixed from the flow requirement. So, you have a fixed flow, for that how much is the water to be added, that is found out. The proportion used are 1 is to 2 m.

So, one stands for the lime of the particular grade specified in the code analytical regenerate. 2 m is m stands for the ratio specific gravity of lime to the Pozzolana and than 9 standards (( )). So, everything else is standardized except for the Pozzolana and then you produce a cube in a standard manner by mixing in a standard manner in a water mixer and also making the cube in a standard manner, curing them in a standard manner. First 48 hours just under cover the glass and moist you know moist cloth or something like that and then in a relative given relative numerity standardized numerity for 8 days. And then test it for compressive strength in a machine compressing testing machine at fixed rate of loading. If you get the sufficient strength then it is acceptable.

Specified strength of the cube is given and that is what we call as lime reactive value, it expressed in M P A. And if you get appropriate or minimum value of specified strength you can use it either in a cement or in concrete etcetera, etcetera. So, this is called lime reactivity test. Then we have got compressive strength of fly ash cement mortar, similar test, but this time we have cement not lime and fly ash, but instead cement fly ash. Fly ash in standard proportion with cement mortar, then drying shrinkage of fly ash cement mortar not very important or common.

Specific gravity can be measured by Le Chatelier’s bottle like we normally do for cement. So, same instruments are used practically and also you can find out particles as distribution by hydro meter analysis. So, using stocks slow, which is done for soil or also you can use particles as distribution by any one of the modern method like x ray diffraction, time of transition, laser time of transition etcetera, etcetera. But in any case, one must understand that the particles are determined by one method is not comparable to that determine by another method. They are essentially comparative tool to find out fineness and particles as distribution.

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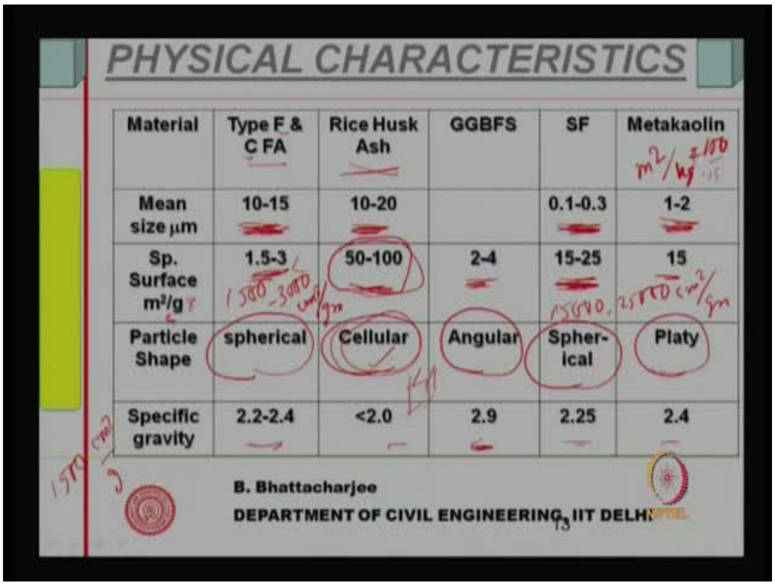


So, if you look at the physical characteristics of some of those Pozzolana, then we will see that fly ash's mean size is 10 to 15 micron. Now, there are two types of fly ash F and C. I think I will will come to that later on. See, one thing at the most moment you can remember is that type C fly ash got can have more lime up to 40 percent where as type F fly ash has got less lime in it not more than 10 percent. This classification is based on American society of testing material, S T M classification of C N F.

Rice husk ash if you look at it it has got mean size 10 to 20 micron mean size 10 to 20 micron and silica fume 0.1 to 0.3 very fine very, very fine; very, very fine. Metakaolin which I said was a calcine clay kaolin clay is heated up calcine to 700 or 800 degree centi grade and then rapidly cooled. They can have a size of 1 to 2 and micron.

So, these are all in micron, so this is in micrometer mean size. You can see the finest one is the silica fume and the coarsest one would be possibly rice husk ash or you know fly ash. Blains specific surface if you look at it if it is in meter square by gram meter square per gram. So, if I write it in centimeter square per gram that would be simply multiplied by meter square to send a 100 100 into you know 10 100 meter square per k g would be how much k g would be 100 times multiplied values the values seem to be okay, is of the order of around 1500 centimeter square per gram.

So, 1.5 so this centimeter square means 10 to the power of 4. I think this is not correct. This should be multiplied by a factor of you know this should be this divided by 10.

There is some problem I think the figure is problem. It should be 1500 centi meter square to about 3000 centimeter square per gram whereas, this is much higher. So, similar scale you should increase the this this this is not correct this is not correct actually the unit would be meter square, but relative values I think are same. So, this should be meter square per gram would have been gram would have been then there is a multiplication of 10 factor.

So, this will be this is almost relative scale are same relative scales are same. You can see this silica fume has got actually 15000 to 25000 centimeter square per gram. So, this is much higher, metakaolin is also higher and rise husk ash is still higher. G G B F S is not so high, it is comparable to type C type F type fly ash. So, specific surface is much higher in case of silica fume, even metakaolin and rise husk ash.

Whereas, fly ash has got low specific surface because particle size is here are large mean compare to this mean particle size is large. But there is a reason why this is this is got very large surface area, because this has got a cellular structure. Cell like structure you know structure will be cell like, something like this. Cellular structure I think I have something diagram.

Whereas, these has spherical particles G G B F S is ground grinded therefore, they are angular in nature. Ground granulated blast furnace slag therefore, they have angular in nature. This is against spherical and theses are platy. So, shape wise if you see this cellular that is why this shows much higher. Now, this is this is you know that is why that is shows that is that is very high that is show very high. Specific gravity of the similar range etcetera G G B F S which has got lime more lime than any other material and all other save around 2 close to 2 or 2.2, 2.25, 2.4 etcetera 2.4 etcetera.

So, this should be if it is milligram than how much it is? Anyway, this relative scale is fine. So, meter square meter square meter square per k g is around 150. So, meter square gram would be this should be multiplied meter square per gram would be much less. So, divided by 1000, so 0.15 and if I multiply this by 10 so this should be centi mili centi gram may be centigram c g. So meter square per centigram would be something like this. Anyway relative scales are fine. What we understand is what we understand is this is got pretty high value of Blain’s fineness. This is got some what much less and this is got higher because of its cellar structure.

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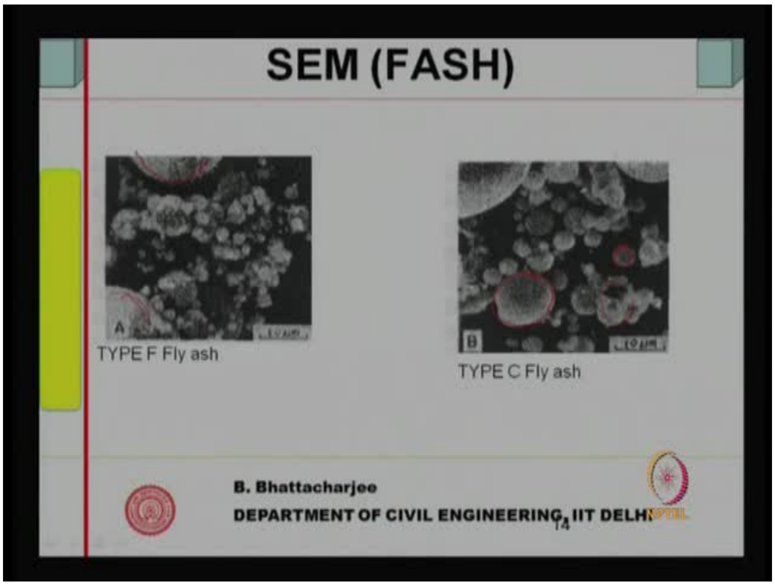


So, silica fume is a finest of all these materials. Now, if we look at scanning electron micron graph of this one of fly ash, you actually see spherical particle the white ones are spherical particles. You know these are spherical particles of the fly ash. So, generally they show spherical particle spericity, you know type C or type F fly ash both fly ash is available as spherical in nature, as you can see here like it is something like this rounded shape.

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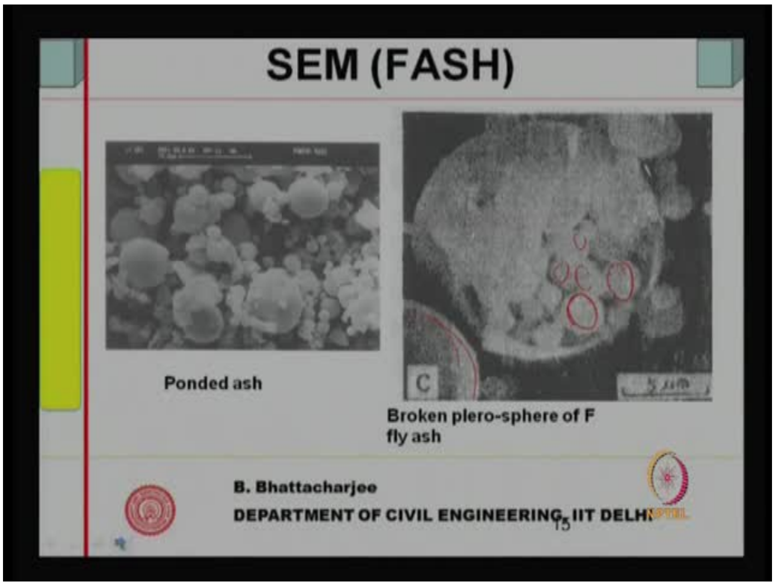

These are all rounded shape so this is this is rounded shape actually as you can see here right rounded shape. So, silica you know fly ash particles are rounded in shape. Scanning electron micros graph if you make them in to solid by bounding with epoxy or something and look in to their shape ponded ash of course, is the one which was collected wet. And this also has got spherical shape, but then there will be mix up of larger size particle. So, all look actually they have spherical shape and there is something called plero-sphere of type F fly ash.

There are largest sphere in ponded ash which will if you break it and you will find finer spheres are within them. There are some hollow sphere, which we call as sinosphere. So, fly ash particle is something like this. You know you look at this they are all rounded they look rounded. So, actually they ensure that you know that shape that you have talked about they are valid.

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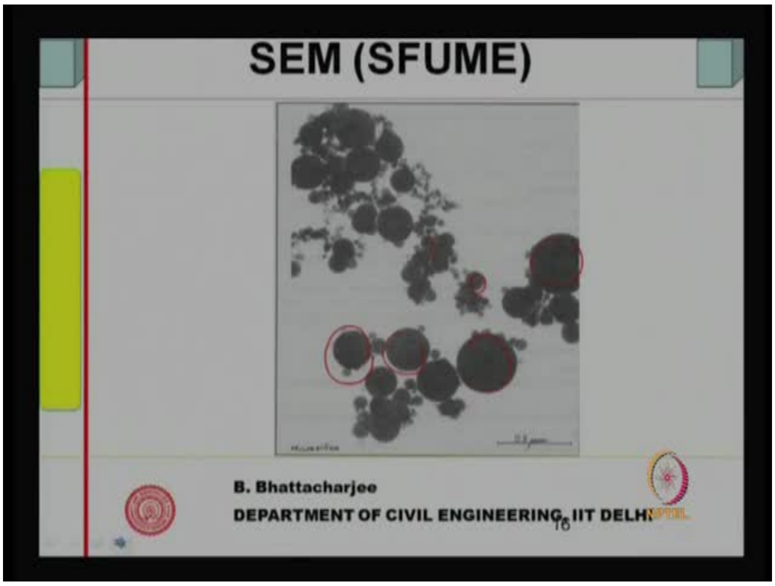


And so is the silica fume you can see that, they are all black one surface on the silica fume. They are rounded shape they rounded shape, micro silica as it is called. These are rounded shape, so these are also rounded shape. So, scaling electron micro graph shows that they are rounded shape, fly ash as well as this.

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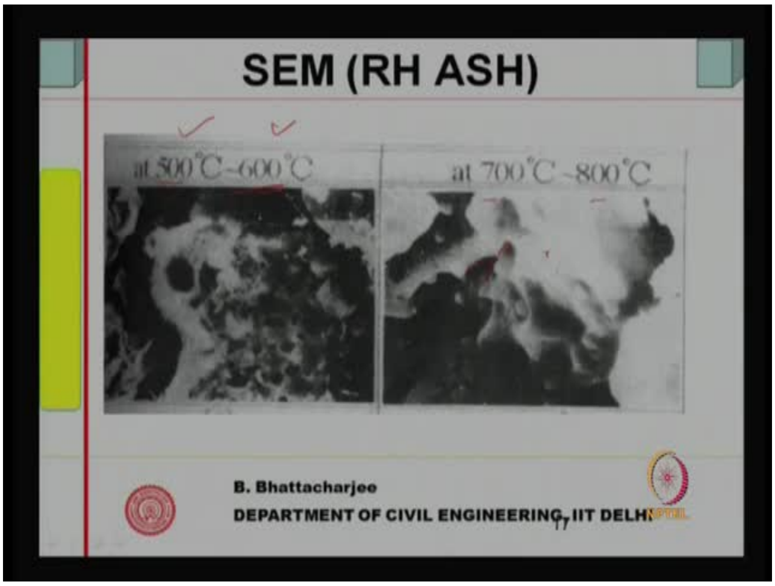


Now, rise husk ash if you see, they turn out to be cellular in nature. You know there are cells. So, this is this is not rounded shape any more, but you can see the cells, cell sort of structure; cellular structure. That becomes visible and that will depend upon what temperature they have been actually burnt 700 to 800 degree centigrade. This is 500 to 600 degree centigrade. So, depending upon the temperature you find that they are there nature differs slightly.

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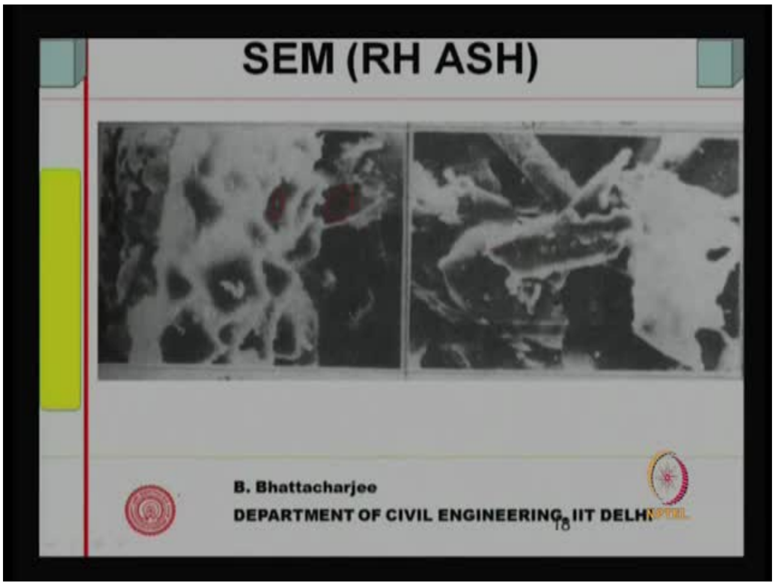

And at high temperature this shows the cellular structure of this material, the cell like you can see this is a holes in between the solid pages. So, they are cellular in structure and that is why they surface area was very, very large or the particle size are not very large.

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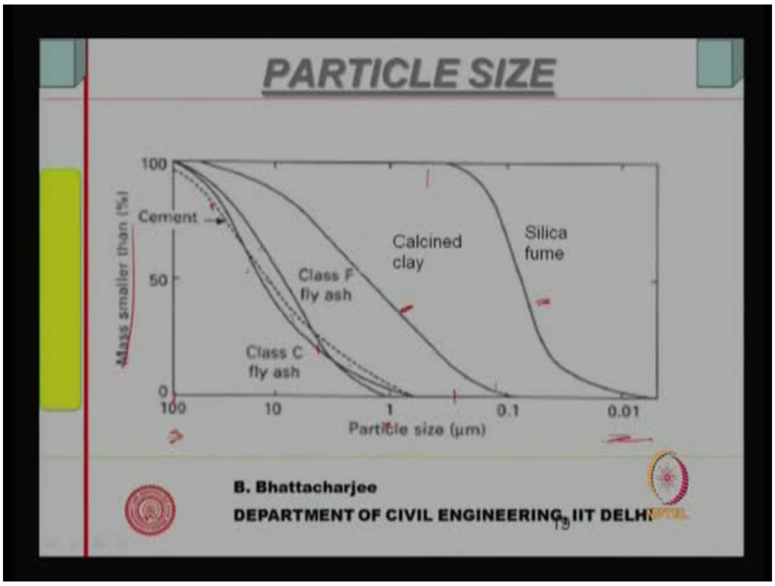


If we look at the particle size distribution, the mass smaller than this size 100 micron and this is 0.01 micron, C fly ash is here. There are you know as I said C fly ash has got lime and class fly ash will not have class F fly ash will not have lime. So, they have size very close to the cement, ordinary portland cement varying from 100 to 1 micron. 100 percent pass through 100 micron and so is the case of cement.

Calcine clay is somewhere there; relatively fine and silica fume is a finest because almost everything is smaller than let us say 0.3 micron or so. So, size wise we understand that this material finest in silica fume and the coarsest should be fly ash, meta kaolin will be somewhere in between.

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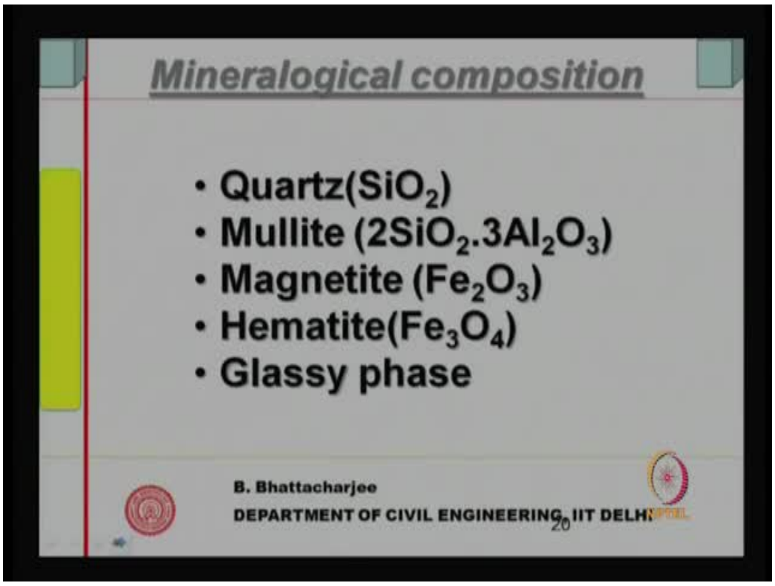


Rice husk ash of course, is cellular in structure. The mineralogical composition one looks at quartz, mullite, magnetite, hematite and glassy phases because this is most important. So, these are the kind of minerals which are present and one can obtain them from x-ray deflection study.

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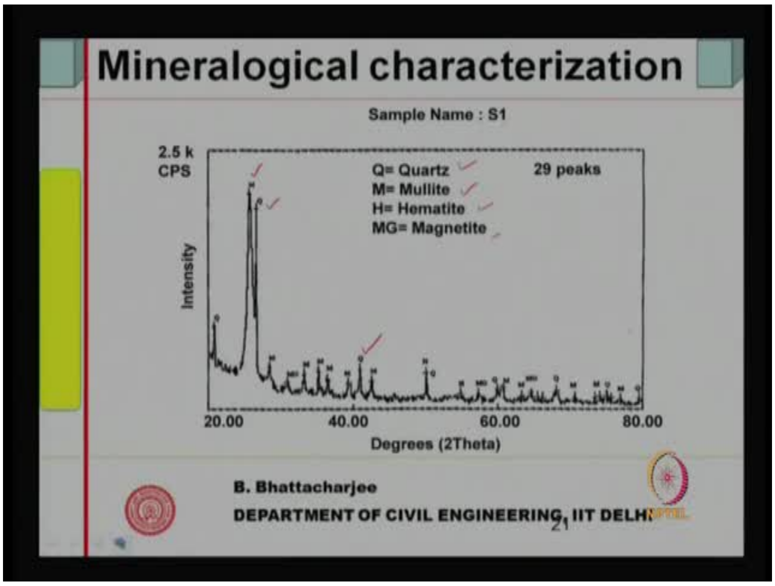


For example, this is for you know this is for fly ash. You can see that quartz is present, mullite is present, hematite and magnetite is present. So, Q stands for quartz. In x ray reflection what you do? It can find out the crystal you know, it can find out the crystal because from angle at which that x ray is incident 2 theta, where deflection occurs from the from you know crystal plane that is actually recorded, and this is mullite peak, this is quartz peak. So, you get quartz mullite, these are the material, which are present in fly ashes fly ashes.

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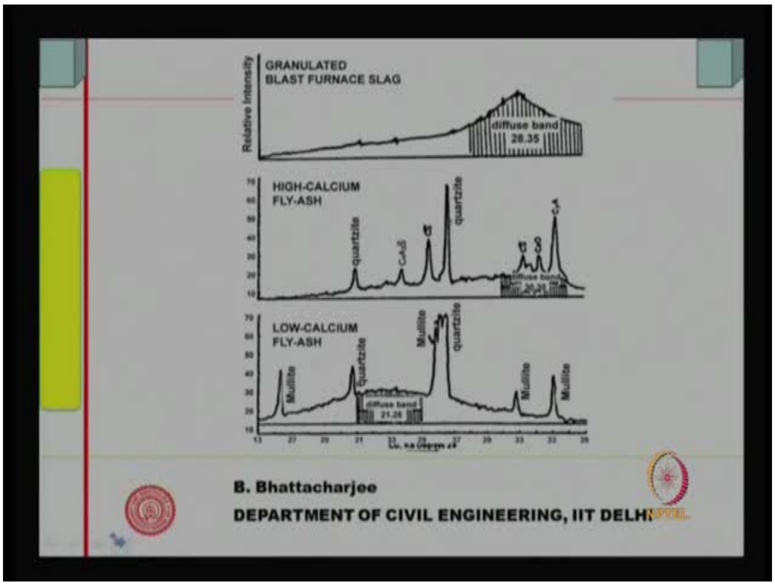


So, there is a comparison of all of them. Low calcium fly ash; you see quartzite, mullite etcetera. High calcium fly ash; again quartzite quartzite peak etcetera, but granulated blast furnaces slag you do not get many peak expect here, but it is something like this. So, it is largely amorphous and you can see this blain, which actually explain where you are got amorphous material.

So, amorphous material you know large quantity of amorphous material is somewhere here. So, these are typically the mineralogical compositions or mineralogical you know x ray deflection results of fly ash and G G B F S. More amorphous material in G G B F S compared to fly ash, which has got some crystalline material. This is shown in slightly more details, low calcium fly ash and high calcium fly ash and G G B F S.

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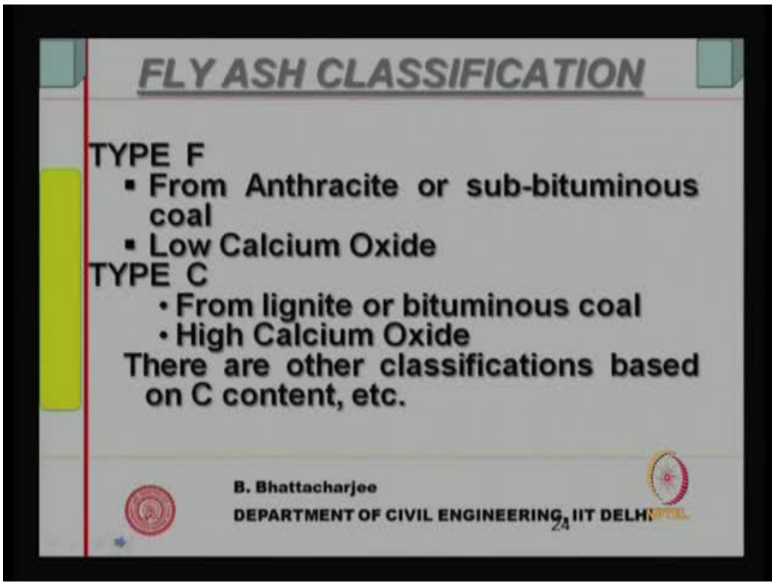


So, classification of now I can talk about the classification of fly ash. There are two types, there are many ways of classifying fly ash, but S T M classification is based on the lime content. There are other ways of classifying, but most commonly adopted classification is based on lime content and that is (( )) S T M classification. So, you have two classes; one is class F and class C and that is what it is. So, class F or type F or type C. Now, type C F comes from anthracite or sub bituminous coal and they have low calcium oxide, that is is the definition.

Type C comes from lignite or bituminous coal and they have got high calcium oxide. There are several other classification based on carbon content etcetera, but this is the main classification. In fact, in India northern India mostly you get this fly ash, somewhere in the south western region you get type C fly ash. Wherever, you get lignite coal it results in burning of the lignite coal is a results in class C class fly ash.

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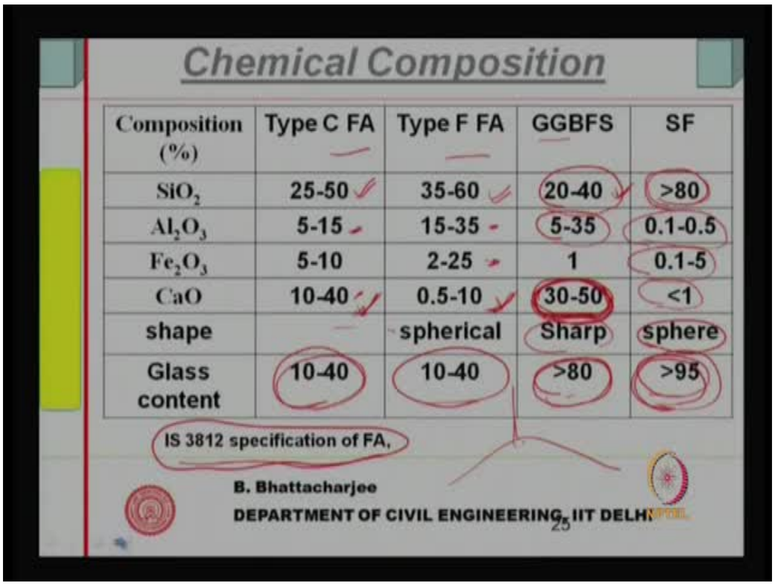
Chemical Composition

| Composition (%) | Type C FA | Type F FA | GGBFS | SF |
|---|---|---|---|---|
| $SiO_2$ | 25-50 | 35-60 | 20-40 | >80 |
| $Al_2O_3$ | 5-15 | 15-35 | 5-35 | 0.1-0.5 |
| $Fe_2O_3$ | 5-10 | 2-25 | 1 | 0.1-5 |
| CaO | 10-40 | 0.5-10 | 30-50 | <1 |
| shape | | spherical | Sharp | sphere |
| Glass content | 10-40 | 10-40 | >80 | >95 |

IS 3812 specification of FA,

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Let us look at chemical composition of all this Pozzolanas. Type C fly ash you have silica 25 to 50 percent, but you have calcium oxide 10 to 40 percent. That is what by definition. Type F fly ash of course, you will have 35 to 60, but this will be less. Granulated ground granulated blast furnace slag you have got silica 20 to 40, so this is reduced actually, but this has increased.

Lime has increased because as we as I said the blast furnace slag is obtained by adding lime to the iron ore for removal of clay. So, where when you want to remove the clay you add lime. Now, this to together form a slag, you know clay is removed by the lime and forms a kind of slag, which is again at very high temperature same like other Pozzolana, but it does what large quantity of lime compared to fly ash. Even type C fly ash you will find more lime in ground granulated blast furnaces slag. So, it has got more lime because lime is been added. Now, this slag usually floats over the molten iron. So, iron is drained out from the bottom and slag slag is taken out from the top. It is in molten state, then it is granulated etcetera.

Therefore, it will have higher lime because that was added and to remove the clay. And you have 90 to 50 percent of the lime, but then silica is less. Aluminum oxide is 5 to 35 and silica fume is slightly it has got all silica you know SiO2, large amount of SiO2 everything else is much less. This is small, aluminum is small alumina small, iron oxide is small, calcium oxide is small. Glass content is very high in this about 95 percent whereas, this has got 80 percent, but this has got less as we could see from x ray deflection diagram that this has got large lime area under that curve is much wide. You know the bottom bottom portion of the curve when peaks wave there much less peaks in this.

This has got what about 95 percent amorphous material, this is got about 10 percent to 40 percent and 10 percent and 40 percent. And if you check it up in type F fly ash you have got alumina here this alumina gas reduced because this is infused. Iron oxide is 2 to 25, calcium oxide is low, but here calcium oxide is high. This particles are spherical, this is sharp that is because we have grinded it. So, ground something which is ground material cannot be spherical because after grinding it will be angular in nature and this is again spherical, this is again spherical.

So, these are the chemical characteristic of this. Now, IS 38 Indian standard 3812 gives specifications of fly ash, it gives specification of fly ash, 3812 gives specification of fly ash. And tells you what should be the chemical composition, preferred chemical composition desired chemical composition of this material. Pozollanic activity index is one of the index.

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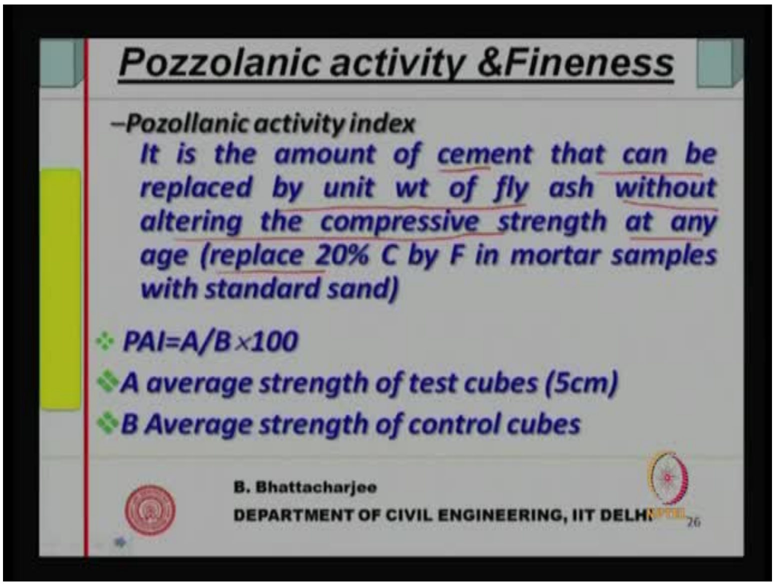


Like lime reactivity is in a pozollanic activity it shows because we tested cubes and the strength is measured. And that lime reactivity tells us about the strength potential of the pozzolana, if you mix with lime. So, that is in a way kind of some sort of pozollanic activity index, I mean pozollanic indicator of pozollanic activity, but pozollanic activity index is define in specific manner. It is a amount of cement that can be replaced by unit varying of fly ash without altering the compressive strength at any age.

So, let us say replaced 20 percent C by F in mortar samples with standard sand. So, you know it is the amount of cement that can be replaced by unit weight of fly ash without altering the composition strength at any age. That is how we define it, so let us say 20 percent cement can be replaced by fly ash without altering the strength then this is what pozollanic activity index in this. It is found out as A by B divided by 100, where A average strength of the test cubes and B is the average strength of control cubes. So, strength should be similar. What is the fly ash, how much percentage of fly ash you can add that you can find out, but in any case should not be less than 75 percent, A by B less than 75 percent.

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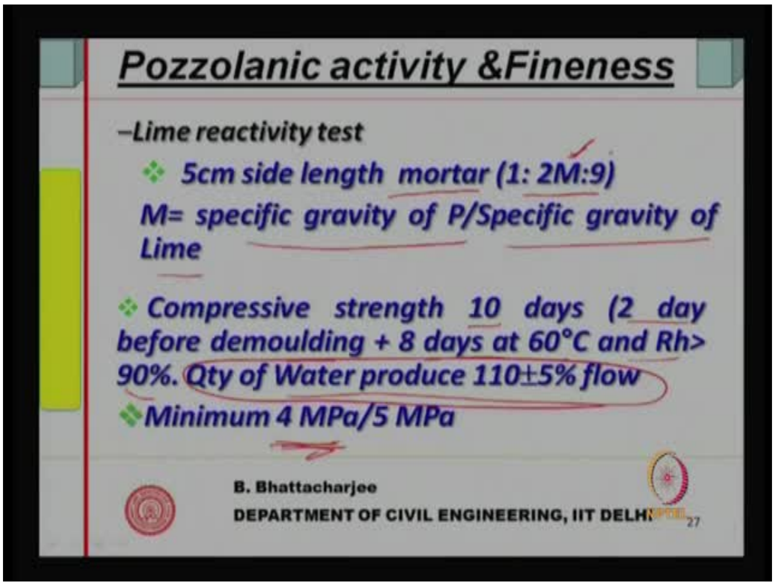


Lime reactivity test I have mentioned. You know this I have mentioned this 5 centimeter side mortar, 1 is to 2 M is to 9. M is the specific gravity of Pozzolana divided by specific gravity of lime, that is M and 2 is the standard (( )). Composite strength at 10 days, 2 day before demoulding and 8 days at 60 degree centigrade and relative humidity 90 percent. Quantity of water is used to maintain a fixed flow of 110 plus minus 5 percent flow and then find out the strength of the 10 days.

If it is less than 4, if it is minimum is you know it should be 4 MPa and 5 MPa for used in I think 5 MPa should be used in cement or concrete, 4 MPa for non structure work etcetera etcetera. So, this minimum value is specified, the (( )) should come 4 MPa at after 10 days. We test the with lime the Pozzolana and standard test perform and it must give you a minimum strength specified by the coal.

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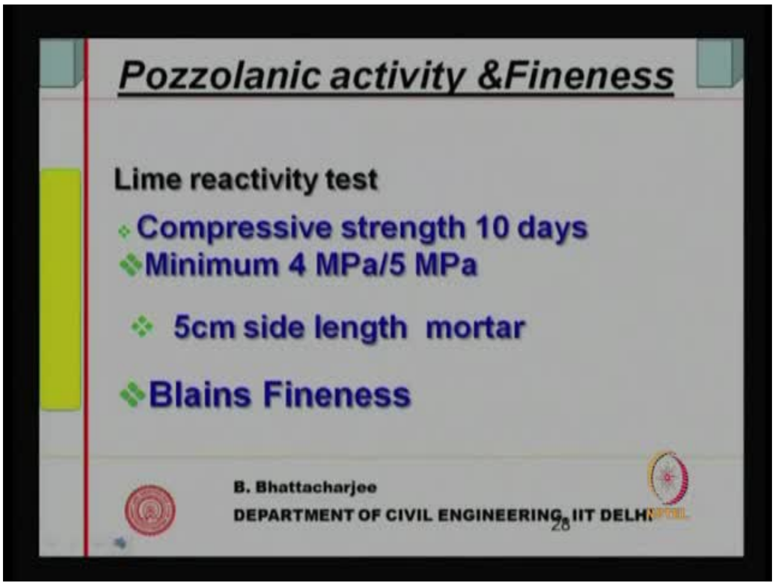


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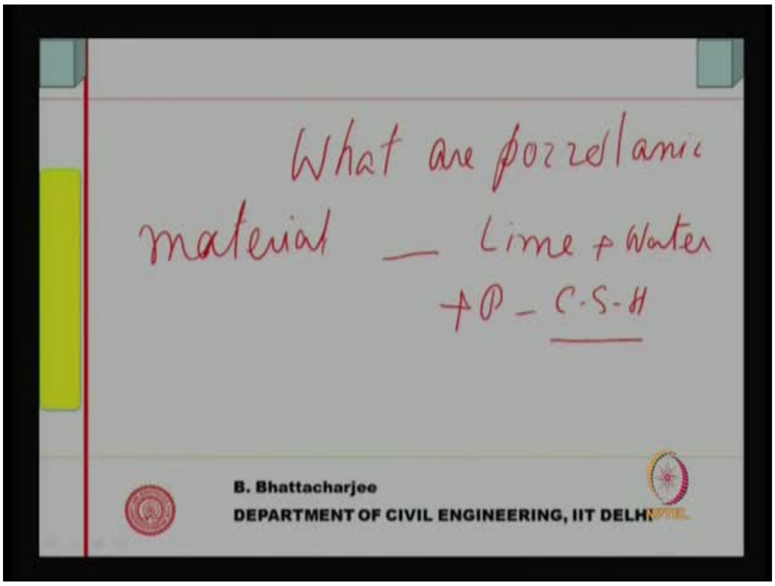


Minimum is 4 to 5 MPa, 5 centimeter side mortar that is we have seen and blains fineness is the other important aspect. Therefore, what we have seen so far? What we have seen so far? We have seen what are the pozollanic materials, what are pozollanic materials, pozollanic materials pozollanic material.

From definition they are from definition they are the one, which reacts with lime in presence of water. Lime water plus p would produce C S H. In fact, there is a little bit of history which I did not mentioned. The name pozzolana is derived for volcanic ash. Actually, volcanic ash if you look at it; they of course are not naturally available everywhere, but available somewhere. This volcanic ash particularly in Italy, volcanic ash when you mix with lime and water could give rise to production of cementing material; that is the C S H. So, that that ash was called pozzolana and from that one from that one the name pozzolana has come into that name pozzolana has come in to practice.

Name pozzolana has been derived from those volcanic ashes. So, all the material which react with lime in presence of water to produce C S H like product there called pozzolana. They are used from you know quite Roman empires 2000 years back they have been used. In fact, lime has been used for over 7000 years that is what I think I must have mentioned in the very first day I have talked about the history of concrete system. So, pozzolana 2000 years back, in India of course, Surkhi has been used in many monuments. So, this use of this aterial in motor or machinery has been there for very long time.

Now, these materials are used as a mineral admixtures in concrete. So, that is what we have discussed. What is pozzolana we have defined and then we have talk by two classify them we try to classify them or name them in terms like fly ash granulated blast furnace slag, some main ones meta kaolin rice husk slag and silica fume. And we have seen the extreme end, silica fume is finest of them, most reactive context is maximum amorphous material and amorphous silica, but and on the other hand in Indian scenario it is of course, will be the costliest of all of them. On the other hand fly ash is the cheapest one, but it size is larger. It has got minimum specific side surface and but it is a valuable free of cost.

Therefore, this material can be used in concretes mineral admixtures. So, you looked into their, first of all we looked into what they are, how they produced and then their physical characteristics, chemical characteristics and mineralogical characteristics, finally some mechanical properties finally some mechanical properties. So, I think with this we can you know we can we can conclude our discussion on mineral admixtures.

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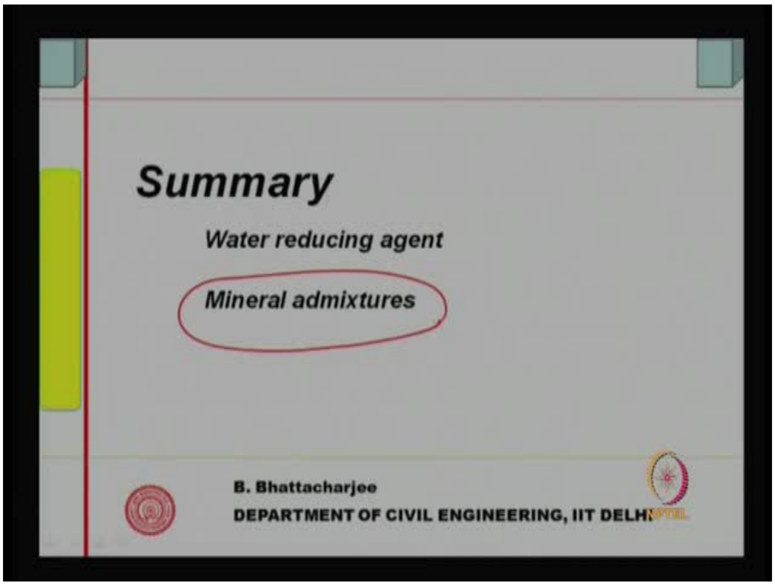


Next class we will, next class we will continue the mineral admixtures, their effect on fresh concrete and their effect on durability and other issues. So, first we look into fresh concrete, then their effect on harden concrete and last we will look into the effect on durability. So, I think we will conclude with this.

Thank you very much for hearing.