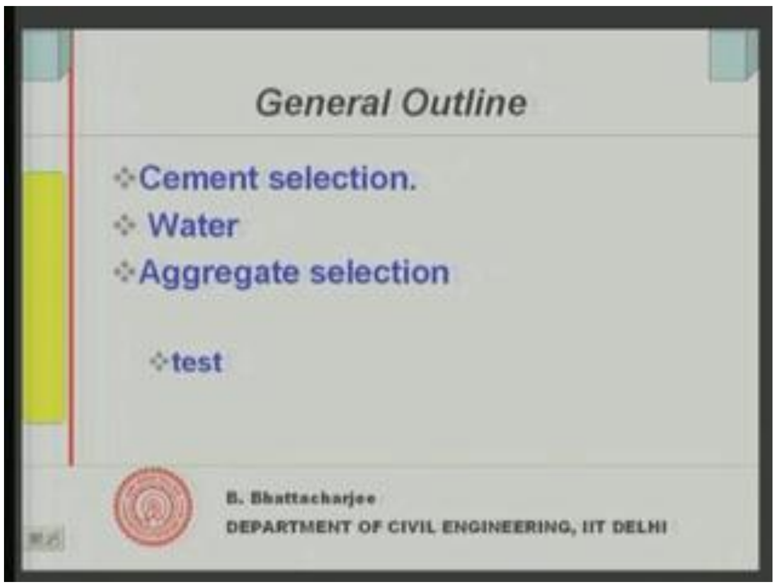
Building Materials and Construction
Prof. Dr. B. Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology, Delhi

Module - 8
Lecture - 1
Cement Aggregate and Water Selection

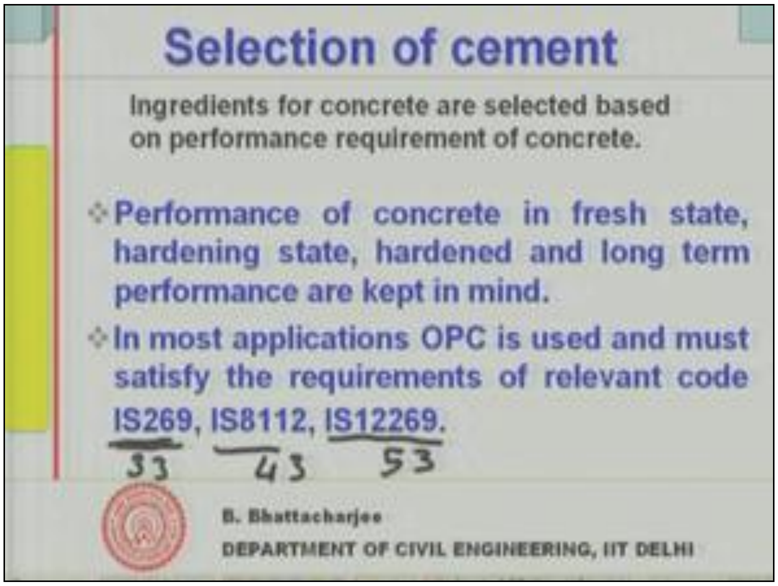
Having looked into all the properties of concrete the production process and related issues. Now, we can look into how you select material for concrete making. So, this lecture module 1 module 8 lecture 1.

(Refer Slide Time: 01:42)



We will discuss about cement aggregate and water selection, and therefore obviously the outline of our discussion to do would be. First, we will discuss with cement selection. Then we will have a discussion on water selection aggregate selection.

(Refer Slide Time: 01:53)



So, ingredients of concrete are selected based on performance requirement of concrete like cement also you select based on what is the performance requirement of concrete. What do you want from the concrete? And as we have mentioned earlier several times; Performance of concrete in fresh state that is this hardening state hardened state and long term performance are kept in mind. So, we select cement based on all this because you know we have seen earlier.

So, when we looked into types of cement then properties of cement, you know the cement itself can actually influence the properties of the concrete. In terms of its setting, in terms of hardening and then when it as hardened and in the long term strength development and durability etcetera. Therefore, cement we select according to the need. You know, as the as required you know like as we as the performance we want from concrete based on that, requirement we select the cement we select the cement.

Well; the most common of course is cement that, we have understood by now and used in. You know, and it must satisfy of course the requirements of relevant code, there are 3 codes I have mentioned here; I S- 269 meant of 33 gates. This is meant of 430 gates and this is meant of 53 gates. Now, you see this obviously is as we have seen this grade means that it will give you 33; strength on 28 days. When tested in the standard huh manner. You know, cement motor cases. So, when we test standard cement motor cube in a standard manner. Then the strength we get would be getting 33 MPA here. 33 this is 43 MPA 28 days and this is 53 MPA 28 days.

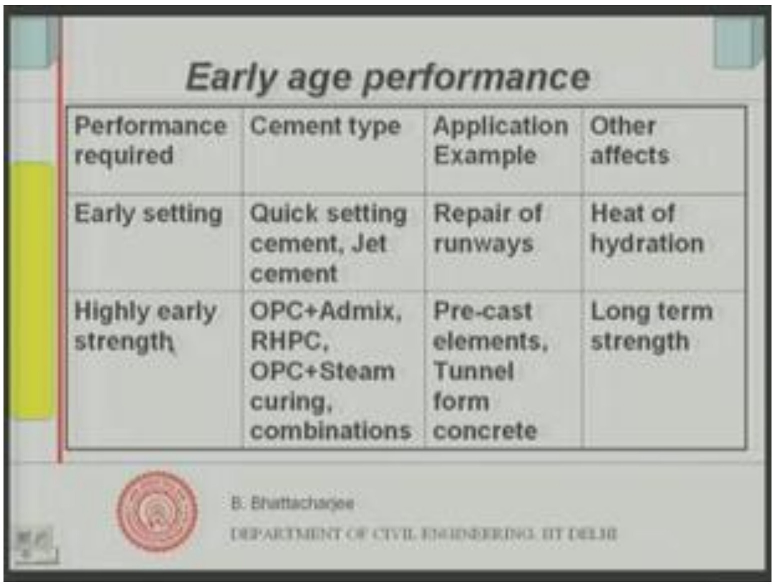
Now, this 3 cements all are ordinary cements, obviously you can understand that this gives a little bit of high 28 days cement itself. And here, it's somewhere in-between and this is huh the least;, so obviously how- how do you get it. If you recall then possibly if you recall in the beginning, we discussed about compounds of cement C3S would gives you high cement. C2S gives you, long time strength, and if you grind it more the physical fineness of the cement also, enhances the early strength.

So, that is what has been done here actually you grind it more increase the C3S content reduce the C2S content compare to this let us say to get high strength high early strength. o there is no specific need where they should be used. In fact any one of them is good enough, but if you think that 28 days strength somewhat early strength you desire this could be 1 thing, but it doesn't serve much of a purpose any one of them can be selected. This will have obviously long strength, obviously; this will have better- compared to this. And when, it comes to production of calcium hydroxide this will have large amount of calcium hydroxide produced compared to this.

The reason being this has got more C3S compared to C2S and we know, C S produces more compared to C2S. Anyway, but there is no specific guidelines or specific places where 1 should use 53 should use 33. The 2 can be used everywhere, but this can also lead to high drain shrinkage and things like that. So, that is it, but you can get a little bit earlier 28 days strength will be slightly more, and so will be 7 days strength because 7 days strength is two-third of the 28 days strength.

So, to that extent this will have some advantage otherwise this does not have much of an advantage. Most commonly, used are these days are 43, 33; was used earlier when nothing else was available. So, this is when it comes to the grade of cement grade of cement, but then OPC is used everywhere, most commonly well. Today, of course; use of OPC possibly in many, you know; small scale usage has reduced because of the availability of cement and mainly cement. You know, blended cement, but most OPC; you can use, in most of the places that is the first thing OPC you can use, in most of the places without any problem and as the most common.

(Refer Slide Time: 06:56)



Early age performance

Performance required	Cement type	Application Example	Other affects
Early setting	Quick setting cement, Jet cement	Repair of runways	Heat of hydration
Highly early strength	OPC+Admix, RHPC, OPC+Steam curing, combinations	Pre-cast elements, Tunnel form concrete	Long term strength

Well, if I am looking at early age performance, then what kind of cement shall I select? This table tells. You these cement selection ideas of cement selection. For example, this column gives you performance required. This gives you cement type this gives you an application example and other effects may be side effects you can say. For example if I want you know repair of runways I mentioned; where you cannot stop your traffic or even road sometimes, where I can’t stop my traffic then the cement I would be using should have the performance that is instead of very high early setting.

In such cases; I use quick setting cement or the jet cement, I mentioned earlier; when we were discussing about, type of cement, which acts very fast. So, if I require very high early setting, then I can use jet cement that’s an extraordinarily very high surface area and you remember that, when raw materials are different and it sets very fast. Similarly quick setting cement; so they can set very fast, but they would generate heat of hydration

So, when only you require very early setting you can't stop the traffic this cost they will be costlier surely they will be costlier cement in fact this as to be imported. Now, when you need you know when the extra expenditure is justified from, the point of view of let us say, traffic flow that; you have stopped because that would if you stop traffic flow especially, in airport runways it would huge loss to various organization. So, if you, if the additional cost is justified, then obviously 1 could go for this ones.

So, you need quick setting very early setting, then you use this sort of cement some places. You might need high early strength, for example: in pre cast element because where you have or pre-cast element. Usually you know, in concrete bridge construction. Let us say, you have bridge guiders, which are now, are actually cast in casting. If it is post tension, I mean pre tension are cast in casting and with a with the pre tensioning. Wire tensioned in the beginning itself and then cast the beam.

Now, once the beam has attained sufficient strength it can with stand some amount of compressive strength, compressive stresses due to the you must release it and you must release the bed as early as possible because that, would give you less cycle time. You can produce more at a faster rate from economy it is justified to release the bed as early as possible. Similarly, when in post tension system where you have pre cast member-segments in case of bridges.

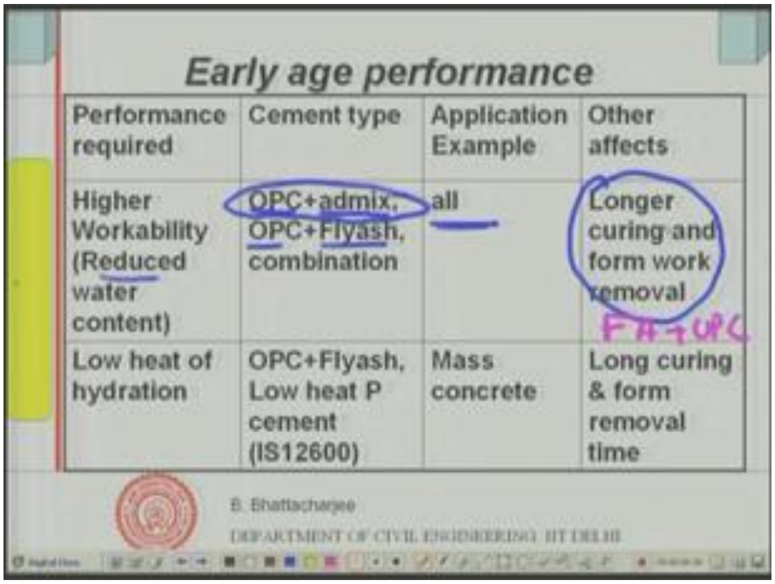
Now, those ones you would like to release it as early as possible the casting bed you would like, to release it as early as possible, because the next element, you can start casting them. So, in such situation where you would like to get some high early strength, so you can, so that you can apply some load the handling load etcetera. There you need high early strength. So, pre cast element is one of them tunnel form construction of building.

You know, in tunnel form construction of building you can possibly finish structural system of a floor in just about, 3, 4 days time. Now, what is done you have a monolithic mono lithic wall and construction and the form work can be shifted, it looks like tunnel and it can be shifted from 1 floor to another very easily, then with a crane and then you pump the concrete in and quickly do the concreting and try to get gain early, strength. So, that you can release fast, because shifting process and fixing process is very short during that period of you know, in this type of tunnel form building construction.

Let us say so to get advantage if you want to get advantage of this first rate construction. You must also do your allow you know release the as fast as possible. So, to do that 1 can use of course various means; you can use OPC with some admix RHPC rapid hard cement or you can use OPC stream, curing heat curing or any combination of them. So, my point is of course today's discussion is we are trying to select the cement. So, if I need high early strength some examples I have given you, then I would possibly use RHPC or other solutions are also available, combinations are available.

So, I can use all of them but RHPC would be used in such situation rapid hard cement would be used in such situations where you know that, I need high early strength. And obviously; we have seen earlier that if you get high early strength, this might have some effect on long term strength. You won not get as good as long term strength compared to OPC or you know other some other cement. So, when I am interested in high early strength concrete. Then I will be actually using rapid hard cement type 3 ASTM type.

(Refer Slide Time: 12:23)



So, still look at the same early age performance if I am looking at higher workability, then cement alone may not do the job. That we have seen that, cement may not do the job. We will use actually OPC plus admix. You know this is useful for all application. As I said today, the modern engineered concrete construction cannot be third of without some out of workability, enhancing plasticizer or admixes, which are plasticizers or water reducing agent and they are also called they reduce the water demand. They reduce the water demand of the concrete for the same or same workability.

So, 1 solution is used OPC with some sort of admix the other solution would be of course use OPC fly ash. As we shall see later on when we do mix design that, fly ash can reduce some amount of water? And we discussed this earlier also in connection with use of material. So, when you have OPC with edition there can be reduction in water demand. Of course, if it is, in the cement itself then in any case you don’t know whether, further reduction if you want, because if you have given water reduction further water reduction you want then you have to use an admix.

So, you can have combination of all of them to reduce the water demand and this has got huh application. Now, if you use only OPC plus fly ash not for this. You know, not for this is longer curing time would be a former time, will increase if you use fly ash combination. So, this is only true for FA; you know this is true only for FA, F A plus OPC; this is only true for FA plus OPC situations, where you might need a longer curing time. You have seen that you need 14 days instead of 10; and you need 10 instead of 7. Well; just OPC you can do with 7 here you would need curing time 10 days, when you are using fly ash.

So, curing time would be longer and so will be the case with because strength gain is relatively less in this case and in the case, of OPC and fly ash and therefore, you needs a longer period of time before you could remove the former. So, this is the other effect, then this is another case, low heat of hydration this is required in mass concrete let us say or in dam construction as we have discussed earlier, many other places where heat of hydration is a problem.

So, if you have excessive heat of hydration that heat would be locked inside the locked inside the concrete in the core of the concrete, because it may not be depending upon the thickness, volume to surface area ratio of the volume to surface area ratio of the concrete. You know, in a thick section your volume is large surface area is less. So, volume to surface area ratio is large in such situation, evaporation rate from the surface is relatively slow and all the heat from inside really do not get out. I mean the cooling rate from the surface is slow and all the heat from the core of the concrete is not dissipated in 1 it remains and as a result there may be internal. You know, it is it might be of high temperature the surface is at a lower temperature, which would like to contract.

So, when it is a thermal contraction occur at the surface, where inside still warm and no contraction takes place. As a result there will be a restrain to the surface con- contraction resulting in cracks. So, you would rather like that low- heat of hydration here the heat of heat generated itself is low. So, that you know dissipation process is low, of course you can have other means of cooling them and things like that but heat of hydration wherever it is a problem, especially mass concrete thick raft or, you know roads pavement etcetera.

In such cases, one option is used OPC plus fly ash because we know the fly ash reduces down slow down the reaction. It will have when you use OPC plus fly ash some amount of, OPC is replaced by fly ash, which means; this heat of hydration will come only from OPC; fly ash do not contribute. So, much to the heat of hydration and in fact it will be initially not reacting till some calcium hydroxide is produced.

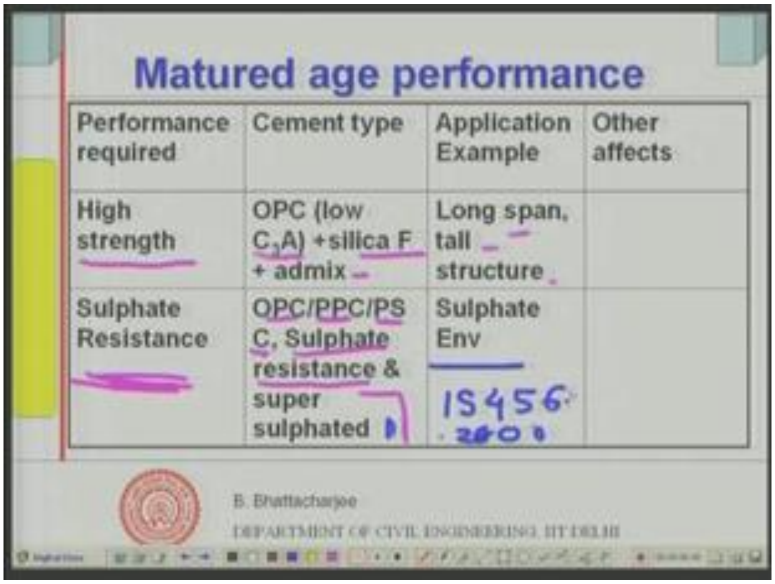
So, it is it has a dilution effect diluted; you know the OPC is now less. So, this results in less heat of hydration because OPC if the heat of hydration is directly proportional to huh quantum of C3A present; C2S, C4F and C3S present mainly C4 C3 A, then C3S etcetera. We have seen the amount of heat of hydration that comes out. So, mainly C3 A; so now quantity of C3A present in the cement. So, heat of hydration will get reduced and do not contribute so much to the heat of hydration.

You can have low heat cement; this is I S 1260 low heat cement essentially it will have less. It is would be relatively coarser, then let us say, hardening cement or OPC and we have seen, the strength development of different cements. This will belong to actually type 4 ASTM cement. You know, it is just opposite to the depict cement, this doesn’t harden cement rapidly.

So, its initial strength gain is lower but heat of hydration is also lower. So, it will have more C2S component possible then C3S component; eventually, this would generate less heat of hydration, but you might require more curing and then form removal if you are using it in situation where form removal is required, but normally when nobody will use them in such situations. They will be used mostly for mass concrete where you don’t require bottom to be removed. Possibly it is onto the ground like think raft and similar situations;, so or you know mass concrete situations.

So, there you will be using this so this 1 as to keep in mind; in case it is being used by chance, but normally; in such situations bottom you know bottom ring is not to be removed. So, usually because it is will be on the ground pavement or let us say, dam thick raft that, comes into the ground straight away. So, but curing time required is longer curing time required is longer.

(Refer Slide Time: 19:18)



So, that is what is the early stage performances are we are talking about let us see, the matured age performance. You remember we talked of maturity matured when it has hardened. Note the early stages it has hardened long durability strength etcetera. We are talking of them talking of those ones. Now, if I now if I need you know the normal strength, then I can use OPC even I can use PC etcetera. There is no problem provided I know, the rate of you know its behavior- which is known to us

So, high strength is desired, then I usually it is preferred that, a low C3A cement is used together with silica and then super plasticizer. This can be used for long span tall structure etcetera, high strength concrete, something like 100 MPA will you define, the high strength concrete above 60 MPA. We said it is a high strength concrete. So, when you are looking for high strength concrete;, so let us say above 100, below 100 instead of this you can even use fly ash and as an as an filler material and p- filler material and use super plasticizer to reduce down the water cement ratio significantly.

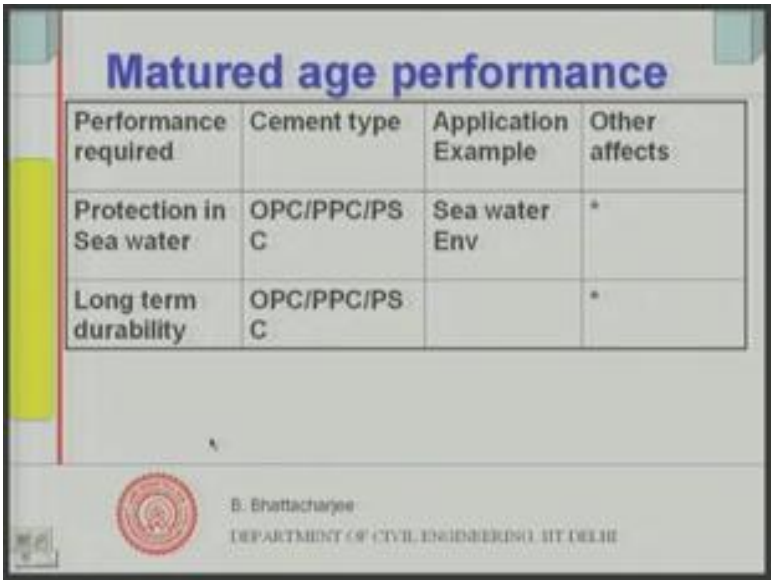
So, while you are using get trying to get high strength; the performance is high strength OPC with preferably with low C3A component. And silica fume and admix that is what is used and this is. You see, the example is in Malaysia where they have used high strength concrete in India; I think J hospital flyover in Mumbai, and there are several other structures which, are where this is being now used. The nuclear power propulsion you know that they use it first time in. So, this high strength concrete above 60 MPA concrete that, there you can use materials and this can be used, in very long span bridges or very tall structures.

So, like I said in Kuala Lumpur that's 1 of the examples, then we have seen this actually the sulphate resisting cement. So, where I want sulphate resistances, where you know, where I am interested in sulphate resistance, then I would use OPC together with PPC or you know preferably, some cases OPC in low. You can even use OPC in low sulphate, but the code gives you IS 4562 gives you the details. You can use this also but with certain additional thing. But, then I can use PPC post cement and sulphate resistance sulphate resisting cement and in very high, content I can use super sulphate d cement.
I can use super sulphate d cement, you know I can use super sulphate d cement.

So, in sulphate environment this 1 can use this you know I S 456, 2000 gives you the guideline. This guidelines for this is available in IS 462 2000, which at what sulphate concentration which of this to be used. At low sulphate concentration of course you can use OPC and some cases super sulphate d cement some cases even may be a coating or something onto the structure.

So, depending upon the sulphate that you are encountering in the environment 1 might select according to the and you remember sulphate resistance cement is 1 where I will have less C3 content cement is 1; which, is useful and super sulphate d cement is produced from we mentioned this sometime earlier 85 percent with OPC and little of gypsum. That's how we use, we produce with super sulphate d cement, which is highly sulphate resisting cement.

(Refer Slide Time: 23:24)



So, this when you have sulphate resistance you know sulphate required desired performance is that it should be able to resist sulphate. We can be using 1 of this cements sea water, again let us remember back we talked about, sea water situation and in sea water we can use some cases, we can use OPC, but PPC and PSC will perform better sulphate resisting, cement is not the not the solution. There because you remember we talked about, that sulphate resistance cements. It doesn’t bind the chloride as much as possibly select cement does PPC and both, by their virtual their low. You know, they give a better structure micro structure of the concrete both PPC and PSC and thereby they actually show you improvement. As far as durability is concerned

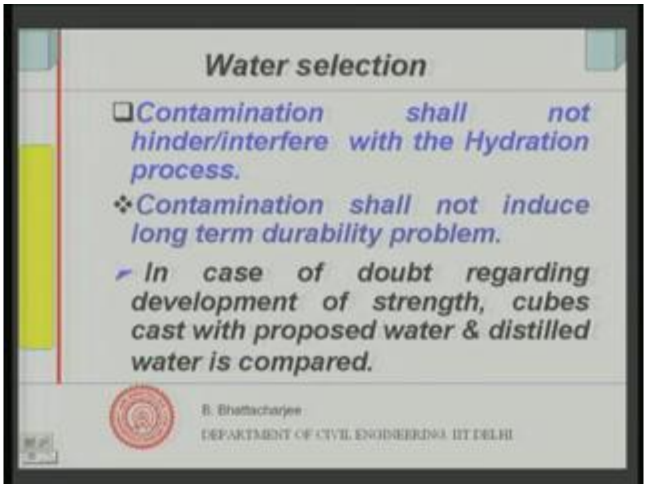
So, in sea water environment sea water environment, 1 would 1 would possibly use any 1 of this cement, OPC also in certain cases, but then we will have certain thing additional things also. You know, there choice are many, but I can use PPC and PSC so that’s what it is for selection sea water. Now, long term strength we have already seen that PPC and PSC actually improves the micro structure of concrete, the reduces.

So, 1 can use them OPC also you can use there is no problem but you know, the way where OPC will not perform as much as you know as good as PPC or PPSC. When it comes to long term- durability etcetera. But supposing I use PPC with slightly higher water cement ratio OPC with slightly lower water cement ratio will perform. So, I have choices available I can choose from, even any 1 of them. The main important issue would be what is available. I mean easily available; you know if you have to for example: if you have to like, produces most of our slack cement.

If you want to have small quantity of slack cement let us somewhere, in the northern part of India. It is not very easy; it would be it would take possible time planning requires to be better. So, what is easily available that is 1 can look into that, and with that 1 you can use you know judiciously, because if you know the behavior then using it, judiciously is possible. But certain, things are for example: almost you know not to be used, like sulphate resistance say it is costly cement.

So, if you don't have a sulphate environment why should you use;, so that kind of judicious decision 1 as to take for selecting the cement, but the cost is a major factor cost is a major factor. Finally 1 as to see what is the cost and you know, cost economy, because you can't construct something without considering the economy. So, that is how we do cement selection, specific cement selection. We will go for cement selection in this manner.

(Refer Slide Time: 26:12)



Let us say, let us look at the selection of water. Now, this is most important because large part of our, you know construction. In the particularly in the northern part of the country, let us say, NCR region of Delhi, Rajasthan, UP and Haryana. There is its it is far away from the coast sea coast and therefore, the chloride induced corrosion should have been a rare phenomena here coming possibly occasionally, but it has been seen in housing sector there is a large amount of chloride induced corrosion.

In these areas too in buildings the if you remember if you can recall the photograph that I showed, with reference to corrosion when we are talking about, durability of concrete.
You know a slab whose bottom was totally the concrete as fall of from the bottom completely. Now, if you recall that photograph this was not for the reason was actually high chloride content. How, where does the chloride comes from it comes from the ingredients of concrete in such situation.

In fact, you can you can you can you can understand you can find out whether such you know, such chloride comes from ingredient or whether they are coming from the outside. You can find out; for example, if I determine chloride in the concrete surface. Now, if the chloride is coming from coming from, coming from the ingredients, then supposing I take a sample from here cut take a sample and this core sample, I have taken out. And I measure the chloride in this I slice it off measure the chloride here chloride slice it off and measure the chloride.

You know, for each of the slice etcetera. Now, I will find the profile of the chloride if it is coming from outside. Profile of the chloride will be something like this. It will be maximum here, and less on- the other side, but if it is coming from the ingredients you will find- more or less similar chloride. You know, uniform chloride the distribution of the chloride will be uniform throughout.

So, this is the chloride from inside internal chloride. If it is internal chloride internal chloride it will be something like this. This will be the distribution, if it is external chloride this will be the distribution. So, this is external chloride;, so 1 can actually find out whether the chloride as come from inside or from outside. Now, by and large if you see the places the buildings particularly buildings. It is infrastructure this problem is not so much, because you have better quality control.

You at least you must be testing the, you know1 as to test the water quality, but housing sector this is relative- problem construction is not fully, engineered. You know, 1 would call like if you have, a sort of converted into a volumetric batching, and then mixing by simple rotary mixture. And that is not fully engineered concrete, and then water is just mixed without real full control. In such situations quite often, it has been observed that it has it has been observed that, contamination, in you know water contamination.

The chloride comes into concrete through water and where does how does it comes from, because water used in most of these north Indian places. You know, is ground water for construction. So, when somebody is using ground water deep from deep ground water source. This could contain a lot of salts soluble chloride salts, the river water will not have, because it will all chloride soluble. I mean soluble in water would go away.

So, contamination in terms of salt concentration high if you go deeper and deeper into the ground and this is supposing this is used without, testing quite often you may have lot of contaminants in it and it can results in long term, durability problem and other problems to. Now, let us see;, so first thing is contamination shall not be you know should be should not be there. And if, it is there water contaminants are there those 1s which hinders. The hydration process or interferes with the hydration process.

So, 1 issue could be contaminant presence in water it should not hinder the hydration process. For example: if supposing there is a sugar factory and the sugar factory is discharged. You know, sugar water discharge goes into the ground there and somebody is using into a pond or some such places. Let us say, somebody using this water for concrete making; obviously concrete is not going to set because sugar is going to be retarded
just as an example sugar is retarded.

So, contaminants supposing little bit of sugar comes from the sugar factory or more something like that, the goes into the water that you are using for concrete making; it may not set properly. So, contamination because sugar interferes with the hydration process. So, contaminants should not interfere with the hydration process that is number 1; it should not interfere with the hydration process this is number 1. Number 2 it should not induce long term durability problem.

The earlier example that, I have given; the example that, I have given is the is of chloride. Now, due to you know the enforcement corrosion due to chloride that is the enforcement corrosion due to chloride. Now, that is a long term durability problem. Now, contaminant actually induced a long term durability problem, whereas if I have some sort of sugar coming as a contaminant into the water, the extreme case. Of course; this means that, it will interfere with the hydration process. It will interfere with the hydration process.

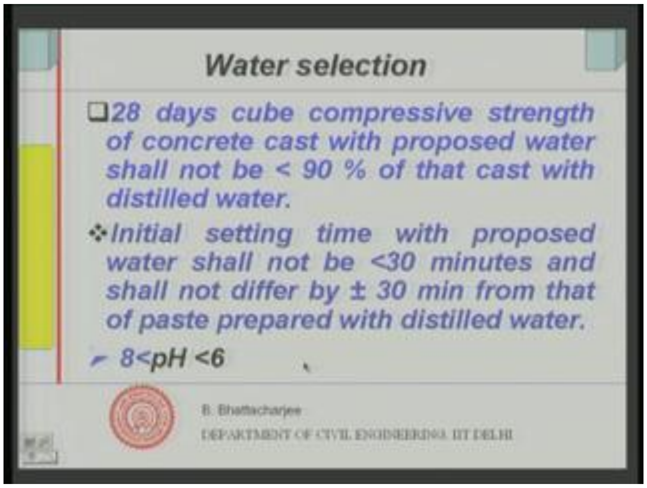
So, neither the contaminants are the contaminants in water should not do both. You know neither it should do this nor that also, it should not have too much of alkali content, which may lead to actually may be help in alkali aggregate reaction? Although that is that is not very well known but such alkalis which can react with some of those silica presence in

the aggregate. So, those are the issues contaminants should not be there; so, what is code we will discuss.
The code is given as we will discuss that the code has given us guidelines. What should be the best sort of water which will not actually lead to either of this problem or you know, problem of long term durability or problem of problem of hindrance with the hydration process slowing down or interfering with in some manner. So, the code as given us guideline that how to tackle this. So, it has given us the range of contaminants that is permissible in water that's we will discuss.

But in cases it may happen that you are little bit doubtful, because you have not been able to you have tested and you are not able to test properly and you are doubtful that it might actually hinder the process of hydration. So, in such cases 2 things 2 tests has been processed by the code. one is with reference to setting you know the contaminants present in water should not disturb the setting process. So, 1 has been 1 is with respect to setting and the other is with respect to strength development. So, it is suggested that in case you have some doubt. In case you have some doubt regarding development of strength.

You can cast cubes with- proposed water and distilled water and you can compare them simple, because where you have doubts so best thing is to do what well; take the most suitable water that is distilled water and use the proposed water, and compare the compare the cube strength results. Let us see what we compare; we actually compare 28 days cube compressive strength.

(Refer Slide Time: 34:42)



We actually compare 28 days cube compressive strength and you know strength of concrete cast with proposed water and that with the distilled water and the 28 strength should not be, you know it should be it should not be distilled water.

You know, this should be more than 90 percent of the distilled water it shouldn't be less than, In fact this is less than should not be less than 90 percent of that cast with distilled water. It should be greater than 90 percent of that, cast with distilled water. So, that is the idea. You know; so if it is coming 90 percent, then we are not really worried about, but if it is coming that, is if I say fc proposed water of 3 samples etcetera. Proposed water it should be greater than, 90 percent greater than, equal to 90 percent of fc 0.9. You know, 90; I mean 0.09 I will say, 0.90 f c of distilled water and then we can accept this water; then we can accept this water otherwise we can't accept. So, that's the idea -then initial setting time.

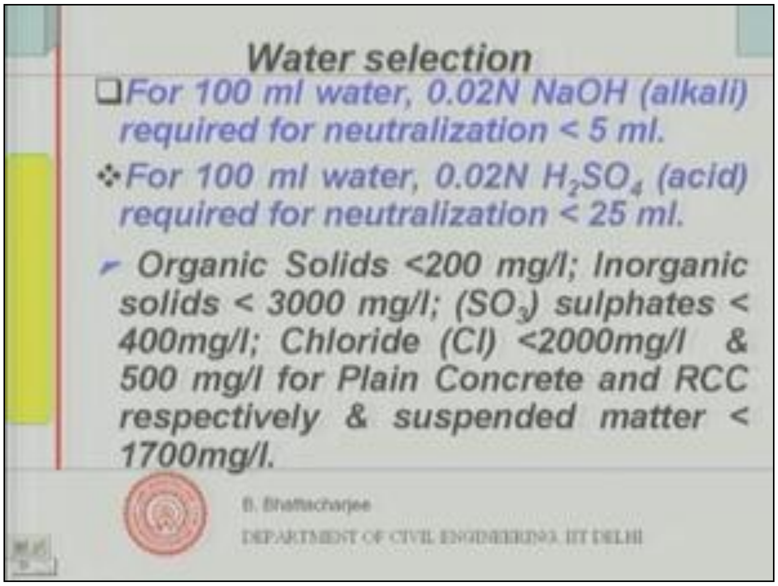
We also test the initial setting time with proposed water and shall not be less than 30 minutes obviously;, then you have a problem, if it is less than 30 minutes then you have a little bit of problem. If it is less than 30 minutes, then we have problem because you see the setting time should not be in any case should not be more less than, 30 minutes. And shall not differ by plus minus 30 minutes from that, of paste prepared with distilled water.

So, you prepare distilled water measure their initial setting time and initial setting time in no case should be less than, 30 minutes because that is the minimum requirement for any cement and this also shall not differ by, 30 minutes from that of, paste prepared with distilled water. For example, if you get with the distilled water let us say you get 60 minutes or let us say just 30 minutes.

Now, you shouldn’t get you know like- the difference between this you get let us say 90 minutes. So, 93 this difference is too large so that’s what is the point, the difference between the 2 should not be also plus minus 30 minutes from that, of paste prepared because then it is disturbing the setting process, hydration process and hardening process etcetera. So, these are the tests required. Now let us see, what are the guidelines given the code gives us a guideline that, pH should be less than 6 that’s the guideline given in code but, it is generally said that pH should be between 8 and 6. It should not be too alkaline it should not be too acidic. Because in such acidic environment the reaction process may not progress in the right way; the chemistry of course is not really of our I mean, we don’t really need into the goal, need to go into the chemistry of it. How cement reacts the mechanism, but at page between, you knows it; the reaction proceeds properly in a neutral environment; in high alkaline or low alkaline or high acidity acid condition.

The reaction couldn’t do not go properly also they might also impart to you know in the I mean; basically, impart or induce some durability problem in future. So, that is why the page suggested page in the code is that it should not be less than 6, but additionally you say that it should not be greater than 8 either. And that is why the code as given you test and this test are for example, for 100 milliliter of water,

(Refer Slide Time: 38:35)



You need the sodium hydroxide 0.02 normal. You know you take 100 milliliter of water. The amount of sodium hydroxide needed to neutralize this 100 milliliter of water. We use 0.02 normal sodium hydroxide solution and this should not be more than 5 milliliter.

If it is more than 5 milliliter that means it is more acidic then we really because this will contain some acidic material, dissolved acidic material and this is neutralized by sodium hydroxide. You know, so if I should not require more than 5 milliliter of sodium hydroxide of strength 0 to normality to you know, neutralize 100 milliliter of 100 milliliter of water. So, that if it is more than this it means that it is more acidic than I require really 1 and that’s not desirable.

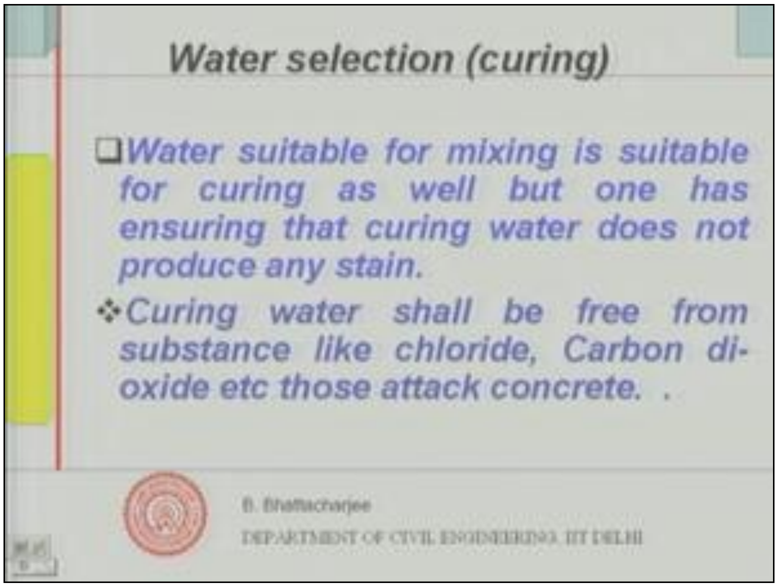
Similarly; for alkalinity I have a test and this test is 100 milliliter of water when I am trying to neutralize, with Sulphuric acid 0 to -normal strength, then I should not require more than 25 milliliter. So, the amount of 0 to normal Sulphuric acid required for neutralization should be less than, 25 milliliter that means; it is properly alkaline. So these are the 2 tests adopted in the code to ensure that it is really not as too much acidic not highly alkaline.

You know, it is within the bounds and this is to test in addition other prescription those are given or other recommendation the organic solid should not be less than 200 milligrams per liter should be less than 200 milligrams per liter to 100 PPM. Because you know, milligram per liter would mean also PPM; I mean, in organic solids 3000 milligram per liter. Now, this is important SO3 sulphate 400 milligram per liter, although you know, sulphate in really doesn't create any problem. Because sulphate in the is not problematic if it is only high. Because SO4 in you know, gypsum in the initial phase actually reacts with C3A, but excess sulphate as got no meaning.

So; therefore, there is a control on the sulphate as well but most important I would say, is this aspect. The chloride most chloride and you see, these values are restricted to 500 milligram per liter for rain concrete and 2000 milligram per liter for plain concrete. So, this is most important because this can induce river corrosion. Just this and in addition to this if you also remember that, we said that the total chloride present in the concrete should not be value certain kg per meter cube, of concrete. You, know we said point 6 kg whatever it is we just mentioned earlier overall but at the same time water should not have this.

So, this there is bound water should not have too much of chloride total chloride some more chloride might come from aggregate etcetera. So, this is most important part because chloride presence can really, create problem in long term durability.

(Refer Slide Time: 42:20)



So, that is these are the these are the requirements as far as water is concerned as far as water is concerned curing water suitable for mixing is suitable for curing as well. It is suitable for curing as well, but 1 has 1 has to ensure that, curing water does not produce any stain same problem curing water of course will not affect the initial hydration process, but it can surely affect the long term durability.

So, you can't use chloride contaminated or sulphate contaminated water for curing;, so water suitable for mixing it's also suitable for curing purposes and 1 additional feature is very much there that it should not produce any stain no color. Because if there are some you know some amount of iron present soluble iron salt is present, then its permissible as for as, the previous you know, recommendation of the code is concerned; IS 400 and 56 2000, but it might give a red colored stain.

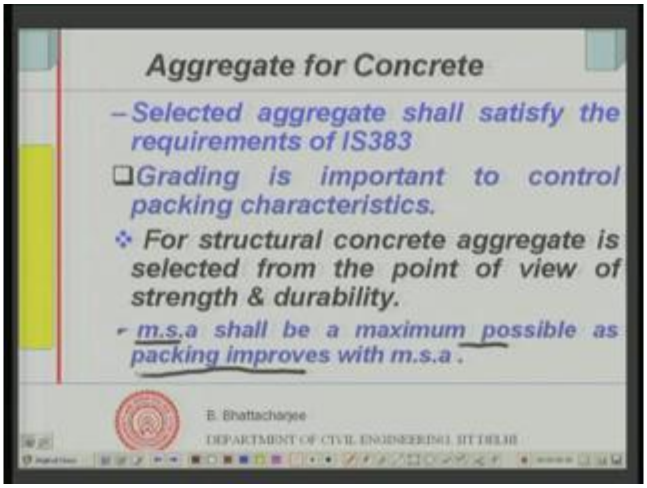
So, that may not be statically acceptable that may not be statically acceptable. So, therefore, 1 has to take additional care that it is not statically it does not create any stain as far as curing water is concerned. I have already mentioned that excess carbon di oxide or chloride which can attack the concrete they should not be present in curing water. One important issue is, this normally it is said portable water which is fit for drinking is also fit for construction or concrete mixing.

Well; by and large this is true because bacteria's all affect human being it doesn't affect the concrete by and large this is true, but- more important is the guidelines that, has been just stated or given in code and 1 has to follow the code actually. This is only some from the code to give the understanding of how should go on selecting, the water and what is the importance of water proper quality water in concrete construction.

So, 1 has to go by the code although loosely speaking people say portable water, if it is fit for drinking, it is also fit for mixing, but that is not may not be always true. Second issue is of course, the sea water well sea water should not be used preferably not to be used without, but if you are know you have no other way, you have no water. You have to use that water, then you have got to take adequate precautions, because then you know you are risking your concrete you have already embedded some sort of a kind of a germ into the concrete a contaminant, into the concrete right in the beginning.

So; therefore, 1 as to take care of this aspect that means you should see that it remains free of water during service period, should not come in contact with water etcetera. There can be more than 1 solution possible but 1 as to be careful;, so sea water is not debarred fully because if nothing is available what to do, but you must test the water whatever is available. They may be difficult that we have no water available. So, what to do well whatever is available, you test it and accordingly take right kind of precaution.

(Refer Slide Time: 45:50)



So, I mean if you can’t treatment may be very costly;, so accordingly, then you take kind of precautions that, is the idea. So, that is how we go about selection of water; let us see, how we go about, selecting aggregate first thing is aggregate should be satisfying the requirements of IS 300 and 83, which is the code meant for aggregate.

So, coarse aggregate or fine aggregate it should satisfy the requirements of IS 383; that is the first requirement; let us see, what are the specific requirements that we are talking about well, if you remember packing characteristics of aggregate is most important. Therefore, grading is important because we got to control the packing characteristics. And as I said that you do not have really a model whereby by finding out proportions of various components of the aggregate various sizes in the aggregate. I am able to find out what is my packing density what maximize or gives me the optimal packing density which, I require since we did not have that kind of packing models available anyway now there is only and not in codes.

So, most of the codes gives you boundaries of grading you know the zones or ranges of grading, which I think, I have shown you sometime earlier. So, aggregate grading ranges are usually given some ideas. I would have given you earlier, but you can also understand the fact that IS 383 gives you such guidelines you know the ranges of the aggregate permissible range zone. What are the permissible ranges of sizes, various sizes proportions of the sizes allowable sizes, that is what is the grading and it is important.

Now, you don’t have the for example; if you are mixing 2 different sizes you can mix them proportion in, proportion to get the overall grading. This is very easy, this is not a it is not a very complex job 1 can find out. Supposing you have a binary mixture consisting of 2 you know x1 of 1 particular and x2 of other particular, then what should be you know, the proportions in the overall aggregate system because we know the proportion of 1 should be between let us say, 90 to 100 another should be from let us say 75 to 95 and so on.

So, knowing the proportions that is required if I know how much of 2; I am mixing and the proportion of each of the aggregate in this, 1 and 2; I can actually simple arithmetic 1 can find out how 1 can satisfy the grading. So, grading it must satisfy and you can mix aggregates from different. Let us say or different size aggregates to get the right kind of grading, fine aggregate to coarse aggregate proportions, 1 of course decide through. So, grading is most important parameter 1 as to look into then aggregate is selected from the point of view of strength and durabil. You can’t select any aggregate; you have to select such aggregates, which will satisfy the requirement of strength and durability. Durability means, alkali aggregate reaction 1 as to look into and some strength it should have sufficient strength. It may not be very strong, but it has to have sufficient strength. And we measure this strength by what is called; you know, direct strength measurement we don’t do. We measure it through what is called aggregate crashing value.

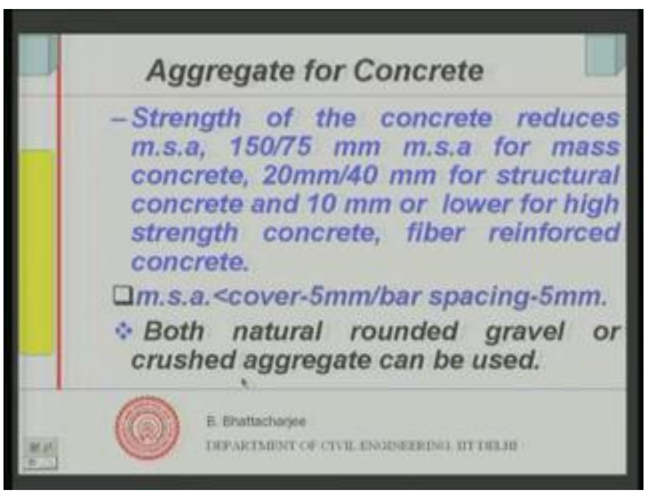
Now, this aggregate crashing value is nothing you take specific amount of aggregate passing through particular sieve and retained on a particular sieve, then crash it in a standard manner like, something like applying 4 tons load in 10 minutes or so on, with specific rate of loading. Now, when you crush this aggregates you know, crush the aggregates then it will be it some powders will be formed. So, sieve it through sieve it through say 2 point 336 millimeter sieve. The percentage passing through that is an indication how much has been crashed more crashed means, it is weaker.

So, we actually make a relative kind of test on aggregates, things like aggregate crashing value test and it must have a minimum value or it must have a maximum value to be selected. As suitable for structural concrete; so it is usually not a big thing most of used aggregates are, you know used whichever already are in use aggregates are further requirement are crashing value requirement.

So, that is 1 issue the strength should be sufficient; you just can't pickup let us say, broken bit pieces bit pieces and put it in the aggregate that will bring down the strength of the normal strength concrete. We are talking of normal strength concrete at the moment maximum of size of aggregate MSA nominal MSA, we talked about, MSA shall be maximum possible, because it will improve the packing.

So, as much as possible M SA I should like to use because that, will improve the packing. You remember we talked of more the number of you knows, number of I will have better packing single size packs do not pack so well. So, 2 will pack better and more the number of sizes are a better packing and you we also said that, I RMSA would improve my you know, it reduced down my water requirement, for mixing water for a given you remember that, when we talked about aggregate. Earlier when, we talked about we mentioned about this more we also discussed the strength.

(Refer Slide Time: 51:22)



So, when we were discussing about strength effect we said that MSA higher MSA is suit-suitable for, leaner mixes. And smaller MSA is required for rich mixes or high strength mixes. So, if you if you look from that point of view strength of the concrete reduce as MSA increases as I increase the MSA. So, we have seen that 150 75mm MSA for you know, it is used for mass concrete and 2 to 4 millimeter MSA is usually, suitable for structural concrete and 10 millimeter for high strength concrete or fiber reinforced concrete. Because the fibers spacing is related to the size of the aggregate, workability of the fiber concrete fiber reinforced concrete is related to the size of the aggregate.

So, this is rough guideline normal strength concrete maximum MSA 2 millimeter or 4 millimeter usually 2 millimeter 40 millimeter aggregate. If it is available you might use and it is suitable but this is this is roughly the idea. So, MSA selected depending upon actually strength and also on the and larger size I would like use, but 1 more issue is related to the aspect of the structural element itself that, is the maximum MSA should be cover minus 5 millimeter because it has to go between the steel bar and the shuttering.

So, it should be less than it should be less than cover minus 5 millimeter or bar spacing minus 5 millimeter. You know, this should have a bracket here bar spacing minus 5 millimeter, whichever is lower. So, MSA cannot be maximum MSA; you use shall be lesser than, this e practical construction criteria which governs in addition to the web criteria.

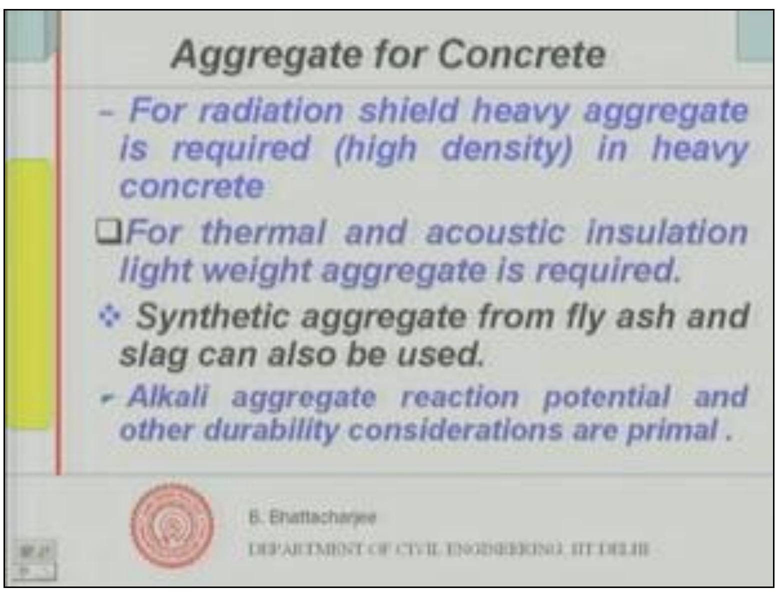
So, you select aggregate according to maximum size of the aggregate according to this. But remember higher the MSA lesser will be water requirement. So, you try to find out an optimal from consideration of this whichever whatever is maximum possible you use that, both natural rounded gravel or crushed aggregate can be used and used effectively.

You know, the behavior then there is no problem because we know that rounded gravel it will reduce down my water requirement significantly, but if its surface character is such that it is not rough, it can reduce down the strength a little bit. So, it is smooth surface of the nature. If it is there then it can reduce down the bone strength, but this might be adequately compensated due to the fact that, you will have significant amount of reduction in water content water demand for the concrete crashed aggregate on the other hand.

Well; but natural round- gravel may not be available I mean finally it is available because you can't supposing; you are constructing something in say Chandigarh. You can't get your aggregate from Chennai that's not possible, even though that must be that might be, the best one- for your purpose. So, that is not the thing that's never done wherever you have the construction you try to get the nearest aggregates possible, because the cost and it is a natural material mostly you just process a little bit a- best you crash it.

So, crashed aggregates locally available if it is sufficiently strong you know, it has doesn't have it is not potentially prone to alkali aggregate reaction, then you can use this crashed aggregate. So, usually 1 uses crashed aggregate or natural gravel whatever is easily available, whatever is easily available.

(Refer Slide Time: 55:07)



Special cases if you have radiation shield; you know like for example nuclear reactor. Now, it is need radiation shielding; you don't want radiation to come out of it. In such situation, we use heavy aggregate something like magnetite or very heavy aggregate density is very because it is the high density and the thickness. Of course, high density is required to absorb the radiation not allowing the radiation to go and this concrete we call heavy concrete. So, when you have heavy concrete heavy density aggregates are used. In very tall buildings in very tall buildings the wall does not carry any load, it is the frame structures whatever, is you know they take the load.

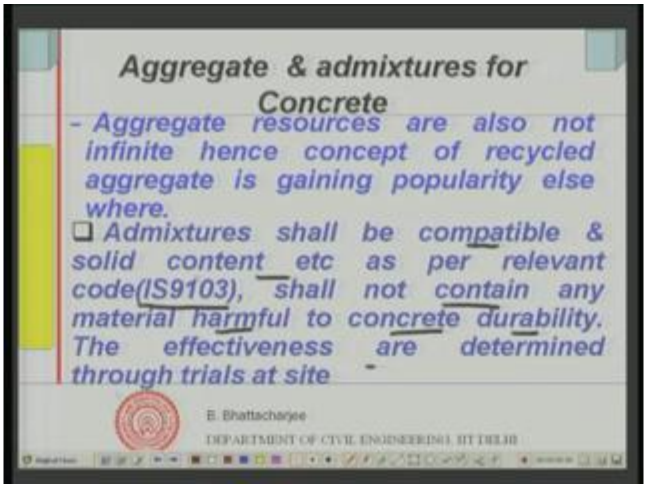
So, the envelope the actually the closing is you know this enveloped is closed. The space is closed by the walls. So, walls serve the purpose of the envelope and it doesn't have to take load it has to actually withstand its self load and any horizontal load. Horizontal load it should not itself collapse. So, it as to withstand transverse loading and some sort of self load, that is all the load it has to take;, so load is not an important criteria in very tall buildings the walls are not meant for carrying loads 56 storey buildings; many cases and nothing else.

But wall has got other functions to do; it may require you know you might require thermal insulation and acoustic insulation and in such cases light weight aggregate does the job, because thermal conductivity is an important parameter and light weight aggregate, when you use them if t- natural or synthetic synthetic aggregate could be there produced from let us say, fly ash or slag or similar sort of thing or various aggregates are produced by processes, this are you know, this they are they are chosen because of thermal and acoustic properties and not much from the load carrying point of view.

So, that is it we select aggregate synthetic aggregate from fly ash and slag can also be used for nonstructural purpose, but you they can take some structural load as well. So, but they will be less you know but load bearing wall of course you need, but load bearing wall if it is concrete monolithic wall as in case of tunnel form construction. Now, that requires strength also here the wall itself is monolithic to slag and it carries the load from, the slag is transferred to the wall and next to the next level and so on so forth.

So, there the strength is required where strength is not necessary you can use lightweight again this is most important the alkali aggregate reaction potential and other durability considerations are primal, when it comes to aggregate selection, these are the primal issues.

(Refer Slide Time: 58:20)



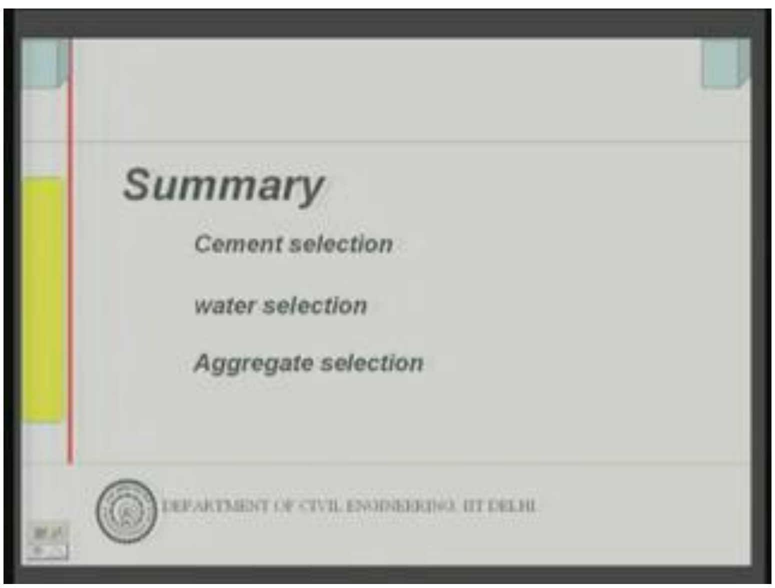
I think we have discussed most of it you know aggregate- selection earlier itself when we were talking of properties of concrete. So, now that you know it so only we are compiling the back again looking re-looking into them while selecting cement or selecting aggregate, water of course you didn't look much into water quality. So, that's what we are doing. Now, one important issue is that when you look at sustainable concrete in future not in this country at the moment we are not really using recycled aggregate, but aggregate resources are not infinite and hence you can't go on using the natural aggregates.

So, this concepts of recycled aggregate is gaining popularity somewhere elsewhere in the world and 1 may you know, think in this direction as well; recycled aggregate is popular not yet on the other hand, because you know the building you have to demolish after 30, 40 years for various reasons, because it must have done away with what is known as functional. Since such situation you demolish this debris what do you do? You have to actually do it is another kind of environmental problem.

So, you try to recycle them and use them in construction again, admixture most important when you are selecting admixtures it should be compatible with the concrete and it is you know, all solid content etcetera requirement should be seen as for IS 9103 code shall not contain any material harmful to concrete durability that's important, but the effectiveness are determined only through trials at site, there is no other way you can do it, admixture finally its compatibility, whether it as got any side effect or not that has to be tested with the concrete that you are using.

So, once tested once you have satisfied then you can use this there are various because these are all commercial product, the blended product the commercial product and when you have to test them, to actually see their compatibility what might be compatible with 1 particular cement, may not be compatible with cement. So, this is an important issue selection is based on systematic procedure of testing and nothing else. So, 1 as to go by testing; in fact there are compatible test for high strength test is done then there are mini test and so on. So, there are several test for testing compatibility of admixtures, finally you do the test see whether it is actually reducing your water demand or not and does it have any side effect or not. So, that is how we select materials for concrete construction.

(Refer Slide Time: 01:01:06)



Well, so what we have seen so far we have seen cement selection how do you go about selecting cement and we have also seen, how do select water the contaminants in water and lastly we have looked into aggregate selection and admixture selection. So, that is the first step in concrete making, but once you have decided then next step is of course is to go for designing the mix and that is it. I think this summarizes our discussion on concrete material selection.

Thank you.