Building Materials and Construction
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Module - 5
Lecture - 4
Fresh Concrete:
Segregation and Bleeding

Last aspects of workability that is what we are going to discuss today are: segregation and bleeding. So far we have looked into workability with reference to fresh concrete. So, this is the last aspect of fresh concrete are segregation and bleeding. These are 2 phenomena which takes place in fresh concrete.

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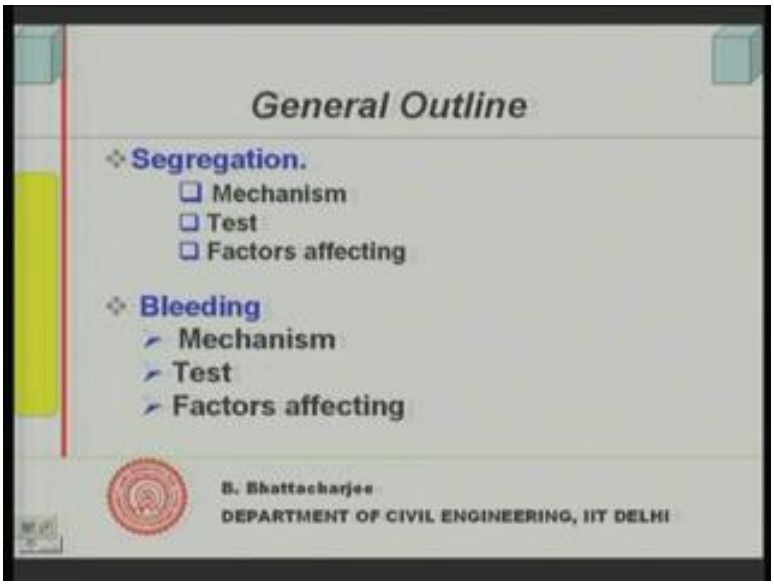

So, we shall first look into segregation. We will discuss about the mechanism, something about the test possible test for segregation and then what factors affect segregation. Then we will look into the other phenomena, that is, bleeding and then we will look into its mechanism, tests and what factors affects or how we can control bleeding. That is what we will look into. So, let us start with segregation.

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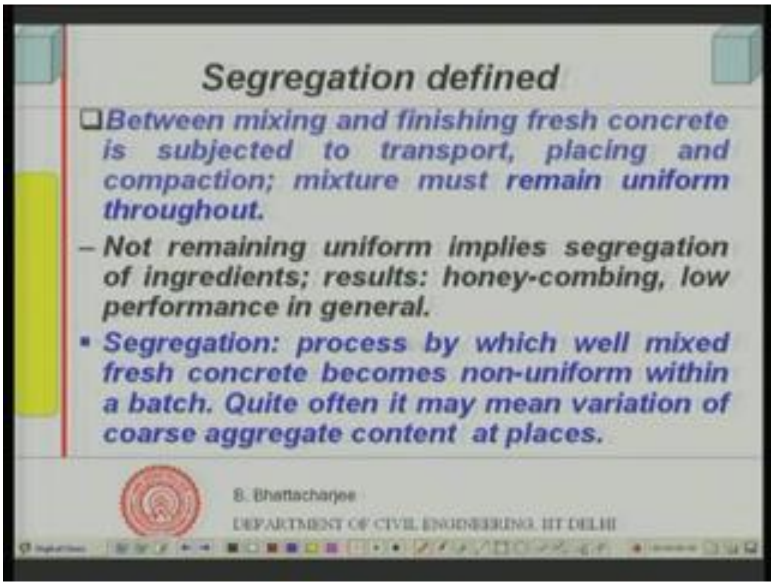

Let us define it. Well we have seen through several of our earlier lectures that, concrete from the time of mixing and finishing. It is subjected to transportation, placing and compaction and during this process it must remain uniform. If it does not remain uniform, then we call it to segregate. Does not remaining uniform implies that, ingredients are separating out and that is what we call as segregating.

Well, results some of the results we have earlier seen namely: we have seen something honey-combing. That takes place that could be the result of segregation, because the coarse segregates remains and the fine aggregate separated off from them and that is what 1 kind of segregation is, it can results in honey-combing. And in general this can result in low performances.

So, that is what the result of segregation is. Then this is therefore, if you define it; is the process by which well mixed concrete, you know fresh concrete becomes non uniform within a batch. So, in a batch which you have mixed properly together uniform concrete, this process of segregation is the process by which, the concrete will become non uniform, it will become non uniform for the same batch. And it may mean variation of coarse aggregate content at places, basically when you were talking of segregation, this phenomena essentially means that, coarse aggregate content would vary, because ingredients they are non uniform now. So, in some places they will have 1 material, some other material place other material.

Since, aggregates are the large part of the material, you know bulk of the material is the aggregate and that to coarse aggregate from bulk of the volume of concrete compared to other ingredients, so quite often the proportions of coarse aggregate in 1 place, would be different then other place when it has segregated. Segregation results in coarse aggregate proportion being different at difference location. So, that is what we are saying; that is how we define segregation right. So, that is how we can define segregation.

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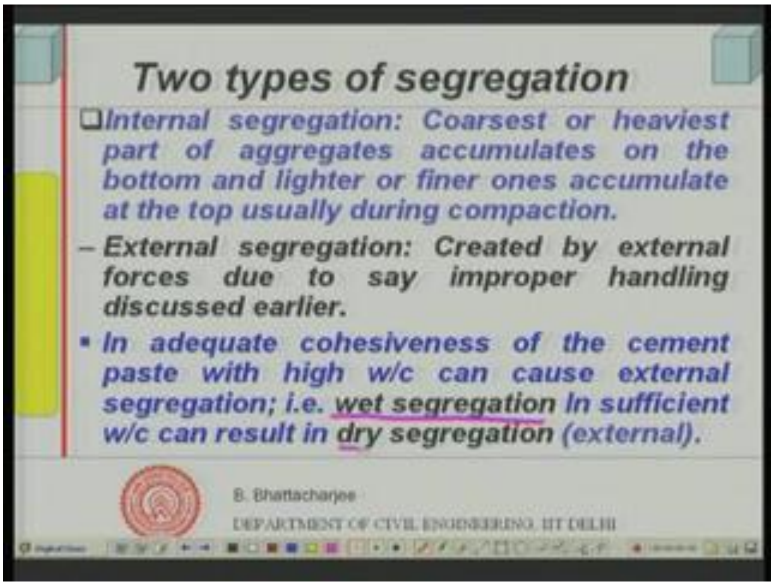

Then let us see what are the types of segregation? Two types of segregations are defined; 1 is called internal segregation, where coarsest or heaviest part of the aggregate, tends to accumulate at the bottom, you see tend to accumulate at the bottom and lighter and if it is usually the finer ones, that tend to accumulate at the top of the mix, usually during compactions.

So, you have a section, you have a section of the concrete let us say and the bottom will have heavier, you know in the bottom will have heavier aggregates right; this portion. And the top aggregate would tend to accumulate at the top, you know top. So, this is lighter, this is light this is heavy coarse aggregate, usually coarse aggregate are heavier and when this happens, we call it internal segregation, usually the aggregates, the coarse aggregate which are heavier will have a tendency to settle at the bottom, compared to the lighter finer aggregate you know and motor containing the finer aggregate, that will have a tendency to set. So, that is the result of an internal segregation as opposed to external segregation.

Now external segregation if you look at it, that is due to some sought of external forces, say improper handling and this we have discussed earlier. We have seen that, if you do not discharge a concrete from the mixture in the right manner, then large size aggregate particle may be placed somewhere whereas, the fine you know like for example, is a drop from a very height more than 2 meter or dropping directly you know or through an inclined very stiff slope if you are dropping it over the bottom opening is very small or inclined etcetera, several of them we discussed earlier. We have seen that, when you are not handling properly, it can result in segregation, because and larger particle will have a tendency to move away from the discharge point and the motor will have a tendency to settle very close to the discharge point. And that kind of segregation you have looked earlier in 1 of our earlier discussion in the context of placing of concrete and handling and placing of concrete.

So, external segregation are results of such handling; improper handling such improper handling. Or due to compaction you know in it vibration etcetera, this kind of thing can also lead to external segregation. If you have inadequate cohesiveness of the cement, let us say high water cement. So, you do not have you remember that, we said that, cement paste shall be cohesive, because it is supposed to disperse the aggregate, it forms a matrix and in which the aggregates are dispersed. And then it must have the therefore, it must have the dispersion capability. And it must have also the capability to hold it together, it should be sufficiently cohesive.

But, supposing we have high water cement ratio, it is thin, the paste itself is thin and not able to hold the system properly, it can results in water just flowing away it is too thin. So, water just goes away alone in the mix leaving the rest of the thing and therefore, this can result in what is known as wet segregation. If you have insufficient water cement ratio; that means, now it is not again you know it cannot hold the aggregate, the paste cannot hold the aggregate, because the water is less it is dry, this may results in dry segregation.

So, what will happen; this can result in usually these are external segregation, you know external segregation while handling. So, this could dry segregation. So, the stones etcetera will go away, the coarse aggregate will go away leaving the dry mortar closed you know near by the discharge point. So, this can wet segregation and dry segregations are the other 2 and these are variety of external segregation. So, this is the types of segregations. Why does concrete segregate mechanism of segregation?

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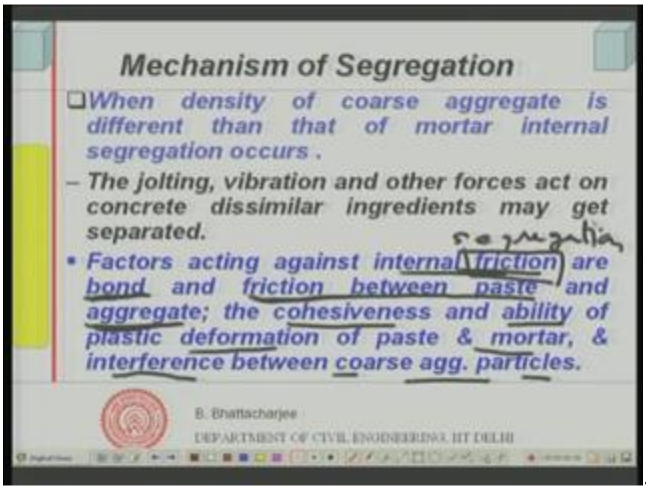

If, you have density of the aggregate different, you know you have different densities of the aggregate, say coarse aggregate has got a different density than the mortar, and then internal segregation will occur. Because we said that what is internal segregation? The tendency of the coarse aggregate which are heavier, as to settle down at the bottom and the finer mortar which has got actually fine aggregate its specific gravity is different, will have a tendency to relatively remain in the top.

So, when you are compacting, if something heavier will have a tendency to go down, something lighter will not go down, so easily it have a tendency to remain in the top. And if the specific gravities are significantly different, say in case of something like heavy concrete. Heavy concrete is used in radiation chain; hematite is used as the aggregate which could have a very high specific gravity, order of 4 4.5 and so on. And if you use a finer aggregate or mortar, which has got much lower density or specific gravity of the sand is very low, this can lead to the sand remaining at the top and the mortar remaining at the top and aggregates going down and result in internal segregation.

So, internal segregation can no occur when there is a specific gravity difference between the 2, because it is internal it is not due to any external agents, not due to handling, just because the specific gravities are different; aggregate will have a tendency to remain separate than the mortar. Let us see what could be the other 1. In case of jolting and vibration and other forces, dissimilar ingredients may get separated.

Now, remember when you are talking about conveyor belt sometime, you know transporting concrete through belt conveyor. So, when you are transporting concrete through belt conveyor, you have jolting, you know when you are trying to transport concrete through belt conveyor, you can have jolting, jolting you can have joltin you know. So, over the belt rollers it can jolt, because you remember we had belt something like this, the belt will travel like this. And when this concrete on top is a heap of concrete travels to this, it will have a jolting, you know it travels concrete is placed here. So, over the belt conveyor, this is in the direction of travel of concrete, it can cause; it can be jolting there can be jolting over the concrete.

So, in such situations since the concrete is been jolted up and down up and down. So, it can so happen that, the larger particle moves in a different way, if the cohesiveness of the mix is not proper; large particle moves up you know does not move moves more, the mortar remains sticking to the sticking to the concrete. So, if you have a too much of aggregate in the system such a thing can happen.

So, similarly vibration can results in dissimilar aggregates ingredients, that is, aggregates and the mortar, dissimilar there both in shape and sizes may get separated they might get separated. So, jolting etcetera can results in jolting and vibration that is external. So, that is the mechanism of segregation. The factors affecting internal segregations are the friction, internal friction and bond and friction between paste and aggregate; the cohesiveness and ability of the plastic deformation of the paste and mortar and interference between coarse aggregate particles. That means, what would stop the aggregation.

If the aggregate is held in position, you know by or in this location by the paste or within the paste, because the paste forms the matrix, aggregates disperse within that. And if you see as slightly ahead, the mortars forms the matrix and coarse aggregate particles are dispersed in that embedded or you can say they are dispersed in that they are inclusions sort of dispersed in that of course, they cannot just not embedded they are large quantity. So, they are dispersed in the mortar.

Now, if the mortar is cohesive, it is effectively dispersed in the aggregate system, then it will be uniform. But it must have also the holding capacity, should form proper bond with the aggregate, should have the right kind of holding capacity of the aggregate so that, there will be no segregation. So, if this bond is not there, there will be segregation and that is being talked about right. So, this acting is a internal friction right that is the bond and friction between paste and aggregate. So, this is what is you know this bond is bond is 1 thing plus friction. So, if something is moving the friction would have held that movement.

So, friction between the paste and the aggregate system and mortar and the coarse aggregate system right, the cohesiveness of the paste and the mortar and ability to plastic deformation. If it holds, then plastic deformation of the mortar and paste would take place and simultaneously it will also cause deformation of the movement of the aggregate together with it. And that is what actually will stop, you know if this is not happening; then there will be segregation.

So, this is these are the resistances or you can say the factors affecting against the internal segregation. So, the factor factors affecting factors, which oppose this internal segregation, are the bond, the cohesiveness the friction between paste and the rest of the aggregate, mortar and coarse aggregate. So, therefore, all this can resist, this is not internal friction; this should be internal segregation. So, internal segregation can be resisted by cohesiveness of the mix.

So, if the mix is cohesive and you can see the solve points out, if you have a good workable mix, which can deform easily, would actually give you proper resistance against segregation right. So, that is the mechanism of segregation and that is how you can see that what opposes the segregation.

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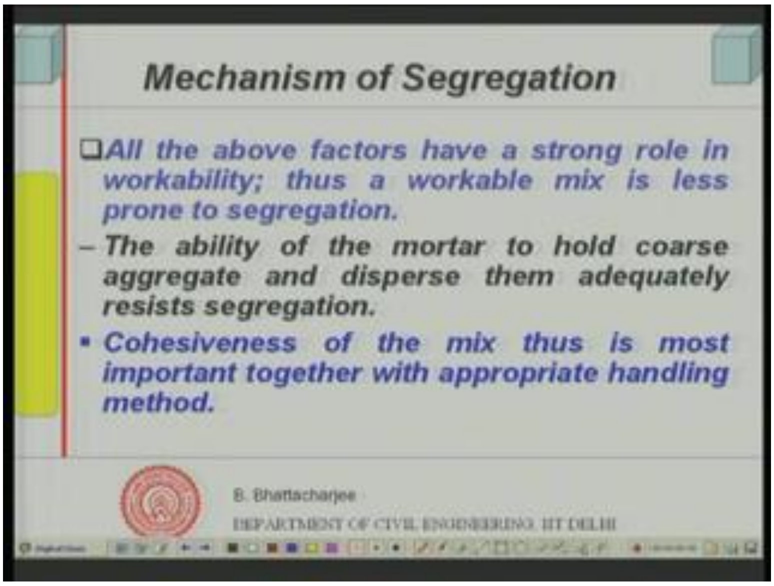

Continuing with the mechanism of segregation, you see as I mentioned all the above factors points to the fact that, you know it points out to the fact that, workability has got a strong role. If you have a good workable mix, which is capable of deforming and moved uniformly cohesively; this will have, this will actually resist segregation. So, a strong role a workable mix is less prone to segregation; that is the idea. So, workable mix properly workable mix is less prone to segregation, you know segregation and separation. So, something has to the paste has to hold that aggregates, the mortar has to hold the coarse aggregate and then there will be no segregation. So, if they mix is that, there will be very little internal segregation.

This is what is being reiterated; the ability of the mortar, the ability of the motor to hold coarse aggregate and disperse them adequately resists segregation. This is very important. This should be understood that, mortar should be able to. So, mortar itself should be cohesive and sufficient enough to hold the coarse aggregate in position. So, quantity of this proportions are important in that aspect.

Cohesiveness of the mix is most important, together with appropriate handling method, because you have seen that if you handle it in a wrong manner, if you we have seen earlier sometime that, if you handle it in a wrong manner like the bottom opened bucket; that does not you know and wide opened bottom opening, bucket with wide bottom opening; they do not cause segregation. If you have a batch part of the batch loaded on a wheelbarrow and another part is loaded onto the another wheelbarrow; this will have definitely sort of segregated mix.

Similarly, when you have 2 stiff chute through which you are discharging the concrete; that can result in segregation. Dropping the concrete over height more than 2 meters; those can cause segregation. So, similarly jolting over the conveyor belt or transporting concrete through simple truck over a undulated road; all this can result in external segregation. So, appropriate handling is very important and also the mix.

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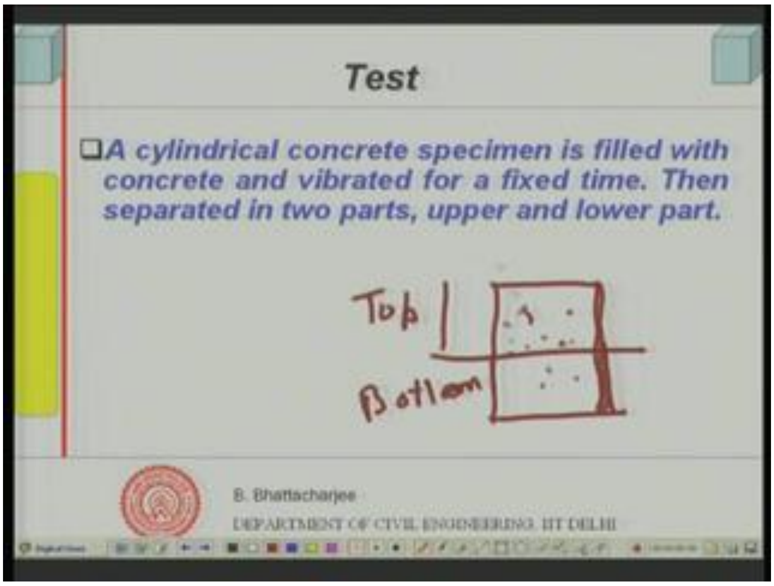

How do we test? 1 of the test that was there earlier are you know, because there is not really these tests are yet to be standardized. One of the tests proposed was that, you have a cylindrical concrete mould something like this; you have a cylindrical concrete mould. Fill this mould with concrete in a specific manner and vibrate it for a fixed time, then separate it out into 2 parts; the top part and the bottom part, upper and the lower part. Then what you do; you measure the proportion of coarse aggregate in this portion upper half and proportion of coarse aggregate in the bottom portion. So, you measure the proportions of aggregate in two halves.

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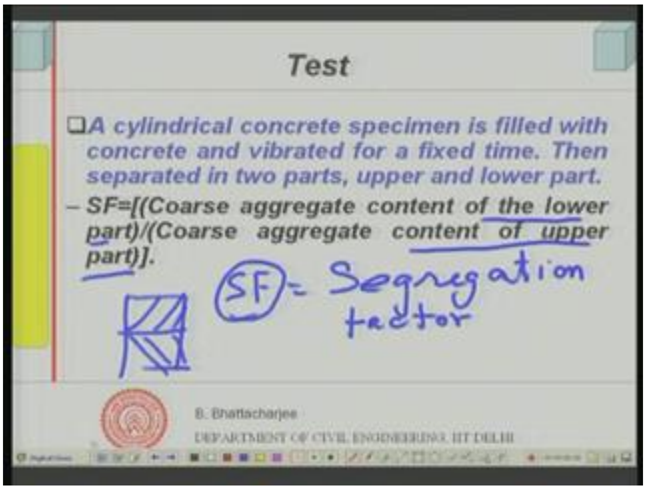

Then, the segregation factor is defined as this is S F this is called segregation factor, which is the ratio of coarse aggregate content of the lower part to the coarse aggregate content of upper. We have separated into 2 parts, if you remember last slide as I was talking about. This is the upper half, this is the lower half and coarse aggregate content is measured in 2 halves and you know ratio of the coarse aggregate to the lower part to the upper part; that is called segregation factor.

So, if it is not segregating, if it is uniform; this should be equals to 1. So, 100 percent non segregating, non segregating mix will have this you know equals to 1, lower you know close this value of S F to 1; the tendency of internal segregation will be least. Tendency of internal segregation will be least, when this is very close to 1. So, this is one method and very simple method of measurement of segregation.

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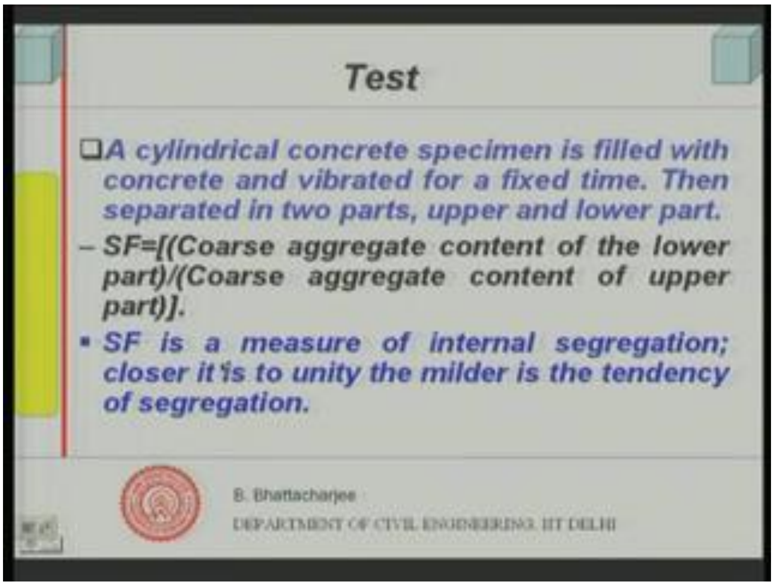

Tendency: you know segregation tendency against internal segregation. So, S F is a measure of internal segregation, the closer it is to unity the milder is the tendency of segregation; that is what we have understood. The closer it is unity milder will be the tendency to segregation internal segregation.

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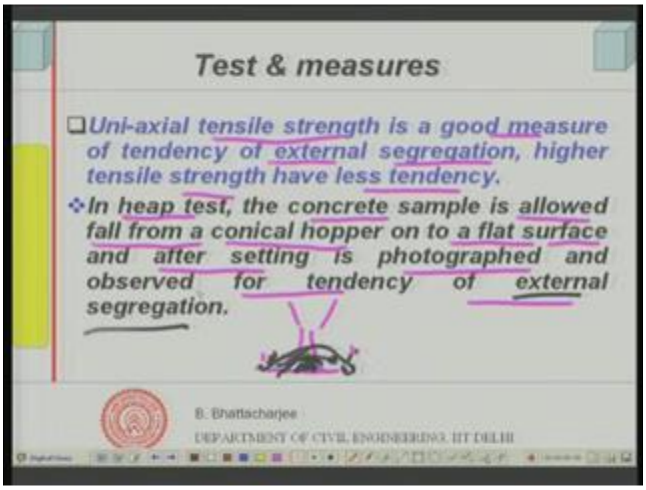

You know this will happen if you have specific gravity difference between the coarse aggregates. So, you have vibrated it, if the coarse aggregate is very heavy compared to the mortar; it will go and settle down at the bottom. And that is we said is a cause of internal segregation by law, because internal segregation means the aggregates proportions will be different in different part of the concrete, different proportion of the concrete. So, 1 of the major reason is this.

For external segregation; uni-axial tensile strength is a good measure of tendency of external segregation, higher tensile strength have less tendency. This is what we talked earlier also, when we were talking about rheology of fresh concrete and paste etcetera. We mentioned that, 3 components in terms of workability of concrete, there are 3 terms if you remember first 1 we said was compatibility, second 1 is the mobility, and third 1 is the stability. Stability means it does not segregate, especially under external handling vibration etcetera. So, this it will not segregate; if the tensile strength of the fresh concrete is high.

So, uni-axial tensile strength is a good measure. There are some ways to measure this against you know external segregation; higher tensile strength have less tendency. So, it is actually if you are workable mix will have less tendency to segregate as well, because it will have sufficient cohesiveness to hold on to the coarse aggregate, the mortar will have sufficient cohesiveness, it will be of sufficient quantity to hold the coarse aggregate in position and also disperse them.

The other test, so external this is the uni-axial tensile strength and that is you remember you know this is related to workability. So, good workable mix are generally less tendency; they have less tendency to have segregation. Now, other test is called heap test. A heap test is you know there are several other tests proposed, but I just picked up 1 more simple test. In heap test, the concrete is allowed to fall from a conical hopper on a flat surface and after setting, it is photographed.

So, it is a very simple method; you have a standard conical hopper which is same use the same 1 for all concrete and it is allowed to fall through it to a flat surface over a standard height over a fixed height, I mean I will not say standard, but fixed height and is observed to photographed after setting. And this photograph is observed for tendency of external segregation. For example, when you have drop through this hopper to the flat plate the concrete you know, if the coarse aggregate particles are separated of there, you know coarse aggregate particles are separated off there somewhere else, somewhere else coarse aggregate and the mortar forms as a heap, you know mortar something like forms as a heap here mortars are something like heap and aggregate particles are separated off and then it has a tendency towards external segregation.

Supposing nothing happens like this and all concrete are forming as a heap of this form, then it has got less tendency to external segregation. So, that is how we can measure the external segregation as well as internal segregation, you know tendency. So, tendency to segregation, but these are not usually these are not very often done, when being in laboratory studies 1 may do it to find out, because this is not possible to do day and out in a quality control situation.

But this is how 1 can test whether it has, 1 faces the segregation problem if the mix is not proper, visually you can observe whether segregation is taking place or not and of course, 1 has to be careful as far as internal segregation is concerned, when specific gravity of aggregates are quite different. But otherwise, well 1 has to just check it. So, these are meant for laboratory testing not really quality control tests.

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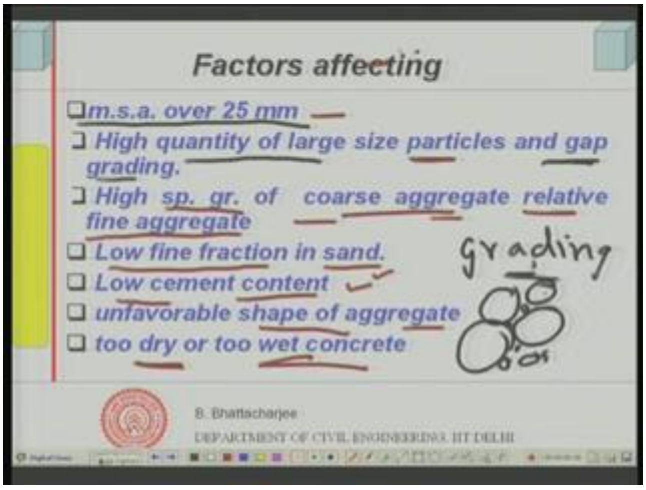

Let us see what is the factors which affects the segregation and this factors are; if you have large size aggregate, maximum size of aggregate nominal maximum size of aggregate over 25 millimeter has a tendency to segregate more, because larger the size this is the tendency to go away from rest of the thing . And higher quantity of large size particles or there is something called gap grading. What is gap grading? We talked about grading in the, sometime we said grading know we talked about grading. What is grading? Grading is having difference sizes in right proportion.

Supposing one of the size is missing, one of the size has got 0, it can happen one can design good concrete with that as well, but 1 must keep in mind what are the possibilities than can happen. Gap grading means 1 size in between is missing. That is not available at the site. So, you do gap grading, right. Now, such gap graded system will have a tendency for the larger size above the gap to move away, because you see gap graded means 1 particular size in your grading is missing, because we said the final next size will go inside this. And the next size will go still inside, this in the finer size and so on.

Supposing 1 of the size is missing, the cohesiveness of the mix would that would be there inside may be relatively less and holding capacity might be less. So, the largest size aggregate will have a tendency to go up, but that does not mean you cannot have a gap grade concrete, you can have ensure that you have cohesiveness of the rest of the you know mortar or rest of the mix, rest of the mix having sizes that contain sizes finer than the larger size. So, 1 can still design there is no problem.

The other issue is of course, the specific gravity of the coarse aggregate, relative to the fine aggregate. This is very important. So, when all this are there, you have to look for measures to reduce down the low fine aggregate fraction in the sand and low cement content; so also, unfavorable shape of aggregate, and too dry or too wet concrete. Now these are the factors which affect the segregation. Now; that means, you know if it is gap graded, if you have this sizes larger than this, it does not mean that, you cannot make concrete without them what you have to do is possibly you have to increase the fine content, may be you have to increase the paste content and cement content and makes the paste cohesive and its holding capacity more.

Similarly, high quantity of large size particles if it is there and gap grading is there, you have to again possibly increase the fines or paste and increase the cohesiveness of the paste to hold this 1. Specific gravity difference if that is there, then again you have to see same thing there, may be the large size aggregate may be quantity can be reduced and you can increase the mortar content relatively more so that, it can hold and disperse.

So, accordingly 1 can design them, keep 1 has to keep this in mind, since we know these are the factors, low cement content is a factor, so you might have to increase it. Low fine is a factor, so you may have to may have to increase it. And, then unfavorable shape of aggregate if it is there may be you have to increase all this. Too dry or too wet mix that we talked about; that means, water cement ratio are to be checked, if I have to dry less water too water cement ratio, there has to be other measures by which we have to actually reduce down the segregation.

So, that is how 1 can control the segregation, if 1 knows factors affecting. Well that is I think all about segregation all right. 1 additional thing is that, air entrainment can usually reduce down the segregation, how does it do it, because in air entrainment when you use air entraining mixtures, air bubbles are formed uniformly throughout the structure, it is very very uniform throughout and it maintains. This air bubble maintains cohesive mix, maintains the mix paste cohesive and therefore, it can hold on to the aggregate system pattern.

So, by increasing the cohesiveness of the paste system and then of course, the mortar system, because paste is included in the mortar and that forms a you know the sensor dispersed in the matrix; paste matrix. This can improve the cohesiveness of the overall mortar and then allow you know maintain or other can contain the aggregate within it in a disperse form hold it together. And therefore, air entrainment can lower the segregation. So, that is all about segregation.

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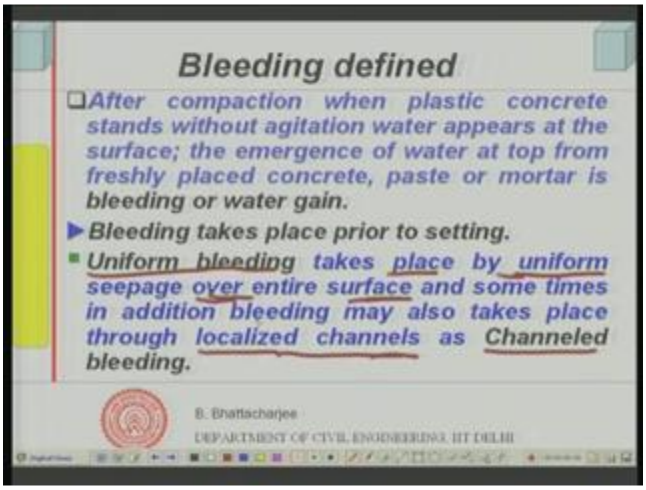

Let us look into the next aspect of the fresh concrete. So, segregation tendency has to be reduced. The other aspect similar aspect is bleeding; bleeding of segregation I mean bleeding of concrete. Bleeding is nothing, but special case of segregation, segregation perhaps is a general term where an ingredient separates out. So, far I have been talking about separation of the coarse aggregate from the rest of the material; that means is the aggregate system, which can separate out from rest of the rest of the matrix, rest of the you know concrete system. Bleeding is where water gets separated from rest of the material.

So, generally segregation is separation of the material, in that sense, bleeding is also part of overall segregation. Let us define bleeding. Now after compaction, when plastic concrete stands without agitation, we are not vibrating it anymore; water appears at the surface, this emergence of water at the top from freshly placed concrete, paste or mortar; we call it bleeding, it is also called sometimes water gain.

So, after you have compacted it, the concrete when it is standing alone without any agitation, you know till it is set what will happen; water generally tends to come up at the surface. And this tendency of water to come up at the surface and accumulate we call it bleeding or water grading. I have already mentioned, bleeding takes place prior to setting.

Now, we can identify 2 types of bleeding, you see one is called uniform bleeding, other is called channeled bleeding. You can identify 2 types of bleeding; 1 is called channeled bleeding other is called uniform bleeding. What is uniform bleeding? It takes place by uniform seepage over entire surface, you know water comes up at the top; that means, there is some seepage of water from the fresh concrete, the green concrete it is also called green concrete fresh concrete, you know it is a fresh state, wet state, and water comes up. You can understand that, this is easily understandable as we shall see later on; the specific gravity of the materials in concrete, the ingredients of concrete are different and water has the least specific gravity.

So, it generally tends to come up it seeps through. And when it is uniformly seeping through the entire surface of the concrete, right this is called uniform bleeding. But sometime what can happen in addition to this uniform bleeding, some places the water might come out selectively, very high rate at a very high rate water might come out selectively, through some channels that are formed localized channels that are formed and this is called channeled bleeding. These are called channeled bleeding. So, 2 types of bleeding we have recognized; 1 is uniform bleeding, other is channeled bleeding.

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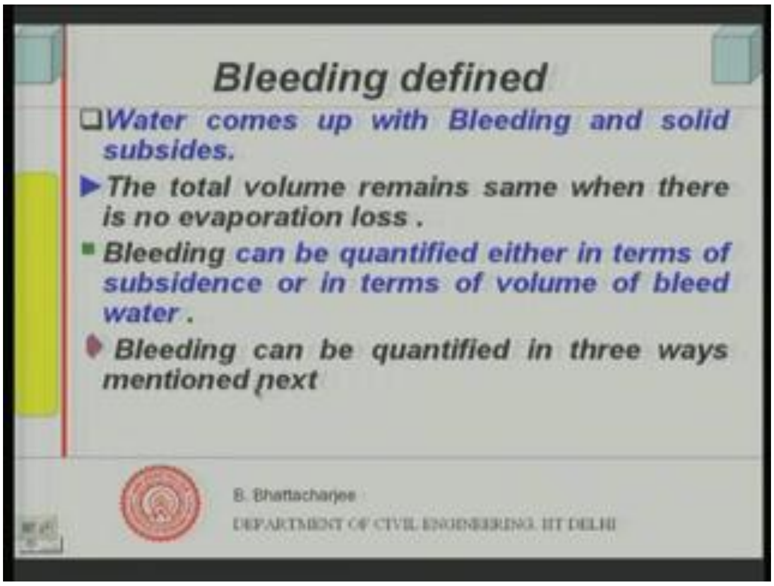

So, what is like this is your let us say this is my concrete. So, when this is my concrete surface, when water comes up throughout uniformly that is uniform bleeding. But sometime you might see that, water comes up uniformly alright, but some place there are you know some places water has water is trying to come out more and getting dispersed all round. So, this is, this place you know water is trying to come out more, rest of the places relatively dry. This place is wet and water is trying to spread from this places.

So, channeled bleeding, because on channel might have formed inside, through which the water is coming seeping through at the top and that is called channeled bleeding. So, channeled bleeding is localized through channels and uniform bleeding is all over the surface. Now when water comes up, you have bleeding and the solid subsides, because overall volume is same; total wet volume contains solids and the water.

Now, water is coming up, water has come up and at the top water has come up at the top. This was the original total volume, now water you will have here and the rest of the solid is there. So, the solid would have subsided, the water would have come and that is what is, you know that is what happens in case of bleeding, so solid comes. Total volumes remain same, if there is no evaporation loss.

So, if there is no evaporation loss, total volume will remain same. When there is no evaporation loss total volume will remain same right. So, in case of bleeding, total volume will remain same, but if evaporation takes place, actually there is a decrease in volume. Now, therefore, bleeding can be quantified in terms of subsidence as well, because the volume is changing is 1 thing and second thing is there is subsidence. So, when you want to quantify bleeding, we can quantify bleeding in terms of subsidence that is taking place, subsidence you know quantified in terms of subsidence and can also in terms of volume of bleed water.

So, you can quantify either in terms of subsidence or in terms of volume of bleed water that is there. So, this is the 2 way we actually, we quantify bleeding. We quantify bleeding in 2 different ways; 1 in terms of subsidence and second in terms of volume of water that has come up. We will quantify it in terms of in 3 ways actually and that is what will be mentioning in the next slides.

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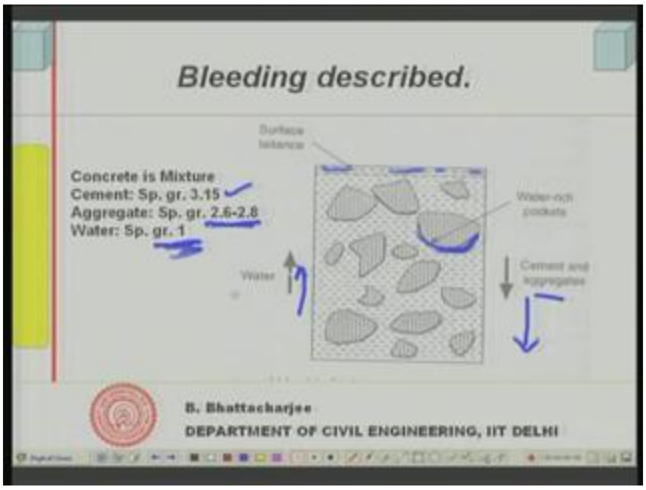

But let us understand a little bit about how the bleeding takes place. You can see, I mentioned the specific gravity of ingredients are different. If you see cement, the specific gravity is 3.15 which has the highest. I think I have, I am repeating this I must have mentioned earlier. And this 1 must realize in concrete, the cement has got a specific gravity of 3.15. The specific gravity of normal aggregate would range from this, but sometime it can be higher also, depending upon the minerals or mineralogical composition of the aggregate. For example, if you are using iron ore as iron ore as a aggregate then; obviously, this will be much higher. But cement is normal piece of cement is around this and water has got a specific gravity of 1.

So, you can see the water is the lightest of all. And this is inherent to concrete. Water will have a tendency to come up. So, these are your aggregate system etcetera, in the mortar water will have a tendency to come up. And it when it comes up, it brings in some amount of cements also with it if especially very fine particles they can come together with the water. Even in case of uniform bleeding some amount of slur will come, in case of channeled bleeding of course, large quantity of slur will come. So, this surface laitance is formed with this mortar which has come up and water which has come up, with the fine you know material it fill form a slur. What about cement? Cement will try to go down also aggregates, because it is somewhere intermediate.

But 1 additional feature which we will discuss again is that, water might get accumulated you know it can trap, bleed water can get trapped below that aggregates larger aggregates system. So, this can be water rich pockets. And this water rich pockets have got their implications in many other things including the strength of the concrete. So, these are water and durability as well. So, these are water rich pockets, bleed water can stuck here.

So, basically why does bleeding takes place and it is somewhat inherent of course, you can control it, reduce it, keep it in an you know keep it in an situation, keep it in a way or to that level where it is not so harmful, but water will definitely will have a tendency to come in. So in fact, we will have higher water here and less cement. So, water cement ratio is higher very high compared to that. So, bleeding actually takes place, because water has a tendency to come up, being the least specific gravity material and cement has a tendency to go down. So, that is what it is. And if you define them, we can now quantify what is you know in different way the bleeding.

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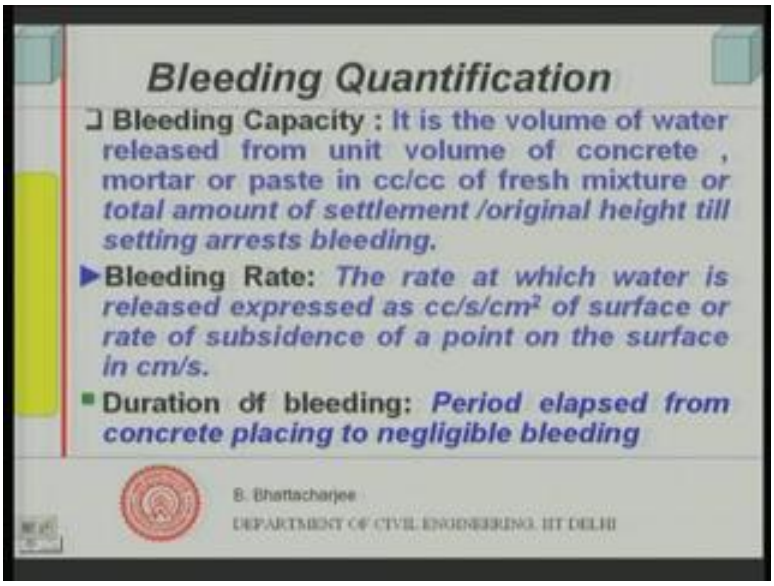

First way quantify is called bleeding capacity, bleeding capacity right, this is what we are calling. So, bleeding capacity we can define in terms of volume of water, released from unit volume of concrete; total volume of water released from unit volume of concrete, you know during the throughout the bleeding, because bleeding does not take place in go. It takes place over a period of time, right from the time you have placed the concrete in the fill the mould to the time it has set the bleeding will continue of course, not necessarily up to the point of setting, but setting may arrest generally may arrest the bleeding process, because once it is solidified the water has reacted it can come out.

So, as the setting process progresses, we will stop gradually. So, during this whole period of bleeding, the duration of bleeding, the amount of total volume of water that has come in from unit volume of concrete that is what we call as bleeding capacity. And it might be expressed in c c per c c of fresh mixture, the amount of you know c c is the volume of water in 1 unit c c of fresh mix mixture of paste concrete mortar everything, whatever you are in the context you are talking. Or it can also be defined in terms of settlement because; we said the subsidence is another way of subsidence is another way of defining the bleeding.

So, quantifying bleeding in terms of bleeding capacity, we can talk in terms of settlement amount of settlement divided by the original height or settlement per unit height. What we are saying is settlement per unit height is the setting you know arrest still setting arrests bleeding. So, during the total process of bleeding, the bleeding that has taken place divided by the original height in which bleeding per unit height in centimeter per centimeter is the bleeding capacity. So, this is 1 way we quantified bleeding.

The other way of quantifying bleeding is in terms of what is called bleeding rate. Bleeding rate is defined as the rate at which water is released and it is expressed in terms of volume of water that is in centimeter cube c c per second the rate per centimeter square of the surface area, per centimeter square of the surface area of concrete. So, it is the volume of water released per unit time per unit surface area of the concrete. Or it can be talked in terms of subsidence at a point on the surface of the concrete in terms of centimeter per second.

So, the rate at which it is subsiding, at any point of time is called you know bleeding rate. This rate is; obviously, cannot be constant, you know it will be constant possibly for certain period of time, but it will reduce down with time. We shall have a diagram to see this. So, bleeding rate would change, but we have we are defining, next slide will define that in details.

Now let us see the third way how we can quantify bleeding duration of bleeding. It is the periods elapsed from concrete placing to the time, when bleeding has become negligible. Well in terms of subsidence if you are looking at it, this diagram will show you how we can quantify this.

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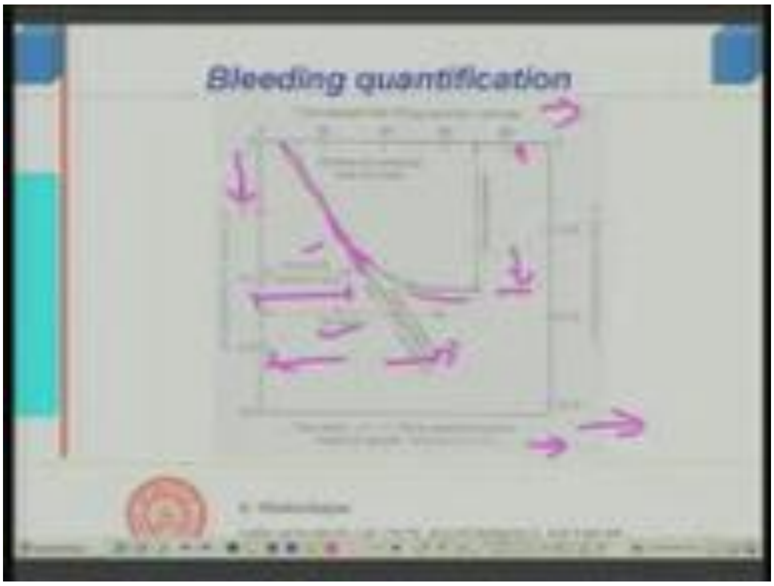

So, you can see this through this diagram that, this diagram shows for a specific type of you know water cement ratio 1.32, because 1 would like to have high bleeding by absolute volume, this by volume. And the sample has been taken as 4.25 centimeter and then bleeding was measured by what is called float method in terms of the subsidence. So, the volume is not there, it is measured in terms of subsidence. This x gives you time, so this gives you time in minute. And then what has been done; subsidence has been measured.

So, originally it was 0, then subsidence increases along this direction; 0.1 0.2 0.3 0.4. So, subsidence has been measured in terms of you know subsidence in centimeter; 0.1 centimeter 2 etcetera, subsidence has been measured with time. So, when you measure the subsidence with time, it is observed that, initially it has got a almost linearly it is decreasing. So, this is the period of constant rate.

Then you can see that bleeding gradually reduces down, the rate of bleeding gradually reduces down. So, this is the rate of bleeding. The initial rate of bleeding we call it rate of bleeding, you know in centimeter per second. So, that is the rate of bleeding. The total subsidence is this and you remember bleeding capacity has been defined in terms of total subsidence right per unit origin of height. So, this is related to total subsidence. So, bleeding capacity can be defined in terms of this.

So, bleeding rate orders are given for example, 103 into 10 to the power minus 6 centimeter per second etcetera, the rate has been defined. And period of constant rate beyond that of course, bleeding rate reduces. So, duration of bleeding which is the third measure of bleeding is shown here. So, you can see all three quantifying terms of bleeding are defined through this, through this curve. These are the actually characteristics through which you quantify bleeding; total amount, rate and duration. You know these shows are how much would be the volume change, total volume change of once the evaporation has taken, you know once the top water has evaporated. So, how much would be the volume change that will take place.

This tells us what is the rate, because initial rate is important, I should have a slow initial rate may be and then; obviously, it will be faster. So, high rate of this is the rate and of course, total duration that is what we mentioned, total duration of bleeding. So, that is how we can quantify bleeding. What happens when bleeding takes place?

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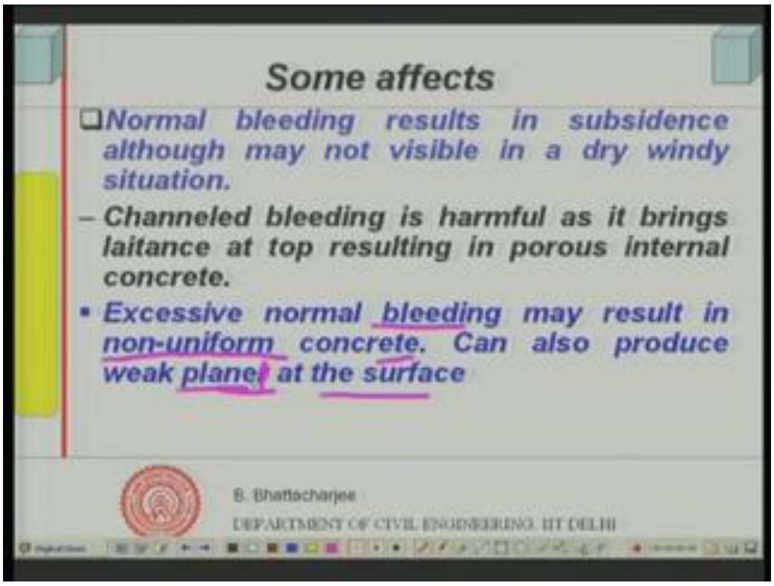

Normal bleeding results in subsidence, although may not be visible in dry windy situations, because if this dries lot of evaporation is taking place. If the rate of evaporation is higher than the bleeding rate, then one may not see it, but it never delays the bleeding is taking place. So, in such situation, the reduction in the volume reduction would be taking place.

So, normal bleeding results in subsidence. That is most important. This takes place and therefore, there will be reduction in volume. So, whether you see it or not there can be some reduction in volume of course, in dry and windy situation we do not see it, dry and windy situation you do not see it, sometime you may not see it. Normal bleeding is also harmful in certain situations, but let us look into more harmful bleeding; it is the channeled bleeding. Channeled bleeding is more harmful, it is really harmful, because it will bring laitance at the top resulting in porous internal concrete. So, it will bring large laitance, because it is locally there is a channel formation. And lot of bleed material you know water bleed water will come and it will bring in lot of cement, because large quantity is coming it has formed a channel.

So, such channeled bleeding can result in large laintance amount of laitance coming at the top. And therefore, loss of laitance from the inside, which means there will be actually porous internal concrete, because material has come out come out from inside and you can have porous internal structure. So, therefore, this is harmful. So, channeled bleeding is definitely harmful.

Now, excessive normal bleeding is also harmful, because it may result in non uniform concrete. Top will have higher water cement ratio and bottom will have much lower water cement ratio, lot of water has come out, so top will have high water cement ratio,. Top layer would be relatively weak layer and that is why weak plane, it will actually create weak plane at the surface not planer, weak plane at the surface. So, it will create weak plane at the surface, because the water has come in, water cement ratio is very high and if some sort of fine laitance or water layer has formed at the top, you can allow it to evaporate, if it evaporates then do finishing then of course, it is not so harmful. If you are casting another lift on top of it, another set of concrete is being placed on top of it, then the water must dry out, otherwise it will create weak planes what is called cold joints.

So, the construction joints would be weak the weaker joints would be there. So, of course, a skillful man, a skillful mason would not finish, until all the bleed water has actually gone out from the surface. So, it can be harmful, because it can result in non uniform concrete bringing in some amount of laitance, but otherwise just coming some evaporative evaporation at the top, does not create any, some bleed water at the top does not create problem if you allow it to evaporate and then put the next lift and or finishing work, you do only after that and then this is not very a little bit of bleeding is not really harmful to the concrete, if it is take care of properly. In fact, it can reduce down the overall water cement ratio.

But such bleeding can be significantly reduced by special mechanized way with control permeability, form outliner etcetera although that is not part of our discussion at the moment, but there are techniques to reduce that. So, that is what effect of bleedings are.

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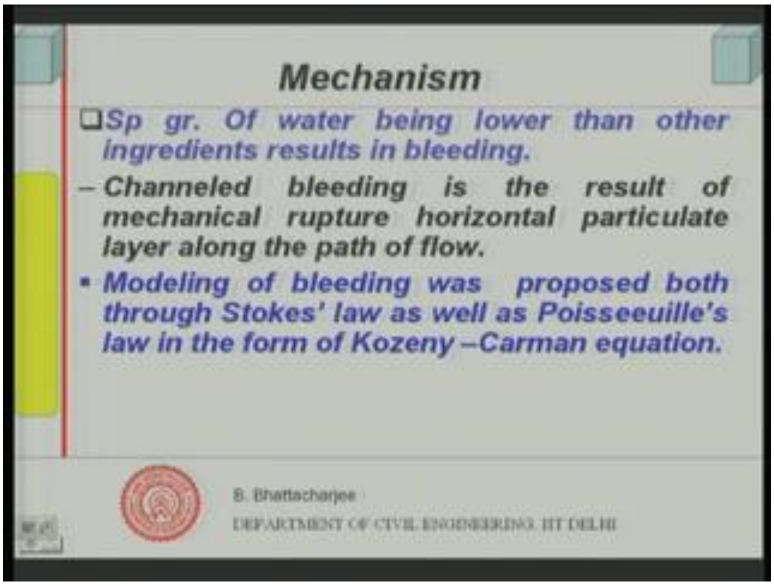

Then let us see; what are the mechanisms. We have already mentioned that, specific gravity of water being lower than other ingredients, results in bleeding. Channeled bleeding essentially is a result of mechanical rupture, of horizontal particular layer you see, when water is trying to come out. If the bleeding rate is high, it might cause rupture of the solid system, there a mat like surface you know layer, which is formed it can cause rupture and take out some material. Once it takes out those materials, the channel is formed. And when this materials complete channel is formed, you know little bit formed it can make exactly bigger channel and finally, a complete channel might form and through that channel lot of water will have a tendency to come out.

So, the channel bleeding is basically rupture of the particulate system or particulate mat that is formed and forms the channel. And that is that is really harmful. So, now, what people have tried to do; they have tried to look into the bleeding process more a little bit more in a systematic manner from scientific approach. And 1 can think in terms of bleeding as a settlement of solids in a suspension of you know water suspension like; if you have suspension of water say soil, not what you call inert solid in a liquid, the soil in water, what happens; the particles depending upon their sizes, particles try to settle down at the bottom, the coarser particles settle down at the bottom, the finer takes longer time to settle down. And that is governed by Stokes law, depending upon the property of the liquid, viscosity etcetera, diameter of the particle and so on.

So, 1 can look in terms of bleeding as a phenomena in a solid actually, settled in a suspension, solid settles at the bottom, you know gradually. The coarser particles trying to settle earlier, etcetera, heavier and coarser particles trying to settle earlier. So, 1 can look that process in this manner. The other way of looking it, you have a wet concrete which is you know wet system, wet concrete and in which you have inter connected pore systems created by the water. So, if you have interconnected capillary system, through this water will try to move out and this is something like flow through pipes as defined by Poisseeuille's law.

Well the modification of this Kozeny-Carman equation which is used in soil, people have tried to model bleeding through this. As if you have a porous system, porous solid system with capillary pores and through that water tries come out. So, this is through this water tries come out. So, this is what this is what is you know Poisseeuille's law. There are 2 ways people have tried to model this system right.

So, 1 way if you look at suspension in a solid suspension, the solid is trying to settle down and other way is as if through pipes, you know capillary pipes very fine pipes water is trying to coming out. So, that is how people have modeled. Any way we will not look into the equations in our discussion, but this is how people have tried to model and try to understand the phenomena of bleeding, well the later the Kozeny-Carmans sort of equation seems to be more reliable.

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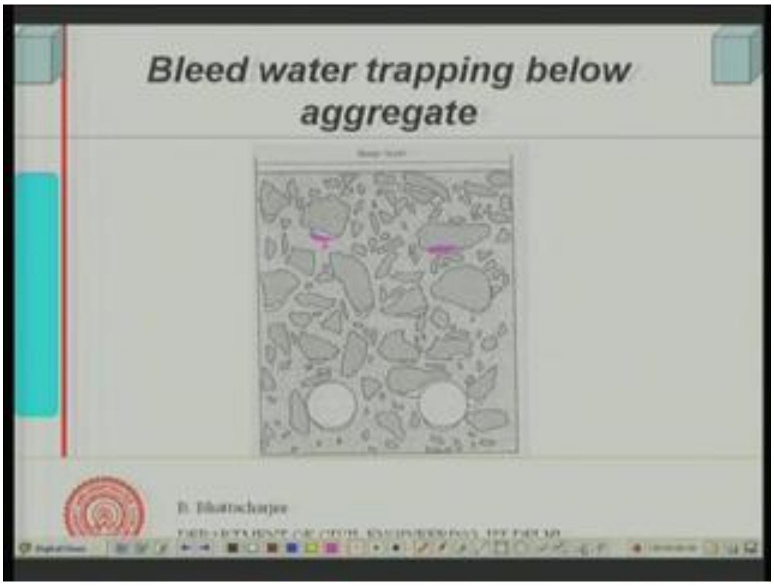

This is the issue I would like to mention, because this is important from the point of view of aggregate, durable you know strength and durability. I have mentioned earlier that, bleed water can get trapped below the aggregate system. So, the water can get trapped below the aggregate system. Now this can form water filled pores and between the water can get trapped below aggregate.

Now, this is for example, this is a water trapped, this is another water trapped. So, as the water is trying to come up, it can get trapped below the aggregate system and this remains porous. So, aggregate and mortar interface are quite often may be porous, because of bleed water trap of course, the other reasons are also there which we shall see later on. This is more porous than the bulk paste we shall see that later on. But bleed water is an important issue which can leave this as porous. So, this I specifically mentioned, because this has got some relation with strength and durability. How do we test float method?

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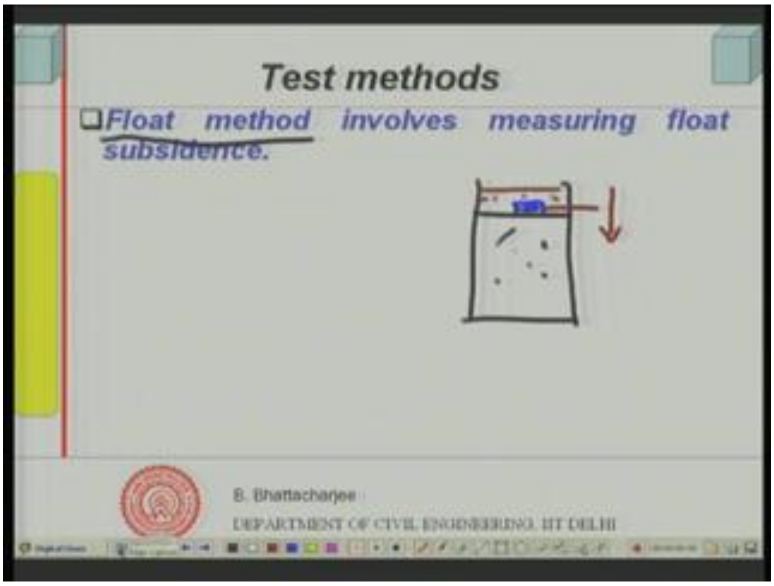

Actually used in research purpose float method. In this you have simply, the concrete you have a float. If this is your concrete let us say you have a float, which will be floating on top, you know you have a float which will float on to the top. Now this float is such that, it is actually heavier than water specific gravity more than 1, but less than that of the concrete solid; that means, less than the bulk concrete 2.4 or something you know I mean you can think in terms of and combined aggregate specific gravity of solids, in case of concrete to be closed above 2.4 or so2 point you know around that.

So, you put a put a float such that, it can it does not it sinks in water, but floats over the concrete. And then what you do is the bleed water comes at the top. So, this was in the beginning it will be at the top and as this settles down, its height of settlement you can measure. Bakelite could be 1 such material, which actually sinks in water, but floats over solid concrete. So, its subsidence can be measured using this float method. Subsidence of concrete can be measured using float method and that is what power used earlier used earlier in his experiments and through which that subsidence diagram was obtained.

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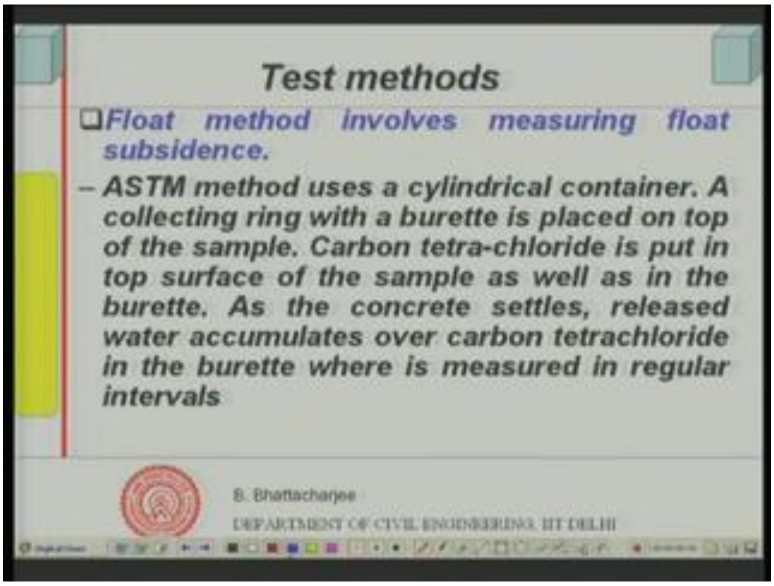

The ASTM method which is the other method and being used as a standard method, it uses a cylindrical container. A collecting ring and burette is placed on top. So, that is the collecting ring and burette is placed on the top of the sample. Then carbon tetrachloride is put on to the top surface of the sample as well as in the burette. So, part of the burette is filled with carbon tetrachloride and this ring actually you now traps the bleed water and comes into the burette right, through a funnel. And comes right on top of the carbon tetrachloride and as the concrete settles, released water accumulates over the carbon tetrachloride and the in the burette and there burette is graduated and where you can measure it at regular intervals.

So, that is how 1 can measure the volume of the water that has come out. This is of course, a way of measuring the subsidence; this can measure the volume of water that has come out. That is the standard method ASTM: American Society of Testing Material method and this can be utilized to measure the bleeding. Again this cannot be a filled method it is mainly meant for laboratory and studies and things like that. So, test methods, details of this test method are outside the scope of our work. Let us see how we reduce bleeding.

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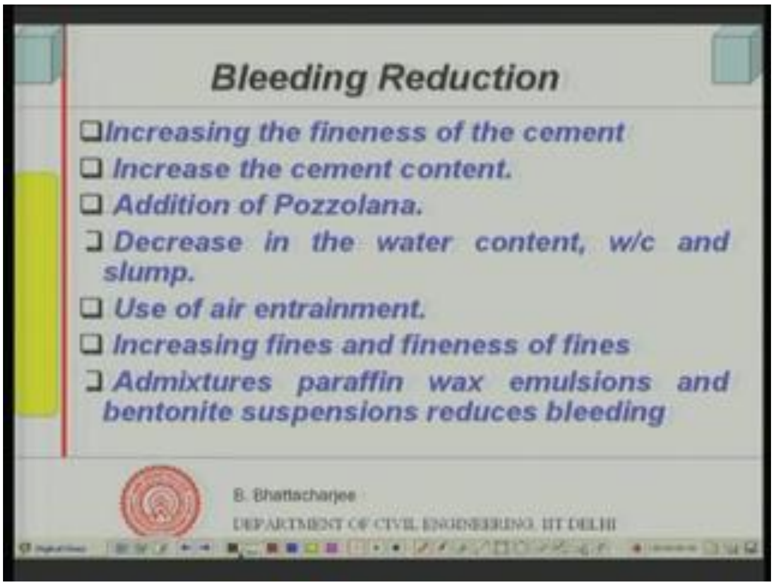

Increasing the fineness of the cement, you see again if the cement and paste system you know solid system and the concrete is such that, the interstitials pore space between them is very small. So, the capillary sizes are very small, water really cannot come up. If they are not interconnected, then water cannot come up. So, therefore, the basic idea is to reduce down the fineness, you know if you have increase the fineness of the cement so that, the interstitial space sizes are smaller, interstitial pore sizes are smaller. You have a finer particles, this space will be smaller, you have a larger particles this space will be larger.

So, cement is a finest particle in the system. And if you have fineness of the cement is slightly high, it will reduce down bleeding. Well that may not be possible it may have other effect, but you can add fine pozzolana to the system and that would reduce down the bleeding. Increase the cement content or cementitious content; that means, add pozzolana, fine pozzolana fineness of the pozzolana and more quantity of this cementitious material, will reduce down the bleeding. Decrease the water content; too much of water would bleed to high capillary system and therefore, the bleed channels can form.

If you have less water content less, such water cement ratio and you know low water cement ratio will have less bleeding tendency, because capillaries will be relatively less and through which it cannot go. Air entrainment reduces the bleeding, increasing fines and fineness of the fines again, makes the capillary pore sizes smaller, bleed capillary pore sizes and the wet concrete smaller. We are not talking capillary in the final hardened concrete, but in the bleed wet concrete itself, interconnected capillary should be you know lesser of diameter and there should be less interconnected. And this is possible if you increase the fines, because the spaces within the fines would be smaller. Increase the cement content or cementitious content, decrease the water content water cement ratio and slump. Some admixtures like viscosity modifier will reduce the bleeding, paraffin wax emulsions they reduce and bentonite suspensions also reduce bleeding. So, these are the means of reducing bleeding.

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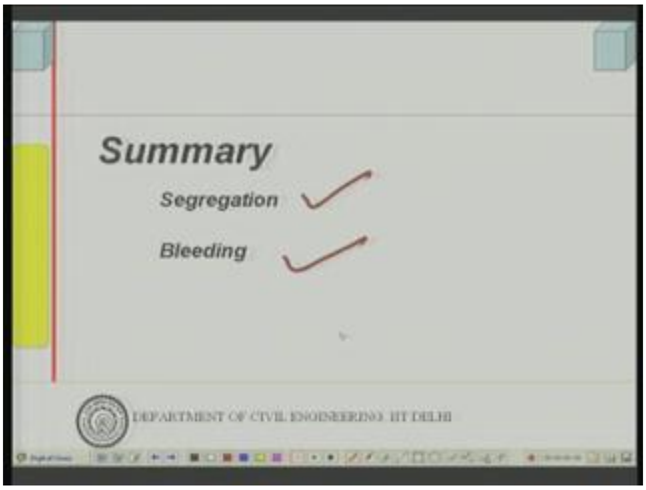

Well I think that, should that would enough, that would finish out discussion on segregation you know segregation and bleeding. So, today we have discussed 2 phenomena; 1 of them is segregation, the other is bleeding. And overall, we have discussed in fresh concrete the issues of workability, their measurement, the rheology of cement paste and concrete a little bit.

We tried to give idea about rheology of cement paste and concrete. And then we have now looked into lastly, we have looked into segregation and bleeding. So with this, we conclude the discussion on fresh concrete. The next turn, next lecture onwards, we shall be discussing on strength aspects of concretes.

Thank you.