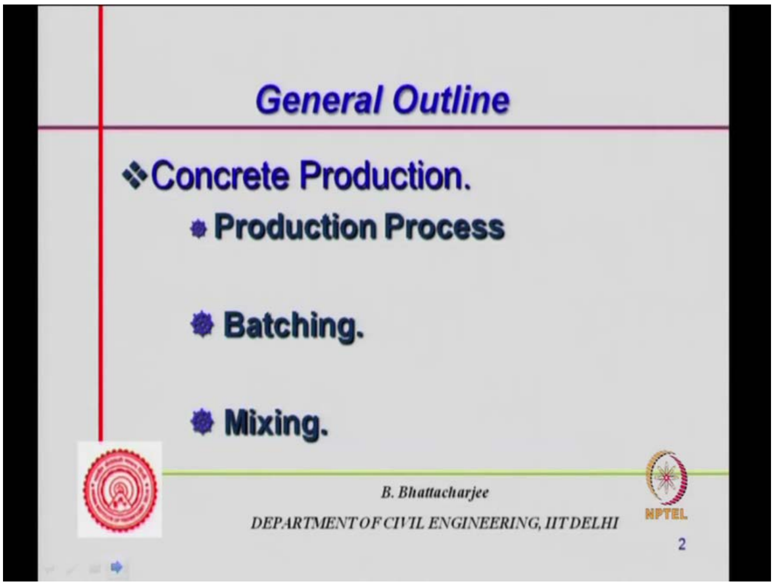
Concrete Technology
Department of Civil Engineering
Prof. B. Bhattacharjee
Indian Institute of Technology, Delhi

Lecture -19
Batching and Mixing of Concrete: General Principles

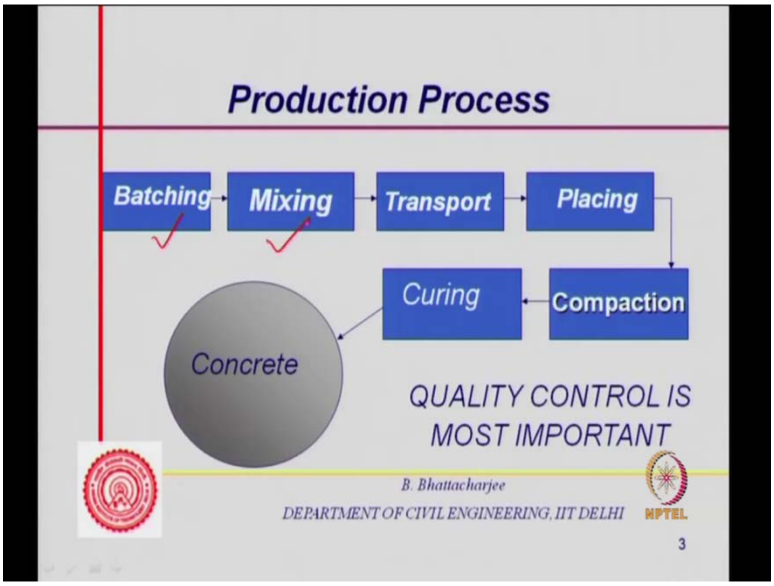
So, after looking choose the concrete mix proportioning in the module four, let us look at module five, and in this one will be looking at the concreting concrete process especially in the ferrous state. So, first lecture on this is actually batching and mixing of concrete.

(Refer Slide Time: 01:03)

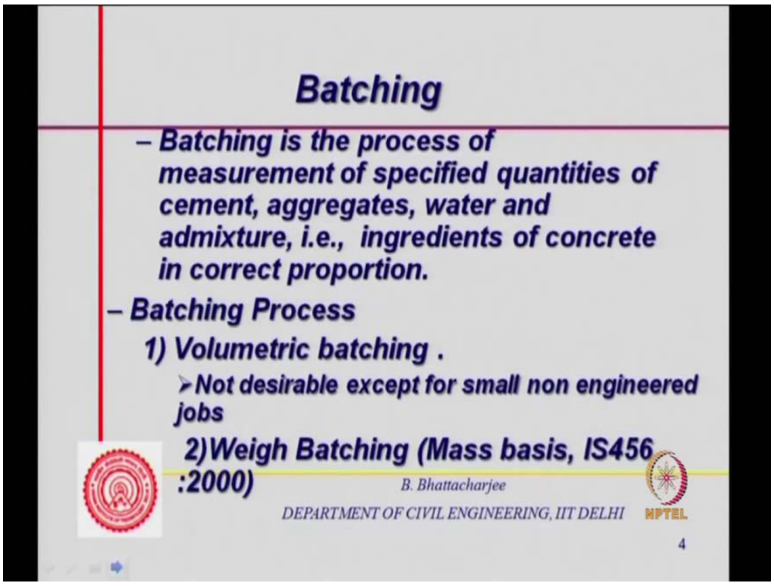


And we should be talking about first what is concrete production, the production process, batching and then mixing in this particular lecture. We will follow it up with transporting, placing of concrete and then curing as the concreting process can be described in this manner. First you have batching, followed by mixing, followed by transport, then place it, compact it, and you have of course you will have to cure it, that gives you the concrete. So, this is the concrete production process and in this process of course quality control is most important, you know finally the product should be as we desire, as we would like to produce you know our requirement. So therefore, this diagram shows the concrete construction or production process. Today of course we will concentrate our self to patching and mixing.

(Refer Slide Time: 01:26)



(Refer Slide Time: 02:27)

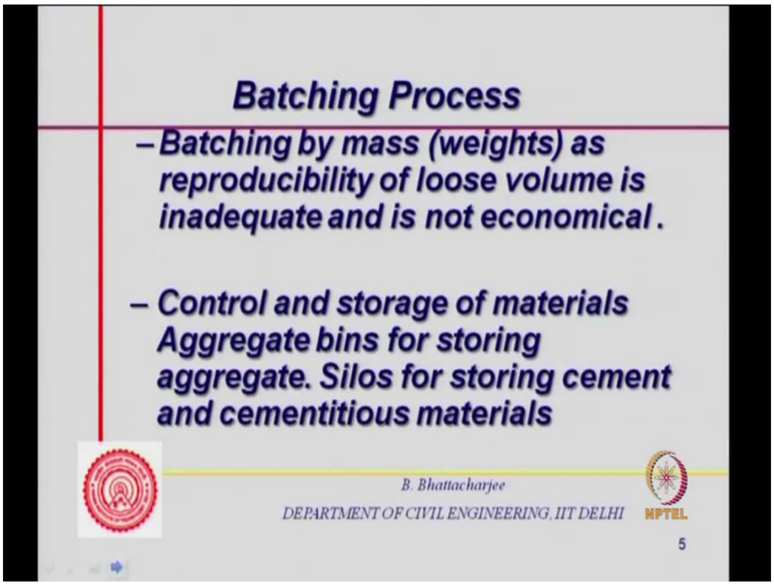


Now what is batching? It is basically the process of measurement of specified quantities of cement aggregate, water and admixtures which we have decided the proportions in the last module. We have looked into from the requirement of the properties or performance requirement of concrete we have tried to find out what should be the relative proportions of different ingredients in concrete namely cement cementations system aggregate water and admixtures. Now batching is the process by which actually we wear them, we measure them, measure those specified quantities in correct proportion; so, that is what is batching. Now batching process can be volumetric or mass basis weight.

Now volumetric batching could have been you know it was done earlier long back and even one might do is you know like one volume with six volume, one volume of cement with six volume of sand one is to six motile and that kind taken of thing is very loose actually. So, volumetric batching incase of concrete is not desired. If you have some container you can fill in the container with aggregate and therefore volumetric one can measure those volume. So, it was relatively easy or less time consuming i will say to just put in some you know up to in a container, for example one cubic feet a box, so just fill it with aggregates, and that is volumetric basically.

Now that is not desirable because controlling the total mass with in a volume is very very difficult; somebody may put in little bit more by shaking it so that it packs better, somebody may just put it as heap and just you know wipe off from the top or travel it from the top, so we will have less volume of aggregates. So therefore, volume is difficult to control. So therefore, engineered concrete is produced on mass bases and that is what your Indian Standard Code IS 456 2012 also says.

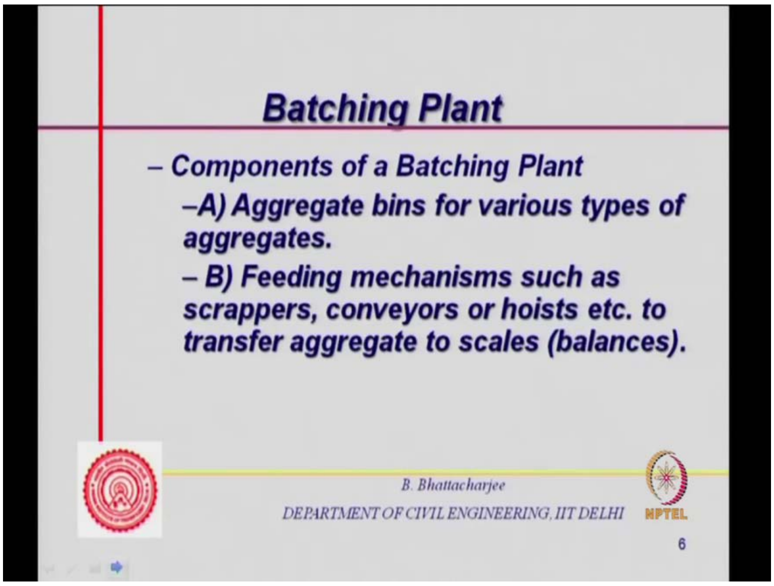
(Refer Slide Time: 05:01)



Because mass bases you can reproduce it loose volume of cannot be reproduced, and it is not economical. So, loose volume is not reproducible, and therefore it is not economical except for some small job you would not do it. Then control and storage of materials you must have aggregate bins for storing aggregates, silos for storing cement and cementations material. Actually storing is very important; it should not get for example, aggregates. That should not get contaminated with dust or something of that kind. Apparently it may look simple, but if you store it in open you can have problem, so dust coming from the environment and contaminating them especially places like. Let us say North-West India where dust terms are quite common in summer like Rajasthan, even in places like Delhi, Kanpur you have such kind of dust terms and storing aggregates in open may be problem.

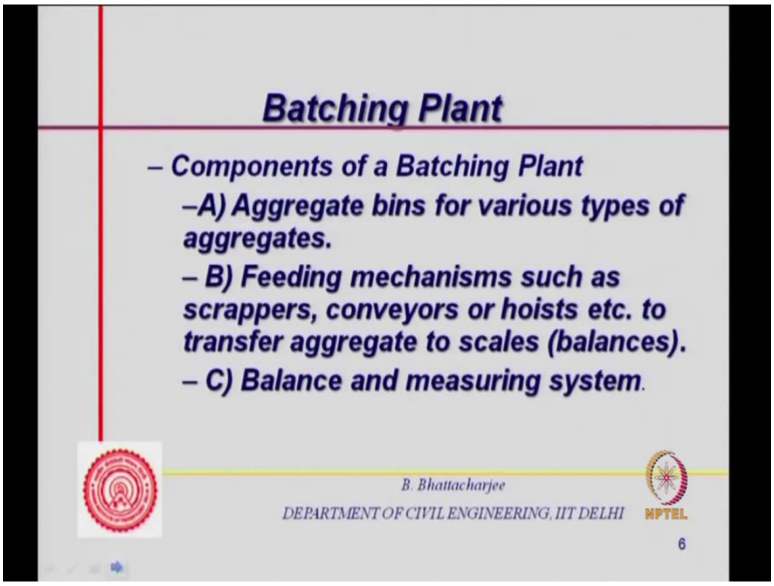
Even when you have rain in other parts of the country not the central and the western northern India rain can bring in lot of things dust along with it and deposit over the aggregate; so therefore, it has to be stored in the right manner so that it does not get contaminated, aggregate do not got get contaminated by dust. Cement of course we know that we have to keep it out side away from water, so they are put in silos so is fly ash. So, all cementations material and aggregates are stored as mentioned.

(Refer Slide Time: 06:48)



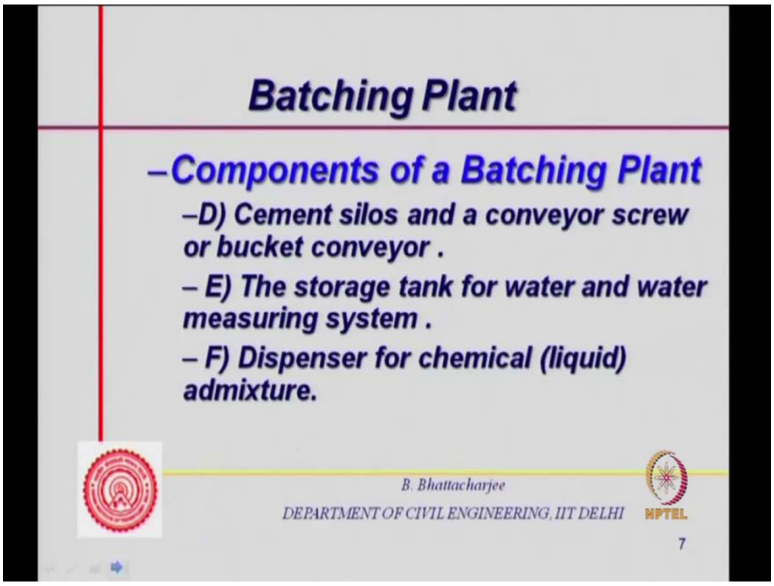
And therefore part of the batching plant. So, if you look at the components of batching plant first aggregate bins for various types of aggregate, right. So, they are stored in bins. Then you must have some kind of feeding mechanism might be scrappers, conveyors or hoists to transfer the aggregate to the scales that is to the balance. Now here there is none of the separate balance, it must be a bucket straight way where you can go on the mass that is added; we will look at that a little bit more.

(Refer Slide Time: 07:29)



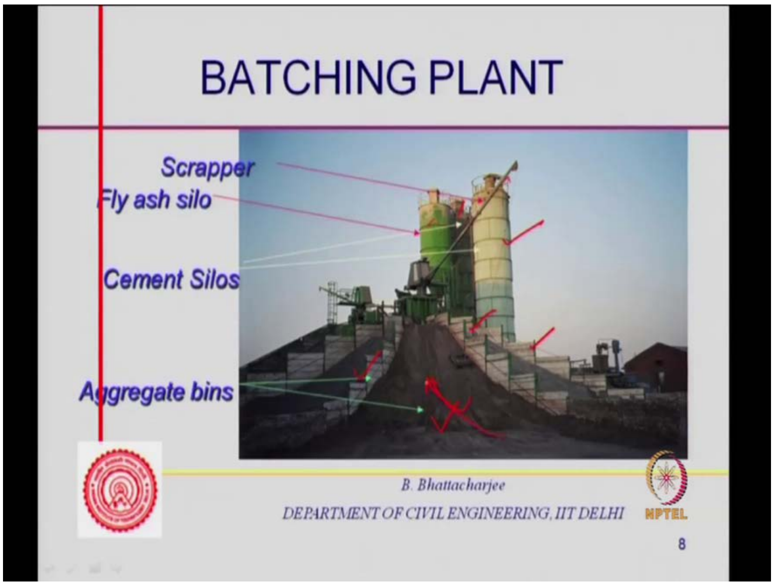
So, feeding mechanism is the next one. Then you have balance of measuring system for the aggregates particularly and also the cement.

(Refer Slide Time: 07:40)



Then you have you know continuing the components, cement silos and conveyors screws or bucket conveyor for transporting the cement from the silos because you got to take it to the balance and then from balance to the mixing mission. Then storage tank for water and water measuring system; if you have admixtures chemical administer some kind of a dispenser for chemical admixtures which will actually add to the system before mixing, so this is the components.

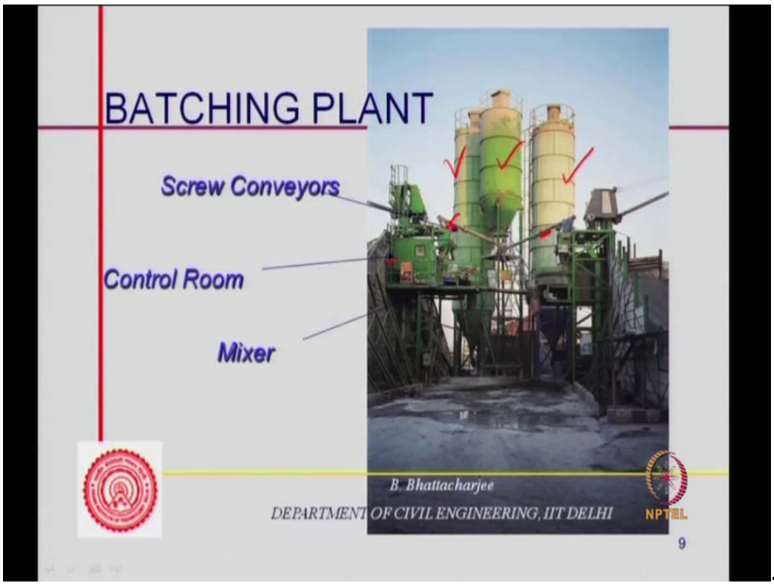
(Refer Slide Time: 08:23)



Now let us look at a batching plant straight way, how does it look? This photograph shows a batching plant, and as you can see these are the silos. In fact it had two in cement silos and one silo of our fly ash. So, this are the silos vertical silos where this is you know metal silos where cements are stored. So, cement will be stored and it is all closed and from here the cement goes to the mixture machine. So, this is the fly ash silo as it is shown two cement silos. One of them you can directly see, the other one is not easily visible. So, this is one cement silo. The other cement silo is there and fly ash silo is somewhere here, and these are the aggregate bins. So, this is the aggregate bin, this is also aggregate bin, right.

So, aggregate bin is here and aggregate bin is there and there is a scrapper which will actually be lifting the aggregates as we shall be seeing from the photographer taken from the other side, okay, there is a scrapper. So, this scrapper is one you know this is the scrapper, this is the scrapper. So, this has got actually a scrapping device which can scrap the B aggregate system close to the wall. These are the walls which are there, you know this is the wall, this you can see this are the walls. So, this wall there is another bin there. So, this is the wall from the other bin. Every bin has got a scrapper. So, scrapper would actually list the aggregate or push the aggregate close to the wall, and in the walls there is gate. So, this gate can open on to the bucket automatically can be as a computer control system and it can just put it in the buckets.

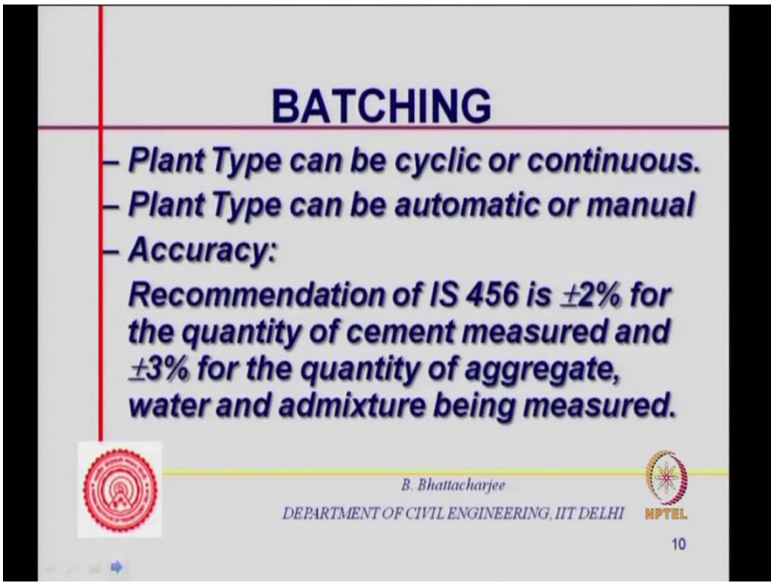
(Refer Slide Time: 10:23)



So, you can see that you know you can see further now more things from the other side. The fly ash silo is now easily visible. This is the fly ash silo; this is one cement silo, other cement silo. So, these are the two cement silos and as you can see this is the control room. You know there is a control room here; this is the control room, this is the control room where you have the computer on which everything is controlled and screw conveyors. So, this one serves as screw conveyors, actually this particular one.

Similarly, there is another screw conveyor through which cements are shifted from the silo to the mixture mission, silo to the mixture machine and you have got the mixture machine ending up somewhere there; you know mixture mission is somewhere here, mixture mission is somewhere there. So, materials are actually this is a component this shows actually components of batching plant currently used batching plant in India, these are called star type and this is fairly common in most of the places. Only thing is storage bins of the aggregate could differ from place to place, but basic structure remains more or less similar. So, this is a typical batching plant.

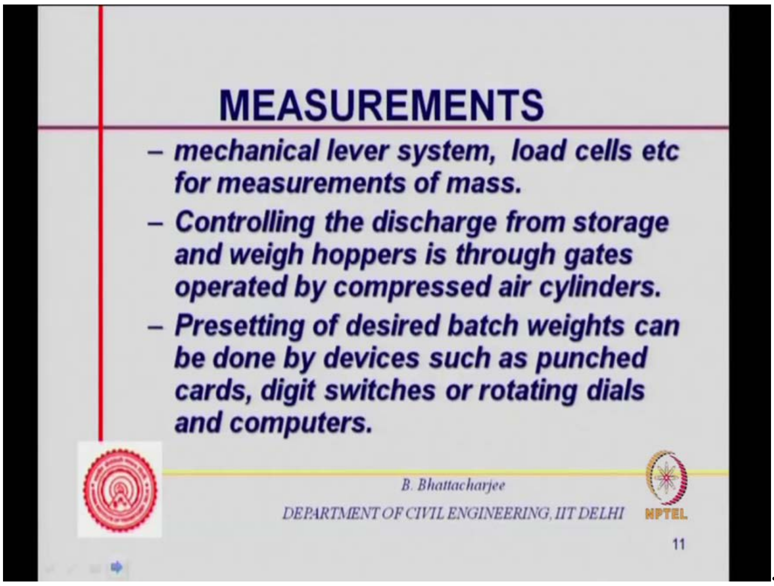
(Refer Slide Time: 11:47)



Plant type of course can be cyclic or continuous. Now this is what I sort of showed was a cyclic. So, every time the material is weighed and then put it into the mixture machine. Continuous it will be continuously fed and weighed. Now that is a very fast process and rarely used in India scenario unless you want to produce large quantity of concrete at a very short time. So, in a casting yard or something of that kind not very common in Indian scenario; the other is classification could be automatic or manual. So, what we normally see is the cyclic type the one I showed. In fact the continuous type even the mixing should be continuous, so it is continuous feed onto a mixture mixing system which is cylindrical in nature and it enters from one side.

The ingredients enter from one side of the mixture machine and it gets discharged from the other side. Now plant type can also be automatic and manual. This is automatic most of the batching plant today with the RMC plants would be automatic, manual would be weighing would be manual, weighing would be done; manually small batching plant could be manual. What is important is accuracy of weighing. So, IS 456 says plus minus 2 percent for the quantity of cement measure; that means the accuracy should be within plus minus at 2 percent you know and 3 percent from the quantity of aggregate, water and admixture that we are measuring. So, accuracy level is 2 percent, right.

(Refer Slide Time: 13:41)



And then measurement earlier manual type would be mechanical lever system but the automatic will have load cells, load cells which we normally use in engineering laboratories for you know measuring the load. For example, if you want to measure the load defluxion curve of a beam flexural member you would have used load cell to measure the load that you have applied. It is nothing; there can be several kinds like piezoelectric type piezo sensing or electro dynamic type. So, the load that you apply additional load would actually induce some kind of electrical signals which is amplified, etcetera, etcetera.

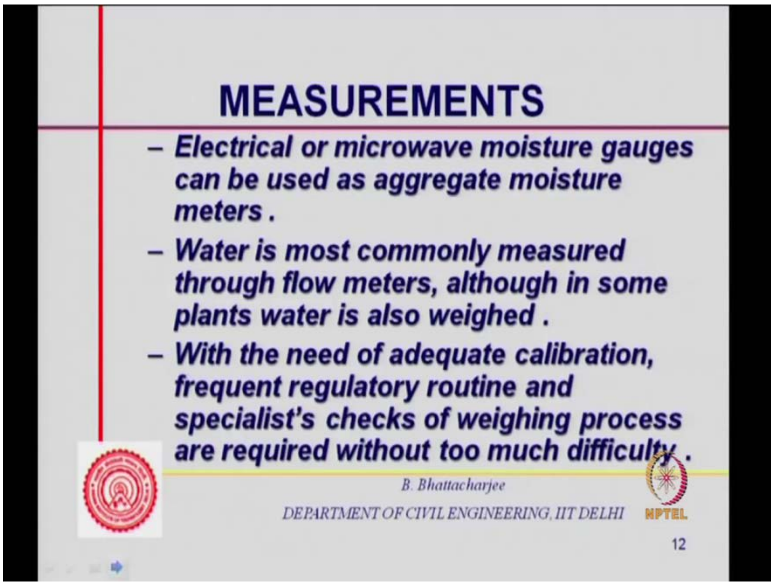
So, these modern machines will have load cells mostly piezo type or some cases electro dynamic type, right. So, that would measure the mass, right, and that would usually measure the cumulative mass. So, you have a bucket which is fitted with load cell and each ingredient let us say if you add cement in the beginning, then if you add cement, the mass of the cement that has gone would be measured, then you add aggregate to it. So, cumulative mass would normally be measured not individually in the bucket and load cell does this.

Then discharge from the storage and we offer this through gates generally. So, this gates are in case of cement is the screw conveyors which will bring it and there must be gates which will get closed down. So, they are actually operated by compressed air cylinder. Similarly, for aggregates there are gates at the wall that I showed you earlier, and this gate would open operated by compressed air. So, they will open only when there is you know at the computer control system the control system says or dictates it to be opened, as soon as the required weight or the mass has been loaded on to the bucket it will get closed. So, they are the automatic type and this is what is used most of these days you know and should be used in engineered concrete.

The manual concrete is not really engineered concrete but weight batching can be done manually also where you have simple leaver on which you move the weights, move you know some weight in to the leaver arm of the leaver arm and it will tell you how much weight you have reached. So, it is a kind of analog handling. It is possible but they are only meant for small sorts of you know small concreting. In fact the most the engineered concretes should be produced only with automatic batching; otherwise, your quality may not be very good. If you want better quality control it is desired that automatic control system should be used, because today you have RMC plants available but of course RMC with appropriate kind of quality control is important and this RMC track you can have it in a centralized batch, centralized batching plant you produce the concrete batching and mixing plant you produce a concrete, transport it through ready mix trucks as usual we will be discussing in our next lecture and deliver it to the sites.

So, even relatively smaller quantities can be produced in a mechanized way especially in most of the town most of the capital state capitals have got RMC plants today and even slightly smaller town. So, with the transportation system improving road system improving it is engineered concrete should largely be produced through automated batching plant rather than manual. However, manual batching plant weighing is done by manual means, right. So, you should preset the desired batch weights and earlier it was done through punch card or digital sutures or rotating dials but today it would be all through computer controls. So, you just put those numbers in your computer you know keyboard and that is it. So, it can be easily done today using automatic control system, alright, and that is what would be the best for the engineered concrete.

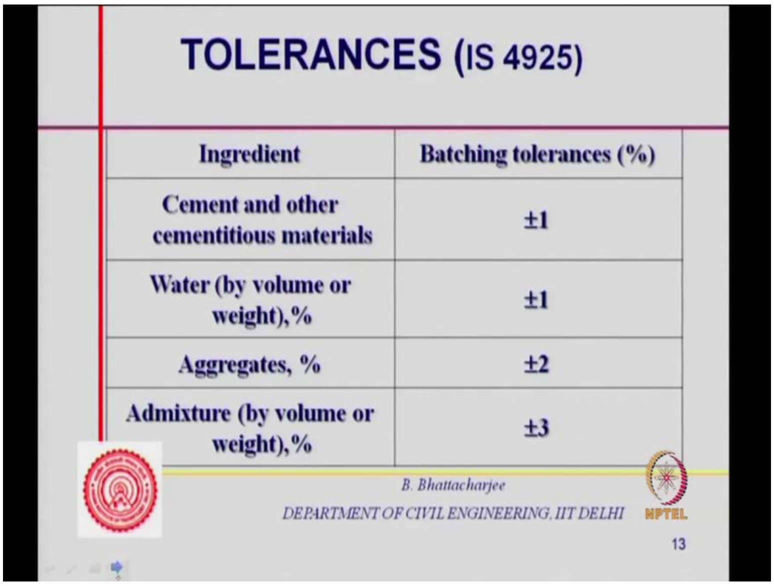
(Refer Slide Time: 18:02)



Moisture gauges usually electrical resistivity type but microwave moisture gauges are available which you just insert on to the aggregate, and you know it will tell you what is the moisture content. Because it is desirable that all the time moisture content of the aggregates are measured and corrections are applied in your mix proportion, because added moisture will be then less because some moisture is there in the aggregate. And total aggregate quantity will be more because aggregate content moisture, so if you have assessed the condition aggregate how much quantity you need, you have to adjust depending upon the moisture condition and therefore, moisture should be measured all the time.

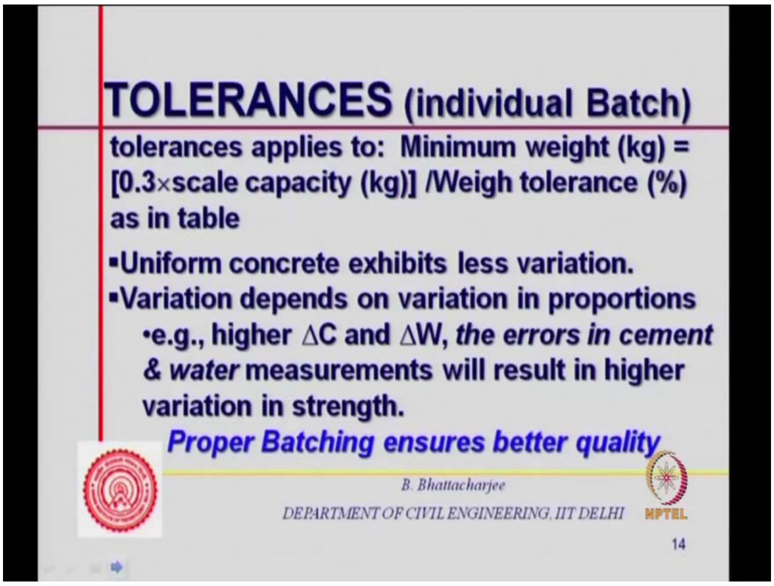
Water is most commonly measured through flow meters, although in some plants water can also be weighed. So, flow meters can be used but you can you know volumetrically you will be measuring. This must be regularly calibrated as regular routine practice and sometime you might do even specialist check of the weighing process, because otherwise you can have problem with the quality control; right kind of proportions you are not giving you will not get the right kind of properties. So, the system should be such that you should be able to check the calibration without too much difficulty, right.

(Refer Slide Time: 19:34)



So, that is the batching process, IS 4925 gives you batching tolerances, many codes or guidelines gives you batching tolerances in elaborate manner, but this is for Indian standard. Cement and other cementitious material it is plus minus 1 percent batching tolerances you know like the tolerance in the measuring system and all that how much error it can have, it is linked to the accuracy that we talked about. Water By volume or weight is plus minus 1 percent and aggregate plus minus 2, admixtures plus minus 3 percent.

(Refer Slide Time: 20:13)



And this is meant for 30 of you know minimum weight; that is 30 percent of the scale capacity divided by the weight tolerance as given in the previous stable. For example, in case of let us say I have a maximum capacity is something like you know about 1000 kg is the maximum capacity of my waving machine waving system. So, the cement the tolerance that has been specified in the previous table will be applicable to 0.3 into 1000 which means that 300 kg divided by 1 percent is the weighing tolerance. So, this should be applicable to 300 kg of the cement minimum cement you know if you have a minimum weight; anything above this you can actually apply this tolerances but anything less than this the tolerances are not really applicable.

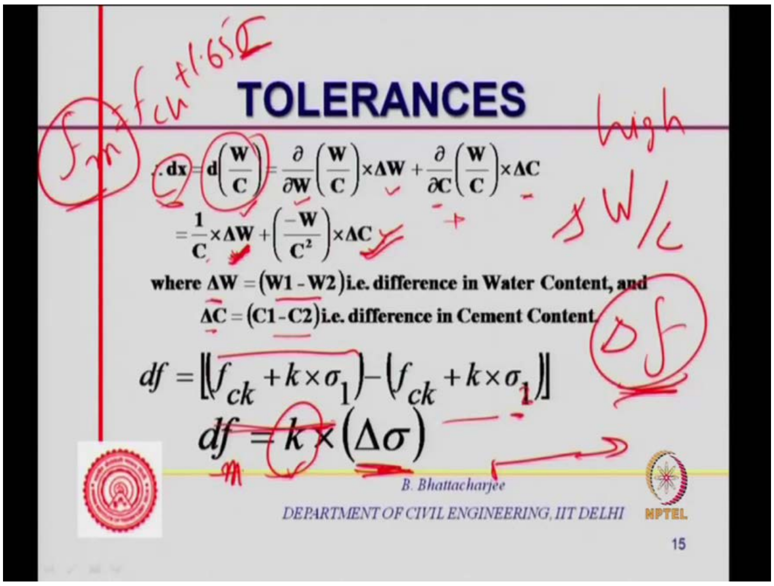
So, this tolerances are meant for 30 percent of the scale capacity dividing by weighing tolerance mentioned earlier while for aggregate this might be 300 divided by 2, so 150 kg. So, accuracy required it is related to that exceeding tolerances given. So, lesser the tolerance you should be measuring more so there it is is less. So, uniform concrete this is actually required all this are required you should always be measuring within tolerances and accurate tolerance should be low. We should measure it as accurately as possible, the reason is you know concrete should be as uniform as possible.

What is then uniform concrete? The one that exhibits less variation; if the variation of property let us say strength variation is large, it is not a uniform concrete. If the slump variation is large it is not a uniform concrete, and uniform concrete will have less variation in properties such as slump, strength, every other properties that you are looking at, air content, aggregate content and so and so forth. So, it should be less variable it should be as uniform as possible. So, if your proportions are varying that is you are batching is not proper, right, batching is varying; one time you have put in x quantity of aggregate next time you put x plus delta x quantity of aggregate. Now this delta x must be as small as possible. If delta x is large the variation in the proportions will be large. So, if this proportion variation is large concrete is unlikely to be very uniform you know in its properties also.

Now let us concentrate on two themes. One is the cement content and water cement ratio. Then you can understand how it affects. For example, delta c is the errors in cement and water measurements, alright. This will result in higher strength variation because we know strength is a function of water to cement ratio; I am talking of ordinary port line cement concrete just for the purpose of understanding an explanation. So, proper batching therefore, if I have less delta c less delta w I will have more uniform concrete less variation in strength better quality. Quality means less variation, okay. So, proper batching ensures better quality. Quality should be less variations, strengths should not very.

So, you know if you desire to provide a concrete of strength let us say with 35 mpa or 37 mpa this concrete I generate or I produce should have the strength 37 mpa plus minus 2 mpa let us say in one case, another case 37 mpa with plus minus 5 mpa. The later is poorer in terms of quality. 37plus minus 2 which means that 35 to 39 is better quality because whatever I have desired whatever I have wished I am getting that kind of concrete; whatever I have promised I am giving that kind of concrete, I am generating producing that kind of concrete. 37 minus 5 is 32 and plus 5 42, so if I am producing concrete from 32 to 42 the quality is relatively poorer because quality is judged by the variations that you have. You know whatever you said you should be giving this. Now this has got lot of implications, otherwise we may be looking it to that sometime later on.

(Refer Slide Time: 24:45)



So, this is related to proper batching is related to batching is related to quality. For example, you can see this you know quality is related to variation, lower variation better quality and if your proportion is not maintained well then you will have poorer quality. More error in measurements introduces you know lack in quality or mix the quality poor because the dispersion is more. Let see just look at mathematically simple algebra no problem; you know for example, if I am looking at change in d w by c water cement ratio variation in water cement ratio I mean I am just calling it a dx. So, x is water cement ratio, d w by c so it is partial derivative and therefore, it will be give as w by c variation with respect to water multiplied by delta w plus from basic calculus we understand this, partial derivative of with respect to cement w by c multiplied by delta c.

Now variation of w by c with water will be given by 1 by c into delta w and variation of w by c partial derivative of w by c with respect to c is given as minus w divided by c square delta c. So, you see if this is my errors in delta w weighing of water and this is the error in weighing of cement; for example, w 1 minus w 2 and delta w is a variation in difference in water content and delta c is the variation in cement contain. So, my water cement ratio higher this value higher this value, this water cement ratio will vary more and strength is a function of water cement ratio, strength is a function of water cement ratio. So, higher this value, higher this value, actually more will be my variation d x water cement ratio will vary more, and if the water cement ratio vary more higher variation in you know delta w by c if it is high high, delta w by c it means higher strength, strength variation also will be higher, strength variation will be higher, right.

So, if the strength variation is higher which means that my mean strength you know it is related to actually standard deviation. So, this should be sigma 2 actually. This is it is related to standard deviation. In fact I can show this strength variation will be 1.65 into delta sigma. So, I will have higher delta sigma strength variation is more I will have higher delta sigma, strength variation is more strength varies from lower value to higher value, standard deviation will be more statistical standard deviation will be more and therefore my actual increasing strength or mean strength increase this is given by for mean strength remember mean strength was target mean strength f m was written as f ck plus 1.65 sigma.

So, if the sigma is higher mean strength will be higher, mean strength in one case is more than that of in other case and therefore I might end up actually getting. This is the difference in mean strength delta f m; mean strength variation will be higher if the standard deviation change in standard deviation is more. So, standard deviation higher variation higher standard deviation results in you know more the standard deviation variation more will be my strength variation. What all I am trying to point out you do better weighing or standard deviation will be lower, and if the standard deviation is lower my f m will be lower for the same f c k, for the same grade of concrete my f m will be lower, and how much lower that will be given into k that is 1.65 into standard deviation difference. So, lower standard deviation is always better, lower standard deviation is always better.

(Refer Slide Time: 29:01)

(Refer Slide Time: 29:28)

Okay, now feed should be raven feed something like this; this is a good feed. You can see that it is feeding through a conveyor belt. Of course this is another batching plant not the earlier one. It is a good feed, feed shows into the bucket, feed to the bucket should be raven feed like this coming almost as a raven and some premixing of the material is good before it comes to the feed. So, this was related to batching importance of batching.

Now let us look at mixing. It is the process you know we produce uniform concrete. So, you have different materials of different specific of different shape, and then we mix them up to produce a kind of uniform cohesive mix. Therefore, I should choose my equipment and method in such a manner that it is effectively capable of effectively mixing concrete material containing largest specified aggregate to produce uniform mixture for lower slump.

It is actually difficult to mix dry material. If it is wet it is easier to make a cohesive mix out of it. So, lowest slump means least water system, this paste and water system and I should choose the mixing machine in such a manner that whatever lowest slump material I am going to use or concrete I am going to use it is able to mix that as uniformly as possible, and larger the size of the aggregate the size variation is more. If it is paste only two material cement and water or cementitious material and water that is easy to mix. You have aggregate it is safe; sand is relatively difficult to mix.

(Refer Slide Time: 31:09)

Now you have three component of three varieties three sizes and if it is still course aggregate it is still difficult to mix. So, larger the aggregates largest aggregate and it will have a tendency to go away you know so segregate also large particle has a tendency to fly away. So, it is difficult to mix; so my mixture machine should be chosen in such a manner that is able to mix uniformly the lowest slump you know with maximum size of aggregate.

Again I can have cyclic or batch mixtures and continuous mixtures. So, cyclic or batch mixtures is what is commonly we use, and continuous mixtures are used only in very large site where production requirement is very high; capacity has to be very high and I should be producing continuously. And remember continuous mixing is much more automated system in a casting here where production capacity is extremely high, and I need very sophisticated system for continuous mixing. It is usually cylindrical comes from one side; the ingredients will come from one side and rotating cylinder through which it would be mixed and by the time the ingredients has moved from one end to the other it is already thoroughly mixed and will be discharged. So, that is a continuous mixture normally you not seen much in Indian scenario I have not heard about.

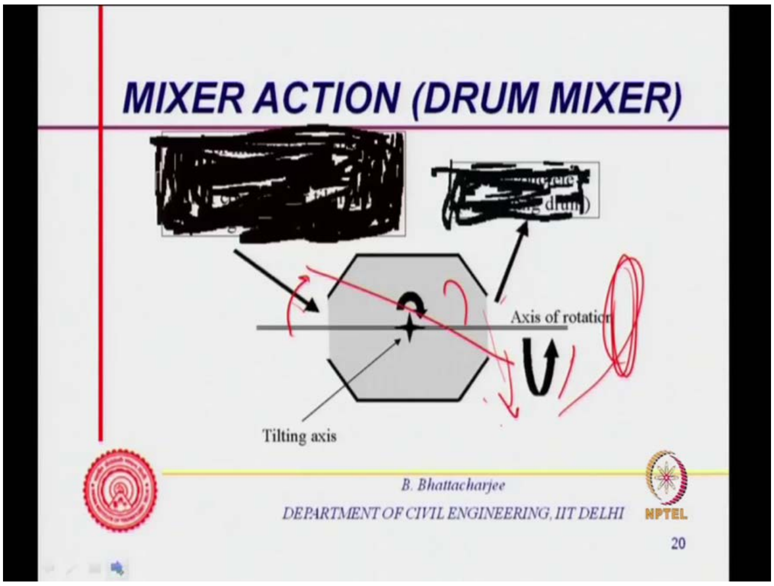
(Refer Slide Time: 32:41)

But the commonly used mixtures are gravity mixtures. So, what they do? They actually bring the material up and then they force to go down. So, some kind of force movement is used for mixing and the gravity mixtures can be tilting or non-tilting time. They are not the very best type. You know normally tilting type of mixtures has been used quite often for small concrete and largely in Indian scenario before the batching plant where batching plant is not used actually use tilting type of mixtures; they are not the best mixtures. Counter-flow mixture or open-pan types of mixtures are the much better one and that is what is used in most of the batching plants, right.

So, tilting type of mixture will look like this you know, it will look something like this. So, you have got some baffles here, you will have some baffles here, you know baffles here, and material is fed in and it is at inclined shape, the baffles would cause them to move. So, this baffle should be of different shape blades and it actually rotates. It rotates, actually it rotates, alright; it rotates about this axis it will rotates and by this rotation up and down also this movement the mixing is done, and when you want to discharge you just drop it downward in this direction. So, you tilt it and it is done, and that is very commonly used small type mixtures.

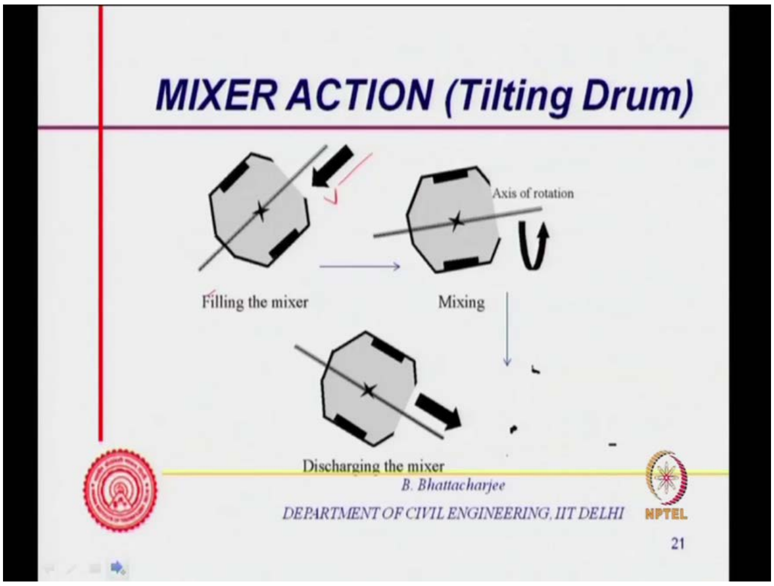
They do not do a very good job as I told you, so that cavity type of mixtures what the baffle does? Baffle lifts up the material, just puts it here and they drop down on their own, and this is how first this repeated lifting up material and dropping it actually causes mixing in this baffles and then finally discharging is through the tilt, discharging is through the tilt actually.

(Refer Slide Time: 33:56)

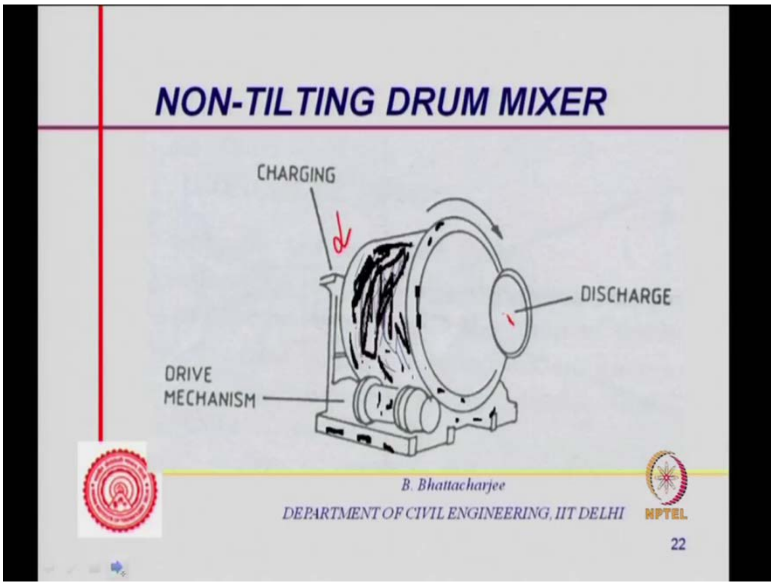


This is tilting drum; this is exactly the previous one what I talked about. So, it rotates actually tilting axis about which it can rotate. I mean this is the rotation axis you know this can rotate about this, it rotates in this direction, so material goes up and down; you feed from here and you know when you want to discharge you tilt it and it will discharge. So, this is the tilting axis, this axis it can actually go like this, whole system can come downwards and discharge. So, this is commonly used mixture for you know small concreting.

(Refer Slide Time: 34:36)

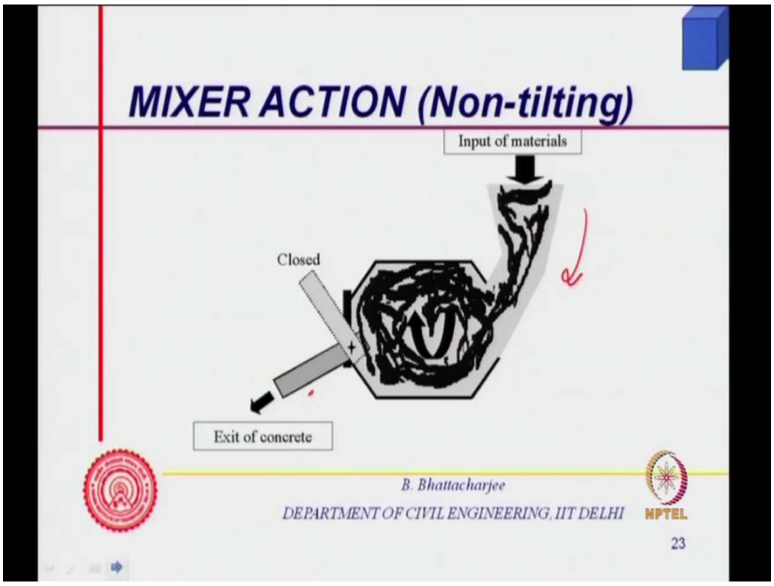


(Refer Slide Time: 34:56)



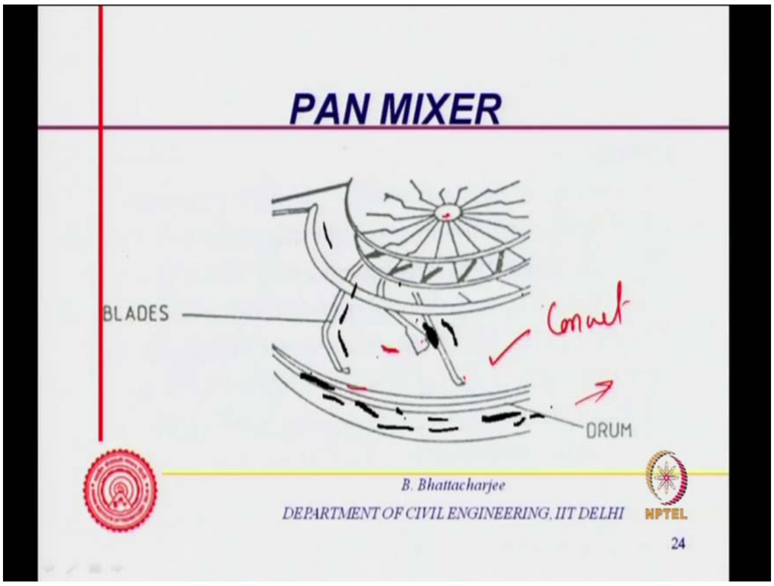
This is the process filling the mixture when you fill from the stop this can rotate about this, then axis of rotation moves. This is where the mixing occurs and then finally discharging is through this. So, this is commonly used mixture type but this is non-tilting type actually. Here you charge from here and it rotates while mixing, a counter rotation would actually cause it to discharge through this one. This is normally closed then you open it up. So, the counter flow causes or the flow causes this to discharge out. There is of course the motor or whatever it is, not very commonly used, not very commonly used, not very commonly used.

(Refer Slide Time: 35:26)



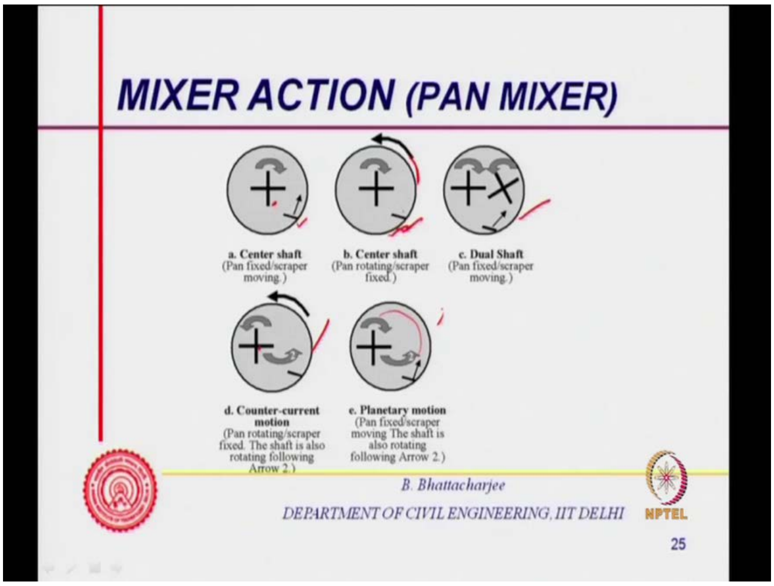
This is the non-tilting type; you feed it, this is closed, and when you want to discharge you can just open this, there is a shoot here. So, this is the feed of the material and that is how actually this is this is your non-tilting type you know mixture not very common.

(Refer Slide Time: 35:45)



This is what is most common. So, you have a rotating drum which will rotate, and this are the blades; this are the blades actually, this is the inner blade, this is the smaller blade outer blade and this you know relative motion of the drum and the blades. So therefore, your concrete is here, here is your concrete and you know this rotates about this axis. So, drum can rotate baffles can be steady or drum is steady baffle rotates and this causes; this is at extreme periphery, this is that inner side and this causes the mixing to take place.

(Refer Slide Time: 36:26)



For example, you can have counter shaft, so there is a baffle here, right, fan is fixed this rotates, this rotates, this rotates, right scrappers; this scrappers are moving. So, this moves; in this one shaft is at the centre, this is also centre in the shaft, and this is rotating drum also is rotating. So, this scrapper can be fixed, sorry, in this one drum rotates scrappers are fixed; in this one dual shaft and scrapper moving this once moves and drum pan is fixed. This pan is fixed; this is fixed. In this case also this is fixed; in this case pan fixed scrapper is moving. So, here scrapper moving pan fix, in this one pan rotates scraper is fixed. In this one pan rotates scrapper also rotates. So, pan rotates scrapper fixed, but the shaft is also rotating. So, this shaft rotates. So, there is a kind of planetary motion, and in this one planetary motion this one shaft rotates in this manner and you know pan of course is fixed. So, you can have different kind of action but most common type is the one that I showed earlier.

(Refer Slide Time: 37:45)

A photograph of the same is like this. So, for example here you can see as you can see in this particular one.

(Refer Slide Time: 37:57)

Scrappers this is the scrapper; there is an inner scrapper which you could have seen before, inner scrapper you know which will look like this; inside scrapper is the inner one, this is the inner one is the scrapper.

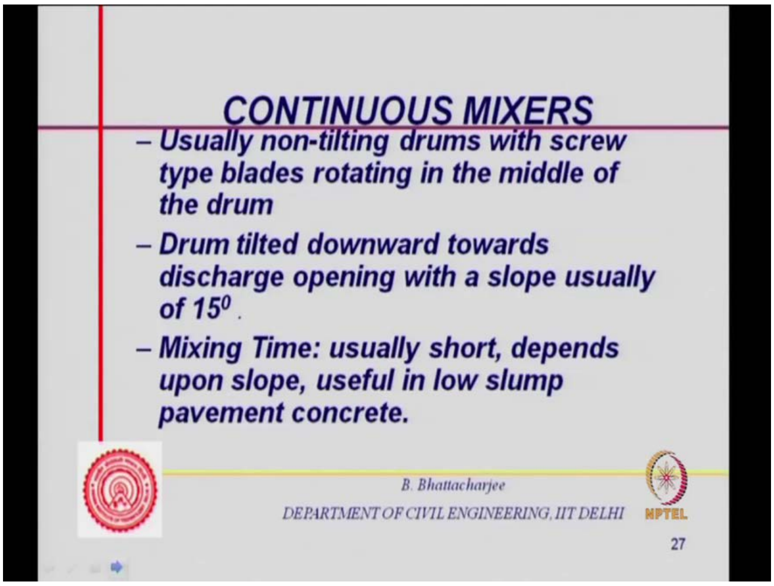
(Refer Slide Time: 38:29)

And then you have got the scrappers again outer one and then finally. So, you have inner scraper here and scrappers there. This is where the shaft, pan is fixed in this particular one pan is fixed. So, this is one type scraper, this is other scrapper; the smaller scraper you can see somewhere up there, you know this is other scrapper, this is the other scrapper, this particular one is other scrapper.

So, this is the inner scrapper is here, this is the inner scrapper, this is the inner scrapper, this is the inner scraper, alright, this is the inner scrapper. So, drum rotates and the pan is fixed here. The scrapers of the two kind you can see the bottom of the scrapper somewhere there, you can see the bottom of the scrapper somewhere there, you see this is the bottom of the scrapper and similar sort of baffles in a scrappers are there. So, they rotate; they will rotate and scoop the material out, put it in the inner site and the rotation continues, you know it mixtures from outer to inner one, and this are much more efficient than gravity type of mixtures.

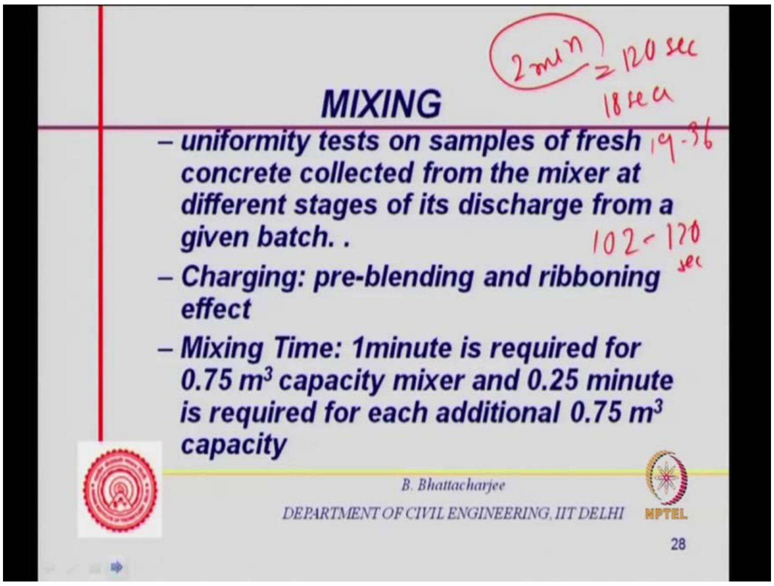
So, this is the commonly used pan mixtures in case of a batching plants which are used today. As I told you continuous mixture is one usually non-tilting drum with screw type blades rotating in the middle of the drum and you have feed from one side, drum might be tilted slightly downwards towards the discharge opening with a slope usually of 15 percent, and you feed from one side; usually very short mixing time depends upon slope useful in low slump pavement concrete.

(Refer Slide Time: 39:38)



So, if you are producing large quantity of concrete this might be useful one. You feed from one side, and then it is a continuous batching also continues mixing also feed from one side and the screw type of blades that causes the mixing as it rotates the rotating drum rotates, and then it discharges at the end by the time actually the mixing has been finished.

(Refer Slide Time: 40:40)

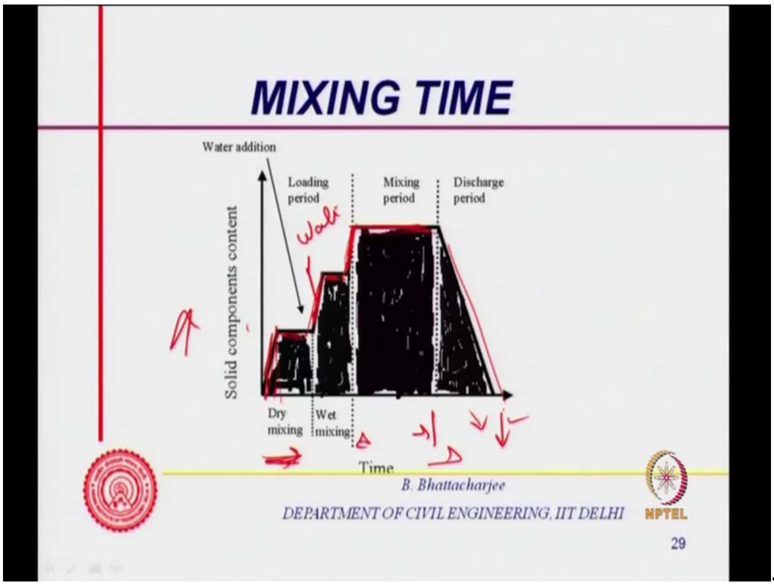


So, you know the most important thing is the uniformity of the mix. We have seen that batching is also required for uniformity. Now how do you do uniformity test? So, we actually take samples of fresh concrete from the mixer at different stages of its discharge from a given batch. For example, either it is in terms of quantity or let us say in terms of time. So, let us say it takes about you know it takes about a two minutes time to discharge. So, I can take from the first 15 percent of the discharge two minute time uniformly discharging let us say, right.

So, I have got actually 120 minutes and 15 percent of that will be 18 minutes; you know sorry 120 seconds two minutes means 120 seconds. So, I can take from first 18 seconds I take some concrete and cast samples out of it, test for slump, cast sample cubes, etcetera, etcetera. Similarly, I can take from another next 15 percent or next 20 percent. Now next 15 percent would be from 19 to 36 seconds or I can take from the last 15 percent which will be actually 102 seconds to 120 seconds.

So, I can go on talking samples at the different time of the discharge, right and measure their properties, and through this actually I will be able to do uniformity test, and I will actually test several things, I will just see; I will just talk about that in a minute. Now charging of the mixer machine should be pre-blending and ribboning effect which I showed earlier and mixing time one minute is required 4.75 meters cube capacity mixer and 0.25 meter required for each additional 0.75 meter cube. This is given as per the quote but we will talk about this a little bit more.

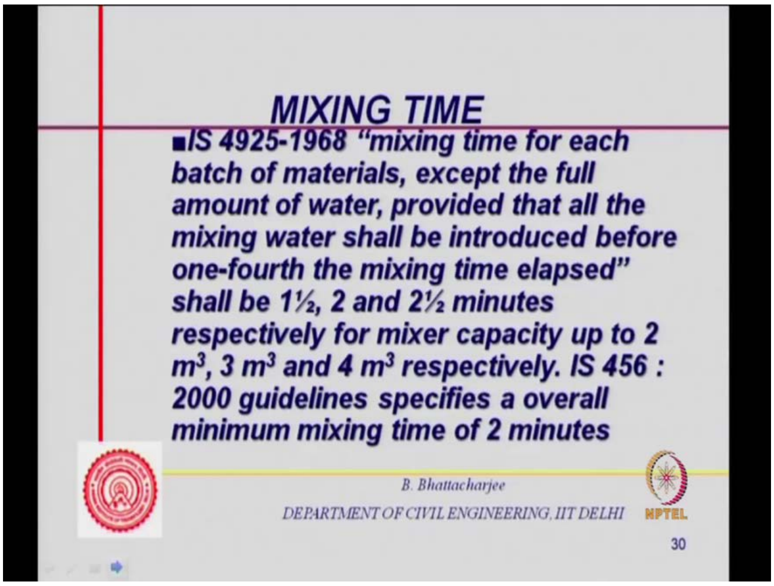
(Refer Slide Time: 42:49)



Let us just talk about the uniformity of mixing; you know typically if you look at feeding we will look at uniformity but if you see feeding first stage is dry mixing I put in dry mixing you know this is time versus solid component in the mixer machine. First I just feed in; during this period I am feeding, and here I am doing a little bit of dry mixing. Then again I am loading but in this case some water I have loaded. During this period I have loaded the water, and this is somewhat wet mixing. Then I load the final quantity of water, and it is total mixing.

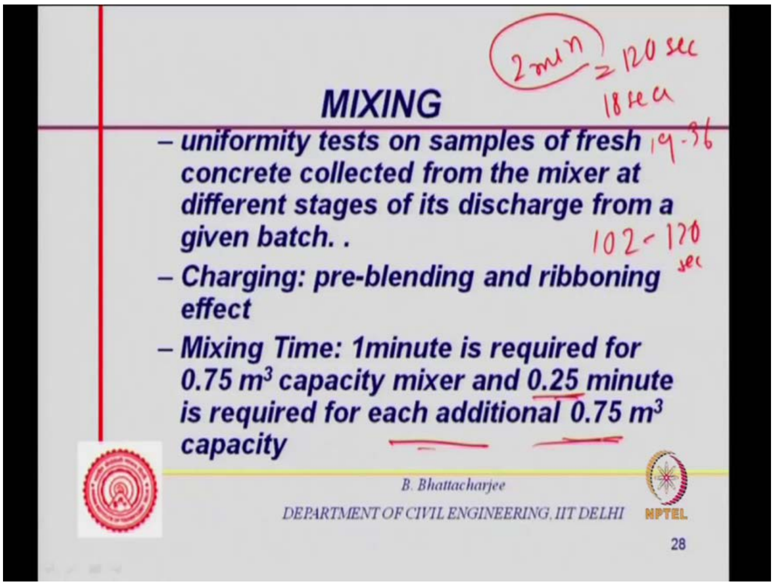
So, this is your true mixing period, and then this is the discharge period, this is the discharge. So, typically first I do a little bit of dry mixing then I add water. So, add the solids dry mixing then I add water also some solid also water and then finally all are added in this zone and the total mixing period goes on and then there is a discharge period. So, this is typically the sequence of mixing or solid component in the mixer machine. So, you can see first I added some solid no more solid here, here solid plus water, then this is again some more solid and then continuous mixing here and then finally this is the discharge.

(Refer Slide Time: 44:10)



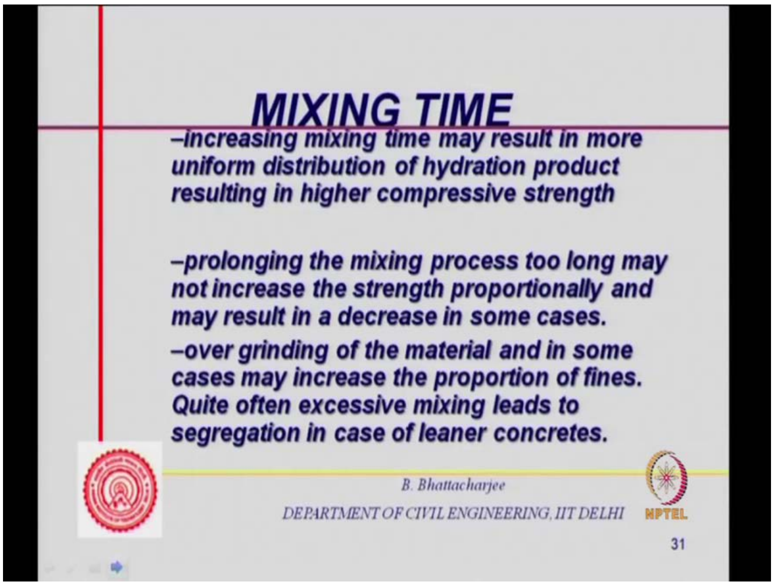
So, this is how the mixing goes on totally mixing time looks like this and IS 4925-1968 previous 1.75 meters this is IS 456: 2000 but 4925 is elaborate. It says mixing time for each batch of material except the full amount of water you know provided that all the mixing water shall be introduced before one-fourth of the mixing time elapse, shall be one and half, two and two and half minutes respectively for mixer capacity up to 2 meter cube, 3 meter cube, 4 meter cube respectively. IS 456 of course is very simple. It says that over all minimum mixing time should be two minutes. So, this is the guideline given in the code one 4925. The earlier one I gave you from I think it is some kind of consideration available in literature, you know 0.75 meter cube at time is given for additional each 25 0.25 meter cube the additional time is given in the previous slides as we have seen, right the idea what I gave you from my thing it is some kind of consideration that available in meter you know something like you know you can go back actually, we can go back to the previous one and this one mixing time.

(Refer Slide Time: 45:18)



That is 0.7 one minute for 0.75 meter cube capacity and for additional 25 meter cube is required for you know 0.25 meter minute is required for each 0.75 meter cube. That means you have got about 1.5 meter cube will require 1.25 minutes. If you have 2 meters cube you will require about 1.25 plus another 25 that is 1.5 minutes where as the IS 456 says that nothing less than two minutes you should be mixing which is simple but than the other one you know like the 4925 tells you one and half minutes for 2 meter cube same as what I said earlier and for 3 meter cube two minutes and two and half minutes for four meter cube. So, these are the mixing time but we will see the basis behind all this.

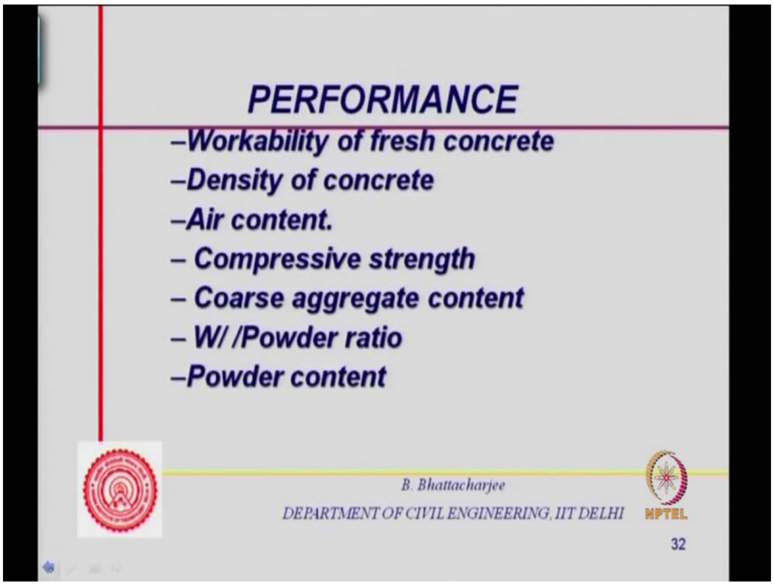
(Refer Slide Time: 46:15)



But first of all let us see you know I need sufficient time, because increasing the mixing time may result in more uniform distribution of hydration product. Because it causes abrasion over the surface of the aggregate, and therefore removes the hydration product and some of the hydration product then further gets exposed to water. New hydration product would get deposited on top of the aggregates and so on. So, it actually causes a better dispersion and more uniform scenario and therefore higher compressive shrink but there is a point of diminishing return. If you go on increasing this it may not increase the strength proportionally and sometime it can even cause decrease, alright.

So, this does is the limit up to which you can do it, because mixing may cause over grinding of the material too much of abrasion between aggregates and some cases may increase in the proportion of fines if the aggregates are weak. Quite often an excessive mixing leads to segregation in case of linear concretes. So, mixing time should be optimal not too much high.

(Refer Slide Time: 47:30)



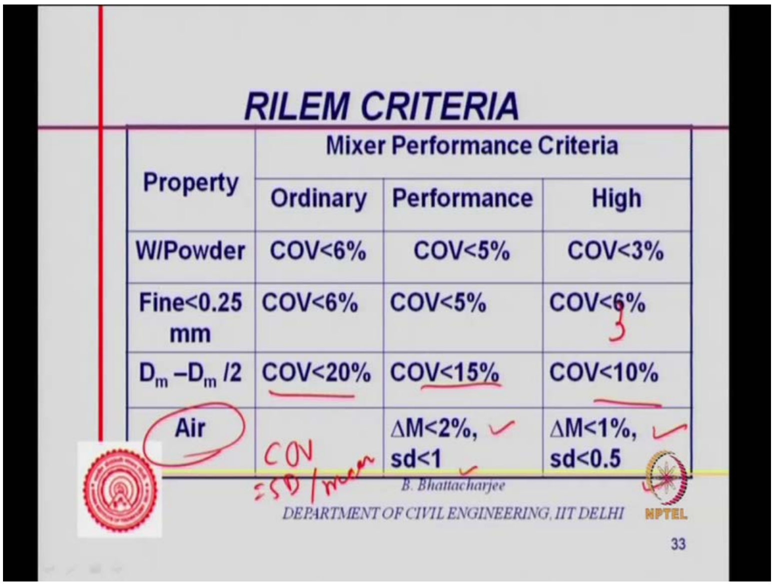
We will come to this mixing curve a little bit later but just look at performance of the mixture. I said that you can take from first 15 percent and last 15 percent or in between any range and the variation should be least. So, uniformity of the mix is measured by measuring workability of fresh concrete at different points of the discharge. Then you also measures the density of the fresh concrete, measure the air content of the fresh concrete taken at different point in the discharge time of discharge; you know you take from the 12 seconds out of 120 minutes let us say, discharge time let us say is 2 minutes. So, first 12 seconds you take one sample next 12 second you take another sample. You can go on taking ten samples and find out the variation but if one way is to take from first 15 percent then last 15 percent, because you know at the end it is tendency of aggregate is to come first.

They will get discharged first; the paste will come last particularly in tilting type of mixtures. If it is bottom discharge this problem is much less, it comes out all equally you know but tilting type of mixtures aggregates will come first paste has the tendency to come first. So, uniformity can be measured from first 15 percent of the mix and last 15 percent of the mix and variation should not be too much. So, compressive strength of cubes you can measure, coarse aggregate content you can measure by analysis of fresh concrete, you know you simply wash it, do wet shaving, put it on a sieve of 4.75 micron size mm size 4.75 mm size, put all the concrete, put a water jet course aggregate will be remaining fine aggregate will go out.

So, course aggregate content you can measure easily analysis of fresh concrete, water to powder ratio you can find out because whatever is going out you can just again put it to a 75 micron sieve, and whatever is remaining it is the same dust water to powder and you can actually find out you know the analysis of fresh concrete can be done, find out the cement content, water to powder ratio powder content you can find out by doing analysis of fresh concrete. So, actually what I was talking of; you can have workability, density air content, compressive strength, coarse aggregate content, water to powder ratio and powder content. Those kind of analysis of fresh concrete done and you can measure them, and workability and strength can be measured at appropriate time, and then see what is the variation.

If the variation is less you are very happy it is within a limit in fact coarse specifies the limit, and it also says that to define a mixed uniform may be five out of the six or four out of the ix or six out of the five seven should be satisfied you know, the various code tells you differently. So, 4925 is quite strange and it says six out of the seven or I think it is five out of the seven should be satisfied the ranges are given. How much is the variability; workability can vary by how much? How much slump variation is possible, how much density variation is possible? These are given and number of test it should satisfy out of this seven is also specified. I have not actually included this because this will become too long. So, one can check this use the code and decide, test the mixture machine to find out whether it is giving you uniform mixture mix or not.

(Refer Slide Time: 50:58)

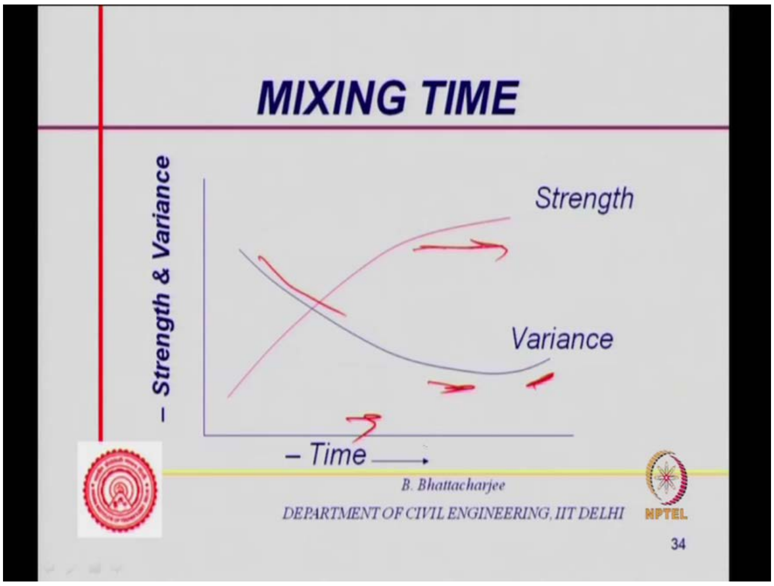


Rilem criteria are of course something like this. You know it depends upon what is called coefficient of variation which is standard deviation from different samples measurement, measurement from different samples divided by the mean. So, you find out coefficient of variation because its standard variation COV, COV is standard deviation divided by mean. So, you find out mean strength mean water to powder and also find out the strength of the variation from ten such samples taken from a single batch, and if the coefficient of variation is less than 6 percent you say it is ordinary. If it is less than 5 percent then you call performance is very good; I mean just good, and first one is ordinary performance and high performance is if it is less than 3 percent. There are several others criteria given; I have just included few of them. Fine aggregate less than 0.25 mm size, fine aggregate less than 0.25 mm size, alright; that is your you know 250 micron.

So, that again the coefficient of variation should be less than 6 percent to be ordinary, less than 5 percent and less than 3 percent it should be; I think there is a mistake there. This should be 3 percent, it should be high. Similarly, coefficient of variation for D m is the mean particle size. Add minus D m by 2 mean particle size minus 2. So, proportion of the particle belonging to particular size you find out and if it is less than 20 percent, 15 percent, 10 percent. Air content residual air content by mass if it is less than 2 percent with a standard deviation less than 1 you call it okay performance. If it is less than 1 percent and standard deviation is less than 0.5 you call it high. Similar other criteria you have given; I have only taken a part of the table. So, therefore performance has just from the variation, right.

So, more variation means poor performance, less variation means better performance; uniformity of the mix that the mixer machine produces uniform concrete less variation that is the better one. In fact this should be monitored from time to time in a computer controlled engineered batching plant because otherwise it does not make sense you know you have part of it is computer controlled if you are not checking routine checking of your mixture machine and batching tolerances and all that, calibration of the batching plant. Mixer machine uniformity this should form the part of the quality control system if you want to produce good concrete because then only you will have concrete most of the time uniform, right; otherwise, it will actually introduce standard deviation in the properties.

(Refer Slide Time: 53:39)



Mixing time I was talking about we can study this from coefficient of variation; for example, if you look at strength and variance in strength variance is standard deviation square. So, strength actually increases but it becomes stable here does not increase further. Similarly, the variance; variance is nothing but square of the standard deviation. It reduces as you increase the mixing time but does not actually reduce beyond that. In fact it might even increase because your fine in fines might increase. So, therefore what we see is that there is an optimal mixing time and uniformity of the mixing is very important, optimal mixing time for example cord size two minutes so preferably two minutes little bit just above two minutes is fine, or the guidelines that is given in 4925 or otherwise available in literature. They must be used but one should not actually prolong the mixing too long.

This can result in higher variation variance and strength. So, higher variation uniformity will be less, alright and uniformity test we have discussed. So, this is a aspect of mixing and batching, and they are all related to quality control better you know if you do a good batching that means proportions are all the time more or less same. The errors in measurement are less, calibration are being checked regularly. So, it is within tolerances the accuracy is within tolerances; that means that proportions if you are measuring 100 kg your batching or weighing machine showing 100 kg it will be 100 or plus minus 1 percent. So, let us say 99 to 101, actual will be 99 to 101.

So, if it is going beyond it much higher let us say 95 to 105 but you are thinking it is about 100; it means that it is actually your actual proposition is different. It would lead to more variation in the strength in your final product or more variation in the slump of your final product. So, batching is very, very important and mixing then is very, very important. Pen mixtures are definitely better and discharge from bottom is better, tilting mixtures can cause segregations because larger particle can go away, mixing may not be uniform, right, the mixing more uniform the mixer machine uniformity of the mix that is coming out of the mixture machine should be changed. Important aspect is the time of mixing type of mixture and time of mixing. Time of mixing too long may not be good, whatever is specified in the code that one may adapt to. So, that way then one can produce good concrete. Quality control is related to both.

(Refer Slide Time: 56:28)

So, you have looked into the concrete production process what are the steps involved. Then you have looked into the batching process and its importance in producing good quality concrete, engineered quality concrete and then we have looked into mixing process for producing uniform quality of concrete. So, that is what has been part of our dissection right now and with this actually we conclude our discussion.