Building Materials and Construction

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Module - 3
Lecture - 2
Concrete: Production (Contd.)

Last lecture we introduced concrete material, on this lecture and one or two subsequent lectures, we shall be discussing about the concrete production process.

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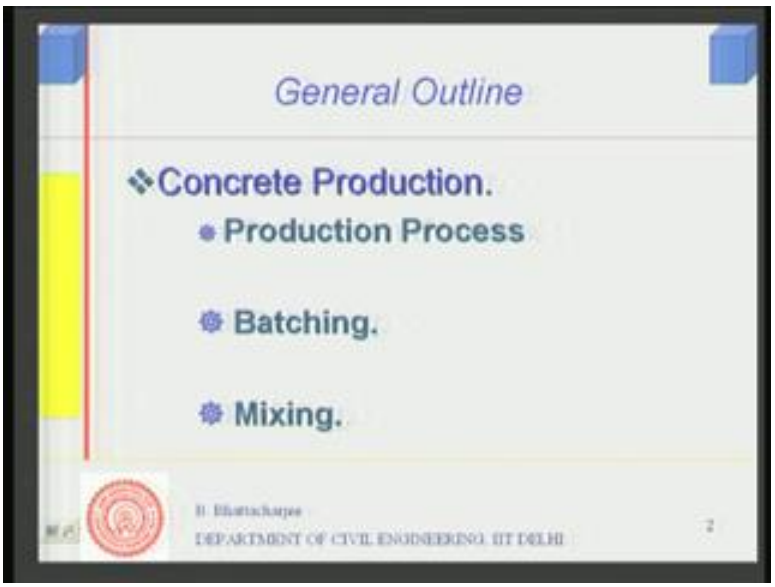

So, general outline of this lecture is, first we will talk about production process itself followed by what is called batching and then mixing. The other part of the concrete production process we shall look into the next class. So, let us look into concrete production process.

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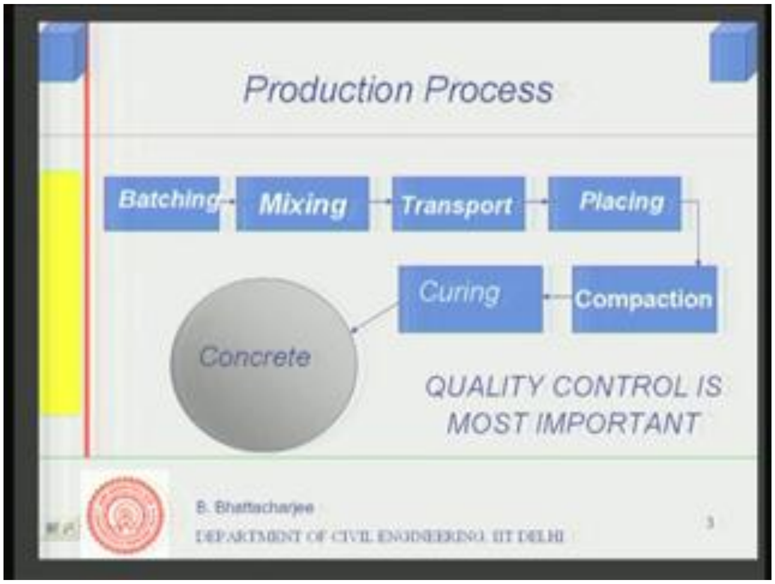

First step in concrete product is batching. This means, weighing the components of concrete. This is followed by mixing these ingredients and once mixed, the plastic concrete is produced, wet, you know produced in the plant and that has to be then transported to the place where actually casting is to be done and there it is placed into the mould. Once placed into the mould, the ordinary concrete generally requires compaction. And then, once compacted, it solidifies or sets into solids gradually, then it has to be hardened. And the process that is involved in hardening the concrete to obtain the hardened concrete, it is called curing process. So, once curing is over, we get the final product, concrete.

Now, in all these process it is important to have quality control of the product that we are producing. We will discuss about this quality control sometime later on. But right now we look into each of these processes one by one. As mentioned in the previous slide, today we will be talking about these two that is, batching and mixing process.

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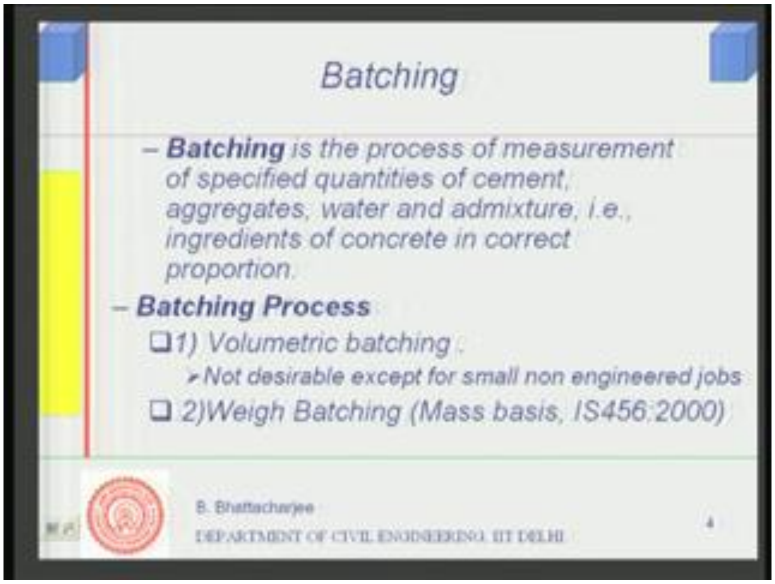

Batching process, now batching is defined as the process of measurement of specified quantities of cement, aggregates, water and admixture, that is all the ingredients of concrete in correct proportion. So, that is what we call as batching. Essentially, weighing ingredients in specified quantities as we have obtained through the mix design, you know, design of the material itself and mixing them. I mean, before mixing them they have to be weighed in proper proportion. So, proper proportioning is done here. This process is important on that count.

Now, conventionally volumetric batching was used in earlier days. However, this is not recommended now except for small non-engineered jobs. So, for non-engineered job, still this is used, but this is not a desirable thing. And in fact, the Indian Standard Code of practice, IS 456 2000 does not recommend this sort of batching for structural grade of concrete. The other type batching is weigh batching, where it is on mass basis and IS 456 2000 actually recommends this sort of mass basis concrete batching.

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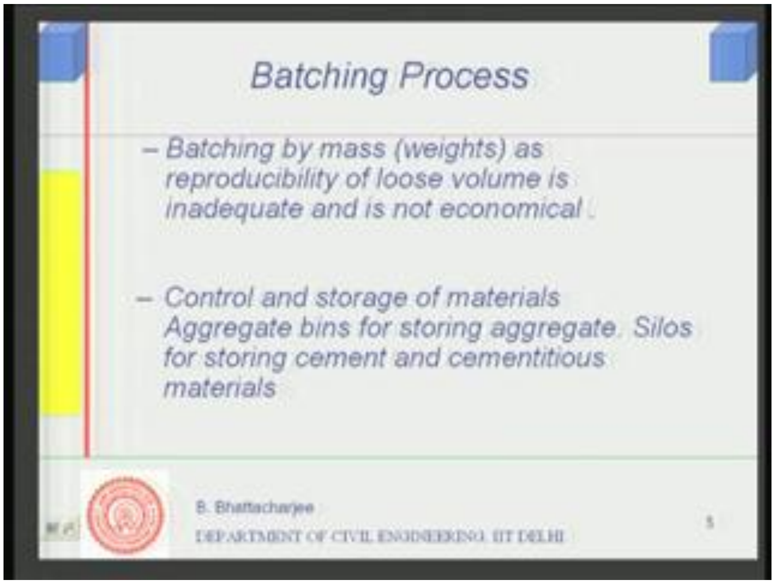

Why it is so? The reason is very simple. Since we want to mix the material in correct proportion, as we have designed it, therefore volumetric batching is not desirable because volume, the mix design is on the basis of mass. And volume of such particulate system depends upon the packing. If it is a lose packing, it will occupy more volume because the bulk density will be less. If it is a compact packing, its bulk density will be more and occupy less volume.

So, therefore control on volume is difficult, whereas mass basis, you can simply weigh the material and it is, whatever amount of mass I want to put in, that would be, that I can put in straight away or I can determine in a very, very accurate way.

So, batching by mass is required when I desire reproducibility. I want reproducibility all the time. I should be able to produce the same concrete. Lose volume is inadequate and it does not result in economical mix also. I can convert the mass into volume, and then put those volumes, but then lose volumes for such particulate matter will always vary depending upon the packing quality. Therefore, lose volume batching is not desirable, not definitely for structural grade of concrete.

We cannot control it, variability will be large and we will get different product, different type. So, that is why, weigh batching is done in the first step. Of course, before even if we do weigh batching, control of the storage material is essential. Control and storage of the material that is what is essential?

For example, aggregates are used bins, are used for storing aggregates, okay. Cements are stored in what is called silos. We have some diagrammatic description of the same and all other cementitious material.

Now, while discussing about the materials, I mentioned you other day, that pozzolana like fly ash, etcetera, they do have some reaction capability in presence of water and lime. So, this material also produce the same product as that of the reaction of cement with water and therefore, we call this material as cementitious. So, cementitious and cement materials are stored in closed silos because moisture from the atmosphere can react with the cement and therefore, you know, it will actually destroy or spoil the cement itself. So, cement has to be stored in a moisture free condition and that is usually stored in a silo.

So, is the fine materials, such as cementitious materials, which are very fine and can actually spread by flying and contaminate the cement or other materials. Therefore, they are also to be stored in closed container such as silos. Aggregates are stored in open bins. Usually these bins, in each bin you will have particular size of aggregate. So, you can have large number of bins corresponding to each size of aggregate and these are measured in required quantity and then added into the mix. So, while batching, they are weighed in required quantity and added into the mix, alright.

So, that is how storage is important. We must store cement such that it is not actually does not get contaminated with water of any form. It is not start setting due to relative, high relative humidity. Aggregates should be stacked in open. It is possible, but very fine material are not stored in open because, because of wind they can fly and contaminate the other materials. So, one has to take care of this sort of situations of avoidance of cross contamination from different material while storing. So, storage is the important issue as far as batching is concerned.

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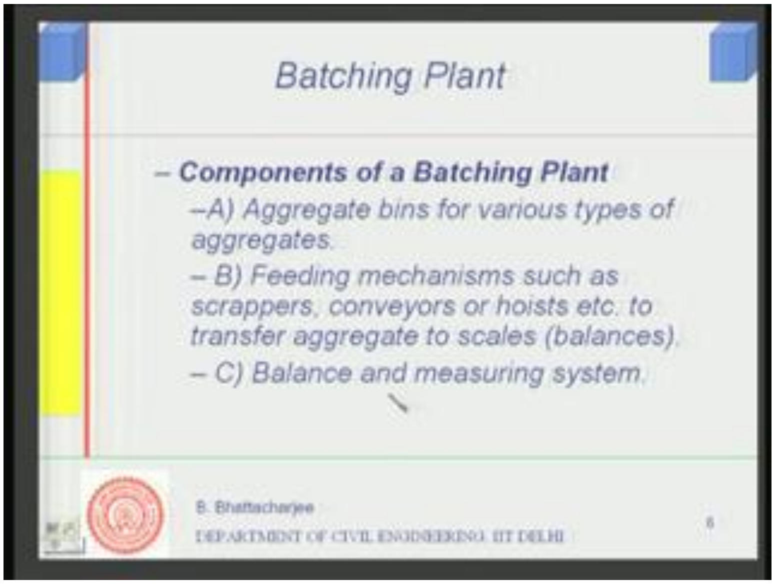

And now, next look into the actual batching and therefore, look into batching plant. The essential components of batching plant would be aggregates, bins, aggregate bins for various types of aggregates. For each type of aggregate, I said, one every size I can store in a given place, so aggregate bin. Then I can have feeding mechanism such as, you know, how do I feed them into the weighing system first.

So, I must have feeding mechanism such as scrappers, conveyors, hoists, etcetera., through which I actually fit them. So, this feeding mechanism is important and followed by balance and the measuring system. So, balance measuring system feeding mechanism, these are the ones.

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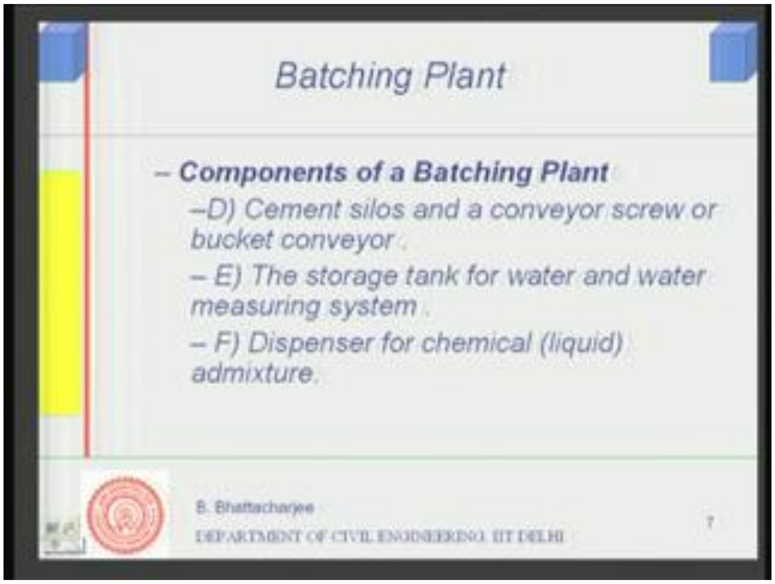

And next one is, of course, cement silos where I store cement and a conveyor, screw conveyor or bucket conveyor through which I actually transport the cement from the silos to the weighing device balance, and then of course, to the mixture. And then, followed by this would be the storage tank for water and also water measuring system, right.

There should be dispenser for chemical admixture, if there is any, because we talked about cementitious in cement. They are treated in the same manner, they are stored in the silos and then transported through screw conveyors or bucket conveyor to the balance or weighing device.

And followed by its transportation to the mixture, mixture machine, whereas liquid ones like water, they are stored in tank. And there is water measuring system, quite often it is volumetric measurement, as far as water is concerned. Since we know that volume of water is controlled easily unlike the lose packed materials of grains or particulate system for chemical admixture, which are added in very small quantity, dispenser itself. So, this is the component of a batching plant.

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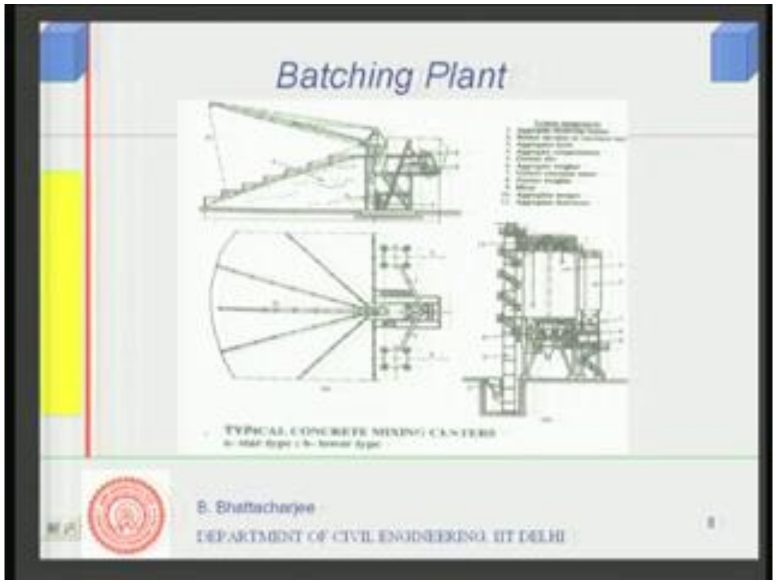

Now, let us see diagrammatically how does it look? A batching plant, you know, there are two types of batching plants, one is called the star type, this is the star type and this is the tower type.

In the star type, you can see, this is in plant, this is the cement silos, this is another cement silos. The mixer machine is somewhere here, this is the screw conveyor, this is another screw conveyor, the weighing device of cement is somewhere here, this is the elevation, this is the, this is the scraper, this is the scraper through which, this is the scraper through which I can pull the aggregates.

You see, this is the scraper through which I will pull the aggregates from a bin, upward and there are gates here, through this gets discharge to the bucket. Now, this bucket is lifted up through this, hoists up and then discharged after weighing.

At the bucket you have measuring system, could be balances or load cells, whatever instrumentation, modern ones, obviously is the load cells, which can measure the mass, which can measure the load actually, that has accumulated. And once the desired load is, desired load is measured or obtained, this gates through which this aggregates comes in, get close.

So, these are automatically opening and closing gates. Once open, it will discharge aggregate till the weight, desired weight is reached or desired mass is reached and it will close down the gates. There can be separate gates for each type of aggregate, may be this is, say 20 mm down aggregates this is for, you know. There is another bin for 10 mm down aggregate. A third bin could be there for sand and so on. So, for each of the aggregate type you will have one bin.

And this is the scraper, which pulls this up into the stack at the top it where there are gates and through the gate this aggregates come down to this bucket where, which is fitted with the load cell, automatic load cell in automatic batching plants, I mean, modern batching plant and then this is hoisted up and put into the mixture.

Cement, on the other hand, is weighed, you know, it is, through its screw conveyor it comes to the, comes to the balance where it is weighed and then put into the mixture and water can also be put in this manner. So, this is the star type, which is most common of the kind of batching plant.

This is the vertical tower type where this is the aggregate, actually aggregate storing in vertical bins. This is cement bin and there are screw, conveyor screw through which it is transported. The mixture machine is somewhere here and from this one, the weighing device is there and it is transported here. The aggregates, aggregates receiving bucket, this is the aggregate receiving hopper from which by bucket conveyor it goes up and stored in this one, and then finally into mixture. This is not a very common system, whereas this is a very common system, which is used often these days.

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A photograph of the same thing from one side looks something of this kind. You know, in this one, as we shall see, this is the cement silo. There are two cement silos in this particular batching plant. There are two cement silos, one and two, as shown by this arrows. There is one silo for the fly ash because this particular batching plant was using fly ash. This is one of the aggregates bins. This is another aggregates bins and there is third aggregate bin here and there is fourth aggregate bin here.

We, depending upon the size and type of the aggregate, one time you might use one particular aggregate, another time you might use a second aggregate. So, it depends, depending upon the size and varieties of aggregates that use, you will have separate number of separate bins.

This is the scraper, as you can see, this particular one is the scarper sorry, you know this is the conveyor screw through. This is the scraper through which actually you can see it is going up. There is a cable sort of thing, which this bucket pulls it upward and these are the walls of the bins beyond, on the other side. There will be, somewhere the gate would be there and this somewhere gate is at the bottom. Once the gate opens, this aggregates automatically falls down into the bucket, that is, there on which the load cell is fitted and it is weighed. So, aggregates bins are been shown and this is the scraper as I mentioned.

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And another view of the same plant from the other side would look like this. You see, this will see from the control room, usually modern batching plants are fitted with computer control system.

So, there is the control room in which the computerized system is there and one just programs it, feeds the data what it needs, every individual input. For example, if I need x kg of, of you know, p type of aggregate in the mix, that will be fed into the computer and automatically, the automatic loading, you know load cells will automatically weigh this and put it into the mixing machine.

So, the control room houses the computer and the operator sits here. Then, this shows the screw conveyor. This is for that cement, one from the cement silo, this other is from the other cement silo and one from fly ash silo. You can see this one. So, this is the conveyor through which actually, you know, from this, this, from this particular silos.

This goes to one of the machine, the other one goes to the other mixture machine. So, actually there are two mixture machines here, two cement silos, one fly ash silos and two mixture machines are fed by these three silos. Mixer is shown here.

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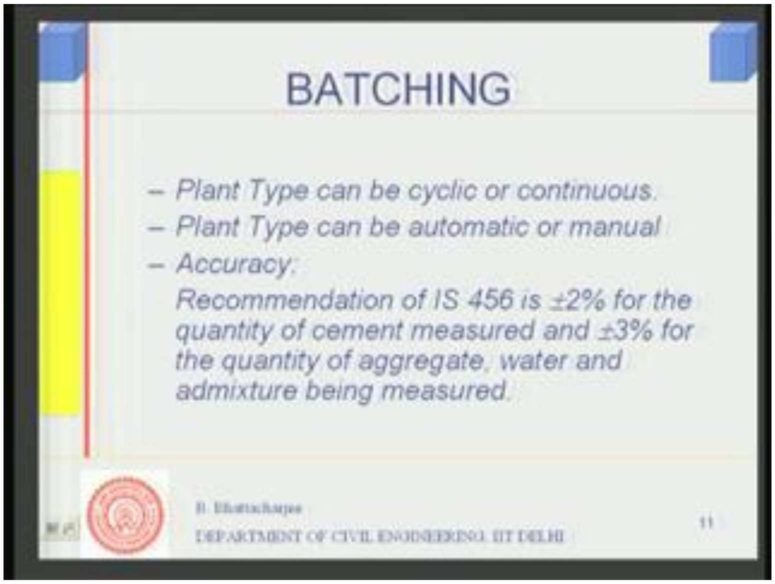

So, this is what batching plant looks like; this is what batching plant. There can be two types of operation possible for batching plants, one could be cyclic type, other is continuous. One I showed was actually a cyclic type; one I was showed is cyclic type.

You know, it finishes one batch, then loads another batch and so on. But there can be continuous batching plants, which operate with continuous mixture.

So, in that one, one side continuously the mixture is fed with the material, its weighed continuously and continuously it is fed. And the mixture machine, this is also continuous, can produce at a very fast rate continuous production where you use very large quantity of material, large quantity of concrete, this is used. But usual practice is to use the cyclic type of batching plants.

Well, as I said, this can be automatic or manual. Manual plants are very, what I was just describing you is a kind of automatic plant or at least semiautomatic plants. Manual plants are ((Refer Time: 17:44)) balancing, weighing is done by manual means. So, you have lever arms. Once the, you know, weight is reached, lever arm is actually placed in the, in the balance. You have lever arm where you fix the weight and as the balance reaches its desired quantity of particular material, then you unload it. So, manual, very small batching plants are available, manual ones, but not, not commonly, not very commonly used, used.

It is very important to have accuracy, accurate measurement that is close to the true value. Accuracy is defined in terms of how close you are to the true value, true weights. So, your balances should be calibrated regularly and you must get the right kind of accuracy of the time. The accuracy recommended in our standard code of practice, that is, IS 456 is 2 percent for quantity of cement measured and 3 percent for the quantity of aggregate water and admixture being measured.

So, accuracy should be, your measured value should be 2 percent of the true value and 3 percent of true value for aggregate water and admixtures measured. So, this is the prescribed accuracy.

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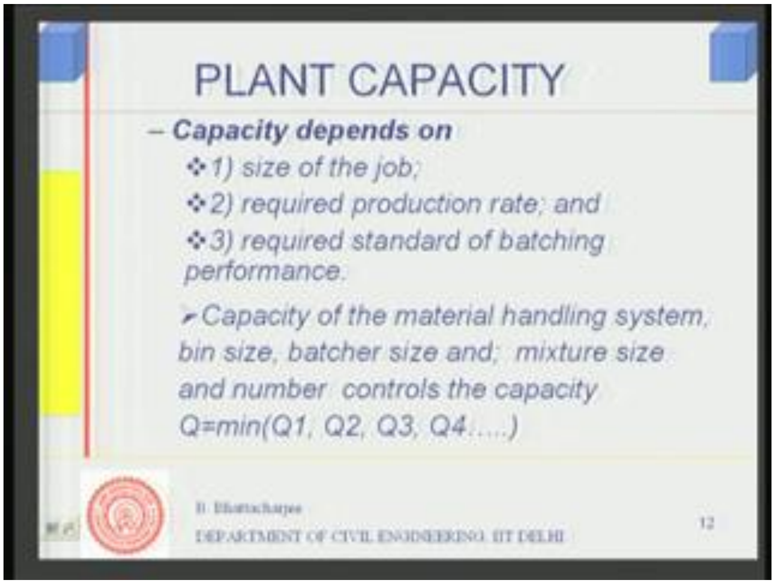

Plant capacity will depend upon the size of the job, what is the size of the job. If it is the small job, then you can use the small capacity plants, manual type. But if it is the large job, one has to use a large batching plant, mostly automatic type.

Then, required production rate, what is the production rate of concrete, at what rate do we want the concrete and required standard of batching performance, right. So, if you want, desire high, you know, standard of batching performance, then you must use automatic plant rather than manual small plants. So, this dictates what should be the capacity.

Well, capacity of material handling system, that is, how, how we handle screw conveyors or the scrapers or the bin size and batcher size, mixture size and number of, you know, mixture that is available, all these controls are capacity of the batching plant, capacity of the batching plant.

In fact, it would be the minimum of all, Q1, Q2, Q3, Q4. If this is the capacity of individual unit, for example, material handling system may have a capacity of Q1, the bin size can handle Q2 and batcher size Q3, Q4, etcetera., it will be the minimum. For most efficient system, of course, the Q1 should be equal to Q2, Q3, Q4, etcetera., then you are utilizing all the component, all the component you are utilizing, you know, to, to its maximum capacity. So, that is how we decide the plant capacity.

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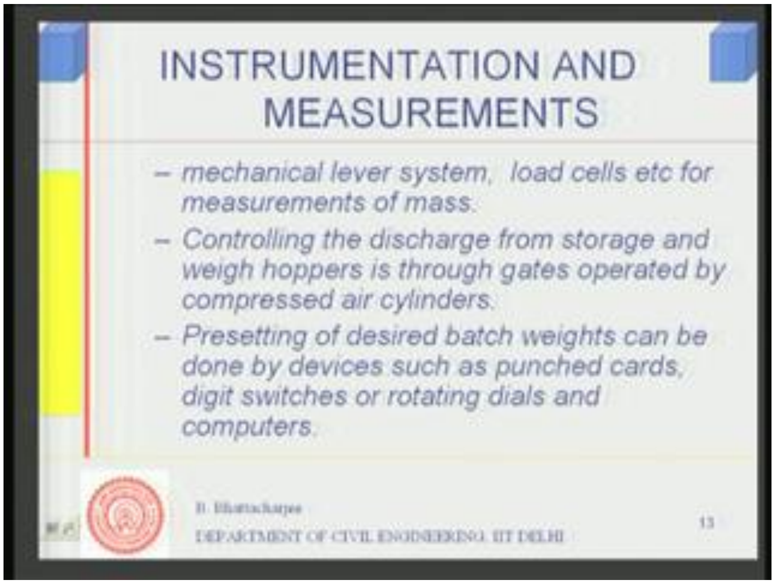

What are the types of instrument we use? Mechanical lever system, I just mentioned, that it could be mechanical lever system for weighing. Then, those are basically meant for manual, manual type of batching plant.

Load cells are used for mass measurement in automatic or semiautomatic system. Now, these loads are nothing, they are usually piezoelectric base, mostly piezoelectric based system, which can measure the pressure, therefore the load itself. So, usually they are the piezoelectric or earlier ones, many of them are electrodynamic type. So, these load cells are used, you know, which can measure the mass.

Discharge from storage and weigh hoppers is through gates operated by compressed air cylinders. As I said, the automatic gates are there and these are, these are operated by compressed air cylinders. So, they open up automatically or sometime you open it, they close automatically once a particular weight has been reached. They are connected to the loads cell, load cells provides a kind of feedback to those system and as soon as the mass, that is, desirable mass has been weighed, it closes down the gate, so that no more material can come in. This is used for aggregate system, this is usually used for aggregates, you know. The gates operated through compressed air cylinder, these are usually for aggregate system.

Well, presetting of desired batch weight can be done by device such as punched cards. These were earlier digit switches and rotating dials and today, of course, it is all with computers. So, as I said, you will have a control room where you can feed in the data, that how much quantity of the particular aggregate you require, how much is the quantity of the sand or the fine aggregate you require or cement, etcetera. and you can feed in the complete data. And accordingly, it will do the weighing and control the, control the, you know, desired batch weight, right.

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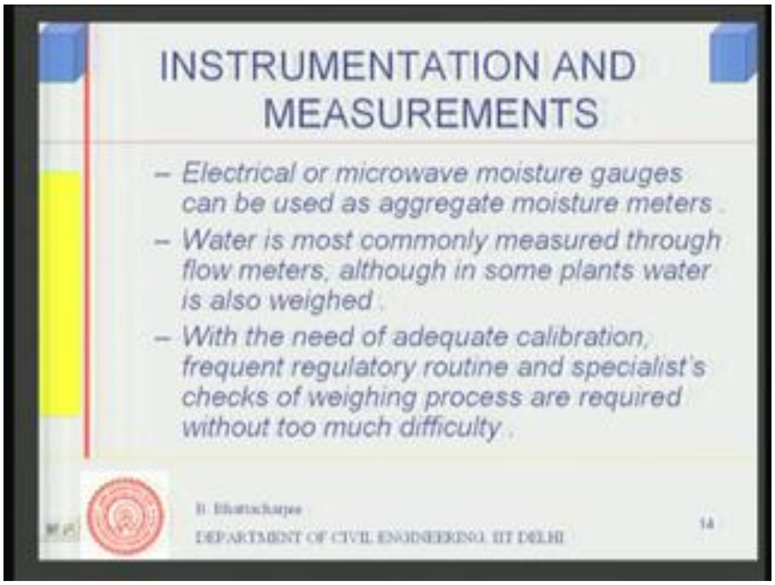

Moisture measurement of aggregate is very, very important. You do not want, of course, cement to get contaminated due to water, that is why, we store them in silos. But when it comes to aggregate, you store them in open. So, if there are rain or due to relative humidity particularly, of course, is mainly of rain or something moisture coming from the environment, so it can absorb some amount of moisture and this moisture needs a kind of correction in the batching.

If aggregates contains moisture, then you must take somewhat larger quantity of or more quantity of aggregate depending upon the moisture content, so that actual, you know, standard condition of aggregate, what we call as saturated surface dry condition aggregate is as desired, as required.

The water, that you are adding or coming through the aggregate, has to be reduced down from the mixing water. Mixing water will be reduced a little bit, because water is present in the aggregate and total quantity of mass of the aggregate will be increased a little bit because it contains some amount of water.

Now, in order to do that you must continuously monitor the moisture content of the aggregate and these are done through moisture gauges, like microwave moisture gauges, which are available because microwave attenuates when there is moisture in the air. So, if you pass the microwaves through the aggregates system what will happen? If it, you know, if there is moisture present in the aggregate, there will be attenuation of the microwave and this attenuation can be correlated to the moisture content of the aggregate or there could be electrical resistivity type of moisture meter. And there are various type of moisture meter, which are used to measure the moisture content aggregate and accordingly, correction is done in aggregate content and water content of the mix.

Water is commonly measured through flow meters because as I said, you can have volumetric measurement as far as water is concerned. Its density at given temperature does not change much unlike the aggregates because they are granular material and granular materials, their density or the quantity, the volume, would depend upon the packing characteristic, but in water you do not have such problem. So, you can even have volumetric measurement as far as water is concerned, but some cases you do where the water as well.

Well, there is need for adequate calibration all the time, okay. It should be a routine practice because calibration it must be measuring, you know, it must, whatever it is showing, it must actually be measuring same one. So, precision of instrument system, the measuring system, they are very important. There should be systematic error and then accuracy, of course, also has to be checked from time and again. So, therefore the calibration has to be done routinely.

And therefore, specialist's checks of weighing, you know, checking of the weighing process are required without much difficulty and that is what is the most important component of this weighing system. This system should be such, that one should be able to calibrate it very frequently without disturbing the sequence of operation, without disturbing the sequence of operations. So, this is an important issue as far as batching instrumentation is concerned, right.

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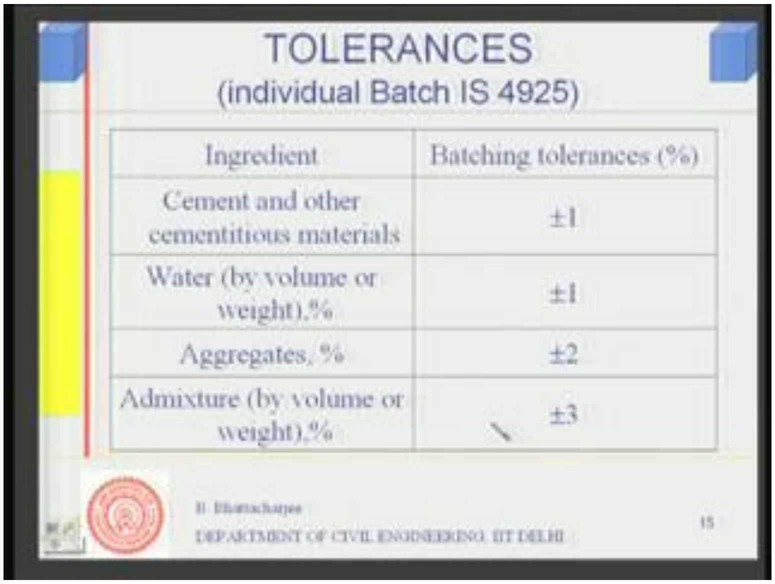

Now, the codes, all codes including Indian code, IS 4925 is the code for specification of batching, right. So, this gives you tolerances, that is allowable, tolerances in case of variance ingredients. For example, for cement the tolerance is, batching tolerance is 1 percent. So, you can weigh, for example, you know it would also depend upon the quantity of cement you are using.

So, batching tolerance can be, water 1 percent, for water both by volume or weight measurement, 1 percent is the batching tolerance. For aggregates, it is 2 percent, for mixture it is 3 percent. So, this batching tolerances are very important issue. Higher the tolerance is allowed, the variability of the mix will be more. You should see this a little bit later on. We shall see this a little bit later on.

Similarly, American concrete institute have their recommendation on batching tolerances. For our purpose, I have only included the batching tolerance that is given in Indian Code, that is, IS 4926, 25, 4925.

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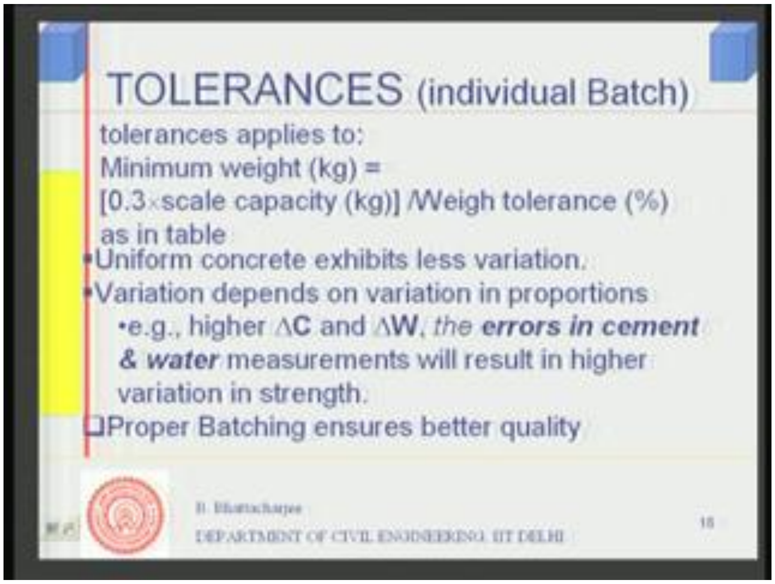

This tolerances, that is specified in IS 4925 is applicable to the minimum weight given by this formula, that is, 0.30 percent of the scale capacity actually, 0.3 scale capacity divided by weighing, weigh tolerance, as in the table. For example, if the capacity of the scale is, let us say, 100 kg, then the minimum weight to which this tolerance is available, I mean, to applicable is, let us say, if it is cement, then 100 into 3 makes it 30 divided by the tolerances, that was available was 1 percent. So, it would be divided by 1, which would mean, that minimum weight of cement to which tolerance, this tolerances that was shown in the previous table is 30 kg, right. It will depend upon scale capacity and weigh tolerance that is given directly as percentage in the table. So, one can calculate based, based on this.

Uniform concrete exhibits less variation, so batching is important from this point of view. We shall see it now. Variation depends on variation in proportions. You see, what is desirable for concrete is, that the concrete I produce every time should be same as the previous time that means, it is a uniform concrete throughout. Not only that, in a given batch also, from one portion of the batch, the variation of it from another portion should be minimal. So, it should not vary from one portion to another port ion in a given batch and not it should vary from one batch to other.

Now, when it comes to variation from one portion of the batch to other, actually that is the property that is related to the mixing. But when it comes to variation from one batch to the other, that is related to batching as well, because if you have weight, the right proportions, same, you know, I mean the weight, the materials in right proportion or quantities of material weight in one time does not differ from the other, then the variation will be relatively less. But if there is a, there, there is large difference from one time weighing to another time weighing, then it would introduce the variation into the concrete and this variation is not desirable.

If you want to get good quality concrete or uniform quality concrete, we shall see, that it has got a lot of implications in terms of economy if we do not have a uniform quality of concrete. So, uniform concrete should, you know, generally exhibits less variation and this variation from one batch to other would depend upon variation in proportion.

Well, this is as an example, we shall see later on that the most important property of concrete, that is, strength is related to water to cement ratio, water to cement ratio. So, this if it is related to water to cement ratio, therefore if delta C is the amount of variation in cement and delta W is the, let us say, error in water measurement, then what I will get?

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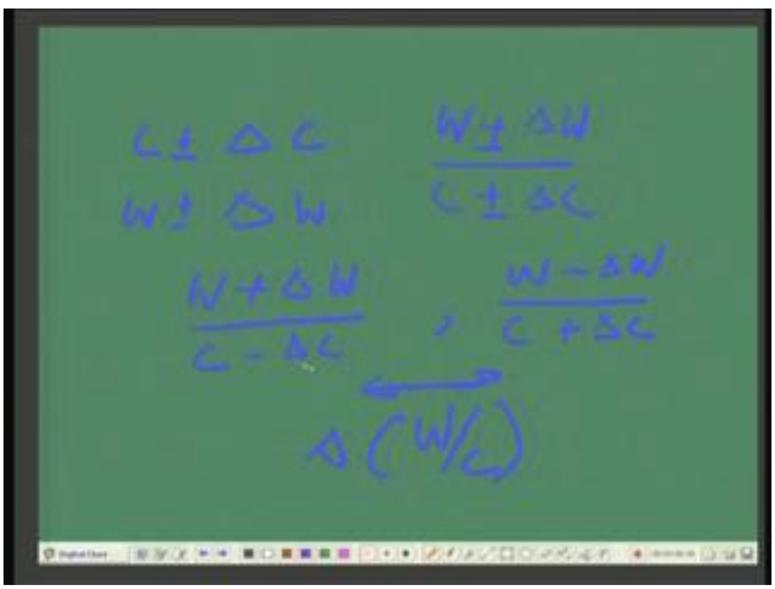

I will get, you know delta C is the variation in cement content and delta W is the variation in water content. So, my actual cement it should have been seen C, so plus minus delta W by C and water actually, originally, was W. Now, my error in measurement is delta W, so my water cement ratio will now become this plus minus delta W by C plus minus delta C. So, the range of water cement ratios I can write like this. The highest water cement ratio will be given by this and the lowest water cement ratio will be given by this ratio, C plus delta C.

Now, if the property is dependent upon water cement ratio, like strength is dependent upon water cement ratio, as we shall see, if delta W increases and delta C increases, you can find this range between these two, you know, the range between delta W by C. If I may call it delta W by C range, this will become larger when delta W and delta C, each of them are independently large, which means, if a property, that depends upon W by C, that would now will have wider variation.

So, it is important to control this delta W and delta C, the error in measurement. The tolerances are based on this, try to have minimum tolerances, you know, or rather variation within a limit. So, that also shows what is the important of batching process; it shows also the importance of batching process, right. So, that is why it is very important, that we should have right accurate measurement or accurate batching, accurate batching.

So, that I think, by and large, you know, completes our discussion on the batching process. Proper batching ensures better quality; proper batching ensures better quality.

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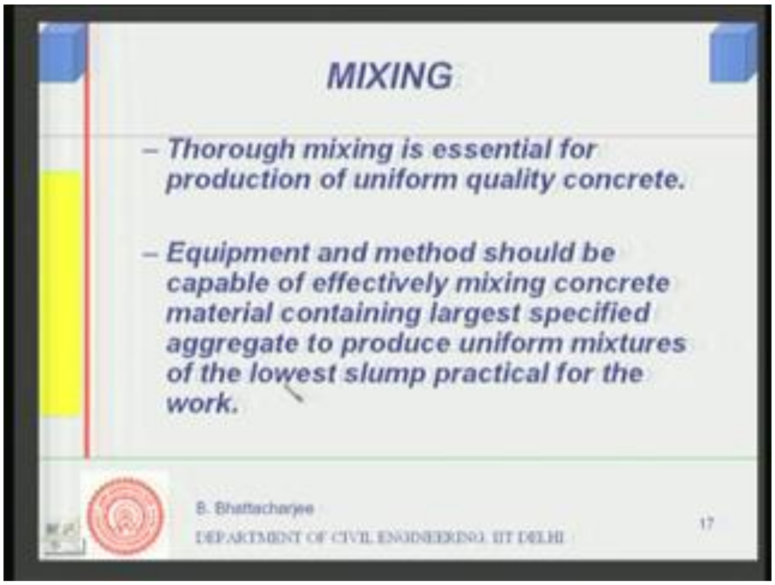

Now, we can look into mixing, the other process, other important process. We have weighed the material, then we got to mix it, the hand mixing is not possible in large jobs, anyway. But even in small job, hand mixing cannot give you a good product. So, mixing is even in semi-engineered concrete, which we normally see all around, even there a mixer machine is always present.

So, mixture, what is the purpose of such machine? Mixing is usually mechanical through mechanical mixture and purpose of mixing is production of uniform quality of concrete. So, I should be able to mix it thoroughly such that from one portion of that batch of concrete that is coming out, it is, you know, one portion, the concrete coming out from one portion of the batch is as good as the other portion of the batch or in other words, is same as the other portion of the batch. Its proportion of the material must be same, therefore its property will remain same. So, it must be uniform quality from, in the same batch, from one portion to other portion and mixing ensures that; thorough mixing will ensure that.

So, thorough mixing should be such that all ingredients are mixed together to give almost a homogenous mass or a cohesive mix, homogenous cohesive mix, so it looks same. I pick up a small portion from one part, pick up small portion from another part, that must be able to give me the same proportions if I mix the, or same properties, same proportion, as well as same properties. So, I must, that is how I should get uniform quality of concrete.

Therefore, equipment and method shall be capable of effectively mixing concrete material containing largest specified aggregate. Now, it is important because as the size variation increases, if I use only one size, the mixing become easier.

But supposing, I increase my particle size variation, you know, cement size is the order of the around 50 micron or less, sand sizes are 75 micron to about 4.75 millimeters sizes and aggregate sizes, the stones are of larger sizes going up to 20 millimeter in many structural grade concrete and 40 millimeter also in structural grade of concrete. And of course, mass concrete can have larger aggregates of the size of 75 or 150 millimeter as well, you know. But let us talk of structural grade of concrete. It can have 40 millimeter size aggregate to finer size of cement or fly ash, which are in micron sizes. So, you have very large size variation.

So, when you are trying to mix them, the larger the size variation, the mixing becomes difficult. So, therefore the mixer must be able to mix the largest specified aggregate and together with a lowest slump practicable for the work.

Now, slump I have not defined so far. We will come across it when we talk of workability of concrete, but let us understand what it denotes is flowability of concrete or how easily you can compact it. Lowest slump ((Refer Time: 35:34)) we have dry concrete, you know, very, relatively dry concrete. Possibly, the water is less and therefore, it is dry. So, such dry materials, dry combination of material, it does not have much water. If you have more water, for us mixing becomes easier. But if you have less water, then you know, it is all dry. So, the friction over one, of one particle over another is likely to be large, lubrication effect will be less. So, in such situation it should be able to mix the concrete properly.

So, that is what is being said when it, even if it is dry and even for the largest specified aggregate, it should able to produce the uniform mix because when you have less water or it is a dry mix, some place it will remain wet and some place it will not be so wet, it will be moist. So, therefore the uniformity may not be there.

But the mixer machine, which you are using should be capable of mixing the one, which is even relatively dry as you have desired, that is, by design not by, by default. It should be by choice. So, lowest slump or lowest, the driest mix with maximum size of aggregate, I have already specified, the mixer machine should be able to mix this.

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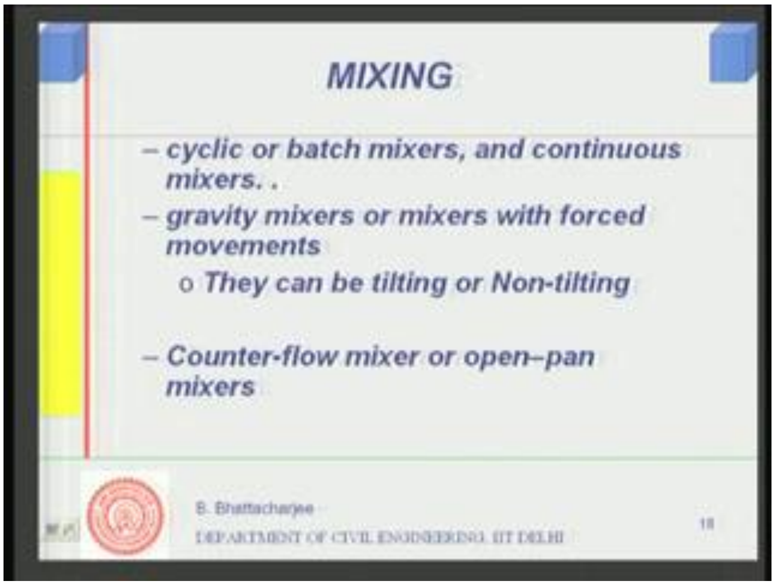

The mixer type, if I look at it, there are cyclic or batch mixers, as I mentioned, because conventionally what we see are cyclic or batch mixtures. It mix, takes one batch at a time, mixes it, discharges it or delivers it and then takes another batch. So, that is the cyclic or batch mixers.

There can be continuous mixers where it is fed from one side and it gets mixed in the process of movement, you know, it is fed from one side, horizontal type of mixture. I am not going to discuss this much because this is not very common. But there can be continuous mixers where it, you know, the material ingredients enter from one side, it is fed into the mixture from one side, which continuously mixes and also, moves the material along the mixer to the discharge point. So, feeding, it is fed from one side continuously and discharge the mix. After getting mixed, it is discharged from the other side continuously. Such mixers are continuous mixers, not very common, but where you need rapid production of concrete, one may use that.

The other type of mixers are depending upon how, what is the mixing mechanism. For example, gravity mixers are the one, which relies on gravity. You know, the material is lifted up and then dropped down due to gravity while mixing takes place. So, the gravity mixers or the others are the type, forced movement type, where the material is forced to move, not by gravity, but you have mechanism by which the materials are moving to by, by force or some by rotary machines blades and things like that and thereby, the mixing is done.

This can be tilting, the first one gravity type of mixers can be titling or non-tilting type, tilting or non-tilting. The gravity mixers are usually tilting or non-tilting type and the counter-flow or pan mixers are usually with the force movements, usually with the force movements. We shall see some of them in our next slides.

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A tilting drum mixer would look something like this, you know, this is tippable. This can trip, this can trip, this can tilt in this direction, and then you have baffles. This is one of the types, there can be other types. Now, this baffles, this will rotate, this rotate, this will rotate about an axis like this and these baffles are there, these internal baffles are there. They are designed such that it will also ensure mixing of the material.

The other type is, of course, what you commonly see is the tilting, time of, type of mixers where the material is scooped up by fixed blades or baffles, which will lift it up and then it is dropped automatically down by gravity while mixing takes place. So, this is one type tilting drum mixers.

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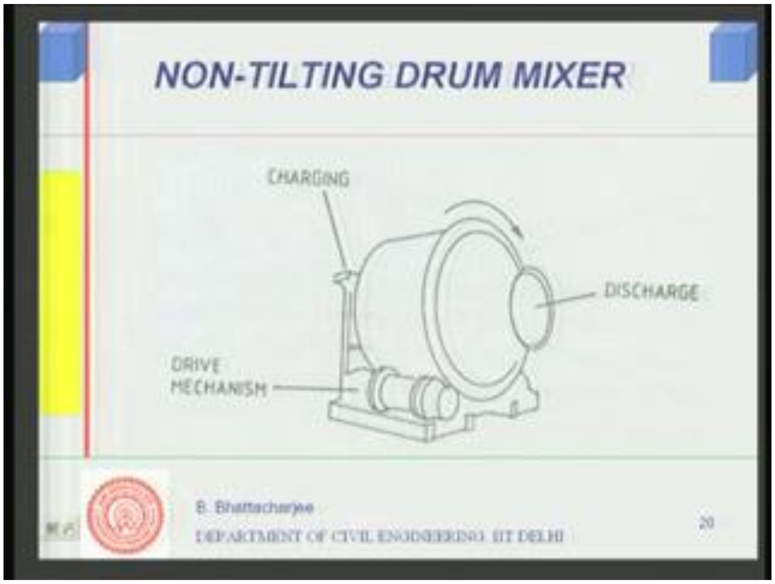

The other is non-tilting type of drum mixer where it is fixed, it does not tilt. So, you have charging hopper on this side and there are, in this one this blades or baffles are there, which lift up the aggregate. As I said, this is non-tilting.

Even tilting can be of the similar mechanism where the blades are fixed, it will lift up the material as it rotates, and then as it reaches the top, the material drops on its own by gravity and gets mixed with some other material, which are there at the bottom in this way. As materials are lifted up and brought down continuously, the mixing process takes place.

The discharge from such a mixer is through this, may be, through a chute or something, but it does not tilt. So, through a chute it can be discharged, you know. As it comes down to gravity, it can be discharged through a chute. So, this is the non-tilting type of drum mixer. The same, one similar kind of drum tilting types are also there, which will get tilted. The other one I showed had a baffle, so this can tilt. These are tilting type also, but this is what the photograph shows. Of course, the sketch shows the non-tilting type of drum mixer.

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A pan mixer will look like this. It is flat, you know, it is not gravity type, it is fixed mixer and you have blades like this and blades like this. Some are in the outer periphery, some are the inner. The pan drum, this drum rotates the blades in the position or they can have counter flow, they can have a counter flow, relatively they must, the drum and this blades, drum and the pan, they must move in the opposite direction, so as the material would be moving, let us say, in this direction.

Blades move in this direction, this one particular, one scoop it up, this one scoops, you know, this one forces it to inside and this particular blade scoop it up. So, one forces the blade is placed in such a manner, that it actually drags put the material. It is at an inclined angle so as the rotation is taking place, it pushes the material inside and the other blades will scoop it up, and then in this process mixing takes place.

So, you can see, we can see the next slide and it will tell us. The photograph is there for particular pan type of mixers, which are used in many batching plant today. So, this is the pan type of mixer and you can see, this blade, this is the inner blade and this is the outer blade. The outer blade inclination, this inclination is such that as the material is moving, it will be scooped up a little bit. And this one is such, that it is inclined in such direction.

When the pan is moving along this direction what happens is, the material gets, material gets scooped, you know, it gets moved, it gets, it gets actually pushed inside, you know, radial direction, radially actually pushed inside and this scoop it up, and in this process the mixing is continuous. This is more common, used with the modern batching plant. Many of them, many of the RMC plants today uses this kind of mixture, these are the type of mixtures

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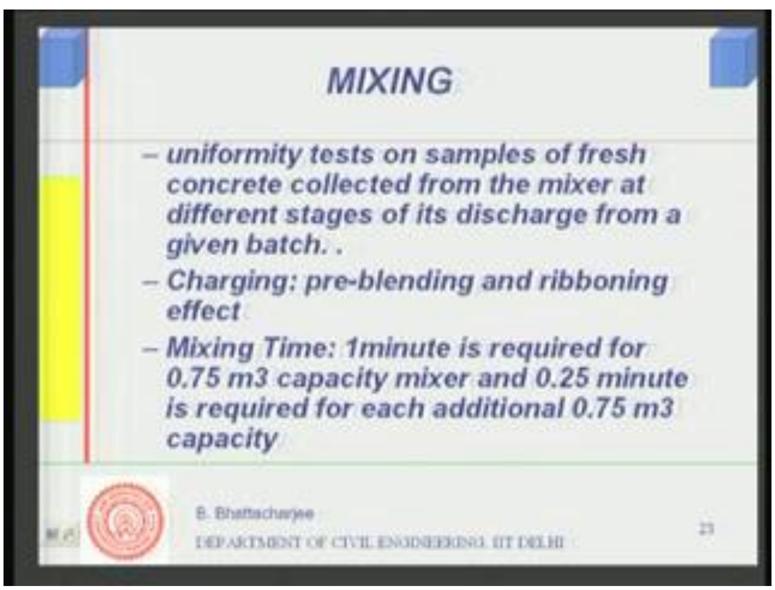

It is important to have uniform mix and that is most important. The mixing produce, the mix produce must be very, very uniform, you know, very, very, mix produce must be thoroughly uniform.

So, one can test the mixer's quality by uniformity test. One can, this is, this is the most important part of mixing. The machine must be able to produce the mix uniform throughout, that means, if I take from first 15 percent of the discharge some material and let me take some from the last 15 percent of the discharge from the mixer and I measure the ingredients proportion, they must be coming out to be same. Or if I do not measure the ingredient proportion, I should be able to measure their properties such as strength or similar other properties and it must give me same properties. The properties of the material coming out, say from first 15 percent of discharge of the mixer and last 15 percent of the discharge of the mixture or anywhere in between, they must be same.

Usually, it is first, you know, the tendency as we will understand later on when we are trying to mix such materials. One has got a specific gravity of 1, that is, water and it is liquid. The other materials, the aggregates, normally they have specific gravities of the order of the around 2.6 and 2.7, that is sand and stone chips they have usually, unless you are using some special aggregates, not usually, not more than, not more than 3 most of the time. Cement has got a specific gravity of 3.15 and if you are using fly ash, they will have a specific gravity around 2.2.

So, all these materials you are trying to mix them together, the heavier will always have a tendency to go somewhere down and the lighter one will have a tendency to come somewhere up vertical, in a vertical column. So, what happens, when you are mixing all of them do not try to be together. In the first discharge, may be, you will get some lose material. The cement will be remaining at the bottom of the mixer, depends upon of course, the type of mixture. So, as a result, the first 15 percent of the mix you may get it different than the last 15 percent of mix.

The variation is maximum in this zone because the heavier materials will have tendency to come and also, the sizes are matters, sizes are also matter. The size of the aggregates are much larger, cement sizes are much finer, so they, this is why, uniformity test of the product, the mix, that has come out is quite often done to calibrate the mixture, mixer machine, whether it is giving the right kind of mix or not. This is important.

One must test the mixer from time to time for the uniformity. That means, you take material from some part of one batch, one given batch and test this material for its property and ingredients proportion with another part of the, another part, another sample is coming out from some other part of the discharge of the mixer. So, this is important, this is done.

And many course specifies how you do the uniformity test, basically testing the ingredients or properties of the materials coming out from some portion of the mix and from another portion of the mix and you can establish the variability. This variability should be least.

Charging the mixture, there should be, it is done in what is called, there should be ribboning effect. It should not be charged as a lump, as a bulk suddenly, but slowly ribbon fed as it is called like a ribbon and there has to be such, that some amount of pre-blending while feeding itself, so ribbon effect mechanism. But the most important issue is, of course, well this, you are, this would not be ribbon effect scenario when you are feeding it manually.

If somebody is just emptying a bag of cement, that cannot be ribbon fed. That will be suddenly going, all cement going together, so there is no pre-blending possible in manual feeding, but automatic feeding could be ribbon effect.

For example, if, if some material comes through a conveyor belt and just discharged into the mixer, then it would be the ribbon fed. So, ribbon fed, this ribboning effect and pre-blending is desirable in case of mixing, but it is only possible in, it is not possible in the manual system where manually some people are feeding the cement or anything, you know, water. Then, it will be just a bucket full of water poured there. So, obviously the mixing process cannot be as good as the automatic one and uniformity of the concrete is the sufferer in such situation, right.

The second issue, of course, with respect to mixing is mixing time. As a thumb rule it is said, that 1 minute is required for 75 meter cube capacity of mixer. You know, if the capacity of the mixer is 7 point, 0.75 meter cube, then you require 1 minute and if for additional, 75, 0.7 meter cube you will need 0.25 minutes each, you know. That means, if you have 1.5 meter cube of capacity of the mixing machine, the mixer, then it would require 1.25 minutes, 1.25 minutes and like that.

So, one can estimate the mixing time required, but normally this is simply a guideline. It should be based on manufacture’s specification or recommendation and also, from by actual test you can find out by doing some test, by calibration actually, you can find out what is the right kind of mixing time.

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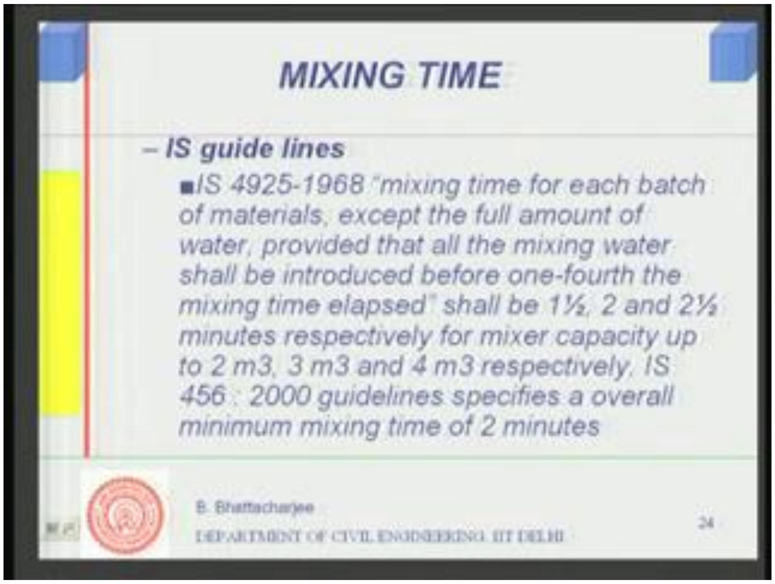

Anyway, the course, of course, specifies some amount of mixing time. IS 4925, which is the code for specification of batching plants and mixers, it suggests, that mixing time for each batch of material except the full amount of water provided, that all the mixing water shall be introduced before one-fourth of the mixing type elapsed, shall be 1 and half minutes, 2 and 2 and half minutes, respectively. For mixture capacity of 2 meter cube, 3 meter cube and 4 meter cube. So, this is, you know, part of the mixing time is actually covered.

If you read it properly, a mixing time for each batch of materials, except for full amount of water provided, that all the mixing water shall be introduced before one-fourth of the mixing time elapsed, shall be 1 and 1 and half minute, 2 and 2 and half minutes, respectively. For mixer capacity up to 2 meter cube, 3 meter cube and 4 meter cube respectively. That is the guideline of 4925.

However, IS 456 2000, which is the recent code, specifies overall mixing time of, minimum mixing time of 2 minutes, minimum mixing time of 2 minutes. Now, we can, we can see on what does this actually depends. Why, I mean, now what will happen if I have mixing time less or mixing time more. Let us see, technically what will happen to the concrete.

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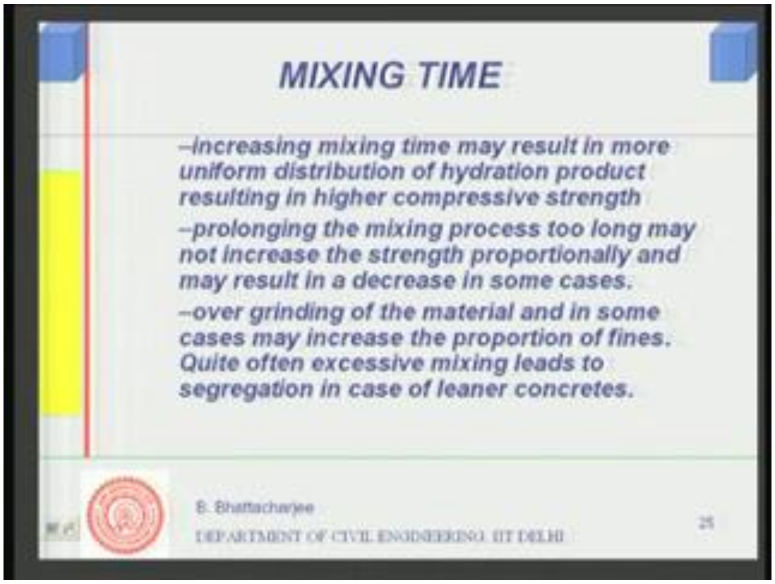

If I increase the mixing time, then what happens? See, in the process of mixing there is the mechanical, mechanical aggression or one material is moving over another material. So, this results, basically this result in, there is the movement of one particle, there is the aggression of one particle over another particle. So, this aggression results in removal of product of hydration, like cement, you know, as a particulate system it would hydrate at its surface, at the surface of the cement product of hydrations form.

Now, this hydration product, now as it comes in contact with aggregates and there is the friction between the two hydration products, which are just freshly formed and soft, will be removed from the surface of the cement particle and will be deposited somewhere else. So, thereby it can result in uniform distribution of hydration product because that will be, it will not be concentrated to the top of the cement particle alone, but it will be distributed throughout the particulate system or you know, the plastic concrete as it is getting mixed. So, thereby, it can result in uniform distribution of hydration product.

The product of cement reaction, which gives you the bonding or strength finally, because this is what will give you the bonding between all the inert aggregate materials. So, this can, this gets well distributed not concentrated in one point as you increase the mixing time. So, increasing the mixing time is likely to cause increase in strength.

Strength will increase as you increase the mixing time, but this has got a, this, you know, increasing does not continuously go on increasing the strength. So, higher compressive strengths are obtained when you get, when you prolong the mixing. But if you prolong the mixing for too long, it may not increase the strength proportionally. Some cases, it may even result in decrease in strength.

The reason, one of the reason attributed could be, you see, there could be over grinding of the material. You might grind the material too much and some cases, it may result in increase in the finer material exceptionally, the aggregates are soft. For soft aggregate it may result in grinding, may result in, you know, aggression of the aggregates and result in generation of fines, more fine contained in the material, which means, the original packing characteristic of the material would be lost. And thereby, you may not, you know, the quantity of cement paste would require, would then differ. There can be many other things happening and this may result in actually loss of some amount of strength.

In many cases it is seen, that strength does not increase proportionally. Initially, we increase the mixing time, strength will increase. But then, as you go on increasing mixing time further, strength does not increase further. So, in some cases it can reduce also.

But it is also understood, that if you mix it too much for too long time, there is an optimal time, it has become homogenous, uniform throughout. Now, go on further mixing, it will have tendency to separate out the larger material possible for the, from the finer materials or heavier ones from the lighter ones and that kind of thing and thereby, resulting in what is called segregation.

Segregation is the phenomena whereby the materials gets separated, you know, different ingredients, they get separated from each other like a uniform mix, will have uniform distribution of the aggregates, cement, water throughout the mixture. But when it is non-uniform, when it is non-uniform, you might find the stones are lying in one places, possibly excess sand is in one place, cement is in the other place. So, that is a segregated mix. Even after mixing, it can so happen, the large particles remains separated. It would depend upon many things, like mix characteristic itself handling the mix and so on.

But prolong mixing can also result in such separation in the materials. Once mixed, you get homogenous mixed continued for very long time. It might get reseparated again because as I said, these materials are all of different sizes, different shapes and of course, of specific gravity. So, they do not want to remain together. You were actually forcing them to be together. So, when you are forcing them to be together, if you overdo it, it may again, you know, get separated and that is the process of segregation. Therefore, especially leaner mixes, leaner concrete means, you have less cement, more of aggregate. So, large size aggregate will have a tendency to get separated out.

In case of coarse rich mix, you know, lean mix is, lean mix means less of cement, rich mix means a lot cement. So, rich mix, rich mix means, cement is more in such a situation, paste will be high and segregation chances are less. But in lean mixes, if you do prolong mixing, there is the chance that there can be segregation again.

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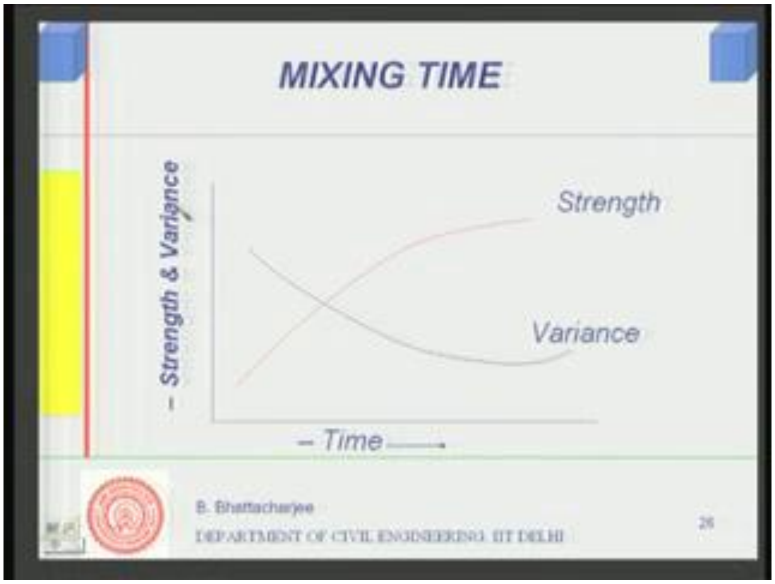

So, therefore what we see is, if you plot, the people have done some experiments on this, then I have not given quantitative results because it is result of some experiments somewhere, may not be universally true, but qualitatively this is universally, definitely true, that if you mix it over a long period of time, you might get an increase in strength, but may not increase proportionally beyond a point.

That means, if you increase the mixing time beyond this point, the strength is not going to increase proportionally, some cases it even comes down, some cases it even comes down. And also, it is also observed, that variation of the property, that is, if I find out, take out samples from sample, take out sample from a part of the batch, part of the mixed batch and take out sample from part of the, another part of the same batch and this continue to do for many samples, find out their average property and deviation of this average property from the values that I have got.

You know, variance is a statistical term, and then square it up, sum it up, divided by the number of samples that I have calculated minus 1, possibly for loss of degree of freedom, 1 degree freedom. So, that is the way of, statistical way of calculating this variance, which is the measure of the variation from one sample to another in a given batch. So, people have actually measured this variance and it has been observed again qualitatively, some cases it might have straight go down, some cases it might show, that there is a minimal point, but after that variance start increasing. Some places it will show, go down, going down may not be as high as it was in the beginning.

So, what is observed is, that as I go on increasing the, prolonging the mixing time, the variance reduces down to a minimum. Some cases it may increase, some other cases it may reduce, but may not reduce at the same rate. So, I get actually an optimum mixing time.

So, whatever is recommended by the code, one may not go much beyond it, but then one can do, especially in plant like a batching plant. You know, where there is a plant and you are producing concrete over a long period of time, you can establish this idea and find out what is your appropriate mixing time, but the code, values given in code are based on experience of large number of people. So, one has to adapt to that**,** may not go much beyond it. So, optimal situation would lie somewhere here. So, that is what is the mixing time and this is an important issue at the site, at production time of concrete to get a uniform concrete, right. I think that is what is all about mixing.

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And in summary you can now say, that what we have discussed today. We have first discussed the overall concrete production system, concrete product process, what are the components in the concrete production process, that is, number one batching, then mixing, then we have transporting concrete, then placing and then compacting and quarrying, etcetera. So, overall process we have discussed.

Then, also we have discussed about the batching process and its importance in producing quality concrete. As I said, if you make large error in the proportions in batching, then you are likely to get a lot of variation, wide variation in the concrete properties, and then we do not say, that its quality is very good. Our aim is to obtain uniform quality of concrete within less variation, as low variation as possible. Therefore, batching the material, weighing error should be as least possible. It must be within tolerances that is specified in code and so on. And that is what we have discussed as far as batching is concerned, together with what are the, what are the batching plants, some issues related to batching plants, etcetera.

Then, we discussed about mixing process that is required for producing uniform concrete, uniform quality of concrete, right. And also discussed a little bit about the equipment, but the technology or good quality concrete production process, you know, what is required as far as mixing is concerned to produce a uniform quality of concrete and how mixing effects the uniformity of concrete that is what we have discussed. So, I think, that should be thing for today's lecture. Then next class we shall discuss other issues of concrete production process. Thank you very much for patient hearing.

Thank you.