Construction Methods and Equipment Management
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Lecture – 21
Concreting Equipment (Part 2)

Hello everyone, I welcome you all to the Lecture 21 of this course construction methods and equipment management.

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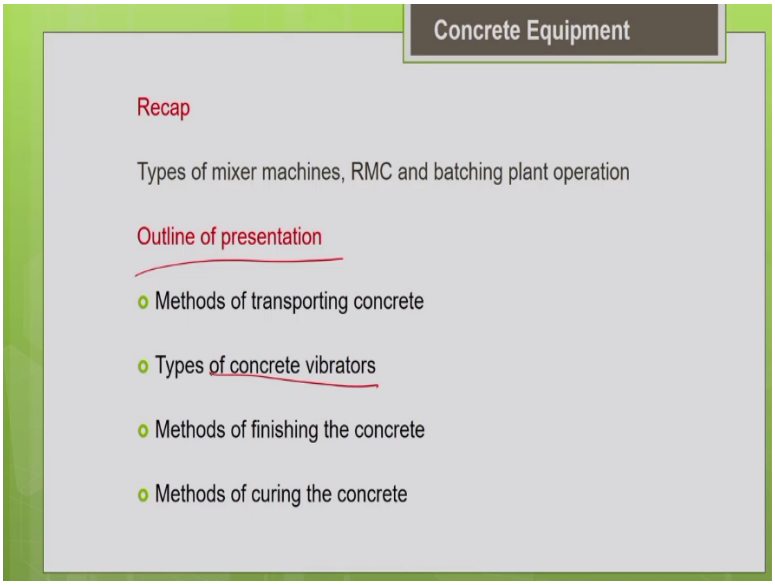

So, in continuation with our discussion in the earlier lecture on concreting equipment, in today's lecture, we are going to discuss about the equipment needed for transporting the concrete, consolidating the concrete and finishing the concrete. So, in the last lecture, we discussed about different types of concrete mixer machines. And also I introduced to you about the ready mix concrete and about the batching plant operation.

So, let us look into the outline of today's presentation. In today's lecture, we will be discussing about what are all the different methods available for transporting the concrete and the concreting equipment involved in that process. And we will also look into what are all the different types of the concreting vibrators which are available for the consolidation process of concrete.

And we will be discussing about the methods of finishing the concrete surface and about the significance of curing of concrete.

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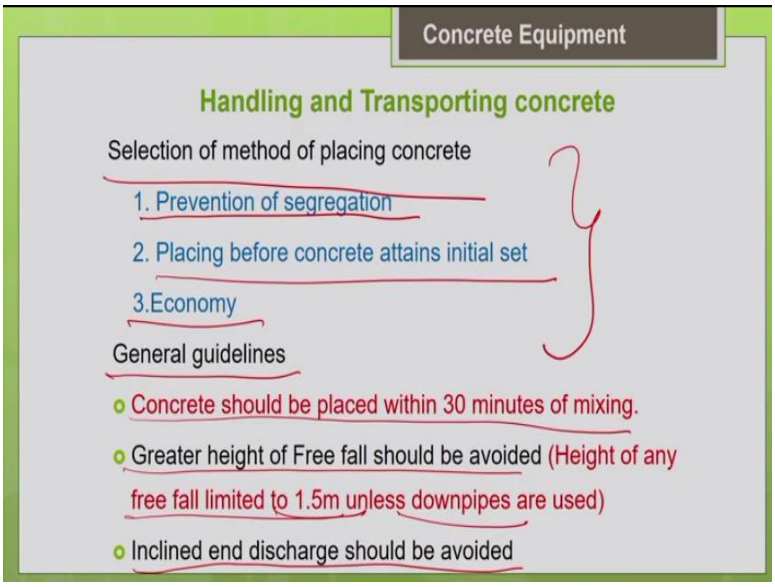

So, very commonly, you can see that people put lot of efforts in mix design of concrete and preparation of concrete, but, very often they do not care much about the method of transporting the concrete. So, what happens is, if you do not carefully transport the concrete to the desired place, so, during the transit the concrete may get segregated. So, if the segregation occurs, you will not get a homogeneous microstructure in the concrete.

And that is going to affect your strength and the durability of your concrete. So, that is why we need to put proper efforts even for selecting a method for transporting the concrete appropriately. So, how will you select the method for placing the concrete? So, once a concrete is prepared, our main objective is to transport it to the place of casting. As early as possible without much loss of time, we need to transport it.

Because, as you know, once you add the water to the cement, your cement starts setting because of the hydration reactions. So, before this cement attains its initial set, we need to transport the concrete as early as possible to the casting place. And also, we should not allow the concrete to get segregated during its transit. Because it is a heterogeneous material, it is a composite material.

You know, it is a combination of materials with different sizes. So, the one which is heavier that is a core segregate will always try to settle down. So, it always results in the segregation, if you do not place a concrete as early as possible. So, that is why we need to transport the concrete and place it as early as possible before it attains a initial set and before it segregates.

So, when you select the method of placing the concrete, we should always keep in mind that we should select a method of its own resulting segregation of the concrete.

So, we should place it or transport it in a homogeneous manner only. And we should place it before the concrete attains a initial set. That is also very important. Otherwise, workability will be lost. You will not be able to work with the, you will not be able to consolidate it properly. An important thing is whatever method you are going to choose, it should fit into your project budget or the project size.

So, we should consider from the economy point of view also. So, these are the basic guidelines we should keep in mind when you select the method for transporting or placing the concrete. One is as early as possible we should transport it. We should transport it before it attains a initial set. Then another thing is we should transport the concrete in a homogeneous form only.

So, it should not get segregated during its transit and whatever method you select, it should be economical. It should fit into your project budget. So, these are the general guidelines we should keep in mind while placing the concrete. So, as I told you, concrete should be placed within 30 minutes of mixing before it attains a initial set. And we should avoid greater height of free fall of the concrete.

Your concrete you should not allow the concrete to freely fall over a greater height that will result in segregation. So, the maximum limitation of the free fall height allowed is only 1.5 meter. Free fall means there is no support at all. You are just freely allowing the concrete to fall from a particular height that is called as free fall. But if you are going for some guided flow like we are going to use some pipes, vertical down pipes.

Steel pipes for transferring the concrete. In that case, you can have a greater height of fall. But for free height of fall, the maximum height allowed is only 1.5 meter. So, beyond that there are more chances for segregation. And another important thing you should note is that inclined end discharge should be avoided. Many times you can see that concrete will be allowed to fall.

Or, it will be conveyed from one level to another level from a higher level to a lower level in an inclined manner with the help of a chute or pipeline. So, the flow of concrete can be in a inclined manner. But, at the end, when the concrete is discharged, the end discharge should be

vertical. That you should always keep in mind. That the end discharge should be vertical you have to make some arrangement in some form so that the flow at the end will be vertical.

This is because when the discharge at the end is inclined if it is going to be inclined, since, as I told you it is material with different sizes of particles. So, you have the heavier coarse aggregate bigger size coarse aggregate. So, the particles with the greater mass will attain greater momentum. So, it will be thrown farther away from the lighter material. So, what happens is when the discharge is going to be in a inclined manner, so, what happens is that heavier particles will be thrown farther away.

So, that means the coarse aggregate will be thrown farther away from the remaining mortar. So, this will result in segregation. That is why at the end we should ensure that the discharge should be in vertical manner. So, for that you can use some vertical downpipes and to facilitate the vertical end discharge.

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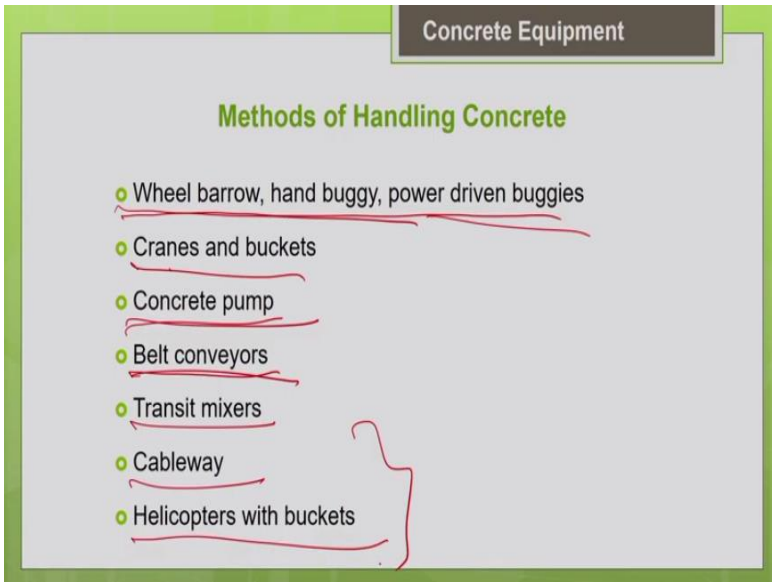

There are different methods of handling the concrete. So, starting from very simpler method like wheel barrows and hand buggies to advanced methods like concrete pumping, belt conveyors. So, there are a range of options available. So, depending upon your job productivity requirement depending upon your placement rate needed. So, depending upon how much horizontal reach you need to cover?

Or, how much vertical reach you need to cover? According to that, you have to make the choice of the method of handling the concrete. So, we have the simple option like a wheel barrow,

hand buggies, power driven buggies. And also we have this option of cranes and buckets. So, particularly when you want to do the concreting at a higher level, say, I want to do the column concreting at a particular floor say 6th floor or 8th floor.

So, to reach greater height, so, generally we go for cranes with buckets, concrete buckets. So, that will facilitate you to reach any vertical height. So, another commonly adopted method nowadays is pumping. Pumping is the most I can say the fastest method or the quicker method of placing the concrete. When compared to the other conventional methods. So, and we also have the belt conveyors.

So, when you want to place very huge quantity of concrete over a large distance, you can go for belt conveyors. Transit mixers which we use it for transporting the concrete from batching plant to the job site. Cableway with concrete buckets, helicopters with concrete buckets, so, these can be used if you are going to have a construction over a the river valley where the mobility of other equipments are not possible on the ground.

Then you have to carry your concrete in a cableway with a concrete bucket. Or, you have to carry the use a helicopter to carry the concrete bucket. So, depending upon the location of your job site, so, you have to make the choice of the equipment.

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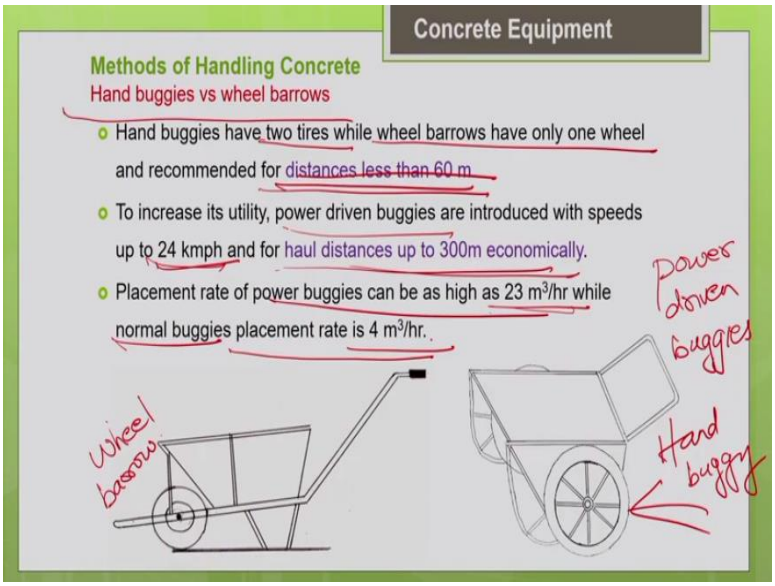

So, let us discuss about all these methods one by one. The first is we are going to discuss about the hand buggies and the wheel barrows. So, these are the simplest mode of transport of concrete. So, I cannot say this is the best method. But, still we can very commonly see in many

project sites using where they use hand buggies and wheel barrows for transporting the concrete.

So, what is the basic difference between the hand buggy and a wheel barrow? Hand buggy you can see that it will have the 2 tires. It has 2 tires. This is your hand buggy. And this is your wheel barrow with a single tire or single wheel. So, obviously, the stability of the hand buggy is more when compared to the wheel barrow. So, when compared to a wheel barrow this will buggy will have a better placement rate.

But all these are economical only for feasible or applicable for only for a shorter haul distance. So, the economical haul distance with these wheel barrows and hand buggies are less than 60 meters. So, but since you if you want to increase haul distance, then you have to go for power driven buggies. Nowadays, these are also very popular. Power driven buggies, which will have a better speed which will give you a higher speed.

Say, you can have a speed even up to 24 kilometer per hour and that will give you a very better placement rate of say 23 meter cube per hour when compared to the normal buggies which can give you only a placement rate of 4 meter cube per hour. So, when compared to normal buggies your power buggies can give you a very high placement rate of 23 meter cube. I mean relatively 23 meter cube per hour.

The power buggies can cover a haul distance of up to 300 meters when the normal buggies can cover a distance less than only 60 meters. So, according to your requirement job requirement and the productivity requirement of the placement rate needed and the economy everything have to take into consideration and make the choice of the machine. So, let me summarize.

So, your hand buggies have 2 tires while your wheel barrows have only one wheel. And these are recommended for a distance less than 60 meters. So, if you want to increase your utility of your buggies you can go for the option of power driven buggies. So, they can have a speed up to 24 kilometer per hour. And they can have a haul distance up to 300 meter, so, when you go for power driven option.

And the placement rate if you compare, power buggies can give you as high as 23 meter cube per hour when compared to the normal buggies whose placement rate is only 4 meter cube per hour.

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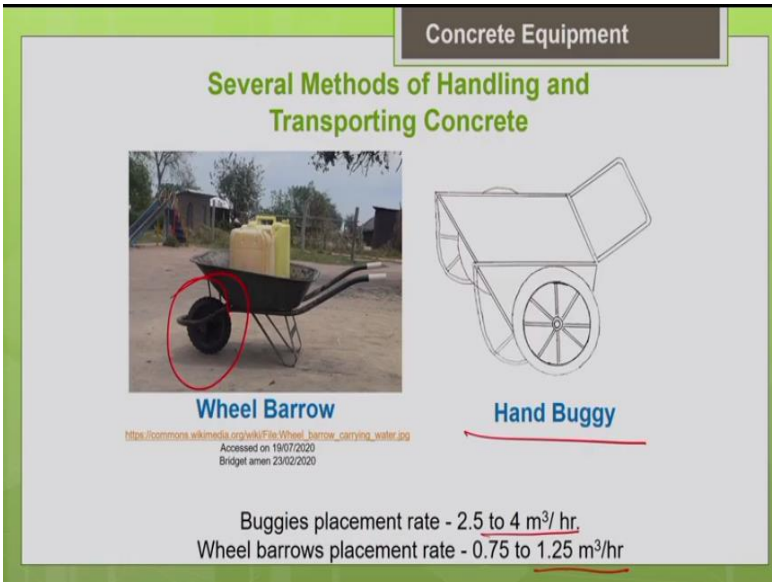

So, this picture again shows you the comparison of your wheel barrow. This is a wheel barrow with single wheel and hand buggy with 2 wheels. So, you can compare the placement rate your buggy is giving you a placement rate of maximum to 4 meter cube per hour. But wheel barrow can give you a placement rate maximum 1.25 meter cube per hour only. So, the best thing is to have a better productivity.

You should go for power driven buggies which can give you a better speed and better placement rate.

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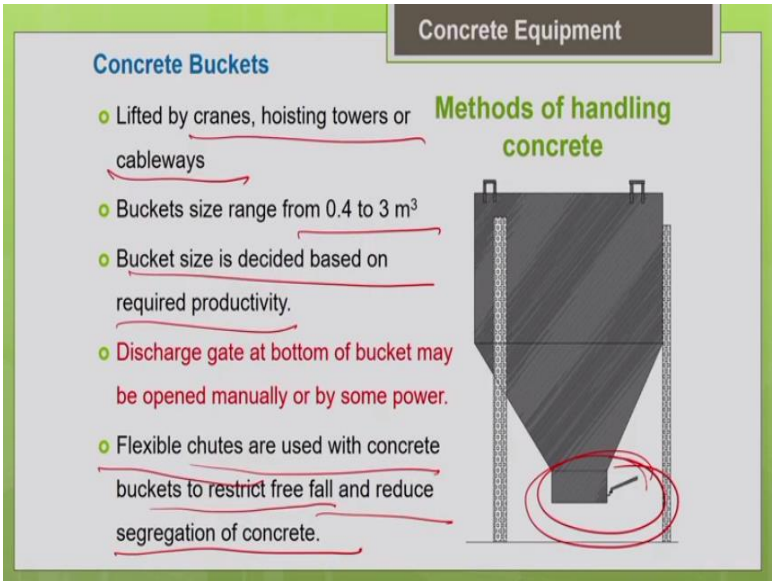

So, next is about the concrete buckets. So, very commonly we use this concrete buckets lifted by crane particularly for the high rise buildings. You can see that the cranes are used to lift the concrete buckets to the particular floor level to do the concreting work. So, not only the cranes, we can also make use of the hoisting towers or you can even use a cableway as I told you depending upon the job site location.

So, I can use any lifting device and with the help of the concrete bucket, you can reach the particular height needed. So, there are different sizes of buckets ranging from 0.4 meter cube to 3 meter cube. So, generally for very massive construction like dams we go for a very big size bucket so that you can reduce the number of cycles and increase your productivity. So, your bucket size is decided based upon the required productivity.

So, your concrete buckets will have the discharge gate at the bottom. So, there are options like you can open the gate either manually or with some power mechanism. But mostly the bigger concrete buckets we cannot open it manually. So, there will be some power mechanism to handle the gate. And also some flexible chutes are provided. Chutes are nothing but a pipe kind of thing, so, which will help you to guide the flow of concrete.

Instead of having a free fall of concrete from the bucket, you can guide the flow of concrete from the bucket with the help of a chute. So, flexible chutes are used with the concrete buckets to restrict the free fall and to reduce the segregation of the concrete. So, whenever you have a guided flow of concrete, there you can see that the chances for segregation will get reduced. That is why we should try to avoid the free fall of concrete as far as possible.

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So, this picture again shows a concrete bucket lifted by a crane.

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So, the next is about the belt conveyors. So, earlier belt conveyors were used only in the mining operations or tunneling operations. But nowadays, there are different ranges different configurations of belt conveyors. So, belt conveyors are very commonly used for material handling. We have portable belt conveyors, series conveyors. So, you can commonly see it in the RMC batching plant or asphalt batching plant or aggregate production plant.

You can see that application of belt conveyors very commonly. So, generally we can go for belt conveyors when the placement rate needed is very high. Say, it is economical for transport of huge quantity of material over long distances. So, when you want to transport the concrete

over a long distance and you need to handle huge quantity, in that case, a belt conveyor will be economical than other modes of transport.

So, any way, you have to work out the economics and justify the cost associated with the belt conveyor. So, basically say for example, if you want to go for a concreting of a very huge foundation of a massive industrial plant industry. So, it is a very massive foundation, in that case your belt conveyor will be economical. So, you need to work out the economics to justify the selection of the belt conveyor.

So, what is a basically this belt conveyor will be having a flexible moving belt. As everyone knows there will be a moving belt operated by a motor. And this moving belt will be supported at intermittent intervals with rollers supported by idlers or rollers.

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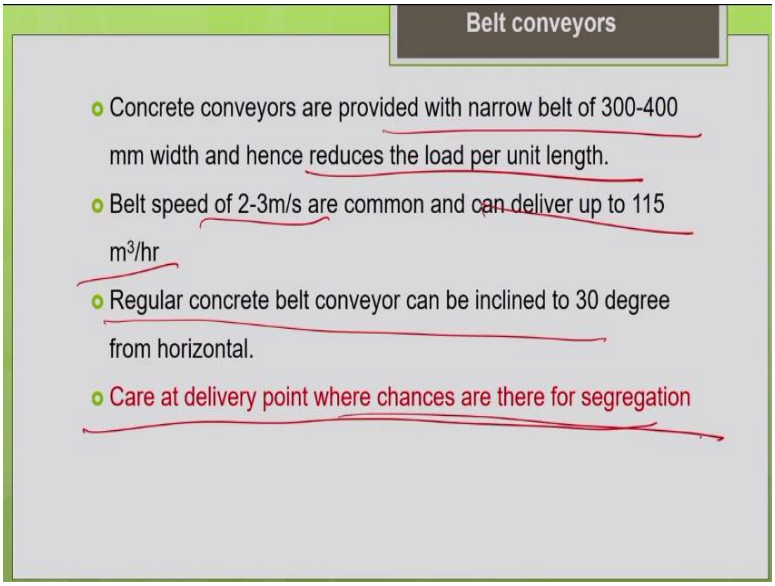

So, when compared to the belt conveyors which are used for the used for handling the other material. So, there are some differences in the belt conveyor which are used for conveying the concrete because a concrete is relatively denser material. So, generally we prefer to go for narrow belt. We restrict the belt width to say 400 mm. So, but commonly you can see a belt conveyor with width of up to even 1 meter.

But generally for the concrete belt conveyors, we try to restrict to 400 mm width to reduce the load per unit length so that you can reduce the load per unit length. And you can have a belt speed of nearly 2 to 3 meter per second. So, as you know that higher the belt speed you can

have a higher placement rate. So, you can deliver even up to 115 meter cube per hour of concrete. So, it can give you a very high placement rate.

And the regular concrete belt conveyor can be inclined even up to 30 degree from the horizontal, so, up to 30 degree of inclination. So, it is proved that the material will be stable in the belt. So, but one thing we have to note that is when the though the belt conveyor is going to convey the material in a inclined manner, but at the end, the discharge should be vertical. As I told you, end discharge, you have to make it vertical.

So, you have to have a vertical down pipe which can facilitate vertical discharge of concrete. Otherwise, what happens? Because of inclined discharge, as I told you, your heavier coarse aggregate will be thrown farther away from the remaining material because of the greater momentum of the heavier material. So, that results in segregation. So, that is why make sure that the end discharge will be vertical. So, care at delivery point is needed where there are chances for segregation.

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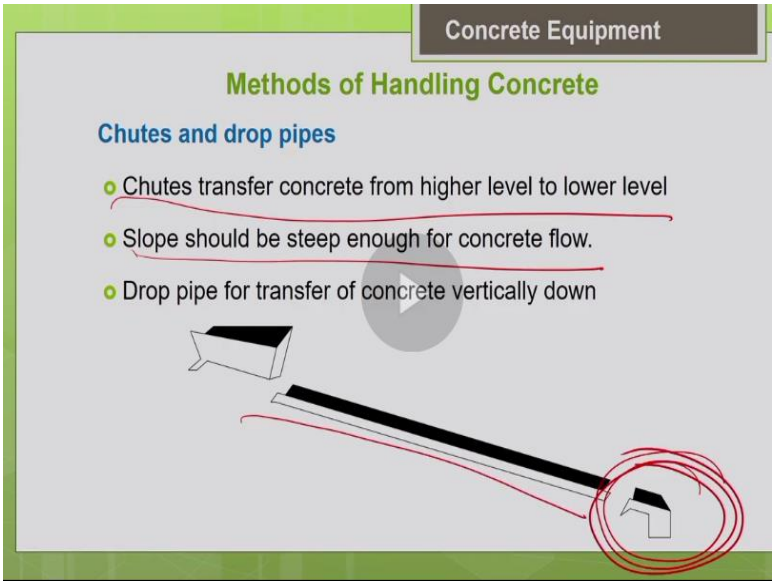

These chutes are nothing but pipelines, which are commonly used to convey the concrete from higher level to a lower level. So, chutes transfer the concrete from higher level to a lower level. So, you should place it in such a manner that the steepness of the slope should be sufficient to facilitate the flow of the concrete. Slope should be steep enough to allow the flow of the concrete.

At the end, as I told you, you should make some arrangement for vertical end discharge. So, though the floor will be inclined in manner, but at the end, you have to provide some arrangement for vertical end discharge with a vertical drop down pipe.

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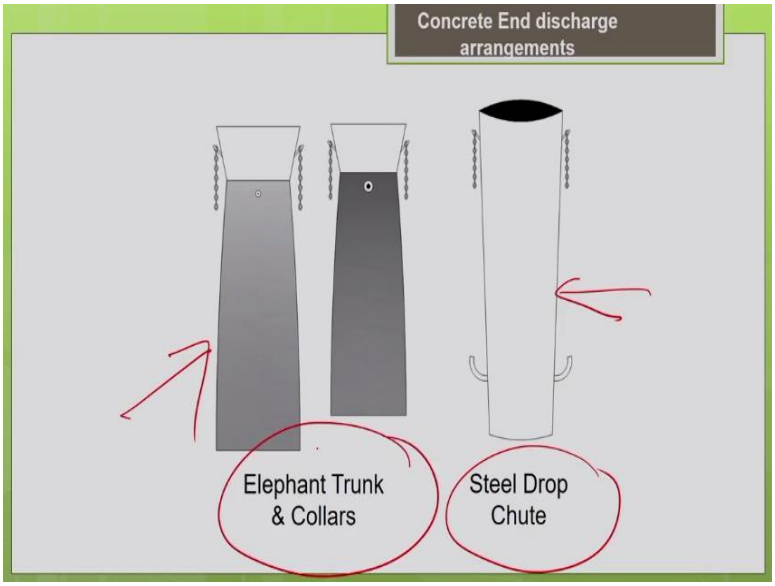

So, these are the devices which we commonly use for the end discharge of the concrete. So, this is nothing but a vertical drop down pipe steel drop chute. It is nothing but a vertical drop down pipe. So, it can be a rigid pipe or it can be a flexible pipe. So, when it is a flexible pipe, we call it as elephant trunk and collars.

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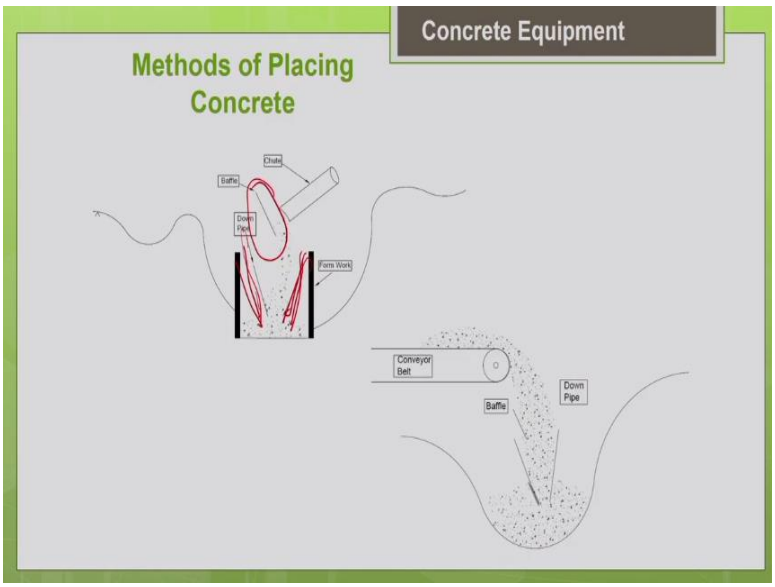

So, these are the schematic pictures which shows the right method of placing the concrete. Say for example, if you want to place a concrete into a concrete column formwork. So, we are going to do the concreting of column. So, you are going to deliver the concrete into this column

formwork. You should not just dump the concrete directly into the formwork. In that case, what will happen?

You concrete will strike against the formwork and that will result in segregation of your concrete. So, there should be some guided flow of concrete. So, for that, what are you supposed to do? So, the concrete is here in this picture is being delivered from a chute into the column formwork. So, it can be from a chute or it can be from any pipeline or it can be from a wheel barrow or a buggy. So, it can be from a transit mixer.

So, you are just discharging the concrete into this column formwork through a vertical drop down pipe. You can see this is the vertical drop down pipe. So, instead of directly just discharging the concrete into the column formwork, you are putting it into a vertical pipe and allowing a guided flow of concrete. This will reduce the segregation. In addition, you can also use a baffle or a deflector which will avoid the dispersion of the concrete, or scattering of the concrete.

So, all these things are to facilitate guided flow of concrete for prevention of segregation. So, you should use a vertical drop down pipe with a baffle. Similarly, so, when you are discharging the concrete from a belt conveyor, so, as I told you, we should make sure that the end discharge should be vertical.

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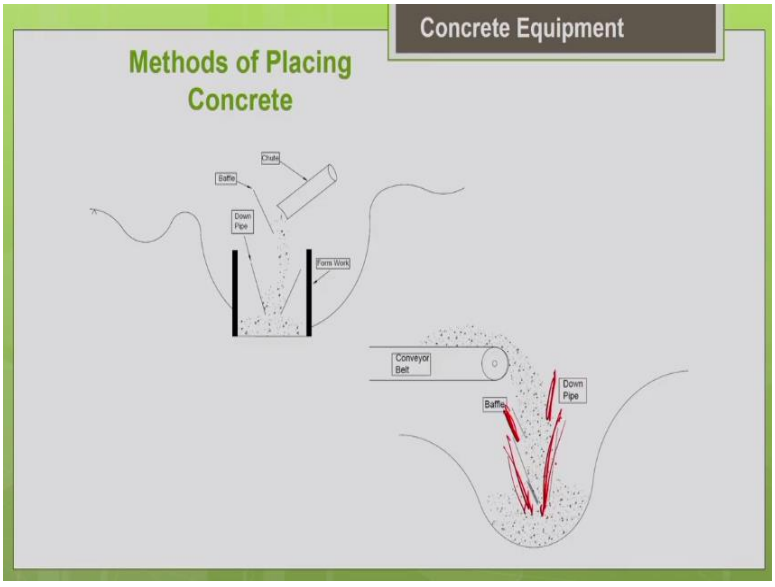

So, you should use a vertical drop down pipe with a baffle. So, this baffle will act like a deflector. You can have a baffle here also. So, this baffle will act like a deflector. And it will

help in the uniform flow of concrete into the required formwork without segregation. So, this is your drop down pipe and this is your baffle.

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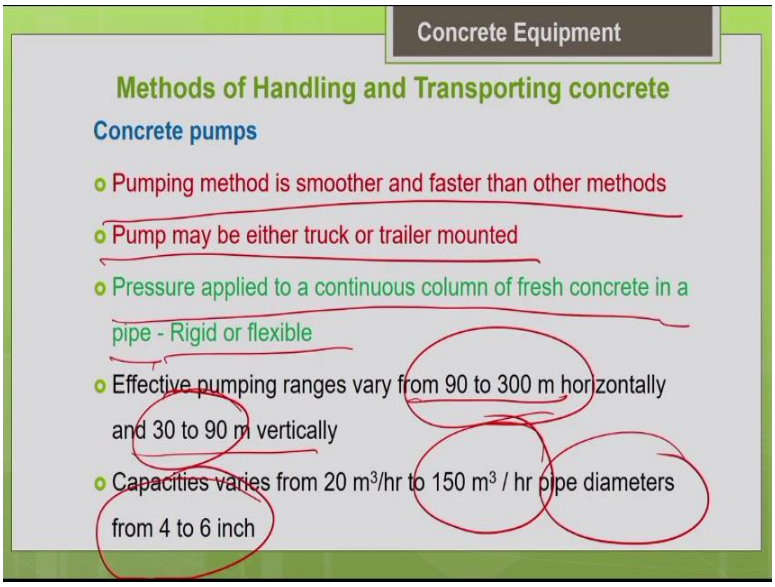

So, the next method of transporting the concrete is concrete pumps. Nowadays, pumping method is accepted as a best method of placement of concrete because main advantage with the concrete pump is you can avoid multiple handling with the concrete. Generally, when you prepare the concrete in one lot, you should place it in one lot. That way we can avoid multiple handling that will avoid segregation of the concrete.

With the help of concrete pump, we are able to place it in one lot. So, that facilitates the prevention of segregation of a concrete. So, the pumping is smoother and faster than other conventional methods. So, basically what you do in pumping is you allow the concrete to flow through pipelines. So, how will it flow? You have to apply pressure to the concrete flowing through the pipeline with the pump.

And then allow it to flow through the pipelines. So, based upon the mobility required at a construction site, it can be either truck mounted or trailer mounted. So, basically, what you are doing here is you are applying pressure to continuous column of fresh concrete in a pipe so that the pipe can be either rigid pipe or flexible pipe, whatever. So, you are facilitating the flowing of concrete through pipelines.

And the pipelines will be taken to the actual placement area placement location. So, this can cover horizontal distance of say ranging from 90 to 300 meter horizontally and vertically 30 to

90 meter. Obviously, when you pump against the gravity, so, the reach is relatively lesser when compared to the horizontal reach possible. So, with pumping, I can have a very high placement rate of even up to 150 meter cube of concrete per hour.

So, you can have a very good placement rate that depends upon the capacity of your pump and the diameter of your pipeline.

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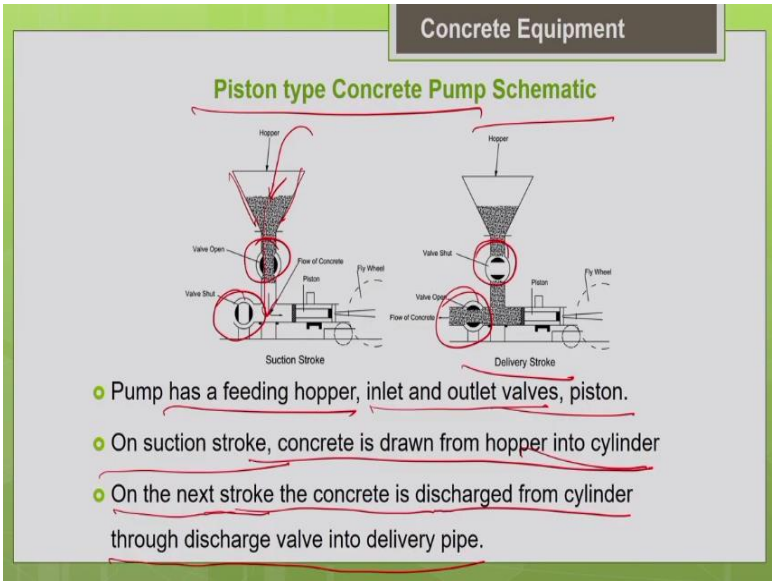

So, there are different types of pumps available. The most commonly adopted method is your piston type concrete pump, reciprocating piston type concrete pump. This is a schematic picture of this piston type pump. So, basically these pumps will be having a hopper. This is the hopper. So, into this hopper, you have to discharge your concrete. From your either transit mixer or from a concrete mixer machine or from a chute or anything, you are going to discharge the concrete into the hopper of the pump.

And this pump will be having a piston you can see the piston. There is an inlet valve and an outlet valve. So, based upon the reciprocating action of the piston that is to and fro action of the piston your suction stroke and the delivery stroke will happen. So, what happens in this suction stroke? You can see that the inlet valve will be open, but the outlet valve will be closed. And the concrete from the hopper will be transferred into the cylinder in the suction stroke.

So, now, what is happening in the delivery stroke? Your inlet valve will be closed. And the outlet valve will be open. And the concrete from the cylinder will be forced into the or discharged into the delivery pipeline. So, that is what is happening in the delivery stroke. So,

nowadays, we have 2 pistons acting together so that when one is having the forward stroke other will be retracting so that you can have a continuous flow of concrete in your delivery pipeline.

So, basically, the concrete pump has a feeding hopper, inlet and outlet valves and the piston. On the suction stroke, the concrete is drawn from the hopper into the cylinder. On the next stroke, that is a delivery stroke. The concrete is discharged from the cylinder through the discharge wall into the delivery pipe. So, alternatively a suction stroke and the delivery stroke will happen.

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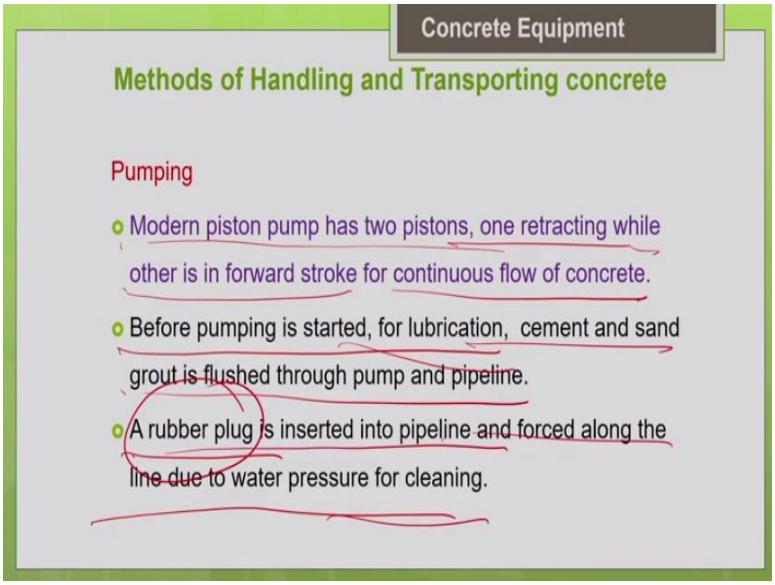

So, when you have the 2 pistons, you can have continuous flow. So, modern piston pump has 2 pistons, when one is retracting other one will have the forward stroke. So, this will facilitate continuous flow of concrete in your delivery pipe. So, another important thing to be noted with respect to pumping, pumping is a little tedious operation because, before you do the pumping of your actual concrete mix, you have to do some lubricating or buttering kind of job as I told you earlier for the conventional drum mixers.

So, otherwise, what will happen is if you do not do the lubricating process, your first batch of concrete whichever is going to be pumped through the pipeline, most of the paste will stick to the sides of the pipeline. And the concrete which is going to be delivered out will be having less amount of paste and more amount of aggregate. So, that batch has to be thrown out. So, that is why to avoid that and also we need some lubrication on the pipelines, which will facilitate the easy and uniform flow of the concrete through the pipelines.

So, for that that lubricating process is needed. So, what we do is basically before pumping of your actual the concrete batch. So, what you do is, you just prepare mortar grout and flush the pump and the pipeline with the mortar grout. So, flush it with the mortar grout that is what is called as lubricating process. So, once a lubricating process is done, then you can do the actual pumping of your concrete mix.

So, after the concrete pumping is done, so, immediately you have to clean the pump and the pipelines. Otherwise, if the concrete hardens, it is very difficult to clean it. So, further, very commonly, you can see that they will insert a rubber plug into the pipeline and flush it along the pipeline with the water pressure. So, this rubber plug will clear away everything perfectly so that there will not be any choking of any aggregate or anything in the concrete pipelines.

So, this is the device they use as a check to ensure that there is no choking or blocking in the pipeline. So, that is why I told you, so, every time when you do this pumping operation, before pumping, I have to do the lubricating process and immediately after the pumping, I have to do the cleaning process. So, if we need the concrete if we need a steady supply of concrete, in that case, pumping will be easier.

Otherwise, if you need concrete in the intermittent manner, in that case, this process will be very tedious because every time I have to lubricate and clean it. So, more efforts are involved in that. So, for steady supply of concrete, pumping is the best option. So, this is what we discussed just now, before pumping is started, for the lubrication purpose, cement and sand grout is flushed through the pump and pipeline.

So, this lubrication process will facilitate the easy flow of a concrete through the pipeline. And for cleaning purpose, a rubber plug is inserted into the pipeline and forced along the pipeline due to the water pressure for cleaning purpose. So, for cleaning of the pipelines, you have to flush this rubber plug with the water into the pipeline.

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So, this picture shows you the concrete pump along with the RMC transit mixer. So, you can see this is the RMC transit mixer. This is your RMC transit mixer. So, it is delivering the concrete through the chute. The transit mixer will have a chute. With the help of the chute it is delivering the concrete into the hopper of the pump. So, from the pump, as we discussed based upon the piston action, the concrete will be delivered into the delivery pipelines.

And these and the pipelines will be taken to the desired placement area. So, this is how it carry the concrete to the placement area through the pipelines. So, basically we are allowing the concrete to flow through the pipelines by applying pressure with the help of the pump.

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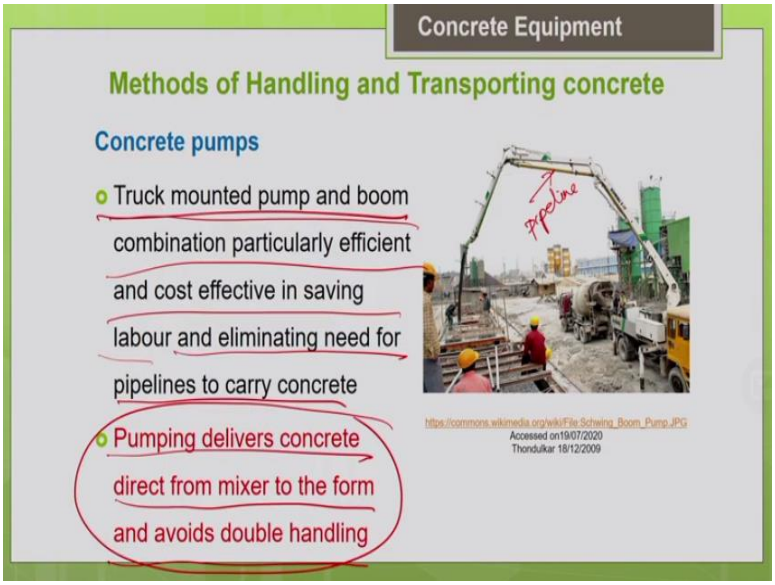

So, in some places the job site will be very much congested that it will not be possible to place the pipelines on the ground. So, in that case, you can go for this truck mounted pump and boom.

Truck mounted, this is called as truck mounted pump and boom combination. So, your pump and the boom is mounted on the truck. This is your boom. Just like the boom of your crane. So, this is a boom.

So, on the underside of the boom, you can see the pipeline, pipeline carrying the concrete. So, the pipeline is fixed on the underside of the boom. So, everything is mounted on the truck that will give you a better mobility. So, this can also be used for reaching greater height also. So, basically we go for this option when the site is congested and not possible to have the pipelines on the ground.

So, this will give you a better productivity in congested sites. So, truck mounted pump and boom combination, particularly efficient and cost effective in saving the labour and eliminating the need for pipelines to carry the concrete. So, pumping delivers a concrete direct from the mixer to the form and avoids double handling of concrete. That is a important advantage of the pumping method.

So, directly you are delivering the concrete from the mixer, the transit mixer or the whatever device directly you delivering it to the formwork. So, that way you are avoiding the double handling of the concrete.

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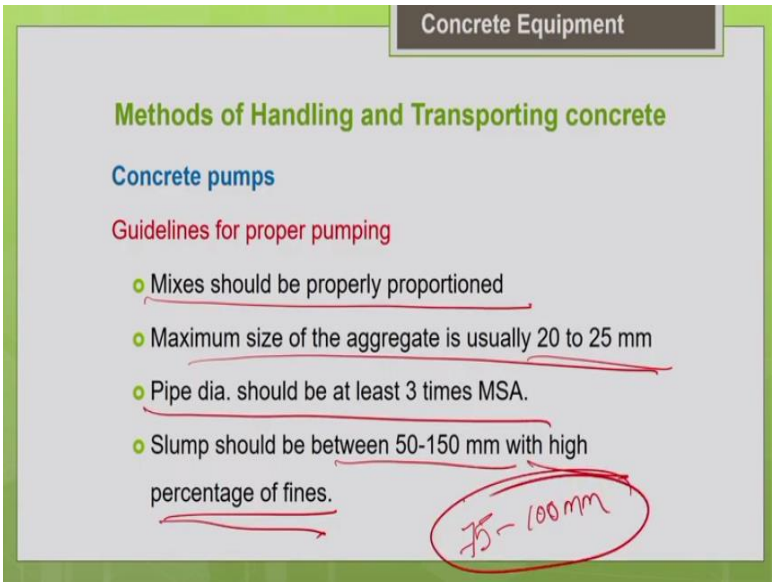

So, there are some guidelines for proper pumping or successful pumping. That we should always keep in mind. So, basically if you decide that you are going to go for pumping method for the concrete placement that decision has to be made even during the mix design itself. So,

while you mix proportion the concrete itself if you decide about the concrete placement method.

So, if you are going to use the pumping method for placement, so, accordingly you have to design the workability of the concrete, so that it can be easily pumpable. So, the mixes should be properly proportioned from pumping perspective. And another important thing is maximum size of aggregate (MSA) is very important for pumpable concrete. So, we should not go beyond 20 to 25 mm.

So, there is a simple guideline like pipe diameter should be at least 3 times the MSA of your aggregate. So, all these things have been done to avoid the blocking or choking of the aggregates in the pipeline. So, the maximum size of aggregate should be limited if you are going for pumping method. And the slump should be between 50 to 150 mm. And we generally use more percentage of fines so that the mixed will be more cohesive.

So, the paste content will be more cohesive and it will be easily flowable through the pipelines. To facilitate that, we use high percentage of fines in the pumpable concrete. So, all these things should be taken into account when you do the mix proportioning itself. So, as per our IS Code, so, we should go for at least 75 to 100 mm. Slump is needed for pumpable concrete.

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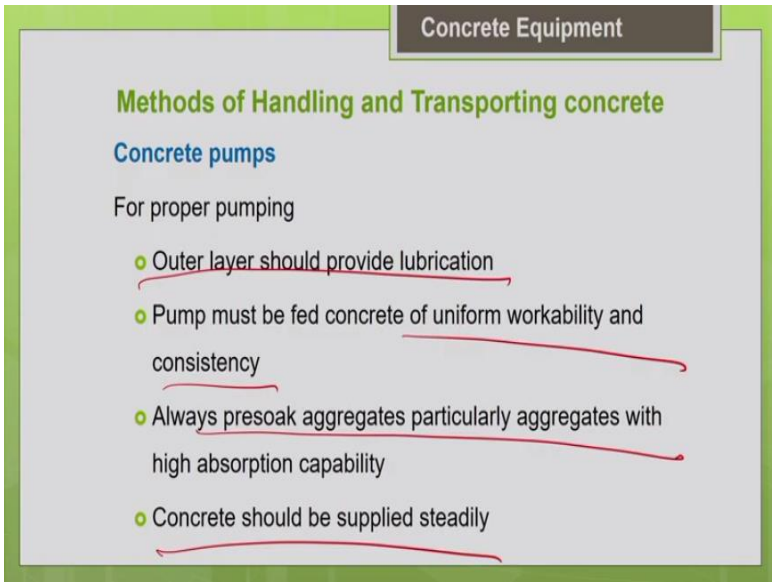

So, what are the other guidelines? Let us see. So, as I told you, the important thing is before pumping of your actual batch of concrete, you have to do some lubrication. So, that lubrication will only facilitate easy flow of your concrete through the pipeline. And we should feed the

concrete pump with uniform consistency and uniform workability. That is very important so that you can have a uniform flow of concrete through the pipeline.

Another important thing is if you are going to use some lightweight aggregates for concrete making, and if that is going to be pumped, so, you know that lightweight aggregates will have higher water absorption capacity. So, when you use that kind of lightweight aggregate concrete for pumping, so, under pressure, the aggregates will absorb more water, more of the mix water will be absorbed by the aggregates.

So, what will happen is the workability or the pumpability of the concrete will get severely affected. So, that is why, so, in that particular case, what you are supposed to do is before pumping you have to do the preconditioning of the aggregates. That means you presoak the aggregates. So, that it will absorb the water well. So, after you put it in the concrete, so, it will not absorb your mix water.

So, that will not affect the pumpability or the workability of your concrete. So, this kind of preconditioning is needed, then another important thing is pumping is a best option when the concrete is needed on a steady basis, you need a steady supply of concrete then the pumping is the best option. As I told you, it involves lot of preparation procedures like you need to do the lubrication. After pumping you have to do the cleaning.

All these involves lot of efforts. So, for steady supply of concrete, this is the best choice but for intermittent placing of concrete pumping is not the right choice.

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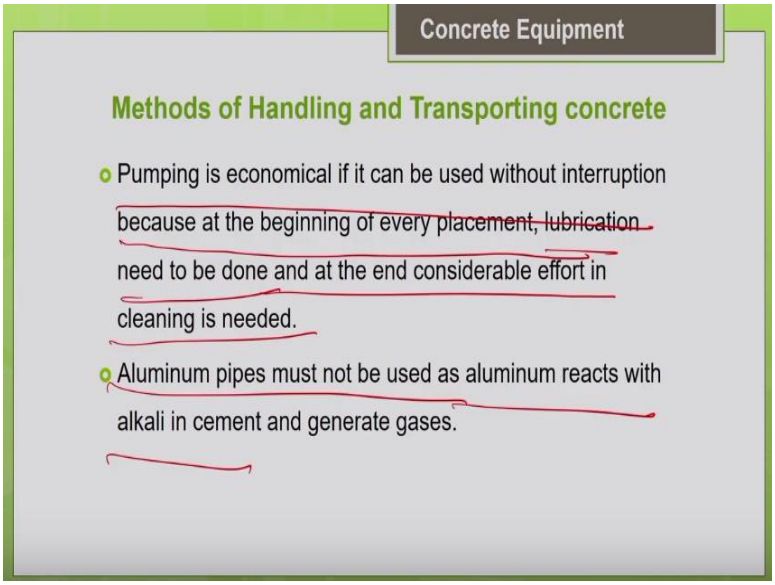

So, pumping is economical if it can be used without interruption because at the beginning of every placement lubrication need to be done and at the end considerable effort in cleaning is needed. So, that is why if you need a continuous supply of concrete continuous placement of concrete the steady supply is needed. In that case, you can go for the option of pumping. And another important thing is we should not use aluminium pipes for placing the concrete because studies have proved that aluminium will react with the alkali content in the cement.

That will generate the hydrogen gas that will affect your concrete strength. So, aluminium pipes are not generally recommended for the concrete placement.

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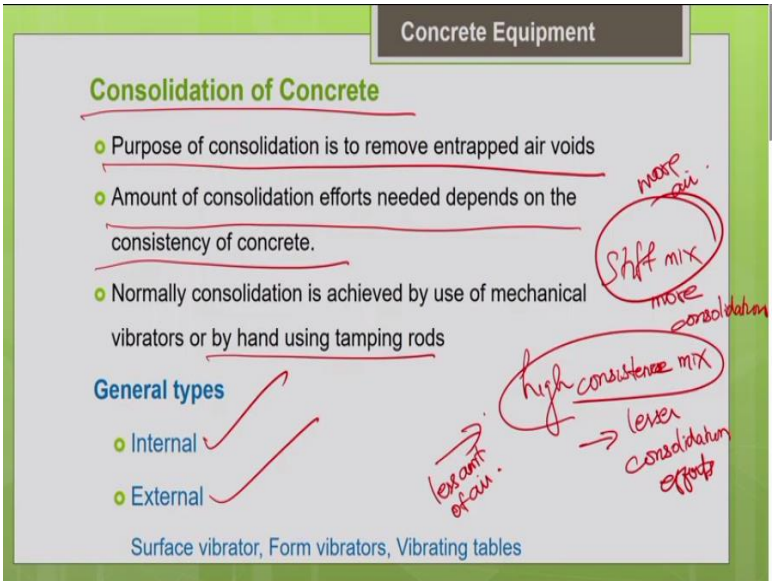

So far we have discussed about different methods of transporting the concrete or placing the concrete. So, starting from the simplest method like wheel barrows and buggies, we have

discussed about even the modern methods like pumping and the belt conveyors. So, now let us move on to the next step in the production of concrete. I hope you remember, what are the steps involved in the production of the concrete?

We started with the batching of concrete then we moved on to mixing of concrete then transporting and placing the concrete. Now, we are going to discuss about the consolidation process of concrete. So, the main purpose of consolidation of the concrete is to eliminate the entrapped air voids in the concrete. So, basically when you mix a concrete when you do the concrete preparation.

So, there are more chances for the air to get entrapped in the concrete. So, this entrapped air will affect your concrete strength and durability to a greater extent. So, the amount of air entrapment may vary from 5 percent to approximately 20 percentage by volume of concrete. So, it depends upon the consistency of your concrete. So, basically if the mix is going to be very stiff there are more chances for air entrapment.

But if the mix is more flowing in nature or it has a very high consistency in that case the chances for air entrapment is very less. So, the amount of air entrapment will depend upon the consistency of your concrete. So, that is why according to your consistency of your concrete the amount of the consolidation efforts needed will also vary. The main purpose of consolidation is to remove the entrapped air voids.

So, how much consolidation efforts you need? It depends upon the consistency of your concrete. For a stiff mix, I need more consolidation. For a high consistency mix or flowable mix, for high consistency mix, you need lesser consolidation efforts. So, this is because in stiff mix more amount of air is likely to get entrapped. In the high consistency mix, only less amount of air will be entrapped because of the presence of more water in the mix.

So, basically we have to match the vibrator with the concrete consistency. So, depending upon your concrete consistency you have to select the consolidation method needed. So, earlier people used to do the consolidation with just manually with hand using tamping rods. But due to advancement in technology nowadays, we have different types of vibrators available in the market.

So, according to your job requirement, you can make the choice of the vibrator. So, we can classify the vibrators based on the mechanism as the internal vibrator and external vibrator. So, we are going to discuss about all these vibrators in the upcoming slides.

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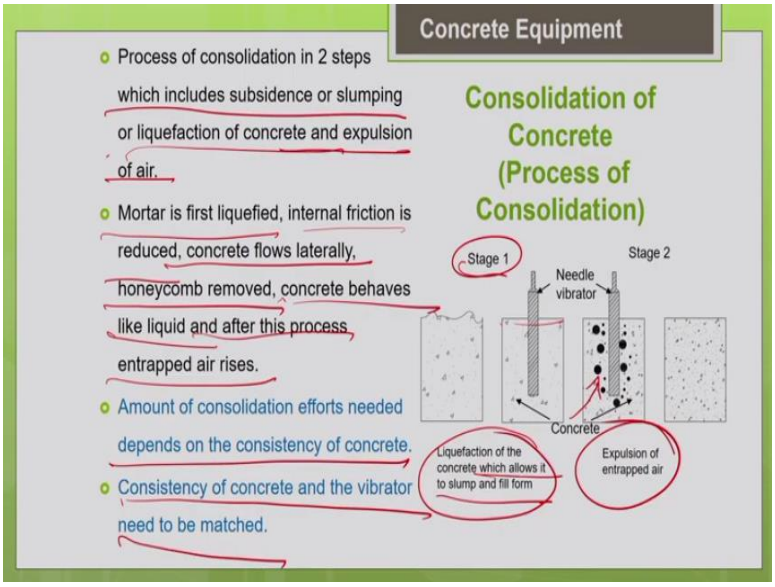

So, basically before moving into the types of vibrators, let us discuss about the actual process of consolidation. How this process of consolidation is happening in the concrete? So, the consolidation usually occurs in 2 steps. The first thing is when you put your vibrator in the concrete, so, what is happening is your concrete becomes liquefied. It will behave like a liquid. It will start flowing laterally.

So, it is we call it as slumping or subsidence whatever way you can call. That the first step what is happening is liquefaction of the concrete. So, your concrete will slump or subside. So, it will completely fill the form. It will completely fill the formwork. So, this will result in rising of your entrapped air to the surface. So, this is how the consolidation process happens. So, the process of consolidation occurs in 2 steps which includes subsidence or slumping or liquefaction of concrete and then expulsion of the air.

So, the mortar will be first liquefied. The internal friction is reduced because of the vibration. And the concrete flows starts flowing laterally. Or any honeycomb, anything is there in the concrete that will be easily removed. As I told you the concrete behaves like liquid and fills the formwork. And after this process, you can see that the air will rise to the top. Your entrapped air will rise to the top surface of the concrete.

So, you can see in this picture also. So, in the Stage 1, what is happening? Your concrete is getting leveled. You can see the subsidence is happening. So, it completely fills your formwork. So, after that you can see that your air will rise to the top surface. So, the first thing what is happening is liquefaction. The concrete gets liquefied due to the vibration action. This liquefaction will allow you to slump and fill the form completely.

And because of that your entrapped air will rise to the surface. So, that is what is happening in the second stage. So, as I told you earlier, how much amount of consolidation efforts you need that basically depends upon the consistency of your concrete. So, for every stiffer mix, you need more consolidation because more chances for air entrapment. So, consistency of the concrete and the vibrator needs to be matched.

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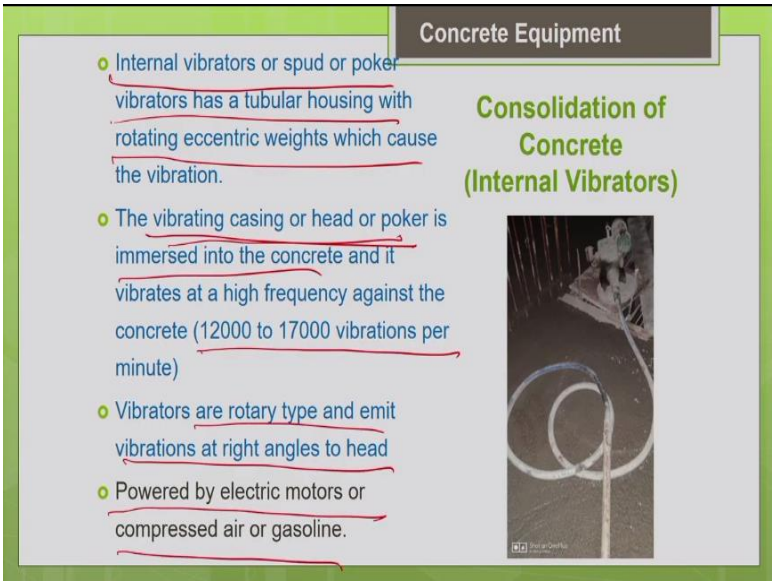

So, first let us discuss about the internal vibrators which are very commonly used for the consolidation of the concrete. We call them as needle vibrator or spud vibrator or the poker vibrator. So, there are different names to call these internal vibrators. These are more effective forms of vibrators, because what we do is basically this needle vibrator has a casing or the head at the bottom.

You can see that there will be casing or the head at the bottom of the vibrator. So, this vibrating casing or the head, it will be immersed into the concrete. So, this vibrating casing or the head is immersed into the concrete. So, how the vibration is produced? As I told you earlier for the pile vibrator again also the mechanism is similar you will be having rotating eccentric weights inside this the tubular casing or the head.

So, these weights which are rotating inside because of the forces produced by this rotating weights it will result in the vibration. So, the amplitude of the vibration and the frequency of the vibration it will depend upon the mass of the rotating weights inside. So, the mass is going to govern the amplitude of the vibration and the speed of the rotation of the weights inside is going to govern the frequency of your vibration.

So, this amplitude and the frequency of your vibration will control the efficiency of your consolidation process. Basically these are internal vibrators also called as spud or poker vibrators. They have a tubular housing. As I told you, a casing or head will be there at the bottom with rotating eccentric weights inside. These rotating weights only causes the vibration. So, this vibrating casing or the head you immerse it into the concrete.

So, wherever the consolidation is needed, you put it at that place immerse it. And then do the vibration. So, it will be vibrated with the help of a motor. So, these generally vibrate at a very high frequency say 12,000 to 17,000 vibrations per minute. So, generally when compared to other types of vibrators, these vibrators give you a very high frequency. And the vibrators are rotated as you know and it emits the vibrations at right angles to the head.

So, and these are powered by the electric motors or the compressed air or gasoline whatever mode.

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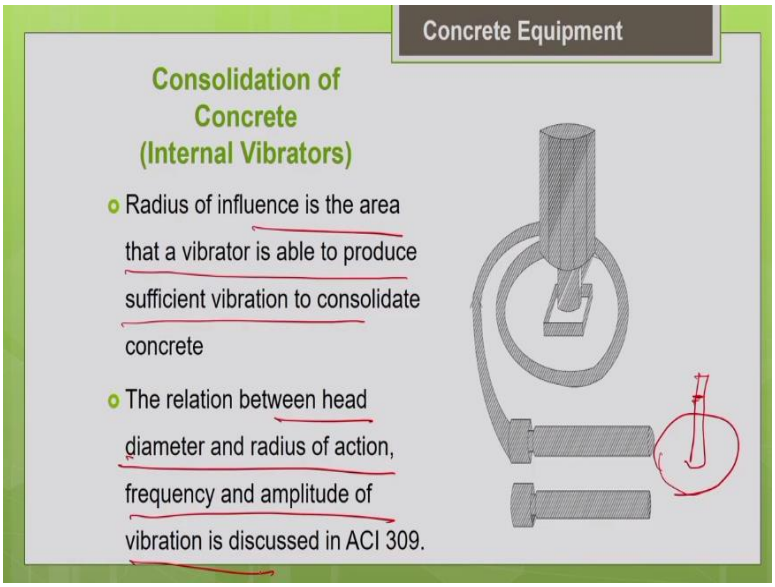

So, basically every needle vibrator, it will have its own radius of action. So, this is the casing or the head you can see. As I told you at the bottom, you have the casing or the head. So, how much will be the area of influence? So, this is your head, how much will be the area of influence? So, that depends upon the diameter or the radius of your the head. So, this this casing head this diameter will determine the radius of the influence.

Also it also depends upon the frequency and the amplitude of the vibration. That also influence the radius of the influence. So, basically, the radius of influence for a particular vibrating head is nothing but it is the area that a vibrator is able to produce sufficient vibration. So, the area over which your vibrations will be effective that is called as the radius of influence or the radius of action for a particular vibrator.

And that is going to depend upon the diameter of your the vibrating head. And it also depends upon the amplitude and the frequency of the vibration. So, the studies have established the relationship between the head diameter, radius of action, frequency and the amplitude of the vibration.

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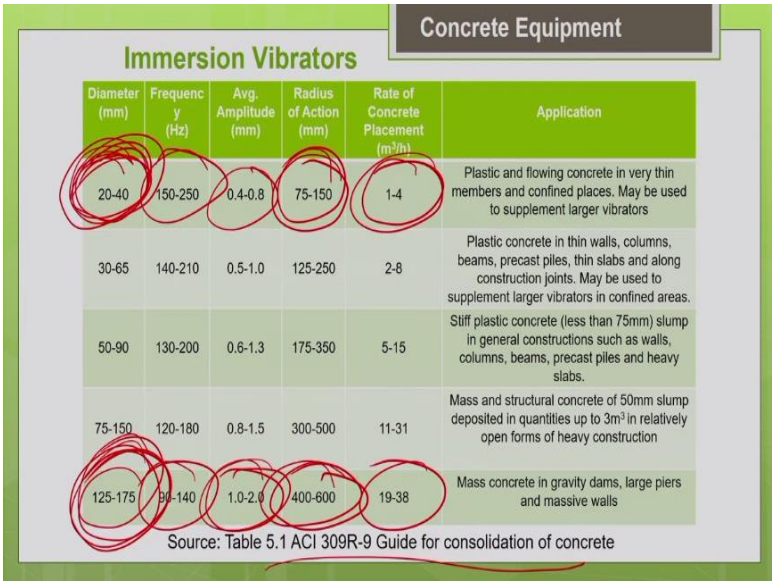

So, you can get this information in ACI 309R which gives you the guide for the consolidation of concrete. So, you can see this table is taken from the ACI 309R. The basically you can see there are different types of vibrators available with diameter ranging from 20 mm to 175 mm. You can see. So, there are lot of options available. So, depending upon the thickness of your section and depending upon your placement rate needed accordingly you can go for the particular diameter of your vibrator.

So, for very thin sections, where there the reinforcement is very much congested it is densely reinforced section you have to go for very thin or a small diameter. But for a thick section say for example, massive construction like dams for thicker sections I can go for a bigger diameter. So, according to the diameter you can see that the radius of action will also vary. As the diameter increases your radius of action also increases.

Also the bigger diameter you can see it can provide you greater amplitude. Amplitude is nothing but your magnitude of motion. So, it gives you greater amplitude, but relatively lesser frequency. So, frequency is nothing but number of vibrations per minute. So, when you go for smaller diameter, you can see that the amplitude is less but the frequency is high. So, according to your concrete consistency according to the thickness of your section, according to the spacing between the reinforcement you have to make the selection of the size of your vibrating head or the diameter of the immersion vibrator.

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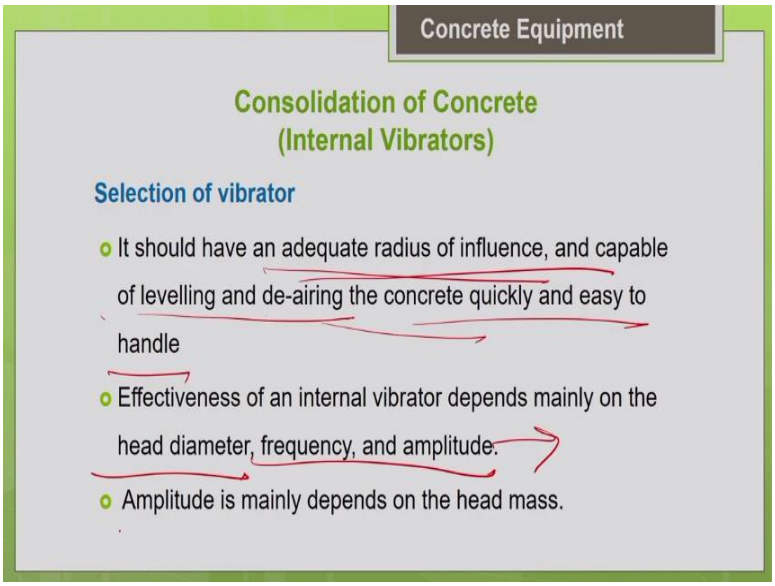

So, whatever vibrator you choose, it should have a adequate radius of influence so that you can have your desired consolidation rate. You can see your rate of concrete placement also varies. For a smaller vibrator, you can see 1 to 4 meter cube per hour. But for a bigger diameter vibrator you can have 19 to 38 meter cube per hour the concrete placement. So, depending upon the productivity needed, so, you have to make the choice of your vibrator.

So, whatever vibrator you choose should have an adequate radius of influence. And it should be capable of leveling the concrete and de-airing the concrete quickly. And it should be easy

to handle also. So, the effectiveness of a consolidation it is going to depend upon your head diameter, because that is going to decide your radius of action and also it depends upon the amplitude and the frequency.

As I told you amplitude depends upon the mass of the rotating weights inside the vibrator and the frequency depends upon the speed of the rotating weights inside the vibrator. So, according to the concrete consistency, you need to vary the amplitude of the frequency. So, very commonly in the job site we are not able to vary much the amplitude and the frequency. But the concrete which is made in factories, you can have a control.

You can have much control over the amplitude and the frequency so that you can have the control over your consolidation. Say if you have a stiffer concrete, you need a higher amplitude basically. Stiffer concrete means there will be lot of voids in the concrete. There will be more space between the particles. So, you need a more amplitude to cover the space. So, you need higher amplitude and lesser frequency.

But if the concrete is having a higher consistency, in that case, I can go with lower amplitude and higher frequency. So, according to the consistency you need to vary the amplitude and the frequency, but that is mostly possible only in factories.

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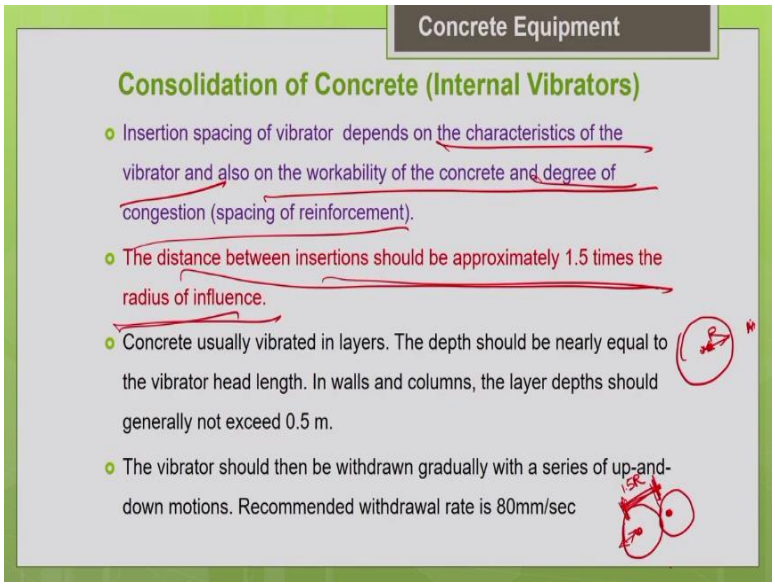

So, very commonly in your job site, you can see that they change the spacing of the vibrator just by looking at the consistency of the mix. So, if the person who is doing the vibrating job if the worker who is doing the vibrating job, when he feels his concrete is very stiff, he will

reduce the interval of spacing. When he feels his concrete is having better consistency, then he will increase the interval of spacing between the vibrators.

So, that is how it is commonly done at the job site, just based on the experience and by looking at the concrete consistency. But theoretically, there are guidelines of the literature which says that the insertion spacing should be approximately 1.5 times the radius of influence of the vibrator. So, basically, this is how it goes. Say you have one insertion point say you have the another insertion point.

So, the distance between the insertion points should be 1.5 times R. R is nothing but your radius of action of your vibrator. So, the distance between the insertion points, the distance between the insertion points should be 1.5 times the radius of action of your vibrator. So, this is what is the guideline available in the codes regarding the spacing between the vibrator.

But basically the spacing the insertion spacing depends upon the characteristics of your vibrator. It depends upon the radius of action of a vibrator. If it has a better radius of action accordingly you can vary the insertion spacing. It also depends upon the workability of the concrete. If it is going to be a stiffer mix, you have to reduce the interval. If it is going to be a highly consistent mix, you can increase the interval.

And also depends upon the spacing of your reinforcement. If it is very densely reinforced, we have to increase the spacing. So, it all depends upon the characteristics of your concrete and spacing of your reinforcement. And also it depends upon the vibrator type. But the basic guideline is distance between insertions should be approximately 1.5 times the radius of the influence. See if this is your insertion point.

So, R is called as a radius of influence, the radius of action of the vibrator. And distance between the 2 insertion points should be 1.5 times R. So, basically we vibrate the concrete in layers. So, the depth of vibration layer will be nearly equal to the vibrator head length. Mostly layer which we are going to vibrate, the layer depth will be equal to the vibrator head length.

So, in walls and columns, the layer depth should generally not exceed 0.5 meter. So, this is the guideline we should keep in mind. You should not exceed 0.5 meter. And after vibration, how do you withdraw the vibrator from the concrete? So, even for that there are some guidelines

existing in the codes. Your withdrawal rate should be very slower. If you rapidly withdraw, so, what will happen is during withdrawal there are chances for air entrapment.

So, that is why we should slowly withdraw the vibrator from the concrete. So, vibrators should be withdrawn gradually with the series of up and down motions. So, the recommended withdrawal rate is 80 mm per second. So, slowly we should remove the vibrator from the vibrator layer.

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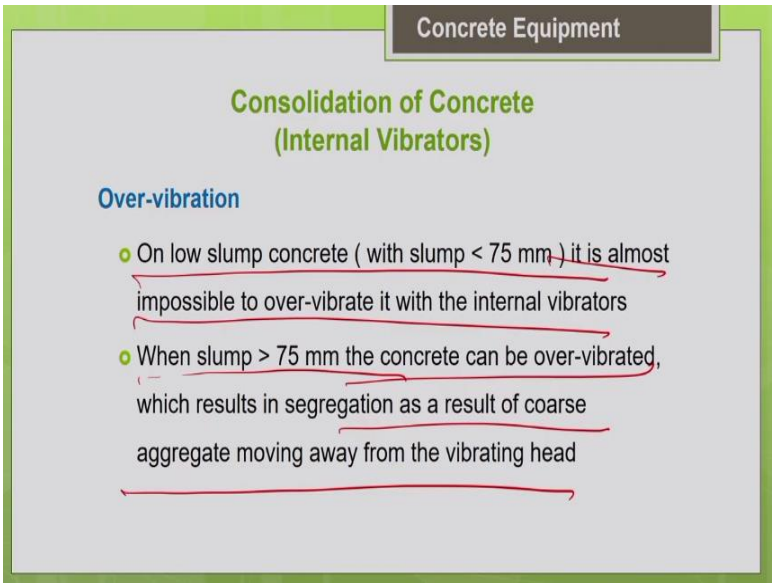

And another thing you should keep in mind is we should never over vibrate the concrete. So, if you over vibrate also the it will result in segregation of your concrete. So, generally the chances for over vibration will be there only in highly consistent mix in flowable concrete. So, when you handle the stiff mixes the chances for over vibration is very less. On a low slump concrete with slump less than 75 mm, it is almost impossible to over vibrate with internal vibrators.

But when concrete with slump greater than 75 mm, there are chances for over vibration with a vibrator which can lead to segregation. So, it will result in movement of a coarse aggregate away from the vibrating head. That will result in segregation. That is why we should not over vibrate.

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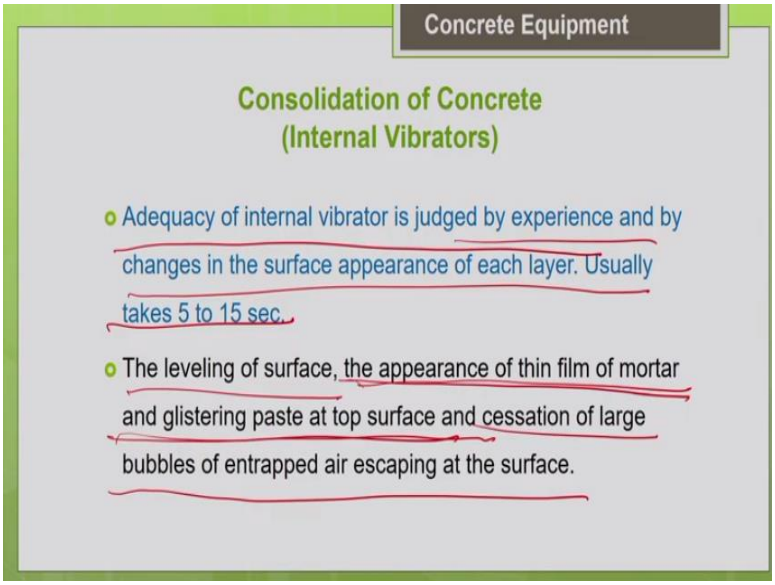

So, how long I should vibrate do the vibration at a particular place. Usually we take approximately 5 to 15 seconds. But it depends upon the consistency of the concrete. Generally, based upon experience what the worker will do is by looking at the concrete itself by looking at the concrete surface itself he can make a guess whether the consolidation is done or not. If he is an experienced person, he can make a guess whether the consolidation is done or not.

So, your surface will appear very level. And you can see that the air bubbles which comes from the surface will stop coming to the surface. That is an indication that consolidation is done. And also you can see appearance of thin film of mortar and glistering paste at the top surface which indicates that the consolidation is done. So, these are the indications that the consolidation process is complete.

So, generally the adequacy of the internal vibrator is judged by experience and by changes in the surface appearance of each layer. So, usually it takes 5 to 15 seconds. So, leveling of the surface, appearance of the thin film of mortar and the appearance of glistering paste at the top surface and stoppage of large entrapped air bubbles escaping at the surface, so, all these things indicates that your consolidation process is completed.

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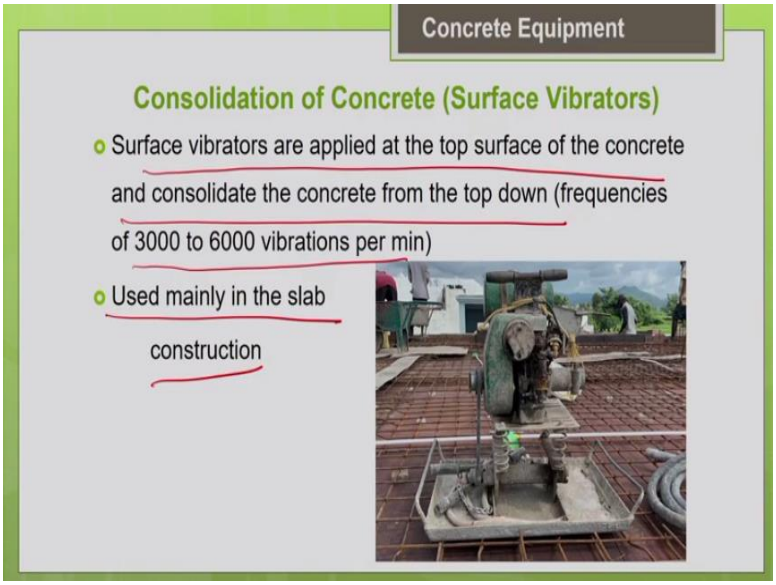

Now, let us move on to the surface vibrators. So, let us see how to do the consolidation of the concrete using surface vibrators. So, these vibrators as the name indicates the vibration is applied at the surface of the concrete and from the surface the vibration will be transferred throughout the entire depth of the concrete. So, generally speaking the internal vibrators are the best one.

They are more effective, because we are directly applying the consolidation at the actual layer of concrete where the vibration is needed. But here the vibration is getting transferred from the surface to the entire depth of the concrete in the case of surface vibrators. So, that is why internal vibrators are the most effective one when compared to the other type of vibrators. But in some cases we cannot use the internal vibrators.

Say for example, if the slab thickness is very small and if your the casing or the head of the needle vibrator is not completely immersed in this slab because the thickness of the slab is very small. So, in that case we cannot use a needle vibrator for such thin slabs. On a similar note if the reinforcement is very much congested, it is densely reinforced slab. So, it is very difficult to find the spacing.

It is very difficult to insert the vibrator in between the reinforcing bars. So, in that case also it is not possible to use the internal vibrators in slabs where it is very densely reinforced. So, in those cases, we go for the surface vibrators. So, wherever internal vibrators are not possible where it is not feasible to use internal vibrators, then we go for other form of vibrators like surface vibrators.

So, these are mostly used in the slab construction. So, you can see that the surface vibrators are applied at the top surface of the concrete. And it consolidates the concrete from top down. And when you compare it with the frequency of the internal vibrator, you can see here the frequency range is only 3,000 to 6,000 vibrations per minute. But your needle vibrators are having very high frequency as high as more than 12,000 vibrations per minute.

So, this frequency range is also only average for the surface vibrator. So, here what we can see? Here, this is a picture of the plate type surface vibrator. It resembles a plate. So, it is a plate type surface vibrator more commonly used for the slabs.

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So, another type of surface vibrator is screed type vibrator vibrating screed. Screed in the sense it is a kind of finishing operation. Screeding refers to the finishing operation. In this vibrator, what we do is we do the finishing as well as the consolidation together. So, you can see the picture. So, it is doing the screeding job as well as the consolidation together. That means screeding is nothing but just removes excess layer of concrete on the top surface of the concrete and level it.

So, that is the preliminary step of finishing of concrete. So, it removes the excess layer of concrete on the surface of concrete and bring it to your right level. You level it. That is what is screeding. So, you are doing screeding as well as consolidation together using this vibrating screed. So, this picture also shows the same thing. So, you can see that they are removing the,

they are leveling the concrete. They are finishing the concrete as well as they are doing the consolidation.

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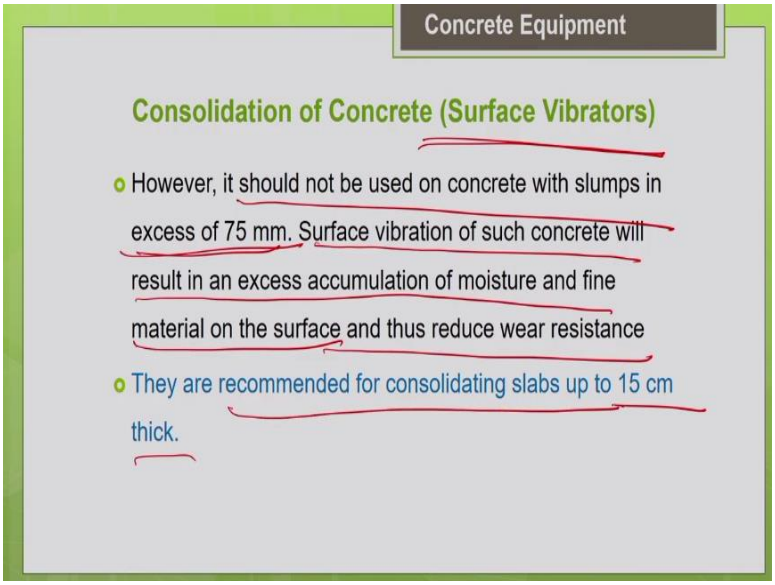

So, one thing to be noted here is this surface vibrators should not be used for a concrete with a very high workability above 75 mm. If the workability is above 75 mm for such high workable concrete mixes, we are not supposed to use surface vibration. So, what will be the major issue is when we do surface vibration for such highly workable concrete mixes, there are more chances for segregation, so, like water and thin layer of paste will come to the top surface of the concrete.

So, when we use the surface vibrators, so, that will make surface layer weak. So, particularly for the floor slabs where the surface strength is very important where the wear resistance is very important. So, we should be very careful regarding this kind of segregation. These kind of segregation should not happen. So, that is why we are not supposed to use the surface vibrators for concrete with the high workability above 75 mm.

So, the surface vibrators should not be used on concrete with slump in excess of 75 mm. Surface vibration of such concrete will result in excess accumulation of moisture and fine material on the surface. That is what is segregation, separation of water and find paste on the top surface of the concrete. So, that will reduce this surface strength of the slab or it will reduce the wear resistance of your slab.

So, that is why we are not recommending surface vibrators for workability above 75 mm. And one more thing to note that is the vibration transfer will be effective only for a depth of 150 mm. So, they are recommended for consolidating slabs up to 150 mm thick. Beyond that the transfer will not happen effectively.

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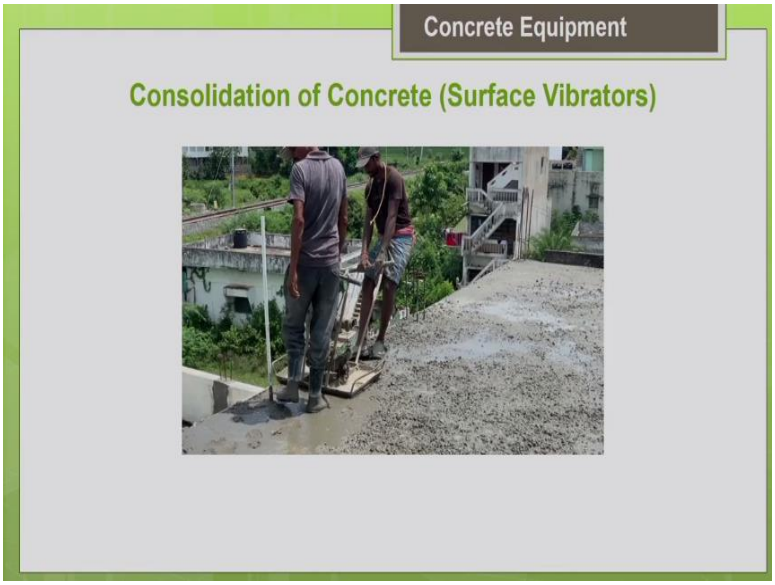

So, this picture also shows how the plate type surface vibrator is used for the slab consolidation.

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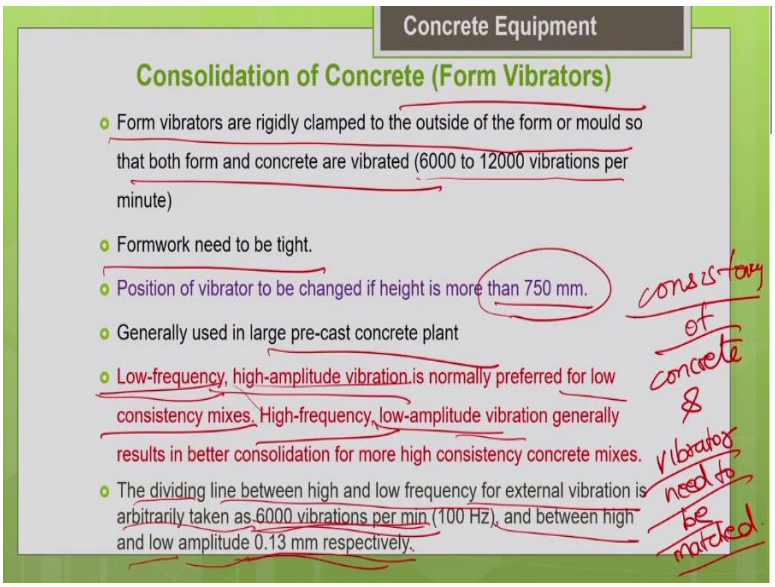

The next type of vibrator we are going to discuss is about the form vibrators. So, these are external type of vibrators. So, basically you are going to clamp your vibrator to the formwork. So, the formwork will vibrate and the vibrations will be transferred from the formwork to the concrete inside. So, this is also an indirect method of vibration. So, obviously, there will be some loss in transfer.

So, that is why the internal vibrators are the best because there is a direct transfer of vibration to the concrete. So, here the vibrator is clamped to the formwork. From the formwork, the vibration is transferred to the concrete inside. So, this is indirect method of transfer. So, form vibrators are rigidly clamped to the outside of the form or the mould. So, that both the form and the concrete are vibrated.

So, here you can see the frequency ranges 6,000 to 12,000 vibrations per minute. And one more thing to be noted here is the formwork should be very tight. So, if the formwork is not tight, when you vibrate the formwork itself concrete will start leaking from the formwork. That is why you should make sure that the formwork should be very tight, so, before you vibrate it.

And another thing is these vibrations are also effective only for a particular height only, say up to 750 mm. Say if you are going to use this form vibrators for a very deep column or a tall column, you have to keep changing the position of the vibrator. So, it is effective only up to 750 mm. So, after that, we have to keep changing shifting the position of the vibrator along the depth of the column.

So, mostly these kind of vibrators you can see that it is used in factories or the precast concrete plants. Sometimes we also use it to supplement the internal vibration. So, as I told you, why do we go for this kind of indirect methods? Because the direct method of the internal vibration or the needle vibrators are not feasible in certain cases, because the section is very thin or the section is densely reinforced or the reinforcement is very much congested that they cannot insert by vibrator inside. In those cases only we go for these kind of indirect methods or external form vibrator. Sometimes what we do is in addition to the internal vibration we supplement it by adding this external vibration also. That is also possible. And another important thing to be kept in mind is always the consistency of the concrete and the vibrator need to be matched.

Say if your concrete is very stiff. It is going to be a very dry mix. So, in this case amount of consolidation efforts needed is more when compared to mix with high consistency. For a flowing concrete, the amount of consolidation efforts needed is less. So, the amount of consolidation efforts needed depends upon the consistency of the concrete. So, the consistency of the concrete and the vibrator we have to match it.

So, another important thing is the frequency and the amplitude of the vibration needed. That also depends upon the consistency of your concrete only because that is only going to govern your efficiency of your vibration. So, basically for dry mixes, which has low consistency obviously the spacing between the particles will be more because there will be a lot of voids in the dry mixes.

In stiff mixes or low consistency mixes, there will be lot of voids. The spacing between the particles will be more. In that case, we need a higher amplitude. Amplitude refers to the magnitude of the motion. We need a higher amplitude to cover the distance or cover the spacing between the particles. So, generally when we go for high amplitude we go for low frequency.

So, for low consistency mixes, we prefer high amplitude vibration and low frequency vibration. On a similar note for a high consistency mixes, we can go for low amplitude and high frequency vibration. So, these are the general guidelines to match the vibrator with the consistency of the concrete. For stiff mixes, better go for higher amplitude and low frequency. And for high consistency mixes, go for lower amplitude and high frequency.

So, on this high and low frequency, I have just discussed qualitatively. So, what is the dividing line in quantitative terms between high amplitude and low amplitude and between high frequency and low frequency? So, generally the frequency more than 6,000 vibrations per minute we call it as high frequency. Lesser than 6,000 vibrations per minute, we call it as low frequency.

Similarly, amplitude more than 0.13 mm, we call it as high amplitude. And less than 0.13 mm, we call it as low amplitude. So, this is a dividing line. So, dividing line between high and low frequency for external vibration is arbitrarily taken as 6,000 vibrations per minute and between high and low amplitude is 0.13 mm.

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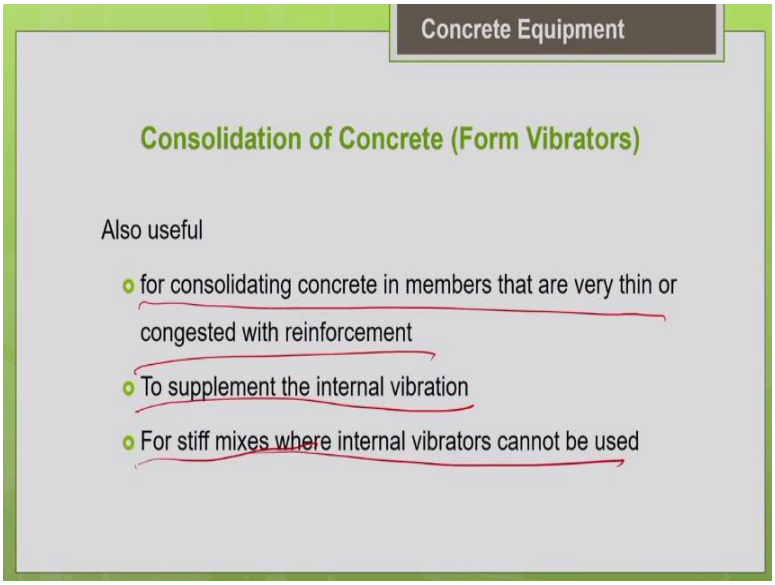

So, where do we use this form vibrators? Basically for thin sections as I told you where the internal vibration is not possible for a consolidating concrete in members that are very thin or congested with reinforcement where internal vibration is not possible. We go for form vibrators. And also in some cases to supplement the internal vibration in addition we can do the external vibration also.

For stiff mixes where internal vibrators cannot be used, so, one thing to be noted here is generally the internal vibration cannot be applied for very stiff mix. So, it will not be effective. So, for very stiff mixes, it is preferable to go for form vibrators. Accordingly you can select the amplitude of the vibration. You can go for high amplitude for very stiff mixes. And you can go for form vibrators instead of internal vibrators.

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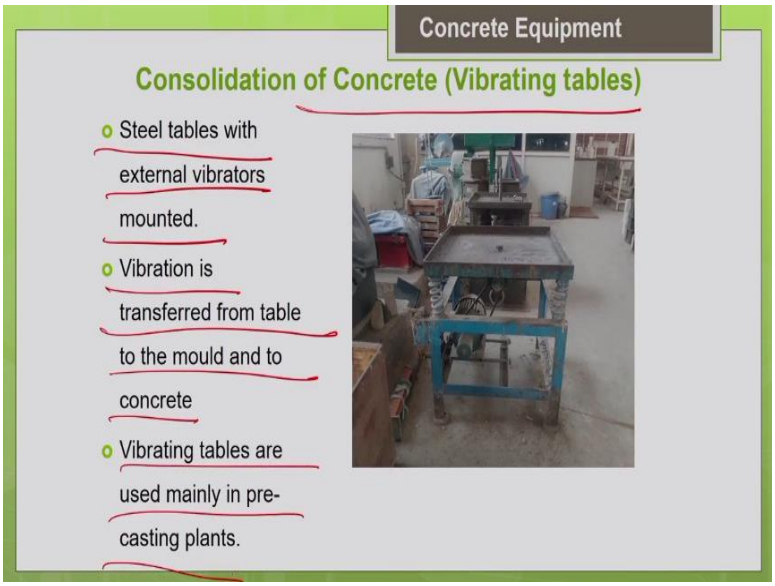

And the next one is the use of vibrating tables for consolidation. So, very commonly you could have seen this vibrating tables in the laboratories. So, in the concrete testing laboratories, you can see this vibrating tables. And it is also commonly seen in the factories like precast factories. So, you can see this vibrating tables. Basically these are steel tables with external vibrators mounted. So, the vibrators are mounted.

So, now the table will vibrate. From the table, the vibration is transferred to the mould. And from the mould, the vibration is transferred to the concrete inside the mould. So, this is also indirect way of transfer only. So, vibration is transferred from the table to the mould and then to the concrete inside the mould. Mostly you can see this usage in the pre-casting plants as well as in the concrete laboratories.

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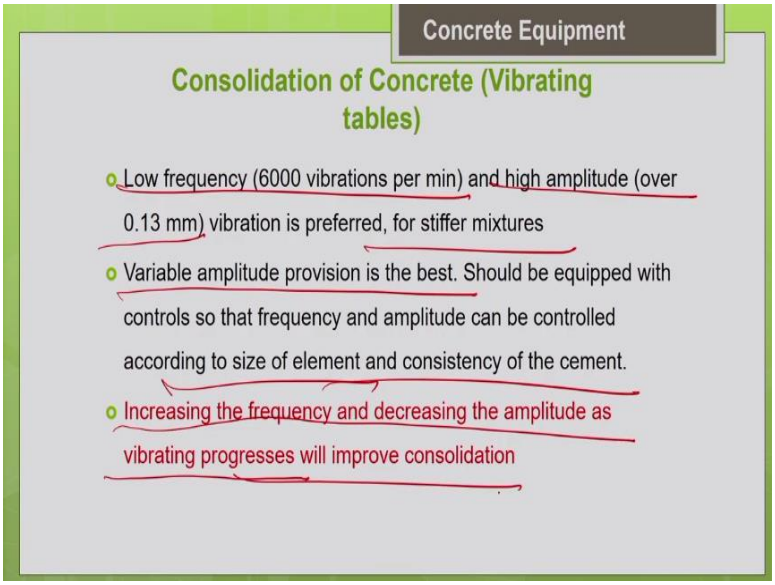

So, here also the same guideline you can apply. For stiffer mixes, go for higher amplitude. So, you go for high amplitude above 0.13 mm and you can go for low frequency less than 6,000 vibrations per minute. So, another thing is always it is preferable to have a vibrator where you have a control to manipulate the amplitude and the frequency so that you can match it corresponding to the consistency of the concrete.

So, variable amplitude provision is the best. But in most of the project sites whatever needle vibrators what we use there we do not have such control. So, but in precast factories there are lot of modern devices modern vibrators where we have control over the amplitude and the frequency also. So, when we have control over the amplitude and frequency according to the

consistency of your concrete or according to the size of your element, you can manipulate the frequency and the amplitude and use it.

So, that is why it is preferable to choose a machine which gives you a control over amplitude and the frequency. And generally speaking for the concrete say when we start the consolidation you can see that initially there will be lot of voids between the particles before consolidation. So, there will be more spacing between the particles, but as you start consolidating as it gets consolidated the mortar will get the concrete will get liquefied.

So, as it gets liquefied you can see that the voids will get reduced. So, that is why to start with you should always start with a high amplitude so that you will be able to cover the spacing between the particles. But as the consolidation progresses you can keep reducing the amplitude and increasing the frequency. That is a general guideline. Increase the frequency and decrease the amplitude as the vibration progresses.

This will give you effective consolidation. So, this is the basic guideline. If you have the control over the frequency and the amplitude then you can do this way. Generally to start with, we should start with high amplitude. And as the consolidation progresses, you start reducing the amplitude and increase the frequency. So, that is how we can achieve effective consolidation.

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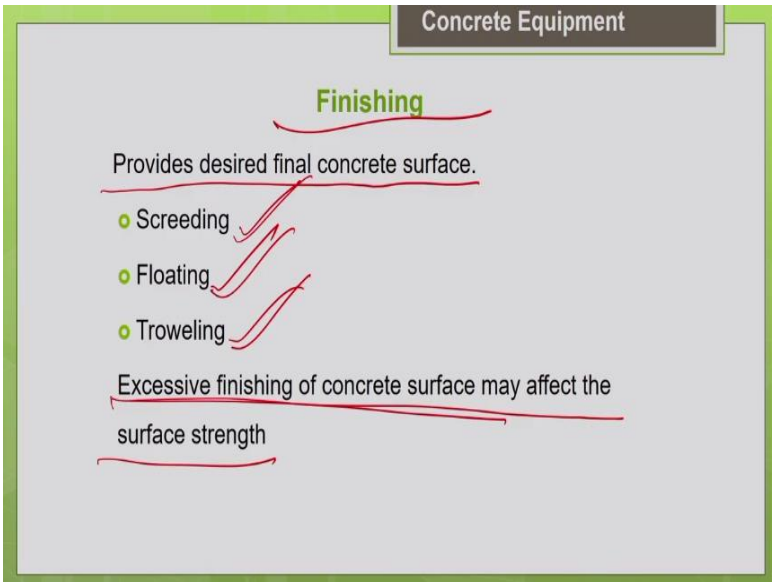

So, far we discussed about the consolidation. Now, we shall move on to the next step of the concrete making that is finishing of concrete. So, this is also a very important step. How much efforts you are going to put for finishing? It depends upon your requirement. What is the desired

surface texture? What is the desired smoothness you need? According to that you have to go for different stages of finishing.

So, this helps you to give you give the concrete the desired final concrete surface. So, but generally speaking, after consolidation, whatever efforts we do or whatever work we try to do with the concrete, it will generally harm the concrete. That is why after consolidation we should not try to do excessive finishing. So, very commonly in project sites, you can see that the finishers they try to manipulate the surface of the concrete by adding water and doing finishing so that they get a very good surface texture.

So, that is really a wrong practice. We should never do excessive finishing. We should not add water and try to manipulate the surface of the concrete to get the desired texture. So, never do excessive finishing of concrete, whatever minimum finishing that is needed to get your desired texture only that much should be done because it will harm the concrete. So, that is what is written here.

Excessive finishing of concrete surface may affect the surface strength. Particularly for the floor slabs where the surface strength and the wear resistance is very important, we should not manipulate the surface by adding water and you should not try to do the finishing operation. So, this finishing is usually done in stages. So, these are the different stages of finishing, screeding, floating and troweling.

So, generally, the actual time period for finishing is between initial setting time and final setting time. The actual window of finishing process is between the initial setting time and the final setting time. Generally as the concrete dries up, if you try to finish it, you will get the smooth texture very easily because if the concrete has not dried up and if there is some bleed water on the surface.

In that case your concrete will not be stiff enough to receive the texture you are trying to offer to it. So, only when the concrete dries up, it will be easy to smoothen it or polish it or harden it. So, that is why between every stage of finishing we should give some time interval. We should allow it to dry and then do it in stages so that it will be easy to smoothen it and polish it. So, let us discuss.

What are all the different steps of finishing one by one? So, the first thing we are going to discuss is the actual time of finishing.

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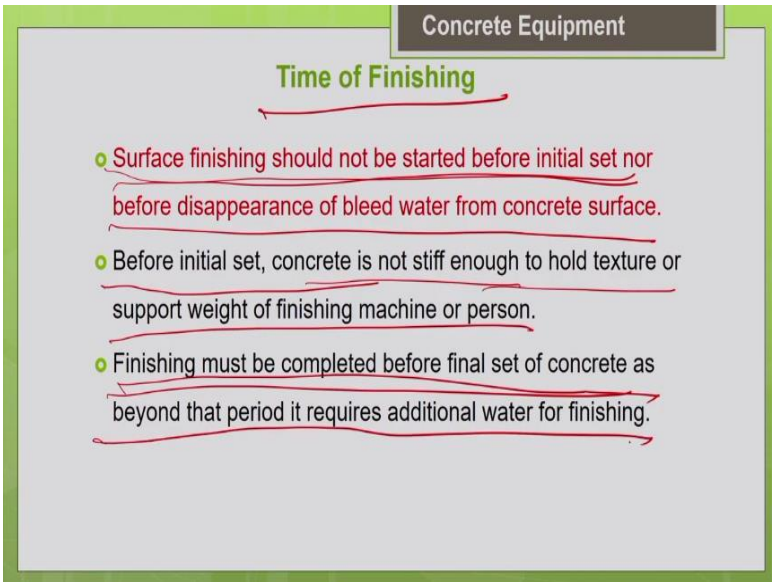

So, when should we start the finishing operation? The surface finishing should not be started before the initial set. So, before the concrete attains its initial set, we should not start the finishing. So, because your concrete will not be able to receive the texture what you are trying to offer. So, if there is some water on the surface and it is not dried up and it should have the strength to support the person who is standing for doing the finishing operation or it should have the strength to support the machines which are going to use for the finishing operation.

That is why we should not start the finishing operation before the initial setting of the concrete. Surface finishing should not be started before the initial set nor before the disappearance of the bleed water from the concrete surface. Only after the bleed water is completely evaporated, after that only you should start the finishing process. So, why? Because, before initial set, your concrete is not stiff enough to hold the texture, or support the weight of the finishing machine or the person who is going to do the finishing operation.

So, that is why before initial set do not try the finishing operation. After the initial set only you should start the finishing operation. And finishing must be completed before the final set of the concrete. So, after the final set of the concrete, if you try to do the finishing operation, you may have to add additional water then only you will be able to do. But adding the additional water and manipulating the surface of the concrete will definitely affect the surface strength of the concrete.

And it will affect the wear resistance of the concrete. So, that is why we should complete the finishing process before the final setting of concrete. As beyond that period, it requires additional water for finishing which is not advisable to do.

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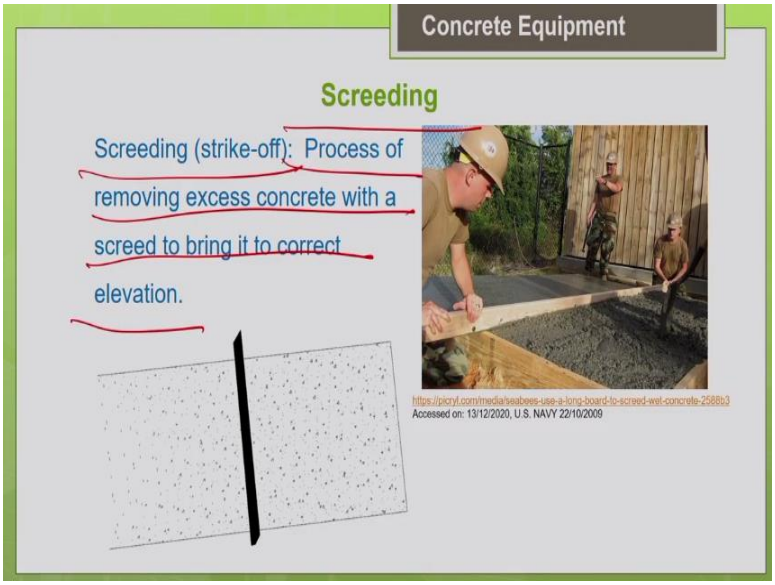

Now, let us see, what are all the different stages of the finishing of the concrete? The first step is screeding. Screeding is nothing but strike off. You can see the picture what they are doing. So, with the wooden screed, they are just trying to remove the excess concrete from the surface and level it to the right elevation or level it to a correct level. That is what they are trying to do here, so, the process of removing the excess concrete with a screed to bring it to a correct elevation.

So, this is the preliminary step in the finishing the first step in the finishing. Just remove the excess concrete on the surface with a wooden screed.

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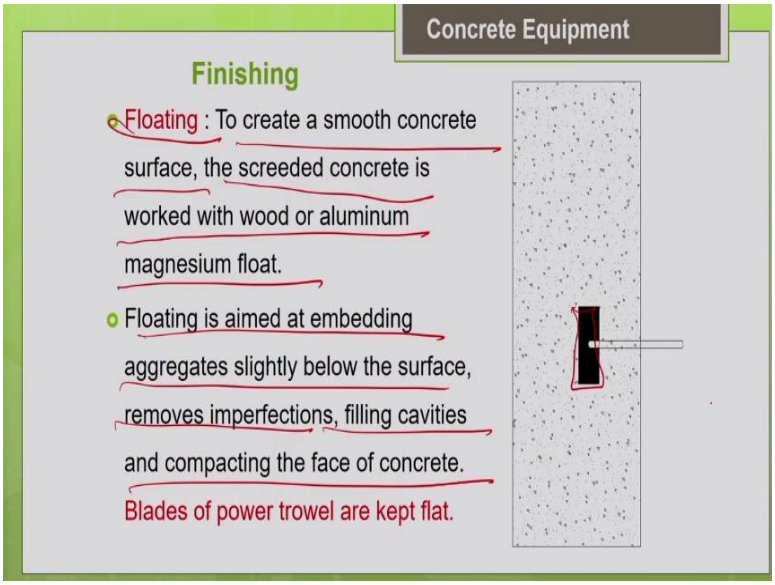

So, following screeding, the next stage is floating. So, always give some time interval between every stage of finishing and then do it. The main objective of floating is to create a smooth concrete surface. So, what you do is you either go for a wooden float like this or it may be even a metal one aluminum, magnesium, the metal floats are also available. So, with this metal float keep this blade flat and then smoothen the concrete surface.

So, the main objective is to smoothen it. And if there is any protruding aggregate, you just push it inside level it. If there are any undulations if there are any difference in the levels you can level it fill any cavities or voids. So, that is the main purpose of floating. So, what is the main purpose of floating? To create a smooth concrete surface. So, the screeded concrete is work with wood or aluminum magnesium float.

So, the main purpose is it is aimed at embedding the aggregate slightly below the surface you press it press the aggregates below the surface. Remove the imperfections. Fill any cavities if any. And compact the face of the concrete. When you do the floating job we always keep the blade flat and do it. So, either you can do it manually using this kind of tools, simple tools like a wooden float or a metal float. Or, there are also machines available to do it which we are going to discuss later.

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So, this picture again shows how the finishing operation is done with simple tools.

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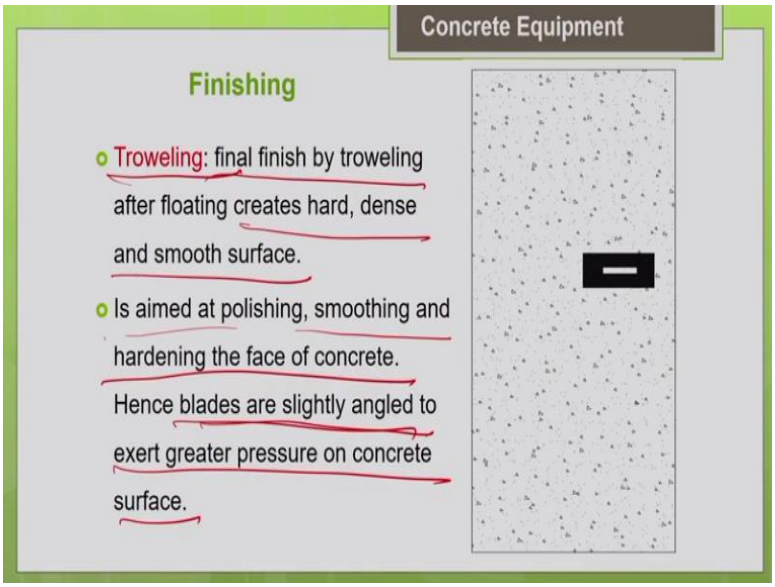

And the next step of the finishing is troweling. So, troweling, what you do? As I told you the finishing we are doing it in stages. So, troweling is also a floating only. But it refers to a different stage of floating. So, the final finish we call it as troweling. So, basically, the troweling is done after floating. So, manually when we do we are using the same tool only. But, since we are doing it in a delayed manner, so, by that time the concrete would have hardened.

So, in order to apply more pressure, we need to apply more pressure to smoothen it or hardened it. To, I mean to polish it. So, to apply more pressure, what we do is we have to slightly angle the blade and do it. That is a major difference between floating and troweling. So, the troweling

is done after some time. It is done at a delayed stage only. It is a final finishing. So, by that time the concrete would have dried up.

And it would have attained its final set. So, it would be closer to its final setting. So, it would have hardened a little bit. So, that is why we need to apply more pressure to the concrete to obtain the desired smooth texture or the polished texture. So, for that, you have to angle the blade and use it. So, the same tool you just angle the blade. Troweling refers to final finish by troweling. It is just refers to final finish.

So, we do it after floating. So, the main objective is to create hard, dense and smooth surface. So, it is aimed at polishing, smoothening and hardening the face of the concrete. So, here you are keeping the blade slightly angled. Why do we angle the blade? Because we need to apply more pressure because the concrete is as little bit it has hardened. So, to attain that polishing, you need to apply more pressure. So, slightly angle the blade and use it.

To exert greater pressure on the concrete surface, you angle the blade and use it for troweling. So, these are all different stages of finishing.

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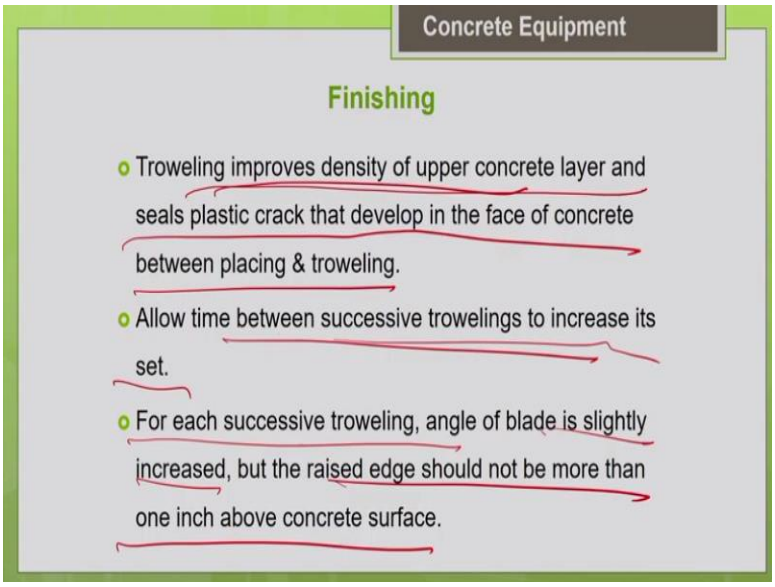

So, by troweling you can improve the quality of the upper layer of the concrete. You can improve the density of the upper layer of the concrete. If there is any crack plastic crack which is formed between the placing and the troweling. Those cracks can be filled any voids can be filled. So, troweling improves the density of the upper concrete layer and seals the plastic crack that develop in the face of the concrete between placing and troweling.

It helps to attain smoother and polished texture. So, as I mentioned earlier, allow time interval between successive finishing operations between successive trowelings to increase its sets. As the concrete dries up more and more, it is easy to smoothen and polish it. It will be stiffer enough to receive the texture which you are going to offer to it. For each successive troweling the angle of blade is slightly increased.

So, as I told you for every stage of finishing slightly increase the blades so that you can apply more pressure to the concrete. But one thing you should keep in mind that the raised edge of the blade should not be more than 1 inch above the concrete surface. So, beyond 1 inch it is likely to damage your concrete surface. So, you can keep on increasing the angle of the blade. But any case, you should make sure that the raised edge height should not be more than 1 inch above the concrete surface. So, beyond 1 inch it can it may affect your damage your concrete.

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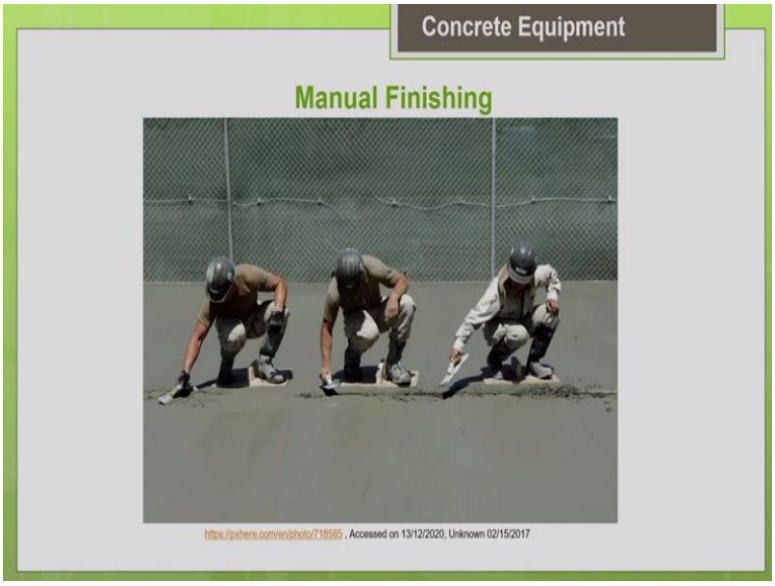

This picture again shows how the manual finishing is done with the simple tools. You can see.

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So, there are also machines to do the finishing job. We call them as power floats or power trowels. So, you can see here, it look like a spider. That is why it is also called a spider. It looks like a spider. So, basically there are rotating blades inside. See these rotating blades inside helps you to finish the concrete surface. The same machine you can use it for both floating as well as troweling.

As I told you, when you do the floating, you have to keep the blades flat. When you do the troweling which you are going to do in a delayed manner, there you need to apply more pressure. So, you slightly angle the blade and use it. So, there are provisions to there are controls to pitch and angle the blade. So, you can change the angle of the blade with the control. And you have a guard ring to protect the blades.

So, basically, this helps you to have a very high productivity. Obviously, with these machines, when compared to manual finishing with simple tools. With this power trowels and power floats, I can have a very high productivity. So, the actual productivity depends upon the size of the power trowel. It depends upon the diameter of this circular area. So, greater the diameter, you can cover more areas. So, the productivity will be high.

So, there are different configurations available. Either this is a walk behind types, simple model. There are even bigger models where the person can ride on. So, he can also sit on the machine. So, the ride on type is also available.

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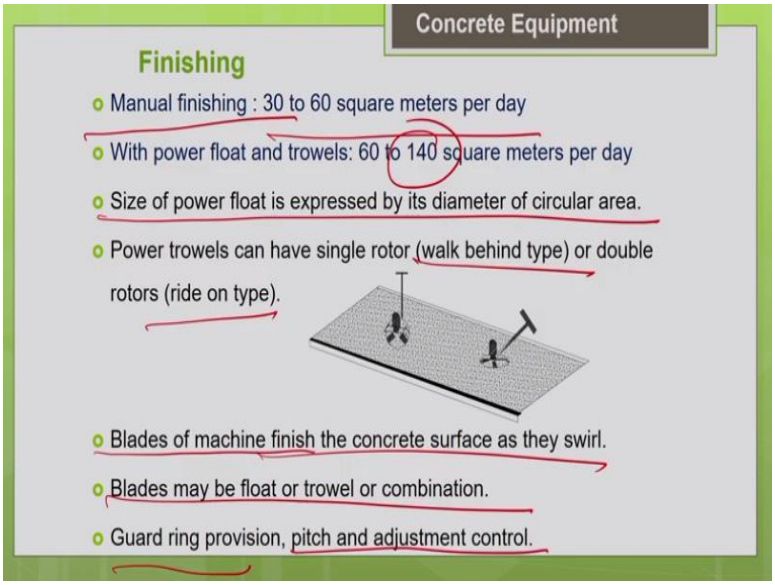

So, when you compare the productivity of the manual finishing with simple tools, you can see that manual finishing maximum productivity the finishing productivity is 60 square meters per day. It ranges from 30 to 60 square meters per day. But with a power float and trowels, you can go even up to 140 square meters per day. So, you can say that you can have a very high productivity using the power trowels and power floats.

And also you can have a very consistent good surface texture when compared to manual finishing. So, it all depends upon your project requirements. So, if it is mentioned in your contract specifications that the variation in the undulation levels accepted is very much less in that case, it is preferable to go for finishing machines like power trowels so that you can have a perfect leveling and finishing.

So, the size of the power float is expressed by the diameter of the circular area. You can have a smaller machine which are walk behind type model or you can have a bigger machines which are ride on type model. So, different models are available in the market. So, according to your project requirement, you can make the choice. So, basically the blades will rotate. And these blades help to rotating blades help to finish the concrete surface.

So, same machine can be used for both floating as well as troweling. Or, there are also separate machines for floating as well as troweling. There is a guard ring provision and pitch and adjustment control for changing the angle of blade so that you can change the angle of blade for floating and troweling.

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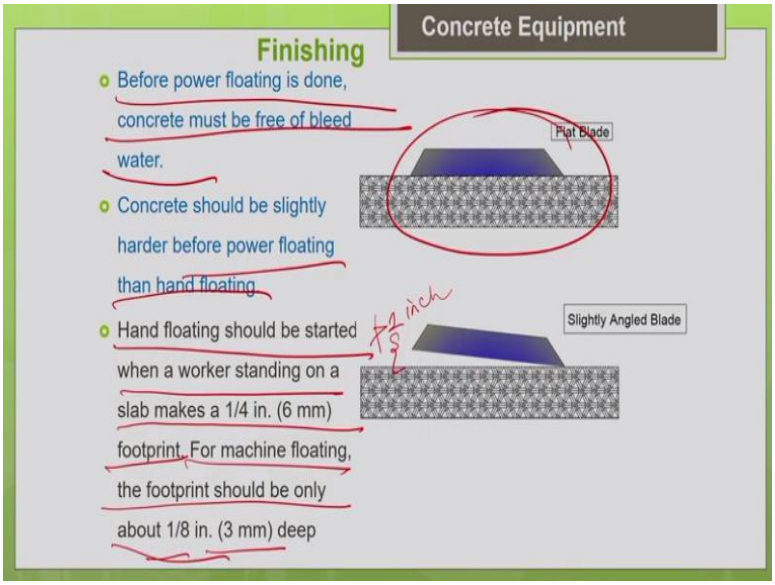

So, the important guidelines you should keep in mind is, so, generally the window of the finishing period is between the initial set and final set. So, the concrete should have dried up well and it should be free of bleed water. So, then only you should do the finishing operation. Particularly when you are going to use your machines as I told you the concrete should be able to withstand the weight of the machine.

So, that is why the concrete should have hardened sufficiently. So, before power floating is done the concrete must be free of bleed water. So, when compared to hand floating or the manual floating, so, the power floating requires that the concrete should be relatively more harder. Then only power floating or power troweling is possible. Then only the concrete can withstand the weight of the machine.

So, how to test whether the concrete is ready for the troweling or finishing? Simple guidelines are available in the ACI manual. So, you can see that hand floating should be started when a worker standing on a slab makes a 1/4 inch footprint. To check whether the concrete hardness is sufficient enough to start the finishing operation using hand floating, so, what they do is if you put your foot on the concrete, the indentation allowed, the maximum indentation allowed is only 1/4 inch or 6 mm.

So, the indentation should not be more than this. Then only you can say that the concrete is ready for the hand floating. But in that case of power floating we shall we should be still careful. The indentation allowed is only 3 mm or 1/ 8 inch. For machine floating, the footprint should

be only 1/8 inch or 3 mm deep. So, then only it indicates that your concrete is hard enough to withstand the weight of the machine.

So, these are simple guidelines to check when the finishing can be started. You can see the picture. So, how they keep the blade flat? So, when you start the finishing job you keep the blade flat and do it. That is called as floating. For different stages of floating you just keep on increasing the angle of the blade. But as I told you the raised edge should not exceed 1 inch above the surface of the concrete.

So, for every stage of finishing, you keep on increase the angle of blade so that you can exert more pressure on the concrete.

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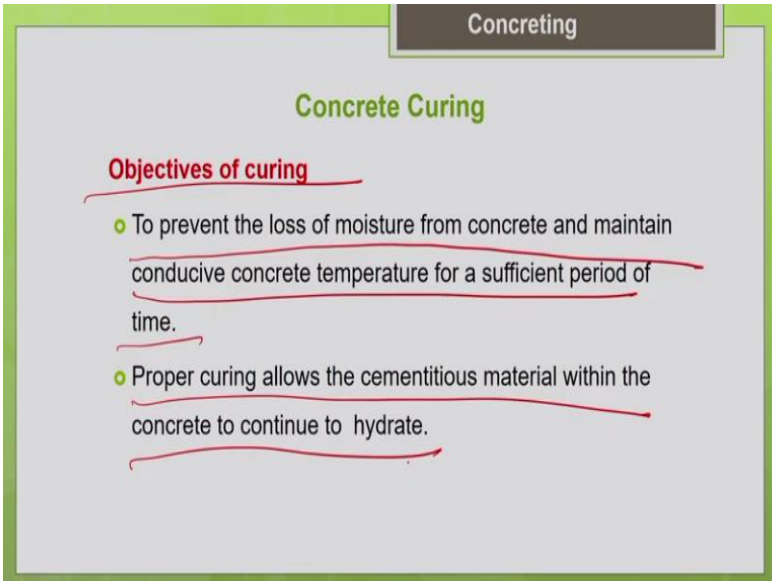

The next important step in concrete making is curing of concrete. So, far we discussed about consolidation of the concrete finishing of concrete. So, now, we are going to discuss about the curing of concrete. So, why is this curing needed? So, as everyone knows the cement hydration is a continuous process. The hydration process continues for a longer time. To facilitate the continued hydration process, so, what we are supposed to do is we need to maintain the internal temperature of the concrete.

And we need to maintain the internal humidity of the concrete or the moisture content of the concrete. So, only if the moisture content is available, then only the hydration process can continue. If the hydration cannot continue, your concrete will not get the desired strength. So,

that is why it is very important to facilitate the hydration process to be continued for a longer time.

Then only you can get your desired microstructure strength and the durability of your concrete. So, but basically whatever water you have added for preparing the concrete, even that water itself is sufficient for the hydration process. So, most of the cases the water we have designed for concrete making is sufficient for the hydration process. But what happens is when the concrete is exposed to the ambient condition, the water from within the concrete will be lost to the outside environment.

So, that loss of water affects the hydration process. So, because of loss of water from the concrete to outside environment, the water is not available for the hydration process of the cement. So, that is why we need curing. So, what is the main purpose of curing? It is to prevent the loss of water from within the concrete to the outside environment. So, the main purpose of curing is to prevent the loss of water.

So, that the water is available for hydration and to supplement the water lost. So, whatever the concrete is lost to the environment, we have to supplement it by curing. So, that is why we do curing. Curing is nothing but we are supplying water to concrete. So, after the finishing is done after the concrete is attained the final setting we supply the traditional way is we supply water to concrete and facilitate the continued hydration process.

So, the main purpose of this objective behind supply of water is to prevent the loss of water from within the concrete to the outside environment as well as to supplement the lost water. So, what are the objectives of curing? To prevent the loss of moisture from the concrete and maintain the conducive concrete temperature for a sufficient period of time so that the hydration process will continue.

So, that the cracking will not happen should not get crack should not happen. So, proper curing allows the cementitious material within the concrete to continue to hydrate. So, since we are supplying the water to the concrete for a sufficient period of time, the hydration process of the cement will continue. And you will get your desired strength. So, as I told you, the water which were added initially for concrete making, that itself is sufficient.

But depending upon the ambient conditions, you can see that in most of the cases water from within the concrete is lost to the outside environment. So, to prevent that loss, we have to add it.

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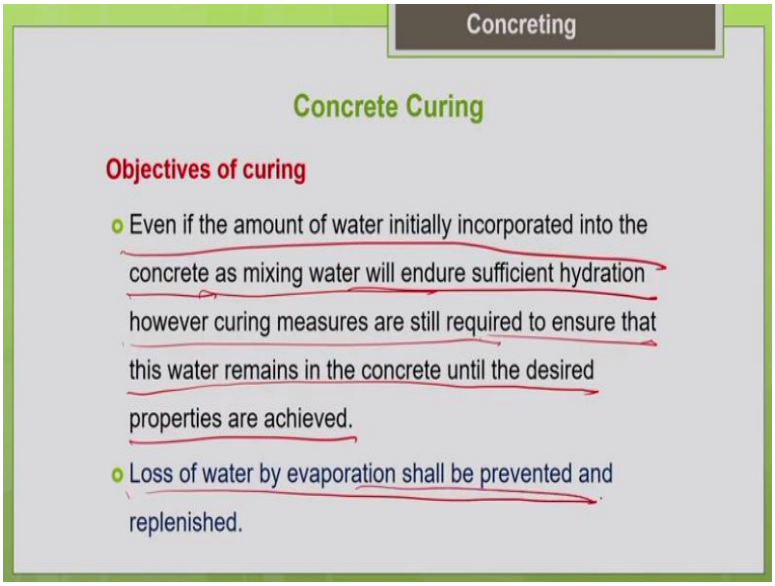

So, even if the amount of water initially incorporated into the concrete as mixing water will endure sufficient hydration. However, curing measures are still required to ensure that this water remains in the concrete until the desired properties are achieved. So, even though the water which you have added for concrete making is sufficient, even then you have to do curing so that you can prevent the loss of this water to the outside environment.

So, loss of water by evaporation shall be prevented by curing. And you can also supplement the water which is lost. So, that is the main purpose of curing. The main purpose of curing is you are supplying water to the concrete so that the hydration process will keep continuing so that you will get your desired microstructure strength and the durability of your concrete. So, water requirement for the continued hydration process.

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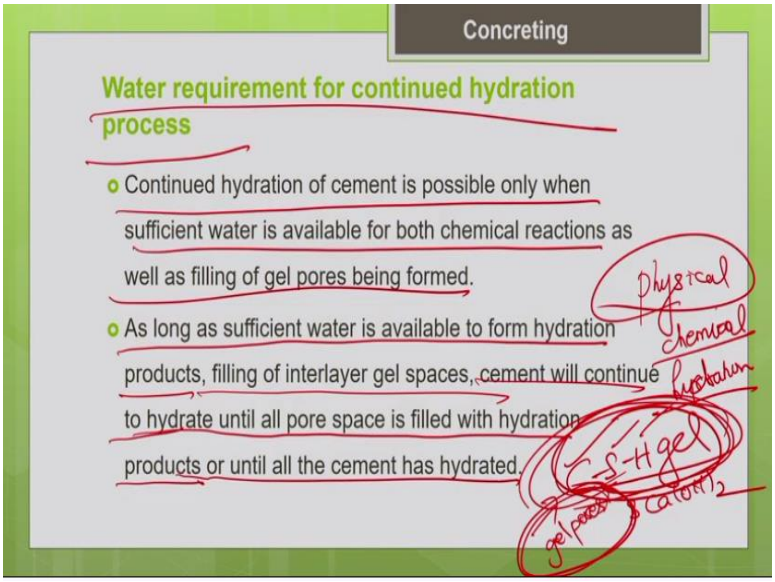

As I just mentioned now, so, for the hydration process to continue, we need water. So, the hydration process occurs in different forms, physical hydration, chemical hydration. So, chemical hydration everyone will be knowing. So, chemical hydration is nothing but the water needed for the reaction of your cement compounds with the water to form the hydration products, so, silicates and the aluminates.

So, they react with the water and form the different hydration products. So, the main hydration products are your C-S-H gel nothing but calcium silicate hydrate and calcium hydroxide. So, there are different hydration products. The main hydration product which is contributing to the strength is your C-S-H gel, calcium silicate hydrate. So, we need water for this chemical reaction. That is chemical hydration.

And what is this physical hydration? So, when these hydration products forms, this C-S-H gel, there are lot of gel pores, there are lot of voids or gel spaces or pores in this hydration products. These pores should be filled with the water. So, that is very important. So, then only your hydration will be complete. So, that is what I said for filling of the gel pores in the hydration products also we need water. That is called as physical hydration.

So, continued hydration of cement is possible only when sufficient water is available for both the chemical reactions as well as for filling up of the gel pores which are formed in the C-S-H gel. That is your hydration product. As long as sufficient water is available to form the hydration products, filling of the interlayer gel spaces, cement will continue to hydrate until all the pore space is filled with the hydration products or until all the cement has hydrated.

So, this hydration process will keep continuing till the water is available to form these hydration products until the water is available to fill the gel pores. So, till all the pores are filled, so, this hydration process will keep continuing. Till all the cement is hydrated, it will keep continuing provided the water is available. So, this curing and the water to cement ratio the interrelation actually it is little bit confusing to understand.

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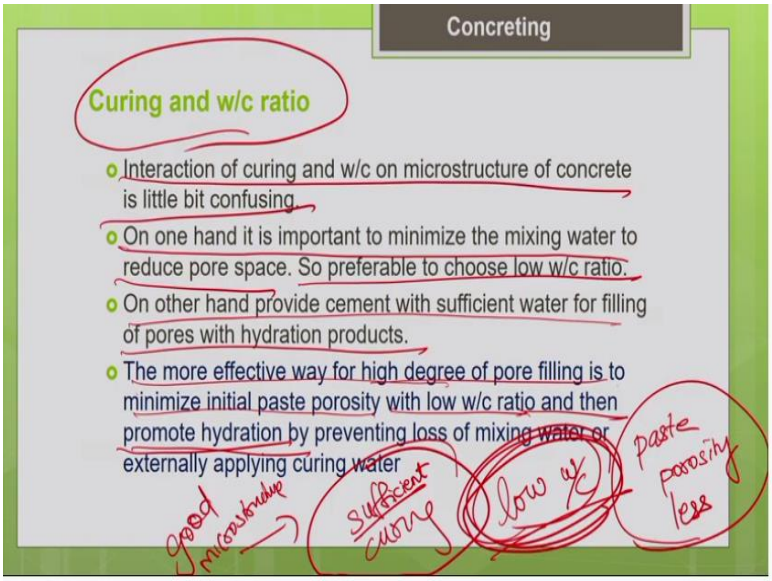

Because on one hand we say that we need sufficient water for the complete physical and the chemical hydration of the cement. On the other hand, we say that when we add excess water, it leads to high paste porosity that will affect the microstructure strength and the durability. So, then what is the best measure to get a good microstructure? So, what is the best solution? So, the best thing is you always go for low water to cement ratio.

It is always preferable to design the concrete with low water to cement ratio. So, when we go for low water to cement ratio your paste porosity your initial paste porosity will be less. So, the paste the pores will be less. But you have to give sufficient curing for the concrete. That is very important. Though you go for low water to cement ratio, the important thing to get a good microstructure is give sufficient curing for concrete.

So, when you give sufficient curing for concrete continued hydration process will occur and all the pores will be filled with the hydration products. As the pores are filled with the hydration products you can see that the microstructure will be improved and porosity of the concrete will

be less. So, thereby your strength and the durability of the concrete will be good. So, the best thing is go for low water to cement ratio mixes.

But give sufficient curing so that you will get a good microstructure. Because, your curing will ensure that the hydration will occur and the pores are filled with the hydration products. That will reduce the porosity of your concrete. And that will improve the strength and the durability related properties of your concrete. So, interaction of your curing and water to cement ratio on the microstructure of the concrete is little bit confusing as we discussed just now.

On one hand, it is important to minimize the mixing water to reduce a pore space. So, you have to reduce the mixing water because excess water will lead to more pores. So, it is preferable to choose low water to cement ratio. On the other hand, provides cement with sufficient water for filling of pores with hydration products. So, which one I should go for? So, the best thing is the more effective way is for high degree of pore filling, minimize the initial paste porosity.

How to minimize the initial paste porosity? Use low water to cement ratio for the mixes. And then promote the hydration by effective curing methods. Promote the hydration by effective curing. So, there are different ways to cure either you can apply water externally and then cure it. That is one method. And another thing is you can prevent the loss of water from within the concrete to outside environment.

There are methods for that. So, either of these methods we can go for. You can choose for curing. But generally when you go for low water to cement ratio very low water to cement ratio mixes it is preferable to go for water application methods. So, that will give you a better microstructure of the concrete.

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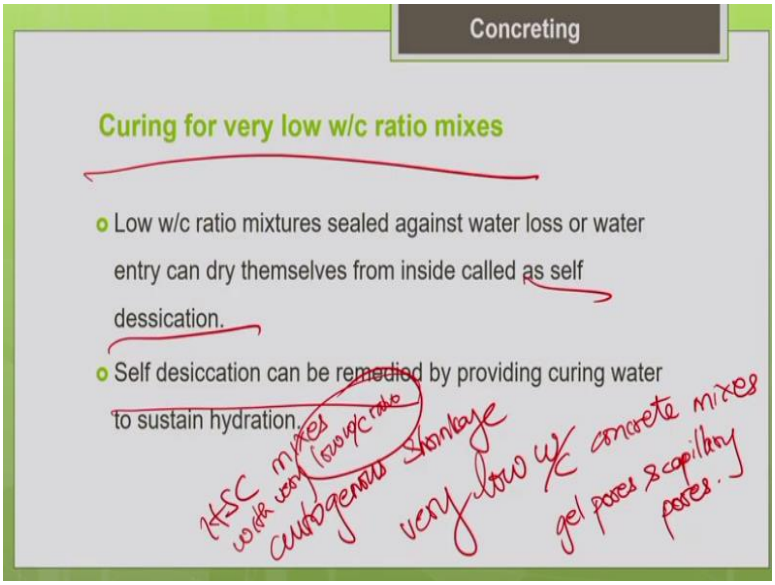

That is what I told you for very low water to cement ratio mixes let us say lesser than 0.35. So, 0.3 for very low water cement ratio for high strength concrete mixes it is preferable to go for curing by external application of water. So, that will be the best method. Because what happens is if you go for methods like which just prevents the loss of water from within concrete to outside environment.

There are some water retention curing methods which we are going to discuss later. If you are going for those methods which just prevents the water loss from inside to outside, what happens is the internal drying of concrete occurs. That is called as self desiccation. Self desiccation in the sense for very low water to cement ratio concrete mixes, what happens is the water from very small gel pores and capillary pores are consumed for the hydration.

So, water from the very small gel pores and the capillary pores are consumed for the hydration process because of the limited water available. So, when these water is pulled up from all this small pores, it results in significant amount of autogenous shrinkage of concrete. So, that is called as autogenous shrinkage. This particularly happens in high strength concrete mixes. It happens in high strength concrete mixes with very low water to cement ratio.

So, what happens is, so, even from very small gel pores and the capillary pores of the water is pulled out for hydration mechanism. So, when this water from small pores are pulled out, it results in significant autogenous shrinkage in such mixes. That is a kind of self desiccation or internal drying of the concrete. So, this the remedy for this self desiccation is for this low water to cement ratio mixes better go for curing by external water application.

So, do not go for water retention methods of curing. So, that will not be much effective for this high strength concrete mixes.

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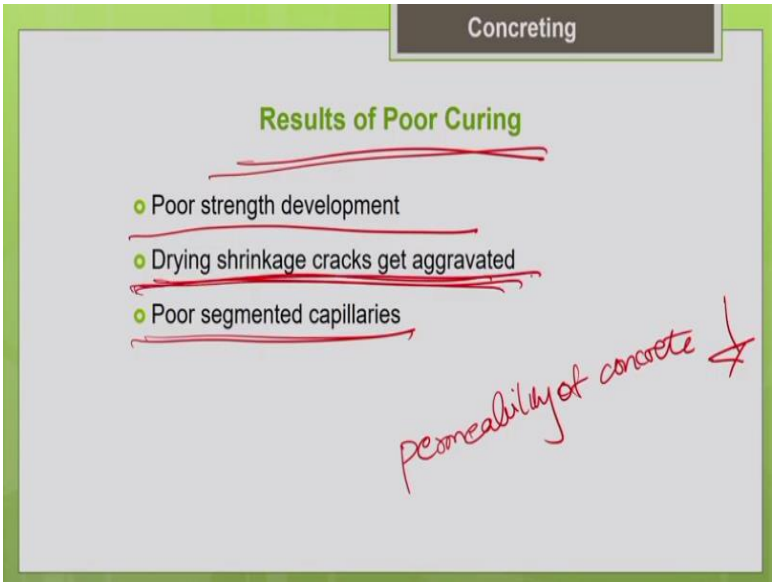

So, basically, if you do not do proper curing for the concrete actually the curing is the cheapest way to improve the quality of the concrete. So, like you can improve the microstructure. You can improve the strength and durability by facilitating the continued hydration of the cement. It is a cheapest method to improve the concrete property. But it is always overlooked at the project site.

So, many of the structure failures happens because of improper curing only. So, if you do not do proper curing obviously, since the hydration process is not completed, you will not get the desired strength. It results in poor strength development. And another important thing is shrinkage cracks may occur, if the rate of evaporation of the water from the concrete is very high. So, you know that the concrete is weak in tension.

So, this will result in the shrinkage cracks in the it results in buildup of tensile stresses in the concrete due to the drying which results in shrinkage crack development. So, to avoid the shrinkage cracks also, we have to start the curing as early as possible. And poor segmented capillaries, basically, when you do curing, what is happening? As it facilitates the hydration process, all your pores are getting filled with the hydration products.

So, the capillary pores are filled with the hydration products. As it fills the pores, the pores are getting segmented. As the pores are getting segmented, the permeability is getting reduced. The permeability of concrete is getting reduced. The concrete becomes more impermeable because the pores are getting filled with the hydration products and it results in segmentation of the pores. But if you do not do proper hydration, so, what happens?

Your capillary pores most of the pores are not filled with the hydration products. So, it results in poor segmented capillaries which increases even the permeability of your concrete and which affects the durability of the concrete in turn. So, your results of poor curing are your poor strength, poor durability and even the dimensional stability of the concrete is affected. It results in the shrinkage cracks also.

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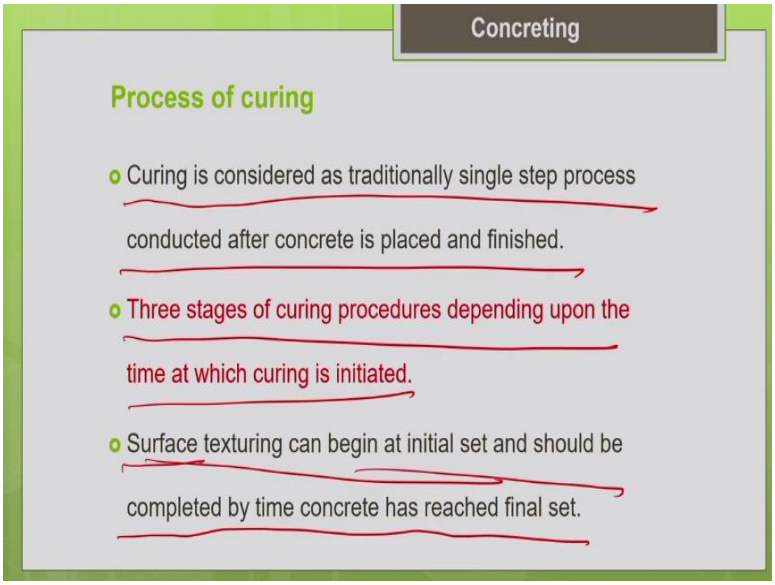

So, basically the process of curing earlier it was considered as traditionally as a single step only. So, very commonly we do this curing operation after the finishing of the concrete. So, mostly after the concrete attains its final set, we start applying water to the concrete for the curing purpose. This is a traditional method. But nowadays, we do the curing also in stages. So, I will tell you why we do it in stages later.

So, basically earlier curing was done in only one step, mostly after the finishing of the concrete curing is done. But now, we do the curing in stages. Curing is considered as traditionally as a single step process conducted after the concrete is placed and finished. But nowadays we do in stages, as I told you. There are 3 stages of curing depending upon the time at which the curing is initiated.

So, as we discussed earlier for finishing, finishing we do between the initial setting and the final setting. Surface texturing or finishing can begin at the initial set and should be completed by the time the concrete has reached the final set. Now, we will see what time we should start the curing?

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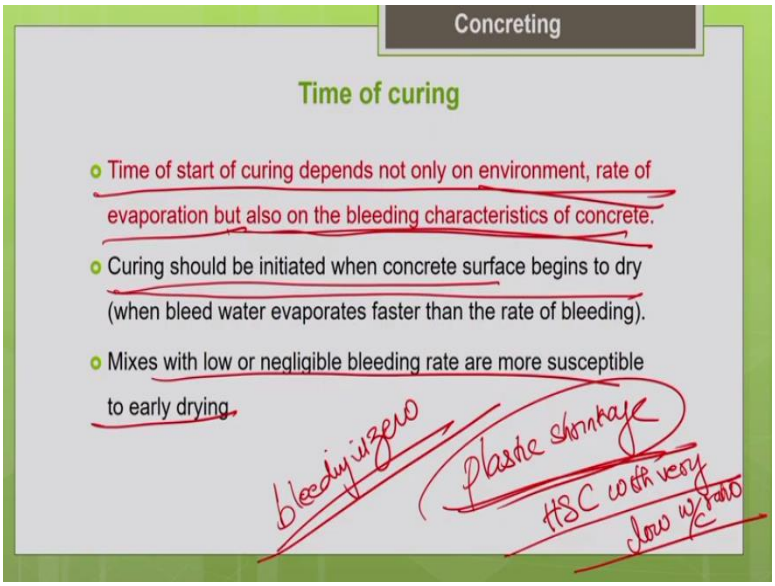

So, generally we cannot generalize when the curing has to be started for a concrete. What should be the right time of curing? Because, it varies from concrete to concrete, it varies from environment to environment, where the concrete is being done. So, basically in aggressive environment conditions where the rate of evaporation is very high due to high wind velocity or due to high temperature, there we have to start the curing as early as possible.

And on a similar note, if your concrete it also depends upon the concrete composition, if your concrete is having I mean it is designed with a very low water to cement ratio, say for example, high strength concrete mixes with very low water to cement ratio, so, where you have used even silica fume, so, the mix is very cohesive there will not be any bleeding at all. So, the bleeding is negligible or almost zero bleeding.

In that case, you have to start the curing as early as possible otherwise, what happens is your drying will result in shrinkage cracks. They call it as plastic shrinkage cracks plastic shrinkage, the shrinkage which occurs in the fresh state of the concrete. So, particularly it happens for the high strength concrete mixes with very low water to cement ratio. So, there will not be bleeding at all, bleeding is zero or negligible bleeding.

In some form bleeding also helps the concrete to certain extent. When there is bleeding on the top surface of the concrete, you can see that it will try to reduce your shrinkage and shrinkage cracks. So, to certain extent I can say. But in high strength concrete mixes since there is no bleeding at all, so, there are more chances that the cracks can occur in the plastic state of the concrete and those cracks are called as plastic shrinkage cracks.

So, that is where we have to start the curing as early as possible. And, when to start the curing? It depends upon the actual composition of the concrete and also it depends upon the environment where the concreting is going to be done. So, time of start of curing depends not only on the environment. So, it depends upon the rate of evaporation, but also on the bleeding characteristics of the concrete.

So, for aggressive environment where the ambient conditions are very severe, high temperature, high wind velocity where the rate of evaporation is very high start the curing as early as possible. And also on the bleeding characteristics of the concrete that depends upon the mix composition. Curing should be initiated when the concrete surface begins to dry. So, when the rate of evaporation is faster than the rate of bleeding, obviously, it indicates that the curing should be initiated.

Then mixes with low or negligible bleeding rate are more susceptible to early drying. That is what I told you. So, if your mix composition is such that it has very low water to cement ratio in those mixes bleeding will be negligible. Very cohesive mixes with low water to cement ratio, you can see that bleeding will be negligible. So, the concrete will dry faster. So, that is why to protect those mixes you have to start the curing as early as possible.

We cannot wait till finishing. So, you need to start your curing even before finishing of the concrete for such mixes. Obviously, before finishing of the concrete, I cannot apply water as my curing method. I cannot supply water for curing because supplying of water as curing that itself will damage your concrete. So, before the concrete attains its final set if you try to supply water to concrete for curing that will damage your concrete. That is why we need some other form of curing. That is called as initial curing.

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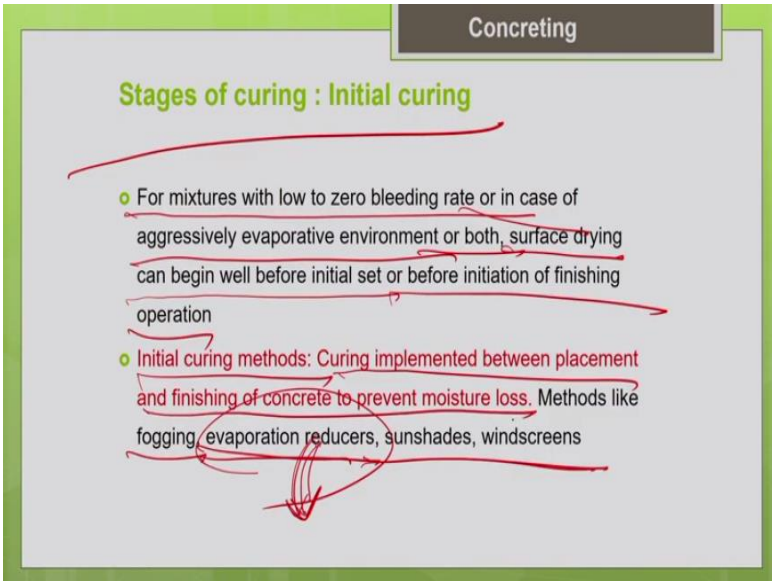

So, here what we do is we just do some fogging or we just cover the concrete with a sunshade or windscreen so that you can control the rate of evaporation. We cannot apply water. That is final curing. So, in initial curing, what you do is just to prevent the rate of drying to prevent the loss of water due to evaporation, so, what you do is even before finishing this can be done.

Before finishing of concrete, curing can be done. So, what you do is you can do some amount of fogging. Commonly what they do is they put some sunshades or windscreen, so, to prevent the loss of water due to evaporation. If that is not possible they can go for fogging also. Or, in some cases, they even use evaporation reducers. So, what are these evaporation reducers? These are basically some chemicals, water based chemicals which are sprayed on the surface of the concrete.

So, when these chemicals are sprayed on the surface of the concrete, they form a film on the oil kind of film on the surface of the concrete and prevent the evaporation and reduce the rate of evaporation of water from the concrete surface. They are effective only for some period of time. So, this you should not confuse with the curing compounds which we use it for final curing.

So, this last only for a shorter time, evaporation reducers these chemicals will be effective only for a shorter time. So, you should keep reapplying depending upon the aggressiveness of your environment. And one demerit of the evaporation reducer is it may sometimes leave staining it may leave some stains on the concrete surface. That is one disadvantage. And it is preferable to apply this evaporation reducer when the concrete bleed water is already there on the surface.

So, before the concrete dries, when the bleed water is there, at that state itself we have to spray the evaporation reducers. That is the best way to apply it. So, when do we do the initial curing? For mixtures with low to zero bleeding rate, that is mixtures with very low water to cement ratio or very cohesive mixes high strength concrete mixes so, or in case of aggressively evaporative environment where the temperature is high, wind velocity is high or both the cases are prevailing together or both, in these cases, initial curing is needed.

So, here surface drying will can begin well before the initial setting or before the initiation of the finishing operation. So, in these cases, drying of the concrete can happen even before the initial setting of the concrete or even before the starting of the finishing process. So, before finishing process itself, this necessitates initial curing to be done to prevent the surface drying of the concrete. So, what are these methods?

Initial curing methods are implemented between placement and the finishing of the concrete to prevent the moisture loss. So, basically, we do this curing between the placement of the concrete and the finishing of the concrete to prevent the moisture loss. So, as I told you even before the start of the finishing process also you can do the initial curing. I cannot apply water but I can go for some wind shades or sunscreens.

Or, I can do fogging. Or, I can spray the evaporation reducers chemicals on the surface of the concrete. So, these are just done to prevent the rate of evaporation from the surface of the concrete. This is called as initial curing because we can do it even before the start of finishing operation.

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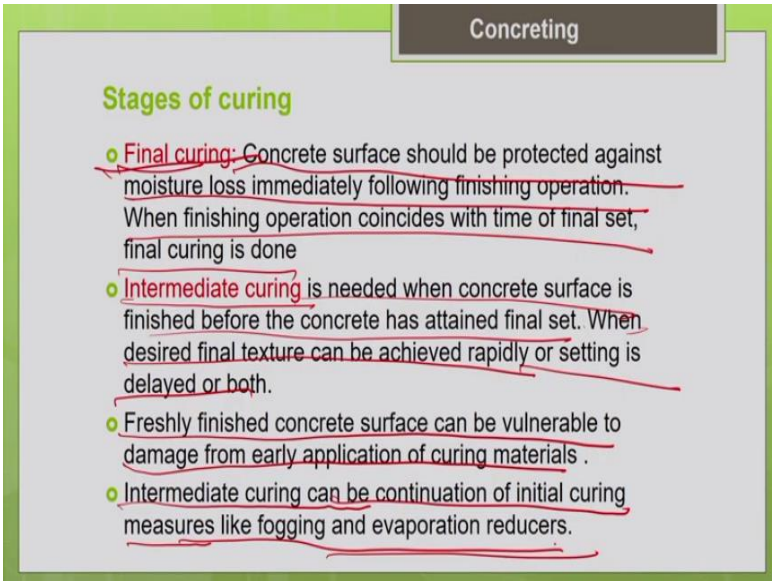

So, the next is about the final curing. So, basically as I told you the traditional way is after the final finishing of the concrete immediately following the final finishing after start the curing that we call it as a final curing. That is the traditional way of during the curing of the concrete. So, the ideal case is your final finishing will be coinciding with the final setting time.

Once the concrete has attained the final set you can easily apply the water for the final curing. So, there the concrete will not get damaged because of application of the water. So, that is the right time to apply. After the final finishing, after the final setting of your concrete you can apply the water to do the final curing of the concrete. But, in some cases, what happens is your final finishing will be completed even before the final setting of the concrete.

So, before the concrete attains its final set itself your final finishing will be completed. So, but before the concrete attains a final set it is not advisable to supply water for the final curing because it may damage the concrete. So, but still we have to prevent the drying of the concrete. How to prevent it? For that we need to do some intermediate curing. So, the curing which we do before the final curing, that is called as intermediate curing.

The same initial curing what you did, you can just continue. The same fogging method or you can spray the water evaporation reducers. So, those things you can continue till the concrete attains its final set because only after the final set it is advisable to go for the final curing methods like application of water. So, till that time, you can continue with the initial curing and you call it as intermediate curing.

So, that is why I told you we do curing in stages depending upon the environment requirement and depending upon the concrete composition. It is not just one step. So, what is this final curing? So, concrete surface should be protected against a moisture loss immediately following the finishing operation. After the finishing operation is done, that is a traditional way, once the finishing is done immediately we have to do the final curing to prevent the moisture loss.

So, mostly the finishing operations coincides with the time of the final set so that it will be convenient to do the final curing. There you can apply your water and do the final curing. But in some cases intermediate curing is needed. When? When the concrete surface is finished before the concrete has attained the final set. In some cases, before the final set itself we complete the finishing process.

So, because in those cases doing the finishing is when desired final texture can be achieved rapidly. You can easily achieve the final texture. Or, if the setting is delayed that could be the reason for completion of final finishing even before the final set. So, in those cases where the finishing operation is completed before the final set but the concrete has not attained the final set, I cannot go for final curing.

I cannot apply water for curing. So, what we do is to do some intermediate curing either you can continue your initial curing itself that we call it as intermediate curing. You can do some fogging or spray some evaporation reducers. Those things you can try as intermediate curing before the final set of the concrete. So, why we need this intermediate curing? Because till the concrete attained its final set it will not be able to receive the final curing methods because of whatever methods we follow for final curing like application of water.

All those things may itself damage the concrete before the concrete has attained the final set. Freshly finished concrete surface can be vulnerable to damage from early application of the curing materials. So, that is why we should not do the final curing till the concrete attains the final set. So, that is why you can go for intermediate curing before concrete attains its final set.

It can be just a continuation of initial curing measures like fogging and the spraying of evaporation reducers.

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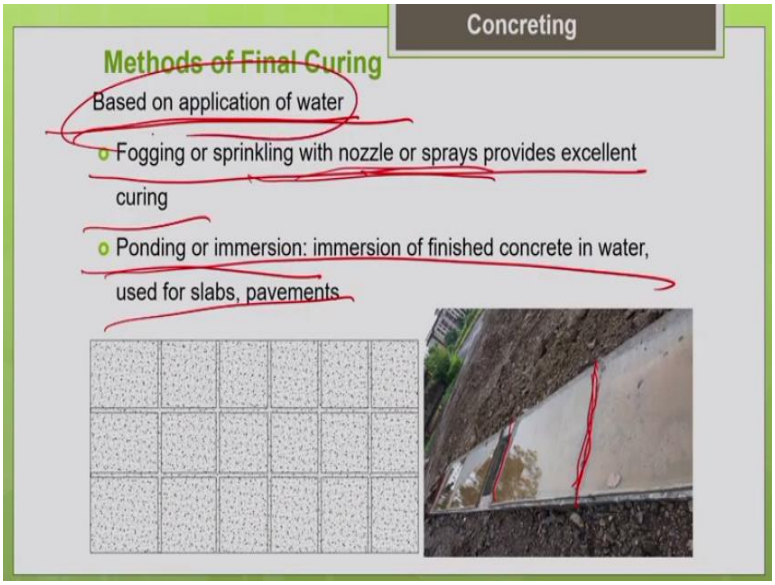

So, what are all the different methods of final curing? So, let us see. So, mostly the traditional way is we apply water for the final curing that is the commonly adopted method and that is the best method for the concrete. So, particularly for the structural elements which have larger surface area like your slabs and pavements, what we do is we go for method called as ponding or immersion.

So, what we do is we construct small barriers like this with the mortar or the concrete. We construct small barriers and allow the water to stagnate on the surface of the concrete. So, when we allow the water to stagnate on the surface of the concrete, it prevents the loss of water from within the concrete to the outside environment. And also it will supplement whatever water it has lost.

So, that is ponding is the best method for these slabs and pavements. It will prevent the shrinkage cracks. So, it is an effective method to prevent the plastic shrinkage cracks in the slabs and the pavements. So, what are the other methods of application of water? You can go for fogging or sprinkling with nozzle or sprays. So, all these provides excellent curing. These are the methods based on application of water.

So, as I told you, the methods of curing we can classify into 2 methods. In one method, we directly apply water. So, in another method, you just prevent the loss of water from within the concrete to outside the environment. So, now we are discussing the method which is based on application of water. You apply the water which is the best method. Particularly for mixtures with low water to cement ratio, we should go for methods based on application of water.

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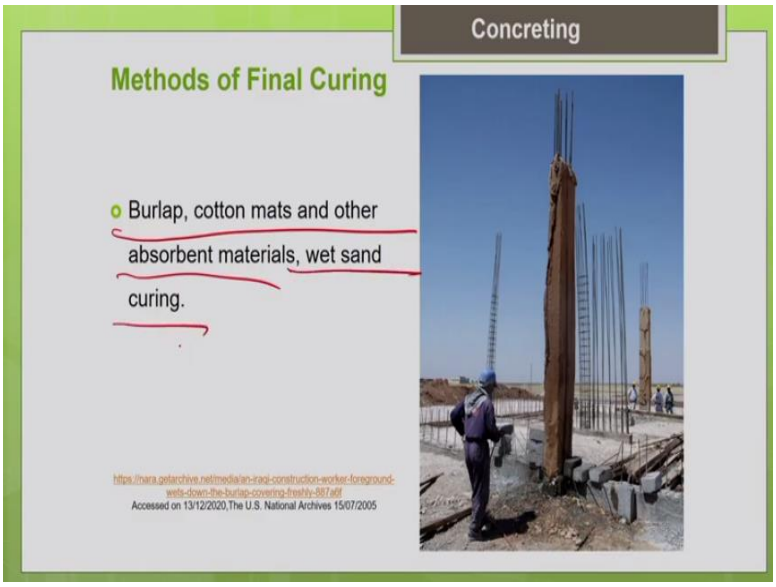

So, this picture again shows the curing based on application of water you can see they are covering with wet gunny bags, wet burlap or cotton mats, any absorbent material you can put particularly for the vertical elements. We can like columns we can go for this kind of method. So, for the slabs, we can follow ponding or immersion method. We can allow the water to stagnate easily.

But for vertical elements like column, we can go for these kind of methods. You can go for water spraying. You can go for the wet gunny bags, wet burlap or cotton mats, any absorbent material. You can soak it in water and put it on the surface of the structural element. You can also go for wet sand curing or wet earth curing.

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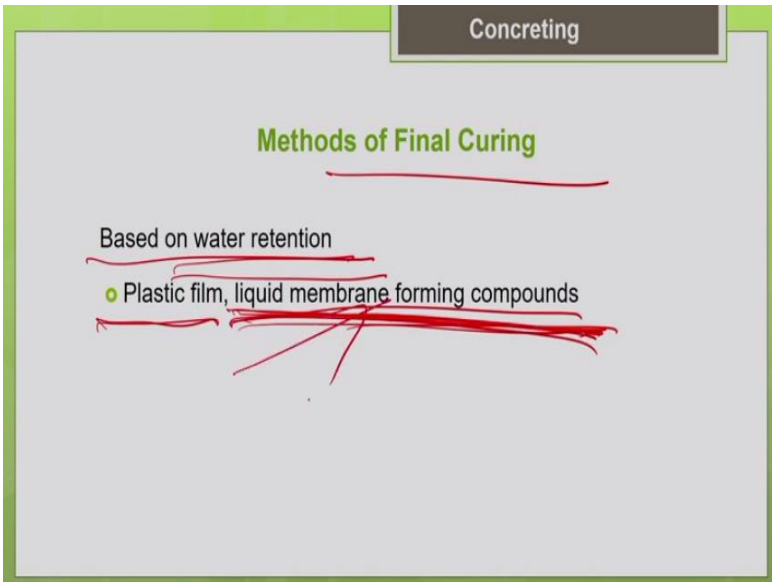

So, the other method which I told you is based on water retention. So, here what we do is we do not apply water for curing but we prevent the loss of water. So, how to prevent the loss of water? You cover the concrete surface with a plastic film or any polyethylene film and prevent the loss of water from within to outside environment. This is very commonly followed in places where sufficient water is not available for curing where there is water scarcity.

And in some structural elements, which is not easily accessible which is where it is not possible to continuously apply water curing. In that case you can go from water retention methods. It depends upon the accessibility of the structural elements for the water application. Some cases, we have to go for water retention only because certain cases it is not possible to continuously supply water for the curing.

In that case, you can go for water retention method. So, cover it with a plastic film or you can also spray some curing compounds. So, these are entirely different from the evaporation reducers what we have discussed earlier. That we applied before the finishing of the concrete. That is why initial curing. This membrane forming compounds or the curing compounds which we use it for the final curing.

So, this also we just spray it on the surface of the concrete. It will remain on the surface of the concrete. It will be effective for even 28 days. So, depending upon the chemical which we are going to use and it will facilitate the self curing of the concrete. So, that means it will prevent the loss of water from within the concrete to outside environment. So, another thing is this will not result in any staining.

As we discussed for the evaporation reducers, there will not be any stain formation. And it lasts for a longer time. As I told you even up to 28 days it can remain. But one thing you have to be careful is this we should do this membrane curing we should spray this membrane curing compounds only when the concrete is completely dried. There should not be any bleed water on the surface. If there is any bleed water on the surface that will affect the efficiency of these compounds.

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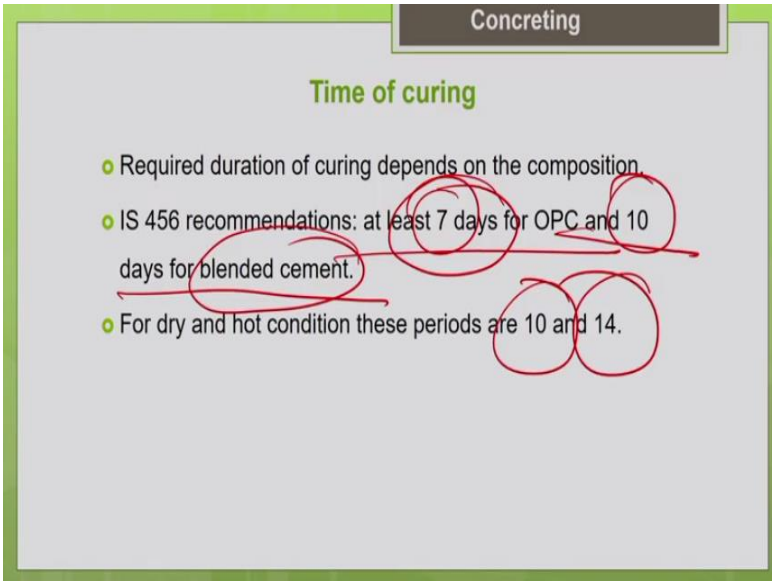

So, how much time you are supposed to do the curing operation? So, obviously, there is always some time constraint in the project sites. We cannot doing a curing for a very extended duration is very difficult or challenging with the construction project sites. So, as per the IS code, at least 7 days of curing is needed for a concrete with ordinary Portland cement.

So, the number of days or the duration of the curing also depends upon the composition of the cement type. If you are going for OPC that is ordinary Portland cement, at least 7 days of curing is needed as per the IS code guidelines. But if you go for blended cements where we use fly ash or slag as a replacement for the cement. So, there you know that these pozzolanic materials like fly ash or slag, the hydration process will be very slow.

So, since our hydration process occurs in a delayed manner or in a slow manner, to facilitate the hydration process or the pozzolanic reaction, we should continue the curing for even 10 days, if you are going for blended cements. So, these are the guidelines available in IS 456. Also, it depends upon the environment. For very dry and hot conditions, you can extend this duration further from 7 to 10 days and from 10 to 14 days for very dry and hot condition places.

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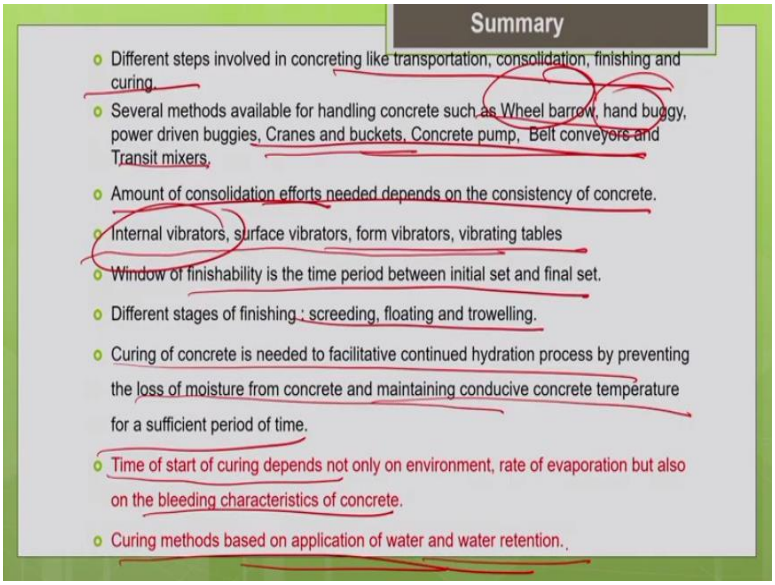

So, we have come to the end of this lecture. So, let me summarize what we have discussed so far. So, we have discussed about different steps involved in the concreting process like your transportation of concrete, consolidation, finishing and curing of the concrete. So, basically there are so many methods available for handling the concrete. We have discussed about the simple methods like wheel barrows and buggies and advanced methods like pumping, belt conveyors, cranes and buckets and transit mixers.

So, the selection of the method which method you are going to select for handling a concrete it purely depends upon your productivity requirement. So, every device has its every method has its own productivity, we have discussed about what is a possible productivity with every method. So, depending upon your job productivity requirement as mentioned in the contract documents, you have to make the selection of your method.

Obviously, it has to fit into your project budget also. But whatever method you choose, it should not result in segregation of the concrete so that you should be very careful that it should not result in the segregation of the concrete. So, then coming to the consolidation of the concrete as I told you, the amount of consolidation depends upon the consistency of the concrete. So, for stiff mixes, you need more amount of consolidation.

For high consistency mixes, you need less amount of consolidation. So, even the frequency and the amplitude of the vibration has to be matched with the consistency of the concrete. That is what we discussed. For stiff mixes, go for high amplitude and low frequency vibrators. For

highly consistent mixes, go for low amplitude and high consistency vibrators. So, that was the guideline.

So, different methods are available starting from internal vibrators, surface vibrators, form vibrators and vibrating tables are there. The best thing is your internal vibrators. But in some locations you can see that internal vibrators are not feasible either because of thin sections or because of congested reinforcement. In those cases, we have to go for either surface vibrators or external vibrators.

So, then coming to finishing of concrete, the finishing you should do only between the initial setting time and the final setting time. That is the time period. And we have discussed about different stages of finishing like screeding, floating and troweling. So, as I told you, between every stage of finishing you should give some time interval. As a concrete dries up only it is possible to do the smoothing smoothening and the polishing process.

So, the concrete should be dried enough to withstand the weight of the finishing machine or the finishing person. So, I told you the guidelines also how to find the time of the exact time of the finishing. So, then coming to the curing of concrete, curing is a very important step. It will help you to facilitate the continued hydration process. So, based on curing only, you can have a very good microstructure in the concrete.

So, basically, why do we do curing? We need to prevent the loss of water or the moisture from the concrete and we need to maintain the concrete temperature so that the hydration process will continue for a longer time. So, that is the reason we should go for curing of the concrete. So, if you overlook the curing, you will not get continued hydration. You will not get your desired strength. You will not get your desired durability of your concrete.

So, when to start a curing? That depends upon the environment. We cannot generalize. For an aggressive environment where the rate of evaporation is high, you have to start the curing as early as possible even before the finishing you can apply some initial curing in some aggressive environment. It also depends upon the composition of your concrete. If a concrete has negligible bleeding or zero bleeding in that case you have to start curing very early to prevent the plastic shrinkage cracks.

So, you have to go for some initial curing also in addition to final curing. So, there are different methods of curing we have discussed. Some based on application of water and some based on water retention methods. That the best thing is always application of water, but in some places it is not possible to apply water continuously. So, we go for water retention methods.

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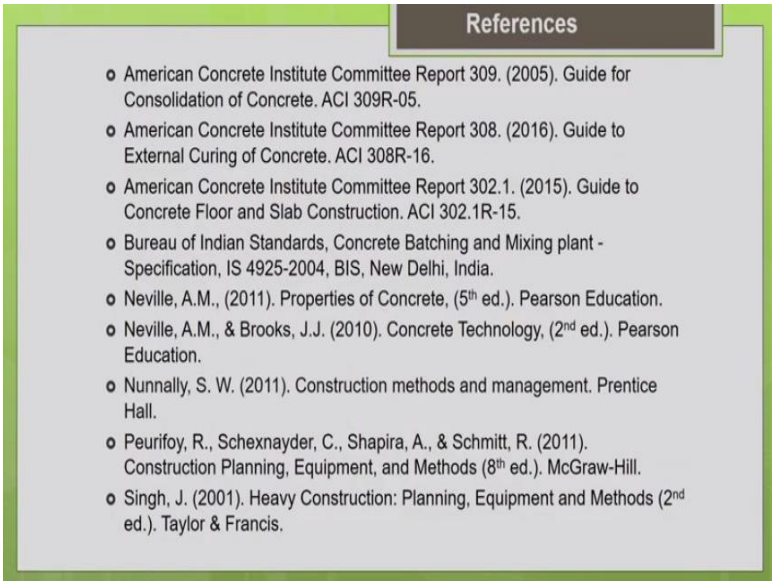

So, these are the references which I have referred for the preparation of this lecture, thank you.