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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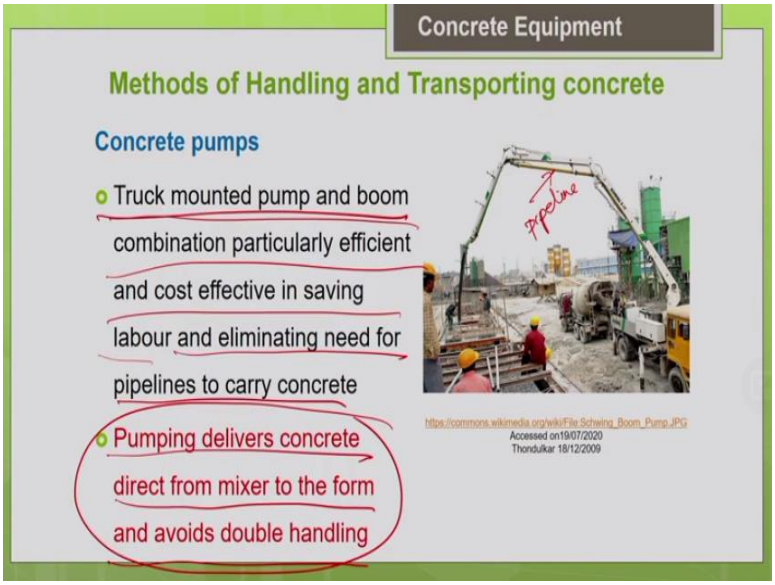

So, in some places the job site will be very much congested that it will not be possible to place the pipelines on the ground. So, in that case, you can go for this truck mounted pump and boom.

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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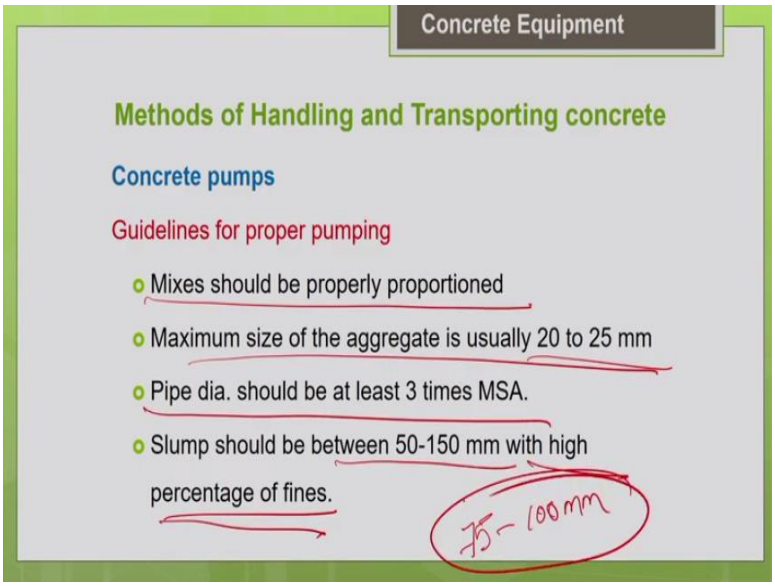

So, there are some guidelines for proper pumping or successful pumping. That we should always keep in mind. So, basically if you decide that you are going to go for pumping method for the concrete placement that decision has to be made even during the mix design itself. So,

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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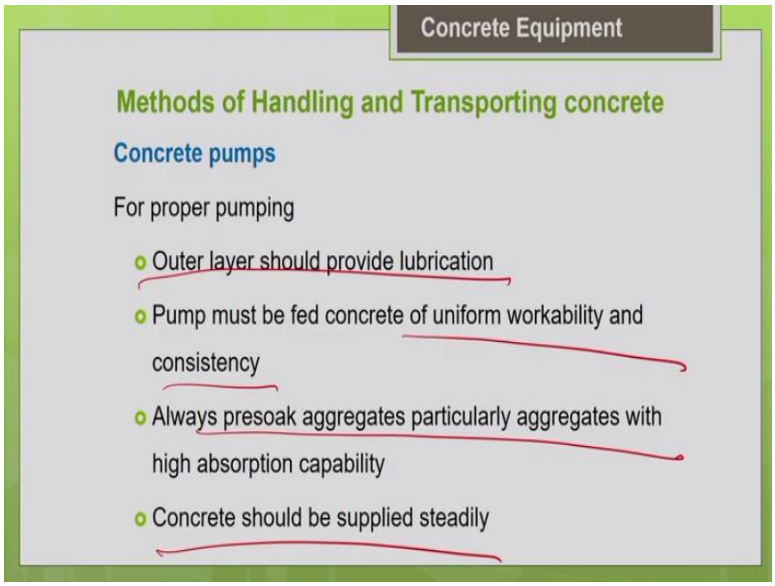

So, what are the other guidelines? Let us see. So, as I told you, the important thing is before pumping of your actual batch of concrete, you have to do some lubrication. So, that lubrication will only facilitate easy flow of your concrete through the pipeline. And we should feed the

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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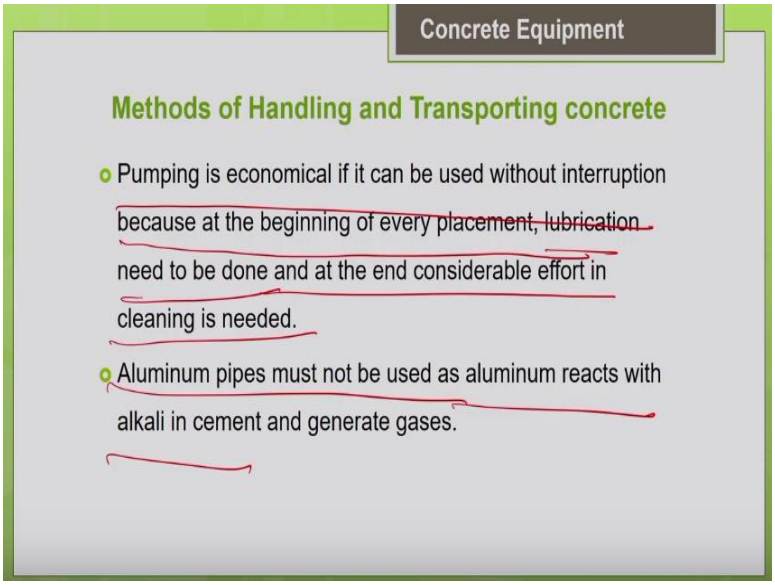

So, pumping is economical if it can be used without interruption because at the beginning of every placement lubrication need to be done and at the end considerable effort in cleaning is needed. So, that is why if you need a continuous supply of concrete continuous placement of concrete the steady supply 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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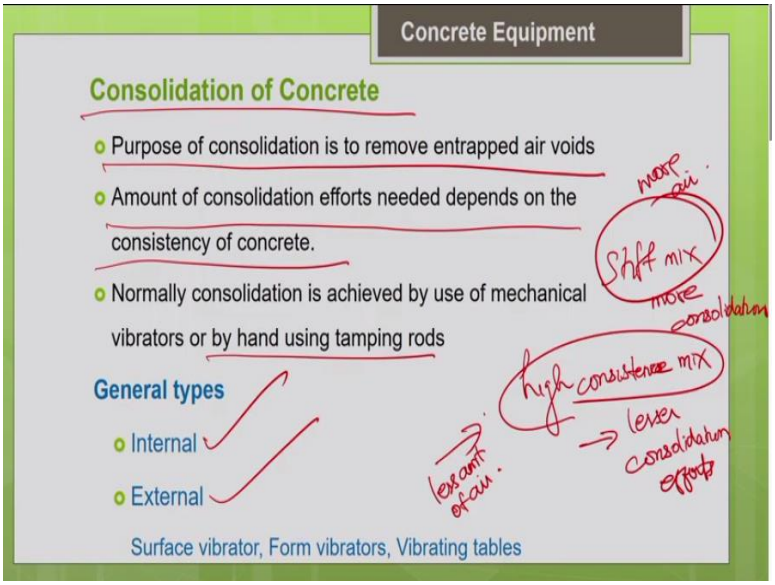

So far we have discussed about different methods of transporting the concrete or placing the concrete. So, starting from the simplest method like wheel barrows and buggies, we have

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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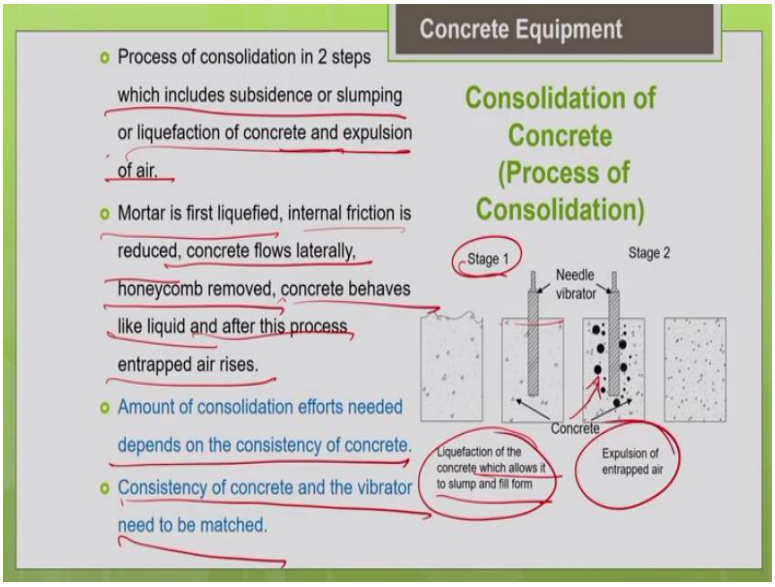

So, basically before moving into the types of vibrators, let us discuss about the actual process of consolidation. How this process of consolidation is happening in the concrete? So, the consolidation usually occurs in 2 steps. The first thing is when you put your vibrator in the concrete, so, what is 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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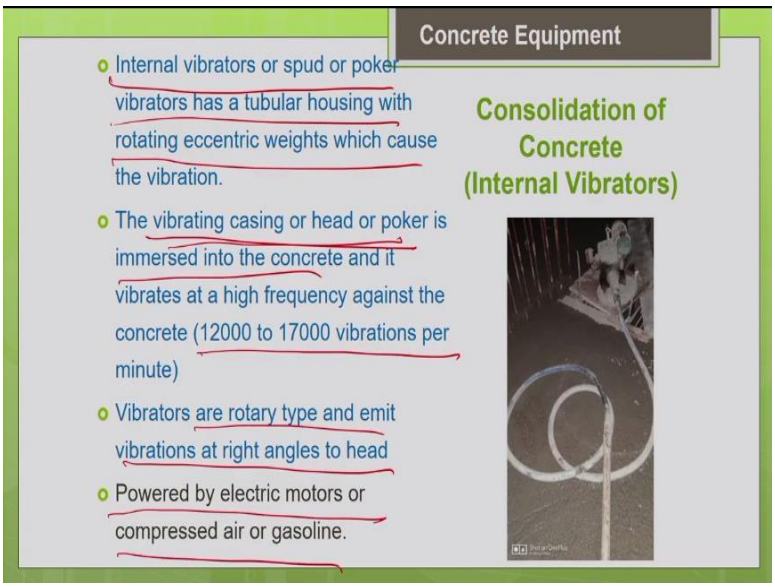

So, first let us discuss about the internal vibrators which are very commonly used for the consolidation of the concrete. We call them as needle vibrator or spud vibrator or the poker vibrator. So, there are different names to call these internal vibrators. These are more effective forms of vibrators, 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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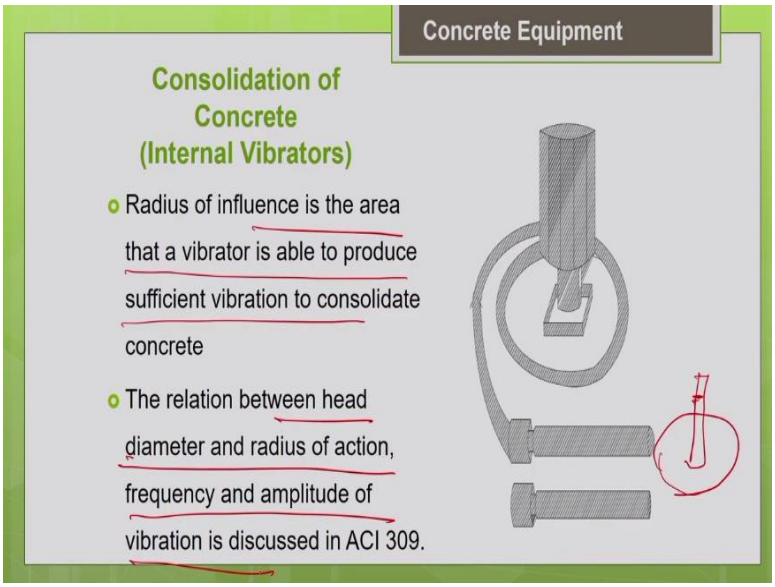

So, basically every needle vibrator, it will have its own radius of action. So, this is the casing or the head you can see. As I told you at the bottom, you have the casing or the head. So, how much will be the area of influence? So, this is your head, how much will be the area of influence? So, that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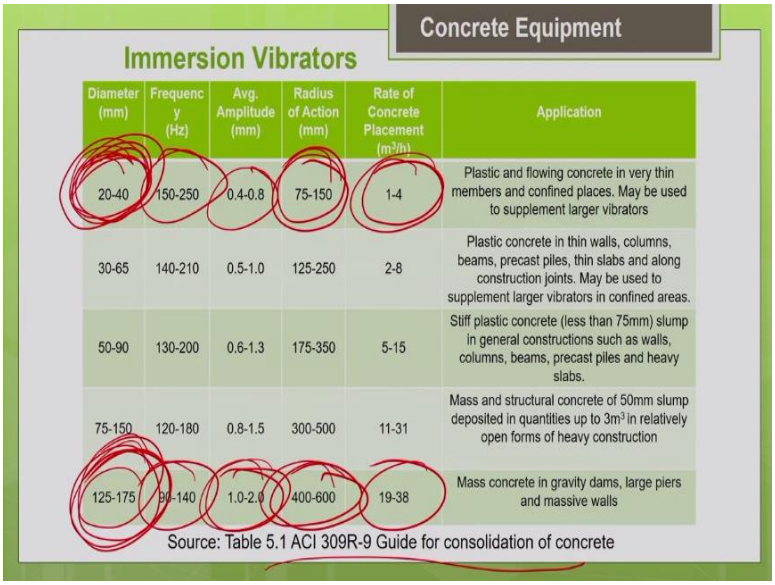

So, you can get this information in ACI 309R which gives you the guide for the consolidation of concrete. So, you can see this table is taken from the ACI 309R. The basically you can see there are different types of vibrators available with diameter ranging from 20 mm to 175 mm. You can see. So, there 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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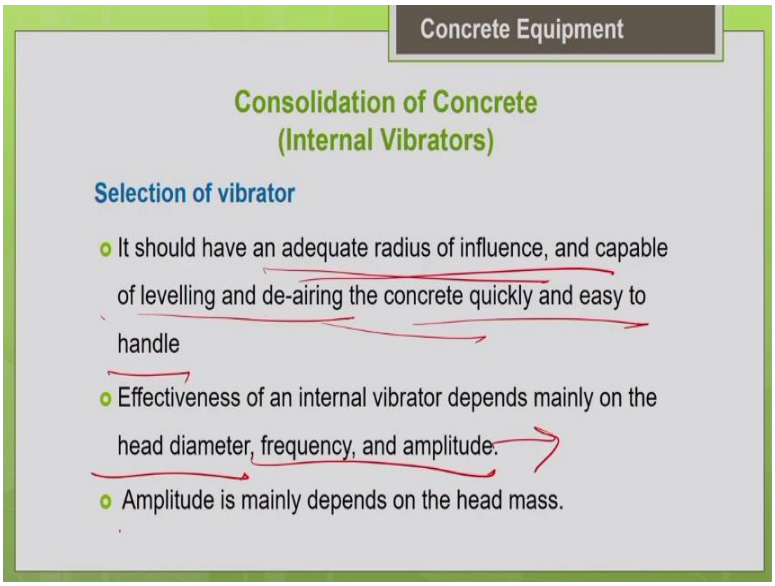

So, whatever vibrator you choose, it should have a adequate radius of influence so that you can have your desired consolidation rate. You can see your rate of concrete placement also varies. For a smaller vibrator, you can see 1 to 4 meter cube per hour. But for a bigger diameter vibrator you can have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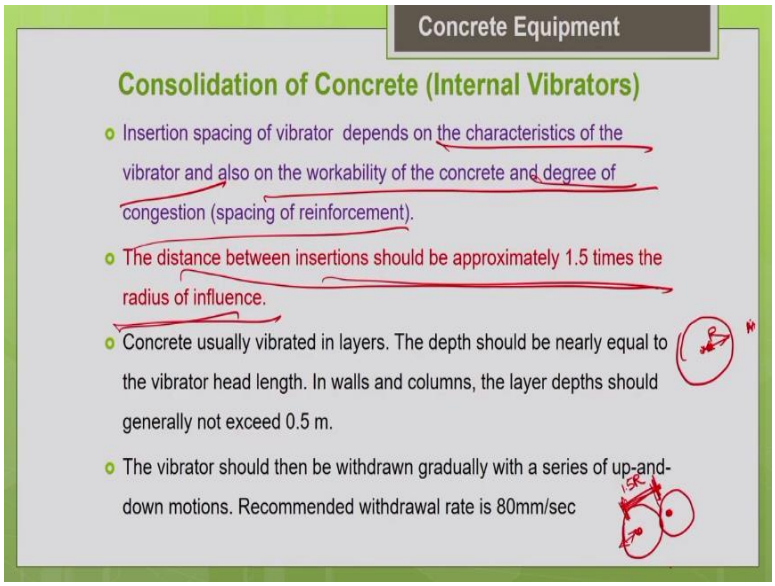

So, very commonly in your job site, you can see that they change the spacing of the vibrator just by looking at the consistency of the mix. So, if the person who is doing the vibrating job if the worker who is doing the vibrating job, when he feels his concrete is very stiff, he will

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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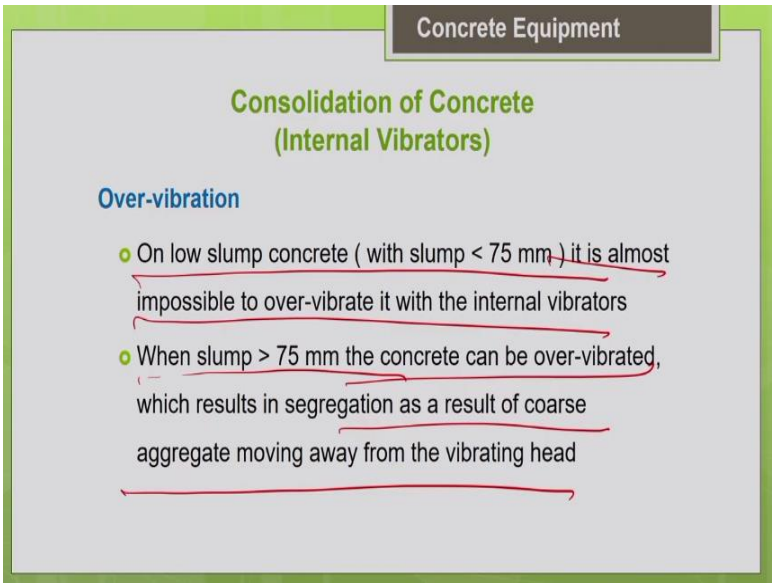

And another thing you should keep in mind is we should never over vibrate the concrete. So, if you over vibrate also the it will result in segregation of your concrete. So, generally the chances for over vibration will be there only in highly consistent mix in flowable concrete. So, when you handle the 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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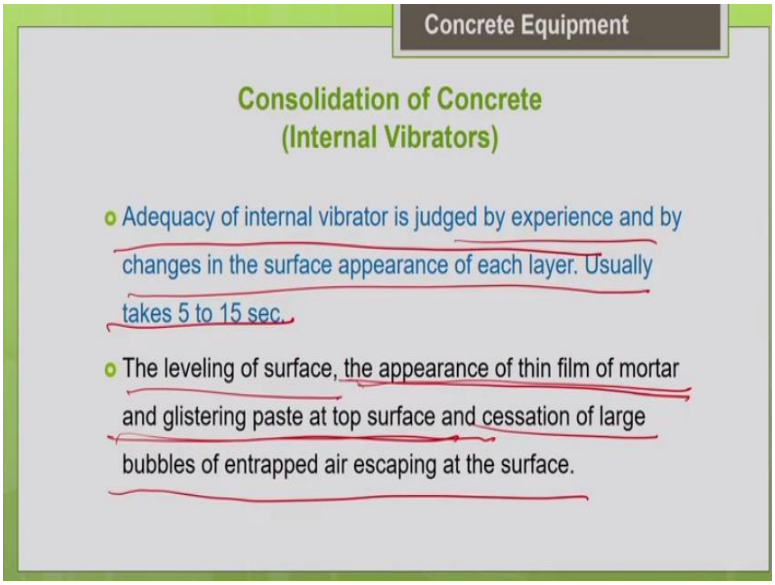

So, how long I should vibrate do the vibration at a particular place. Usually we take approximately 5 to 15 seconds. But it depends upon the consistency of the concrete. Generally, based upon experience what the worker will do is by looking at the concrete itself by looking at the concrete surface itself 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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