Advanced Concrete Technology
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Lecture - 28
Fresh properties – Part 3

In last lecture we discussed about different aspects of fresh concrete behaviour. We saw how rheological design of concrete can be done to control its flowability for specific applications primarily dealing with special concrete with self compacting concrete.

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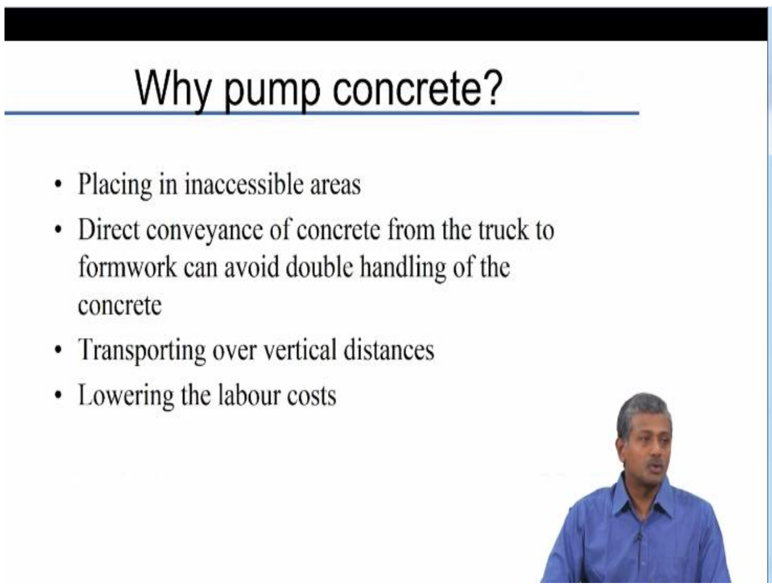

Today we will continue the discussion on pumping of concrete. Now pumping as you know as become increasingly crucial because of number of reasons, we want to place concrete at in inaccessible areas obviously which cannot be easily place by people carrying concrete and different ways of conveyance. Direct conveyance of concrete can be done from the truck to formwork to avoid double handling.

You know that the more number of hands that are in between the concrete that is delivered by the truck and what actually goes into the structure; the more number of hands implies there is possibilities of more segregation. Then of course the transporting over vertical distances. All of you know about the fact that today the pumps are strong enough to really pump very large vertical distances. So one of the examples is Burj Khalifa where the world record for pumping was created 600 meters vertical pumping was done. And please remember that was not done just done based on a trial laboratory mix they actually did a free trial with about two plus kilometers length of pipe which were laid on ground.

And they tried this same mix through the 2 kilometers of pipe to ensure that they were able to understand the extent of pumping pressure that they need and whether the concrete which is coming at the other end would have robust properties or not. So that was a properly simulated experiment which is done on the site after the lab design was done with the concrete. And of course we can also lower the labour cost; this may or may not be required depending on the situation.

But in such conditions even when you have access to lot of labour it maybe more preferable to go for pumping from the point of view of saving time and also accessing areas which are not easy to access by humans, . So requirements for pumping are on the rise; we want to pump more and more because construction projects today are handled on very tight schedules and just relying on labour to fulfill the concreting operations may not be always a good task.

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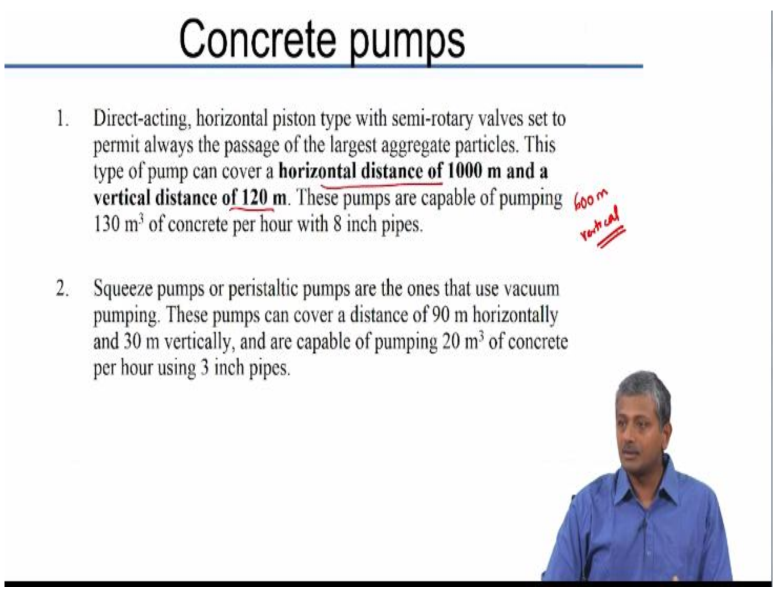

So there are different types of concrete pumps that are used in construction. There are 2 principal types of pump one is a Direct-acting piston type pump which essentially applies pressure with a piston. The other is the Squeeze pump which uses vacuum to pull the concrete. A piston pump has a lot more ability to pump over longer distances, in general you can cover a horizontal distance of 1000 meter nearly a kilometer and a vertical distance of 120 meter with the conventional pipes which are about 8 inch. But there is specialty applications where up to 600 meters of vertical pumping is also done using the Direct-acting piston type pumps. The Squeeze pumps are a little bit less effective. But then you are spending less energy in doing the vacuum process. So these are peristaltic pumps. And these pumps can pump over a 90 to 100 meters distance horizontally and about 30 meters vertically. And assuming 3 inch pipes you can pump about 20 meter cube of concrete per hour. So the capacity of the pump will obviously depend on the amount of pressure that you can pump to concrete with and also the pipe line which is carrying the concrete. So your concreting operations depending upon what the conditions demand you would be choosing one or the other type of pump.

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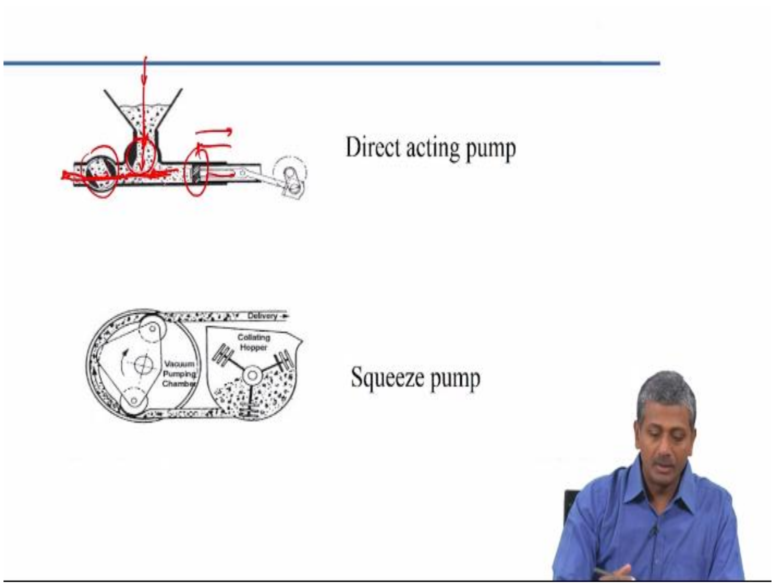

This is just diagrammatic representation and here you can see the Direct-acting pump has a piston that is trying to push the concrete. There is a hopper into which the concrete is poured from the truck,. And there is a valve which opens to ensure that the concrete continuously gets filled up into this pumped section.

So as the concrete is pumped this valve rotates in this direction so that the concrete is able to continuously get pumped outside. So what happens is that the pipe is always full of concrete so that the piston; when it moves forward obviously pushes the concrete through and when it moves backward it pulls in more concrete into the pipe.

So the hopper has to be continuously fed with concrete to ensure that the pipes keep getting filled up with concrete. You do not want any breaks in the pump process because that would create air gaps and obviously when there is an air gap in the pumping processes you have a problem. That creates chocking in your pipe. So as long as the pipe is continuously filled up with concrete your pumping can happen without any interruptions.

So in the case of a Squeeze pump this is a collating hopper and this is a vacuum pumping chamber so it is simply pulling the concrete and conveying it directly to the pipeline. So there is just a vacuum which is pulling the concrete and then conveying into the pipeline.

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So this is some examples of pump manufacturer REED. Common pump manufacturer in India is obviously SCHWING. You must have seen that name somewhere. SCHWING Stetter is joint venture company that makes a lot of concreting equipment including the RMC plant equipment, RMC trucks.

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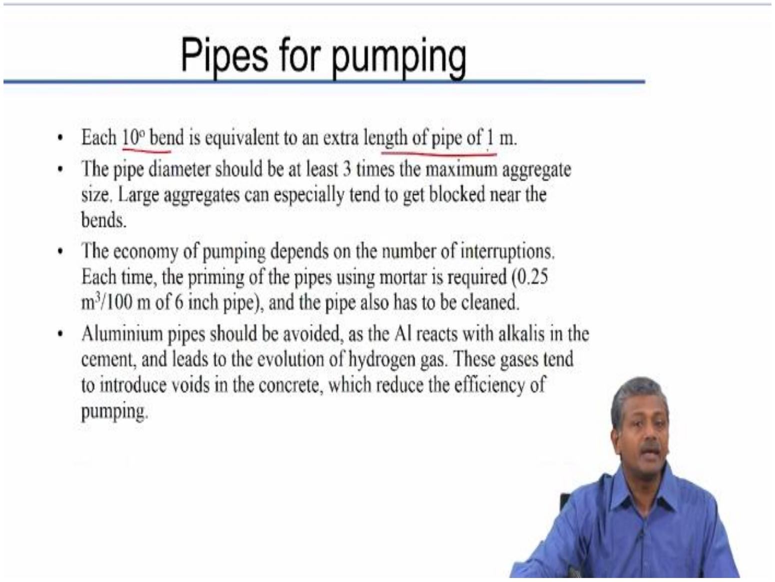

So what are the criteria that we have to use for selecting the right pipe for pumping? First of all, what we need to understand is when we lay the pipeline which is going to convey the pumped concrete we need to avoid the bends as much as possible because every time there is a bend there is a possibility of the concrete choking. So each 10 degree bend is equivalent to an extra length of pipe of 1 meter.

What is an extra length mean? More friction because of the extra length of the pipe. So you are losing your workability with additional length of pumping. So when you have a 10 degree bends that is equivalent to 1 meter length of pipe. So every time that you have a bend you need to ensure that you are overcoming that extra friction that is created because of that. The pipe diameter typically is chosen to be at least 3 times the maximum aggregate size.

Otherwise what will happen is that the larger aggregates can start getting blocked especially when there is a bend in the pipeline, . So, pipe diameter has to be chosen based on the type of concrete that is being used at the site. How is the aggregate size in concrete decided? By the spacing between the reinforcement or the clear cover whichever is lesser. Based on that, you reduce 5 millimeters and decide on the maximum size of aggregate in the concrete.

The other aspect to consider is the type of concrete that you are pumping. If you are pumping a highly flowable concrete the size of the aggregate should be even controlled to be smaller otherwise a lot of aggregate flowing together in a rapid succession may start blocking at the obstacles. The economy of pumping obviously depends on number of interruptions, so as I said you do not want interruptions during pumping.

There has to be continuous supply of concrete through the pump. Because every time you interrupt and you start a new batch of concrete you need to ensure that you send in some mortar first to prime the valves of the pump. Why do we do that? To reduce the friction between the pipe and the concrete. So before we pump a new batch of concrete we need to send in a primary mortar and that can take considerable amount of time to prime this surface of the pipe using this mortar. So as far as possible minimize the interruptions while pumping.

Aluminum pipes have to be avoided you know very well that aluminum in the alkaline environment of concrete can react with the lime and produce hydrogen gas. This hydrogen gas liberated can obviously create bubbles inside your concrete and you are trying to then push air which may not be a very wise thing to do. And that is why you know very well that for aerated concrete the concrete that is lightweight, aluminum powder is used to generate the air bubbles in the concrete.

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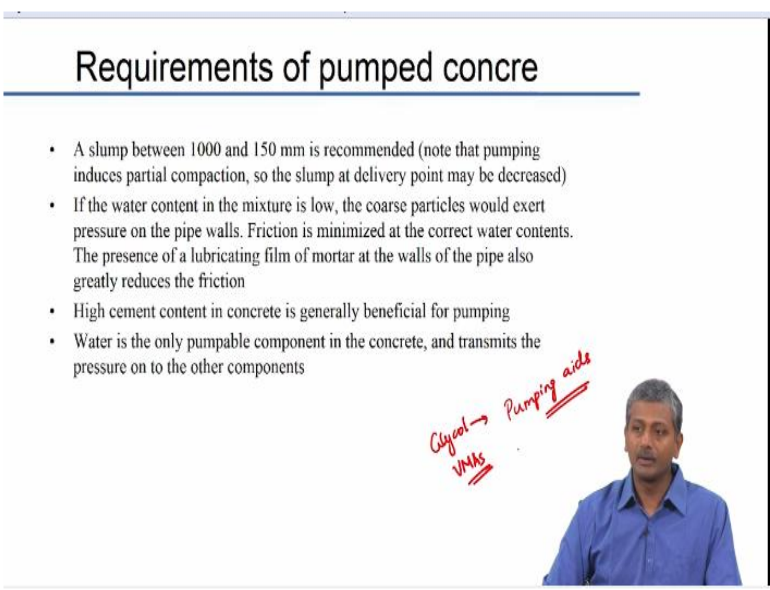

What about the concrete itself? We want a fairly high workability for the concrete. But at the same time too flowable a mix would tending towards segregation if you are trying to pressurize it. So you need to control the slump of the concrete to be about 100mm to 150mm otherwise when you working with self compacting concrete, you need to be extra careful in designing your right pumping system deciding the pump pressures and all based on that. Because very high pressures can tend to segregate highly flowable concrete. So your concrete mixture can segregated primarily because fines are not enough. . If your water content is low again your friction is high; if the water content is high then your possibility to segregate is more. So again designing the concrete has to be done very carefully. Now high cement content is generally beneficial for pumping obviously because you are forming a richer mix.

When you have a richer mix it captures the water quite well and the paste is more cohesive which causes an ease of pumping. Now what I have not talked about is that also admixtures which are available which are called Pumping aids. , these are Glycol based admixtures. So the pumping aids simply helps to reduce the pressure required to pump the concrete, or even the VMAs would actually be good pumping aids.

Why because they make the mix more cohesive and once your pressurize the mix it will move as one. So if you have a self compacting concrete for instance to make it get pumped uniformly it may be better to have a viscosity modifying agent also in the mix. So your water does not get segregated from the concrete, it stays within the concrete if you have a VMA and the whole mass moves as one.

So essentially, because water is the component that you are trying to pump, the solid components are going to reduce the efficiency of the pumping. So water is carrying the other components along with it, . So pump concrete has to be designed carefully, of course in most cases we deal with regular mix design without considerations of pumping. So very often when we take the lab based mix design to the site we need to do a field testing operation to see whether all the criteria are getting satisfied or not.

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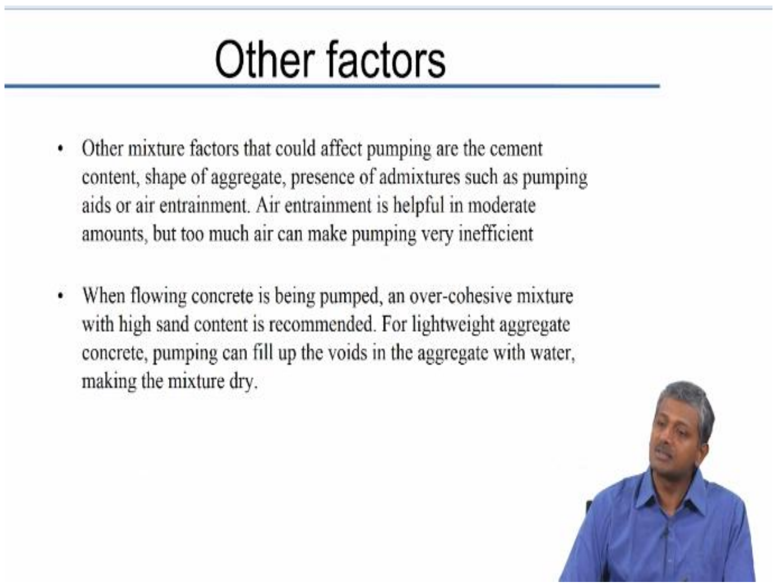

There are several other factors that affect pumping include shape of aggregate, presence of admixtures like pumping aids or sometimes air entrainment. When you are trying to pump air entrained concrete what you expect? Air voids will do what? Air voids will tend to slowdown the efficiency of the pumping. So again air entrained concrete you need to be careful with pumping especially lightweight concrete which is based on lot of air which is inside the system.

Foamed concrete and cellular concretes; may be very difficult to pump those types of concrete because there is lot of air in the system. So pushing that type of concrete through may not be an easy task. So flowing concrete you need to ensure that your mixture is highly cohesive that is why utilization of a VMA is always better as far as pumping is concerned. The VMAs can in some instances even in normal concrete they can act as pumping aids.

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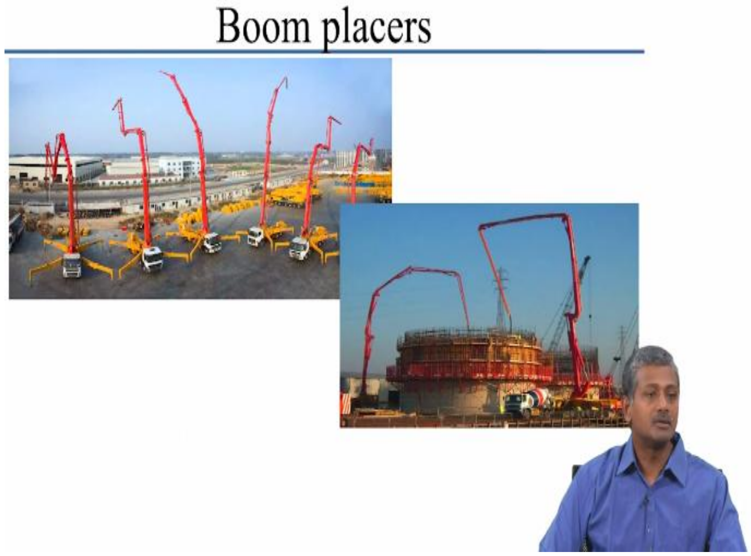

Of course these days a lot of pumping is done in conjunction with the use of Boom placers because these are extending the reach of your concrete. So there is actually some case study in China where because of the use of boom placers they were able to place the entire raft for a huge stadium for indoor stadium they were able to place an entire raft in probably a matter of couple of days or something like that.