Building Materials and Composites
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Lecture - 16
Introduction to Concrete

Hello everybody. So today we will start module 4, which is entirely on concrete. Now more or less you all are aware of what is concrete not as a student of architecture, but as a general observer, you have or you may have seen different areas or sites where such kind of casting is done, where an entire thing is held with or supported with some bamboo props and someone is waiting to for some period of time to get it ready for use.

So concrete is again another building material, which we all need to know as architects and the beauty of it is, it can be given any kind of shape, which you as an architect desire. Yes, the civil engineers are with us to design exactly whatever shape you want. They will come up with the reinforcement plan.

But yes, some basic ideas you will have for reinforcement, because concrete is a very good material in compression, but it cannot take tension that much.

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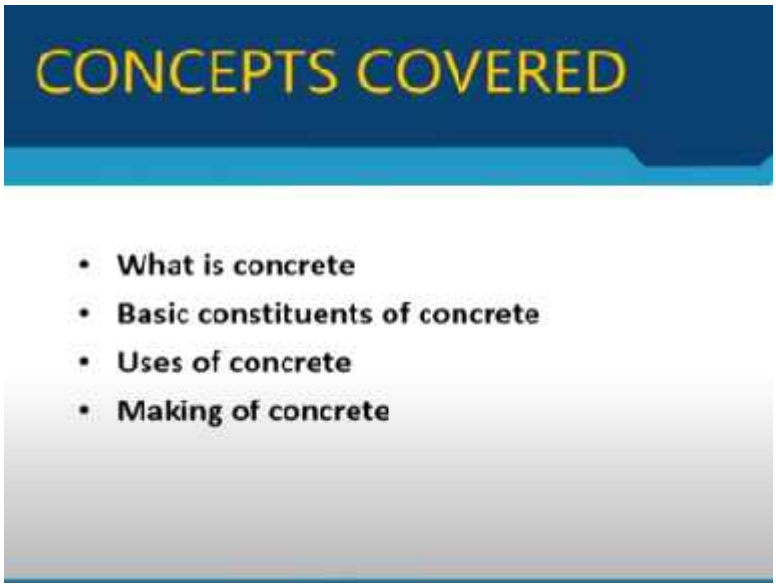

So if we look into this particular lecture, we will try to cover what is concrete, the basic constituents of it, use of concrete and particularly making of concrete. Now why

do we discuss what is concrete first instead of going to the details of its ingredients? We will go to its ingredients one by one in the later lectures of this particular module.

But presently we will deal with what is concrete and what are the major points of making it because that is also a very important part in the entire process.

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So we will start with telling that concrete is a man-made composite, consisting of hard chemically inert materials that is known as collectively aggregates, which again has two parts. One is fine aggregate other is coarse aggregate. Now this fine aggregate usually refers to sand and this coarse aggregate usually refers to the gravels or the stones of a particular dimension.

So as we will go into details into the fine aggregate and the coarse aggregate and the cementitious material, which is in context of concrete, it is mostly or generally cement, but we also use lime and gypsum as a binder. So who will bind all these things? Cement, when it is given water to it, a number of reactions happen and the whole thing gets bound together.

As we had seen, if you remember in case of wood, engineered wood it was adhesive, which was binding the whole thing and it was pressure, which was the next item which helped in the compaction or compactness of it. So here also you have your raw materials and you can actually make the concrete which is called unset or raw concrete. You can place it in any shape and it will you will get your desired shape.

But yes, remember as I told you, it is good in compression but not good in tension. You have to remember that to take tension; you might have to use something called reinforcement. They can be metal bars, they can be mesh, means metal mesh. It can be even bamboo as reinforcement. So reinforcement is the stiff that you are adding something which will be capable of taking the tensile force.

However, when we are embedding it within the concrete, we still keep the name as concrete with reinforcement. Now you can take any shape means, you can have a flowing form, it may be vault like, it may be circular, it may be meandering. When there is no reinforcement in it, we call it plain cement concrete. So any kind of compressive load it can take, but it is not capable of taking any tensile force.

So there should be a support below. Usually, you will have this kind of flooring on the consolidated ground at the plinth level. And it forms the ground level support, ground level floor. Concrete with reinforcement, is known as reinforced cement concrete or RCC.

And these are used when you need to span between two walls, the floor plates of the building i.e. first floor level, second floor level third floor level, the floor slabs, which is of regular use for any kind of building structure, which we see quite often. Even the floor on which I am sitting, it is a reinforced cement concrete slab. The roofs, yes roofs may not have further floors. So it may have different shapes.

The staircases through which you are moving up and down, maybe partially of reinforced concrete and it may be entirely of reinforced concrete. So these are the major areas where we see the use of reinforced concrete.

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These are some pictures you see concrete being cast in the first floor. You can see something very raw, which is here, which is not set, it is little messy item and within through the reinforcement it is being placed. So the reinforcement is a separate entity, but this mix is a concrete mix. Here you see a free flowing form supporting the staircase and it is entirely made of concrete. So the staircase is winding up.

So that particular shape in that curvature it has been cast. That means this raw concrete has been placed in a support which showed like this and once this concrete got set or consolidated the support has been taken off. But more regularly you see concrete application in such kind of structures, where you can see the floors are made of concrete. Even the parapet walls**,** the weather boards up to the sill level, many items are made of concrete.

So now we need to know if you have a small building and small sized rooms on top of which the floor has to be cast, you may not use such strong mix. You can go for lesser strength mix because you do not need more strength. But if you have a huge casting, huge span, that is distance between two supports, then you might have to use much stronger concrete. That means stronger in compressive strength.

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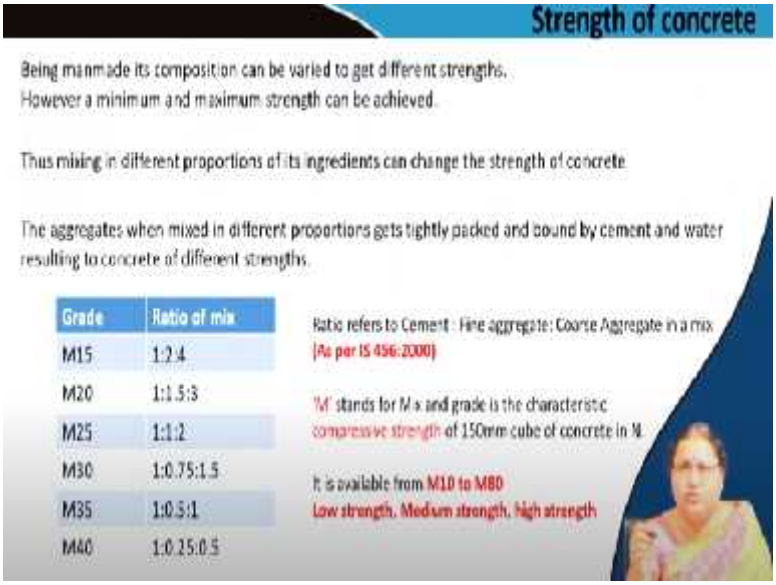

So being manmade, you can alter its proportions and hence, you can change the strength. So it is not only one kind of concrete existing obviously, there would be a minimum and a maximum strength and if we come down to the list it will be 10 N/mm^2 (Newton per millimeter square) to 80 N/mm^2 of compressive strength.

So on mixing with different proportions of the fine aggregate, the coarse aggregate, the cement and the water, we can get different strengths of concrete. So let us try to look into it, where again the important point is, they are needed to be tightly packed and bound by cement and water that is the slurry, resulting to the concrete of different strengths. We have generally M20 to M40 as standard concrete.

Below that M10 and M15 are lean concrete. And M45 to M80 we have high strength concrete. Usually for our buildings we vary between M20 to M40. So we need to know the proportions where you see all the first ones are 1 and that accounts for the cement. So cement is one, which means against 1 unit of cement, you are using 1.5: 3 of fine aggregate and coarse aggregate.

Then you see M25, it is the amount of cement and the amounts of fine aggregate are same and double the amount of sand or cement is the coarse aggregate. And if you also look into the proportions, you can see 1.5:3, 1:2, 0.75:1.5, 0.5:1, and 0.25:0.5. You see that fine aggregate is always double the amount than coarse aggregate in all the cases from M15 to M40. And for latter you need to go for mixed design.

Now what you see 1 is the cement and the rest other two is the fine aggregate is to coarse aggregate. So this means, 1 is the mandate, which is against one bag of cement as we have large volumes usually of concrete mix, it is a bag of cement, which is the unit. And one bag of cement is 50 kg of cement. And it can also come in a particular volume we will come to that.

But, M refers to the mix and the value against it refers to the strength of 150 cube of concrete in Newton. So for qualitative terms we can say low strength cement, medium strength cement, high strength cement. But finally it is cement is to sand is to coarse aggregate, which makes the variation.

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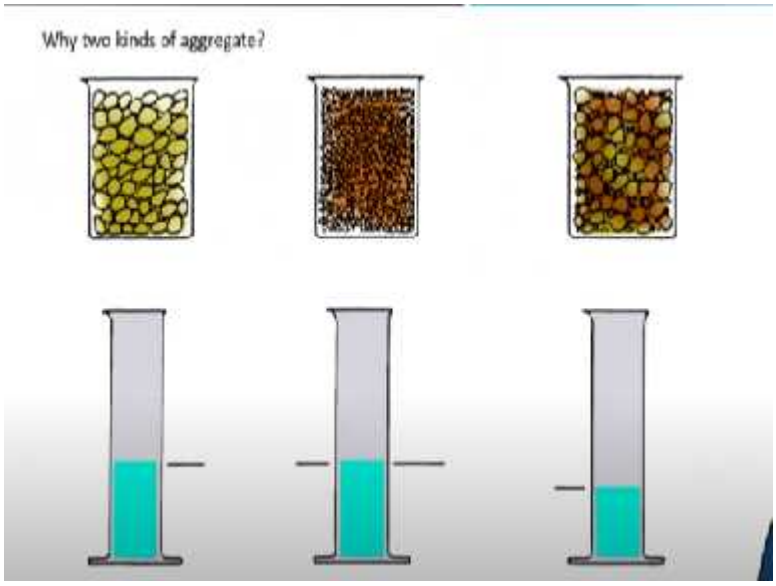

Now why two kinds of aggregates? You see in this jar with a specific volume, you can actually pour this amount of water into it. It will move through the spaces and will get accommodated. If we look into the fine aggregate, and the same amount of water, the same amount of water will go into it. But if we mix the two, the fine aggregate and the coarse aggregate, you will see even with the same things, the fine aggregates can go into it.

And then if we add the water, you will require less amount of water because the inter particle space reduces. So what is happening? If instead of water, this is cement mixed with water that will go and actually gel the whole thing. If it is a cementitious material and water it will go and gel this whole thing and requirement of this solution would be less doing the same task, what it was doing here or here.

So you can reduce the volume or use of cement and still get the same thing, same product because cement is costly. This coarse aggregate and fine aggregate itself can be together and with addition of the cement solution, the further it gets consolidated, in a better way.

So we need to use two kinds of aggregates to fill in the gaps between the larger particles with the next size granules and then we use the cement solution to make it one. But no, we are not making things like this; we mix it outside, take it to the site and place it. So let us see what happens.

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So the steps for making concrete, number one is batching. I think I have discussed this term when we were doing glass and batching refers to measuring in fixed amounts which are designed already, considering the design strength. Next is mixing. We will come to each of them. Mixing means the mixing of the different ingredients together.

Next is transporting the mixture to the place where it needs to be needs to be cast. So you need to transport and take it to the site and then you need to place it. After placing you need to compact it and finally, you need to allow it to cure.

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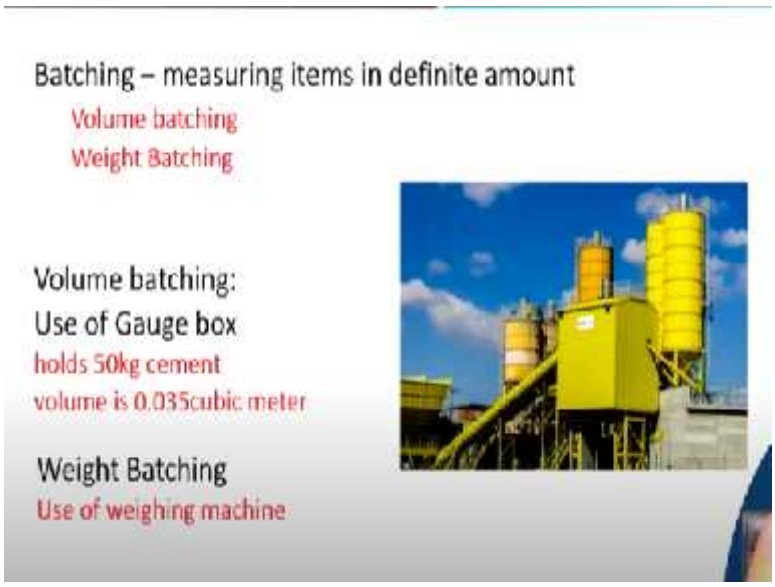

Now when we talk of batching, that is measuring the amount in amounts measuring the items in given amounts or defined definite amounts. You can do it by volume. You can do it by weight.

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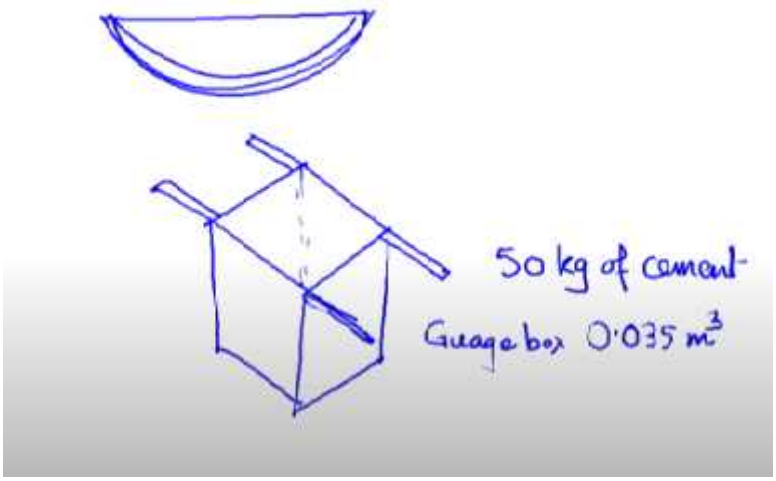

Maybe you have seen an item like this on site. Or maybe you have seen an item like this on site These maybe two bamboos. This is a sac which is called the gauge box. And this is a kind of container which contains a specific amount and this is a kind of measure like a spoon. So this actually can contain 50 kg of cement and its volume is some 0.035 m^3 (meter cube).

So one bag of cement as you remember the proportion, it was one bag of cement versus one bag of fine aggregate, two bags of coarse aggregate or whatever is the

strength required, you will have to take amounts considering the gauge box as your unit or the vessel or the container as your unit and you can carry on. What is the problem here? Here you are not taking things by weight, you are measuring it by volume.

Weight batching is considered to be more precise, where actually weights are taken. This ratio is taken as per weight and it is done by using the weighing machine. Another is automatically done when it is large scale construction. You can have a batching plant, where the items are coming out in definite proportions.

You are only using an electronic board where you are entering your data and the mixing is happening and the concrete mix is coming out. So you have to understand what is the scale of operation, how big is the site. If it is a small residence, you can do it by gauge box you can go by volume batching. But if it is a large scale construction you can go for mix that you have to buy the mix against as per the order.

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So let us come to see the mixing. Here you can see it is a small scale domestic operation, where you can actually mix the items when the coarse aggregate is laid below.

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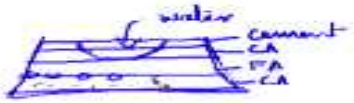

On top of which the coarse aggregate is placed below at the lowest layer. Then on top of it is sand, again coarse aggregate, again cement spread on it and at the center a circle is made. So this is coarse aggregate, this is fine aggregate or sand, this is coarse aggregate and again on top of it, it is cement and you are digging up a kind of hole.

So this takes a trapezoidal shape and you are putting water to it. Now this water is to be measured. We will come to that later, but you have to measure the water and you have to put it here. And then it is a manual operation of mixing the whole thing. So you can see the picture now, the manual picture and below it is a little large scale construction where labor may not be that cheap.

Or you can manage to order this machine and you can hire this machine and you can use it and you can get your mixing done avoiding the manual part. So these are the two ways and obviously this will happen very near to the site and transporting it will be not so difficult. You have to carry it from the point to the level where it is to be transported.

Whereas, for a ready mix machine, where you need to transport it to site in one hour. As you had seen in the batching plant, it can actually take orders from several points and it can actually supply the mix as per the order. But they are to be transported. So this is the vehicle to transport and it should be done within one hour of the construction or one hour after being made to the construction site.

And that too when it is carried, it should be rotating very slowly so that no setting starts there. Because ultimately this mix which is unset, will start setting in a given period of time. So this unset concrete needs to be transported.

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After being transporting to site, here you can see the item is being placed. If it is done at a very nearby site, it may be pumped through nozzles. As you can see the concrete is coming out at this point and it is being poured in between the reinforcement. So reinforcement had no connection with this concrete. Reinforcement is given as per the design of the tensile load that the structure is going to take.

But this concrete is given poured on top of it. And how are they holding this? It is a shuttering there which is supported by props (steel props). You can see the steel members that are the props, which is holding the shuttering in place. This is the shuttering onto which this entire mass is being poured. So usually it is plywood, metal sheet used as shuttering, steel props or bamboos used as the support to the shuttering.

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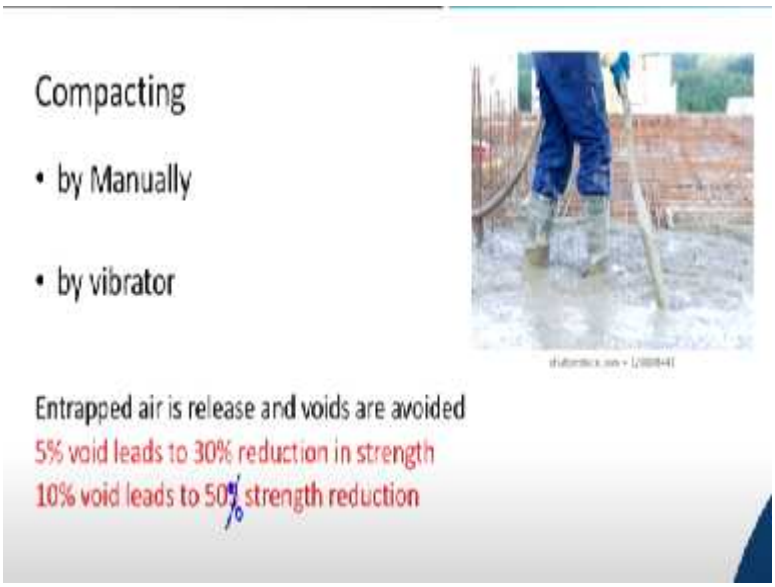

Next is the operation of compacting for the entire concrete. So what will happen? You are already pouring it. What is the point of compacting? It is done manually when it is a small project. When it is a big project you can see the person wearing Wally boots and doing the operation of compaction. It is a vibrator, which is actually moving the concrete and it is allowing it to release the entrapped air.

So the entrapped air, whatever has been inside the mix gets released and the voids are avoided. As you can see, marked in red, 5% of the void leads to 30% reduction in strength of concrete. And again 10% void leads to 50% reduction in strength of concrete.

Now if you keep on vibrating, so as to get rid of voids, the items may get segregated. That means the ingredients with which the concrete was made, may get segregated. So you cannot do any operation beyond the given time. So this vibrating operation has to be very carefully done and the entrapped air has to be released. Once that is done, the entire casting is ready for curing. So it is totally unset now and gradually it will set. How gradual?

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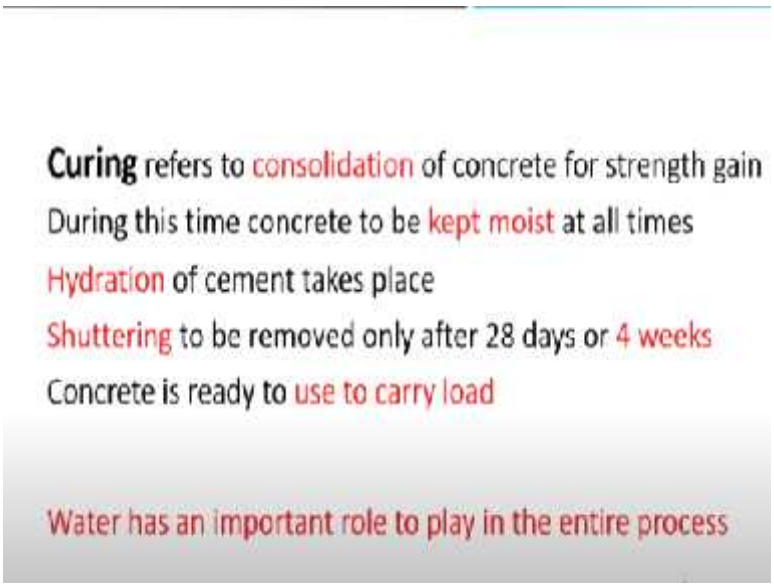

It will be taking 28 days or 4 weeks. So curing refers to the consolidation of the concrete to build up the strength. During this time concrete has to be kept moist, because the hydration of cement takes place. So a series of reactions take place to make the cement, achieve its maximum strength keeping all other ingredients with it, the entire thing becomes a monolithic item. So there is no gap, there is no joint in the entire unit.

Unless it is a huge casting, you may require a joint. But otherwise there is no need of any joint. Usually the casting has to be made continuously. It may be a day and night operation. If it is a huge casting, you can get your ready mix concrete transported, placed, and it continues with different sets of laborers of people. But, it is best to have the casting in one period of time i.e. one continuous period of time.

And after the period of 28 days, the entire support system can be withdrawn and the concrete is ready for carrying load. So as we learn this entire step of making the concrete and also knowing that by changing the values, changing the proportions, you can get different strengths. From the next lecture, we will try to enter and know each of the ingredient and the role there.

I have not discussed on the items which are admixtures, which you can add to concrete to get different further properties. You can change the plasticity of it, because you may have to transport it for a far distance. So that the beginning of the setting process can be prolonged.

So we need to know what are the admixtures or additions apart from the basic items that is the cement, the coarse aggregates, the fine aggregated and also the other ingredients. But more and more important is the amount of water which has to be very much fixed, very much controlled in the entire process, because water also has a role in achieving the strength of concrete.

So we will move to the next lecture and we will see how we can achieve a good kind of concrete by using the different materials.

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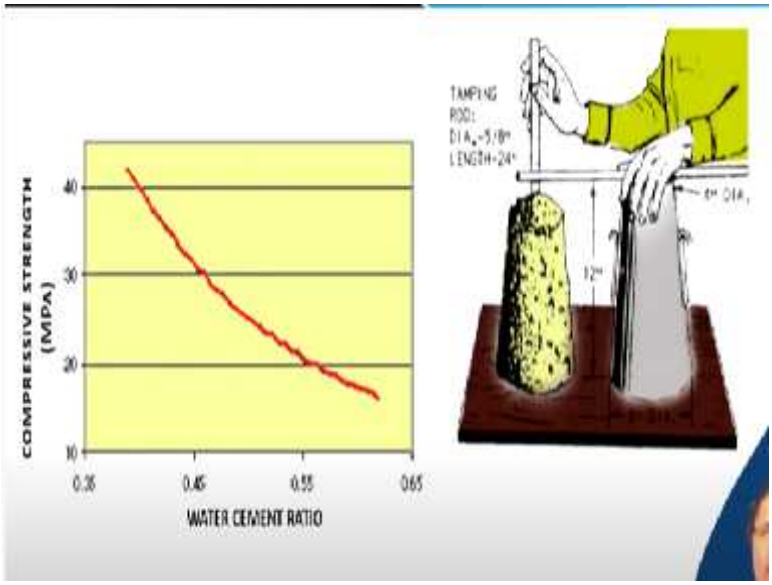

So with these opening with this opening lecture, we will move to the next where we will understand the water cement ratio, we will understand how the concrete mix would be workable and the slump tests and we will further know the details of each of the ingredients. So thank you for today.