Building Materials and Composites
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Lecture - 18
Coarse Aggregates

So we are in lecture 3 of module 4. So module 4 is on concrete and on this particular lecture we will be discussing on coarse aggregate. The earlier two, we tried to explain what is concrete and then in the previous lecture, we had covered define aggregates. So we are coming into the next ingredient that is coarse aggregate.

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In this particular lecture, we will try to cover the definition of coarse aggregate, classification of coarse aggregate and again coarse aggregate size and grading. Unlike the fine aggregate, which was very fine particles, which you all had seen, which you all know, it is mostly sand predominantly used across India. Here we will deal with the larger particles, which are known as coarse aggregates.

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Already we had discussed that particle sizes below 4.75 mm (millimeter) were considered as fine aggregates. And you can go down and down and in the calculation we had seen if something is passing through 0.15 mm of sieve size, we consider that as clay, which actually is not to be considered as good quality sand if it is more in percentage, because it does not allow the mixing or binding with the coarse aggregate.

So however, in this case particle sizes above this particular threshold, we are considering as coarse aggregates. So will we go upper and upper as per our will? No, we have to look into particle sizes. We usually restrict ourselves to particle sizes up to 20 mm, which we will discuss it little later. However, particle sizes up to 40 mm are used as coarse aggregate in large scale mixes.

So generally for regular building industry we go up to sizes of 25 mm and below, up to 4.75 mm. So in the picture here, you can see different sizes of coarse aggregate, which is differentiated by the line and it is visibly much clear to you all. So what are the sources?

Unlike the sand which was mostly from the rivers, here you see these are stones obtained from the igneous rocks, sedimentary rocks, the gravels obtained from the river, the lime stones with specified dimensions as I already told and they are mostly clubbed under coarse segregates. Why we go for igneous rocks, sedimentary rocks, gravels? We use it because ultimately these are imparting the strength to the concrete.

Instead of bringing a rock which had a definite shape here you are binding the rocks of lesser dimension together to form something like a rock. So what is concrete? It is a man-made mass, which is one, you cannot break it. And it is coming or being bound by these particles. And if you see, proportion wise you will see the aggregates in the mix had the maximum share, largest share.

If you remember 1:1:2, 1:1.5:3, 1:2:4. So the largest share is that of the coarse aggregate and that is the strength provider of the entire concrete. So the mix actually comes from this. The strength of the mix comes mostly from this aggregate, but do remember that the binding is also very crucial, how it is being bound. So we will come to that also.

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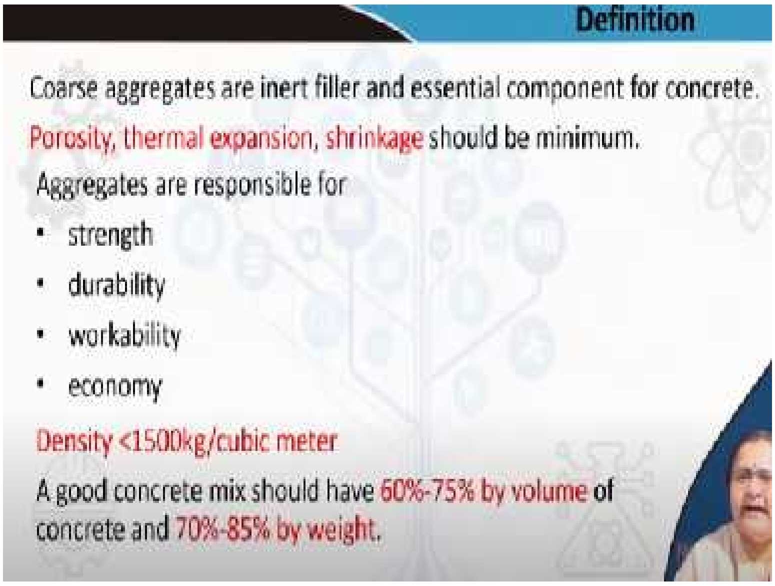

So coarse aggregates are basically inert fillers and are essential component of concrete. Porosity, thermal expansion, shrinkage are the key points, which should be minimum, because it is having the maximum share in the mix. Any kind of expansion, any kind of shrinkage, any kind of allowance of moisture inside it will lead to cracks.

So it has to be kept in mind which is more easily available, which is higher or better in case of the igneous rocks, the basalts, maybe the sedimentary rocks too and these are responsible for strength, durability, workability as well as economy of the entire mix. If we talk of the density you see it should be less than some 1500 kg/m^3. So this also gives a clue of the density of concrete.

A good concrete mix is said to have around 60% to 75% of its volume and it is furthermore 70% to 85% by weight of the coarse aggregates. So now you can understand from these figures, the role of this coarse aggregate it is actually the component which is bound very precisely, and the preciseness in the binding will give better strength to it. So who binds it?

It is the cement, the sand, water together binds it. We will come to that in our next lecture later.

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Now apart from the stones, we have some other source like the vermiculites and the perlites which are obtained from the volcanic glass. They are quite light in weight. You see the figure is less than 1100 kg/m^3. So they will give you lightweight concrete and these items are compressible, insulators, fireproof, non-combustible, and non-reactive too.

So you needed inert materials. So these are chosen when we need lightweight concrete.

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Sometimes there is non-availability of stone. In our country context, say in Tripura etc., there you may not get lot of stone in abundance. So you cannot get coarse aggregate. Is it so? Or you have to transport it from a location which will increase the cost. Then the economy would not be achieved. There also you can use this lightweight broken brick aggregate as a coarse aggregate in the mix.

These are also used for road constructions. Fourth grade bricks, brick parts are all also used for constructions. So these can also be used as coarse aggregates in a concrete mix. Similar to the lightweight varieties, we have another end which is the higher side. Those are known as heavy aggregates, which are usually iron shots, steel pellets and where do they go?

They are used for shielding nuclear radiations. So wherever there is a nuclear reactor being constructed, there you may use such kind of aggregates and as you see they are obviously going to be higher in density. As you can see it is 2000 kg/m^3. So not only the stones but we have so many other things to be used as coarse aggregates. One point which I would further add to this is recycled coarse aggregate.

You may have a construction being dismantled, because of aging and it is falling apart. Even the concrete which you get from there, you can actually use that. You can take out the coarse aggregate from it try to move away the sand and the cement mix from top of it by washing and then you can also reuse it. So that is a kind of waste consumption. So these are also being experimented and used in this particular field.

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Now coming to the very important and critical is the shape. And if we classify the shapes, we will see they are rounded, irregular and angular, maybe both are almost similar. And the last one if you see it is the flaky one. So as you know, that spheres has the minimum surface area. So the rounded are not all spherical, but roundedness actually will give less of surface area. That means less of coverage or binding space.

Furthermore rounded means it is not having many surfaces, no edges. So if we see a picture, you see these particles you see these particles they are very much circular. So there edges are not there to hold the adhesive or the binder that is the cement and the sand. So here the binding will be less. Rounded aggregates have least surface area; produce minimum voids in concrete, but causes bond failure due to poor interlocking property.

And it has the minimum surface area as already I have told and hence the surface contact is also minimal. So let us look into the other type that is the irregular aggregates. Here you see which you mostly have witnessed if you have come across any construction site. From now on you please keep your eyes open so that you can see these kinds of things. You will never get the first variety on site.

But this variety, which is already displayed here in this second picture, you must have seen it. What do you see here? They are not circles. They have lot of faces. And they can actually hold the or bind hold the binder on its each face and can have a more closer or compact and they can actually contribute to the binding process, which will eventually give the strength.

Angular aggregates they may have sharp edges also as you can differentiate between the two pictures. They create maximum voids in concrete. Since you cannot get everything hundred percent irregular, hundred percent angular, you can have these two for your regular use.

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Next are the flaky aggregates. Flaky aggregates means they are thin and they are long. So here you see they are elongated aggregates where length is almost twice that of its mean dimension and the thickness is quite low i.e. 0.6 times its mean dimension. That means it is almost three times long compared to its minimum width and these are identified as flaky aggregates.

They reduce the flexural strength and they also tend to segregate. Now we have not discussed the process of segregation. We have discussed it, when we had discussed the compaction process. If you keep on compacting for a prolonged period of time, your coarse aggregate will segregate from the entire mix. So if you have flaky aggregates in the mix it will further come out easily.

It will enhance the process of segregation, which is not at all desired. So if you keep this in mind, you will look for irregular, angular aggregates. And this flakiness, you have the flakiness index. You have the elongation index. I am not going into further details of it. You can measure it. There are appropriate tools to measure the elongation index. There are appropriate tools to look into the sphericity, i.e. the roundedness and the flakiness index.

But yes, human eyes are always there to take it out. In an entire heap of aggregate which you receive few of such kind can always be there, some 1% can be always there. Some hand sorting can be done, but an entire lot cannot be used which is flaky in nature.

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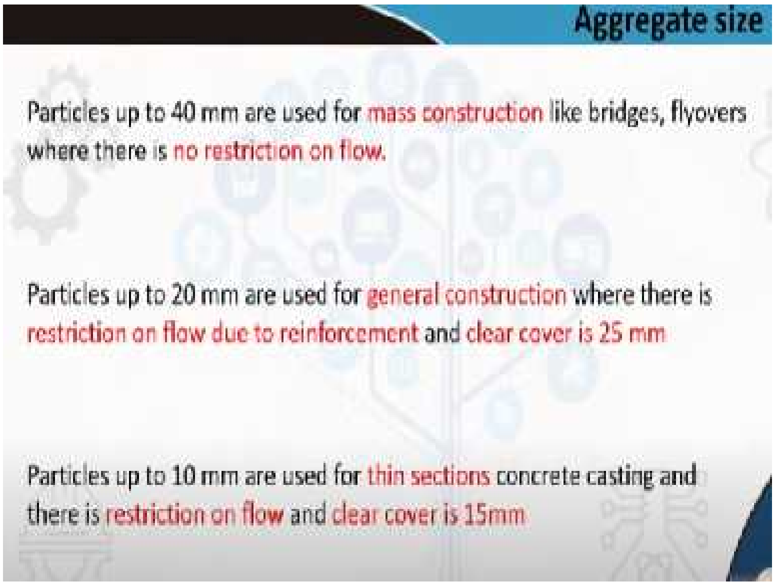

Now coming to another interesting thing which I had already discussed is the particle size. These aggregates have to move through the reinforcement in case of a reinforced cement concrete. So the gap between the reinforcement will allow these particles to move from one end to the other since no human intervention can cross these particles one by one.

So the sizes should be as appropriate to the gaps present between the dense reinforcements. If it is dense, you have to go for smaller sizes. If it is a huge mass construction you can go for larger particle sizes. So usually for mass construction you can use 40 mm particle size. We have 80 mm particle size. We have even 150 mm particle size, but those are not much of our interest.

We have beams, columns, slabs as reinforced concrete structures where these particles have to pass. Another important point that you have to look for is the clear cover. What is clear cover?

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Whenever you are having, say a beam to be supported. This is a slab. So you will have different reinforcements, layers, various rods. So every time to protect these rods from the outside and have enough binding with the concrete you have to keep a minimum cover on the sides. Here, here, here at all points. And this gap is called the clear cover. This has two purposes.

One is to develop the bond strength with the concrete, the plain concrete and secondly to protect these rods from the environment because these are usually iron and they can undergo rusting. So this clear cover is the basic minimum which has to be provided. So where will my aggregates go? If we take another color, we will have our aggregates sitting in these gaps.

So if this is 25 mm then your aggregate size should not be more than that. So that gives the aggregate sizes for general construction, the particles up to 20 mm are allowed. So you will mostly see that these aggregates are 20 mm and below. So I hope that the concept of clear cover, the size of aggregate, reinforcement size and the aggregate are clear to you.

For particles up to 10 mm, these are also coarse aggregates. Where will they be used? They are used in thin sections, thin castings, very thin shells, not so heavy beams. So there is a restriction of flow. The clear cover is 15 mm. For such kind of structures you will have low particle sizes. For castings where Ferro-cement is used, where it has to move through mesh (chicken wire mesh), you will have to go for very smaller size chips, stone chips.

So hope you understood the significance of aggregate size.

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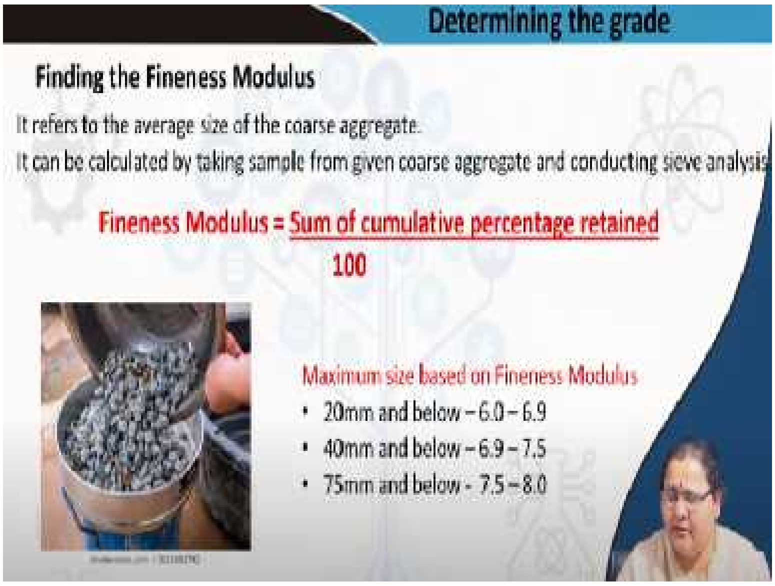

Now we move to another interesting part which is very similar to that of fine aggregate. That is the fineness modulus. How do we find the fineness modulus of aggregate? Because it is not possible for humans to individually measure each of the particles even though they are larger than that of sand. And neither it is as fine as sand, but the principle remains the same.

You have larger size mesh sieve through which you have to pass the aggregate which you have considered. First of all through understanding you have to reject the elongated flaky stone chips by maybe hand picking. But more or less you will get a regular size which has to pass through the sieves and then you have the specific sieve sizes and you are allowed to stay up to 4.75 mm.

So let us see the maximum size based on fineness modulus. For aggregate sizes 20 mm and below you will get a fineness modulus of 6 to 6.9. For aggregate sizes 40 mm and below, it will vary from 6.9 to 7.5. For 75 mm and below it will be higher. And again if you put further larger sizes, this value will be more. The principle of calculation remains the same.

Amount of aggregate retained in each of the tray has to be cumulated and the cumulative percentage has to be calculated. What will happen?

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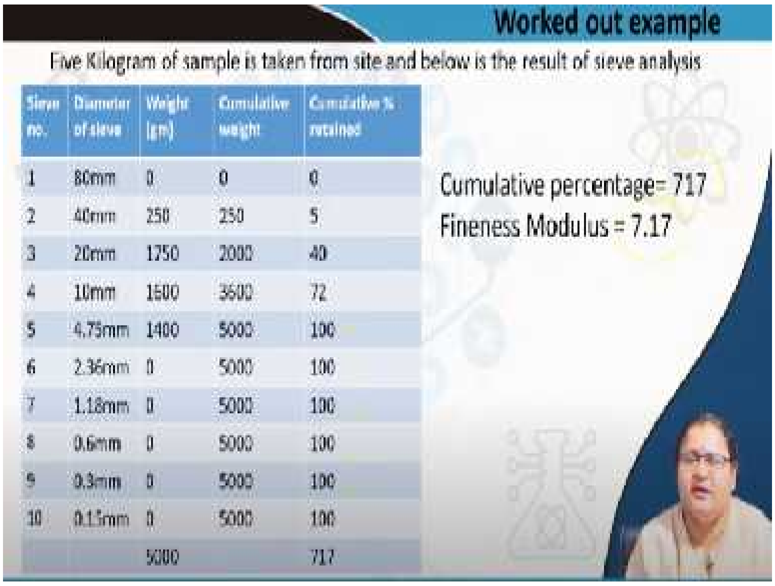

Let us see the example. What will happen? If you see the lower part of this chart 4.75 onwards it has reached the maximum because beyond that it was qualifying for sand. It will be qualifying for fine aggregate. Needless to say this 5 kilogram sample does not have any sand in it. So you are getting 0 as the weight after 4.75 mm sieve size.

So up to 4.75 mm sieve, you are getting your 5 kilogram total. So the 40 mm sieve had retained only 250 grams (g). The 20 mm sieve has retained 1750 g. The 10 mm sieve has retained 1600 g and your 4.75 mm has retained the rest. So what is happening? Beyond this, when you are accumulating they are from here onwards these are all hundred percent.

So you will always add up 1, 2, 3, 4, 5, and 6. So these 6 trays are always going to give you the 600. And the upper part is actually giving the correction, is giving you the value, giving you this 717 which when divided by 100 gives 7.17. See as because there is some granule in the 40 mm sieve, the entire bunch has been qualified as 40 mm and below.

So we should always remember these are giving you the indication, what is the actual, what will be the fineness modulus.

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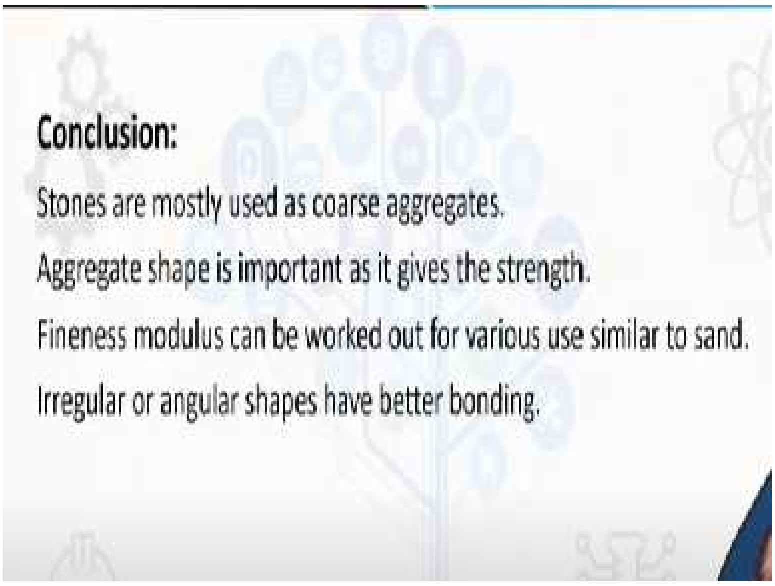

So let us conclude by saying that stones are mostly used as coarse aggregates. Yes, we also knew a few more things which are used of which brick is mostly used other than stone. Aggregate shape is important. Aggregate type is also important as it gives the strength. Fineness modulus can be similarly worked out like that of sand, but here the values are more since the last few trays are not holding any item and it is having a value more than that of the fineness modulus of sand.

Irregular and angular shapes have better bonding than rounded or elongated shapes. So with these, I would close this lecture and in our next lecture, we will move to cement and further more to know more of concrete. Thank you.