Concrete Engineering and Technology
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Lecture - 8
Proportioning of concrete mixes (Part 2 of 3)

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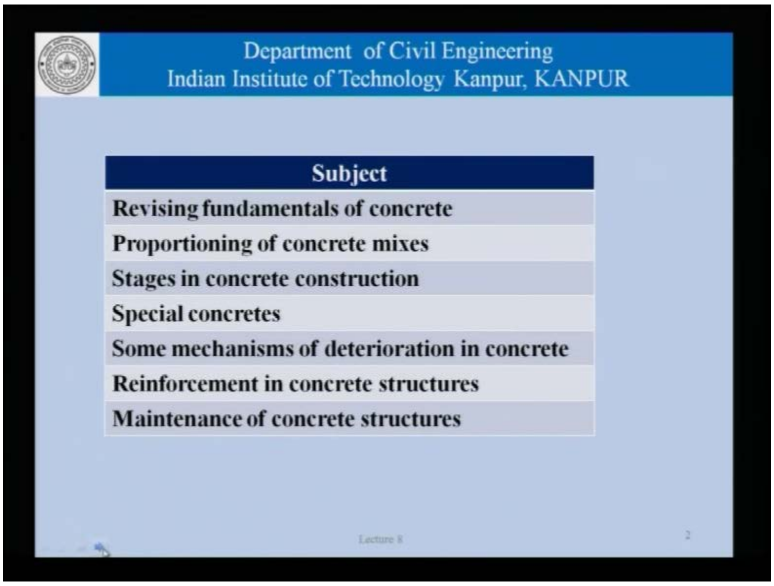

[FL] and welcome back to this discussion on concrete engineering and technology. Here, we are studying fundamentals of concrete proportioning of concrete mixes stages in concrete construction special concretes and so on, and continuing with our discussion on proportioning of concrete mixes. What we will do today is to focus on proportioning of simple concrete mixes that is only those which have water cement fine aggregate and coarse aggregate the mixes. These have other ingredients like chemical admixtures or mineral admixtures, we will take up for discussion subsequently.

Now, before we get started with our discussion on actually proportioning concrete mixes lets quickly go over some of the things that we have done in the past. We have gone through the properties of the basic ingredients of concrete that is cement water fine aggregate and coarse aggregate. We have gone over concrete properties like work ability which is typically measured in terms of slump and compressive strength.

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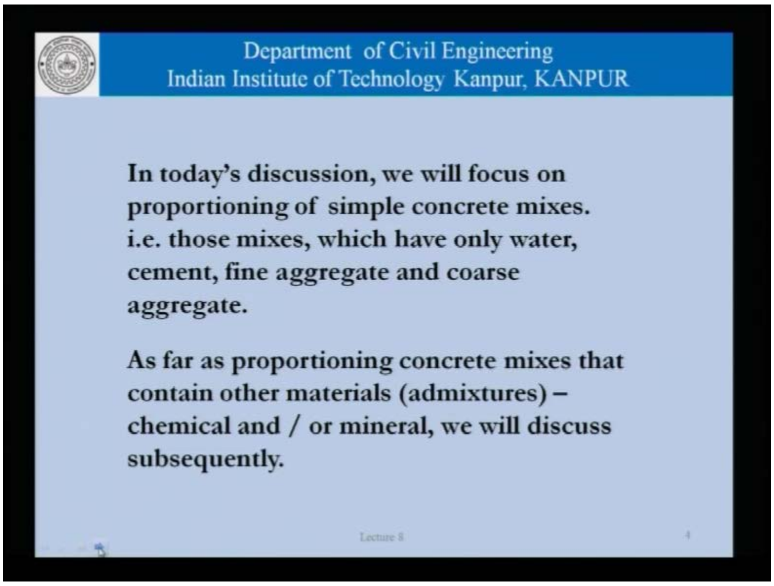

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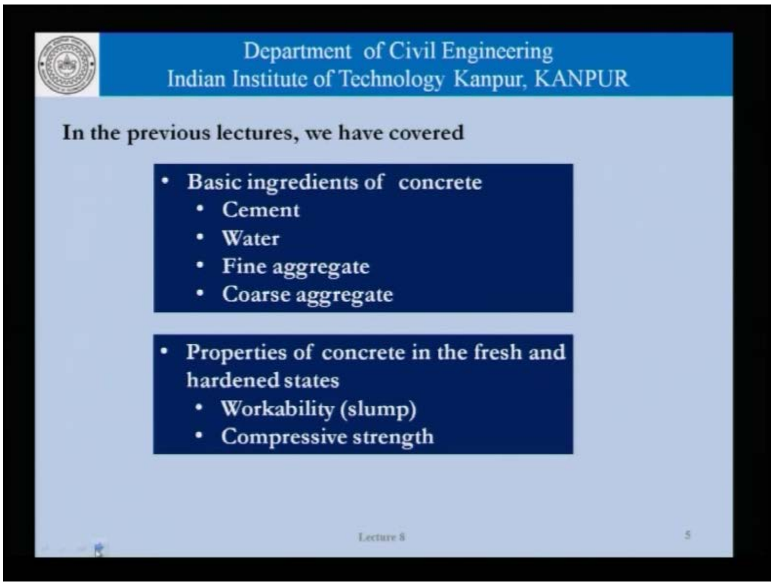

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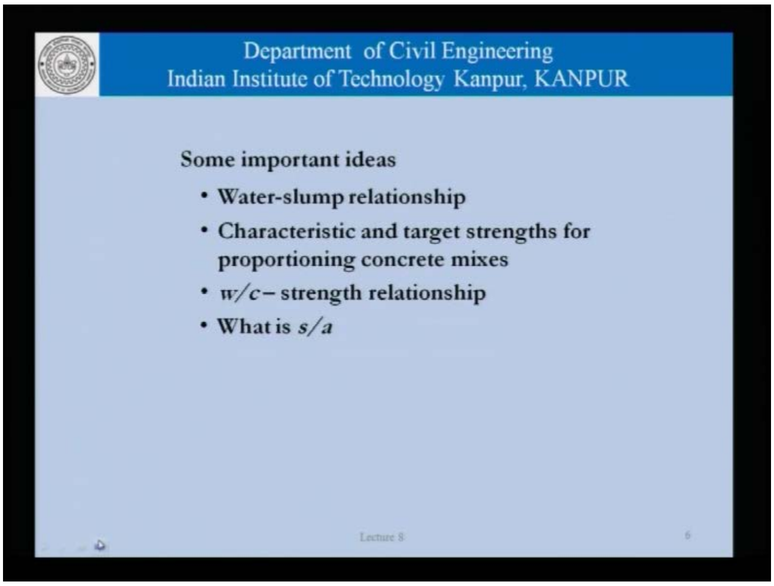

We have gone through some of these very important ideas which govern our proportioning exercise. This is the water slump relationship the characteristics and target strength for proportioning concrete mixes water cement ratio versus strength relationship and the importance of s by a.

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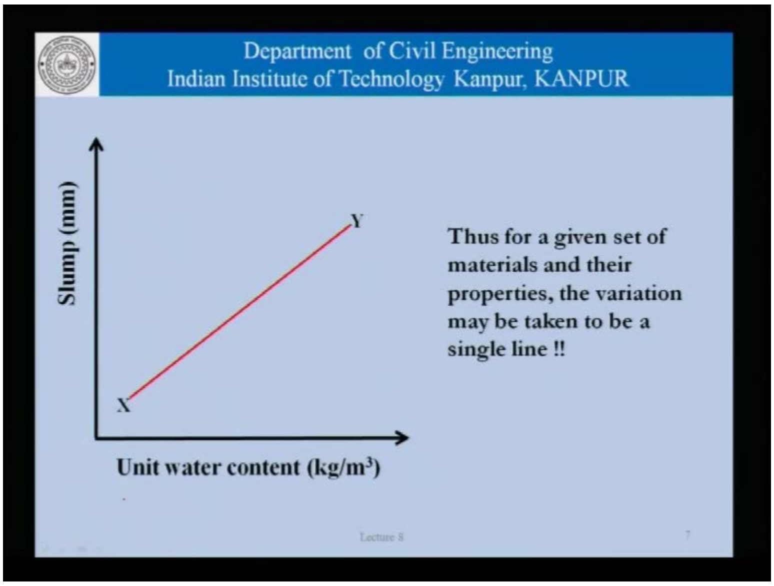

Now, this is the final relationship which we had agreed on slump and unit water content we have said that for a given set of materials. Their properties, the variation may be taken to be a single straight line that is there is a particular variation for slump and unit water content depending on the actual materials being used in a project.

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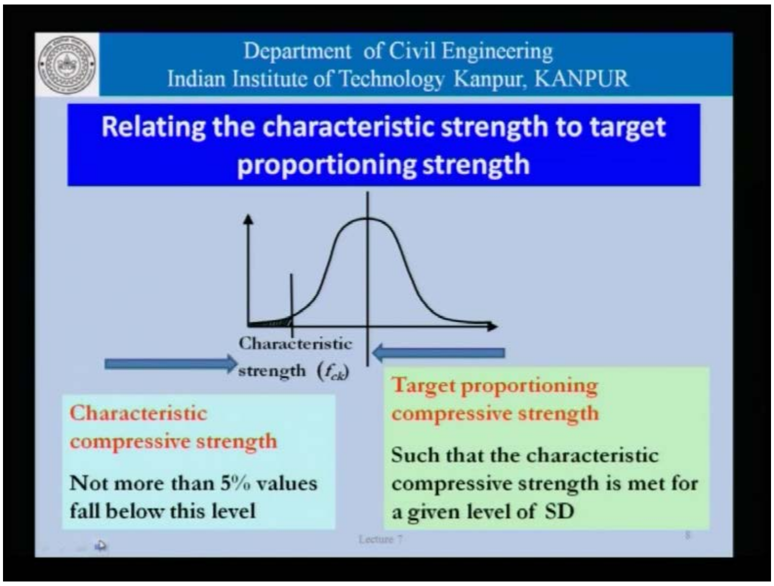

Similarly, when we talked about that characteristic strength versus target mean strength for proportioning concrete mixes. We had said that characteristic strength is what a designers use to design structural elements like beams columns so on. The assumption that he makes is that not more than 5 percent of the values that are obtained in the concrete actually will be lower than this value.

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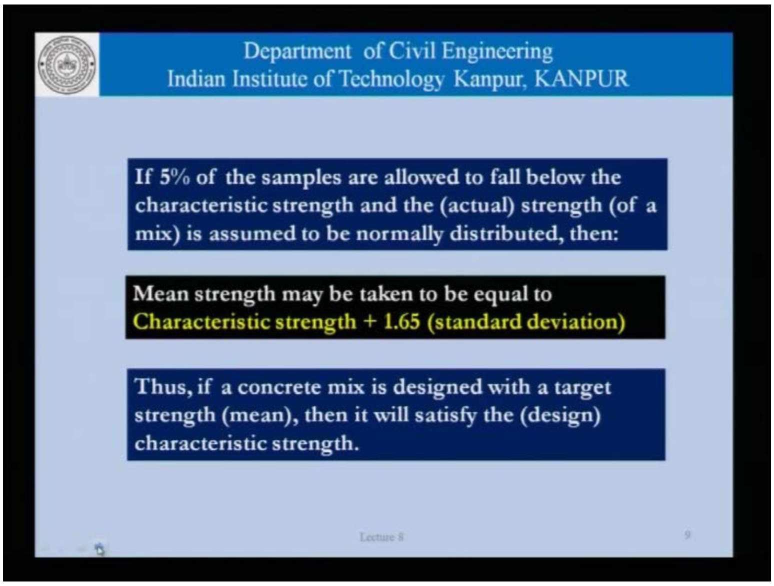

The concrete proportioning has to be carried out using what was called the target proportioning strength of concrete. The target strength of concrete which is basically the strength of the mix that we used and that has to be determined in a manner that the characteristic strength criteria is satisfied.

We had said that if 5 percent of the samples are allowed fall below the characteristic strength and the actual strength of the mix is assumed to be normally distributed. Then, then mean strength may be taken to be characteristics strength plus 1.65 times standard deviation with the factor, 1.65 coming from the fact that we are allowing 5 percent of the samples to fall below characteristics strength. Thus, in other words if a concrete mixes design with a target strength which is the mean, and then it will satisfy the design characteristic strength.

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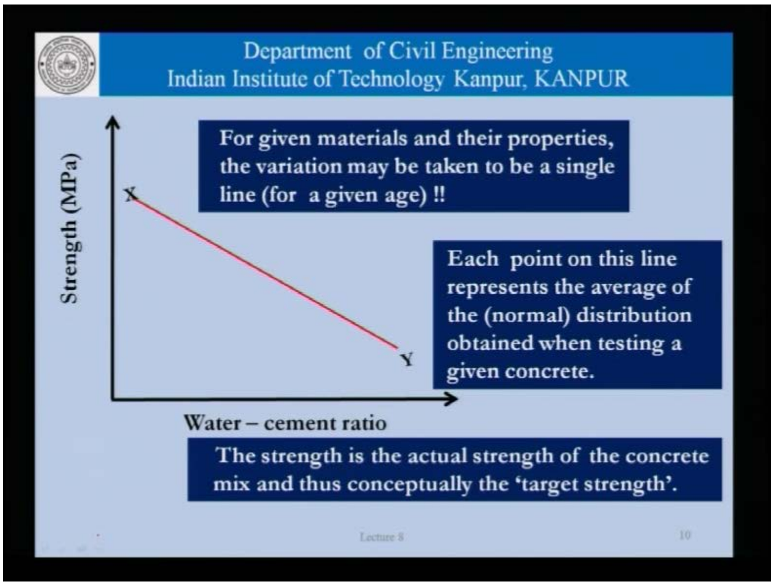

Carrying on, from our previous discussion we had said that much like the relationship between slump and unit content the relationship between strength. The water cement ratio can be taken to be a simple straight line in a manner that as the water cement ratio increases the strength decreases. Each point on the line really represents the mean of the normal distribution of strength that we get when we test a large number of concrete cubes or concrete samples at a given water cement ratio.

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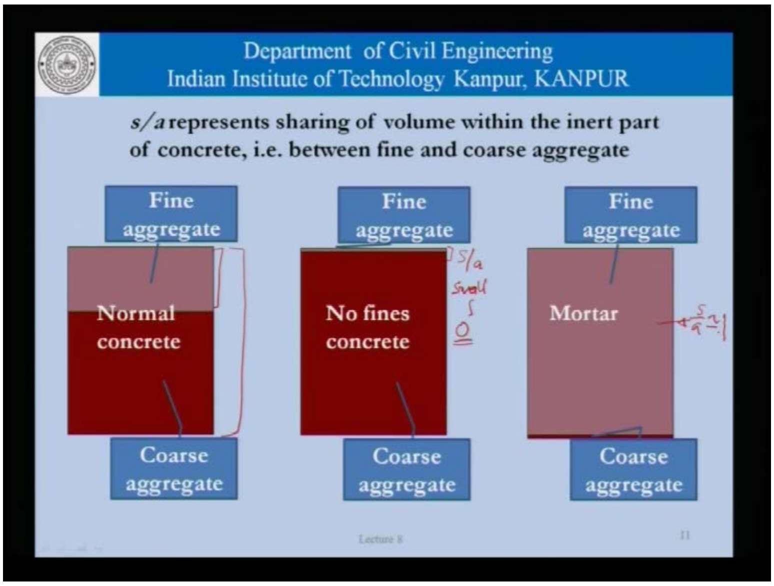

Then, discussing the s by a or the importance of the sand component or the percentage of sand in the total aggregates that is the total inert material, we had said that normal concrete has a certain amount of fines as a proportion of the total inert content. If we go to no fines concrete, we have basically said that s by a will be a very small value, it may be 0 in the extreme case in which case we are talking of no fines concrete. Similarly, on the other extreme we have mortar where s by a is virtually 1 that is no coarse aggregate in the system.

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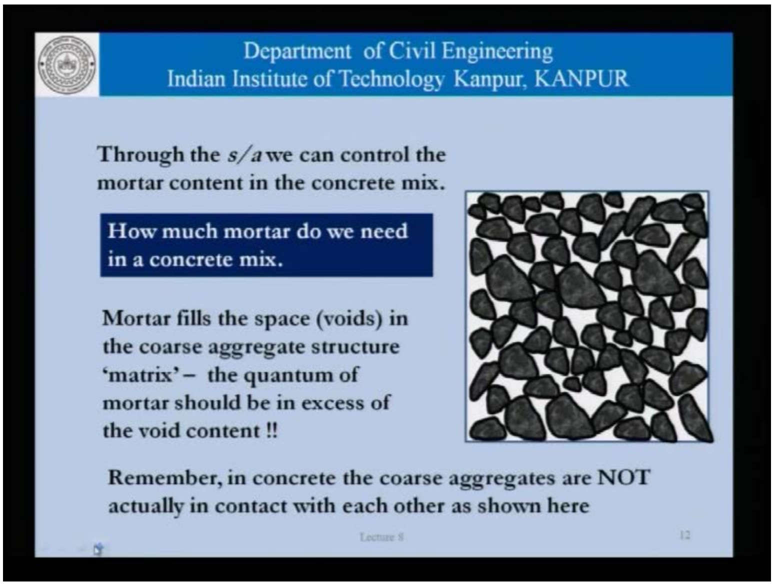

In other words, s by a is used to control the amount of mortar in the concrete mix and how much do we need. How much of mortar, do we need in the concrete mix is determined by the type of coarse aggregate the size of the coarse aggregate, its properties particle size distribution and so on.

Basically, what our requirement is that the mortar should be able to fill all the voids within the coarse aggregates. Not only that, since in concrete the coarse aggregates are not really in contact with each other we have to provide additional amount of mortar so that concrete comes out as a homogeneous mix in a particular volume.

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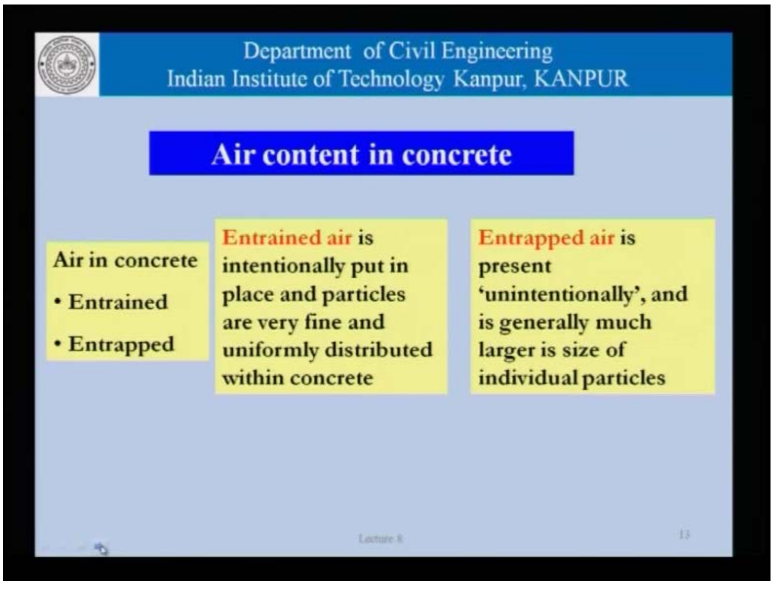

As far as air content is concerned we have talked about it and we have said that air is either entrained or entrapped depending on whether we are talking of air entrained concrete or non air entrained concrete. In the case of entrained air, that part is intentionally put in place and particles are very fine and uniformly distributed within concrete. In this case, entrapped air is present unintentionally and is generally much larger in size as far as the individual air particles or pockets is concerned.

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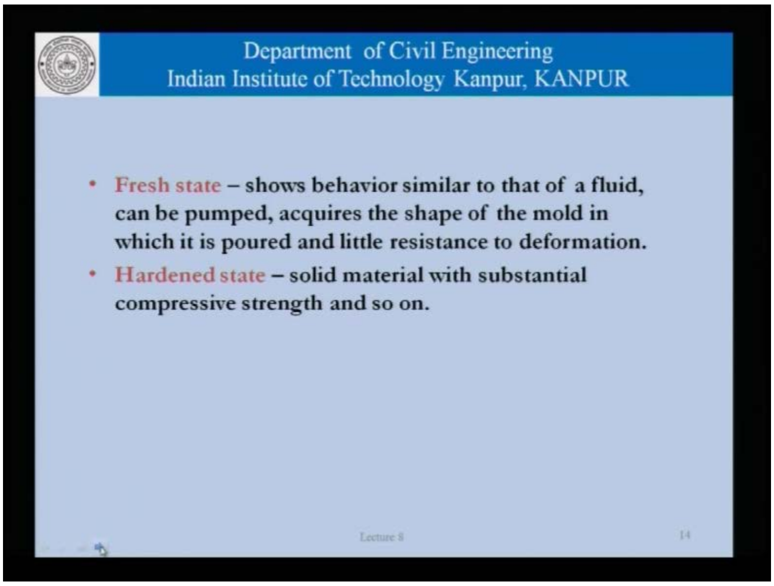

Now, from this recapitulation we move on to our exercise of proportioning concrete mixes where we have to make sure that the concrete satisfies the requirements in fresh state which could show in the fresh state which could be workability and so on. In the hardened state which is strength please recall that in the fresh state concrete shows behavior which is similar to that of a fluid. It can be pumped it acquires the shape of the mold in which this poured and offers very little resistance to deformation.

However, as the hydration continuous and the concrete becomes more and more solid in the hardened state the solid material. That means the concrete has substantial compressive strength, so we have to make sure that mire these properties are satisfied as far as the proportioning is concerned.

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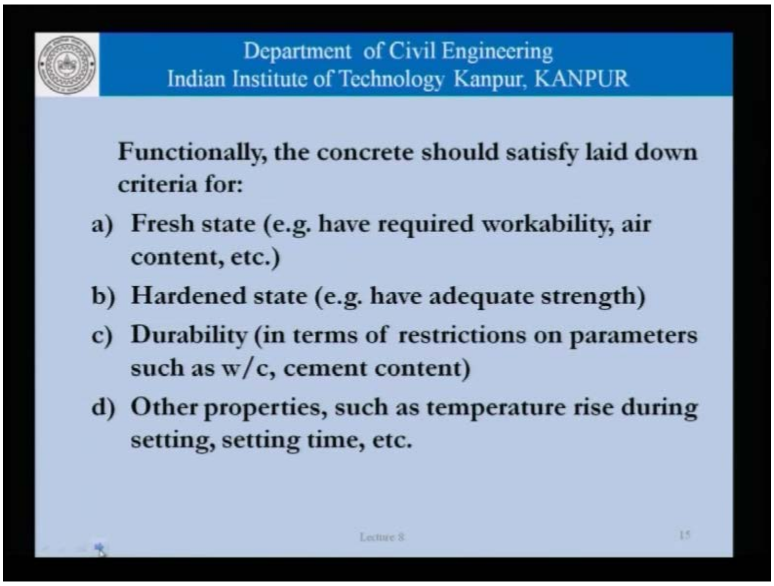

So, functionally concrete should satisfy laid down criteria for the fresh state that is it should have the required workability air content and so on. In the hardened state it should have adequate strength and other than that there could be requirements in terms of durability. For example, it could be in terms of restrictions on parameters such as the water cement ratio cement content. That could be other requirements like somebody may say that the temperature rise that occurs during the hydration process should not exceed a certain number.

The setting time of concrete should not be less than or more than a certain number if I want to explain let us take the example of setting time. Once again in the case that concrete is being used for a there we would expect the concrete to set faster than a normal concrete. Therefore, there can be a requirement that the setting time of concrete should not be more than a certain number or a certain time period.

Similarly, certain cases where we want to prevent the formation of a coal joint that is we pour some concrete there is something needs to be done at site before a concrete is poured, again we want to prevent the formation of that coal joint. We may say that the concrete is not allowed to set in which case the specification will be that the setting time of concrete should be at least a certain number.

Please remember that the setting time of concrete is not really the same as the setting time of cement setting time of concrete is determined in a certain different way which we have talked about earlier when we were talking about the properties of concrete. Remember and recall that to determine the setting time of concrete we removed the coarse aggregates and used mortar and use the principle of penetration resistance to determine that property.

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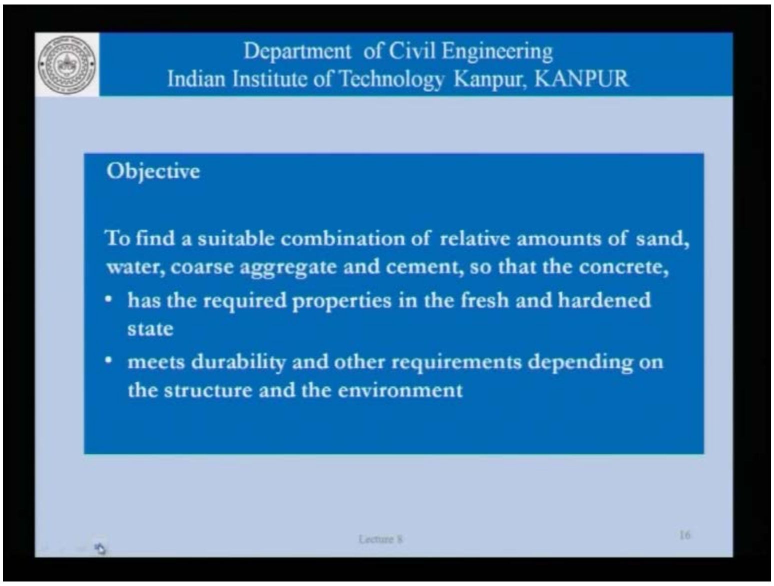

Now, the objective therefore, of the proportioning exercise is to find the suitable combination of the relative amounts of sand water coarse aggregate and cement so that concrete has the required properties in the fresh and hardened states. It meets the durability and any other requirements that may be imposed on the structure depending on the type of the structure or the environment in marine environments certain coarse requires certain maximum water cement ratios. The main force restrictions of certain minimum cement content in certain cases, there may be a restriction on the maximum amount of cement used and so on, so all those criteria have to be met as far as the concrete that we design.

Now, look at this picture once again which is what this course began with concrete as a multiphase material composite as a multiphase composite looks like. This this is the slice of normal concrete modeling this we want to go to this kind of a picture. Here, we say that all these aggregates and sand and cement everything is spherical suspended in a solution of water and suspended in water and so on.

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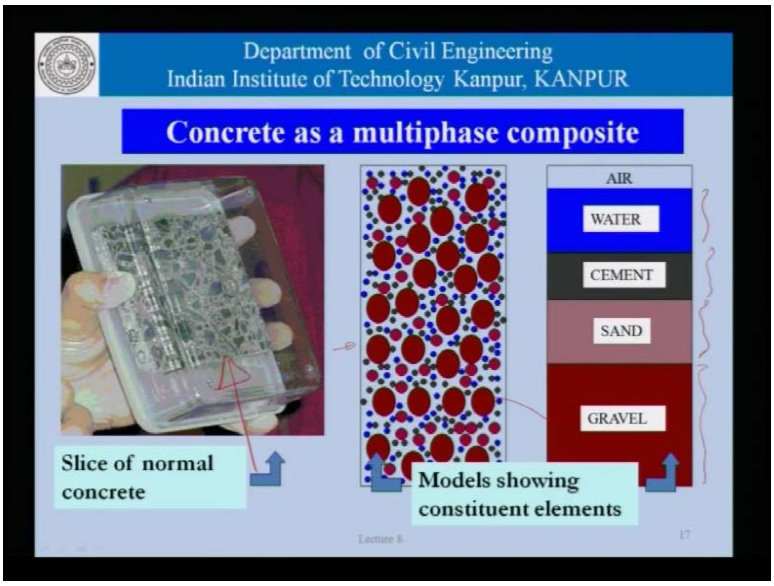

If we lump all these things together, we have so much of gravel, so much of sand so much of cement and water. That is what we have talked about all these while that is we have what we have talked about all these while and now the challenge is to find out the relative amounts of each of these ingredients.

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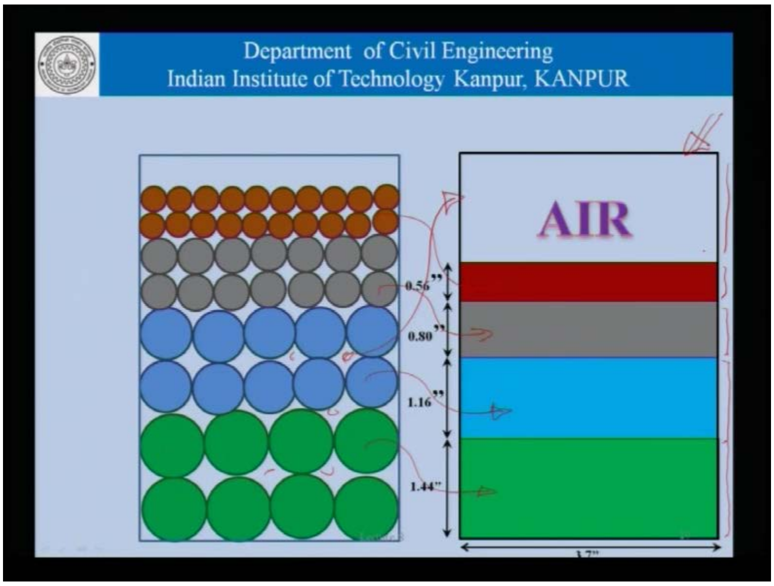

Now, let us look at this picture once again and this is what sand and coarse aggregate and fine aggregate everything looks like. Now, if I was to just run a model which says that I have brought all my coarse aggregate together at one place and it is something like this.

All my fine aggregate is brought here all my cement is brought here all the water is brought here and all this void space at different places is taken to the air, so this is really what proportioning the concrete really boils down too.

So, let us take a look at this animation once again, so you can see how the animation works or what really has the basis for this picture which is a very important picture as far as proportioning is concerned. It really tells us that this is the amount of coarse aggregate that we are using this is the amount of fine aggregate that we are using this is the cement that we are using this is the water and air. Of course, when we do the proportioning we have a certain procedure, we have follow certain step to make sure that this happens.

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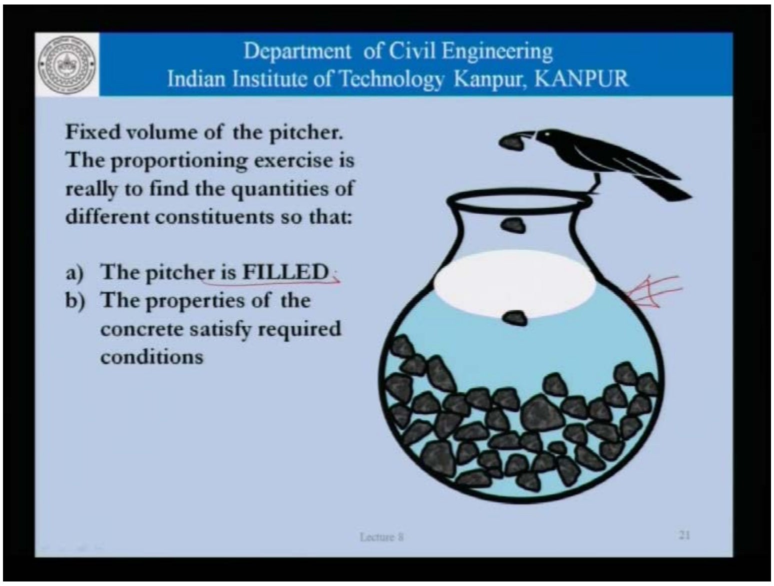

Another important picture that we have for as the proportioning exercise is concerned is this story of the picture and the crow. The importance of this picture is the following in this picture what we have heard all this while is that there is a fixed volume of the pitcher that is the volume of this pitcher is fixed. The proportioning exercise as far as concrete is concerned is really to find out the quantities of different constituent that is sand cement coarse aggregate such that the pitcher is filled.

This is the sum of the volumes of all the ingredients is equal to the volume of the pitcher and the properties of the concrete satisfy the required conditions. We cannot just have water there we cannot just have coarse aggregate there; the combination of the different materials should be such that when they are held together then the concrete satisfies the properties. Also, the sum of the volumes of the ingredients is the same as the volume of the pitcher. Now, to make things easier for us what we do is we work with the one cubic meter or 1,000 liter pitcher and determine the quantity is in kilograms.

We have to determine the quantities in kilograms because determine the absolute volume of coarse aggregate or fine aggregates or cement is a very difficult job. It is much easier to weigh those ingredients and find out the kgs per cubic meter of each of these ingredients. Having said that, we also need to know their specific gravities so that we can convert them we can convert the mass to the absolute volume. Then, make sure that the sum of the absolute volumes is the volume for the pitcher and for sake of convenience; we take the volume to be a cubic meter or a thousand liters.

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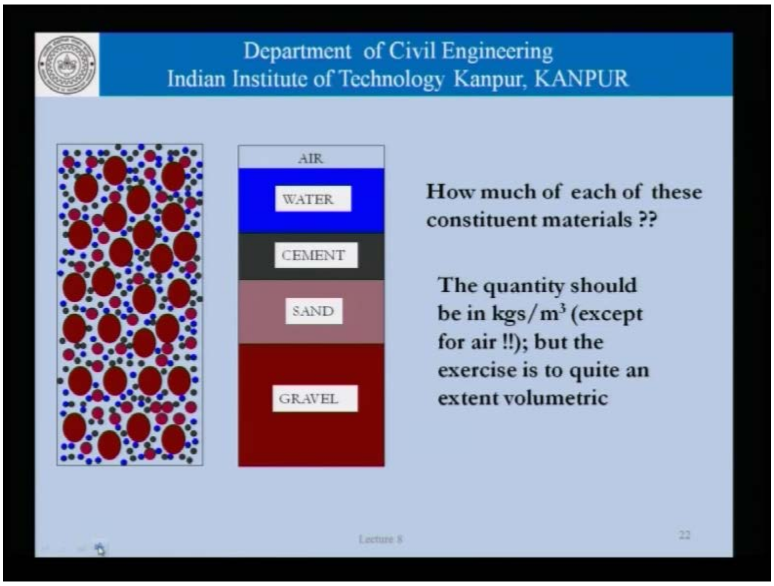

So, this is what we are trying to do we are trying to find out how much of each of these constituent materials is such that the quantities expressed in kgs per cubic meter except for air of course, but the exercise is quite to an extent volumetric. Now, what is the fundamental basis of determining the relative proportions of cement water fine aggregate, coarse aggregate. The fundamental assumptions or the basis is that for a given concrete mix the slump is determined primarily by the unit water content. That is what we were talking about when we talked of and we discussed in great detail the unit water content versus slump relationship.

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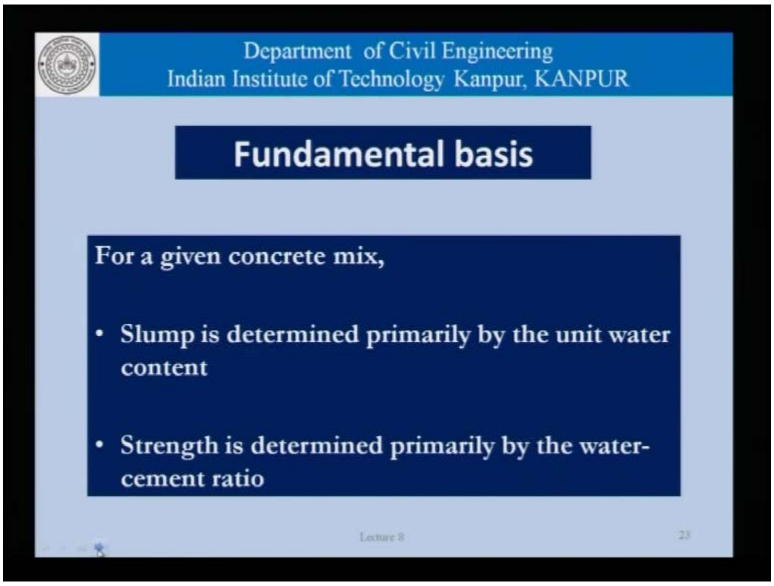

We said that slump or workability of concrete is determined primarily by the unit water content and that depends also on the type of materials being used. Then, the strength is determined primarily by the water cement ratio, so with these two assumptions we actually gets started and carry out the exercise of proportioning concrete mixes.

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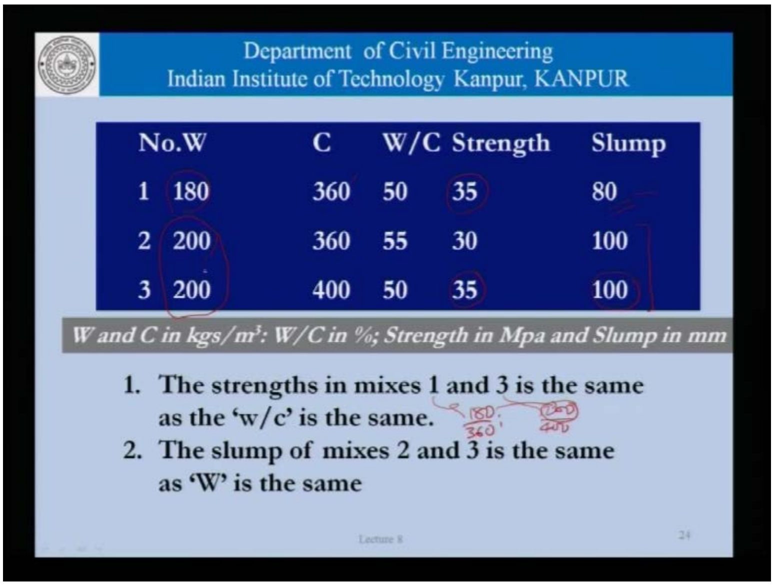

It means in numerical terms as an example is shown here, if we have three mixes 1,2 and 3 and they have water content these values are in k g per cubic meter and water cement ratio is in percentage the strength is in m p a and the slump is in millimeter. Now, if 180, 200 and 200, these are the water contents that we have for these three mixes and the cement content is shown to be 360, 360 and 400 as given here. The water cement ratio for these mixes turns out to be 180 by 360 which is 50, 200 by 360 which is 55 and 200 by 400 which is 500 which is 50 once again.

Now, the assertion is that water cement ratio of 50 percent gives a strength of 35 MPa and 100 and 80 kgs of water a unit content of 100 and 80 kgs of water per cubic meter of concrete gives the slump of 80 mm. Then, what we are stating is that the strength in mix 1 and mix 3 is the same as the water cement ratio is the same. So, water cement ratio in mix 1 is 180 upon 3, 60 which is 50 percent.

In mix 3, it is 200 upon 400, both are 50 percent and therefore, the strength values is the same 35 MPa. However, since the water content in mix 3 is higher than the water content in mix 1, the slump in mix 3 is higher. Let us say 100 mm compared to the 80 mm that we had in mix 1.

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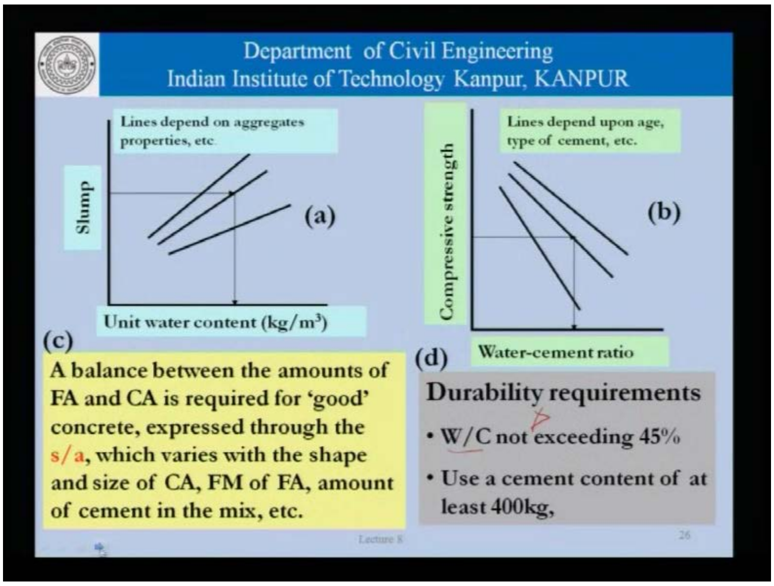

However, continue from that argument the slump in mix 2 and mix 3 is the same as the water content is the same. If you look at mix 2 and mix 3, since the water content is the same that is 200, both these mixes will have a slump of 100 mm of course these values of 100 mm and 50 percent and 35 MPa of strength. These are illustrative values and please do not attach more importance to them than that the principle being emphasizes that the slump is determined primarily by the unit water content and the strength is determined primarily by the water cement ratio.

Now, let us try to look take a look at governing consideration, once again we know that the unit water contents slump relationship is linear and the line could depend on aggregate properties and so on. Similarly, the water cement ratio and compressive strength relationship is again linear and these lines also depend on factors like the age the type of cement the amount of cement and so on. Then, a balance between the amounts of fine aggregate and the coarse aggregate is required for good concrete that is it should have the just the right amount of the mortar.

That is expressed through the s by a, which varies with the shape and size of the coarse aggregate the fineness modulus of the fine aggregate amount of cement in the mix and so on. You will recall that fineness modulus is a single parameter which is representative of the particle size distribution of the aggregate whether it is fine aggregate or it is coarse aggregate.

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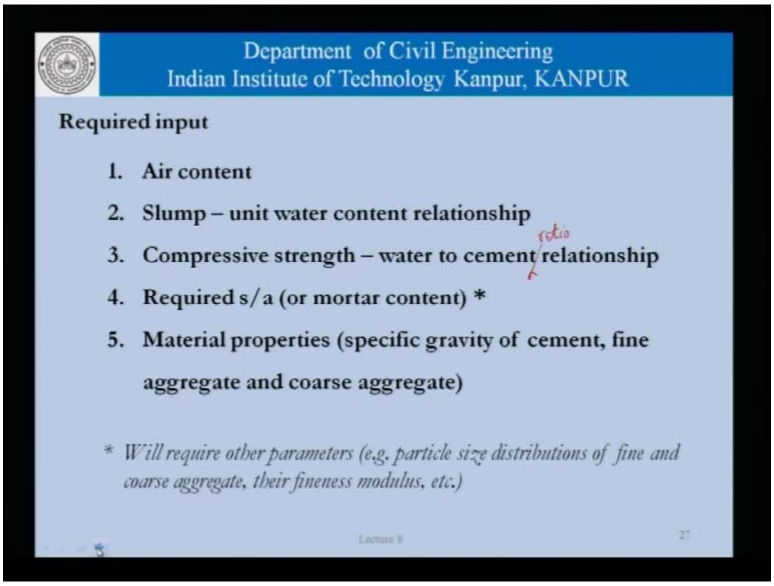

We have durability requirements or any other requirements that may be imposed on the concrete mix in terms of water cement ratio which can be said that it should not exceed 50 percent or 45 percent. Similarly, that can be restriction on the use of cement to be at least 400 kgs per cubic meter or at most 350 kg s per cubic meter and so on. So, with these governing considerations, we proceed to carry out the portioning of concrete mixes that is determining amounts of water cement fine aggregate and coarse aggregate in a concrete mix.

Now, what is the required input based on the air content that we need in the concrete the slump unit water content relationship. This has to be either given or determined for a given set of materials and their properties the compressive strength versus water cement ratio relationship. That again has to be either given or it should be determined in a certain range depending on the properties of the materials being used.

The required s by a or the mortar content which will determine the mortar volume and requires other parameters such as the particles has distribution of fine and coarse aggregate fineness modulus and so on. The material properties per say that is specific gravity of cement fine aggregate and coarse aggregate if we have all this input then we can proceed to proportion of the concrete mix as we shall see.

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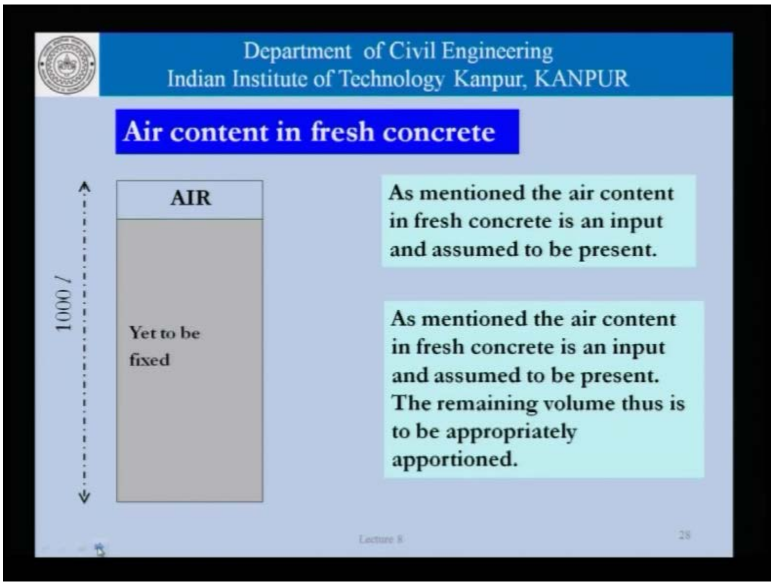

As far as the air content in fresh concrete is concerned that is the first step, so given that we are trying to work with a 1,000 liters that is the pitcher volume the air content in fresh concrete is an input. It is assumed to be known for the present and what we are left with this to fix the remaining volume in the 1,000 liters.

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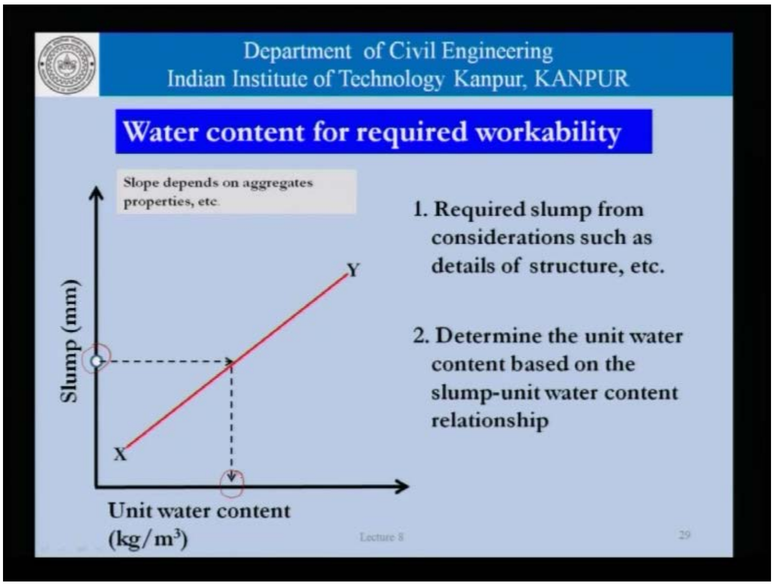

Now, we come to the unit water content in slump requirement, we told we have to know the required slump what is the slump that we need for the particular concrete depending on parameter such as the details of the structure. If the structure for example, has a lot of dense reinforcement we may need that the concrete should have higher slump. If the concrete has to be placed in a structure, which has very nominal amount of reinforcement we may be able to make do with a slump which is very small.

So, somebody has to tell us what is the required slump and once we have that this is the required slump that we are working with we can determine the unit water content based on the slump unit water content relationship in this manner. So, if we know this slump here we know that this is the unit water content that we knew this is the unit water content that we need.

In other words, what we have achieved now is that we knew the air content earlier now we also know the unit water content and for water the density being 1 we can convert from the mass to the volume with relativities. We have fixed the amount of water in volumetric terms the remaining part of the pitcher is still to be determine how much cement will going to it, how much fine aggregate and how much coarse aggregate that is still has to be carried out.

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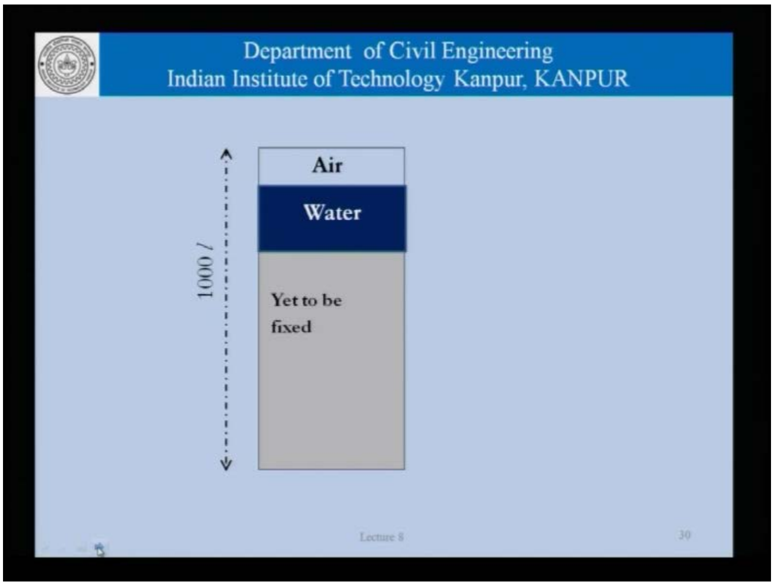

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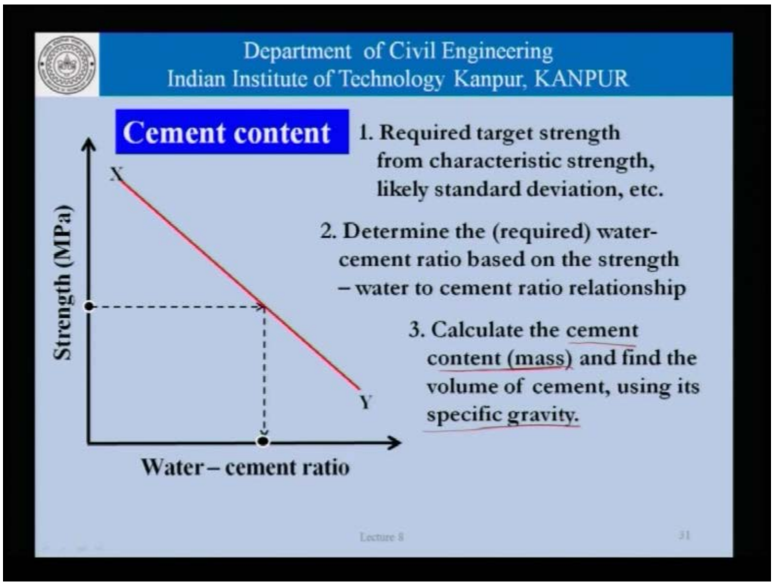

Further act, we now need to determine the cement content and how do we determine cement content we know the strength versus water cement ratio relationship. We need to calculate the target strength from the characteristics strength the likely standard deviation and so on. This is what we have done in a previous exercise and we know how to work with it that is given a target strength, sorry that is given a characteristic strength and the standard deviation we can find out the target strength.

Once we know the target strength then we know how much is the required water cement ratio based on this graph x y or this variation that we have assumed, and we know what the water cement ratio that we need is. Once we know the water cement ratio, we can calculate the cement content because the water is already known to us from the previous discussion on slump.

So, we know the water content we know the water cement ratio and therefore, we know the cement content now please remember that water cement ratio is by mass water cement ratio is not by volume. Therefore, once we get the amount of cement that is the cement content, we really get the mass of the cement that we need in a cubic meter of concrete and in order to convert this mass to the volume we need to know the its specific gravity of the cement.

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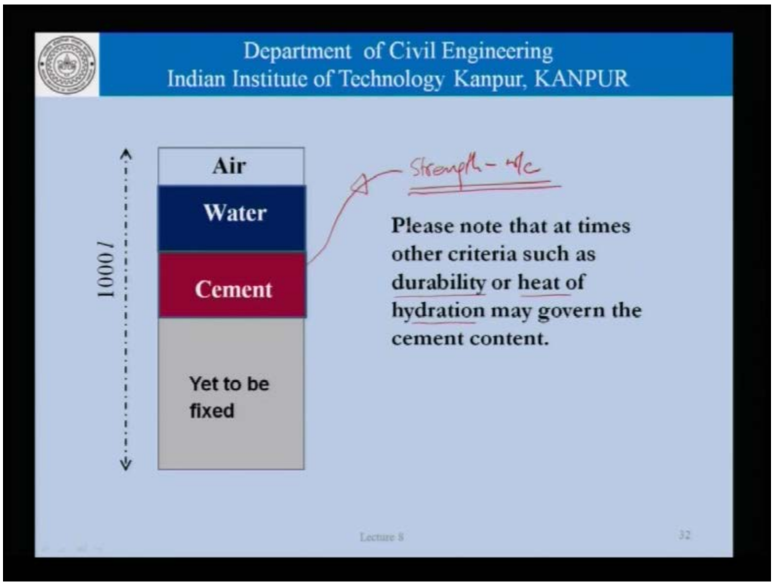

So, going back to that model where we are trying to proportion the thousand liters which is the absolute volume of the pitcher we already knew the air content we knew the water content from the slump water content relationship. We now know the cement content from the water cement ratio relationship with strength the remaining part is still to be fixed.

That is the part which is the inert material, we should remember that this cement content that we determine in this example was coming from the strength and water cement ratio alone. It is possible that other criteria such as durability or the heat of hydration may govern the cement content. So, it may be stated that this cement content that we get from strength may be higher or lower than that permitted or required from durability concentrations in fact that holds for the water cement ratio itself.

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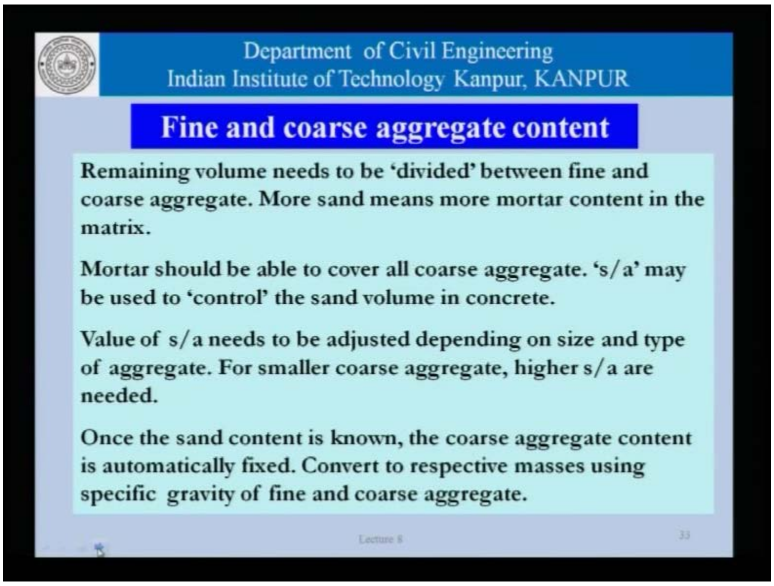

So, we will work with those examples as we go along in this discussion now as far as the determination of fine and coarse aggregate is concerned, what is the crux of the problem? The remaining volume needs to be divided between the fine and coarse aggregates, more sand means more mortar content in the concrete or in the matrix and less sand means less mortar.

What governs the mortar demand the mortar amount or the volume of mortar should be such that it is able to cover allowable the coarse aggregate and sand to aggregate ratio. That is s by a what we talked about is used or can be used to control the sand volume in the concrete depending on the mortar amount that we need.

The value of s by a needs to be adjusted depending on size and type of aggregates for smaller coarse aggregates a higher s by a is needed. If the coarse aggregate is smaller, the surface area of those coarse aggregate that needs to be covered with mortar is higher. Therefore, the volume of mortar is higher this implies that we need to work with higher s by a arguing complete the other side if the coarse aggregate size becomes larger area of the coarse aggregate. That needs to be coated with mortar is lower and therefore, we need a smaller amount of mortar in the concrete mix and in order to get a smaller amount of mortar we need a smaller s by a.

So, with this understanding we have, now once the sand content is known the coarse aggregate content is automatically fixed. We could convert from the volumetric considerations to the respective mass using a specific gravity of coarse aggregate and fine aggregates.

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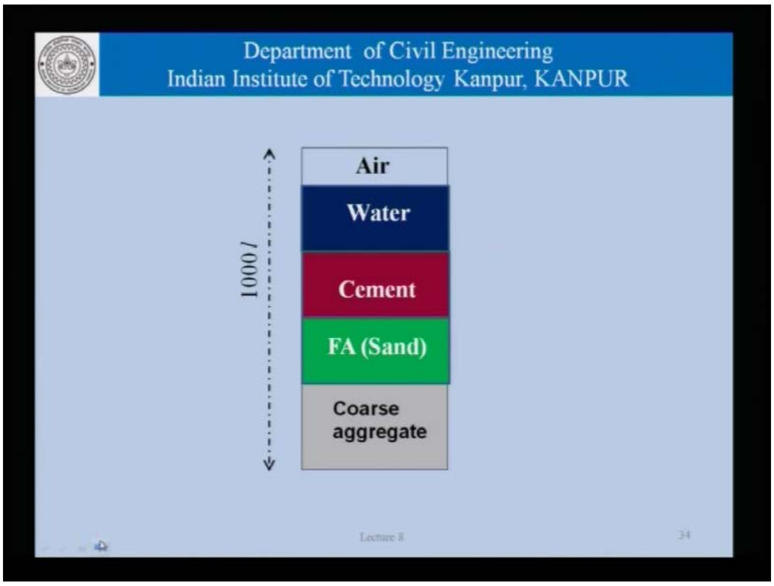

What we have done is that we started with a thousand liters of volume which we need to proportion first of all we fixed air which was a volumetric measure, then we fixed water which was a volumetric measure. Then, we determine the cement by weight converted it to volume and as far as the remaining part of the pitcher is concerned. We divided the sand and coarse aggregate using s by a and we found a fine aggregate content and the remaining part was the coarse aggregate. So, this in principle defines the process or procedure that we follow for proportioning simple concrete mixes.

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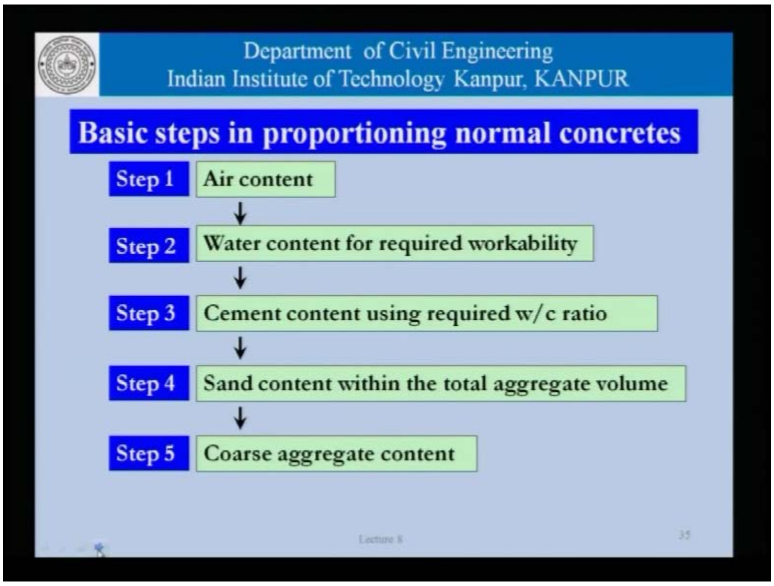

The basic steps once again are to know the air content to know the water content for the required workability the required workability itself is related to the kind of construction that we need to do whether it is a beam or a column with congested reinforcement not. So, congested reinforcement a plain concrete construction for example, in a dam or a very lightly reinforced construction which may be for example, in a pavement and so on.

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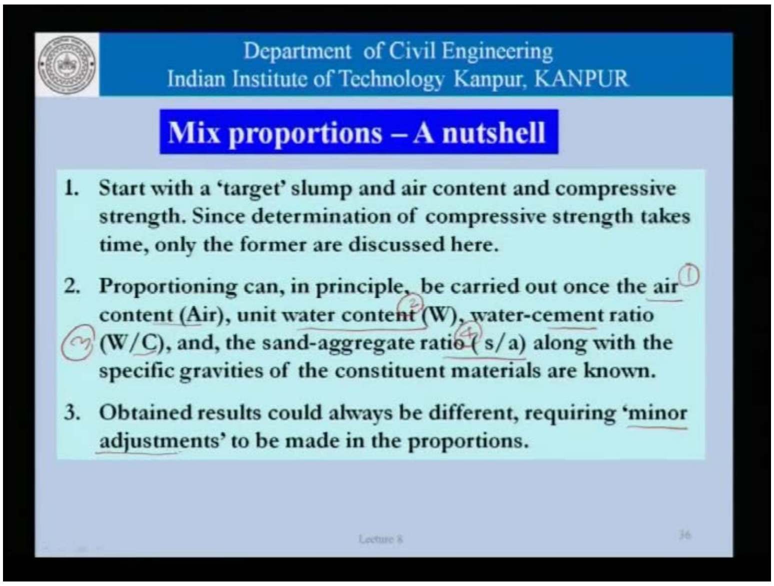

Then, we determine the cement content using the water cement ratio versus strength relationship the required strength itself is determine from the characteristics strength. The standard deviation that we may have as far as the inert content or the volume of the inert materials is concerned that is determined using the s by a concept. We find the sand content within the total aggregate volume and then the coarse aggregate content automatically gets fixed, so this inner nutshell is the exercise of proportioning basic concrete mixes.

We start with a target slump and air content compressive strength since the determination of compressive strength takes time only the former are discussed in this taken a discussion. Here, we work with slump and air content we assumed that the compressive strength issue will be taken care of a new course and if a requirement is there to change the required water cement ratio.

It can also be implemented proportioning can in principle be carried out once the air content the unit water content and the water cement ratio and the s by a, these four parameters 1, 2, 3 and 4.

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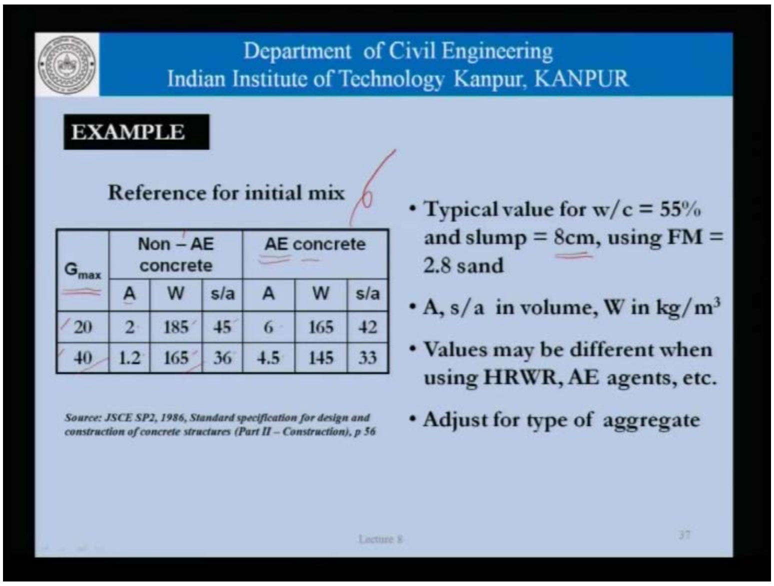

If these four parameters are known, and then the proportioning can be carried out almost mechanically except of course to determine each of this parameters there is a lot of effort that needs to be done. There is a lot of data that needs to be generated there is a lot of understanding that we must have of concrete engineering. Having achieved the proportion as I have described here we will possibly need to make minor adjustments which we will also see in our subsequent discussion in the concrete proportioning that we determine.

Now, let us take up an example a table of the type which is given here is often the starting point where it is stated that for a given size of coarse aggregate, let us say 20 mm or 40 mm whether the concrete is non air entrained or air entrained. The air content will be taken to be two present or 1.2 percent it may be taken to be 6 percent four and half percent whatever it is. The water content that will be normally required would be about say 185 kgs or 165 kgs the s by a maybe 45, 36 and so on. So, these are values which are typically given for a certain condition may be for water cement ratio 55 percent a slump of 8 centimeters with the sand being used having a fineness modulus of 2.8.

Now, as far as these values are concerned the air and s by a is by volume and water is by weight that is it is given in kgs per cubic meter and of course as far as a concrete is concerned. We may need to do chemical admixtures in order to make sure that a certain amount of air gets entrained in the system as far as this table is concerned. I would like to draw your attention only to the fact that once the size of the coarse aggregate increases the amount of water required for that same workability which we are working for example, at 8 centimeters.

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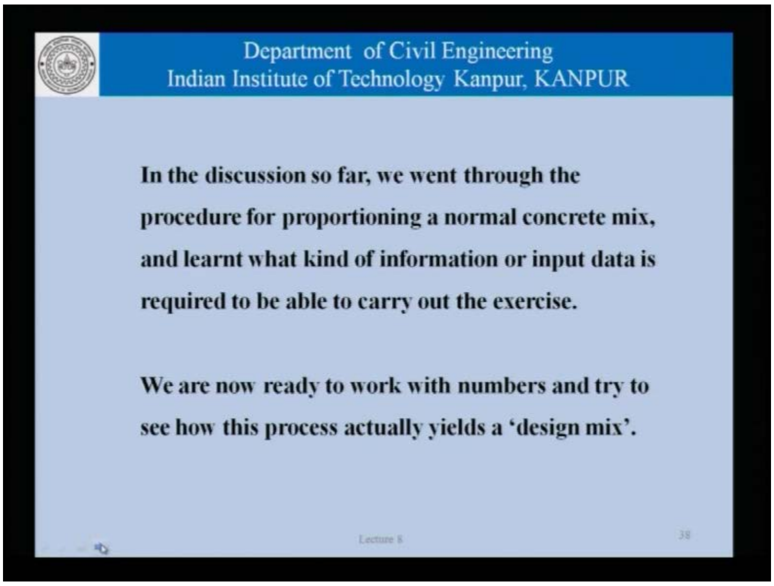

Similarly, much lower that is something which you should keep at the back of the mind and then start proportioning to concrete mix. For a certain set of conditions, this is the starting point that is the reference which can be used to initiate proportioning exercise we need to adjust this particular values for the aggregate type cement type and so on and so forth.

Now, in the discussions so far we have gone through a procedure for proportioning a normal concrete mix and learnt what kind of information or input data is required to be able to carry out that exercise. We are now ready really to work with numbers and see how this process actually yields a design mix. We are now ready to work with numbers and try to see how this algorithm or this process works and gives us a mix design.

Let us take the examples of a little let us take the required basic input for a illustrative example we say that we need an air content of 5 percent a slump 80 mm, we have a characteristic strength of 25 MPa. Expected standard deviation in strength is 3 MPa, the s by a given aggregate characteristics that is the part of the size part of the size distribution of the coarse aggregates and the fineness modulus of the fine aggregate.

The required s by a or a or an s by a with which we would like to start our iteration is 0.36 and the material properties in terms of specific gravity of cement fine aggregate coarse aggregate are known to be 3.1, 2.61 and 2.63. So, with this basic data, we are now going to start the exercise of proportioning a concrete mix.

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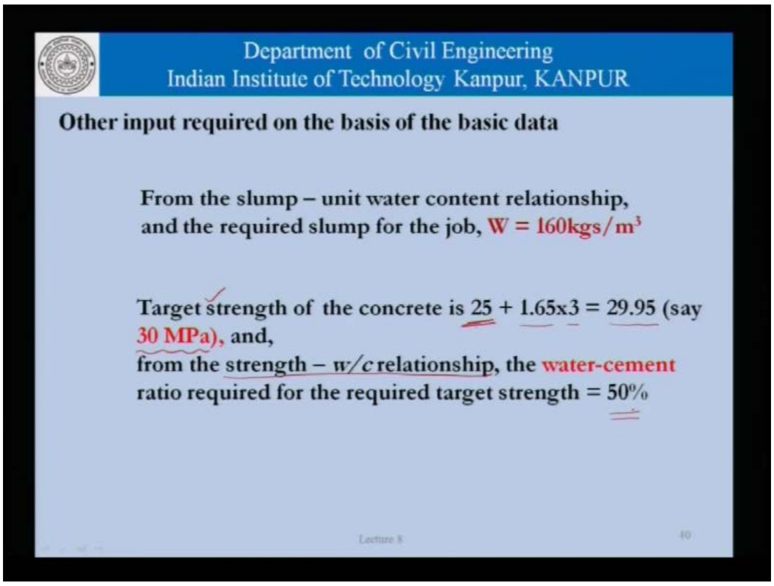

Other input that will be required is from the slump unit water content relationship we need to have water content and let us say that for the required slump the water content is found between 160 kgs cubic meter. Similarly, given that the characteristic strength is 25 MPa and we knew and we are following a model where the target compressive strength is determined using the characteristics strength plus 1.65. The standard deviation we get 29.95 or 30 MPa as the target strength and from the strength water cement ratio relationship the required water cement ratio for this concrete is let us say 50 percent. So, that is the data which we have to have in addition to the basic requirement.

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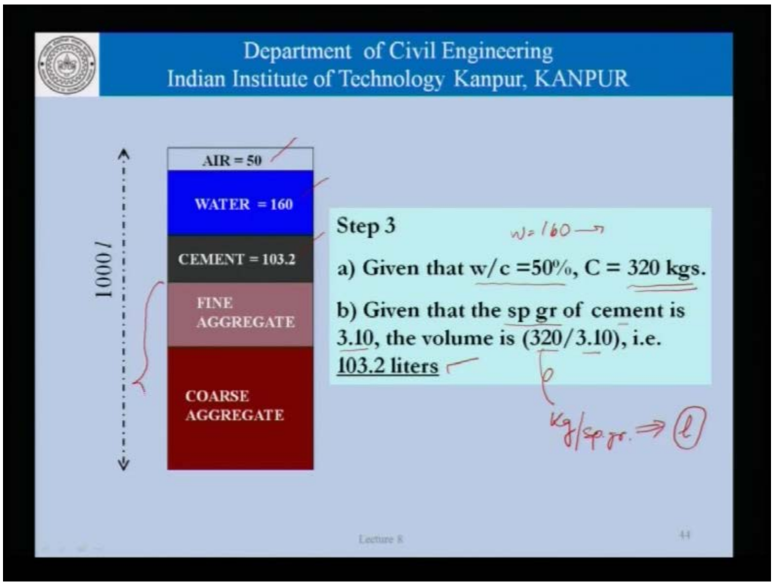

That was in the previous slide and with this information we are now going to embark upon the process of determining the relative volumes of air water cement fine aggregate and coarse aggregate as we have been doing. Now, the first thing that is given to us is that that is 50 liters of air given that the air content is 5 percent by volume 1,000 liters of the volume of the pitcher.

We have 50 liters of air in the system that is we know that there is 50 percent or we know that there is fifty liters of air in the concrete continue from there. We know in the second step that we need a 160 liters or 160 kgs per cubic meter of water from the unit water content versus slump relationship and for the required slump. That is we have the air content fixed and the water content known, so we have fixed 160 liters of water per cubic meter of concrete.

Continuing from that point, we go to the third step where we are now also given that the water cement ratio is 50 percent by mass which means that given the fact that we are using a 160 kgs of water, we have 320 kgs of cement. Further, since the specific gravity of cement is known to be 3.1, the volume that is the absolute volume of the cement that we have is 320 divided by 3.1 which is the 103.2 liters.

I am leaving it to you as an exercise to convince yourself that the amount of cement given in kgs divided by the specific gravity will straight away give you liters of the material that I am leaving out. What we are getting now from here is that we have 50 liters of air, 160 liters of water and 103.2 liters of cement in the system or in that particular concrete what is left is this volume.

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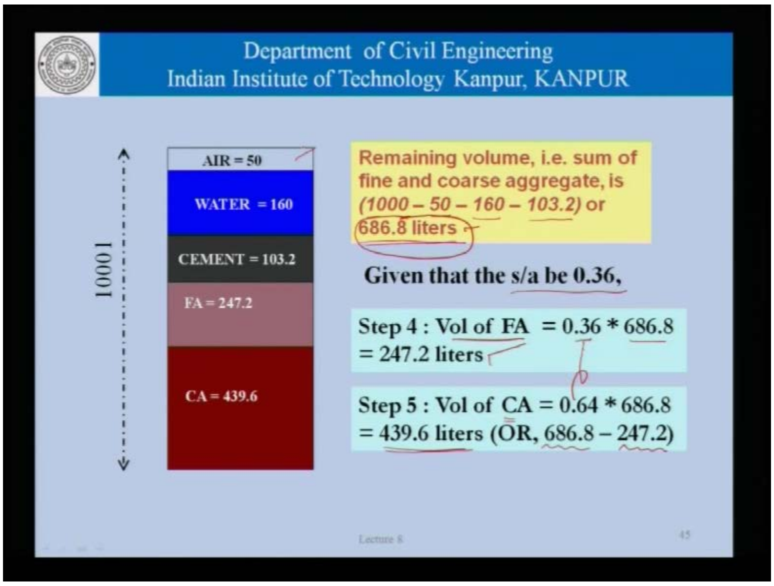

This means that the remaining volume that is sum of the fine and the coarse aggregate which is a 1,000 liters that is what is the total volume this is the volume of the air volume of water volume of cement. The total volume for inert material left to us is 686.8 liters and this has to be proportion in the fine aggregate and coarse aggregate given that the s by a is 0.36, the volume of the fine aggregate is 0.36 multiplied by this volume that we have for all the inert material.

We get the volume of fine aggregate to be 247.2 and the volume of coarse aggregate can be either determined by saying that that is the remaining volume that is 1 minus 0.36 is 0.64 times the total volume which is this amount of volume for coarse aggregate. We could simply say that this was the total amount of inert material available to us and out of that 247.2 was a sand content and therefore, 686.

Therefore, 439.6 is the volume coarse aggregate pictorially represented, this what we have achieved. We have the concrete which will have 5 percent of air that is 50 liters of air a 100 and 60 kgs per cubic meter of water 100 and 3.2 liters of cement 247.2 meters of fine aggregate and 400 and 39.6 of coarse aggregate. That is the absolute volumes of different ingredients as far as the concrete is concerned.

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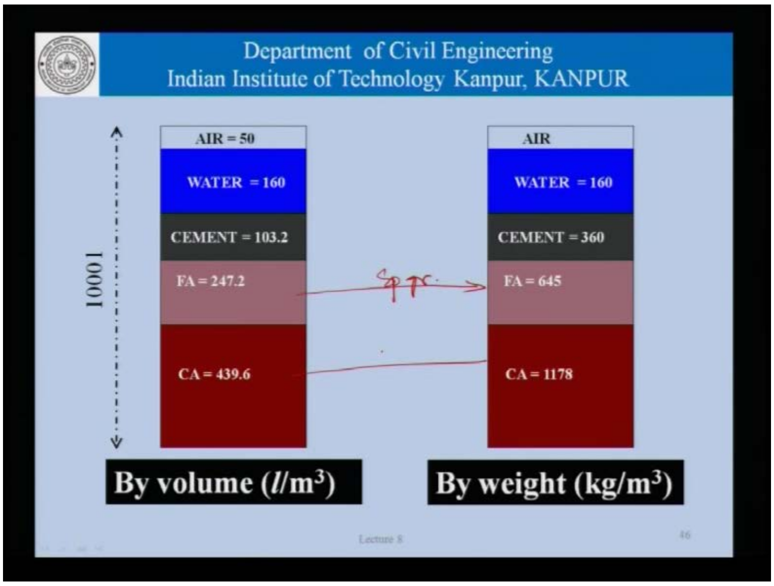

Now, we can convert all this which was by volume to mass that is we multiply this by the specific gravity here and we get 645 kgs per cubic meter of fine aggregate. Similarly, we multiply this specific gravity of coarse aggregate which was supposed to be 2.63, we get 1,100 and 78 kgs per gram, and we get 1,178 kgs per cubic meter of coarse aggregate. We could convert all this calculations that we have done to a final figure which will give us 50 liters of air 160 liters of water, 100 and 3.2 liters of cement, 247.2 liters of fine aggregate 439.6 liters of coarse aggregate.

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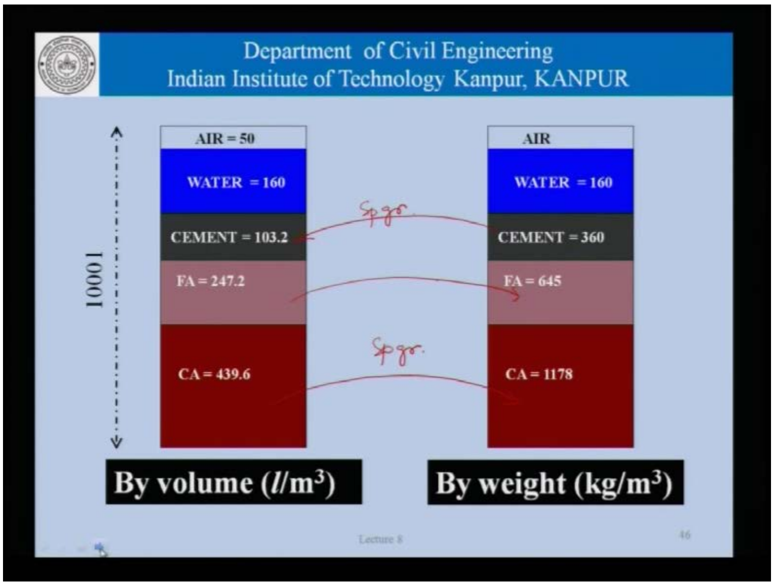

We can convert all this volumetric to the mass and say that the concrete will have 50 liters of air, 160 kgs per cubic meter of water, 320 kgs per cubic meter of cement, 645 kgs per cubic meter of fine aggregate and 1,178 kgs of coarse aggregate per cubic meter. What we have really done is converted these volume to this mass using specific gravity and in the initial part we went from here to here. From the mass of cement that we determined for a given water cement ratio, we determine the volume of cement again using the specific gravity, so that is what has been the outcome for the day.

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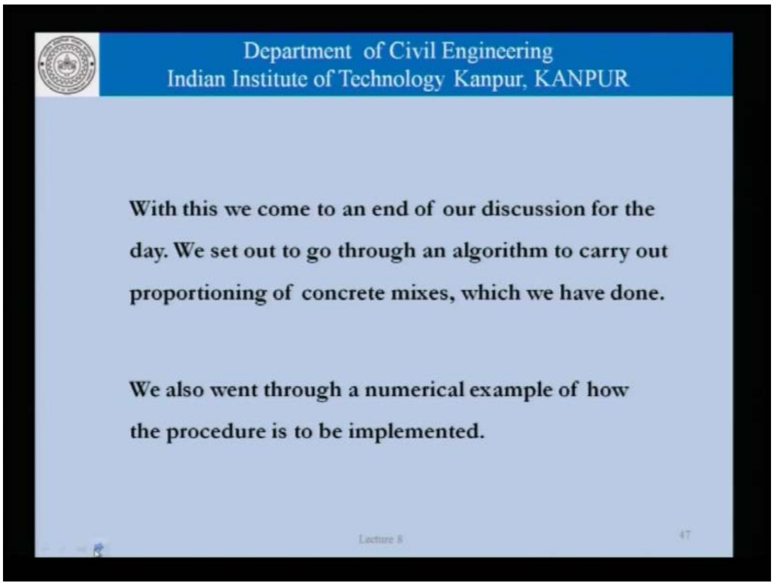

Here, we have tried to understand the algorithm to carry out proportioning of concrete mixes and we have also gone through the numerical example of how the procedure was actually implemented.

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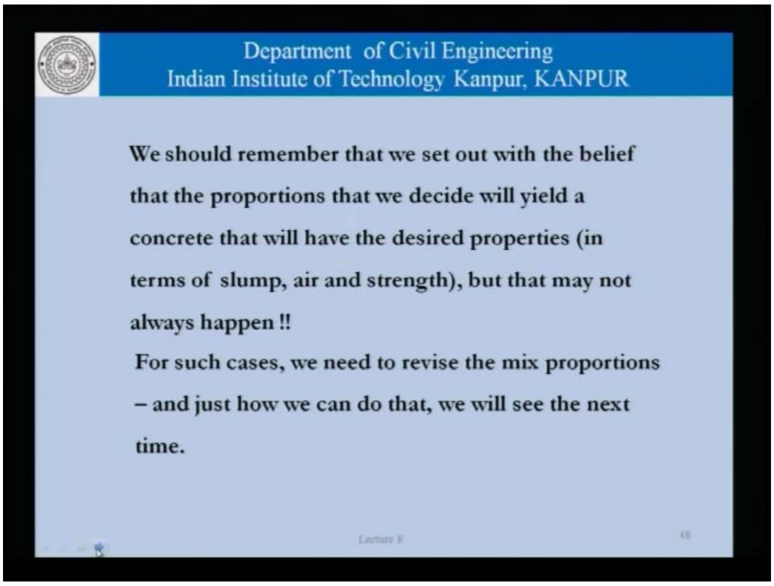

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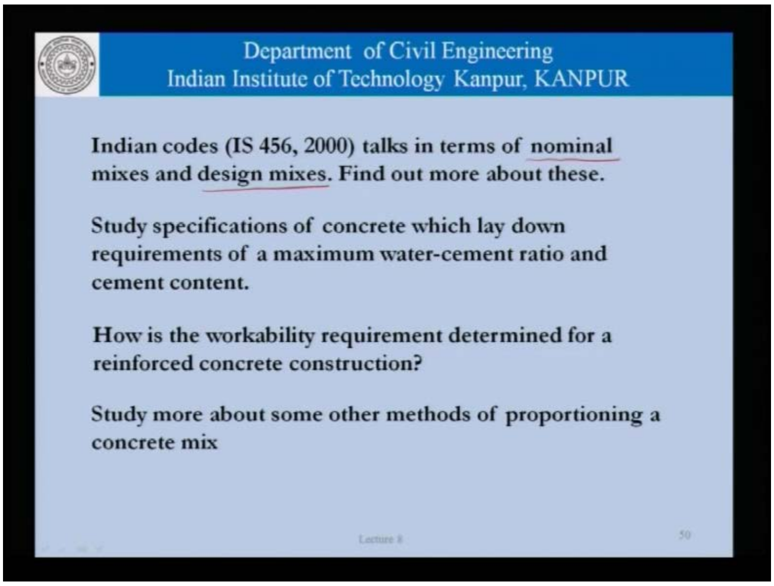

Now, before we close the discussion we should remember that we set out with the belief that the proportions that we decide will yield. The concrete that we make will have a desired properties in terms of slump air and strength, but that may not always happen for such cases we need to revise the mix proportions and just how we can do that we will see the next time.

Having said that, lets go back to recapitulate the few things and do some work on our own Indian codes for example, IS 456, 2000 talk in terms of a nominal mix and the design mix. I would like you to find out more about these, what is the nominal mix what we have done today, these are procedure for designing concrete mixes.

I would like you to study specifications of concrete which lay down the requirements of a maximum water cement ratio minimum cement content or a maximum cement content. We can better understand what are the kind of conditions or applications of concrete construction where such restrictions are imposed on the concrete in terms of its constant materials. How is the workability requirement determined for a reinforced concrete construction, I did mentioned that if we have congested reinforcement we would need a concrete with a higher slump, but that statement needs to be quantified and different specifications of world help us determine.

This actual slump requirement for a given level of density of the reinforcement in the concrete construction which is measured in terms of kgs of steel per cubic meter of a concrete. We would like you also to study a little bit more about some other methods of proportioning of concrete mix. Then, we have to run here which was a simple method based principally on volumetric though we converted the volumetric to a mass based discussion at the end and with that we content me to an end for today’s discussion.

Thank you.