Concrete Technology
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Lecture - 8
Properties

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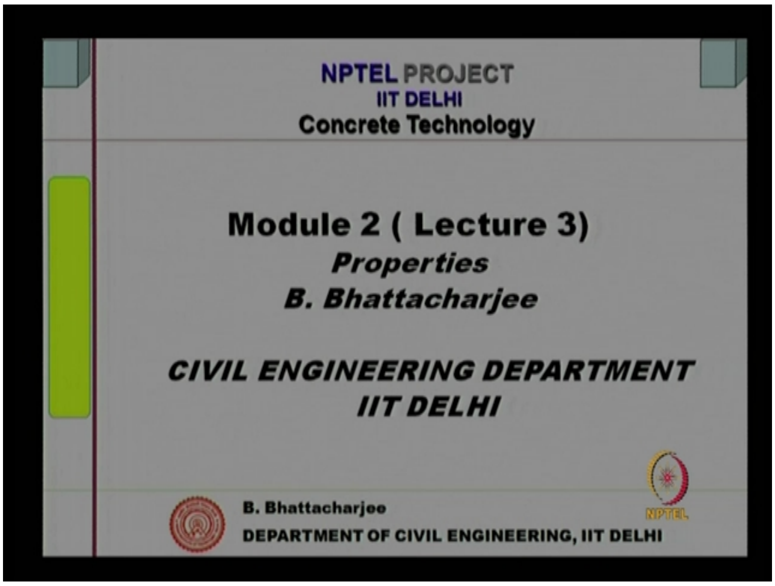

Welcome to module 2 lecture 3

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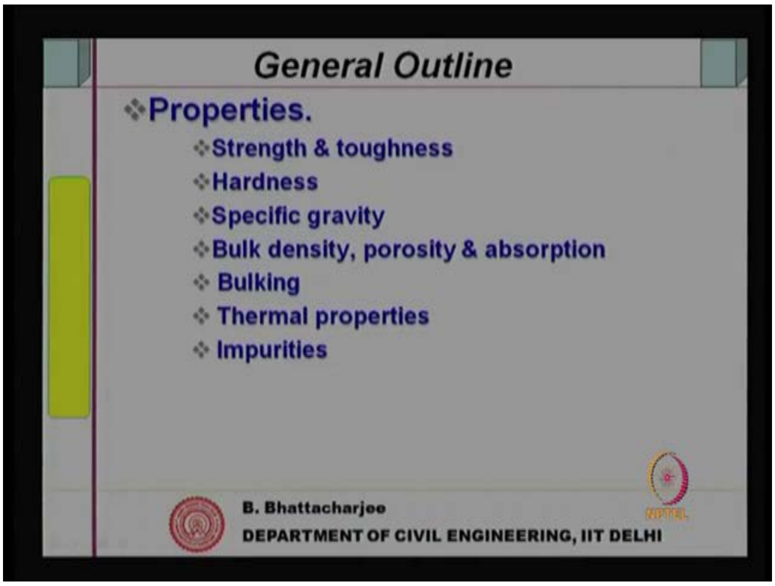

Will continue from where we have finished in the last class, that is in the last class we talked about fineness modulus at the end. And surface modulus will define today in addition to this will look into properties of aggregate namely strength, toughness, hardness, specific gravity, bulk density.

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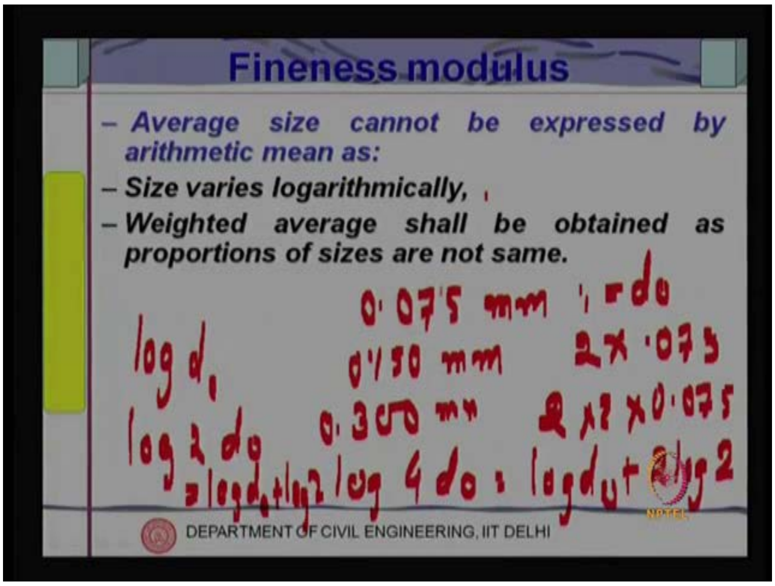

Porosity etcetera thermal properties and impurities and last we look into aggregate blending. So let us look into fineness modulus if you recall yesterday or last class we are talking about average size you know transcription of aggregates. How do you describe one way is the grading that we have mentioned, in which you talk of proportion of aggregate in each size group which we represent by square seems. So proportion in each size group that is what one of the ways of representing the aggregate size distribution see, when are through seven analysis we determine that and another way of single through a single parameter describing the aggregate's.

Is in terms of what is known as fineness modulus. Similarly, surface modulus is another characteristics. So, fineness modulus let us look at it first you know first of all average size cannot be expressed by arithmetic mean. So you cam size you cannot express it by arithmetic mean because sizes varies logarithmically size varies sizes vary logarithmically right? Ship sizes vary logarithmically in other words, it actually where is in geometric proportion like minimum size is let us a 0.075 m m. Next size is double of it

150.15 m m or 150 micron then would be 300 micron or 0.3 millimeter and so on so you can see that.

This is 2 into 0.075 this is 2 into 2 into 0.075. So it where is in geometrical proportion geometrical progression it varies in geometrical progression. So if you take you know if you take log, log of the sizes log d. Let us say d 0 let me call this as d 0 this is d 0 log d 0 this will be log d 0 this will be log of 2 d 0 and this will be log of 4 d 0. So there is a you know in log scale there will vary in arithmetic progression because every time you are increasing d log d 0 plus log 2. So this can be written as log d 0 plus log 2.

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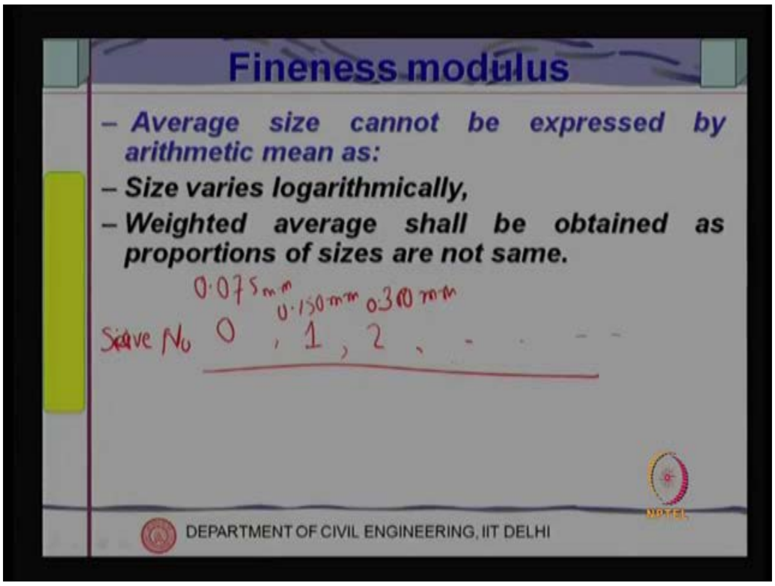

This will be written as log d 0 plus 2 log 2 and so on so it varies in arithmetic progression in logarithmic scale right. So sizes varies is in geometrical progression and therefore it varies logarithmically. So when we talk of size when we talk of average size we do not talk of average particle size but, what we talk of is average sieve number and fineness modulus actually presents average sieve number average sieve number. What we can do is we can define we can define sieve numbers as for example 0 sieve number sieve number 1;sieve number 2 etcetera, etcetera. So this may corresponds to 0.075 m m this may corresponds to 150 m m sieve number, so this is sieve number.

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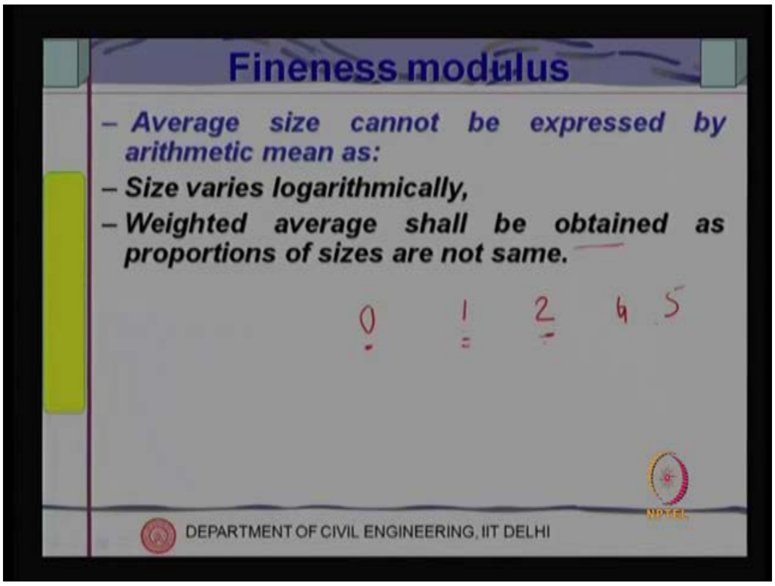

This is you know sieve number sieve number 0; 1; 2 300 0.1 0.300 m m sieve number 2 etcetera, etcetera. So I can talk in terms average sieve number. So if it is 3 you know average value is 3.5 which would mean that the average sieve number is 3.5. So that is what we do weighted average. So we find out average sieve number and fineness modulus represents actually average sieve number.

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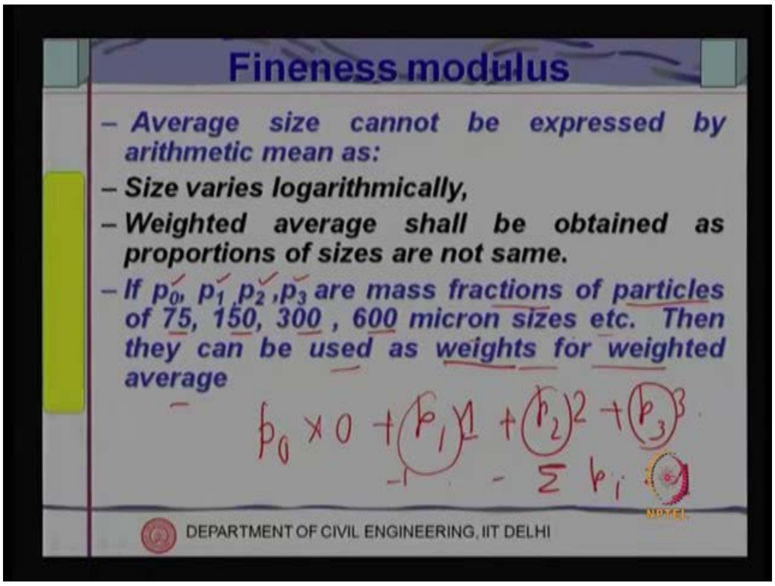

So we find out weighted average as proportions of particles in a given size are not same you know for example, proportion in sieve numbers 0; proportion in sieve number 1;

proportion sieve number 2 or sizes corresponding sieve size. I mean particle size 0 size number 0; size number 1; size number 2 proportions will not be same.

So therefore if they are same then my average would always be for example, if there are 5 sieves 4 5 average would have been simple some total of all of this divided by 5 but, actually proportions on on this ones are not same. Therefore, we talk in terms of weighted average so if we know p 0; p 1; p 2; p 3 etcetera as a fractions of particles in 75, 150, 300, 600 micron sizes etcetera. Then they can be used as weights for weighted average. So p 0 is the proportion, so p 0 into 0 plus p 1 into 1 plus p 2 into 2 etcetera etcetera p 3 into 3 and so on.

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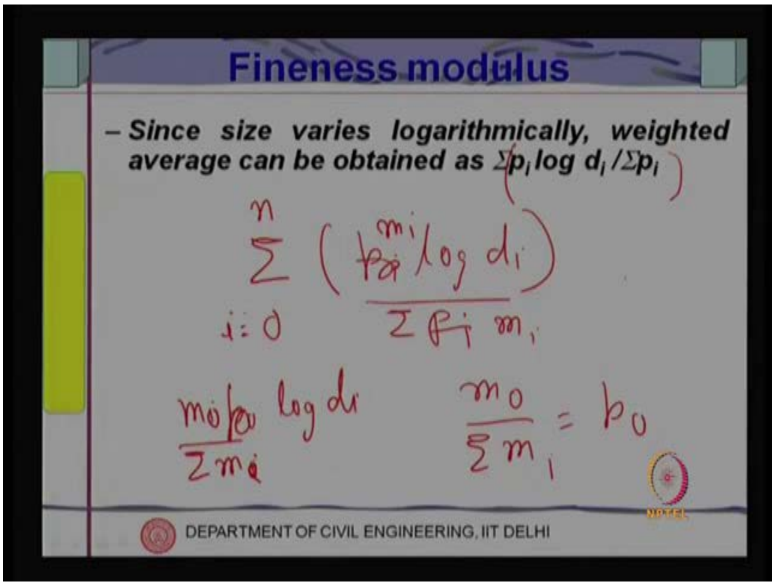

I can sum this up and this sum would nothing but, the weighted average because this are the fractions of the mass in corresponding to 0 size the 0 number size corresponding to first size, second size. So 0 size, 1 size, 2 size, 3 etcetera etcetera. Since these are fraction of the total mass fraction therefore they represents weighted average. So there used as weights for weighted average right they are fraction. So some total of p 0, p 1, p 2, p 3 p 3 sigma p I is equals to 1 sigma p I is equals to 1 therefore, this represents nothing but, weighted average sieve number weighted average sieve number, if I start my numbering from 75 micron or 0.075 millimeter itself. So, fineness modulus is that so, fineness modulus since size varies logarithmically weighted average can be obtained as sigma of the whole thing actually there is a bracket here.

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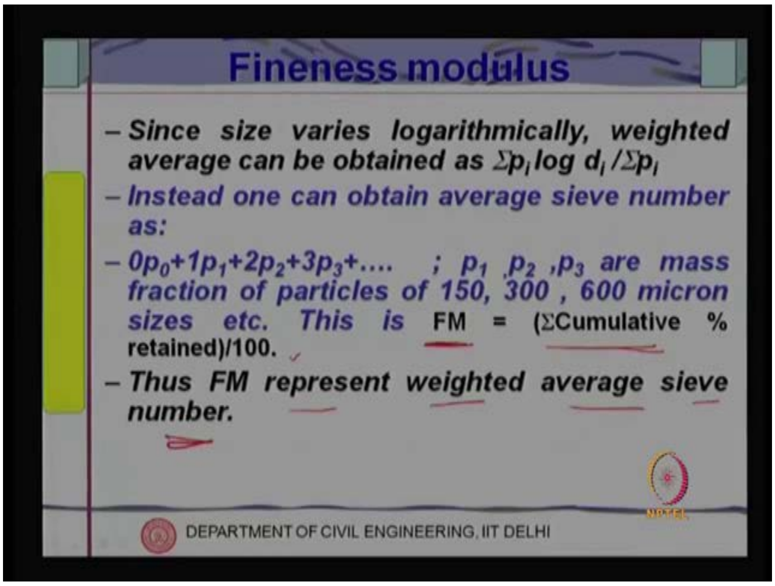

So you can call it sigma p i log d i divided by sigma p i that is what it is the sum of this; that means, varying for i varying from 0 to n may be. So first term will be p 0 proportion not proportion log d i log d i the mass this could be even mass. You can talk in terms of even mass instead of p if I talk of m i m i this will also do because m i divided by sigma m i m 0 divided by sigma m sigma m i m 0 divided by sigma m i is equals to p 0. So this could be m but, otherwise one can have sigma p i also is correct. There is no problem because; this is will be always equals to 1. So this is the weighted average. This is the weighted average. So we can find it out in this manner.

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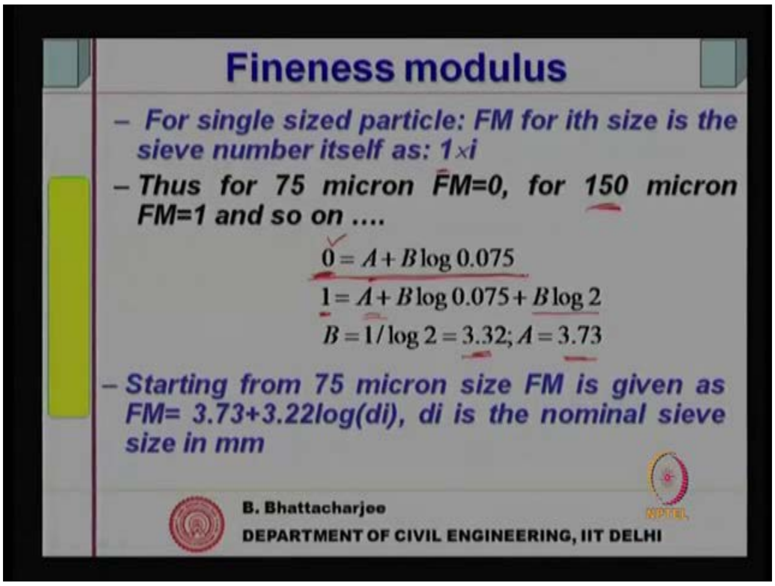

So average sieve number can be written as 0 p 0; 1 p 1; 2 p 2; 3 p 3 at there the mass fraction of particles in 75, 150, etcetera, etcetera. This is fineness modulus this is called fineness modulus right. And if you look at this this can be written as cumulative percentage retained divided by 100 sum of all the cumulative percentage retains sum of cumulative percentage retained in all the sieves divided by 100 right this is percentage. Thus fineness modulus represents weighted average sieve number average sieve number in which your particle belongs all right. Let us see how it is cumulative for single sized particle fineness modulus of i'th size will be simple sieve number itself right. So, because there are single sized particles of this value is 1 fraction is 1.

So it is sieve number itself. So 75 micron FM equals to 0 for 150 micron FM is equals to 1 single sized particle and so on. And from this so 0 for all particles being you know I can write it in terms of A B log 0.075. And as I said logarithmic of the size sieve size or logarithmic size of you know average sieve size is arithmetic is in arithmetic progression. So this increases simply by log 2 B log 2 therefore, I can derive an expression for fineness modulus for a single particle size for 75 micron size. This is the fineness modulus is 0 for 150 micron sieve fineness modulus you know particles all particles belonging to 150 micron.

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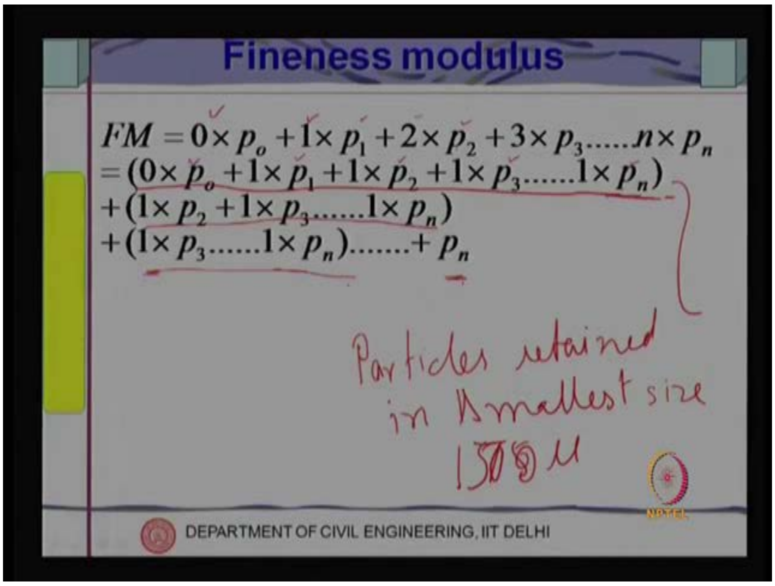

Fineness modulus is 1 and from this actually I can derive out A and B A comes out B comes out to be 3.32 and A comes out to be 3.73. So, starting from 75 micron size FM is given as 3.73 into 3.2 because B is 3.232 3.32 log d i, d i is a nominal sieve size in millimeter. For any size you can find out fineness modulus like this and for combination fineness modulus is given by this formula as we have seen for mix you know number of particles there are some particles in 75 microns. So cumulative we can write it like this 1 p 1; 2 p 2 these are the proportions and n p n now this if I break it up I can write it 0 p 0 plus 1 p 1 plus 1 p 2 1 p 3.

Etcetera the second term would be 1 p 2 because there is a 2 here and rest all this 0 is does not matter this is only 1 this appears twice. So I can write it 1 p 2 plus 1 p 3 etcetera and next series will start from 1 into p 3 to 1 into p n and last term will be p n. Now what is this? What is this? This is the proportion of all the particle right so particle retained in bottom most size particles particles retained in smallest size that is 75 micron. This is particle retained in you know this is particle retained in this is particles retained in not 75 150 micron.

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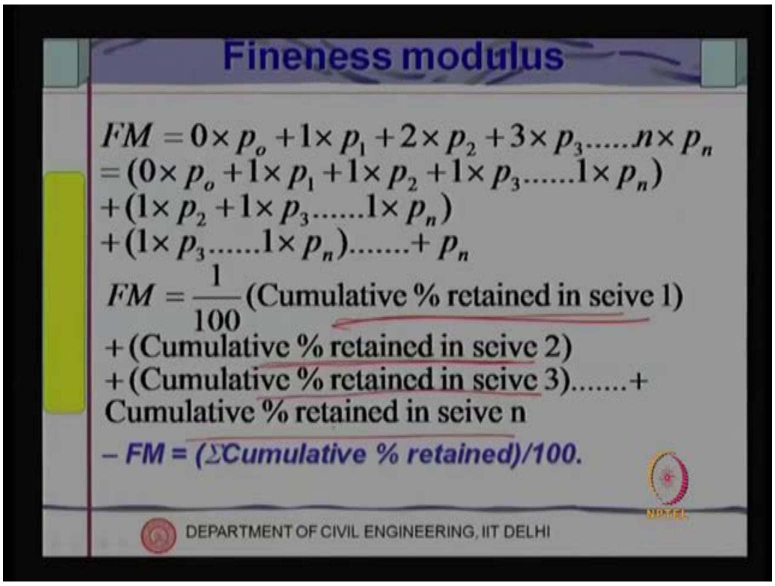

150 micron this is retained in 300 microns because its starts from p 2. So, 75 150 this is particle retained in 300 and this is particle retained in that top most sieve. So therefore, this is the summation of particle retained in the bottom most sieve to bottom most sieve to you know the top most sieve. So this is nothing but cumulative percentage retained in all the cumulative percentage retained in all the scivc, scivc number 1 plus cumulative retained in sieve 2, cumulative retained in sieve 3, cumulative retained in sieve n. So this

is the sum total of you know not cumulative percentage retained in sieve 1 percentage retained in sieve 2 not. So all retained in all the sieves this is retained in n sieve this is in the you know n minus 1 etcetera, etcetera. So first one is percentage cumulative retained on sieve number 1 bottom most 2 cumulative retained 2.

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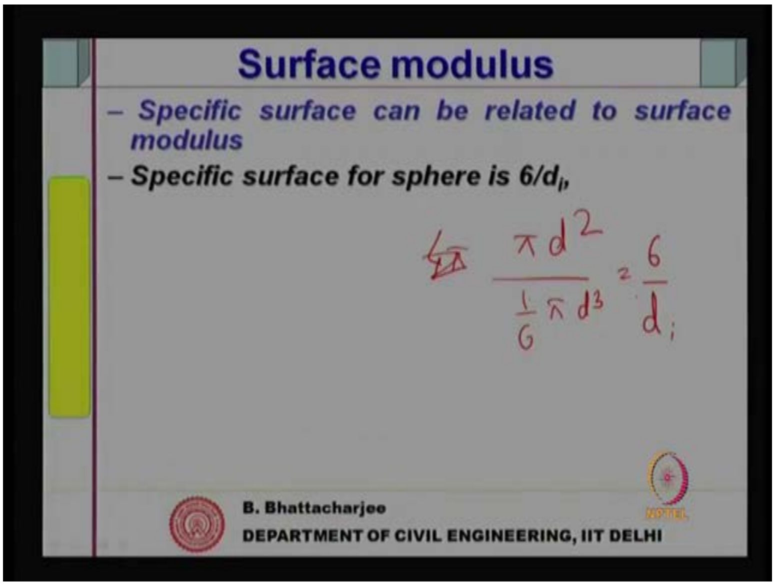

Everything so therefore this is nothing but some total of cumulative percentage retained in all the sieves right. Cumulative percentage divided by 100 because this where in percentage that will give you the fineness modulus. So from the definition fineness modulus can be derived in this manner. We calculate out fineness modulus on the bases of cumulative percentage retained on all the sieves divided by first sieve you take how much is the percentage cumulative percentage retained, then you find out what is the cumulative percentage retained on the second sieve, third sieve, four sieve cumulative percentage from top you can start you start on the top. It is the last top sieve only where cumulative you know the percentage is retained that will form the cumulative. If you go to the next sieve then the that retained in top sieve and the next sieve this to sum is a cumulative percentage retained, you got a third next next bottom one. So it will be the top next and next the sum total of all the particles retained in the top three sieves.

That will found the cumulative percentage retained in this manner you calculate out cumulative percentage retained in all the sieves sum them up divided by 100 that gives you fineness modulus. Actually it represents average sieve size of the particles you know particle average size of the sieve size not size average size of the particle and you want to find out corresponding average size, you can find out using the formula that I have given you that must be equals to that must be equals to a plus b into log of log of d i I mean log of you know log of d 0. So you can find out what is a log of d i. So what you can find out what is the d i value, what is the average size value you can get some idea but, we really use this size what we use the average sieve number that is a fineness modulus right to represent because it is essentially.

For comparing to aggregates which is finer one is finer another is less finer right and this is used in mix designs some of the mix designs because you can designate a particular greater aggregate according to their fineness modulus. Similarly, there is another one called surface modulus another index called surface modulus. Specific surface can be related to surface modulus specific surface is sphere is 4 you know or if you write it pi d square as a surface area divided by 1 by 6 pi d cube, so this will be simply 6 by d for a ith particles size is 6 by d i so specific surface for sphere you can find out in this manner.

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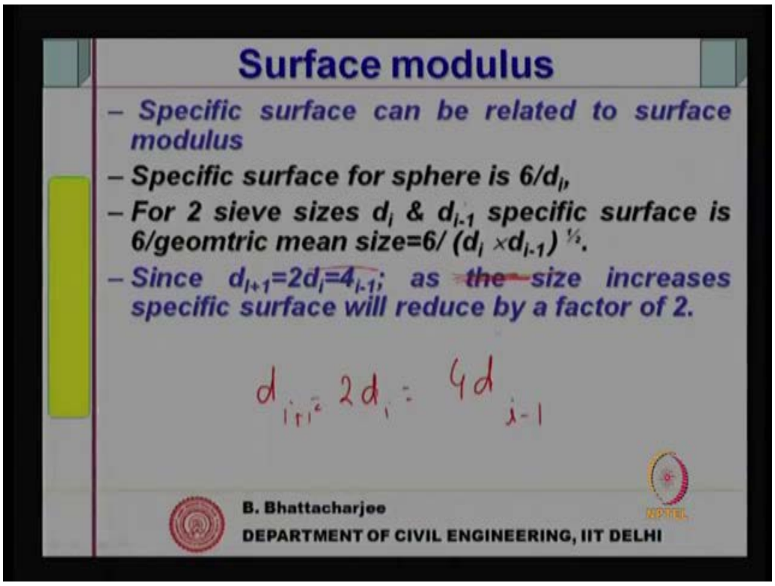

Specific surface is surface area per unit volume for 2 sieve sizes d i and d i minus 1 I can talk in terms of average sieve size geometric mean so geometric mean is a root over this two so for 2 sieve sizes d i and d i specific surface is six of the geometric mean size. And that is given by this. Since d i plus i minus 1 of z d i plus one is two d i which is equals 4 d i minus 1 so d i plus 1 is equals 2 d i equals to 4 d i minus 1 right, so as the sieve size increases as the sieve size increases as the sieve size increases right as a sieve size increases what will happen to the…

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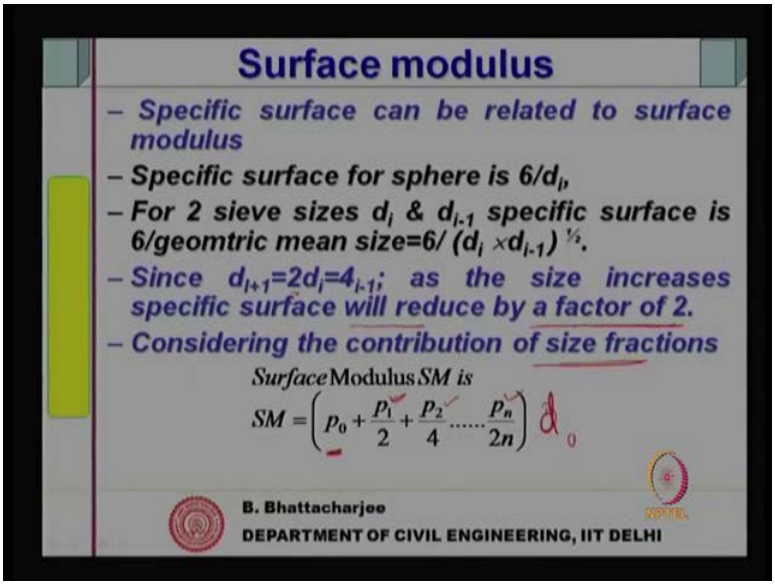

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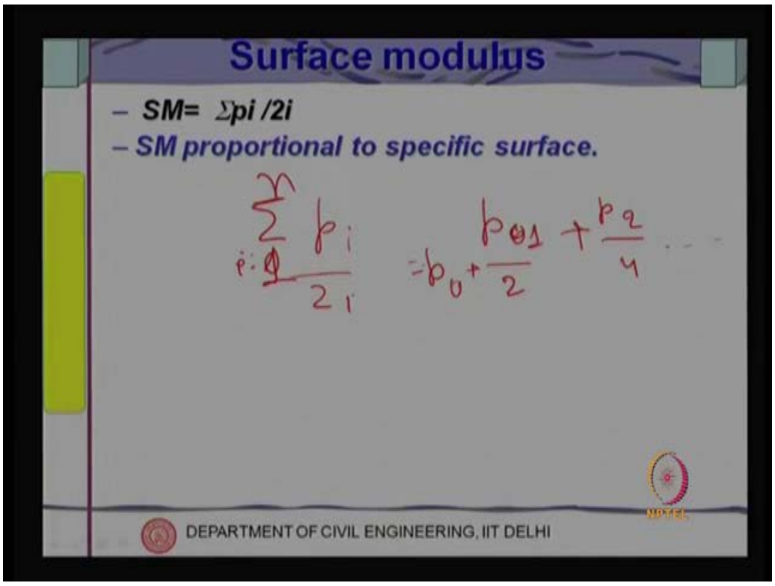

Specific surface as sieve size increases the specific surface will as a sieve size increases specific surface will reduced by a factor of 2 right because simply proportional 2 6 over inversely proportional to d i. So if you have higher d size specific surface will reduce by a factor of two. So considering the contribution of size fraction all size fraction I can write it therefore, surface modulus as this is the size fraction of the bottom most sieve there is retained in 75 micron passing through 150 and this is the p 1; p 2; p 3. So size contribution will proportional to, so if I write this multiplied by d you know the smaller size is d 0 that will be the that would be that would give me the total some approximate value of surface specific surface of the aggregate.

So that is how surface modulus is defined as 2 sigma p i divided by 2 i you know if you expand this that is sigma p i divided by 2 i. So I can write it like this i going from 0 to n first one will be p 0 right I mean this will not be a valid p 1 it should from p 1. So first one is p 1 plus p 1 by 2 and p 0 comes otherwise, so p 0 divided by 2 i 0. If you I put 0 then there of course, it will be infinity not defined p 1 plus p 2 by 4 etcetera. So this generalize it in this manner. So surface modulus is defined by this this multiplied by factor which we have defined earlier right, d 0 gives the total surface area.

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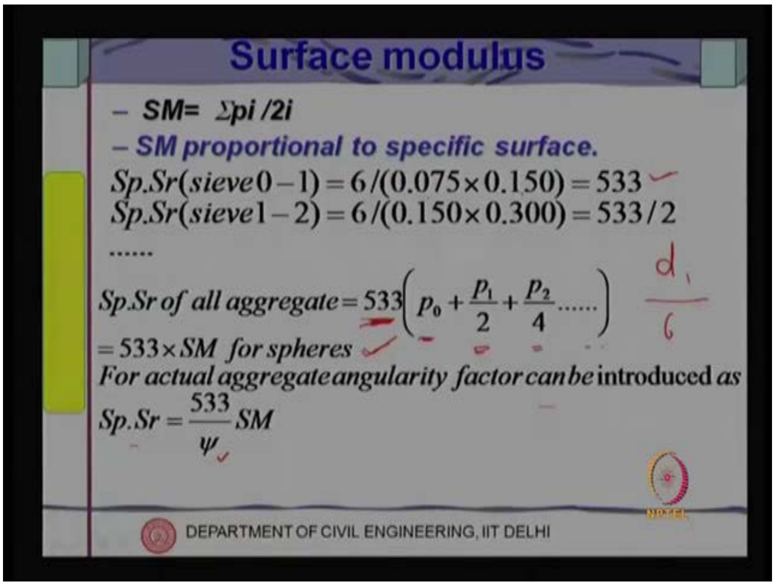

Now sieve 0 to 1 is you know average sieve between 0 7 5 and 150. So this corresponds to 533. When it is in millimeter sizes in a millimeter next for next level 1 and 2 it is 533 by 2 next level. So, therefore specific surface of wall aggregate will be surface modulus multiplied by 533 because surface modulus is defined as this term, this multiplied by the specific surface of the smallest group 0 to 1 it gives you 533. Now this is for spheres, because we have used d by 6 d by 6 for actual aggregate angularity factor can be introduced, and therefore specific surface is given by 533 by you know angularity.

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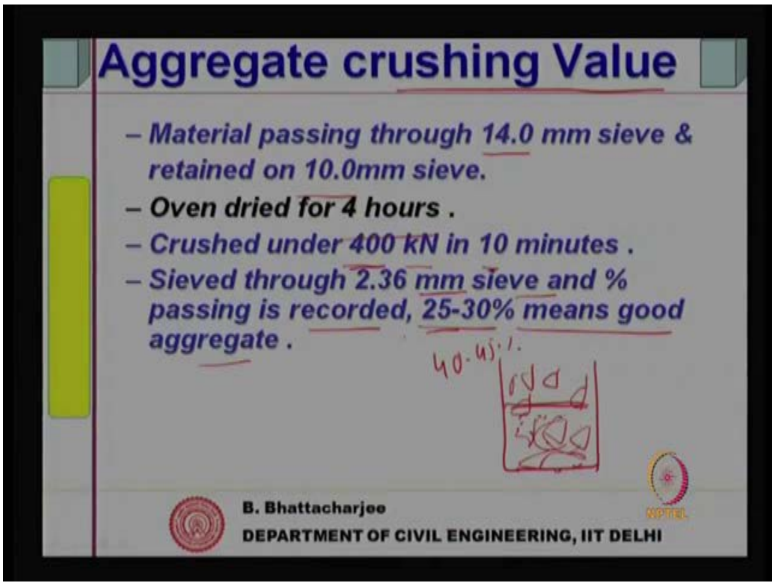

So this is what is surface modulus? Because for irregular shape particle for circle this is the surface area is minimum, for irregular shape particle surface area will increase. So 1 by psi which you increases with irregularity or angularity this would this this will be the specific surface. So from surface modulus you can calculate out aggregate surface area specific surface area aggregate that is area per unit volume get an approximate idea about this.

Some of the mix design method uses surface modulus as a parameter to define the kind of you know compare to different aggregates well surface area is important, because more the surface area more water you will require for waiting the aggregates. But perhaps packing characteristics is more commonly used, because that is seems to be more logical. So therefore, packing characteristics is more often than surface modulus.

Some of the mix design concepts uses surface modulus this index for fining of the proportion of aggregates etcetera, etcetera. Now, the properties of aggregates the strength of aggregate is measured strength of aggregate is measured through aggregate crushing value aggregate crushing value because you see parent rock strength is usually is not relevant. In case of concrete, because once you fracture the parent rock its strength would be higher, because fracture has already taken place through the fraction planes. So whatever is remaining must be stronger well size effect sort of things larger the size probability of finding a failure plane or fracture plane is more.

Therefore we no point using rock strength in aggregate second issue is this is the aggregate if they are in aggregation forms it is very difficult to measure their strength esters. So what you do is we compare to compare two aggregates we use a test call crashing value test, there is another similar test called impact you know aggregate impact value. So crashing value test is very commonly used in this one what we do is we pass aggregates through 14 m m sieve and retained on 10 m m sieve.

So this only this size we take effect of size is actually eliminated this is oven dried for 4 hours. So moister condition is again modulus fineness fixed standardized and then crushed under 400 kilo newton in 10 minutes. So the rate of loading is also fixed now what will happen when you crush… This once aggregates the originally it was something like this filled in right and once you crush they will occupied this areas only this fines and but, they will have number of fines generated through crushing so then you sieve this material through 2.36 millimeter sieve and percentage passing is recorded 25 to 30 percent means good aggregate. If it is high 40-45 percent then it is not so good aggregate comparatively 25 to 30 percent is good aggregate.

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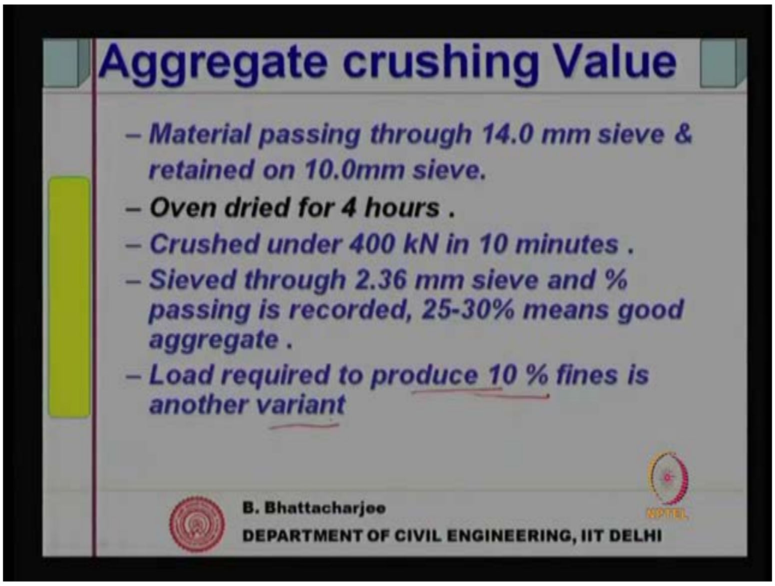

So can be used in concrete so therefore this is used to measure relatively compare to aggregates relatively and also to specify the two uses specification; that means, you specify that aggregate crushing value which is expressed a percentage should not be more than 32 or something like that. For using structure concrete and so on so for so relative comparison one having lower crushing value is better compare to one having higher crushing value. You see then there is a another way of testing the same one that is load required to produce 10 percent fins is another variant of this test. So in this one we found out percentage passing but, in another variant of this test we just try to find out the load require to produce 10 percent fines right load required to produce 10 percent, fine.

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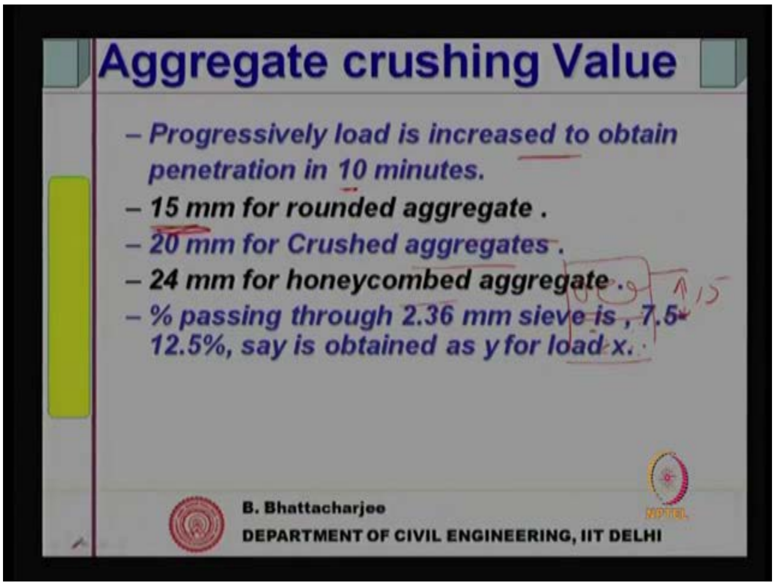

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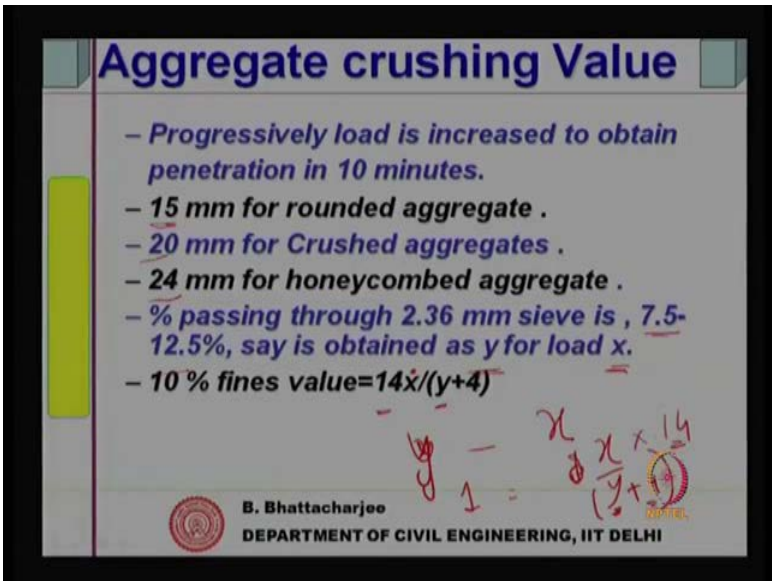

What is they done is the progressively load is increased to obtain penetration in 10 minutes right. So then this should be 15 millimeter for rounded aggregate, so this penetration is specified increase the load such that you get a penetration of 15 millimeter in 10 minutes so this if you know you get a penetration these are your aggregates. So this change new here is a new aggregates after crushing.

This should be 15 millimeter for rounded aggregate then 20 millimeter for crushed aggregate already crashed aggregate because this will have still some failure plane this will have less. So this is what you do 20 millimeter for honeycombed aggregate we have looked into honeycombed aggregate when you talked of shape. So this is what is given and then percentage passing through 2.36 millimeter sieve is found out should be between 7.5 to 12.5 percent and let us say this we got y for load x, so the load is unknown here you try to find out how much is the load required to achieve this much penetration or this much penetration or this much penetration depending upon type of aggregate and let us say the load is x for a penetration of.

You know y not penetration y percentage passing 2.36 percents sieve 10 percent fines because we want to find out how much will be 10 percent what is the load required for 10 percent fine. So supposing a found out 7.5 percent is x load so 10 percent fine value is given by this 14 plus y by 4 so y you found out at a given load right y you find out at a given load x so for x you found out you know for y y percentage y percentage is for x load 1 percentage is for y by x by y load right but, y plus 4 is used y plus 4 is used. So this into 14 so that is gives us 10 percent right so this is should be 10 percent fine 10 percent fine.

So here 10 plus 4 y plus four and 10 plus 4, so it is assume the things you know 4 m m you will be just getting straightforward after that it varies linearly. So 14 y plus 4 y is what we found out and 10 plus 4 4 is 14. So this is the relationship used to find out the 10 percent value 10 percent value and this is also used as a as a near stick for comparing two aggregates.

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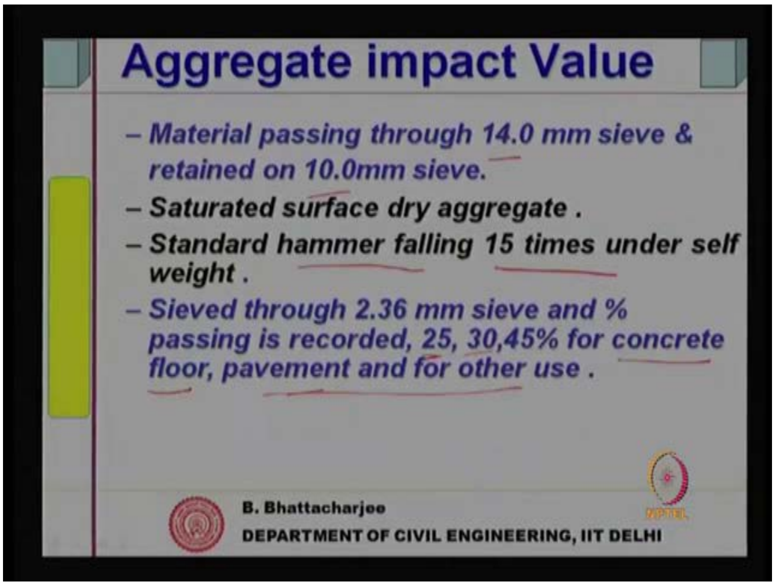

As we used as a near stick to compare two different aggregates. Impact value is also measured on the same machine you take materials passing through 14 millimeter sieve and 10 m m sieve all these are specified quantity etcetera the aggregate should be in saturated dry surface dry.

And now only thing you have standard hammer falling 15 times under self-load so you have a hammer which is lifted up and down which is lifted up and down you know it is just lifted up and down so under self-weight that hammer mass falls twist 100 height 15 types and then find out how much is the percentage passing through 2.36 mm. So then you sieve through 2.36 m m and percentage passing is recorded 25, 30, 45 for concrete floor, pavement you know for a concrete 25 is recommended for concrete for floor 30 pavement and other use for 45 percent.

So aggregate impact value 10 percent fine value and aggregate crushing value these are the measures for strength relative you know these are used for relative strength comparison of aggregate and it must satisfy the minimum required otherwise sand of the concrete will be limited by aggregate itself, in normal concrete strength of the concrete is not limited by aggregate because aggregate really fails as usual see later on.

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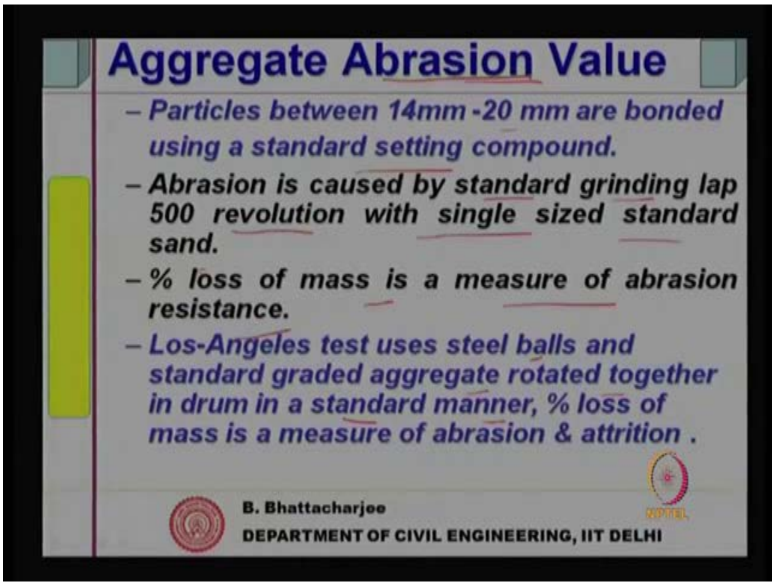

Aggregate abrasion value particles between 14 m m and 20 m m are bonded using standard setting compound. So we want to find out the aggregate abrasion value quite useful in case of pavement and flooring where you expect lot of abrasion will be there. Abrasion is caused by standard grinding and lapping through 500 revolution with a single sized standard sand so you cause abrasion through sand of single size right.

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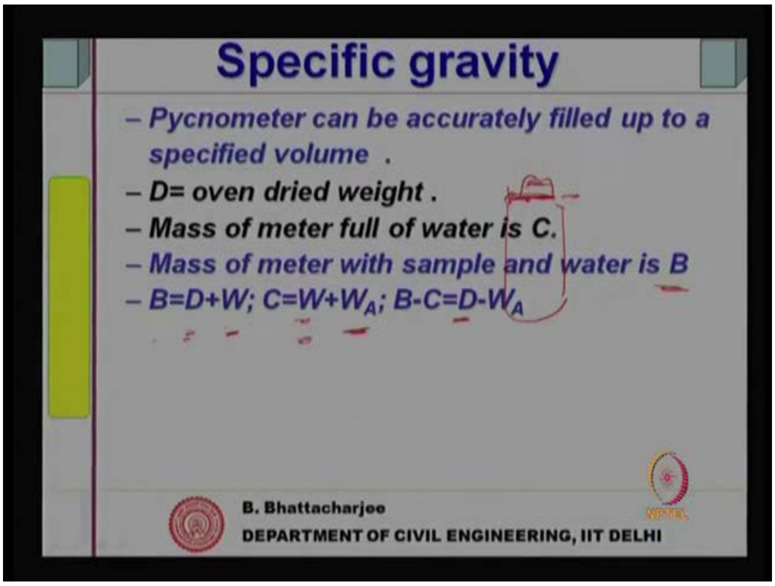

So there is 20. What is called lapping and grinding? And percentage loss of masses measure of abrasion resistance. So you grind it putting sand on top of it and once you have done that some of the aggregates will become powder loss of mass will be there. So loss of mass is measured and that gives us abrasion resistance. Lowerities better lower the mass better is the abrasion resistance los-angeles test is another one which uses steels balls and standard graded aggregate rotated together in a drum in a standard manner. So there it was sans through which are grinding in this case your steel balls and the aggregates there rotated in a standard in a standard manner and percentage loss of masses measured and that gives us abrasion as well as attrition specific gravity specific gravity pycnometer can be accurately filled up to a specified volume suppose I have got a bottle or something like that you know and which I can fill in up fill again you know I can close it possible something like this. I have sealed lead is there and I can fill it the water up to some specified volume.

Then D is oven dried weight of the aggregate so mass of this pycnometer full of water that is C so first I found what is C is the mass of the water full mass of the meter is sample and water that is B. Now you remove some you know put this oven dried aggregate and all the time you will have some water filled up to same height so remove water such that it fills up to the fix height all the time there volume is fixed. So let us take mass is B right so B is equals to D plus w that is D plus some weight of water C is equals to weight of water this W plus weight of same volume of aggregate weight of same volume of aggregate so B minus C will give you B minus C will give you D minus W A that means that is the.

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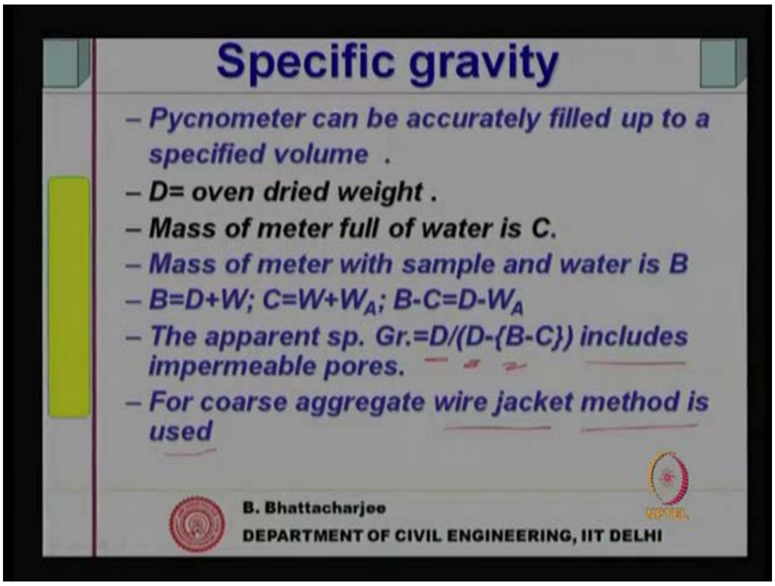

Mass of the aggregate over dried mass of the aggregate minus mass of the same volume of water. The apparent specific gravity therefore one can calculate out D divided by D minus B minus C. Because B minus C is this so if you subtract from D you get the mass of water of the having same volume. Now if you are doing it in c g s units that is centimeter grams per c c. So then in that case simply specific gravity you can find out without deviation or anything of that kind simply D will be D divided by specific gravity will be D divided by D minus B minus C. This includes impermeable pores the D specific gravity is not specific gravity or the material but, it is apparent specific gravity because the pores which are not filled by water will be considered as solid in this sort of measurement.

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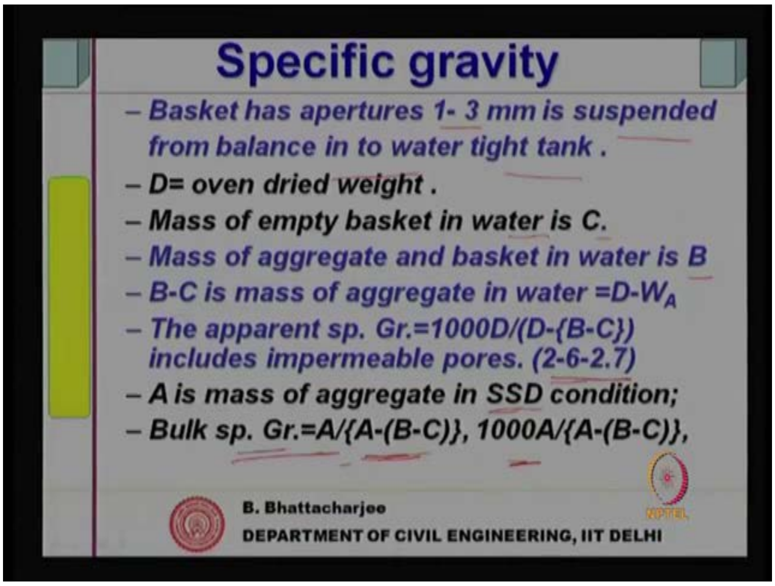

Sometime wire jacket method is used to find out the specific gravity of coarse aggregate; that means, you have a jacket fill in the mass put it in water so see the volume of water displaced from that you can find out you know take again the weight in the some much conditions so from that you can find out accurately volume of water this place and then find out the specific gravity. The basket has apertures as 1 to 3 millimeter is suspended from balance into water tight tank and let us say these D oven dried weight mass of empty basket in water is C mass of aggregate and basket in water is B.

So B minus C is mass of aggregate in water and that is the loss in weight you know so, the apparent specific will be 1000 D divided by D minus D minus C because if everything is in k g then here we have to multiplied by 1000 in order to get the specific gravity. What you are doing? You are using simply Archimedes principle the mass of the you know there is the loss in weight of the material when you sub merge them in water and the losing weight is equals to the mass of the volume of water displaced.

So you using this concept you can find out the specific gravity using this formula again it includes all pores impermeable pores as well so this varies from 2.2 to 2.6 to 2.7 so A is the absorption basically if A is the mass of aggregate in S S D condition bulk specific gravity is sometime given by this A bulk density you can say supposing I find out A is a mass of the aggregate A minus B minus C in the same manner you can call it bulk specific gravity where A is the mass of the aggregate.

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Not oven dried condition but, in what is called saturated surface dry condition. You look into saturated surface dry condition quickly, saturated surface dry condition refers to situation. Where absorbed moisture is present inside while surface is dry and that is a standard condition we used because it is very difficult to control them. You know like defined or standardized moisture contain but, saturated surface dry; that means, inside there is a water outside surface is dry. That you can find out by wiping out the water from the surface using a flannel coarse cloth of or something of that kind or even by visual observation while drying sand. The color wood change suddenly from wet to the dry state you know surface dry state right. So water absorption is measured with respect to oven dried condition always we do that. Free water is the water content in concrete that excludes.

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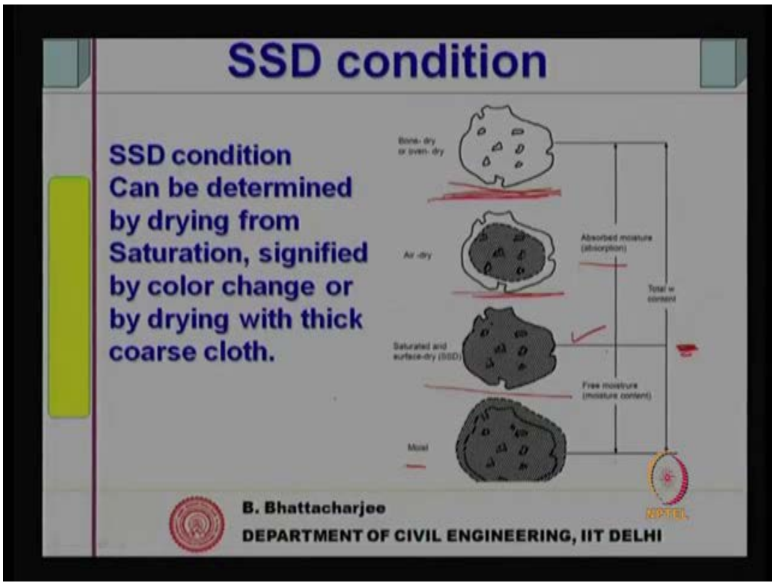

Water required for S S D condition, because S S D condition saturated surface dry condition is considered to be the standard in case of concrete because you know water will be absorbed by the aggregate themselves. Now this water has to be taken into a account in adding water while we add water for mixing because this water will not be available or neither for reaction nor for mixing purposes. We exclude out water which is absorbed inside the aggregate.

So surface dry and water inside that we call it as saturated surfaces dry condition and it is a standard condition that is used for moisture content for moisture content you know content of aggregate in concrete production as well as mix design this illustrate what is S S D condition this is bone dry fully oven drive situation there is no water. There are pores no water if you come to this this is air dry; that means, the air surface has dried out fully up to certain depth but, moisture is still inside, if it is saturated surface dry condition there is moisture inside al through also surface there is no moisture. And moist is even outside you never layer of water. So this is our standard condition right.

So these are absorbed moisture and this is also absorbed moisture this is somewhat it will have some free moisture from this point to this point excess water outside and we do not in our standard condition you consider this because this are the fixed condition this might vary depending upon porosity this might vary depending upon porosity but, this is the standard condition and the water now inside will not be available for it will absorbed by the aggregate and will not be available for reaction. So therefore, that is why this is used as a standard condition saturated surface dry condition.

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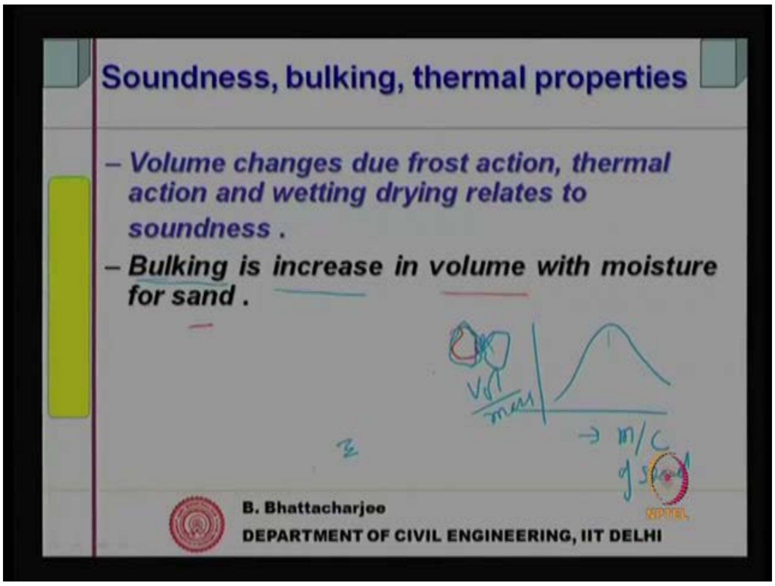

This can be determined by drying from saturation signified by a color change of drying with thick coarse cloth. So you take thick coarse cloth flannel or something of that kind wipe of the water from the surface and that is S S D condition. Then volume changes due to frost action, thermal action and wetting drying relates to soundness. This is also somewhat measured. Bulking is increase in volume with moisture for sand it is only for fine particle because particle particle will absorb sand particle can absorb moisture sand particle can absorb moisture it can absorb moisture in the surrounding sand particle can absorb moisture in the surrounding right. So sand particle can absorb moisture in the surrounding.

In its outside periphery it can actually absorb absorbed moisture now when it absorbs moisture its effective size increases. So initially there will be pushing of the particle but, at a time comes when the all this water collapses and particle then comes close to each other. So if you plot volume for a fixed mass when you get this sort of curve if volume increases with moisture content of sand it increases fix up a pick and it is reduced reduces. So this is called bulk bukling I mean bulking of sand bulking of sand it becomes bulk volume increase. Well this this has got do not have much to do because we do not use volume with mix design but, one must remember this because it will change the packing characteristics particle size becoming larger.

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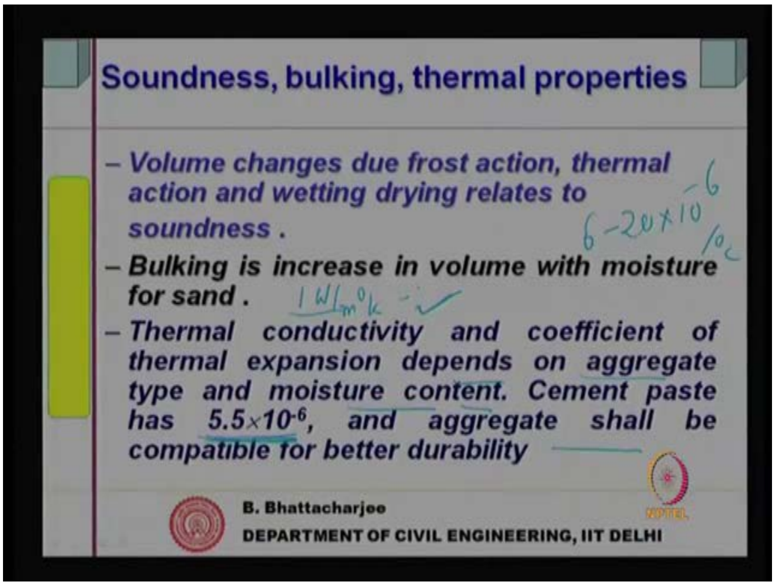

It will change the packing characteristics, so this is important from that point of view otherwise, bulking is not very important because in mix design we do not want we do not use volumetric batching in earlier days quantity the amount of moisture content corresponding to bulking was an important issue because volumetric batching was done. So you have to add a correction in terms of volume since you do mass basis these are all not required and you always considered the aggregate in S S D condition.

So this issue is not so relevant, thermal conductivity is an important property and its co-efficient of thermal expansion of concrete. It depends largely on aggregate thermal conductive of concrete is a function of aggregate thermal conductivity. And it would depend upon type of aggregate and moisture content cement paste has a thermal co-efficient of thermal expansion is 5.5 into 10 divide by minus 6 and aggregate has got.

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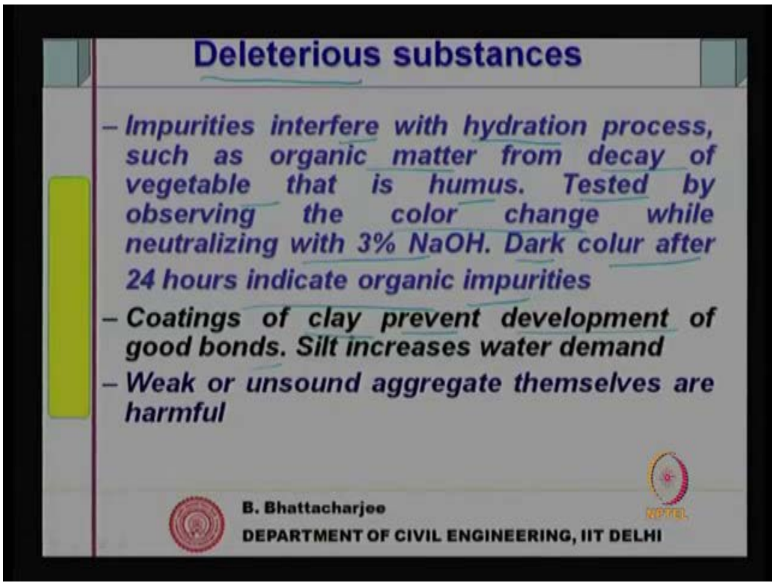

Different and it should be compatible with the cement paste for durability so generally, order of concrete thermal conductivity is may be 6 to 20 into 10 to the power thermal coefficient of thermal expansion is of this order path degree centigrade. Thermal conductivity is bearing may might vary from 1 watt meter degree centigrade or degree kelvin to about 2.5 or 3 watt meter degree kelvin depending upon aggregate type maximum is for quartz or quartz height. Now important aspect is deleterious materials you know I was telling you to that fineness size we take aggregate size we take is a sand fine up them that size like silk etcetera they are harmful in concrete the reason is silk always has a tendency it was very fine size so it has got kind of forces surface forces.

And which will actually make it get to stick stuck to the aggregate surface. So silk clay etcetera they will get stuck to the aggregate surface and if cement will not bounded to the aggregate. So this are important once but, besides that there are some other deleterious material impurities which is interfere with the hydration process like organic matter from decay of vegetable such as humus are deleterious materials. This is tested by observing the color change while neutralizing with 3 percent sodium hydroxide dark color after 24 hours in the indicate organic impurities.

So organic impurities are tested with alkalis and the color change tells us because they organic impurities they can react with alkalis and color change test test tells us whether there is a organic impurity deleterious organic impurity in the aggregate right. This is why the clay we do not want clay prevent coating and develop into good bonds. Silt also does this little bit but, also it will increase allow water demand because it is very fine so if you trying to use silt in the aggregate system or the too much of silt.

Let us say more than 3.5 percent or something like that then it will have a tendency to absorb the lot of water, clay would obviously do not allow any bond between the aggregate and the cement hybrids. So actually strength would be a lower. Weak and unsound aggregate themselves are harmful. So weak aggregate means aggregate crushing value very high you would not like them and unsound aggregate means which themselves will expand in volume they will calls cracking of the concrete.

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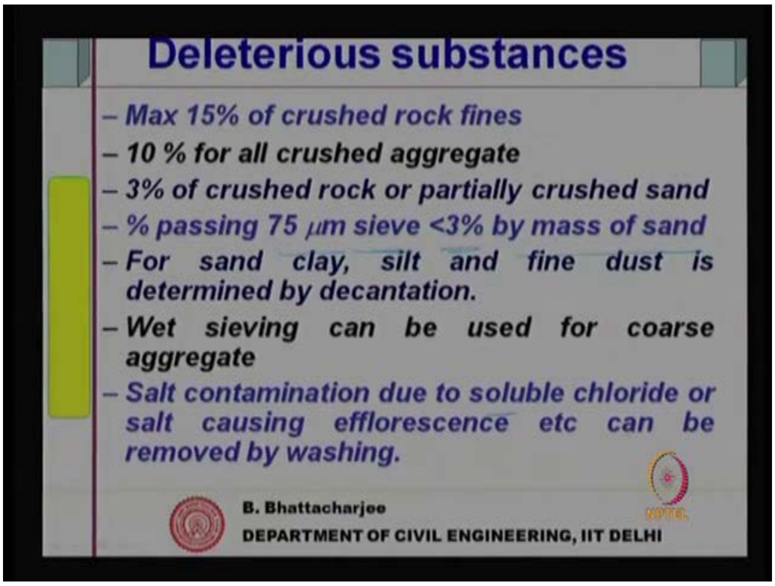

Maximum deleterious substance should be 15 percent in crushed rock fines and 10 percent for all crushed aggregates 3 percent of crushed rock partially crushed crushed rock or partially crushed sand these are the limits and percentage passing through 75 m m sieve should be less than 3 percent mass of sand. This is the sealed or clay which should be less. So this are percentages are given for sand clay silt and fine dust is determined simply by decantation you put it in a jar measuring flux and weight for long period of time will find that silt with settle at the top because this is the fineness size sand will go at the bottom and the color distinction.

To from color distinction one can find out what is the percentage of particles fineness and 75 micron and that should be not more than 3 percent should be less than 3 percent.

Well you can do wet sieving to find out do sieve analysis for coarse and fine aggregate and salt contamination due to soluble chloride or salt causing efflorescence can be removed by washing. So if you put for example, aggregates in water for some time and if you have find color is white white a efflorescence or salt getting deposit in the top that would be some sort of leaching or efflorescence by washing they can be removed, unsoundness that is volume changes are due to.

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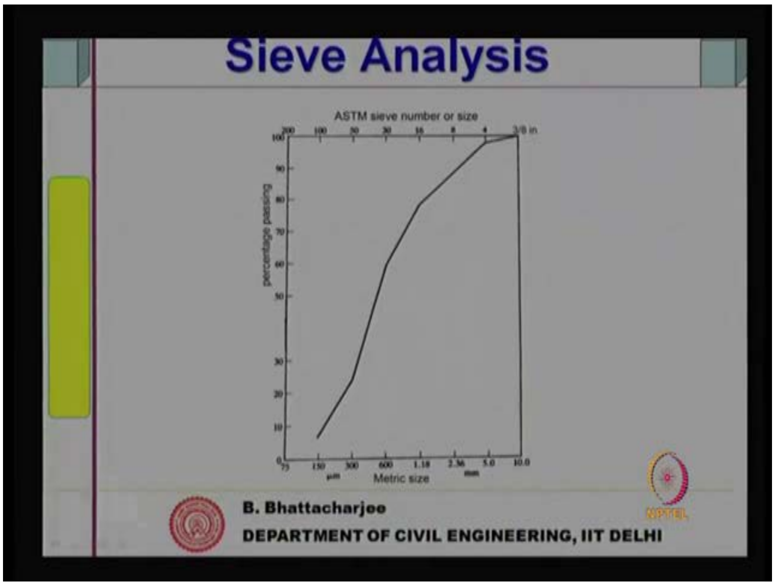

Nondurable impurities disruptive action during freeze thaw actions this is what and clay lumps or shale if there are they will expand in volume wood coal leads to pitting and scaling this are unsoundness, mica and gypsum sulfates and sulfides shall be avoided they they result in kind of unsoundness. In the sense they will expansive changes durability properties would be hampered and disruptive action during freeze thaw actions could be there. So we do sieve analysis as I said the earlier to find out the grading and this is the sieve analysis typical sieve analysis result. What it shows is percentage passing busses size you know 175 micron, 153, 100, 600 up to 10 m m size its shown 100 percent is going along passing along 10 m m and so on this is for sieve.

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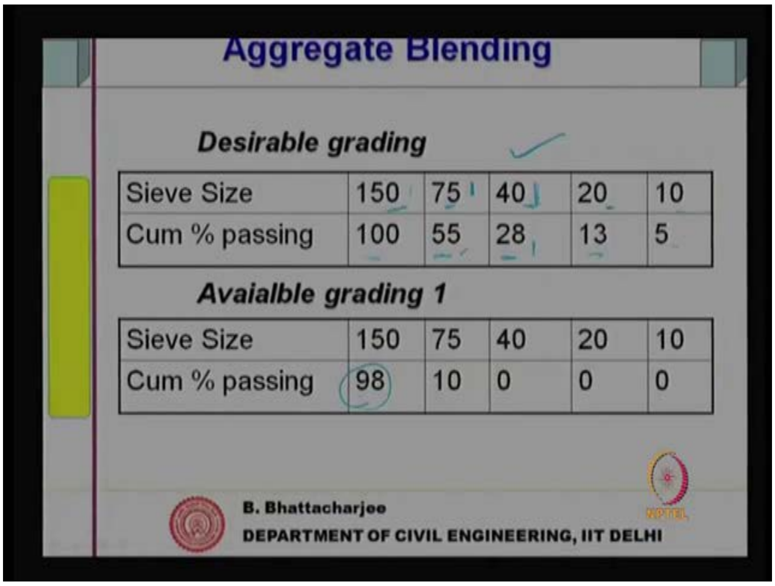

Sieve analysis for grading curve for 10 m m say aggregate this can similar things you can plot for 20 and 40 m m also and this is in s theme sieve number or size is in inches c at inch the 4 numbers, 8 numbers, 100 number, 200 number sieves. This is normally the standard most of the standard uses this well to get a good to get a good grading you may have to blend aggregates for example, you have 150 let us say 150 this is a sieve cumulating passes through 150 m m is 100 percent to 75 is 55 percent to 40 m m is 20 and 20 m m is 13 and 10 m m is 5.

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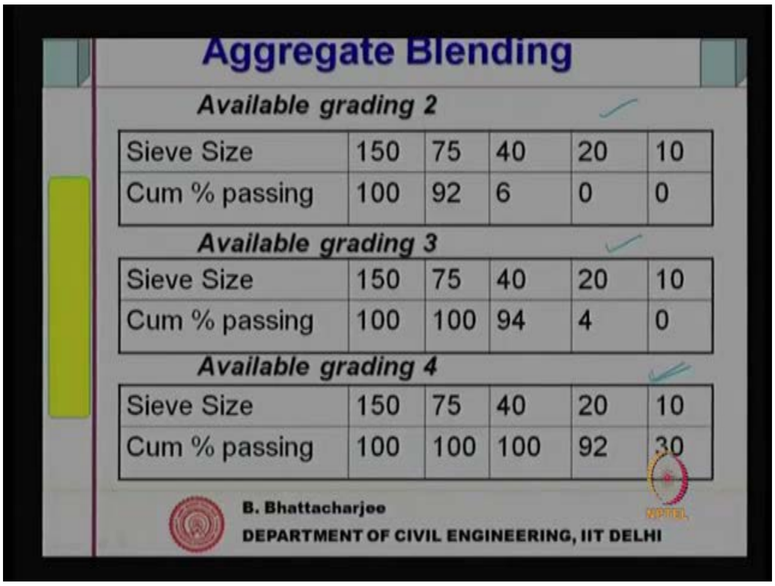
Aggregate Blending

Available grading 2

Sieve Size	150	75	40	20	10
Cum % passing	100	92	6	0	0

Available grading 3

Sieve Size	150	75	40	20	10
Cum % passing	100	100	94	4	0

Available grading 4

Sieve Size	150	75	40	20	10
Cum % passing	100	100	100	92	30

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Let us say available grading this is what is my desirable grading just as an example how do you do blending I want 100 percent should pass through 150 m m sieve 55 percent pass should pass through 75 m m sieves 40 percent should I mean 40 28 percent should pass through 40 m m sieve and etcetera.

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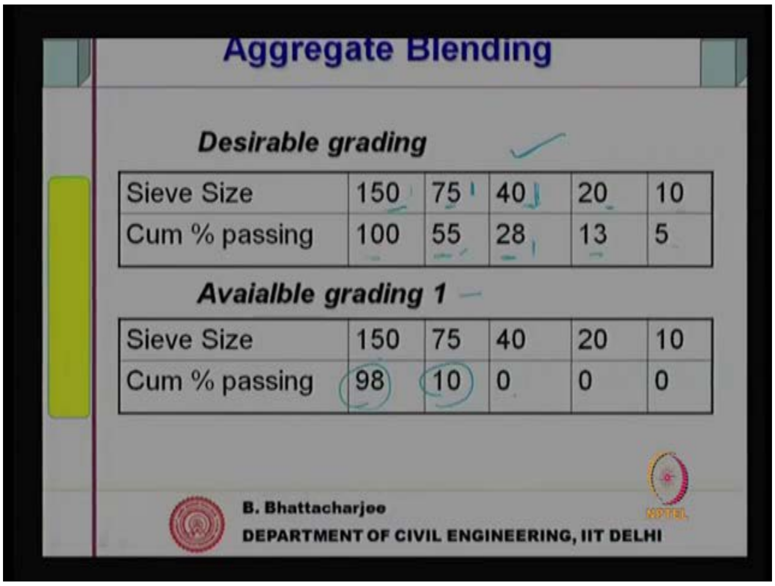
Aggregate Blending

Desirable grading

Sieve Size	150	75	40	20	10
Cum % passing	100	55	28	13	5

Avaialble grading 1

Sieve Size	150	75	40	20	10
Cum % passing	98	10	0	0	0

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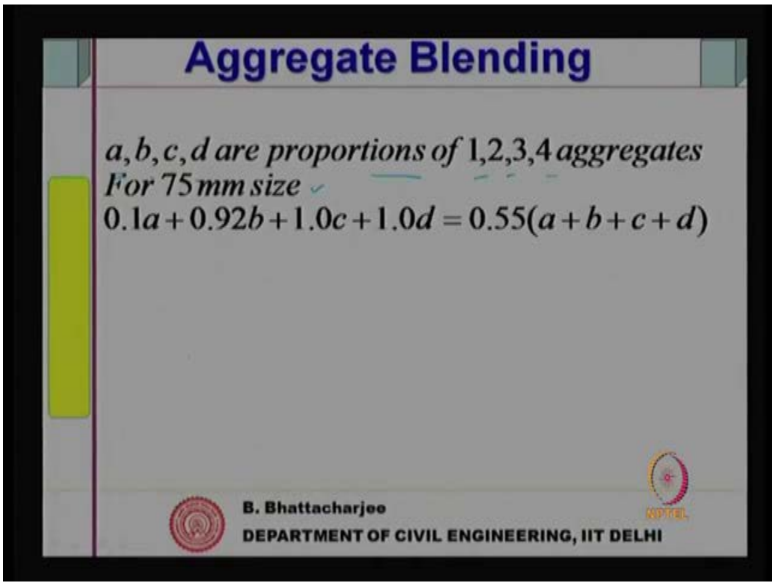

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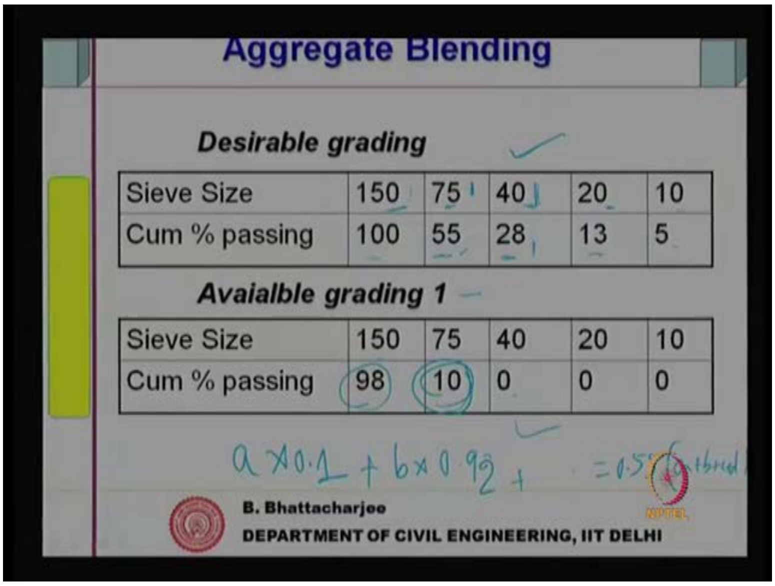

What is available to me is 98 percent passing through 150, 10 percent passing through 75 this is grading 1 and this nothing passing through this and I have got second aggregate 150 100 percent 75 92 which is you know 46 nothing through 20 and 10 then I have got third sieves 150, 100 and something available here also and if you can see this forth one which has got large number of fine so this what fine finer particles less fine. Still lesser fine and this is the coarser one this is the question coarser one and I want to get blended aggregate of satisfying this desirable grading. So what I do? I have 4 I have got 4 aggregates greater aggregates and I got to mix them right. I got to mix them to find out the desirable grading so basically proportion of each one I must have. So let us say a b c d are proportions of 1, 2, 3, 4 aggregates then at 75 m m micron on 75 m m size m m size here. If I take you know the if I look at this this one first one first one 75 m m sieve only 10 percent passes so if I take a amount of this aggregate 1.

Its multiplied by 0.1 will be the quantity of 75 m m available to me similarly, if b is the amount of you know b is the amount of aggregates I take from grading 2 available grading 2 so this multiplied by the corresponding value that is 92 0.92. So this multiplied by 0.92 0.92 and similarly, for c and d that would be the quantity of materials passing through 75 m m how much I should have this must be equals to 55 percent my over all. So 0.55 of a plus b plus c plus d. So I can said a equation at 75 m m size and this what I am trying to do and this what I am trying to do so I am trying to do some.

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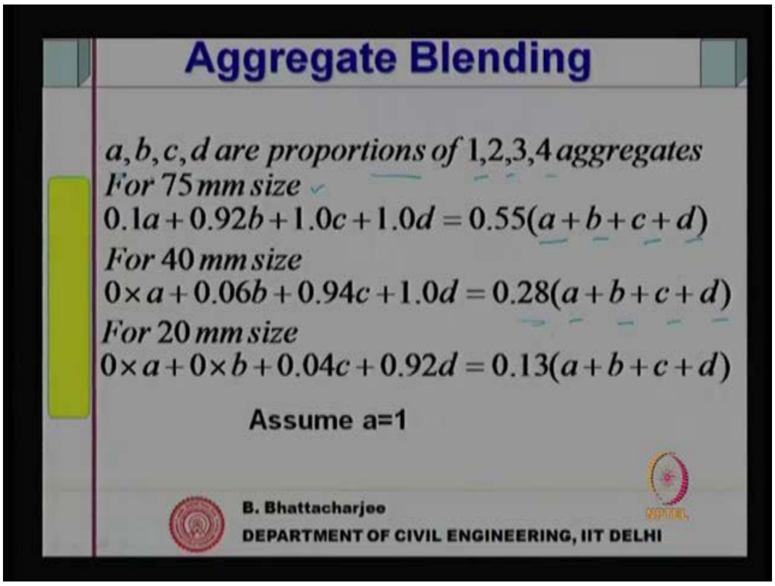

Put an equation for 75 m m size 0.1 a 0.92 b point 1.0 c 1.0 d because that did not 100 percent was passing through them must be equals to 0.55 a b c d similarly, for 40 m m size this hardly anything nothing for a only 6 percent for b 0.94 percent of the c aggregate passing through 40 m m and 100 passes for d aggregate and desirable is 0.28 I can set a third equation. Now I must said 4 such equations because I have 4 unknowns. So for 20 m m so I had actually 150 m m, I had 75 m m, 40 m m, 20 m m, and 10 m m. So for force such once I can set 4 equations 4 equations 4 equations here of course, we have done one thing we have assumed a equals to 1.

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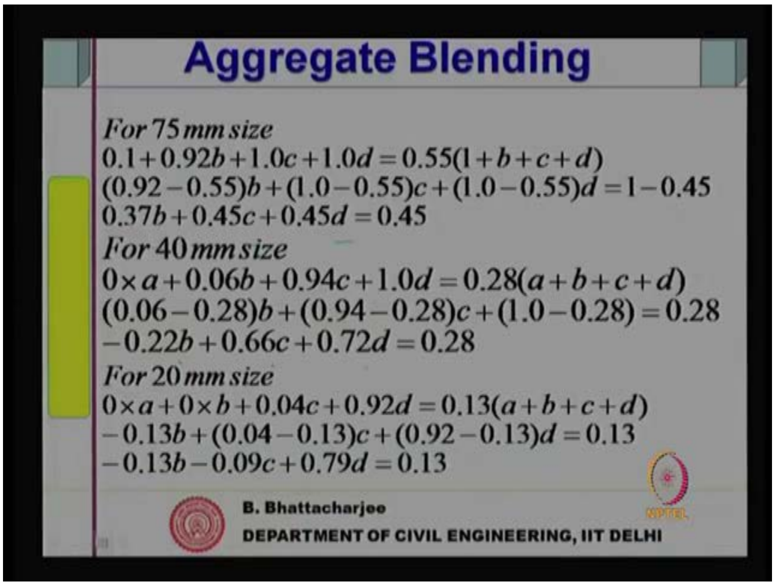

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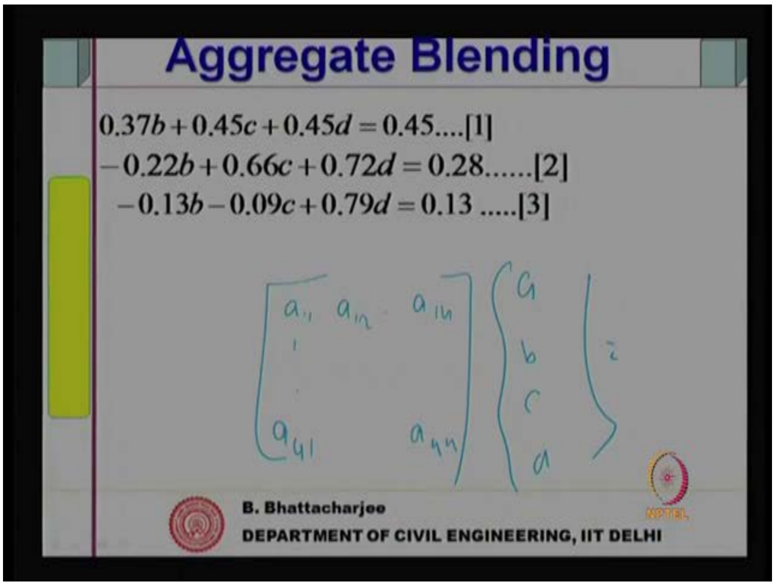

So that 1 is the eliminated straight way so I need only 3 equations right. So if I assume a is equals to 1 because you know I can if I assume a equals to 1 rest all can be obtained as a fraction of a itself right. So assuming a equal to 1 for 75 m m size this is one and this is right if we given. So I can I expression involving b c and d if I assume this equals to 1 similarly, for 40 m m size I will get an expression involving b c d and for 20 m m size I will get an expression using b c d and I can solve them I can solve this 3 equations. So these are the 3 equations I am getting well I could have solve 4 equations of its also not difficult because questions of matrix. So simply solving the 4 you know like a b c d are your unknowns.

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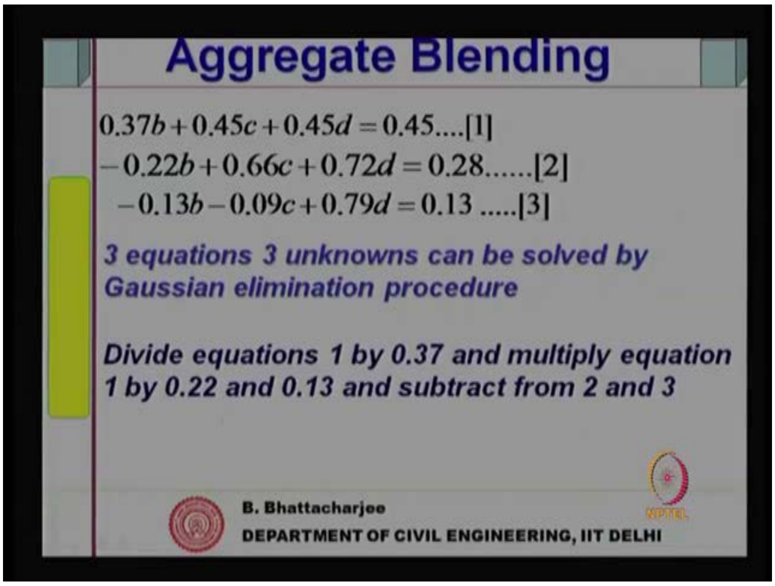

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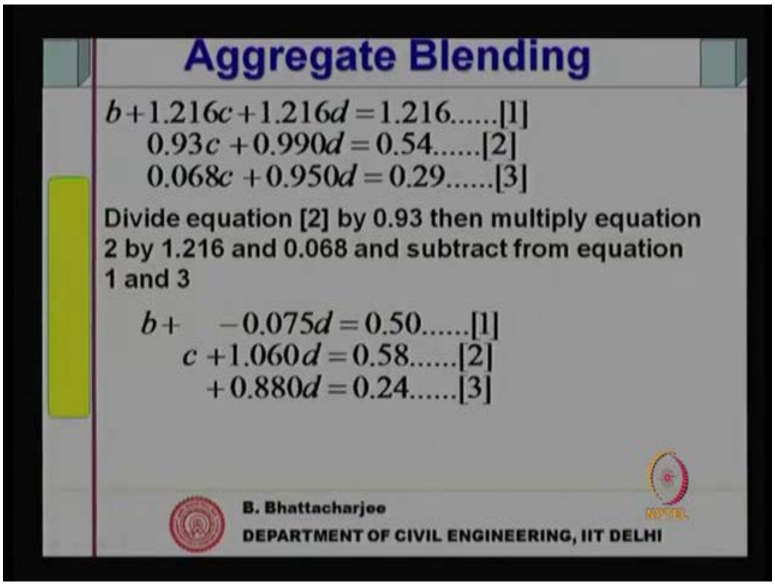

You had a matrix on this side the coefficients are known etcetera a 1 4 and so on a 4 1 a 4 4 and that is the right hand side is known to you so you just got to invite the matrix or solve it this days it is not very difficult to solve it in excel and that is what you can do. However by conventional wisdom or the old days one would actually solve this 3 by 3 unknowns can be solved by Gaussian elimination process or 4 unknowns can be also solved by Gaussian elimination process suppose divide the equations one. If these are the 3 are the case just for example, purpose divide this by 0.37 and multiply equation one by 0.22 and add and 0.13 right and this divide by 0.37 multiplied by 0.22 and multiplied by 0.13 and simply add.

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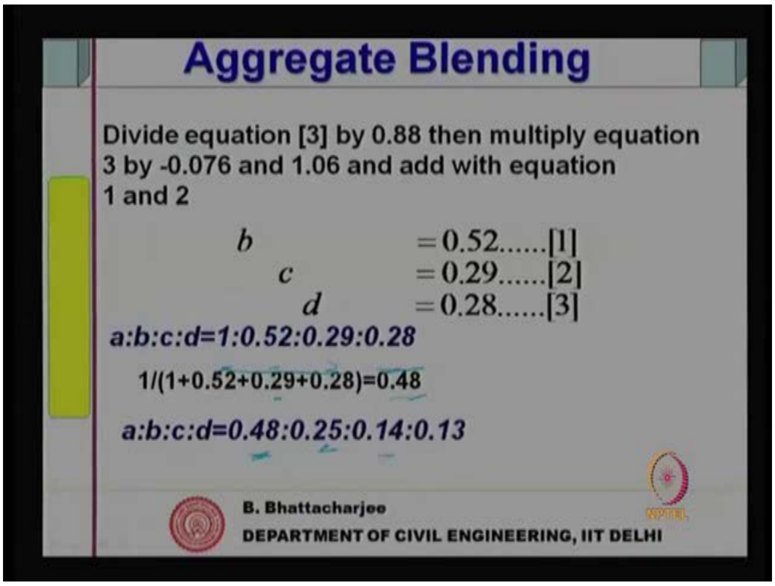

You eliminate out b right and if you do that you eliminate out b the equation then get is something like this then you take point b we got this element divide the equation 2 by 0.93 and multiply equation 2 by 1.216 and subtract and 0.068 and subtract from equation 1 and 3 and this will lead to b c equals to this then the next step would be divide this equation by 0.88 and you get the value of d so multiply this by 1.060 and subtract from this then you will get straight way value of c and if you do this process you get b c d is equals to 0.22 0.29 and 0.28 you have assumed a equals to 1.

So a b c d proportion of this is 1 0.5 you know 0.52 0.29 and 0.28. So proportions what we are looking at therefore a b c d proportions you can get so aggregate blending can be done in this manner simply and obtained you will get 4 equations one of them of course, you can assumed to be 1 because you want to find the proportion of the all the fours four of them or five of them depending upon how many aggregates you have.

So if you have 4 aggregates what you do? You set 4 equations set for important points and then 4 equations because you know the proportions of desirable great for desirable grading and proportion and each of the grading you can sum this up and by summing up get you know the you can form those equations assume one of them because two one rest all then you can determine and this we can find out the proportions. So you can find out the proportions right so you can find out proportions.

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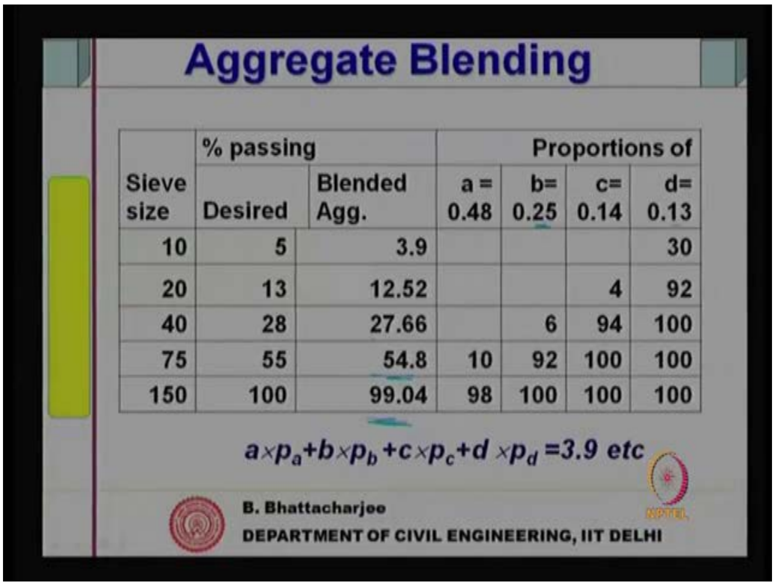

So from this you can actually determine because now instead of one relative proportions you want to find out you will find out 0.48, 0.48 for a because this was 1 1 divided by the total. So this is 0.48 percent will be the a multiplied by 0.5 to 28 25 percent will be b 14 percent multiplied by 0.29 will be c and multiplied by 0.28 will be almost similar.

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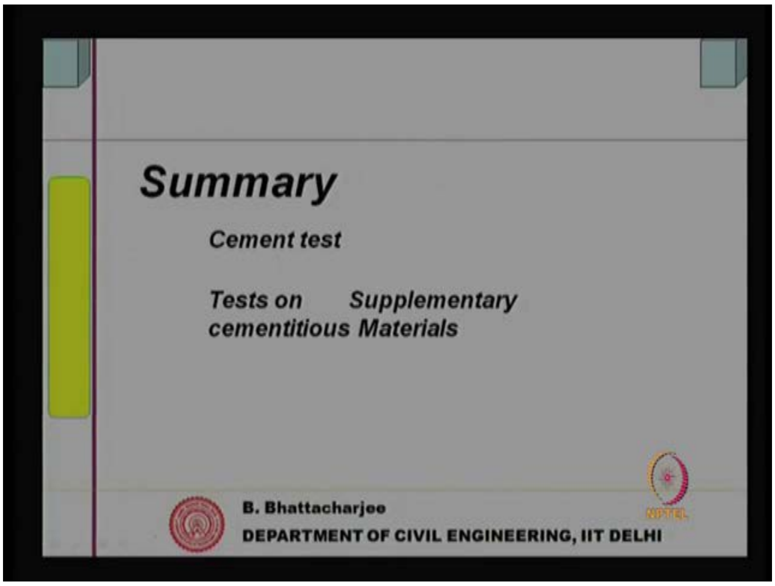

So this is the proportions of a b c d right. So this is how finally, therefore I get this by solving this equation I get 150 each one of the them this is the proportions of each one of them will be this and blended aggregate quantity I can calculate out because I know 150 this is my desirable 98 into 0.48, 100 into 0.25, 100 into 0.14.

And 100 into 0.13 gives me 99.04; 10 into 0.48 92 into 0.25 and 100 into 0.14 and 100 into 0.13 will be 54.8 and so on and if we calculate out all of them you get the blended aggregate. So therefore total you can find out and this is how we can obtained the proportion of all the aggregates. So therefore, this is how we you know we find out the proportions of aggregate right. So to summarize to summarize just to summarize we have actually in this module 3 we have looked into aggregates packing characteristics test some index like fineness modulus and surface modulus but, in the beginning we also defined how do we defined size, shape because and there important in packing we have looked into this some of this ideas will be very useful when you discuss workability and other issues.

Thank you very much.