Pavement Material
Professor Nikhil Saboo
Department of Civil Engineering
Indian Institute of Technology, Roorkee
Lecture 14
Classification and Gradation of Aggregates (Part - 2)

Hello everyone, welcome back.

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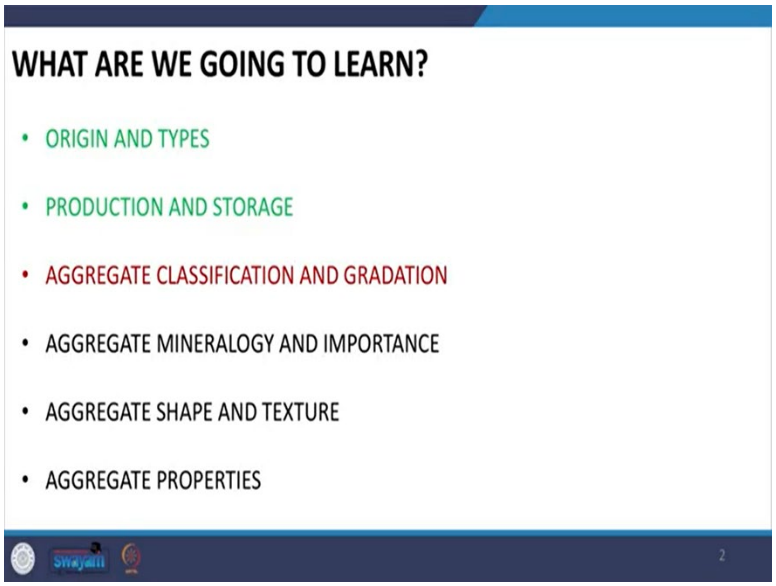

If you remember that in the last class we started discussing about aggregate classification and the gradation of Aggregates. And we discussed about the maximum density line and how the maximum density line can be produced and how the gradation when varied about the maximum density line looks like. So, today, we will continue our discussion on the same topic and we will start discussing about the blending of Aggregates.

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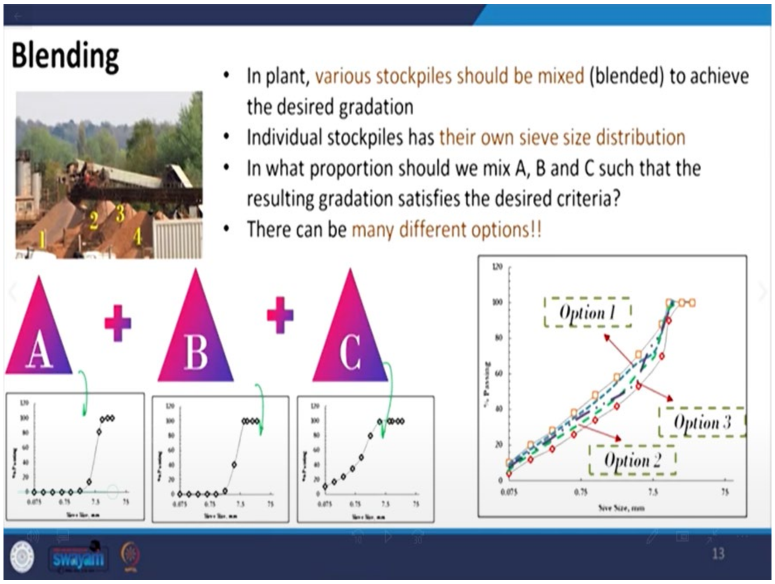

Try to understand it in this way that what happens in plant. If you remember we discussed in plant we have stock piles, now these stock piles are fractionated which means one stockpile will have let us say Aggregates ranging from A to B size only. Another stockpile can have finer Aggregates from C to D, so different stock piles have different ranges of a narrow-sized aggregate. They themselves are not individual gradations which can be directly used in construction or making the mix. So, in plant these stock piles of different sizes needs to be mixed together or Blended together in such a way that we achieve the desired gradation and what is the desired gradation the one which the highway agency provides us.

So, let us say you have plant you have different stockpiles 1 2 3 and 4 or 5 or 1 2 3 and these individual stockpiles have their own sieve size distribution is not it. Say you have three stock piles A B and C so stockpile A has this sieve size distribution B has this sieve size distribution C has this sieve size distribution so all these stock piles have their own sieve size distributions. But these distributions are not directly used as the Final Mix is not it. We have to decide that in what proportion should we mix a b and c such that the resulting gradation satisfies the desired criteria.

And what is the desired criteria the criteria is the one which the highway agency is providing us with the upper bound and the lower bound limits all right. So, of course if you talk mathematically there can be various ways of mixing A B and C to meet the band criteria so this aggregate band or the gradation band it is an area so you can have multiple curves passing through the area which are produced through the same stock piles same set of stockpiles but mixed in different proportions all right. So, again we have another important question here that which is the best combination of A B and C such that it satisfies the desired criteria.

So, there are two question one is in how many ways can I mix A B and C so that I am within the gradation band. And let us say there are thousand different ways in which I can mix A B and C and still be within the gradation band then the next question is which is the best solution out of these thousand number of solutions. Now, importantly you have to also note it is also possible that irrespective of any combination of A B and C you never satisfy the desired gradation maybe the stockpiles which you have some sizes missing which are required in the actual final gradation.

In that case what we have to do we have to change one or two stock piles so that we have sufficient options available or at least one option available the mixing of which will give us a final gradation which is within the gradation band or the desired gradation band. So, before I tell you about the blending part let us see the blending calculation what do I mean by mixing this stock piles and what do I mean by the final gradation using this stock piles.

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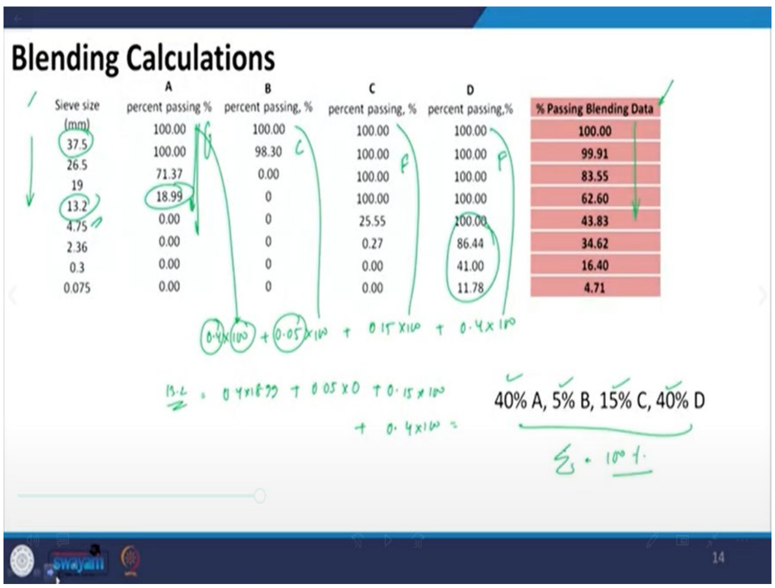

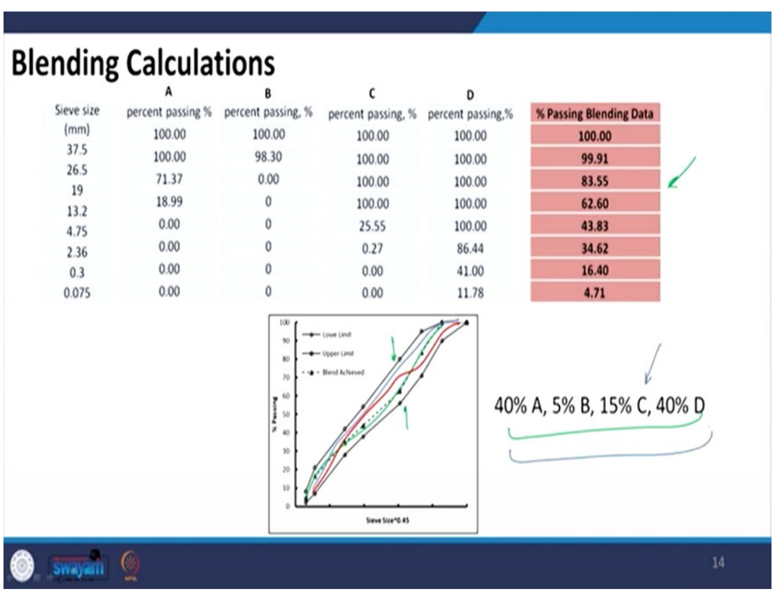

Let us say you have these standard sieves here I have taken another gradation having a different set of sieves here ranging from 37.5 to 75 micron. Let us say you have the first stock pile and you did the sieve size analysis of the stockpile you calculated the percentage passing corresponding to different sieve sizes and you got these values.

So, I think it has moved little up and down so anyways let us say you got these values. Let us say you have another stock pile B, B has its own seat size distribution again you have another stockpile C and C also has its own aggregate distribution you have stockpile D and D has its own aggregate gradation here just to inform you. For example, A looks like a coarse aggregate gradation B is also a core segregate gradation this is a medium aggregate gradation refine aggregate gradation this is also fine because you can see you have material on the lower side also so maybe this is a filler or material you know passing 4.75 mm sieve.

So, now the question is that you have to mix A B C and D and let us say the proportion which we have decided is 40 percent A 5 percent B 15 percent C and 40 percent D. Now, please remember we have not discussed how to decide this proportion we are just discussing about the calculation. So, let us say using some process we have decided the proportion of Aggregates to be used and these are 40 percent A 5 percent B 15 percent of C and 40 percent of D and remember that the summation should always be 100 percent because this is a proportioning which we are doing. By mixing these stock piles what will be the percentage passing 37.5. So, 37.5 will be $0.4 \times 100 + 0.05 \times 100 + 0.15 \times 100 + 0.4 \times 100$.

So, I am multiplying individual proportions which I have written here with the corresponding percentage passing that particular sieve. So, for example if you want to calculate for let us say this one for 13.2 the combined gradation will be $0.4 \times 18.99 + 0.05 \times 0 + 0.15 \times 100 + 0.4 \times 100$ and so on. So, corresponding to each sieve I am multiplying the proportion of the stockpile with the corresponding percentage passing that size all right.

And I am summing it across different stockpiles so I get my percentage passing final Blend. And this is how I know that what will be the gradation if I mix these stockpiles in this proportion I change the proportion the values will change all right I change the proportion the value will change again.

So, in this example which I have chosen this is the graph which is obtained so you see you have upper bound lower bound given by the ministry. And this dotted line shows this gradation which means that this proportion which I have selected is good enough to be selected because my gradation falls under the gradation band.

But again, an important point to note here is that we can have several other combination of proportion I can have a proportion maybe which will look something like this still within the gradation band but a different proportion. I can have another proportion say which will look something like this all right still within the band. So, now the question is how do you find that which combination will at least satisfy the criteria.

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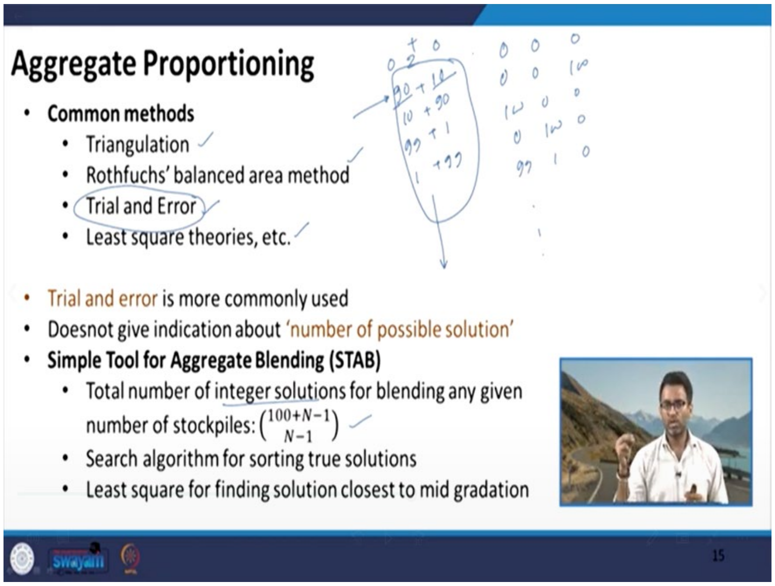

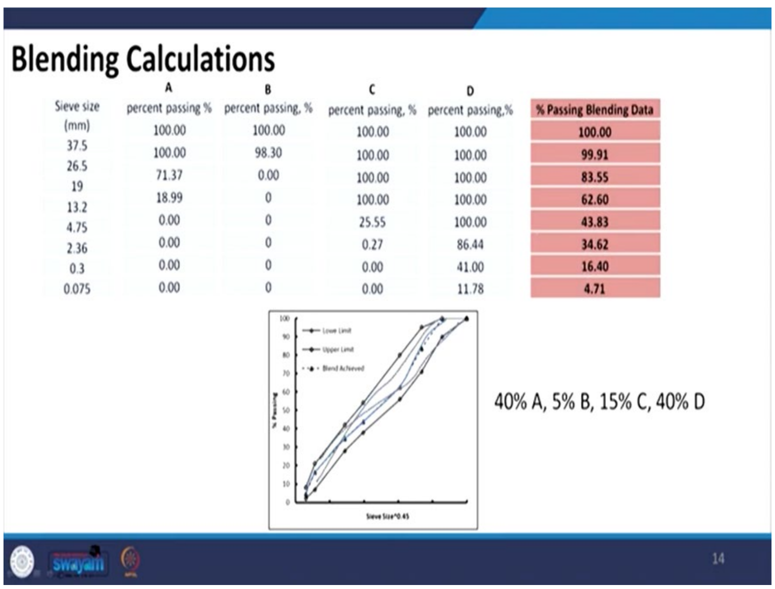

So, here comes the question of aggregate proportioning. Now the common methods that are used for aggregate proportioning which is in what proportion should I mix this stockpile to satisfy a my gradation criteria. There are various methods like triangulation, Rothfuch balanced area method, trial and error method there are least Square theories and many more. But usually in practice we mostly use the trial and error method because this is more convenient in nature. With some experience by looking at the individual gradation we can have a good start of aggregate proportions to see whether the combination is satisfying the criteria.

We can use a simple excel sheet and make a simple preprogrammed sheet and just by changing the values we can see whether the combination or the proportion is satisfying the gradation criteria. But again, trial and error method can be too much iterative and most importantly we will be able to find the combination which satisfies the gradation but it will not tell us about the number of possible solution which I just explained you in the last slide. Let us say this is through trial and error so I was able to achieve but what about another gradation something like this for this what will be that proportion of each stockpile which I have to select.

So, sometimes the designer might be interested to know how many possible solutions are there with the given stock piles to arrive at the gradation band all right how many possible solutions are actually there. We have recently developed a simple program which is called a simple tool for aggregate blending I will just try to give you an very brief idea about the theory which is very easy to understand which we have used to create the program which will tell us about the total number of integer Solutions of mixing the different stockpiles to satisfy the gradation criteria.

Here what we do in the background first we create a space of calculations you can say of blending different stockpiles. For example, if you have two stock piles how many ways you can blend it you can blend it let us say you can take the first stockpile as 90 the second stockpile is 10 then 10, 90 you can have 99,1. 1, 99 and remember I am talking only about integer Solutions of blending the stockpiles so that the summation is 100. I am just trying to find in how many possible ways these two stock piles can be added such that the summation is hundred all right.

So, I can create a space for this solution if we have three stock piles of course the number of solutions will increase I can have an options like (0, 0, 100), (100, 0, 0), (0, 100, 0), (99, 1, 0) and so on so many different solutions so mathematically it is possible to know how many such solutions are possible it is basically (100 + N – 1) or (N-1) and you can easily create a program to create this data of solutions based on the number of stockpiles in questions. So, here what we did we created this database for maximum five number of stock piles because beyond five number the number of solution is so large that it takes much time for the program to run.

Typically, the number of stock piles which are used in practice is always less than or equal to five so we restricted our program to blending up to maximum five number of stockpiles. And then you have so many solutions then you run its Solution on the actual gradations of individual stockpile and you see that mixing 90 percent of A and 10 percent of B what is the value corresponding to its shift size. And then you compare whether the solution which you are getting falls within the band or not.

The next step involves a search algorithm after doing the analysis and then based on the search algorithm you sort the solutions which satisfy the gradation brand criteria. And these sorted solutions will be the total number of solutions which you are looking for all right. And then in the same program we also have an option where you can find the solution which is closest to the midpoint gradation all right. So, here we have just used the least square technique and we have calculated the error for all the solutions and the solution giving the minimum error corresponding to the mid-size gradation will again pop up as a separate solution which you can see.

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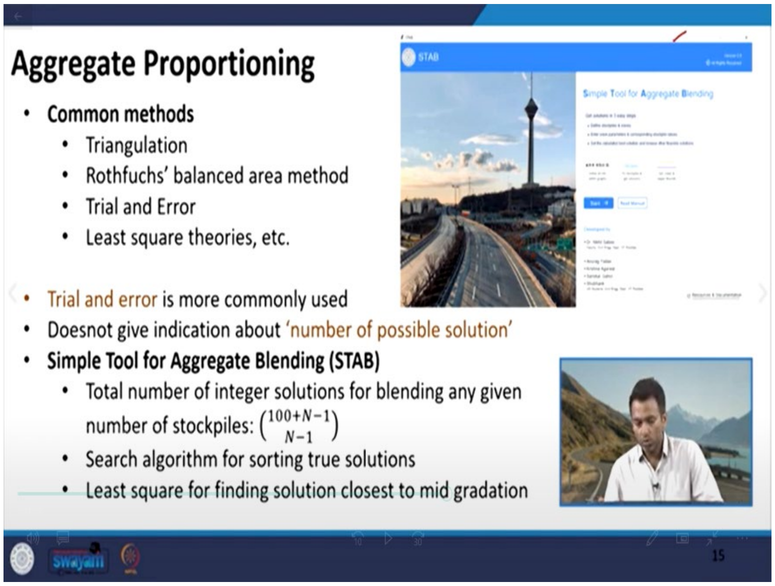

The front page when we open the software will look something like this which you are seeing on the right side of the screen. We will be looking at this software once we solve a problem using stab and then I will try to explain different interfaces and different pages which come and how to you know give the inputs to use this software for solving the problem of blending.

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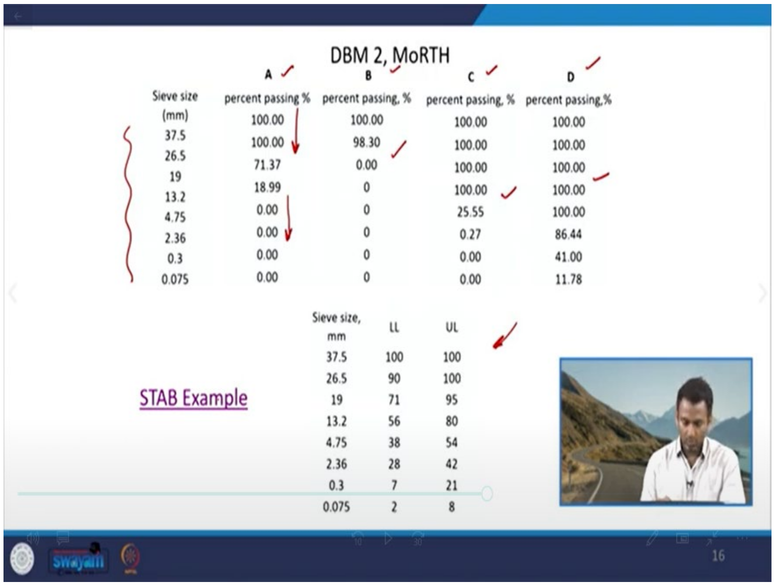

So, let me first outline this problem for you so we are going to see the gradation DBM 2 as per Ministry of Road Transport and highways. And let us say that these are the stock piles which we are using to solve the problem. Here we have four stockpiles A B C and D each stock pile has been separately sieved and the person passing has been calculated corresponding to different sizes of the sieve. And which you see here that these are the sieve sizes which are standard and then corresponding to each sieve size we also have percentage passing all right.

And now for example you see stockpile A is a core stockpile as you can see that below 13.2 we do not have any aggregate passing in this particular stock pile. Similarly, stockpile B is also a core stockpile and then C and D are relatively finer stockpiles. And the lower bound and the upper bound limits of DBM 2 is shown here. We will also use this as an input when we are trying to solve the blending problem.

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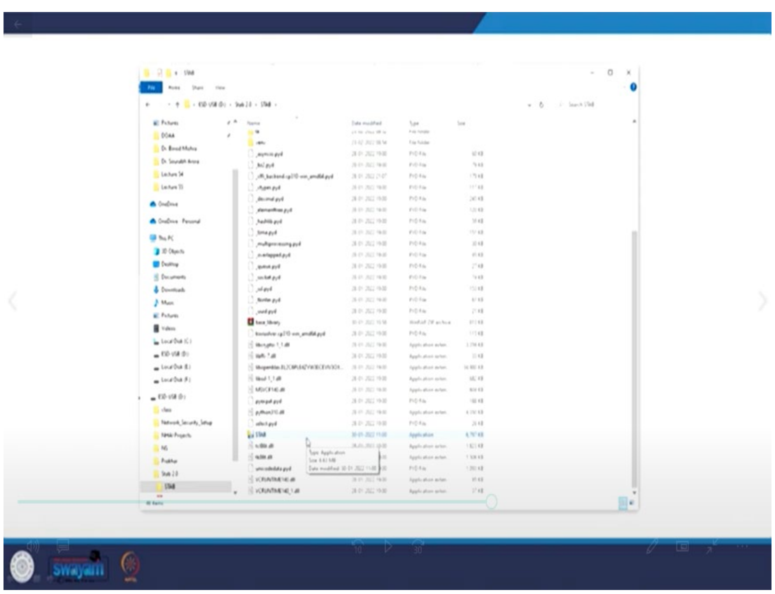

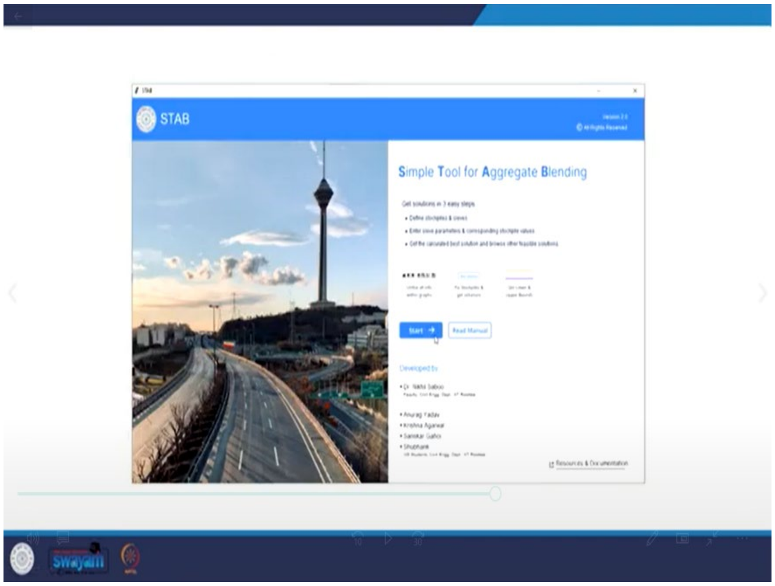

Let me very quickly go to the software now so I hope you are able to see the folders opening so you see that once we open it we will click on this application files tab. We will just double click it to start the program and this is what you see all right. So, it says simple tool for aggregate blending get solutions in three easy steps what are these steps we have to define stockpiles and sieves.

We have to enter sieve parameters and corresponding stockpile values and finally we will get the solution and we will also get something which is called as a best solution which I have already described previously like how this best solution is defined in this particular software. So, just to mention that this software which you are seeing in the present form has been developed by a group of undergraduate students from the Civil Engineering Department of IIT Roorkee.

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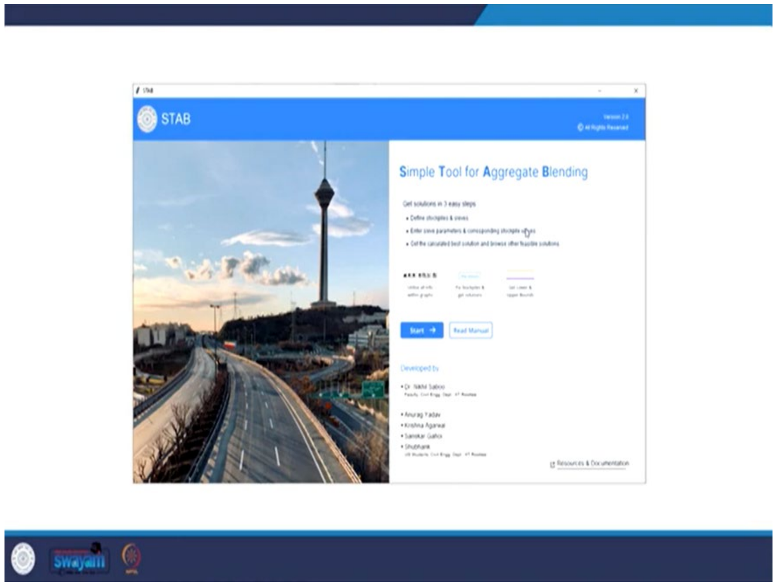
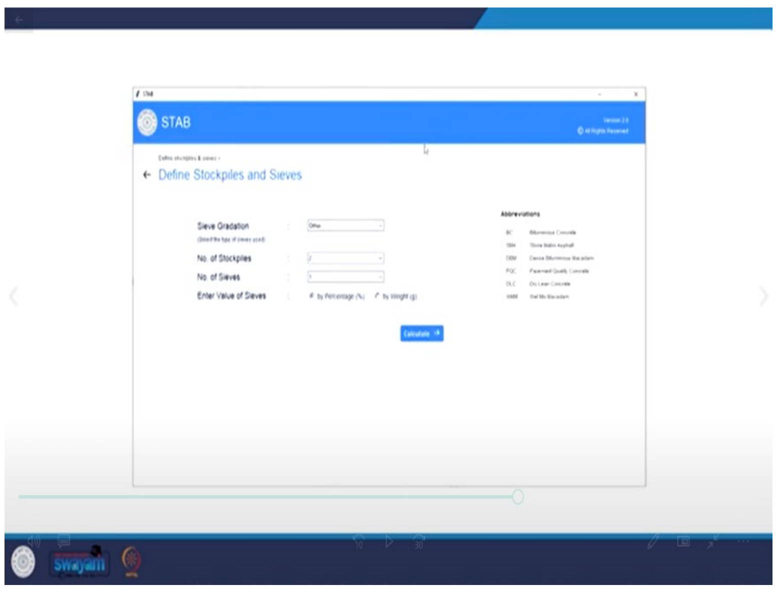
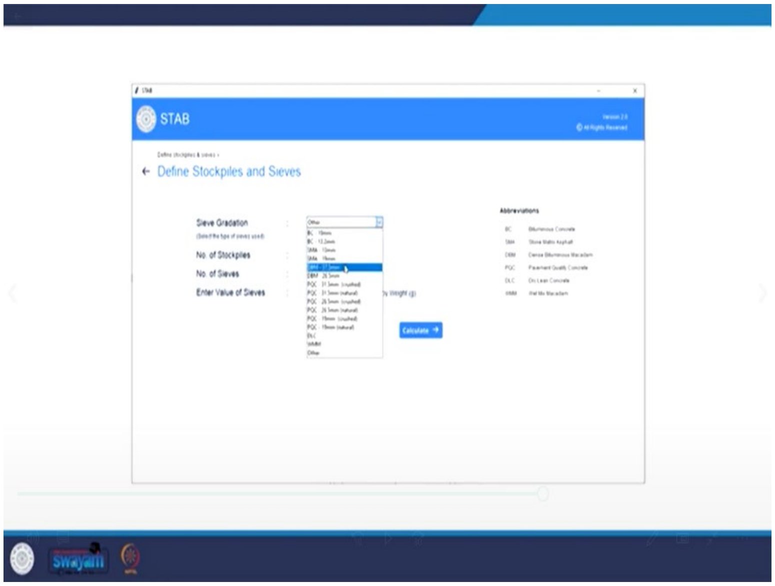
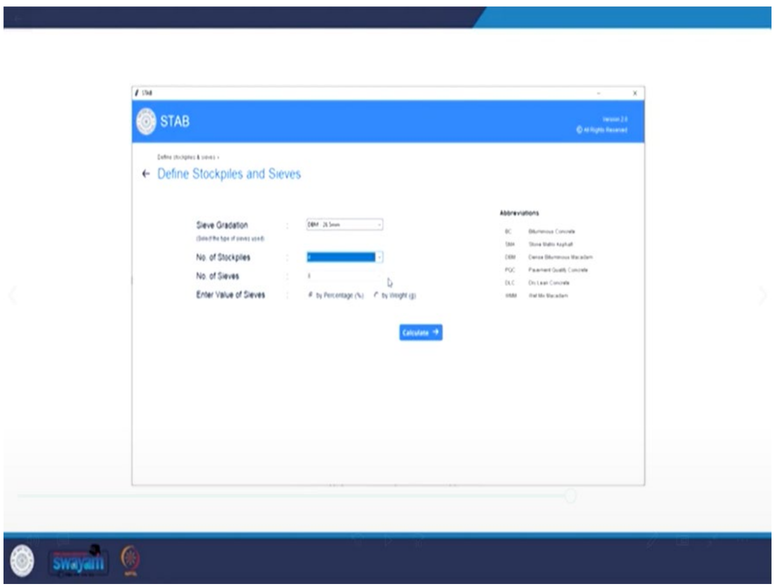

STAB
Simple Tool for Aggregate Blending
Get solutions in 3 easy steps
Define stockpiles & sieves
Start
Read Manual
Developed by
Dr. Nikhil Saboo
Anurag Yadav
Krishna Agarwal
Sanskar Gahoi
Shubhank
Resources & Documentation


STAB
Define Stockpiles and Sieves
Sieve Gradation
No. of Stockpiles
No. of Sieves
Enter Value of Sieves
by Percentage (%)
by Weight (g)
Abbreviations
Calculate





So, now let us start this particular software will click on start and it says that you have to first select the sieve gradation. Now since we have developed this software more specifically for the corresponding to Indian specifications, we already have given certain standard mixtures as an input here. So, that we do not have to manually enter the lower bound and the upper bound limit again and again. So, these gradations include BC SMA DBM we also have for concrete mixtures PQC DLC and granular layer we have WMM. So, these are some standard gradations which have been already included here.

If you are trying to use stab for another gradation for another standard gradation or any other gradation we will select the option other as you are seeing on the screen. Else we will select the option which we have already decided in our case it is DBM 26.5 mm. Number of stock piles as you already saw is equal to 4 so we are selecting 4 here you see that we do not have any option to change the number of sieves as we have selected the standard gradation. So, the number of sieves has been logged here. If you select other then you will also have an option to input the number of sieves in the standard gradation which you are targeting.

Enter the values of sieve so here you have two options either you can enter the value of weight of Aggregates retained on each sieve in different stock piles or you also have an option to just enter the number as percentage passing. In this case since we have already done the analysis on the individual stockpiles and we have evaluated percent passing as I showed you in the presentation. So, we are selecting here by percentage and then we will move to calculate.

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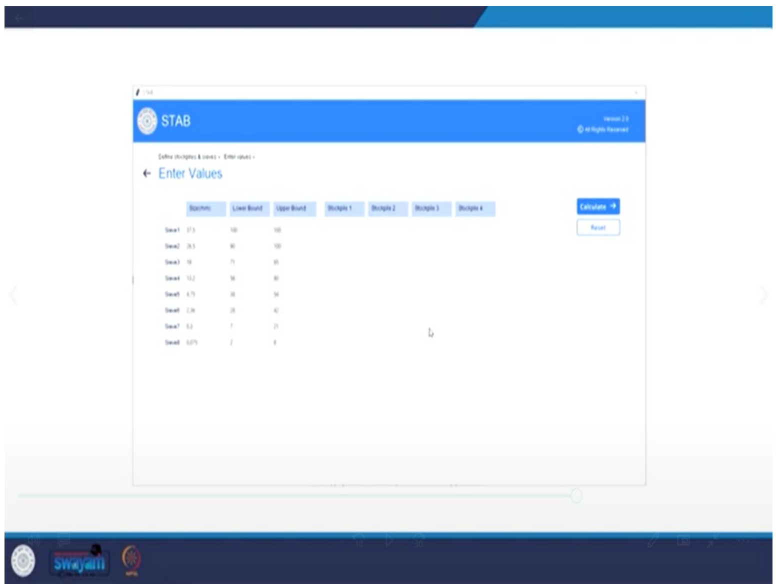

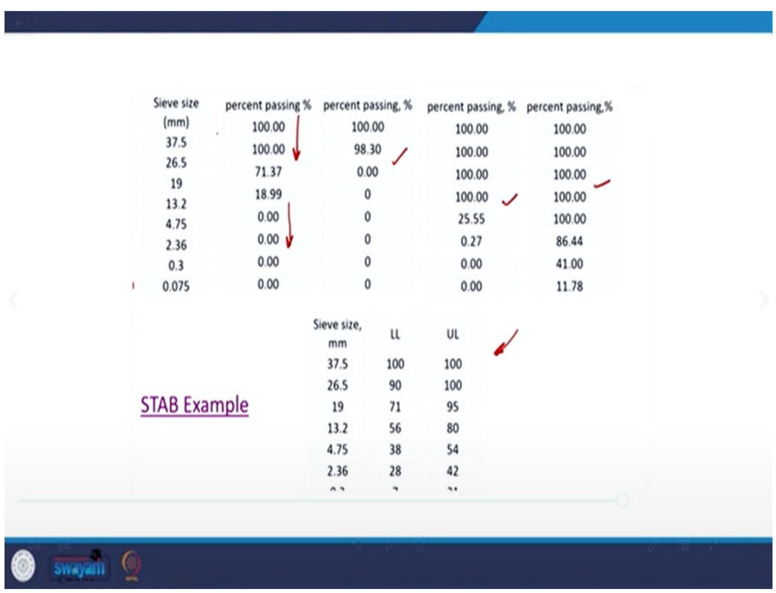

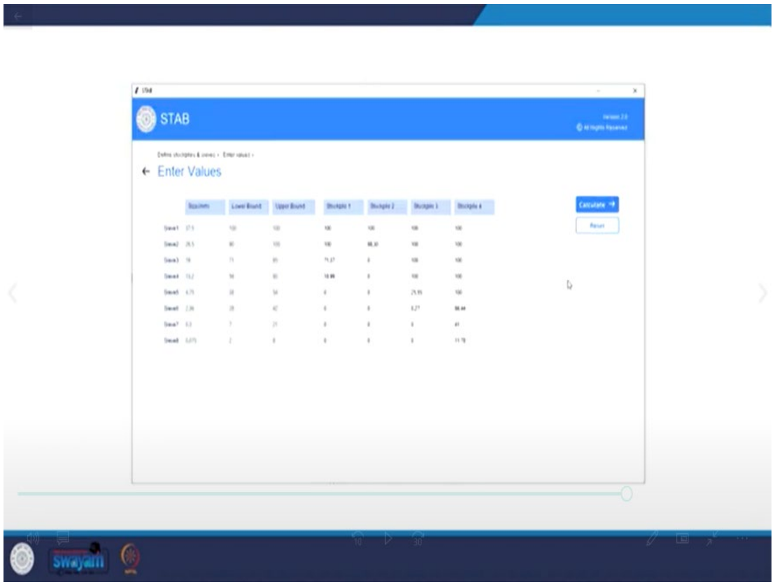

Here you see that corresponding to different shift sizes the lower bound and the upper bound limit have been fixed because we have selected the standard gradation. And now the option appears that we have to enter the percentage passing corresponding to different sieves in each stock pile. So, let us do that in stockpile 1 we had the values as a 100 and 100 again 71.37 18.99 and then the finer Aggregates are not present in this particular stockpile. Similarly, we will enter the percentage passing for stockpile 2, now we move to stockpile 3. Before we move to the next step let me just tell you what we have done here we have entered these values which you are seeing on this screen all right so these values we have entered.

Let us now go back to the software and let us go to the next step. So, now after entering all the values we will just click on calculate and you see that the software gives the result in a fraction of seconds. You see that the number of possible solutions here using these stockpiles counts to 11626 which means there are

11,626 possible ways of blending stockpile 1 2 3 and 4. So, that we fall within the gradation band that is within the lower bound and the upper bound limits. Which you are also seeing graphically the orange line and the blue line indicates the upper bound and the lower bound values and the green line which you are seeing it shows the best solution.

Now, this best solution has been defined corresponding to the mid gradation of the standard band so this is the solution which is closest to the mid gradation all right. And what is that combination stock 28 percent of stockpile 1, 9 percent of stockpile 2, 23 percent from stockpile 3 and 40 percent from stockpile 4. So, if you select this percentage from each stockpile and blend them together you will be able to see the resulting radiation will be the green line which you are seeing on the graph.

Here we also have an option of first saving all these Solutions so you see there is an option save report. So, if you save the report it will generate a DOT CSV file so in in an excel form you will be able to see the solutions and if any designer wish to choose any other solution for this particular example or for the design he will be free to do so. In the filter solution options what we can do we can fix this stock pile and then we can you know see the solutions corresponding to the fixed stockpile. Let us say we want to fix the stock pile 1 to 30 percent and we want to see that what are the other options available.

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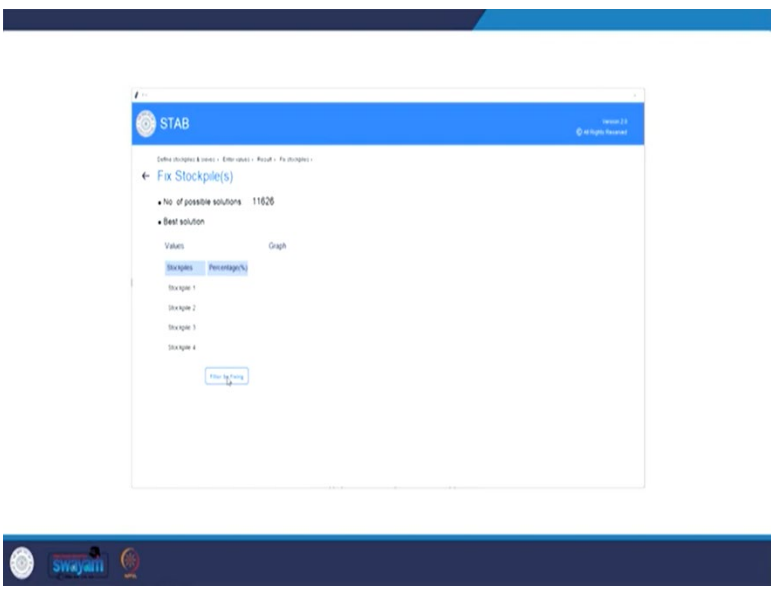

So, we will click filter Solutions here so I will fix this stockpile 1 to 30 I will just input the value 30. And I will click filter by fixing after we select that we have now 318 options available which means there are 318 possible ways where 30 percent of stockpile one can be taken and the percentage of other stockpiles will be varied so that we are within the standard gradation range. And again, here you are seeing a best solution again closest to the mid where you see that the solution is 30 percent of stockpile 1, 8 percent stockpile 2, 22 percent stockpile 3 and 40 percent of stockpile 4.

I hope that this is very clear to you that how we are using STAB and how we are able to get more information about blending of stockpiles about fixing some of the stockpiles it can be a single stockpile or multiple stock pile. And you know we have various options of selecting the blend so that we are able to do the blending. So, we will stop here today and I hope that this lecture was useful for understanding the proportioning of stock Pines and aggregate blending. And in the next class we will start discussing about mineralogy of Aggregates. Thank you.