

Course Name – Pavement Construction Technology
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A very warm welcome to all of you. I am Rajan Chaudhary, a Professor in the Department of Civil Engineering at the Indian Institute of Technology, Guwahati, and the instructor for the NPTEL MOOC course, Pavement Construction and Technology, funded by the Ministry of Education, Government of India. Today's lecture will be part of module 4, and it will include a discussion on the design of unbound granular courses for flexible pavement construction. At the very beginning, I would like to acknowledge the use of text, information, graphs, and images sourced from various textbooks, codal standards, journal articles, reports, newsletters, and public domain searches. Now, the mix design in general is the best combination or the optimum combination that we can arrive at using the available materials. When it comes to the unbound courses specifically, where you have your granular sub-base courses or granular base courses.

So, the mix design is an approach where you decide the blend of the different aggregates available to you to finally meet certain minimum requirements, which may be in terms of density or the blend of the aggregates, which will affect the strength derived from that particular blend. So, here it says the primary objective of the mix design of the unbound granular courses, such as granular sub-base course, wet mix macadam, or water-bound macadam. These are three examples of unbound granular courses, and the approach of mix design here is to develop a suitable gradation and material blend. Now, in most cases, you will have already predefined gradations based on numerous field exercises and research that are usable for different courses, depending on the layer thickness and the aggregate size available.

Here, what you are trying to do is look for a gradation, a possible gradation, and a material blend. So, what gradations there may be, 2-3 different aggregate stockpiles need to be blended together, and this blend should provide adequate strength and stability, as well as drainage, depending upon where we are using it. If it is used as a drainage layer, it should serve the purpose of drainage and the durability of the pavement under anticipated traffic and environmental conditions. So, we try to judge the suitability in terms of this blend through different parameters of strength. Now, if we outline some of the steps involved in this particular process, then first of all, for any mix that needs to be designed, you require the materials that are suitable or can be used for that particular mix.

So, the selection of materials definitely requires you to rely on the available resources nearby because you cannot bring materials from very far distances as it increases the cost. So, you will always try to come up with a blend that makes use of most of the locally available materials. Before putting them to use, you need to determine the suitability of those materials and whether they are suitable for use in that particular course. Here we are talking about the unbound courses, so whether that material, especially the aggregates, is suitable for use as a granular surface course, wet mix macadam, or water bound macadam. Then, as I said, you need to target a gradation.

So, to achieve that particular gradation, you may have to combine two or three stockpiles of different sizes of aggregates to achieve the desired gradation. So, this blending of aggregates also forms an important part of this mix design exercise, and this needs to be carried out as per the requirements of the gradations that may be stated by MoRTH or IRC guidelines. Then, once the blend for unbound courses is finalized, you determine the relationship between the water content and density to arrive at your optimum moisture content and maximum dry density, which are required to further evaluate the strength of those materials and are also useful once they are selected for construction purposes. So, once this relationship is derived, you obtain the OMC and MDD of these materials, and then you proceed to determine the strength specifically at these densities or at some specified percentages of these densities. Now, we will discuss these steps.

Now, first of all, when we look into the blending of aggregates, especially, as I said, the different aggregate gradations to ensure pavement layers perform their functions effectively, different aggregate gradations are specified by the Indian Roads Congress or the Ministry of Road Transport and Highways guidelines based on extensive research and field experience. So, they have specified that if you want, and if your intended purpose is this one, it is advisable to use this particular gradation. So, you will try to target that gradation in your mix. So, in that particular case, you may have aggregates of different sizes, which may be due to locally available materials, locally riverbed material, gravel, some alternate materials, some slag, crushed gravel, or crushed stones from aggregate crushers. So, they need to be blended to arrive at that particular target gradation.

So, a blend of different sizes of aggregates is attempted to achieve the desired gradation meant for different purposes and layer thicknesses. Now, here you can see this is an important step. Now, for granular sub-base courses, MoRTH 2013 specifies six different gradations. These are six different gradations, and all are preferred for different uses, such as the gradation for the drainage layer; the fifth and sixth are preferred for the drainage layer. Then we have IRC SP 42, which also recommends the characteristics of a material for use under the drainage layer.

Now, here you can see that in addition to this particular one, there are materials. Now, if grading 1 is to be used for a specific purpose, then the material under this category should

be all 100 percent passing the 75-micron sieve size, the 75 mm sieve size, the 80 to 153, the 26.5, the 55 to 90, the 9.5, and the 35 to 65. So, a range is given.

And also, from 75 microns, a material less than 5 percent is there. So, similarly, it is there for other gradation requirements also. Now, this is for granular sub-base cores; similarly, this is one that has been taken for the gradation from MoRTH, which is there for the wet mix mechanism that is widely preferred for use as your base courses. Water-bound macadam also provides a gradation range, with both an upper limit and a lower limit, as well as potential target and mid gradation. So, ranges of gradation; this is one where a tabular form is present, and you can plot and see in which ranges your material should fall.

There will be a lower limit; this is a lower limit: the material should at least 25 percent pass through 4.75, and a maximum of 55 percent should pass through 4.75. So, similarly, it is given for about 425 microns that 10 to 15 percent should be in this range; 10 percent is the lowest passing, and 15 percent is the maximum passing. Certain sieve requirements are not given for a few gradings, and there are other requirements.

So, different courses and different materials will have different combinations for the purpose of using a filter layer, whether I am using it as a filter cum drainage layer or as a drainage layer. So, for this one, the MoRTH and IRC specify that gradation 4 is to be used, gradation 6 is to be used for this particular purpose, and that is based on the extensive research and field experience provided by the different gradations. And, as said, normally you will prefer that your layer thickness should be at least 2.5 times your NMAS, nominal maximum aggregate size; the layer thickness should be at least 2 to 3 times the NMAS of your aggregates. Now, in the field, you will not have what is required since there is a range of material needed, but in the field, whatever stockpiles are available from aggregate crushers, or there may be some, say it is quite clear that single natural or quarried material will not be able to meet your requirements; it is quite unlikely that it meets all your needs, as one stockpile cannot provide gradations varying from, say, 75 mm to 75 microns.

Now, it is quite unlikely that a single natural or quarried material will meet the entire gradation; two or more aggregate stockpiles can be seen: this is an aggregate crusher, this is one stockpile being generated, the second stockpile, the third stockpile, and the fourth stockpile. So, stockpiles mean aggregates of different sizes, but one stockpile will have aggregate gradation that may vary from 3 to 4 sieve sizes. So, the other one will be varying, so there may be an aggregate that may be called a 20 mm. So, in that particular case, most of the material may pass through 1 inch, and you can say that around three-quarters of an inch of the material is retained. So, it can be called a 20 mm aggregate, 10 mm aggregate, and 6 mm dust in this way.

So, all will have aggregates in a small range compared to. And what we require is to blend these different stockpiles of 20, 10, 16, or 6 dust together so that you can finally achieve the gradation that you are targeting for a particular mix. Even though there may be a chance that one gradation is giving you a good number of sizes, it is normally not preferred because, in that case, if one stockpile has sizes varying from very coarse to very fine, then there are a lot of chances that segregation may happen whenever the material is dropped, whether when it is stockpiled or during production; they have to be kept in the cold-filled bins. This we will discuss when we discuss the construction of these particular mixes at that time of production and construction. During the construction phase, these aggregates of different sizes are stored in cold-filled bins.

Now this is a plant; it can be a wet mix macadam plant or it may be a hot mix plant where the aggregates that are to be used are stored in these different cold bins. Cold bins are at ambient temperature. Now, you have to figure out how much of blend 1 is to be used, how much of stockpile 2 is used, how much of the third is to be used, and how much of 4 is to be used. So, this is an important exercise during a mix design to figure out or determine what proportion of these individual stockpiles is to be used to achieve your desired gradation. So, one way to attempt this particular proportioning is that there are different methods, but one important aspect in all cases is that regardless of the number of aggregates or the blending technique selected, the basic expression will be given by it.

It says P is the percent of material passing any particular sieve size 4.75, which is arrived at through a combination of three materials: material A, material B, and material C. Now, what does capital A stand for here? The percentage of material passing a given sieve size for each aggregate. So, if I am targeting, say, 4.75, and I have three aggregates A, B, and C, I will write how much percentage of A is passing through 4.75 here. How much percentage of the second material B passing through 4.75 has to be written here? How much percentage of third do I have if I have 3 stockpiles; this is a cold fill bin? So, I have 3 aggregates: A, B, and C. When I did the individual gradation, I tried to ensure, as I mentioned, that the aggregates may be in the range of a few sieve sizes. So, I will check; there may be a chance that this is 100 percent passing, and there may be a chance that this is 0 percent passing, as this material retains everything over 4.75. Then this is for B; for this particular material, this is for material C. It may happen that 100 percent should pass through this 4.75, and for this particular material, it may happen that 80 percent may pass through it. So, three stockpiles of aggregates are used, and now I want to show that if I combine them in a particular proportion, what proportion I am using? a , b , and c have to be 1 because when they are combined together, the total must equal 1. So, I can just randomly put up a combination where this can be 0.7, this can be 0.2, and this can be 0.1. Now, if I am using that, it means 70 percent of the shear is coming from A, 20 percent of the shear is coming from B, and 10 percent of the shear is coming from C. So, this is

expressed in fractions. Now, this together has to be 1 because it has to be 100 now, or in fractions, it is 1.

Now, here for this particular example, if I want to see how much percentage is passing through 4.75, then as I said, 80 percent is passing, so 80 into 0.7 for the first case; in the second case, I mentioned here that 0 percent is passing, so there is 0 into 0.2. Because 20 percent of this material is shared, and the third one is 100 percent passing.

So, 100 of this C and how much share of it is a share of 10 percent? Now, this will give you 56; this value will come up as 56, and this value will be 10. So, this makes 66 percent passing. So, if I combine A, B, and C in the proportions of 70 percent, 20 percent, and 10 percent, then on this particular sieve, this proportion will give me a material that will be 66 percent passing 4.75. So, now this is, this I have ensured for 1 C.

Now, when a material is to be used for a particular layer, as I mentioned there are 6 gradations given for granular sub base course itself and each gradation has a range. So, it is not, for my particular use, that if a range is given, your material should pass through 4.75 in the range of 50 to 70. Then this particular percentage passing is okay, but if the range is given, it should be 50 to 60 only; then this proportioning or this blend is not okay. Now, I am checking only for one sieve; I have to check which sieves are required in that gradation.

I can because there are 4 or 5 sieves, or maybe more than 8 sieves, for a particular mix type, and for each sieve size, a range is given. So, I have to ensure that for the blend I am formulating. The combined gradation, this percentage should be for each sieve falling within my required ranges; we will do that exercise. So, this is an important aspect that needs to be checked whenever you do this blending exercise. So, this is an important part of your mix design exercise that you always like to see: in what manner you can combine the materials so that, finally, you are able to proportion the materials to achieve your target gradation.

Achieving the desired gradation within the specification band by blending two or more aggregates of different sizes is often attempted through trial and error. With experience, you get a good idea that this is coarser. Here, as I mentioned, if 66 percent is passing, I require 70 percent for passing. Then, as C was a material where 100 percent was passing. So, if I want to increase this percentage passing, I will increase this share of C, which was earlier 10 percent; I will make it 15 percent.

So, at the shear, some other material has to be reduced. So, it comes from experience, and you can just try to see which material is contributing to which particular shear—coarser shear, finer shear—and you can adjust those percentages to arrive at a blend. So, you can attempt through trial and error. And now various mathematical, grammatical, and

programming tools are available through which you can attempt a quick and easy approach to get this particular blend.

I will just give you an example. Now, in this one, there is a requirement that two aggregates are given: A and B. I have two aggregates with me for a particular work, and my specification says that for the mix I need to produce, the required aggregate gradation ranges are as follows: for 12.5 mm, 100 percent of the material should pass, and for 9.5 mm, 80 to 100 percent of the material should pass. So, simultaneously I am also writing the mid values; I will call them mid values.

So, my mid value here in this case, 100 percent, should pass. So, it is 100 only for this 9.5, 80 to 100. So, my mid value is 90; then it says that 4.75 to 45 percent of the material should pass through it.

So, approximately 17 has to be added. So, I can round it off to 62 percent that should pass through it. Similarly, 30 to 50 should pass through 2.36, so 40 percent of the material is the mid value. Why am I mentioning mid values here? Because I will be targeting the mid values. If I target the mid values, hopefully what I will arrive at may be within the range.

So, I will prefer targeting the mid value for my combination. Now, here in this case, you have only two aggregates, and you have to combine them. Now, if I see these gradations, the individual gradation of these two materials is given. Can I work out by having only a single source? So, if I think that I will not use aggregate B, I will go with aggregate A only. If it is possible to have it, it says that if I use 100 percent of it, then this material will pass 100 percent; this meets the requirement of 95 percent passing, which also meets this requirement.

When it comes to this, only 17 percent or 17.5 percent is passing, but I require a material that should pass 62 percent. So, using A alone will not work. I need to reduce this percentage; I need to add another material that is finer because I need a percentage that is at least 62 percent passing, and I currently have a percentage that is only 17.5 percent passing. And can I do it the other way round instead of A? If I go only with aggregate B, I will not use, say, aggregate A.

Whether that is possible, then here when it comes to 4.75, it is even at 9.5. It says 80 to 100, okay fine, 100 is there, so the extreme limit is there, but when it comes to 45 to 80, it says 95 percent is passing, and I require a material which should only pass. The minimum limit is 45 and the maximum is 80, and here it is, if alone it is used, then 95 percent is passing.

So, alone, B also cannot be used; now I need to blend these two. So that I can mix A and B in whatever proportions, my combination should give me a result within this range, and

my target will be my mid values. So, here it is now given for this particular one specifically what I can observe: it comes with experience. I can observe this is a sieve size; here you will see there is a good difference in this one. Both of these materials are 100 percent passing, here 95 and 100 percent passing.

So, here too, more or less, something similar is there. Here, it is 17 percent passing; it is 95 percent passing; it is a good difference. When it comes to this particular part, it gets significantly reduced; only 2 percent is passing, while here, more than 80 percent is passing. So, this is important; here you will get material only from this percentage passing because there is very little material available with it. So, these are important sieves that need to be worked out when you are doing these trial-and-error exercises.

So, if I will select say 2.36 as one of my sieves to attempt the trial and error. Now, for this trial and error, I will choose now if I have A; a is my proportion of material, small a is for the proportion which I am going for material a, and this small b is for me. Now, if this is there, then as per this equation, it states how much percentage of material A is passing 2.36, 2.2, and how much percentage of B is passing 82.5. Into B, and this is to be equal to what I desired out of it, which is 40 percent; this is my target. So, I will set my target value, and my expression states that a plus b is to equal this; combined, this should be 1. So, I can work out; I can simplify this as this one. If I simplify this particular one, what I will get I will show you on the next slide. So, here I just started with the important thing: you need to work out what sieves you are trying to use.

So, here 2.2 A 82.5 B as we have seen this is for this one, this is for this one and this is what your target was there. So, this target is mentioned here. Another is this. So, I will solve these two variables with the two equations I have.

So, I will solve it. What I get out of it is that the value of b is determined to be 0.475. So, when I get this, it means the share of the B material is 47.1 percent, and the share of A will be 52.9 percent. So, this gives me the first trial or trial proportions that I can work out. So, the first trial that came out to me is that I can use 47.1 percent of material A and 52.9 percent of material B; this is a combination. So, the proportion is to be mentioned in fraction, so point as it is shown here for 0.471; B is 0.529. Now, with this, I will try to see whether what happens at the other sieve sizes also allows me to get the materials within the range. So, if I work out for 0.3, 0.3 mm, see what it says here: I am trying to work out the percentage here.

The first one says 0.6 percent, only 0.6 of your 0.471 plus what is there: you have 25.2 into 0.529, and this gives you a percentage of 12.2. Now, whether 12.2 is acceptable, I will see what the required range is; the range says 5 to 25, so 12.2 is within that range, and the target was 15, so it is acceptable. Now, whether it is coarser or finer, it is coarser than I was expecting; I wanted to target 15 percent material passing, but mine is only 12

percent passing. So, my material at this sieve is coarser. So, now with this particular blend, I am trying to see whether what I arrived at with A as 0.471 and B as 0.529 is coming in the ranges; then I saw that 100 percent was my requirement here, 100 came here, the range was 80 to 100, and the target was 90; I got 97.3. So, it is a bit finer at this sieve.

Because I got a higher percentage of passing. When it came to 4.75, the target was 62; I got 54, which is within the range. So, it is within the range; it is acceptable, but mine is coarser compared to what I am requiring. Around 60 percent is my target mid-value. When it came to 40 here, I got exactly 40 because I solved this equation for 40 only. Now, when I am here, the target is 32; what I got was 31.4, very close to my mid value.

So, it is good for 1.1 mm and 1.18 mm when 16.6 mm or 600 microns are called. Here, the mid value I got is 22.5, and the target was 22. So, it is good again. So, similarly, I have seen here that I got 99 as my mid value; what I got is 9.4; here it was 4.5, and I got 3. So, this proportion is able to meet the target. Requirement of the gradation. I can fine-tune it, depending because all are still within ranges, but as I mentioned here, it is coming to be a bit finer compared to what I was requiring, which is 90 percent. So, if that means the share of B is more because B is the material that is finer here in this case.

So, what can I do? I can reduce the percentage of B slightly. I will make it smaller. What was happening here? I was having 52,529. So, I can make B as, say, 0.51, and similarly, I can make A as 0.49. So, with this one, I can make one attempt to see whether this is working or not. So, in this manner, with the trial-and-error method and with experience, you try to work out important considerations, such as which material is more important; for instance, in certain cases, you have to place more stress on the type of materials you have for the one that is passing 75 microns because you will get it from. Here, we just looked for 2 aggregates; there may be more than 2; 3 or 4 aggregates may be present. So, you need to target which one is most appropriate for you. Now, another method that is quite often used is a graphical method, which is also known as the Rothfuch method, and the details are given in IRC SP 89. Especially there, they have used it for soil and granular material stabilization using cement, lime, and fly ash materials having different sieve sizes, and how they can be blended to achieve a target gradation, because this gradation gives a good amount of information about the whole mix.

If the gradation is dense, we can expect a higher density. We can expect lower permeability. If the gradient is open, we can expect that the density will be lower. We can expect that the permeability will be high. So, a good amount of information is derived from the gradation itself. In this graphical method, what is attempted is normally done when you now have a good amount of programming and software tools.

So, you do this gradation very easily with those ones compared to others, but this is one where it is still practiced when you have in the field three or more aggregates to be blended together. Now, in that particular case, the first exercise to be done on any graph paper is to plot a rectangular figure. Now, this is a rectangular figure.

This is what the target gradation is that you have. This is an example. Here it is given a material from 53 mm to 75 microns, and for each, a range is provided. So, I can also arrive at the mid values for each sieve size. So, here I can say 100; this will be 97.5, this will be 70 percent, 50 percent, this will be 32, this will be 22, this will be 12, this will be 6.

So, these are my mid-values. Now, what we do on this particular one, once you have this graph paper, is we will plot the percentage passings on our y-axis, and then we will have this particular diagonal here, which is drawn to join these two endpoints. Here on this one, you need to mark the sieve sizes on your x-axis, the sieve sizes on the x-axis. For marking the sieve sizes on the x-axis, you need to work out the mid gradations and mid values of your required gradation. So, I will have 100 percent; I will show you one example.

So, I have 100 percent; I will have 100 percent, here it says. So, 100 percent, I will mark this particular 100 percent over, and this will become my sieve sizes; this is my 100 percent passing. So, these are my sieve sizes; this is a different sieve size. So, what I will do with respect to the percentage passing using this diagonal line is mark the sieve sizes on my x-axis. So, if the sieve size is here, 40 percent is the mid value.

So, I will use 40 percent here; 40 percent I will draw for this particular one. I will extend this one, and it is brought down, and this will give me my, sorry, there is no 40 percent; this is 50 percent. So, I will go for 50 percent. What do I do? I will go for 50 percent; I will drop a line down, and this 50 percent will show me for my 11.2. So, here is another example of the 11.2 sieve size that I will mention. So, similarly, all these will be marked here and plotted down. So, I will get all these sieve sizes on my x-axis corresponding to these mid-values of mine. So, it says on a graph paper that the percentage passing is the first mark on the y-axis, the x-axis represents the particle size, and the sieve indicates which is to be marked based on the desired gradation; this is an example. So, this desired gradation, the proportions obtained, and the sieve sizes are marked corresponding to the percentage passing of the required gradation. This is done by locating the average percentage passing, which we worked out for locating that point on the y-axis; we locate that percentage passing and then proceed to cut this diagonal line, and then we project it down to get the sieve sizes.

So, once this is done, you get your sieve sizes on the x-axis for this one. Now, whatever blend of aggregates you have to attempt here, it may be, say, for this particular case, there

may be three aggregates, or there may be four aggregates. If three aggregates are present, I need to plot the individual gradations. I will use the sieve sizes given there, and with respect to those sieve sizes, I will plot the gradation. So, this gradation for A is plotted here.

The gradation for this second material is plotted here in this manner. So, these are the gradations which say 75-micron 0 percent passing; it indicates how much percentage is passing for this 10 mm, and for 40 mm, how much percentage is passing. So, this needs to be plotted in this particular way. So, at then in this manner, all sieve sizes are marked. This is the gradation distribution of materials A, B, and C, and it is then drawn using the sieve sizes marked on the x-axis and the percentage finer marked on the y-axis.

So, I have drawn three gradations accordingly. Thereafter, since it is graph paper, I will draw a line to represent what I will call a balancing line. So, this is a balancing line for materials drawn in such a manner that the areas on either side of the balancing line are equal, and the minimum balancing and the gradation are equal as well; you also have to ensure that this is the minimum. So, what if you can see this is one gradation; this was the one gradation B gradation going from here. This is your aggregate gradation B. So, a balancing line of this particular one is drawn this one, this dotted line is drawn. What is there? On the graph paper, I will see how many squares are on this side and how many squares there are. So, this number of squares plus this number of squares should equal this number of squares. Now, this makes this balancing line, and this total number of squares should be a minimum.

So, I will try to make this balancing line as close to the existing one. So, this one best represents gradation B. This straight line best represents gradation B. This dotted line best represents my gradation A. Once these three are there, this is again here for this particular one.

This is the best gradation for my C material. Now, once you have these balancing lines drawn for your aggregate gradations, you will join the balancing lines of one gradation to those of the other gradation. Here, this one is joined. So, this is for A, this is for B. Now, it is joined here, and where it cuts the diagonal, this is marked in this manner. Whatever you get from this percentage passing, how is it happening? When you are at the lower point of your balancing line A, which is joined with the upper point of your balancing line B, where it cuts diagonally, you will project it onto the y-axis.

When I project it on the y-axis, the percentage I will get will be my material A, which is my 50 percent. Where it cuts, this is now the balancing line of second; this is the balancing line of third. Where it cuts the diagonal here, when projected, it came out to be this one. So, what I will say in that particular case is, how much percentage this is; if this is 7 up to this particular one, then this will be 43 percent, and what will be the percentage

of C? It will be 7 percent. So, my combination is: A is 50 percent, which I have to use; B is 43 percent, which I have to use; C is 7 percent.

So, it will be A as 0.5, B as 0.43, and C as 0.07. So, we arrived at this proportion through this graphical method. So, when you have a larger number of options, as you do nowadays, you have a good amount of programming available where you can attempt this particular one to get the best possible gradation that can be close to this one. So, this is again an explanation where it is mentioned that once you have this gradation, you have the balancing lines, and you project and get the percentages of all these three materials. One example has been taken by using three aggregates A, B, and C with this graphical method.

Here you can see the ranges that are given. The aggregate sizes vary from 32.5 to 75 microns. The range is given, and then the mid values are provided. So, I will take graph paper. I will mark the gradation on my y-axis. I have joined the diagonal line from here to there.

What I am doing, since I will project the sieve sizes, is that 100 percent passing is my 32.4 and 32.5; this I have written here. Then, I will select 97, drop it to this diagonal line, and project it down.

Here, I marked my sieve size 25.4. Similarly, I checked for the 78 percent here; this is extended to the diagonal line. Again, it went down, and here I marked my 12.5 sieve size. So, in this manner, all my sieve sizes are marked here.

Once that is marked, I will draw my aggregate gradation. For A, what it says is that 32.5 is 100 percent passing, so this is again 100 percent passing; 25.4 is 100 percent passing. The second point is here. Then, it says that for 12.5, 63 percent passed. So, for 12.5, my 63.5 is here. So, at this point, in this way, I have marked all these points, and I can join all these points with a straight line. This is drawn by freehand. You can join these points by scaling.

Now, once this is done for aggregate A, it is done for aggregate B as well, and then it will be done for aggregate C as well. So, you will have the three gradations of A, B, and C plotted on this particular one using these percentage passing and the sieve sizes obtained on the x-axis. Now, once that is there, you draw this balancing line, you can put up a scale, and you can see how many squares are there on this side of, if I choose this as a balancing line, how many squares are there above it and how many squares are there below it. So, you can see this is my graph paper; these many squares are below here, and this particular balancing line represents the area above the balancing line and the area below the balancing line.

So, what I will preferably do here is try to move this balancing line slightly up. So, I will be able to get this. Either I need to go this way or that way. I would prefer to move because I find this area slightly bigger than the area above this particular one. So, I will bring this balancing line slightly to the lower side. So, I will have more area on this upper side, and then this area plus this area will be more or less.

So, in this way, I will draw balancing lines for all three gradations by using a scale. So, here you can see that one balancing line is drawn, a second balancing line is drawn, and a third balancing line is drawn. Now, once these balancing lines are drawn, we will see where this is, say for material A; this is the balancing line for A, this dotted line is the balancing line for A, and this is the balancing line for material B. Now, I am joining the end of this balancing line of A with the starting point of the balancing line of B, and here it cuts the diagonal at this particular point where, when it was projected, the percentage of A came out to be 73. Similarly, for the next case, I will see where the endpoint of B, when joined with the top point of C, cuts down here.

So, that gives me the percentage of B, which is 19 percent. So, a will be my 0.73, b will be my 0.19, and c is 8 percent. So, c is your 8 percent, 0.08. Now, this will be a plus b plus c is your 1. So, this is the way you can attempt it now. For different materials, when you do soil stabilization, in that case, you also blend different materials together to arrive at the desired proportioning.

So, this is the initial step that we normally take whenever a mix design of these unbound granular courses is to be done: to look into the blending of the aggregates and determine in what best manner different stockpiles of aggregate can be blended to achieve the desired target gradation, which is suitable for use as a sub-base course or a base course, as different gradations are specified by IRC and MoRTH. Thank you!