

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 a continuation of our lecture under module 4, and it will be lecture number 11, which will discuss the mixed design of the thin bituminous courses used in rural roads. 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, when it comes to rural roads, it is one of the basic infrastructures. We have a very large length of roads falling under this particular category, and dedicated efforts have been made by the Government of India, especially in the improvement of rural roads.

So, it provides one of the basic infrastructures for achieving the objective of integrated rural development. This is one of the targets of the Government of India, and in the hierarchical road system in the country, rural roads mainly comprise our other district roads and village roads. We discussed this in our initial lectures when we talked about the different categories of roads. So, just to mention, under the rural roads specifically, the two categories that are typically considered under the rural roads or other district roads that serve the rural areas of production, providing them with an outlet to market centres, block development, tassel headquarters, or main roads.

And the other is your village roads; these are roads connecting villages and groups of villages with each other or to the market centers and to the nearest road of a higher category. Now, the typical bituminous surfacings used for rural roads include open graded premixed carpet, which is used with a seal coat; closely graded premixed carpet, also known as mix seal surfacing or mix seal surface; and surface dressing. This is another particularly semi-dense bituminous concrete; it has a design very similar to what has been discussed earlier under different bituminous courses. So, its design is very similar to what we discussed in the previous lecture regarding your bituminous concrete design. But these three, which are very popular especially on rural roads, are more like a recipe mix in terms of their design approach, because the combination of the type of material and the materials has been arrived at based on the vast experience gained with these materials at both laboratory and field scale.

Now, coming to the first one, the first surfacing, these are typically thin bituminous surfacings like open-graded premixed carpet; it states that it consists of laying a 20 mm. So, less than 1 inch of bituminous mix comprising small aggregates premixed with it. So, the term "open graded" means the gradation is a bit open, and it is a premixed material designed to serve as a wearing course for low-volume roads. What is the problem, as the term itself says, it is an open gradation? The chances are that it may be permeable to rainwater, and that is why the open gradation typically uses limited

or uniform sizes of aggregates. Therefore, an application of a coat, specifically a seal coat, which comprises different types of seal coats, is quite important to seal the surface of open-graded premixed carpet.

So, there is no intrusion of water, and it becomes impermeable. So, various caudal specifications refer to these thin bituminous coatings. We have the information in our specifications for roads and bridge works, which are MoRTH specifications. We have specifications IRC 14, which is a recommended practice for open-graded premixed carpet. We have this orange book, similar to the red book, which contains the specifications for rural roads from the Ministry of Rural Development (MoRD).

Now, coming into the composition of the open graded premixed carpet, it typically consists of a blend of two uniform sizes of aggregates. The first one has a nominal size of 13.2 mm; it passes through 22.4 and is retained on 11.2. And second size is predominantly a size that has an NMAS of 11.2, which passes through 13.2 and is retained on a 5.6 mm sieve. The quantity and quality of these aggregates need to be ensured, and we need to look into the physical characteristics, which, as you can see here, are the requirements taken from MoRD specifications, as well as from the IRC premix carpet specifications and the MoRTH specifications.

So, there are requirements for particle shape, aggregate impact value, durability, and even stripping. In addition to this particular one, there is a specific requirement. Otherwise, in most cases, we might have seen that the water absorption requirement is up to 2 percent, but here it says that the water absorption for these aggregates has to be less than 1 percent. And again, if we are using any crushed gravel, then whatever materials that are retained over the 4.75 mm sieve, 90 percent of them by weight should have at least 2 fractured faces.

So, this is now why I call them a recipe mix because the quantity of aggregate and the quantity of binder, which have been derived from a lot of experience with these mixes, are directly given. You do not have to work out any designs and combinations here. The recommended values are already provided based on the experience with different kinds of aggregates that have been tested throughout the country at laboratory and field scale. So, it states that when we are using the quantity of aggregate required for premixed carpet for the first size, which has a 13.2 NMAS passing 22.4 and retained, it should be 0.18 cubic meters for an area of 10 square meters when it has to be premixed carpeted. And, the second size, which is the one passing 13.2 and retaining 5.6, should have a quantity of 0.09 cubic meters spread over an area of 10 square meters. So, a total of 0.27 cubic meters of aggregate has to be put in an area of 10 square meters. Now this is for the aggregate part; what about the binder? It says that for open-graded premix carpet, you can go with the paving grade binder as per IS 73. You can also go for a modified binder as per IRC SP 53.

Most of the time, we use the conventional paving grade binders recommended by IS 73, and the grade has to depend upon the region in which the maximum air pavement temperature can occur. We will look into the grade of the binder to be used. And the quantity required for the binder for these two combinations of aggregates has been mentioned; it states that for the 0.18 cubic meter of 13.2 NMAS, we require around 9.4 kg. For 0.09 of the one that has 11.2 mm NMAS, we require 15.2 kg. So, around 14.7 kg will be required for that 10 square meter area.

So, this is one thing, and specifically, now the other requirement comes when we are using, say, an immersion in this particular one. If we are preparing these open-graded premix carpets with immersions, then the requirements are there, and for using the immersion, we call it a cold mix open-graded premix carpet. Otherwise, the general term is open-graded premix carpet, where we are going with paving-grade binder or modified binder. When we produce it using immersions and the thickness remains the same at 20 mm, the cold mix open graded premix carpet, and the immersion that is preferred is a cationic immersion of medium setting grade, which has to follow the IS8887 specifications. An important part is, as I mentioned, that this is an open-graded mix.

So, there is a chance that the mix is permeable to water. So, here in this particular case, a seal coat has to be immediately applied after the construction of the OGFC. Whereas, in the case of these cold mixed open graded premix carpets, as you are using an immersion, you have to allow at least 4 to 6 hours before you apply a seal coat over it. And again, it is mentioned here that if you are using cationic bitumen immersion, this is the quantity of aggregate, which is the same as what we have done in the case of paving grade binder, but the cationic bitumen immersion quantity is around 20 to 23 kg for 10 square meters of area. So that is why it is a sort of recipe mix where the amount of aggregate quantity you have to put in a given area and the amount of binder to be added is already recommended by the specifications.

Now that we are dealing with this open-graded premixed carpet, the seal coat is very important. What is seal coat, and what does it comprise? So, it is specifically a material that is applied for sealing the voids of a bituminous surfacing, and according to Moody specifications for rural roads, there are three types of seal coats that are recommended. What type A, type B, and type C seal coats are there? The first one is type A; it is a liquid seal coat where we apply a bituminous binder followed by a cover of stone chips. So, we will apply a bituminous binder on the top of the premix carpet, and then we will put the stone chips on top of it. The other two are a sort of premixed ones.

So, the type B varies in the sizes of the aggregates that we are using. The premixed seal coat comprises a thin application of fine aggregate premixed with a bituminous binder. So here we are going to premix it, and then we are going to apply this seal coat over the open-graded premixed surfacing. Type C also includes a premixed seal coat consisting of the application of 6.7 mm-sized stone chips premixed with bitumen.

So, here the sizes are a bit bigger compared to what we have in the type B seal coat. Now, the requirements of the aggregates for the seal coats are given again, and some specific requirements are mentioned here. Type A stone chips, sand, or grit can be used, and here also stone chips, because we make the application once the bituminous binder is applied. An important part is that the chips, which are to be applied over the bituminous binder, should have a water absorption of less than 1 percent. Here, also in this case, when we are using these bigger sizes, the water absorption should be less than 1 percent.

Now what fraction are we using? Where we are once the binder is applied, and then you are putting those chips over it, it says that it is a size which is referred to as 6.7 mm; it is 100 percent passing through 11.2 and retained on 2.36 mm. So, everything is coarse aggregate, which is retained over 2.36, and it says you need to use this quantity of seal coat for the stone chips, as 0.09 cubic meters per 10 square meters of area. So, this is the requirement of your seal coat in terms of the stone

chips. Second, it says when we are going for the type B seal coat, which is a premix seal coat, that the aggregate passes through a 2.36 mm sieve; it is a finer one and is retained on a 180 micron sieve size.

Here, again, the requirement in terms of the quantity of aggregate per 10 square meters of area is given. Now, when this type C seal coat, where the sizes are again referred to as the same as what was there, it is a premixed one. In type A, it is not a premixed one; it is laid after the bituminous binder is applied. So, here it is a 6.7 mm size, 100 percent passing 9.5 mm. And the retention on 2.36 is a bit smaller compared to what you have in the case of type A. Again, it says that it should cover around 0.09 cubic meters per 10 square meters of area. And we want these stone chips to be free from dust, disintegrated straw, stones, flacon, elongated particles, or organic and deleterious material.

The general requirements are also there for these seal coat materials. Now, which binder is to be used, because there is an application of binder and then stream chips in type A, and in the other two cases, these are premixed ones. It says that a viscosity grade binder can be used as per IS 73 specifications, or we can also use a cationic bitumen emulsion of medium setting grade. Here. And here, in the case of these cationic immersions, the IS 18887 specifications in terms of their quality have to be ensured.

Now, what are the typical requirements in terms of the quantity in that 10 square meter area? It says that per 10 square meters, if you are using a liquid seal coat and making a paving grade binder application, the binder should be 9.8 kg. When I am going for the one where the premix seal coat is used, then I will go for an application of 6.8 kg in a 10 square meter area. The one that is again with slightly higher sizes says 4.5 by weight of the total mixture. Here, this is an important part; it mentions the weight of the total mixture. And when it comes to bitumen immersions, you can see in the first case the bitumen immersion, cationic bitumen immersion, medium setting rate, which is the most preferred one; it has provided the quantity of bitumen immersion for type A, type B, and type C. When we are done with the premixed carpet, open-graded premixed carpet, it is important to apply a seal coat as well. To seal the surface specifically against any intrusion of water, we are laying an open graded mix, which is then sealed with the help of a seal coat. There is another way around, which is one more mix combination that is given and is called closed graded premix carpet or mixed seal surfacing.

So, these are synonymous; many times we refer to it as MSS, or it is a closed graded premixed carpet. Now, in this particular case, this is a sort of recipe mix for a typical thickness of 20 mm. We use this particular construction, and it is used as a wearing course, which is very popular in low-volume roads and rural roads. And here again, two aggregate gradations are recommended: type A and type B. Two gradations are recommended, and there is a codal specification also, IRC SP 78-2008, which is a specification for mixed seal surfacing or close-graded premixed surfacing.

Now, here you can see this is type A, type B; from this particular one, you can very well realize that type A is a bit finer compared to type B. You can see that for the 2.8 mm sieve here, 14 to 38 percent is passing compared to this 5 to 25 percent. Both are considered closed graded premixed carpet or come under MSS. Type A is preferred for high rainfall regions compared to type B, which

is normally used when the rainfall is about 150 centimeters per year, as per the recommendations of MoRD and IRC SP 78.

Now, in this case, we are again determining what the amount of and what type of gradation is to be used, in addition to that particular one, and what the requirements for the binder are. It says that viscosity grading paving binder or modified binder can be used with this closed-graded premixed carpet or mixed surfacing. And here is another important point: the total quantity of aggregates used for type A or type B mixed self-referencing shall be 0.27 cubic meters per 10 square meters; again, it is a recipe mix, and it gives you the desired result. So, you can work out how much length and how much width you are going to lay out.

Typically, for rural roads, you have an intermediate width of 5.5 meters. So, you can work out, and the thickness is 20 mm. So, what is the width, what is the length, and what is the thickness, which is already 20 mm? So, you can work out the volume, and it says that for a 10 square meter area, this much is to be used, whether you are using type A aggregate or type B aggregate gradation. The quantity of binder required shall be 22 and 19 kg per 10 square meters for type A and B surfacings because, as we have seen, type A is a bit finer compared to type B.

Therefore, to cover those, you will need more binder since the surface area fines are greater. So, you will require more binder to properly coat those aggregates. So, as the grade of the binder can be selected on the basis of this table, which has been provided by the MoRD specifications for rural roads, it indicates the regions for which you can select VG 10 binder, VG 20 binder, and VG 30 binder. So, depending on the maximum daily air temperature, you can work out this particular grade of binder for this close-graded premixed carpet. Now, the other popular thin bituminous surfacing used for rural roads is surface dressing, and it has been used in different countries for many years since the 1920s as a wearing course specifically for low to medium traffic.

It has been used in urban areas as well, and it provides a water-resistant paved surface suitable for vehicle movement. This particular course can be laid out in two courses or multiple courses. You can opt for one-coat surface dressing, or you can choose two-coat surface dressing. In each application coat, you first apply a bituminous binder. So, each coat will comprise an application of a bituminous binder followed by an application of stone chips.

So, when you are going for the first coat, you need to first ensure that the granular base has been prepared on which this bituminous surfacing is to be done. First, any loose materials have to be removed, it has to be brought to grade, and any depressions have to be rectified because this bituminous surfacing is very small in thickness. So they cannot fill your depressions. So, you have to correct your underlying courses for any profile-related issues first before you come up with these thin bituminous courses. So, the surface is prepared, the granular surface is prepared, and you are going to put it over an existing bituminous surface, also, but in new construction, you are doing it over a granular course.

So, the base is to be prepared, the binder is to be spread over it, followed by an application of stone chips, and if we do it in two coats, then the same has to be repeated. So, surface dressings in many countries are also known by the name of chip seals because what we apply on top is how it looks from above; the stone chips, and if the chips are uncoated, it looks in this particular manner. You

may feel that there is less binder available because only the stones are visible, as our normal conception is that we want to see a black surface with the bitumen. So, this may be one concern when uncoated chips are used in this particular surface dressing; there is a provision for using pre-coated chips also. So, we have IRC 110-2005, which is there for standard specifications and code of practice for the design and construction of surface dressing, along with the information that is also in the Ministry, MoRD specifications, as well as the MoRD specifications.

Now, coming to the composition again, there will be a requirement for a binder and a requirement for stone chips. So, what binder is preferred again? A paving grade binder, as the most commonly used grade is a VG 10 grade here in most applications, but it has to be decided on the basis of the climatic conditions, particularly the highest daily mean air temperature, on which you can determine which grade is to be applied. Now, if we are working it out with an immersion, it is to be a rapid-setting cationic immersion; again, it has to be ensured with IS8887 specifications. This is the table that provides information on the selection of paving grade binder based on the highest daily mean air temperature. So, first on the prepared base, we are going to apply the binder; the binder application is to be done.

So, a binder distribution tanker is to be there that has to spray the defined quantity of binder over that particular length and area. If we are going with welding spray jets, this is the temperature; an example is given, this is the temperature that is to be there with the VG 10 binder, and this is the temperature. So, this depends on how the binder is distributed or applied to the surface with these binder distributor tanks. Now, the aggregates or the stone chips that are to be used need to have their physical characteristics ensured.

These are the requirements that are given. This is as per IRC 110-2005, which states the aggregate impact value, abrasion value, combined flakiness index, stripping value, and polished stone value. When they are used as a wearing course, they are recommended to have a polished stone value of at least 60; in some cases, we have seen dense graded mixes mentioned as 55. Here, the requirement is 60 in the case of surface dressing to offer good skid resistance, and the water absorption of this aggregate should be less than 1 percent. Now, the gradation of the stone chips has been mentioned here, and it states we can use stone chips with four different nominal maximum aggregate sizes. It says the ones which are recommended as per IRC 110; also, it states that MoRD, 19 mm, the ones which are 13 mm, 10 mm, all with 6 mm.

And you can see the gradation is given along with it; since this will be a uniformly graded material, it mentions that a minimum of 65 percent of the material should pass 19 mm and retain a 13.2 percent passing point 13.2. Specifically, this is for the first one with 19 mm, then it is for 13.2, and 9.5 is for this particular range. When it is 9.5 and 6.3, it is for this particular range, and 6.3 is written on 3.35, so this is for this particular. So, predominantly a single-size aggregate, we are referring to this particular one, and as I mentioned, if the chips are uncoated, it normally gives the feeling that the binder is not there; this surface may not perform well because this is our normal conception.

The surface should shine in black. So, this is our black gold. So, it should be there. So, in that case, many times we go for pre-coating of these stone chips, and the percentage that is normally used for pre-coating is 0.75 to 1 percent by weight of the stone chips. But when we are doing this pre-coating, we can use the paving grade binder for it. We have to cure them for a period of around one

week to ensure that they become non-stick because we have to spread these stone chips over the binder.

So, this pre-coating has to be done at least a week before we go for the actual application of a surface dressing. So, which NMAAS has to be selected out of these 19, 13 normally depend on the underlying surface category. So, it says that if you have a very hard surface, an existing very hard surface, and an existing bituminous surface, there may be a hard surface, a normal surface, or a soft surface because these chips can penetrate into the existing surface. So, depending on how much traffic is coming in, it states the approximate number of commercial vehicles with a laden weight greater than 3 tons currently carried per day in the lane under consideration.

So, the ranges are given as 200 to 1,000, 20 to 200, and less than 20. So, you can see that for very hard surfaces, you can go with a smaller NMAAS; for very soft surfaces, you need to go for higher NMAAS sizes. And very hard, what type of surfaces are referred to as very hard? Surfaces such as concrete or very lean bituminous structures with stony surfaces are considered very hard surfaces. Normal surfaces into which chippings can penetrate moderately under medium-heavy traffic are very soft surfaces that are already rich in bitumen in the underlying surfaces. So, depending on what type of existing surfaces we are using, we will go for the selection of the NMAAS, considering the amount of traffic that is also given.

So, this is what is given according to our MoRD requirement. So, we can select the NMAAS of the stone chips depending on the category of the existing surface. And then once that category is finalized, stone chips are finalized, then how much quantity of binder is required? So, since there will be two categories of binder: an immersion binder, which is there, and a paving grade binder for both of these particular ones. The requirement is mentioned here: if you are using an NMAAS of 19.2, the bitumen per square meter is mentioned as 1.2, emulsions as 1.8, and this is for a different NMAAS.

It is given when you can see that for 0.75, emulsions are 1.8, 1.5, 1.3, and 1.1. Now, coated aggregates, specifically when I am using pre-coated chips, will be slightly reduced in that particular case. So, here is the binder that reduces and aggregates the quantity of aggregates because it is given in a binder per square meter. So, here the aggregate volume per square meter is given, where we were referring to a 10 square meter area; here it is per square meter. So, you can see for the different NMAAS how many stone chips you require. So, for NMAAS 19, 13, 10, and 6, all these required quantities of the stone chips, as well as the required quantity of your bitumen or immersion, as per your selection, are given here.

Now, as I mentioned, we are doing this construction in two coats. So, if I am using immersion, what I will do is calculate the total quantity of immersion required for these two coats. Preferably, it is done by adding these two; for this particular case, the emission quantity is usually added, and 40 to 45 percent is applied in the first coat, while the next one is applied afterward. So, we want the upper one to become more impermeable in that case. So, this is what is gained from the experience, and specifically, this is bitumen for coating, which excludes the quantity of bitumen required for coating. Yes, this is what is mentioned here: when we use pre-coated chips, we will reduce the quantity of binder that needs to be present, because the important part is, as we discussed in previous lectures, the characteristics of different mixes.

The aggregates will get embedded in this layer of bitumen, and so they are nicely held with the bitumen. It provides a good texture on the surface, and because of the binder, it seals the existing surface against any permeation of water. So, these are thin bituminous courses that are widely used in the construction of rural roads. Thank you so much.