Course Name – Pavement Construction Technology
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Institute Name – Indian Institute of Technology Guwahati
Week – 06
Lecture – 23

A very warm welcome to all of you. I am Rajen 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 under module 6, and we will discuss the construction aspects as well as the construction process for granular unbound courses. Now, 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, typically in flexible payments, the unbound courses are constructed as sub-base courses and base courses. So, under that particular sub-base course and base course, the courses which are constructed are the most common ones: the granular sub-base course, and under the base course, the granular base course, unbound base course, we have the water macadam course, and we have wet mix macadam.

These are the most popular courses that are used in the construction of flexible pavements for laying the sub-base courses and the base courses. Now, for this discussion, I will be referring to the specifications for road and bridge works, MRTS 2013. Pocketbook for road construction equipment IRC 2018. Guidelines for Wet Mix Macadam IRC 109: 2015.

Standard specifications and code of practice for water-bound macadam, IRC 19: 2005. Manual for the design and construction, design, construction, and maintenance of gravel roads, IRC SP 77, 2008. Then, guidelines for wet mix plant IRC 26, 2015. Many other codes will also be simultaneously referred. These are some of those that are listed here.

Now, during the construction of a granular sub-base course, it is important to first select the material for any pavement course. You have selected the material considering the requirements as per the standards and the project. So, once you have ensured that the material quality meets the standard requirements stated in the CODEL provisions, and also included in your project document. After this one, the next task involves the design part, the combination that has to be planned, and then, finally, once that particular aspect is over, the next thing is the construction of that particular course. All these steps play a vital role in achieving the desired performance from any pavement structure.

So, when we are constructing a granular sub-base course, there are some key steps that are involved, which need to be carefully checked and monitored. The first one is the preparation of the subgrade over which your granular subbase course has to be placed. Second is the spreading of the granular sub-base coarse material; whatever material you have selected for the design, it has to be spread or laid in layers over the prepared subgrade. And the third exercise specifically comes in relation to the rolling or the compaction of these layers to achieve the required density. And finally, to have a finished surface with any minor rectifications that are required must be done before we proceed with the construction of the next layer over it.

So, under the aspect of preparation of subgrade, the important part is that before laying the sub-base course, it should already be prepared because we have already prepared the subgrade top. The prepared finished subgrade should be cleaned because there may be some amount of delay between the preparation of the subgrade top. And when the construction of your granular sub-base course has started. So, during that particular delay, if some amount of changes have happened, specifically because it may be the rainy season, some amount of vegetation has grown, or there may be some uncontrolled movement of vehicles that has occurred, which may have loosened the topsoil. So, in that case, what we will prefer is to prepare the subgrade in terms of the removal of any vegetation or unwanted materials that are there, and if needed, if there has been a gap between the construction of the subgrade top and the laying of the granular sub-base course, it is always preferred that the surface can be lightly sprinkled with water and one or two passes can be given with a smooth wheel roller.

So, that ensures a good surface to take your granular sub-base coarse materials. So, the prepared subgrade should look in this particular way. There should be no unwanted materials present on it, and it is always better to sprinkle water and make one or two smooth passes to get a good, firm foundation for placing your granular subbase coarse material. Now, we have already discussed that since MRTH recommends 6 gradations, one of the gradations, as per the CODEL requirements and the project requirements, has to be selected and ensured for the physical characteristics. Thereafter, the water content, as we determined with respect to IS 2720 Part 8, has to be worked out, and this water has to be added pre-mixed with your granular sub-base course material.

This mixing can be done with harrows, with rotary mixers, or premixing to achieve your optimum moisture content, and then this particular mixture is to be spread out. So water content, as determined in accordance with IS 270, has to be mixed mechanically by suitable mixers; sometimes a grader is also used with provisions for controlled addition of water and mechanical mixing. So there should be mechanical mixing; this is important. It should not happen; manual mixing is going on for this granular sub-viscous material. And once mixed with water, it should be spread over the prepared subgrade.

Here, a greater, fantastic role is played. Having adequate capacity means the width required for spreading, depending on the hydraulic blade, allowing for wider widths. So the grader should have a blade with hydraulic controls to set and maintain the cross slope and grade during operation. As we have seen, when we are constructing two layers of sub-bases, we will preferably use the upper layer as our drainage cores and the lower layer as filter cores. So this is important, and when the thickness is less, the combination of a filter cum drainage layer can be provided.

But it is important that this drainage layer or the granular sub-base core is as per the required cross slope because when it is constructed, we are maintaining the cross slope from the subgrade construction itself. So, again, when you are constructing one individual layer, this needs to be ensured. So, the grader will spread the material according to the required cross slope on the prepared subgrade. The moisture content of the granular sub-base course is to be checked; it is to be ensured that this loose material is compacted. And adjust it specifically because when you are going to mix it, and then finally when it is compact, it gets compacted; there may be around 1 to 2 percent water

content, which may be less than your optimum moisture content, and which is also good for your compaction.

The water should not have excess water; if excess water is present, then the surface needs to be aerated before you start the rolling process over it. Now, to take up the rolling process once it has been spread to the required cross slope using a motor grader, we have to start with the rolling process immediately; otherwise, there will be a loss of moisture content, which will make compaction difficult and may lead to inadequate density as well. So, it says that if the thickness of the compacted layer is less than 100 mm, we can preferably go with a smooth wheel roller weighing 80 to 100 kilonewtons. But usually, we construct granular sub-base courses with a thickness of around 200 mm. So, there we prefer to use vibratory rollers with a static weight of 80 to 100 kilonewtons.

So, this is a selection of the rollers based on the thickness of the construction. Now, when this rolling process has to start, if you have, say, this is the width that is there, this may be your centerline that is there. So, it appears that we are doing a two-lane construction, or it may be a four-lane construction; the center line is there without any median. So, in this particular case, there will be a camber in this manner: the crown will be here, and the sides will be at a lower level compared to this one. So, this is like a cross-section here that is drawn.

So, this middle part is raised, and the edges are lower down. If this sort of thing is there, then you will prefer to start your compaction from the edges and move towards your camber. And so this will happen in both directions; you will also do this direction, you will start from the edges, and you will move towards the camber. If there is, say, a curve, it is called. In this particular one, there will be a super elevation.

Superelevation means that if I draw a cross-section here, this particular edge will be raised, and this particular edge will be at a lower level. So, in this case, when one age is at a raised level and the other one is at a lower level, we will start the compaction from the lower age and proceed towards the upper age. So, this is a compaction pattern that must be followed to ensure a uniform and adequate amount of density is achieved. So, it says the rolling shell should commence at the lower edge and proceed towards the upper edge longitudinally for portions having a unidirectional cross slope or superelevation. So, this refers to this one, where it starts from the lower edge and proceeds towards the upper edge for a carriageway having a cross slope on both sides.

So, this refers to this case. Rolling shall commence at the edges and progress toward the crown. So, this is how the rolling pattern works. This rolling pattern is also important to ensure uniform and proper compaction. Now, during this compaction process, we normally prefer to have the speed of the rollers at less than around 5 kilometers per hour, and the cross slope, as I mentioned, is very important.

Not only for this layer, but for the other layers as well, the cross slope is very important; however, here the granular surface courses also play the role of a drainage layer. So, it becomes very, very important to ensure this particular one. So, it says the cross slope and surface levels have to be continuously monitored for any irregularities, such as bumps or depressions, because that should not happen with any of these granular surface courses. If it happens that at certain locations you are

able to figure out there is some excess material, it should be trimmed out; your graded blade can do it very well. If you are finding that there is a lack of material at certain locations, there is some excess material with proper gradation.

It should not be that you are only putting fines there or only putting a course there because this will alter your gradation, which can hamper your performance in that particular layer. It says each pass of the layer shall overlap by at least one-third. So, when, as I mentioned, if I have this particular one, this is my crown if I am proceeding. So, when I make this one pass, then when it comes to the second pass, it should already overlap the existing one by one-third. So, you can see how the rollers will move in the field.

They will move in a pattern. We have multiple rollers that compact this particular one. So, they move in a manner that the drum of the rear one has an overlap of one-third with respect to the one that is moving in the forward direction. So this is how we try to ensure that there is an overlap of at least one-third of the area compacted in the preceding pass. So, rolling is continuing until here, it is the soil, or normally this is the granular sub-base coarse material that reaches a density of 98 percent. Now, we have already determined this density, where we have determined our OMC and MDD.

So, the density is to be simultaneously ensured as we discussed that we can do it by sand replacement method or some non-destructive testing. where we can use nuclear density gauges or non-nuclear density gauges to monitor that the density of your granular sub-base course material is at least 98% of the laboratory-determined maximum density. The surface of any layer of material upon completion of compaction shall be well closed. Now you can very well see that once the surface gets compacted, you can see a good surface finish material, and while compaction, you can also observe if the material is moving in front of your roller; then the compaction is not good enough. Specifically, over-rolling is also harmful because it breaks down your aggregate.

So, the breaking down of the aggregates results in a change of your gradation. So, that is why both under-rolling and over-rolling are harmful. We need to ensure that this particular one achieves a density of around 98 percent. So, the surface of any layer of the material, upon completion of compaction, shall be closed and free from movement under compaction equipment. When this compaction is completed, you can see there is no material movement; you will observe it from the compaction planes because when one pass is made, another pass will follow, and you will see this when these passes occur.

Then there will be a plane that will be formed when the next pass comes, having an overlap of one-third over it. When this continues for a certain period of time, you will find that these compaction planes or ridges are removed. And there should be no loose material lying on the surface. So, that makes your surface or the granular sub-base course ready to take up the second layer, which may again be of a granular sub-base course material or a material that can be a base course. Now there is another very popular course that is used, which is waterborne macadam.

This water-borne macadam is also used as a sub-base course and as a base course, and we have earlier discussed its requirements. The water-borne macadam course comprises clean crushed coarse aggregates because, in this particular construction, we are going to put the coarse aggregates

on the prepared surface. Now, here the prepared surface, if it is used as a base course, will be a sub-base course, and if it is directly placed over the subgrade, then the prepared surface has to be a subgrade top. So, it comprises the course aggregates, which are first applied under the construction of a water-bound macadam course, and should be clean crushed course aggregates that are mechanically interlocked by rolling. So, what is done is we put those coarse aggregates, and rolling is done over those coarse aggregates.

Thereafter, you apply the screening material, or the binding material; application of water is there. Simultaneously, rolling is there. So that fills those screening materials and binding materials, fills up the voids, and gives you the desired water-borne macadam surface. So it says the waterborne macadam course shall comprise clean crust course aggregates that are mechanically interlocked by rolling, and the voids in these course aggregates will be filled with what? By screening and building materials with the assistance of water, you will require water laid on a prepared subgrade. If I am going to use the water bond mechanism as a sub-base course, then it will be laid over a prepared subgrade, or it can also be on a sub-base course or a base course.

Even sometimes, when we are going for the strengthening of certain pavements, you may have to construct a base course. So, there may be some bituminous surface existing over which you may have to construct the waterborne macadam course. For those cases where the existing surface is a bituminous top, certain precautions have to be taken; we will discuss this in the upcoming slides. Otherwise, it is mostly preferred as a base course, so it will be constructed over a prepared sub-base course. Now, what are the key steps that are involved specifically in the water-bound macadam construction? First is the preparation of the base, which may be your subgrade top or your granular sub-base course.

Then the preparation of a drainage course specifically depends on whether it is layered over a subgrade directly. Lateral confinement of aggregates involves laying and compacting coarse aggregates. So, during the compaction of the coarse aggregates, the edges of the coarse aggregates have to be confined well for proper compaction. The spreading of coarse aggregates should be well spread to the desired quantity specified by the project document, as well as the MRTH guidelines. Then the rolling of the coarse aggregates takes place; thereafter, the application of your screenings occurs.

Then, followed by the sprinkling of water, which allows the screening material to go inside the voids, compaction is done simultaneously, and the grouting of those voids is completed. Wherever there is a further requirement for binding material, it is again put over it and compacted with the application of water. Finally, it is allowed to set, dry, and be checked for any surface irregularities or defects to achieve a finished surface for the next layer to be constructed. So, in this particular case, as in the case of other layers, the important part is that the surface where the WMBM course is to be placed should first be brought to the correct grade. Why? Because it may happen that you have constructed a subgrade top or a granular subbase course a few days ago, and there was a time gap before coming up for the next layer.

So, you might be doing, say, a sub-base course construction for an entire length of 10 kilometers. Once that sub-base course construction is over, you can come back and start with your water-bound macadam construction. So there may be a time gap between the one surface that was prepared and

the next layer when it comes up. So, in that case, if the existing surface has been damaged for any reason due to the movement of vehicles, growth of vegetation, or any construction activity, it has to be rectified, corrected to the grade, camber, and cleaned of any dust, dirt, and unwanted materials. So, it should be ensured that when you are putting up the next layer, the existing layer should be in a proper manner, or it should be in a good foundation stage.

Also, if any ruts or soft spots are found, because there may be rain in certain locations, standing water will make your material soft. So, before you proceed with the construction of the water bond mechanism, it is important that you aerate that particular one; again, aerate it. So, if material is required, you need to mix it with it and then compact it to bring it to the required density and grade before you put up your next water bond mechaderm course. So, if any ruts or soft spots are formed, they should be fixed and rolled until the surface becomes firm and stable to receive the water-bound macadam course. The existing road surface should be scarified and reshaped to the correct slope and level before laying the coarse aggregate.

If you find any defects later on, if you are able to see that the levels were not properly ensured, and you find that this course has levels that are higher than what is required for the top of a granular sub-base course, then you need to rectify it at that particular stage, and then you can proceed with the construction of the water-bound macadam course. This has to be ensured for all layers, as the tolerances are already given. If things are out of those tolerances, rectifications must be made before proceeding with the construction of the new layer. Again, as I mentioned, when the WFBM course is constructed over an existing bituminous layer, challenges arise because there will be an issue specifically with the internal drainage between your existing bituminous surface and the water-bound macadam layer. So, at that interface, we are constructing the water-bound macadam by using the application of water.

So, that water may be there in the layer between what we have between your existing bituminous and the water-borne macadam course. So, it is always preferred to have a thin bituminous surfacing, which is usually present when we are looking for rural roads, low-category roads, or low-volume roads. It is always preferred that you remove that thick-wearing course because you are doing strengthening, as the surface might have already shown some amount of distress. So, it is better to remove that thin bituminous surfacing and then go for the construction of your water bond mechanism over it. Now, as mentioned, in certain cases, if you are using the water bond mechanism as a sub-base course, which you are placing directly over the subgrade, then it is always preferred that the WWM course be placed directly over the subgrade without any layer in between at a 25 mm thick layer of screening.

The screening material gradation is already specified; this is the screening grading B of the water bond mechanism itself, as specified in MRTS 2013, or any coarse sand having a thickness of around 25 mm is layered between the subgrade and the WBM as the separation layer. So, in case the soil is silty, specifically fine sand or silty clay subgrade soils, or if the subgrade is constructed using these kinds of soils, it even recommends a 100 mm thick layer of screenings, coarse sand, or fine-grained soil. So, this is because there should be no intrusion of the soil particles into your water-bound macadam course. So, we will prefer to lay a layer of screening material, and the thickness will depend on the type of subgrade soil over which this waterborne macadam course is going to

be placed. In certain cases, if the project allows, it is always preferred that we go for some combination of geosynthetics.

As we discussed in one of the earlier lectures, you can have a geocomposite, where on the lower side you have a geotextile and on the upper side you have a geonet. So, this geonet serves the purpose of allowing the drainage of water, and it serves the purpose of both your filter and a drainage layer. So, if the project allows, it is always preferred to go for the construction of a geocomposite layer that will serve both purposes. So, it serves the purposes of drainage as well as your filter-cum-separation layer. Now, once the existing surface is ready, you put up the spread of the coarse aggregates for your water-bound macadam course.

So, for WBM construction, side support for the aggregates is preferably provided by building the shoulders. So, it is good that you start your construction of the subgrade simultaneously. So, it's good enough to build up your subgrade simultaneously. This subgrade layer will be able to provide confinement to see if this is the age of the coarse aggregates; there is no confinement on this particular size. If there is some confinement in another manner, this is a curved wall; otherwise, I will prefer a raised subgrade construction along its edges so that when the compaction is being done over the edges, there is no shift of material happening at the edges, and this will allow me to achieve good compaction at the edges.

So, I will try to ensure that I protect the edges of this granular sub-base coarse material that is spread here. So, coarse aggregates are spread evenly over the prepared subgrade or subbase. This is very important. How are these? I will always prefer some mechanical means for spreading these coarse aggregates so that there is a uniform spread, and no segregation occurs. Preferably a thickness that is no more than 75 mm. So, the coarse aggregates, here you can see a motor grader is used for spreading it out; it helps you maintain the cross slopes also, and along with it, I can use templates to ensure that the thickness is what I am trying to achieve: 75 mm. So, I can put up some templates placed at intervals of, say, 6 meters across the width of the road to ensure some levels while spreading this particular material, that is, the required thickness has been spread over it. Wherever possible, an aggregate spreader should be used. Nowadays, these are very common equipment items that are available at construction sites with many contractors. So, always prefer to use aggregate spreaders so that they can spread aggregates evenly.

And this will allow us to minimize the need for manual rectification because otherwise, things become more challenging at a later stage when some segregation is present. So, the segregation of coarse aggregates is to be avoided, and this can be done by avoiding the manual spreading of the WBM coarse aggregates; it is better to use some mechanical means for spreading. Uniform gradation and spread shall have uniform gradation with no pockets of fine. Otherwise, segregation means coarse comes at one side, fines remain at the other side. This is what segregation is: they are different sizes; they are not properly blended; not all blends are present in that case.

The surface of the aggregates shall be carefully checked for any high or low spots. Simultaneously, as templates are also present, we can move around on the surface and ensure that if there are some local depressions or certain locations where excess material is present, it can be removed or added at the beginning itself. So, you can see a surveyor's exercise is also simultaneously going along with the spreading of the aggregates with your motor graders, while spreading and rolling, and then

you start the rolling of the surface as well. The surface shall be checked often using a straight gauge to make sure it meets your surface level requirements. So, if you have good control of your grader, you are mostly able to achieve the levels in that case.

Simultaneously, your surveyor will do some exercises; templates are also there. So, if these multiple checks are in place, you will definitely achieve the required levels. The coarse aggregates shall not be, and shall not normally be, spread more than three days in advance of the subsequent. Now this is important. It should not happen that you spread the coarse aggregates and then the next stage of construction is delayed for some period of time.

So that is not required. You have to; the important aspect is that when one layer is constructed, the entire exercise of those involved in that one layer should be completed simultaneously. So once the coarse aggregates are spread, you thereafter start the rolling process. So, immediately after the coarse aggregates are spread, we should prefer to go for the rolling operation without delay. Rolling should commence using a 3-wheeled roller; you can use a 3-wheeled roller, a tandem roller, or a vibratory roller having a weight between 80 to 100. Different rollers were discussed, so you have the availability of the rolling pattern, which is to be ensured.

When you are rolling the coarse aggregates, the pattern is to be followed in the same manner: if there is a camber or crown in the middle, the rolling should proceed from the edges to the crown. If there is a side slope, then it should be from the inner edges or the lower edges to the outer edges. On super elevated sections, rolling preferably starts from the edges and moves towards the center when there is a crown. On super elevated sections, we discussed roads with a one-way slope; this is like a one-way slope. So, here I will prefer to start from the lower edge, and I will prefer to go towards the upper edge.

So, we start from the inner edge, and this is what we call the inner edge. Inner edge, because when we move along these horizontal curves, this will be at a lower level; this will be at a higher level. If I cut down the cross-section, it looks like this. So, it is always said that it should start from the inner edge and go towards the outer edge, or I can say from the lower edge and go to the upper edge. So, the edges are to be compacted first by rolling forward and backward, and we will first prefer to roll these edges so that the material gets good support from the compacted width of it.

So, we will prefer to go for some, and the edges again need to be protected. So, we will then roll the roller inward towards the center in the overlapping passage, and here it says that for this particular one, coarse aggregate around an overlap of half the width of the previously compacted width should be there. So, there should be an overlap, which was previously one-third in the case of the granular sub-base course; when we are compacting the coarse aggregates for the water-bound mechanism, the overlap should be around half of the width of the previous pass. Now, once this rolling operation is done, we come up with the spreading of screenings and binding materials. But there are certain cases where, if you are using weak or soft aggregates, we do not go for screenings. So, screenings are usually not used when materials like brick, metal, lateral, or canker are used.

Here, in this case, then, because they themselves get crushed during this compaction exercise. So, you do not need to put up any screenings to fill the words. They themselves get crushed, and the fines fill up the words between this particular one. And, you have to be very careful that there is a

proper filling of these voids so as to give tightly packed and locked-in-place aggregates. So, you need to be careful when using these soft materials; you have to be more careful.

Otherwise, as the materials specifically in soft materials crush down, the rolling is done along with a light sprinkling of water so that these screenings further get the fines created by the soft materials, which get packed in a good manner to give you a desired surface. Otherwise, if you are using good-quality aggregates, then you will be applying screenings and binding material as per the requirements. So, after the normal courses, when you are using crushed stones, the coarse aggregate compaction and screenings are gradually spread over the surface. So, these, and then again, there are two gradings of screenings specified, and there are quantities of coarse aggregates also specified; quantities of screenings are also specified, and quantities of binding material are also specified.

So, as per the codal specifications and project document, that has to be picked up. So, then after that, if a contradiction is found, the engineer in charge should be taken into confidence to decide which one to pick based on experience and which one gives good performance. So, after the coarse aggregate compaction, screenings are gradually spread over the surface to fill the gaps between the stones completely. So, in small-scale projects, this spreading of screenings can also be done manually. But it is always preferred that a mechanical spreader be used so that proper spreading of these screenings is done.

The screening shall not be damp or wet at the time of application. This needs to be ensured; otherwise, they will not go inside the words. So, they should not be damp, specifically when they are spread over the surface. Dry rolling is done while the screenings are being spread; simultaneously, we do the drying rolling, and this process occurs concurrently. So, some amount of screening is spread, rolling is done, and then some amount of screening material is spread to achieve the required quantity of screening.

So, we will do this screening application rolling simultaneously exercise. So, by that vibration and that rolling compactive effort, the screening material goes inside the voids. So, the vibrations of the rollers cause them to settle and fill the voids of the coarse aggregate. So, this is again an intelligent exercise that has to be taken into account while applying the screenings over the compacted coarse aggregate bed. The screenings are not to be dumped in heaps; this is another concern. If that is why it is said that even if it is spread manually, it has to be carefully spread.

The heap of screening material should not be created in any place; it should not be dumped but spread over the coarse aggregate surface. Instead, they must be spread evenly, mostly in thin layers, using hand showers if there is a small project. Mechanical spreaders are always preferred, either directly from a tipper or, in that particular case, the one carrying the screening material, which has certain arrangements. Many of them nowadays have arrangements.

They can spread the material along the width, and this can be controlled. So, the spreading can be done directly from the tipper only, which has that screening material with it. So, this tipper with a proper grid-spreading setup is there. Many of them are coming up with those attachments these days. There has been a lot of advancement in construction equipment as well. Rolling and brooming, and if you find that more material is present in some places, then you will broom it.

Broom, this exercise will try to disperse your screening material within the voids of your coarse aggregates. So, brooming of screenings is carried out in such lengths of the road that can be completed within one day's operation. This is as I mentioned; I will prefer to complete one course. We can pick up a length, say it may be a 500-meter length section or a 1-kilometer length section; the important part is, depending upon your production capacity, your construction equipment availability, how many tippers you have, how many rollers you have, and how much manpower you have. So, depending on that particular one, you should pick a length that can be completed in one day's exercise.

So, following the application of screenings, the surface has to be thoroughly sprinkled with water. Now, here comes the important exercise. Now the water is sprinkling. So again, you need to have the proper distributors or sprinklers with you so that it spreads water in a uniform manner.

It should not happen that more water is poured in one place compared to the other places. So there should be no non-uniform distribution of water. So, we will consider these distributors, water distributors with proper nozzle arrangements or sprinklers that are there. So, with the water swept clean and then compacted, the compaction process goes over it again. So, hand brooms can be used to sweep the wet screenings into voids and simultaneously push your screenings within your air voids to distribute them evenly. So, if you find that at some locations, there are certain spots that have more screening material compared to the other spots.

These hand brooms and mechanical brooms can be used to distribute that one evenly. The sprinkling, sweeping, and rolling operations continue with additional screenings as and were felt necessary. Wear excess can be removed where you find it because we already have the control quantities that have to be spread over a particular length, as it specifies how many kilometers in area, how many square meters of area, and how much quantity is to be spread. So that is already controlled. So, we need to spread it out because those are well-defined states in our specifications until the coarse aggregates have been thoroughly cleared. Now, because of this, these screenings will go inside the voids with the help of compaction and water, and will lead to well-bounded and firmly set coarse aggregates through their entire depth.

And this has a grout that has been formed from screening. So this is what screening has got, like we say, cementaceous grout is there. So this screening is acting as a grout to hold your coarse aggregates together. So care must be taken to ensure that the subbase or subgrade does not get damaged due to excessive quantities. This happens if there are no proper distributors; water distributors are present, and if you directly open a mouth normally, if you do it with one pipe and spread it manually, there may be a lot of water, which may result in uneven distribution. And that water may go down and hamper your underlying layer, which may be your subgrade layer or any subbase layer.

So that should not happen for that particular one. Nowadays, these water tankers, or those that have attachments for uniform distribution in terms of sprinklers or distributors, are very common. So, they should be used for this particular exercise. So we can see the screenings, water application, and the rolling going on simultaneously. Once this application of screenings is done, there are certain cases where a binding material application is also required. There, as I mentioned, the

quantities of binder materials are already specified, and this quantity of binding material has to be put over it.

So, the binding material is required as per the CODEL documents, or as it will say many times, as per the MoRTH guidelines. So, it mentions how much binding material for a particular grading of screenings is to be used, or how much binding material quantity is to be used, and a straight edge is applied successively in two or more thin layers at a slow and uniform pace. Now this particular product has to be applied in thin layers, with at least two to three layers to be applied. So that it finally goes inside the voids and gives you a good surface over it.

After each application, the surface shall be sprinkled with water. So once the binding material is applied, the water distributor is to be used for uniform sprinkling of water. The resulting slurry is swept into the voids, and you can see that a slurry will be formed with this particular one, using binding material and water; we will prefer using mechanical brooms or hand brooms for this particular one, while the slurry goes inside the surface voids during this compaction exercise. The surface is then rolled, preferably with the application of water, and when this exercise is done, the slurry sticks to the roller drums as well. So, we spread, we put some, but judiciously, or we will use wet jute clothes, or we will sprinkle water, but that should not be in high quantities; otherwise, the excess water will create a problem for the ongoing layer, as well as may damage the underlying layers. So, some application of water is required, specifically to clean these drums and roller wheels as needed to prevent binding material from adhering to them.

These operations shall continue until the resulting slurry, after filling the voids, forms a wave aside ahead of the wheels. Now, when all these voids get filled, whatever fine binding material is there in the form of slurry because of water will start moving during the compaction in front of your roller if there is no further requirement for it or no space for this slurry to go inside the voids. So, then you can understand that even this, there may be certain quantities you can stop at that particular one, considering that all your voids got filled up with the screening and then your binding material. So, you do not need to apply any further binding material.

So, a range of quantities is given for binding materials. So, while the construction needs to be ensured by your monitoring of that particular surface. So, once this particular exercise is done, you have now ensured that all the surface voids are filled, the binding material is enough, and the compaction is completed. This surface has to be left overnight specifically to make it dry. The next day, we can come and see if there are any hungry spots; then we can apply some binding material there, along with a small sprinkling of water, and repair those particular spots. We can look for any hungry spots, and if we find that there is some excess material, or if there are excess water spots that are holding a good amount of water, it may need to be aerated or left to dry for a longer period.

So, this needs to be done the next day; construction should not be carried out over a water-bound macadam until it dries. This is very, very important. So, the water-bound macadam surface is left to dry for at least overnight, and the next day, any hungry spots found are filled with screening or binding material, then lightly sprinkled with water if required and rolled. So, this has to be the next day; we need to ensure it, but the important aspect is that the water bond mechanism must be completely dry and set before the next pavement course is laid over it.

This is an important exercise. If this is not ensured, the water remains trapped inside that particular layer, and if it is used as a base course followed by a bituminous course, it will damage the upcoming layers. So, it is very important to ensure that whatever water is there, that layer becomes dry, and then you proceed with the construction. So, you need to plan your construction activities in such a way. The entire WBM layer construction is completed in one day's work. So, depending on your availability of construction machinery and the stretch that is available to you to undertake the water bond macadam course, you need to ensure that the work gets completed in one day.

So, this is what the construction practices related to the granular sub-base course and the water-bound macadam course are about. In the next lecture, we will start the discussion on the construction of wet-mix macadam. Thank you so much.