Retrofitting and Rehabilitation of Civil Infrastructure
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Lecture 43
Construction of Concrete Overlay

Hello friends. Welcome to the NPTEL Online Certification Course Retrofitting and Rehabilitation of Civil Infrastructure. Today we will discuss Module F. The topic for Module F is Concrete Overlay for Pavement Rehabilitation.

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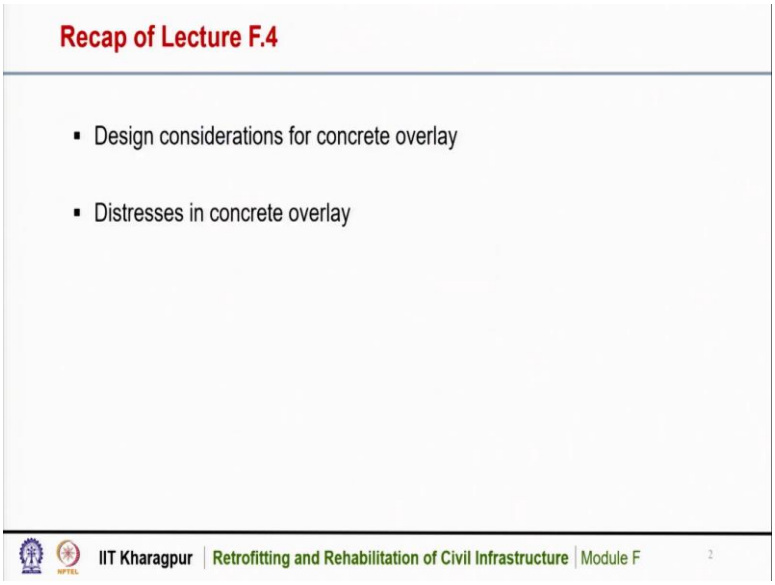

In the previous lecture, we have discussed the design considerations for concrete overlay. We have also discussed the several distresses that may occur in concrete overlay.

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Today we will discuss the overlay materials and construction of concrete overlay or white topping. Concrete overlay is comparatively a new concept in India. The design concept and the design approaches are being developed. The construction of concrete overlay is also much less as compared to other types of pavement construction.

In few cities, white topping has been adopted as a rehabilitation measure for deteriorated bituminous pavement, so that they can serve in a better way and last longer. However, still the construction is new comparatively and special attention and care is needed for the construction of concrete overlay. Today we will discuss the overlay materials that are used for the construction and the construction practice in brief.

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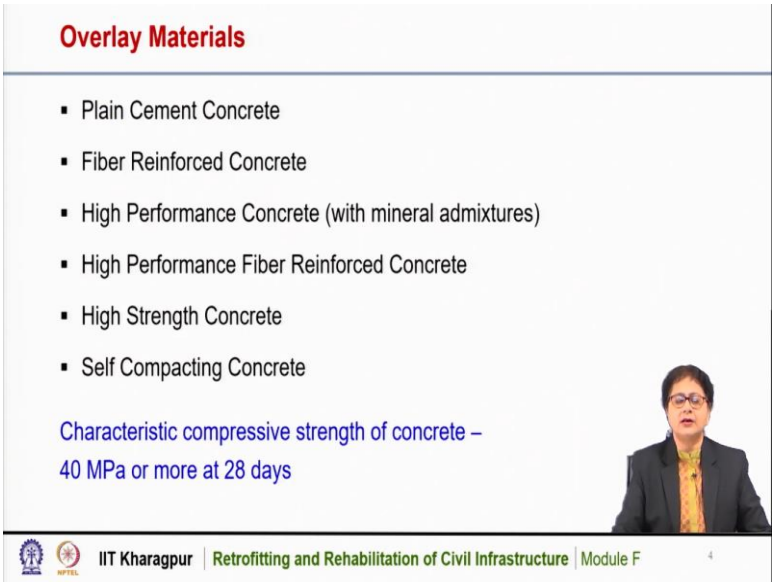

The overlay materials are different types of concrete. It may be plain cement concrete or fiber reinforced concrete. It may be high performance concrete with mineral admixtures. High performance fiber reinforced concrete is also used for overlay. High strength concrete and self-compacting concrete are also used for overlay construction.

Generally, the compressive strength of concrete is kept as 40 MPa or more at 28 days. So, for all these types of concrete, the strength of concrete should not be less than 40 MPa. Fibers are used. It may be microfibers or macro fibers. And those fiber reinforced concrete also should have a compressive strength not less than 40 MPa.

High strength concrete of strength 60 MPa may be used when the road needs to be open for traffic at early stage. So, in that case we can use high strength concrete. Or high-performance concrete can also be used in those cases.

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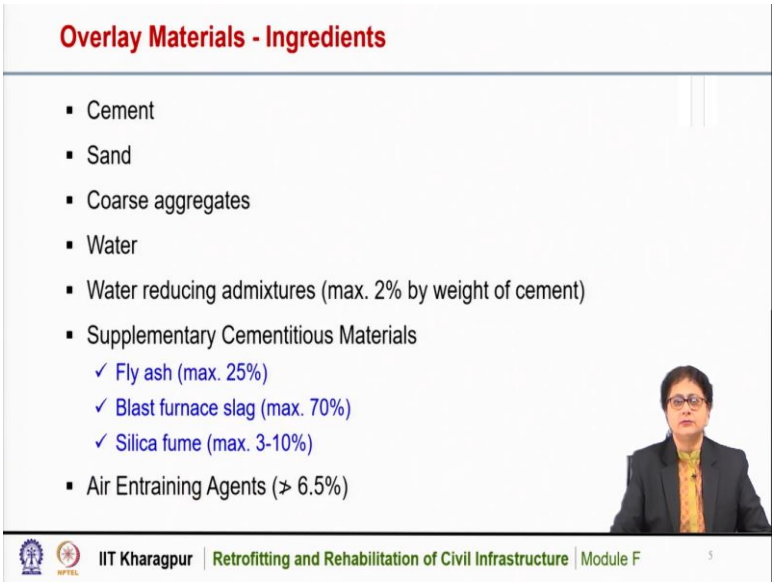

For plain cement concrete or fibre reinforced concrete or high-performance concrete, the ingredients are cement, sand, coarse aggregates, water. So, here also the same ingredients are used. We can also use water-reducing admixtures, maximum 2 percent by weight of cement because we also need to have sufficient workability.

Supplementary cementitious materials are also used in overlay. Fly ash, blast furnace slag or silica fume can be used with specific percentage by weight of cement. As per Indian Roads Congress guideline, maximum 25 percent of fly ash can be used, 50 to 70 percent of blast furnace slag can be used. And silica fume, maximum 3 to 10 percent by weight of cement is allowed as cementitious material.

Air entraining agents can also be used in the concrete. Particularly, when the overlay is to be constructed in an area where the temperature is much low, below freezing. So, in that case to reduce the freezing and thawing type of distress, we can use air entraining agents and that should not be more than 6.5 percent by weight of cement.

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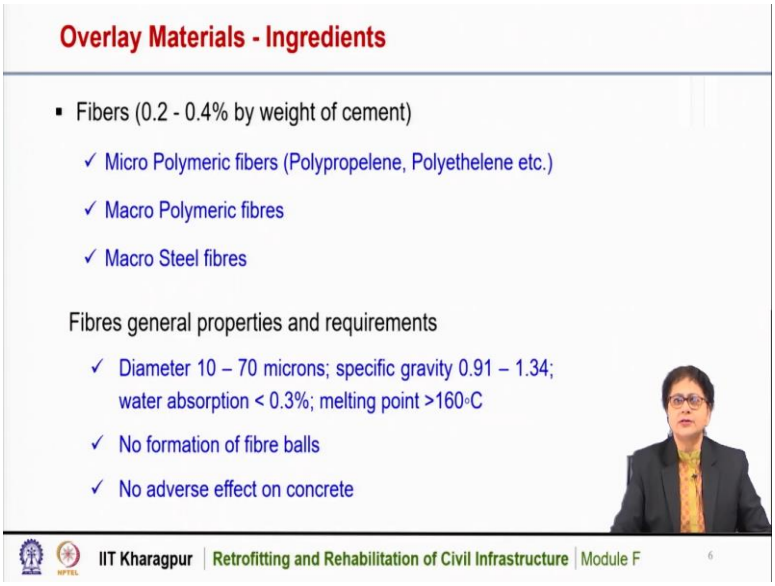

Fibers are used in most of the cases for concrete overlay. Fibers may be of different types and the amount of fiber is much less. It is approximately 0.2 to 0.4 percent by weight of cement. We can use micro polymeric fibers or macro polymeric fibers or macro steel fibers. So, different types of fibers can be used. Micro polymeric fibers include polypropylene fiber or polyethylene fiber, etcetera. They are of very small diameter and length, very fine materials.

Macro polymeric fibers are of much longer length as compared to micro fibers. They may be of 30 to 60 millimetre in length. And macro steel fibers are also used. They are also of a similar length as macro fibers. So, micro polymeric fibers are not for strength enhancement, but they are used mainly for reducing the shrinkage type of distress and also to improve the abrasion resistance, and the ductility.

The macro polymeric fibers and macro steel fibers may be used for strength enhancement and improvement in toughness and abrasion resistance. Generally, the fiber properties include that the fibers must have diameter very small in the range of 10 to 70 microns. The specific gravity should be in the range of 0.91 to 1.34. Water absorption should be less. It should not be more than 0.3 percent. Melting point should be more than 160^{o} centigrade.

So, these are the general requirements for adding fibers in the overlay mix. And this is as per Indian Roads Congress guideline. The fibers should be mixed evenly in the concrete mix, so that there should not be any formation of fiber balls. And the fibers should not have any adverse effect on the concrete performance or properties.

So, it should not be harmful to the concrete, should not have any adverse effect in the concrete properties. Fibers are used for arresting the cracks or to reduce the shrinkage effect. So, in most of the cases, the microfibers are used for arresting the cracks or to reduce the shrinkage, whereas macro fibers can be used as for strength enhancement as well.

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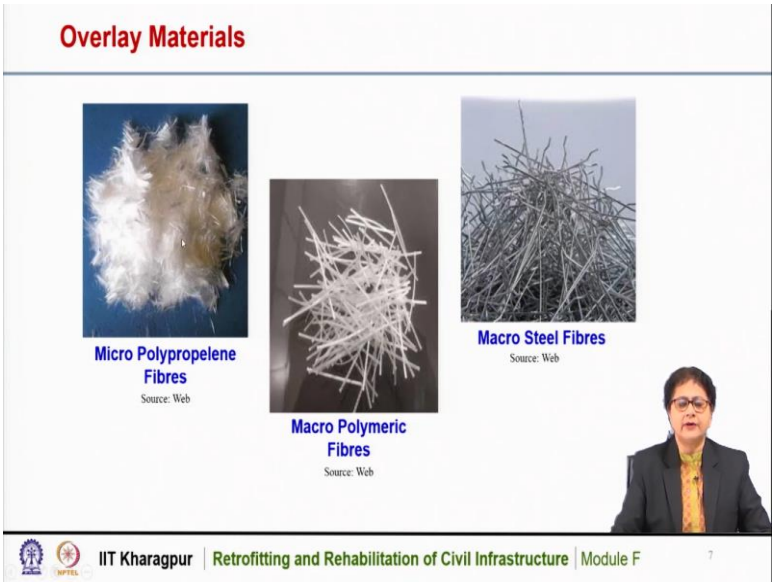

So, these are the pictures of different types of fibers. This is micro polypropylene fibers. They are very fine fibers that are used. This is macro polymeric fibers. They are of significant length. As we can see that this is a macro polymeric fiber of sufficient length. And these are macro steel fibers. They are also of sufficient length that are used in the overlay. And these fibers should be mixed evenly while preparing the mix.

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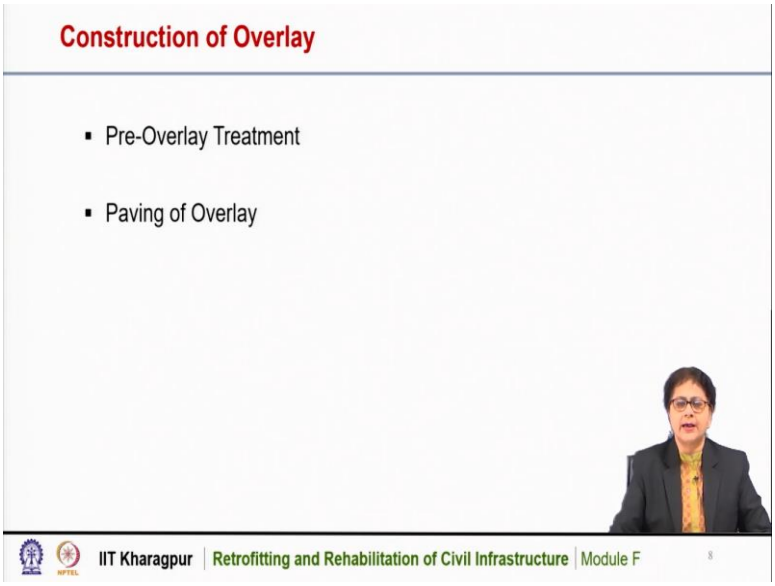

Now for the construction of overlay, there are two broad steps that need to be followed. One is pre-overlay treatment and the other is the paving of the overlay. So, for this type of construction it is important to have a proper pre-overlay treatment. And then we can carry out the paving of the overlay

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For pre-overlay treatment, there are several steps. One is milling of the top surface, then repairing of the existing pavement and then the cleaning of the surface. So, these are the three steps for pre-overlay treatment or surface preparation.

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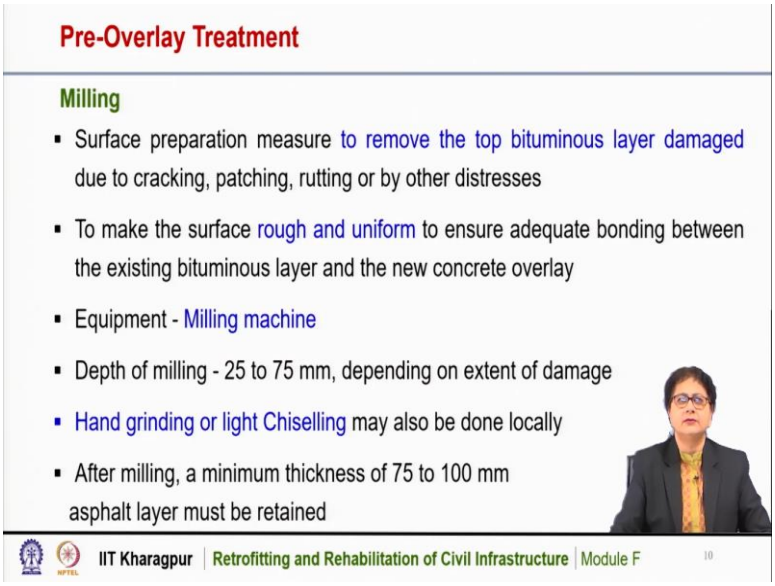

Milling is the surface preparation measure to remove the top bituminous layer damaged due to cracking, patching, rutting or by other type of distress. So, the first step of pre-overlay treatment is to make the surface ready for the paving. So, that can be done by milling. So, by milling, we can remove the top distressed portion of the bituminous surfacing, which are damaged due to cracking, patching or rutting or there may be some other type of distress.

So, we can remove that distressed portion by milling. Milling is done to make the surface rough and uniform, so that adequate bonding is achieved between the existing bituminous layer and the new concrete overlay. The equipment that is used for carrying out the milling operation is milling machine and it has the capability of removing the top layer of different depths.

The depth of milling could be 25 millimetre to 75 millimetre, depending on the amount of distress the pavement has. So, we can adjust that how much the top surface to be removed. We can also do hand grinding or light chiselling to remove the top distressed portion of the surface. So, that can also be done and locally we can remove those distress portion by light chiselling or hand grinding.

After milling, it is important that the minimum thickness of the existing asphalt layer should be 75 to 100 millimetre. It is important that a minimum thickness of asphalt layer is to be retained because the existing asphalt layer behaves as a base layer to the overlay. So, the asphalt layer should have sufficient strength and a minimum thickness of 75 to 100 millimetre before laying of the overlay.

If after milling we see that, the minimum thickness is less than 75 millimetre then we can pour another layer, so that the minimum thickness of 75 millimetre is achieved.

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So, these are some of the pictures of pre-overlay treatment and surface preparation. This is a typical damaged bituminous pavement. You can see that there are lot of cracks and potholes on the surface and the surface quality is really bad. So, this pavement has been selected for concrete overlay. So, this is a part of a MDR, near Kharagpur and in this project, concrete overlay was placed.

So, this is the existing bituminous pavement as we can see. And some part of this pavement is done with chiselling. So, here you can see that the top portion is removed which is badly damaged, and locally by chiselling the damaged portion the surface is prepared. The surface is prepared also by milling. So, this is a typical milling machine and by using this milling machine, the surface is prepared. The top 25 millimetre of the damaged portion is removed by milling. And this is the milling operation carried out here in this picture.

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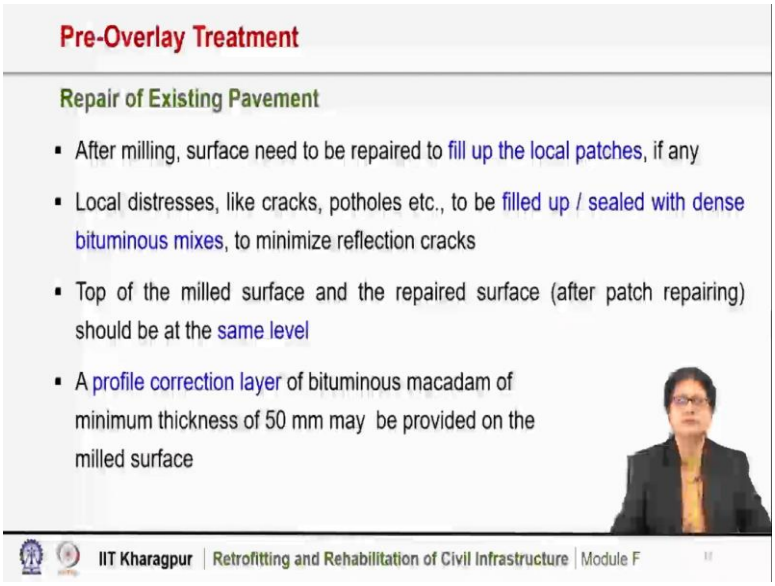

Now after milling, it is important to repair the existing pavement. So, the surface needs to be repaired, to fill up the local patches if any. If the surface after milling has some more patches or potholes, there may be potholes because pothole is quite common for bituminous pavement. So, that may cause depression to the surface and even after milling that depression may be there.

So, it is required to fill up those local patches, local distresses like cracks, potholes, etcetera are to be filled up or sealed with dense bituminous mixes to minimize the reflection cracks. Because, the cracks should not be there on the overlay, should not reflect to the overlay. So, that is the reason we need to fill up all the cracks or patches and potholes also.

So, after milling, the surface needs to be repaired by filling up all the local patches, potholes if there is any. Top of the milled surface and the repaired surface after patch repairing, should be at the same level. In many cases, we have to add some amount of hot mix bitumen layer on those patches. But we have to be careful that the top of the milled surface and the repair surface should be at the same level, so that the overlay on it should have uniform thickness.

Sometimes a profile correction factor or a profile correction layer of bituminous macadam of minimum thickness of 50 millimetre may be provided on the milled surface. So, if the profile is really bad then we can also add a profile correction layer of bituminous macadam on the milled surface of the pavement. And that the profile correction layer is of minimum thickness 50 millimetre to be maintained.

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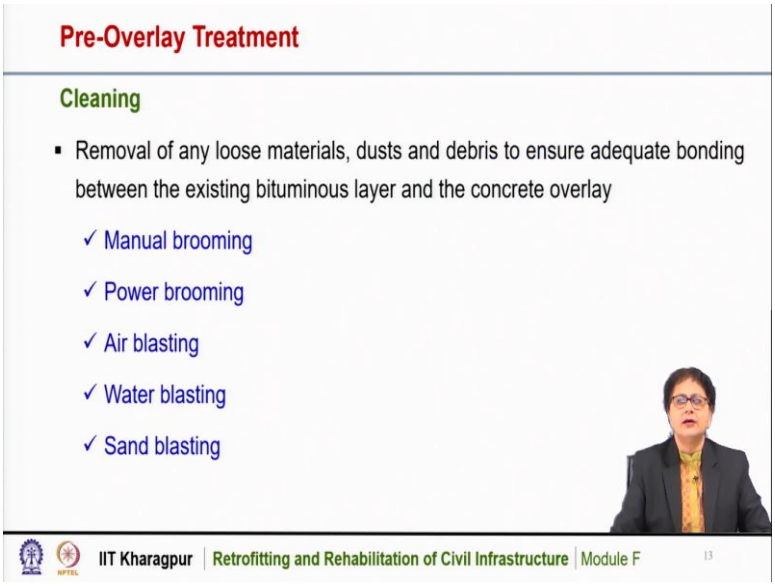

Now after milling and surface preparation, we need to clean the surface, so that any loose material, dust or debris, if it is there that should be cleaned. To ensure that adequate bonding is achieved between the existing bituminous layer and the concrete overlay. So, it is important that there should be adequate bonding between the existing bituminous layer and the concrete overlay, particularly, for thin white topping and ultra-thin white topping, the bonding is necessary.

So, that is why milling is necessary that makes the surface rough, so that bonding is achieved between the existing bituminous layer and the concrete overlay. For cleaning the surface, we can use manual brooming or power brooming. We can also do air blasting, water blasting or sand blasting. So, by these techniques, we can clean the surface. And it is now ready for the paving operation.

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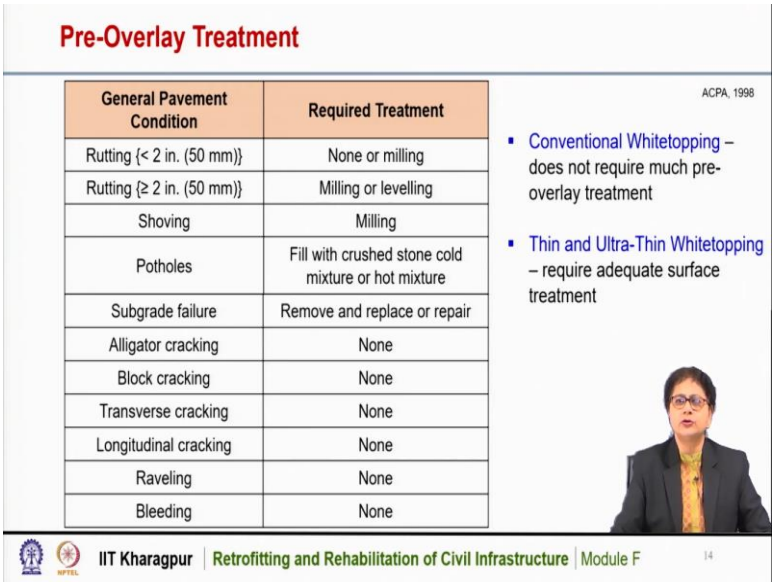

So, for conventional white topping, actually, we do not require much pre-overlay treatment. Because the conventional overlay or conventional white topping is designed as a new pavement, whereas thin or ultra-thin white topping that requires adequate surface treatment. So, if the existing bituminous pavement has significant amount of rutting, then we have to do some treatment, both for conventional white topping as well as for thin and ultra-thin white topping.

So, if the rutting is less than 50 millimetres, either we can do nothing for conventional white topping or we can do milling if the rutting is more than 50 millimetres then milling or levelling of the surface is needed. For other types of distresses like shoving, we can do milling. If there are potholes that need to be filled up with crushed stone or hot mix asphalt.

If there is subgrade failure locally, that portion of the subgrade to be removed and a new material should be placed. So, these types of distresses, if it is there, we need to address those distresses. Whereas, if the existing bituminous layer has cracks like alligator cracking or transverse or longitudinal cracking for conventional white topping, we do not require much treatment if there are cracks.

Because the overlay is designed as a new pavement. And the contribution of the existing pavement is not considered in the design. Whereas in case of thin or ultra-thin white topping, if such cracks are there that needs to be removed by milling. And we have to do adequate surface treatment, so that a proper bonding is achieved.

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Now we will discuss the paving of the overlay. For paving of concrete overlay, we need to use a paver. Two types of pavers are generally used for the purpose of laying. One is fixed form paper and the other is slip form paver. This is a typical picture of fixed form paper and this is a typical picture of slip form paver.

Fixed form paver is semi-mechanized. It requires two fixed forms that needs to be attached during the time of paving and the paver is moved along those two forms. Those two forms need to be fixed on the surface on the ground and the paver is moved along those two forms. And the concreting is done in between those two forms.

So, this is fixed form paver. It has inbuilt vibrators and it is semi-mechanized equipment. For small construction, we can use fixed form paver. Large structures like highways and all we now use slip form paver. So, this is fully automated equipment. It does not require any additional forms at its sides for movement. So, the forms are inbuilt into this equipment and the construction is done.

It has several sensors. So, it assesses the location of its concreting and it moves quite fast. So, this is the slip form paver that is fully mechanized and this is a fixed form paver. This is semi-automatic equipment. And these are used for the paving of overlays.

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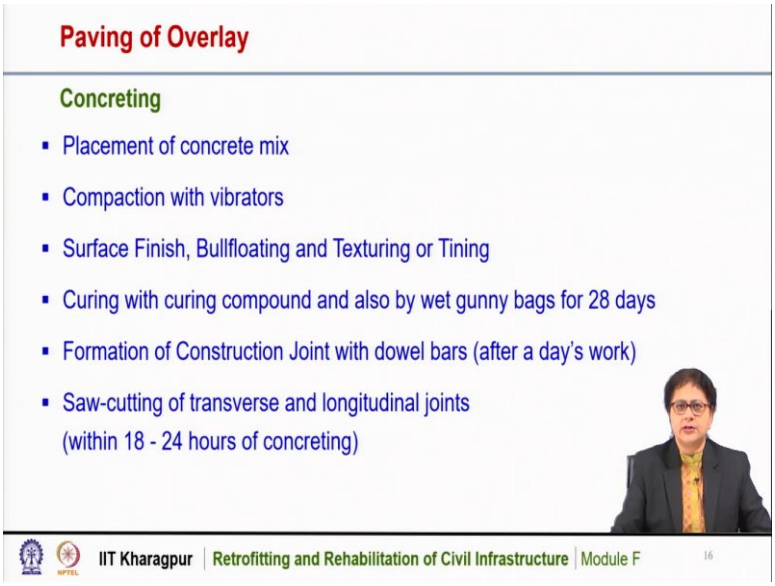

Now the concreting work. It is the first step is the placement of the concrete mix. Then it is to be compacted with vibrators. In case of fixed form vibrator, some vibrators are inbuilt, but in addition to that, needle vibrators are to be added. In case of slip form paver, the vibrators are also inbuilt; we do not require any additional vibrator from externally. So, compaction is done by the inbuilt vibrators.

Then we have to do surface finish, bullfloating, texturing or tining need to be done for the pavement. Then curing is to be done with curing compound and also by placing wet gunny bags for 28 days. Then formation of the construction joint with dowel bars after a day's work. Generally, for concrete overlay, we do not require dowel bars or tie bars. However, for conventional pavement or conventional white topping, the dowel bars are required because it is constructed as a new concrete pavement.

Whereas, thin white topping or ultra-thin white topping, we do not require dowel bars. But, after a day's work, when we have to stop the construction, at that point of time we have to provide construction joint, a full depth construction joint need to be provided and there we have to provide dowel bars to maintain the continuity.

Now after the concreting work, it is required to form the transverse and longitudinal joints and that is done by saw cutting the concrete slab. So, saw cutting of the transverse and longitudinal joints are to be done and that is to be done within 18 or 24 hours of concreting. So, it is important that after say, 18 to 24 hours of concreting, saw-cutting of the joints to be done to form the transverse and longitudinal joints on the overlay.

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These are some of the pictures of paving of overlay. This is concreting using fixed form paver. Here, near Kharagpur, this overlay has been constructed very recently. And these are the pictures of that project IIT Kharagpur. In IIT Kharagpur that has been done. So, this is the fixed form paver and this is the transit mixture through which the concrete is poured.

And this is the portion where just concreting has been done. And this is the front view of that. So, this is the paver, the concrete is poured and then it is compacted with vibrators. So, the inbuilt vibrators are there and then additional some needle vibrators are also there. So, concreting was done and the paver is moving.

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These are the pictures of surface finish. This is bull floating. After the concreting is over the paver has moved and then beyond the paver the portion which has been just concreting that needs to be finished properly. So, this is the bull-float. So, surface finishing is done by this bull floating. And after the surface finishing, the texturing need to be done.

So, this is the equipment for doing the texturing or tining. So, here we can see that the texturing is being done on the concrete portion. And after some time after say, 18 hours or so saw cutting of the joints need to be done. So, this is a typical saw-cutter and the saw cutting is being done with this saw-cutting equipment. So, this is the saw cutting of the joints.

First, we have to mark the location of the joints, because in case of concrete overlay the joints are much closely spaced. It may be of 1 meter or 1.2 meter 1.5 meter in both directions. So, a number of joints are there. So, proper care needs to be taken, so that the joints are cut properly and the joint is cut up to one-third the slab depth. So, the joint cutting is to be done with proper care. And then the surface needs to be cured.

So, it is important to properly cure the surface. And for that, curing compound is to be added. In addition to that, wet gunny bags also need to be put and for 28 days, the curing should be maintained.

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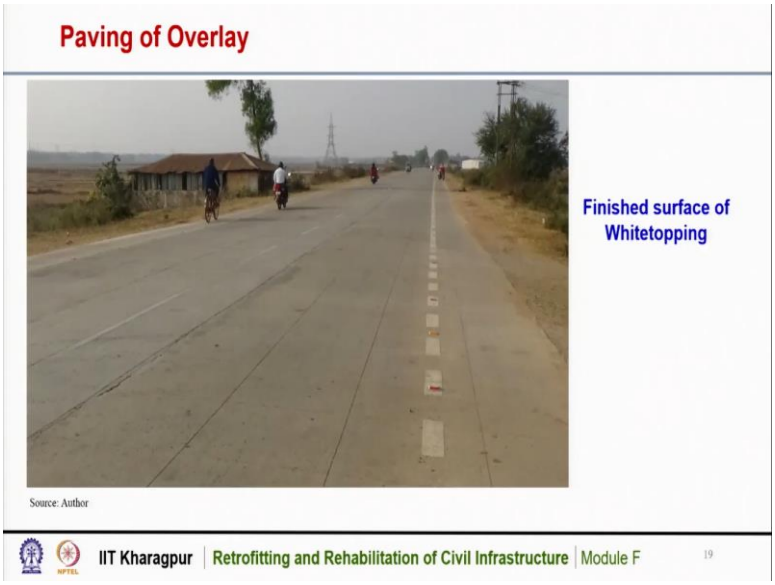

This is the finished surface of the white topping road, which has been constructed here. So, we can see that this is a 10-meter-wide concrete overlay on an existing bituminous road. This

is after the construction is over. Now the road is open to traffic. So, this is the picture of that finished surface of a white topping.

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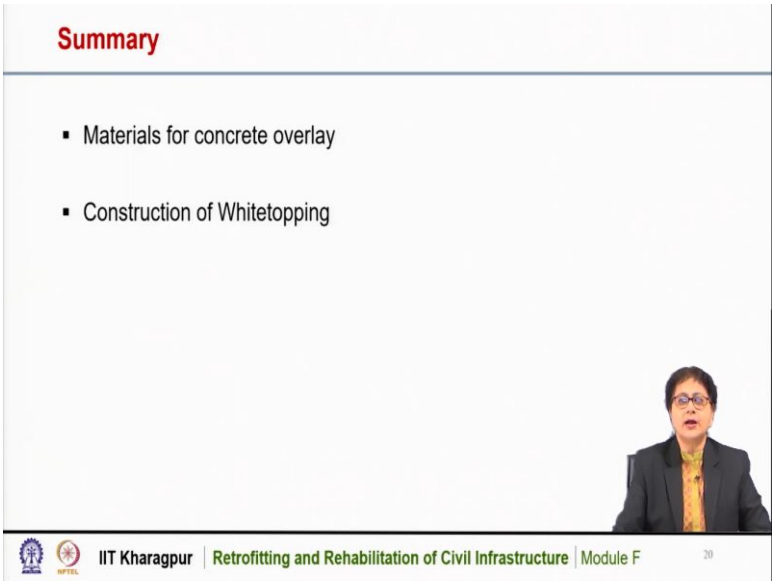

So, to summarize, we have discussed the materials needed for the construction of concrete overlay and the steps that need to be followed for the construction of concrete overlay or white topping.

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These are the reference for Module F lectures. Thank you.