**Retrofitting and Rehabilitation of Civil Infrastructure**
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**Lecture 39**
**Concept 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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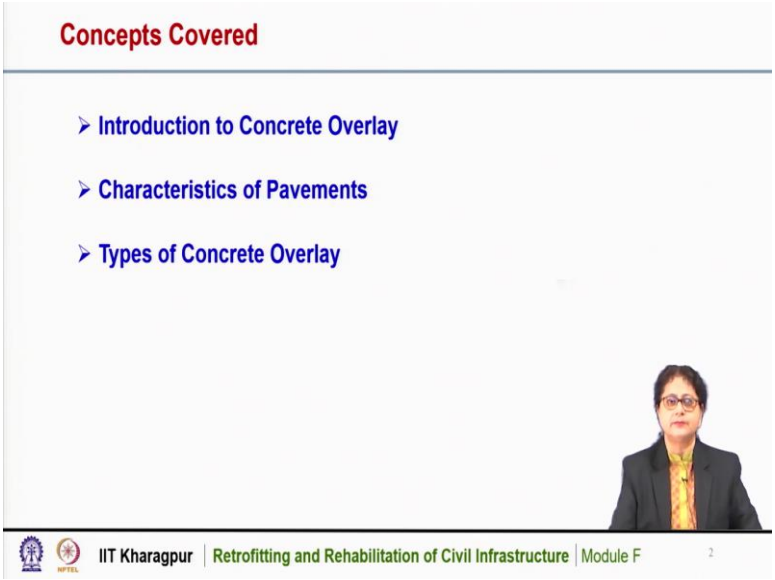


The concepts that will be covered today are introduction to concrete overlay, the characteristics of pavements over which the concrete overlay is to be applied and the types of concrete overlay and their characteristics.

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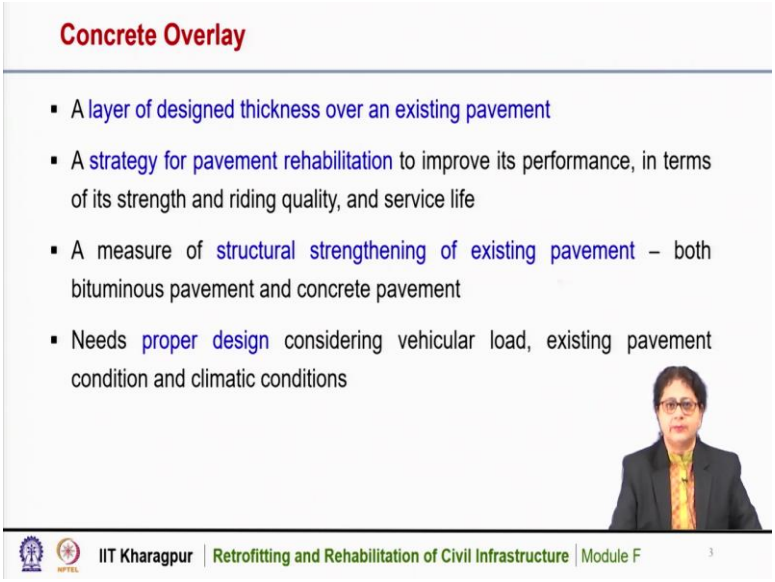


Concrete overlay is a layer of design thickness over an existing pavement. It is a strategy for pavement rehabilitation to improve its performance and service life. The performance is in terms of its structural capacity and also the functional capacity, that is the riding quality and safety. So, it is a strategy for pavement rehabilitation, so that its structural capacity is enhanced as well as its functional capacity is improved.

The functional capacity involves the riding quality and safety of the road users and the structural capacity includes the strength and load carrying capacity of the pavement. So, to improve its performance and service life, concrete overlay is a strategy for pavement rehabilitation. It is a measure of structural strengthening of existing pavement when it is deteriorated and its load carrying capacity is reduced.

So, to improve its strength or load carrying capacity, a concrete overlay can be used and it can be used for both bituminous pavement and concrete pavement. A concrete overlay needs a proper design considering the vehicular load on the pavement, the existing pavement condition and the climatic conditions.

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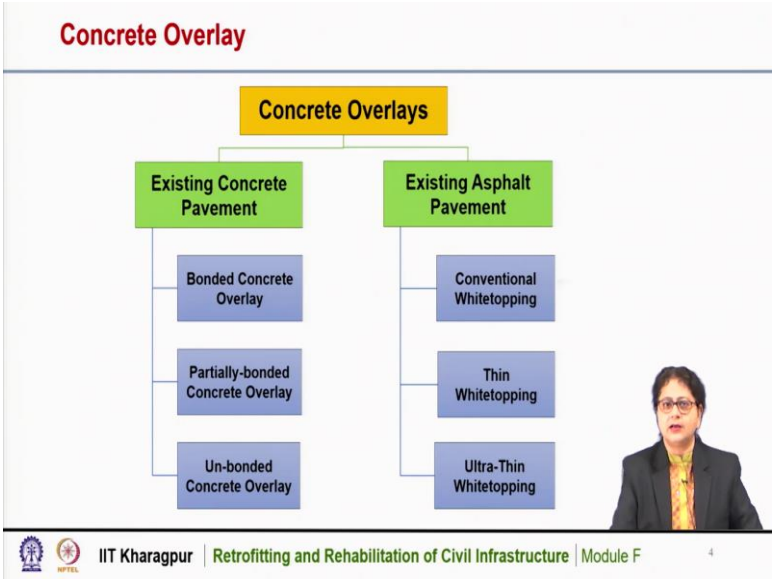


Concrete overlays can be applied for both concrete pavement and asphalt or bituminous pavement, depending on the bonding condition the overlays can be of different types. In case of concrete pavement, the concrete overlay can be of three types, bonded concrete overlay, partially bonded concrete overlay and unbonded concrete overlay.

So, these classifications are based on the bonding condition between the existing pavement and the overlay. In case of asphalt or bituminous pavement, also we can have three different types of concrete overlay. One is conventional white topping, another is thin white topping and another is ultra-thin white topping. Concrete overlay over a bituminous pavement is also called a white topping.

Bituminous pavement is generally black in colour, because the main ingredient is the bitumen which is a hydrocarbon and its colour is black. So, when a concrete overlay is applied on a blacktop bituminous pavement, it is sometimes called white topping. So, white topping is also a very common terminology for concrete overlay over bituminous pavement.

So, for a bituminous pavement, we have three types of concrete overlays, one is conventional white topping, another is thin white topping and another is ultra-thin white topping depending on the thickness as well as on the bonding condition. Today we will discuss different types of concrete overlays.

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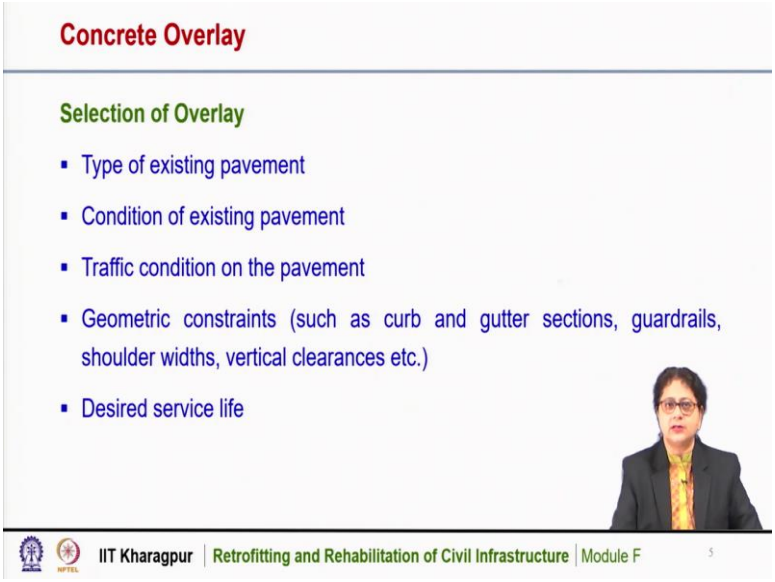


Now, we will discuss that how we can select an overlay. What are the parameters that govern the selection of overlay? It depends significantly on what type of the existing pavement is, whether it is a bituminous pavement or it is a concrete pavement, these are the two broad classifications of pavement there could be different other types and depending on where the pavement is situated, that also governs the type of overlays selection.

So, it depends significantly on what type of pavement and also what is the condition of the existing pavement. Since concrete overlays are rehabilitation strategies. So, the existing pavement needs strengthening or to improve its service life and the existing pavement may be in a deteriorated state. So, how much deterioration has been taken place on the existing pavement, what are the distresses on that existing pavement, that is an important consideration for selection often overlay.

The traffic condition on the pavement is another important parameter for the selection of overlay, because that is the main load coming on the pavement. The geometric constraints if it is there for any road pavement like curves or vertical clearances, etc that may also govern the selection of overlay and the desired service life, how much service life increment we want that also governs the selection of overlay.

So, what type of overlay we will select that depends significantly on several parameters, what is the type of pavement, what is the condition of the existing pavement, how much deterioration has been taken place and what is its present strength that governs the selection

of overlay. What is the traffic condition, whether there are any geometric constraints or not and how much increase in the service life we want, that also governs the selection of overlay often deteriorated pavement.

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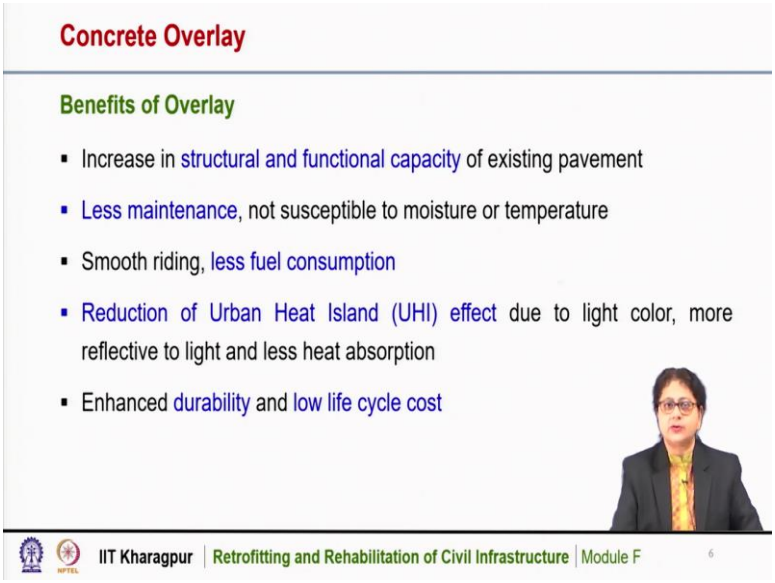


There are several benefits of overlay. It increases the structural capacity as well as the functional capacity of an existing pavement. So, the structural capacity that means its strength and load carrying capacity is improved, when we use overlay on an existing deteriorated pavement. In addition to the structural capacity, the functional capacity of the pavement is also improved that is its riding quality is improved.

So, the road user cost is also reduced, the safety is improved since the road condition is improved. So, there are several improvements in the functional performance as well as in the structural performance of the pavement when it is overlaid. A concrete overlay when it is applied on a deteriorated pavement that provides a smooth riding and this results into less fuel consumption to the road users. So, this is also another benefit for the road users.

A concrete overlay causes less maintenance to the pavement because concrete as a material is not that susceptible to moisture or temperature. Though it may experience thermal expansion or contraction, but the susceptibility is less as compared to the bituminous material. So, less maintenance is required for concrete overlay. Reduction of urban heat island effect due to the light colour. Concrete overlay is more or less white or greyish in colour.

So, the urban heat island effect is also less. It is more reflective to light and less heat absorption. So, from the environmental consideration also, this is beneficial and it provides enhanced durability and low lifecycle cost. So, concrete overlay when it is applied on a deteriorated pavement, it increases its service life. So, the durability is enhanced. And if you see the total lifecycle cost is reduced. So, there are several benefits of concrete overlay. It is an effective strategy for pavement rehabilitation to improve its performance and service life.

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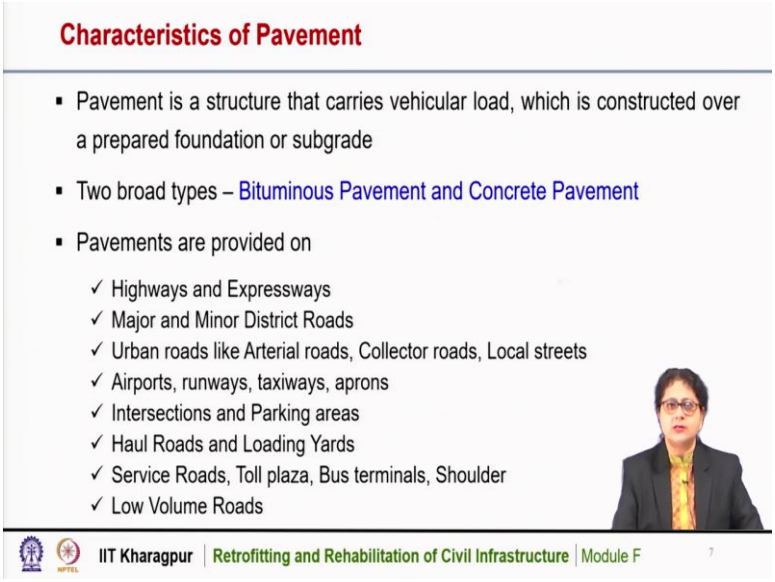


Concrete overlay is applied on pavement. So, here we will discuss very briefly the two broad types of pavement, pavement is a structure that carries the vehicular load which is constructed over a prepared foundation or subgrade. It is not the footpath. So, it is the structural component which carries the moving vehicular load.

The pavement is constructed over a prepared foundation or subgrade and generally it has several layers and the type of layers depends on the type of pavement and it has to be designed properly considering the vehicular load, the environmental conditions like temperature or moisture.

So, it requires a proper design and it is constructed over a prepared foundation like all other structures. There are two broad types of pavement one is bituminous pavement and the other is concrete pavement. Pavements are provided on highways and expressways on major and minor district roads and urban roads like arterial roads, collector roads, local streets, airports, runways, taxiways, aprons, etc.

Intersections, parking areas, haul roads, loading yards, service roads, toll plaza, bus terminals shoulder and also for low volume roads. So, pavements are provided for all these types of roads, highways, expressways, these are the top categories of road then major district roads, urban roads, even low volume roads, airports etc.

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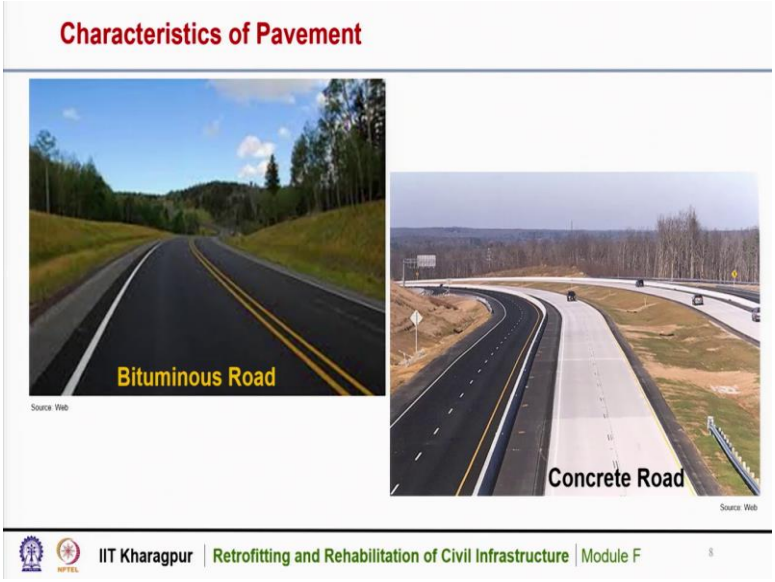


So, these are the two broad types of pavement. One is bituminous pavement or sometimes called blacktop pavement, we can see here that this is a typical bituminous road. The main ingredient is the bitumen which is hydrocarbon and the colour is black. So, the colour of the pavement is also black and this is a picture of concrete road.

So, here we can see that this is a typical concrete road and concrete being greyish or whitish in colour. So, that is why it is sometimes called white top road. So, these are the two-broad classification of pavement and most of the highways or expressways or MDR are either bituminous road or concrete road.

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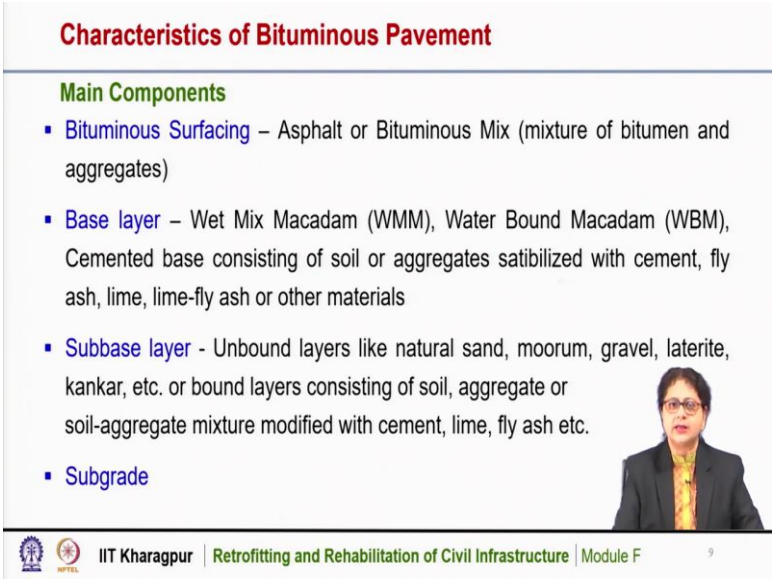


Now, we will discuss very briefly the characteristics of bituminous pavement. The main components are bituminous surfacing, base layer, subbase layer and subgrade. So, the bituminous surfacing is the top layer, it is the asphalt or bituminous mix. The surface layer is composed of bituminous mix, it is a mixture of bitumen and aggregates.

The next layer is the base layer, there may be different materials that are used as base layer, it could be Wet Mix Macadam or Water Bound Macadam or a cemented base consisting of soil and aggregates, stabilised with cement, fly ash, lime or lime fly ash, et cetera. There is another layer next to the base layer that is called subbase layer. This is an unbound layer like natural sand, moorum, gravel, laterite, kankar et cetera.

Or it could be bound layers consisting of soil aggregate or soil aggregate mixture modified with cement lime or fly ash etc. And the next layer is the compacted subgrade. So, for a bituminous pavement there are different layers. The top layer is the bituminous surfacing. Next is the base layer. Next is the subbase layer and these are all on the compacted subgrade. So, subgrade needs to be properly compacted or consolidated so that it can take the layers over it.

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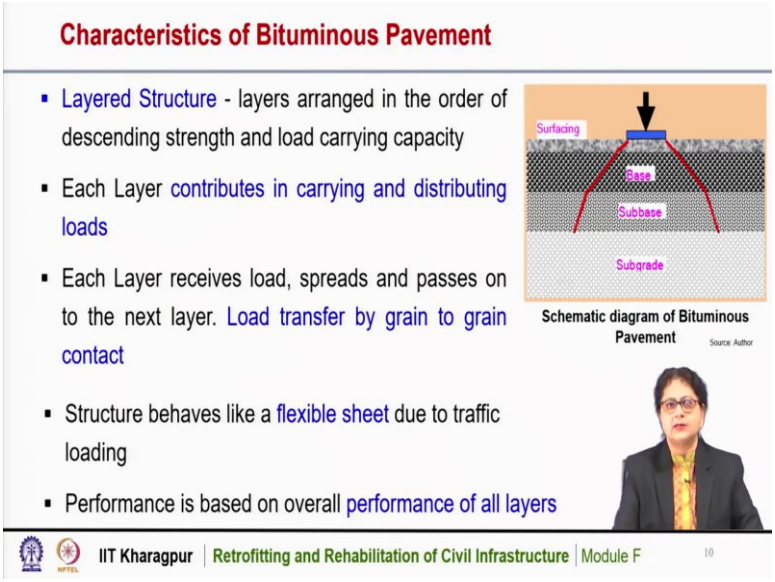


So, the characteristics of bituminous pavement is that it is a layered structure, layers are arranged in the order of descending strength and load carrying capacity. So, the top layer has the maximum strength and as we go down the strength reduces. So, the layers are arranged in the order of descending strength and load carrying capacity.

So, here it is a schematic diagram of the bituminous pavement, the top surfacing is made of bituminous layer, next is the base layer and it could be WBM or WMM or other cement treated materials, this is an unbound layer or sometimes it could be also bound layers and this is the compacted subgrade. Each layer contributes in carrying and distributing load in case of a bituminous material.

So, all these layers actually contribute in carrying and distributing the load coming on it and the load is the vehicular load. Each layer receives the load, spreads and passes on to the next layer. The load is transferred by grain to grain contact. So, here we can see that when the load is coming on a bituminous pavement at its stop, so it is taking by this layer and then it passes to the next layer and then to the next layer and finally to the subgrade.

So, load transfer is by grain to grain contact. The structure behaves like a flexible sheet due to the traffic loading and that is why sometimes it is also called a flexible pavement. And the performance of the bituminous pavement is based on the overall performance of all the layers. So, it is a layered structure and the performance of the bituminous pavement is based on the overall performance of all the layers.

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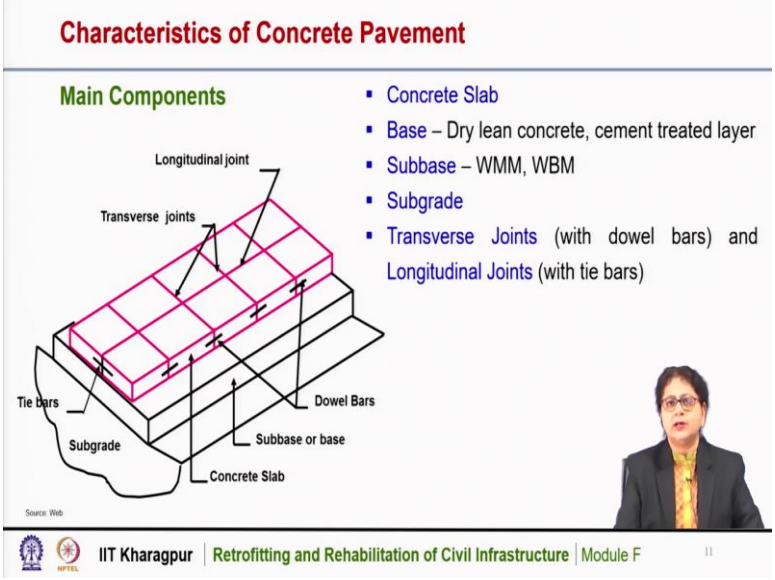


In case of concrete pavement there are different components. The main component is the concrete slab, concrete pavement also has base and subbase layers, the base could be cement treated layer or it could be a dry lean concrete base, the sub-base maybe Water Bond Macadam or Wet Mix Macadam or it could be some unbound layers or cement treated material.

And then subgrade, the subgrade is compacted subgrade that has to be provided. And concrete pavement has joints and these joints are provided along its transverse direction as well as its longitudinal direction. So, transverse joints are there and the transverse joints are provided with a series of dowel bars for load transfer and longitudinal joints are provided with tie bars. And these tie bars are provided to hold the two panels in their position.

This is a schematic diagram of a concrete pavement. This is the concrete slab which is supported over base layers and subbase layer and below that, it is the subgrade. The base, subbase and subgrade actually comprise the foundation for the pavement for both bituminous pavement and concrete pavement. The foundation composed of the base, subbase and the subgrade layers. In case of concrete pavement, the joints are provided.

So, these are the transfers joints and they are provided with dowel bars, they are short mild steel bars provided at the mid depth of the slab for transferring load from one panel to another panel. And these are the longitudinal joints. These are provided along the length of the road and they are provided with tie bars. So, tie bars actually hold the two slab panels in their position. So, these are the main components for concrete pavement.

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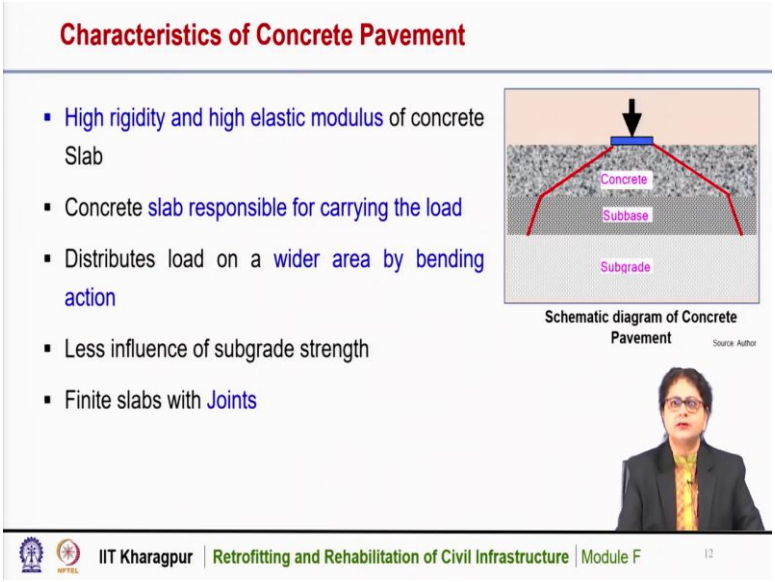


The characteristics of concrete pavement are somewhat different as compared to bituminous pavement. In case of concrete pavement, it is the concrete slab that is responsible for carrying vehicular load. So, the concrete slab is the main component in case of concrete pavement and the load is taken by the concrete slab itself.

So, high rigidity and high elastic modulus of concrete slab that results into the strength of the concrete pavement, the concrete slab distributes the load on a wider area by bending action as you can see that the when the load is applied to the moving vehicle on the top surface the load is transferred from the concrete slab to the base subbase and then finally to the subgrade. However, as compared to bituminous pavement this distribution area load distribution area is much more as compared to bituminous pavement.

So, the load is distributed on a much wider area and the load is taken by this bending action. So, it is the strength of the concrete slab that matters and less influence of the other layers base or subbase or subgrade. So, less influence of the subgrade strength and also the other layers and concrete pavement has joints as we have just shown in the previous slide, it has joints, so the slabs are finite slabs. And in case of bituminous pavement, there is no joint. So, the pavement is constructed continuously.

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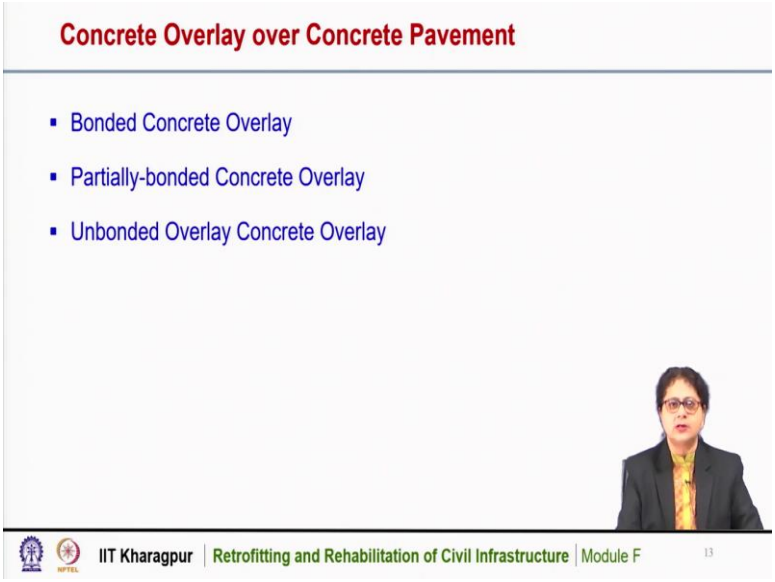


Now, we will discuss the different types of concrete overlay and these concrete overlays are provided on either bituminous pavement or concrete pavement. So, depending on the characteristics of the existing pavement we have to select the concrete overlay on the pavement. So, in case of concrete pavement, if it requires rehabilitation, then we can use concrete overlay and it may be of three types one is bonded concrete overlay, another is partially bonded concrete overlay and the other one is unbonded concrete overlay.

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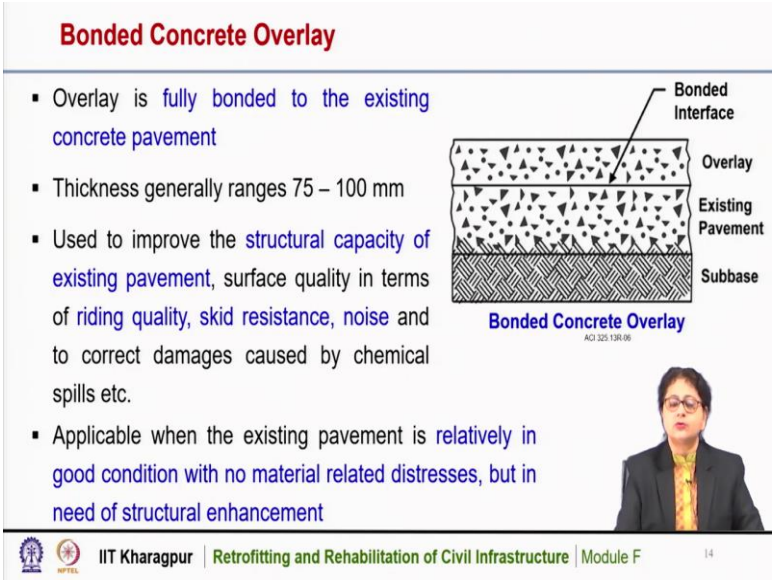


Bonded concrete overlay is fully bonded to the existing concrete pavement. The thickness of concrete overlay is generally in the range of 75 to 100 millimetre. It is used to improve the

structural capacity of the existing pavement. The surface quality is also improved that is in terms of its riding quality, skid resistance, noise and to correct the damages caused by chemical spills etc.

So, these pavements are used to improve the structural strength of the existing pavement which may be deteriorated. It also improves the surface quality and that results into improved riding quality, skid resistance and reduction in noise. Bonded concrete overlay is applicable when the existing pavement is relatively in good condition with no material related distresses, but in need of structural enhancement.

So, it is to be remembered that when the existing pavement is relatively in good condition and there is no major material related degradation, the existing pavement requires structural strengthening, maybe due to increased load on it. Then we can use bonded concrete overlay on the existing pavement.

This is a schematic diagram of bonded concrete overlay. This is the existing concrete pavement and this is the foundation or the subgrade or subbase and over which another layer of concrete is to be placed. So, this is the concrete overlay on the existing concrete pavement, and the interface is termed as bonded. So, the new overlay is to be placed directly on the existing concrete pavement.

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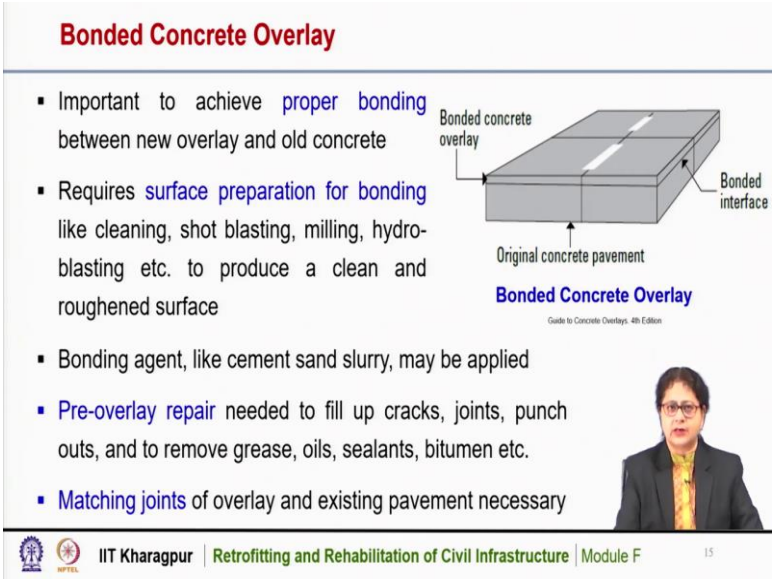


In case of bonded concrete overlay, it is important to achieve proper bonding between the new overlay and the old concrete. And that requires proper surface preparation so that proper

bond is achieved. For surface preparation, it requires cleaning, shot blasting or milling of the existing pavement or hydro blasting etc to produce a clean and roughened surface.

We need to have a rough surface and for that a proper surface preparation is needed. We can also do milling of say 25 millimetre or 50 millimetre depending on the type of pavement and with that, the surface is prepared. On that, we can apply the overlay. And if the surface is sufficiently rough then bonding can be achieved, we can also use a bonding agent like cement sand slurry to improve the bonding between the new overlay and the old concrete.

Pre-overlay repair is needed to fill up the cracks, joints, punch outs and also to remove grease oil sealants, bitumen, etc. In case of bonded concrete overlay, it is important to have proper bonding between the new and the old concrete. So, any sign of grease or oil or bitumen needs to be removed properly and if cracks or joints etc are there that needs to be filled up also, and it is important to match the joints of the overlay and the existing pavement.

So, here is a schematic diagram of bonded concrete overlay. This is the existing pavement and this is the overlay, which is bonded and the interface we can see it requires proper treatment, so that the two layers are bonded. And here it is shown that the joints of the overlay and existing pavement should match each other.

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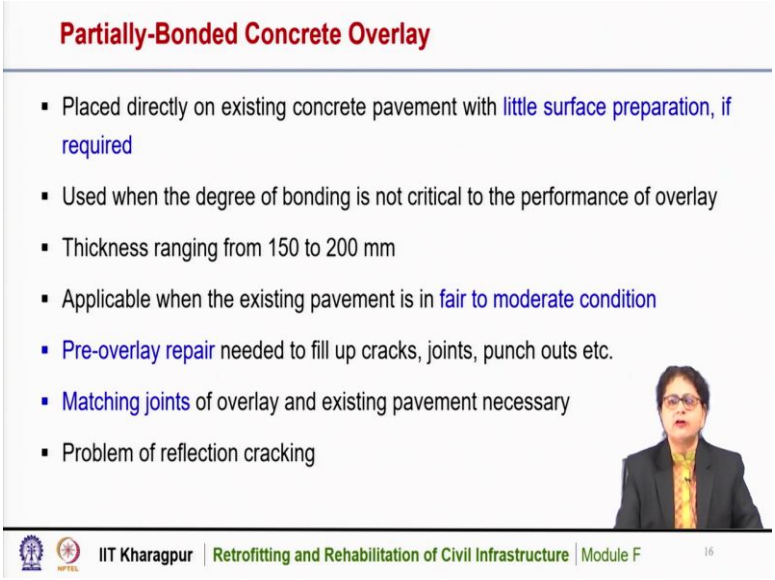


In case of partially bonded concrete overlay, the overlays to be placed on the existing pavement and the existing pavement may require a little surface preparation. It may be placed

directly on the existing pavement but to achieve a partial bonding, a little surface preparation may be required.

It is used when the degree of bonding is not critical to the performance of overlay and its thickness is ranging from 150 to 200 millimetre. Partially bonded concrete overlay is applicable when the existing pavement is in fair to moderate condition. Pre-overlay repair is needed to fill up the cracks, joints or punch outs, etc if it is there on the existing pavement. And in case of partially bonded concrete overlay, matching of joints is necessary like in case of bonded concrete overlay. So, here also the matching of joints is to be done.

However, in case of partially bonded concrete overlay, there may be a problem of reflection cracking, if the existing pavement has several cracks and since it is partially bonded and there is no interface properly placed in between. So, the cracks may reflect to the top layer as well. So, sometimes the problem of reflection cracking may be there in case of partially bonded concrete overlay.

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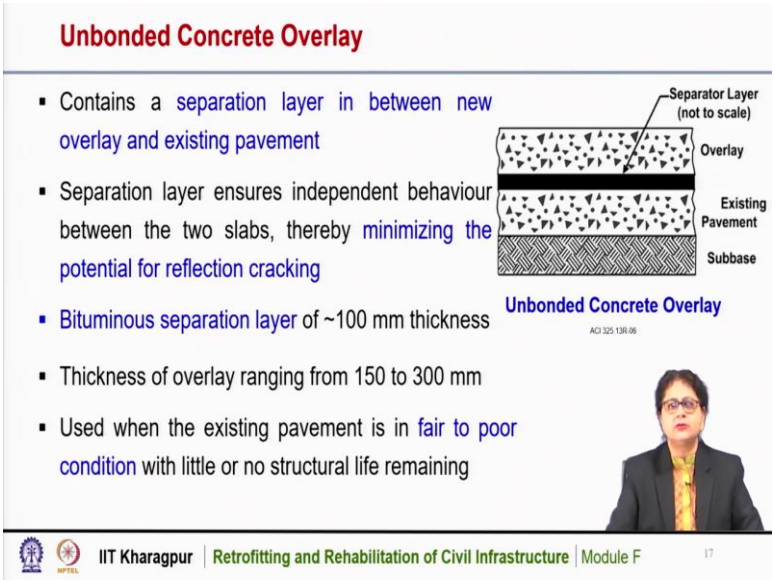


In case of unbonded concrete overlay, it contains a separation layer in between the new overlay and the existing pavement. So, a separation layer is to be provided and that creates the unbonded condition between the new overlay and the existing pavement. This separation layer ensures independent behaviour between the two slabs, thereby minimising the potential for reflection cracking.

So, in case of unbonded overlay there is a separation layer and that prevents the cracks to reflect the top layer. The separation layer could be a bituminous layer, approximately 100-millimetre-thick or so, or it could be a polythene sheet that can be used as a separation layer. The thickness of the overlay ranging from 150 to 300 millimetre and it is used when the existing pavement is in fair to poor condition with little or no structural life remaining.

So, here in this case an unbounded concrete overlay can be applied when the existing pavement is in a poor condition. And the structural strength is also reduced significantly. So, this is a schematic diagram of unbonded concrete overlay, this is the subgrade and this is the existing pavement, this is the separation layer, over which the new concrete overlay is placed. So, this is unbonded concrete overly.

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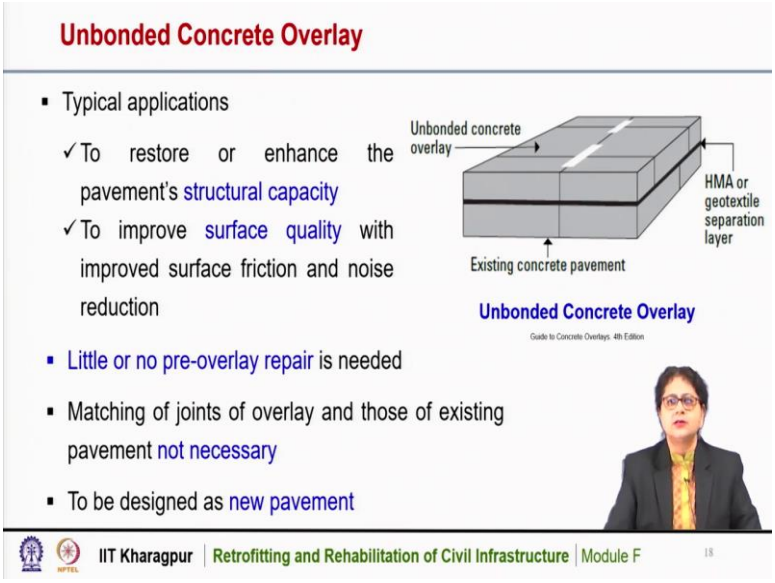


Typical applications for unbonded concrete overlay are to restore or enhance the pavement structural capacity and to improve the surface quality with improved surface friction and noise reduction. So, to improve the strength or structural capacity of the existing member, we can use an unbonded concrete overlay and since it is unbounded, so there is no requirement for pre-overlay repair of the existing pavement.

So, we can avoid the pre-overlay repair in case of unbonded concrete overlay. Matching of joints of overlay and those of existing pavement is also not necessary. Because we are having a separation layer. So, matching of joint is not necessary and it is to be designed as a new pavement. So, unbonded concrete overlay is practically designed as a new pavement.

So, the existing pavement actually behaves as a base layer and it is the entire overlay that is now responsible for taking the load. So, it is as good as a new pavement. So, that is why the strength of the existing pavement does not matter. So, when the strength is much less for existing pavement we can go for an unbonded concrete overlay.

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Now, we will discuss the concrete overlay over bituminous pavement. As we have mentioned earlier, there are three types of concrete overlay over bituminous pavement one is conventional white topping, thin white topping and the other is ultra-thin white topping. This is a typical picture of white topping over bituminous pavement.

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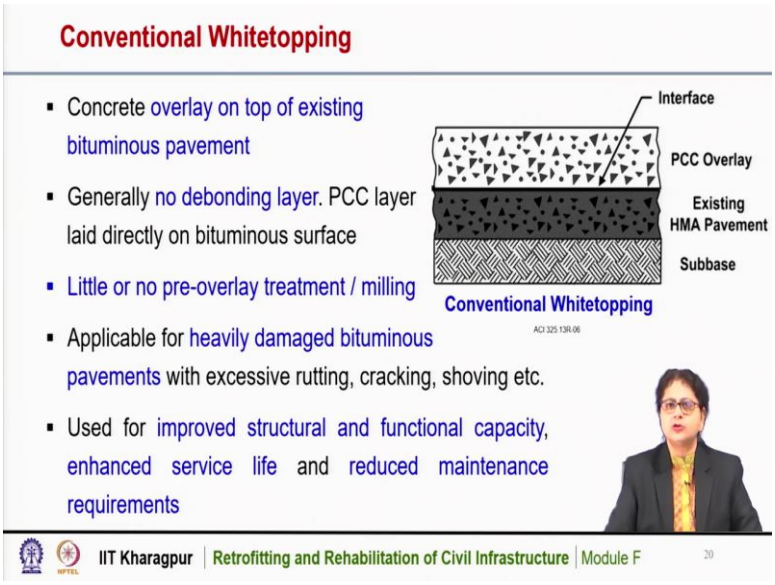

Now, we will discuss this in detail. Conventional white topping is the concrete overlay on top of existing bituminous pavement. It is generally having no debonding layer, the PCC layer is laid directly on the bituminous surface, little or no pre-overlay treatment is required or we can do a milling of the existing surface. It is applicable for heavily damaged bituminous pavement with excessive rutting, cracking, shoving etc.

So, here in this case, the concrete overlay is placed on the deteriorated bituminous pavement and when the existing pavement is damaged significantly and there are several distresses on the pavement, its load carrying capacity is reduced, there we can use conventional white topping. And here also we do not require any bonding because the conventional white topping also is designed as a new pavement.

So, the strength of the existing pavement does not matter and we do not require the debonding layer. So, it can be placed directly on the existing pavement. So, it is used for improved structural and functional capacity, enhanced service life and reduced maintenance requirements. So, bituminous pavement generally require much more maintenance as compared to concrete pavement.

But when it is rehabilitated with an overlay, the maintenance requirement is also reduced significantly and its structural capacity and functional capacity is enhanced. This is a schematic diagram of conventional white topping. This is the subbase or subgrade and this is the existing bituminous pavement or HMA pavement or Hot Mix Asphalt pavement, over which we can have white topping or concrete overlay. So, this can be directly placed on the existing bituminous pavement and no debonding layer is required.

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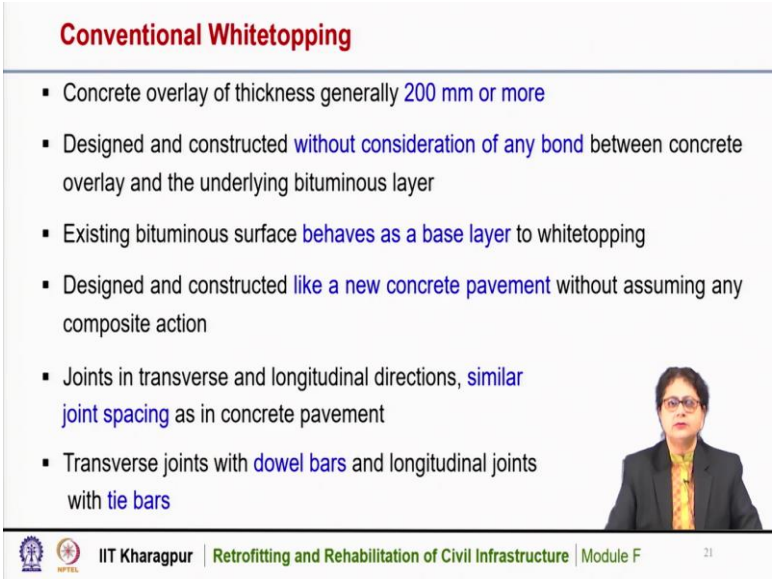


Conventional white topping has thickness generally in the range of 200 millimetre or more because it is designed as a new pavement. It is designed and constructed without consideration of any bond between the concrete overlay and the underlying bituminous layer. The existing bituminous surface behaves as a base layer to the conventional white topping.

And it is designed and constructed by a new concrete pavement without assuming any composite action. The conventional white topping has joints in transverse and longitudinal direction similar to the conventional concrete pavement and the joint spacings are also maintained similar as in concrete pavement, the transverse joints are provided with dowel bars and longitudinal joints are provided with tie bars.

So, conventional white topping is similar to conventional jointed concrete pavement. Only difference is that it is placed on a bituminous pavement. So, the existing bituminous pavement acts as a base layer to the conventional white topping.

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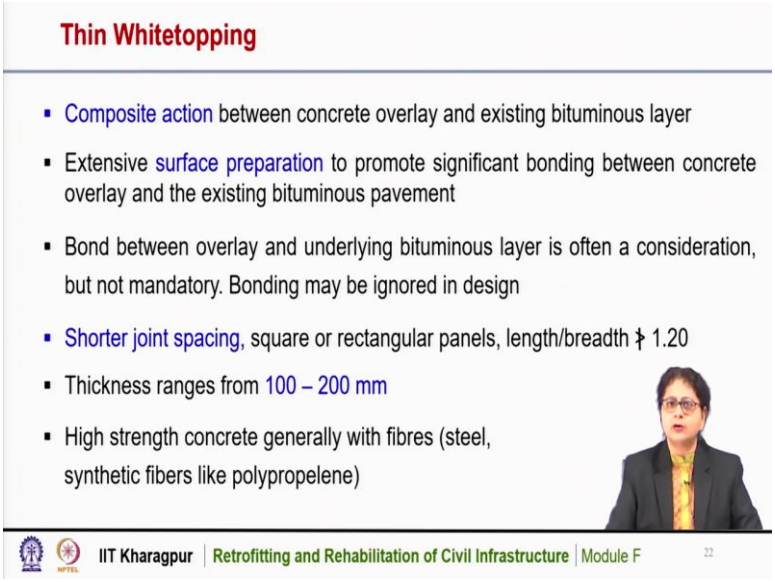


In case of thin white topping, there is a composite action between the concrete overlay and the existing bituminous layer. For thin white topping, it requires extensive surface preparation to promote significant bonding between the concrete overlay and existing bituminous pavement. The bond between overlay and the underlying bituminous layer is often a consideration but not mandatory.

So, it is desirable that we have a bonding between the existing bituminous pavement and the new concrete overlay, but we can also design it as unbonded. So, it is not a mandatory that bonding is to be there. For thin white topping the joint spacing is much smaller as compared to conventional concrete pavement.

The panel sizes are small, it may be square or rectangular in shape and the length by breadth ratio should not be more than one point. In case of conventional concrete pavement, the panel size in India is 3.5 × 4.5 metre whereas in case of thin white topping it is 1 metre to 1.5 metre etc. So, the joint spacing is much less both in case of a transverse joint or in case of longitudinal joint.

The thickness is less, it is in the range of 100 to 200-millimetre. High strength concrete is generally used and we generally use fibres. The fibres may be steel fibres or synthetic fibres like polypropylene fibres. So, concrete is generally with fibres and of a high strength.

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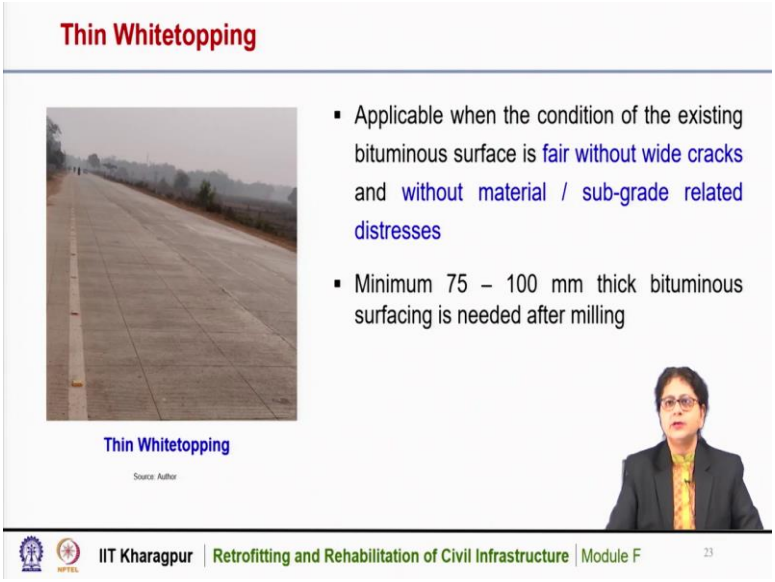


This is a typical picture of thin white topping road that is constructed near IIT Kharagpur in recent years. So, this is a typical thin white topping road, the joint spacing is much small and the panel size is 1 metre × 1 metre. Thin white topping is applicable when the condition of the existing bituminous surface is fair without wide cracks and without material or subgrade related distresses.

Here in case of thin white topping, the existing bituminous pavement behaves as the base layer to the thin white topping. So, it should not be very much damaged. So, the condition of the bituminous pavement should be fair or moderate, without wide cracks or without material related degradation or without rutting of the subgrade or subgrade failure.

So, moderate condition of the existing pavement is suitable for thin white topping construction and the minimum thickness of the existing bituminous layer is to be maintained as 75 millimetre to 100 millimetre. If the existing bituminous layer is less than this, then we have to add another bituminous layer, because it should have sufficient strength to act as base layer. So, minimum 75 to 100 millimetre thickness of the existing bituminous surface is needed after the surface treatment for thin white topping.

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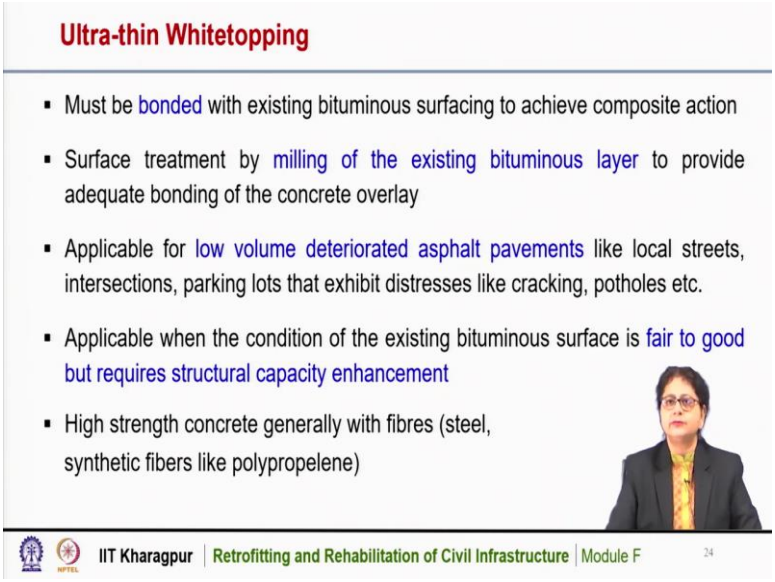


Now, ultra-thin white topping must be bonded with the existing bituminous surfacing to achieve the composite action, in case of conventional white topping bonding is not necessary, in case of thin white topping bonding may be done or we cannot, we may not use bonding, but in case of ultra-thin white topping bonding is a must.

It is to be bonded with the existing bituminous surface to achieve the proper composite action, the surface treatment is necessary and that can be done by milling of the existing bituminous layer to provide adequate bonding of the concrete overlay. Ultra-thin white topping is applicable for low volume deteriorated asphalt pavements, like local streets intersections, parking lots etc, that exhibit distresses like cracking, potholes etc.

So, if the pavement is distressed and the surface quality is damaged, then we can go for ultra-thin white topping. It is applicable when the condition of the existing bituminous surface is fair to good but requires structural capacity enhancement. So, concrete overlay improves the structural strength and when the existing bituminous surface condition is fair to good, we can use ultra-thin white topping. Here also high strength concrete is generally used with fibres, we can use steel fibres or polypropylene fibres.

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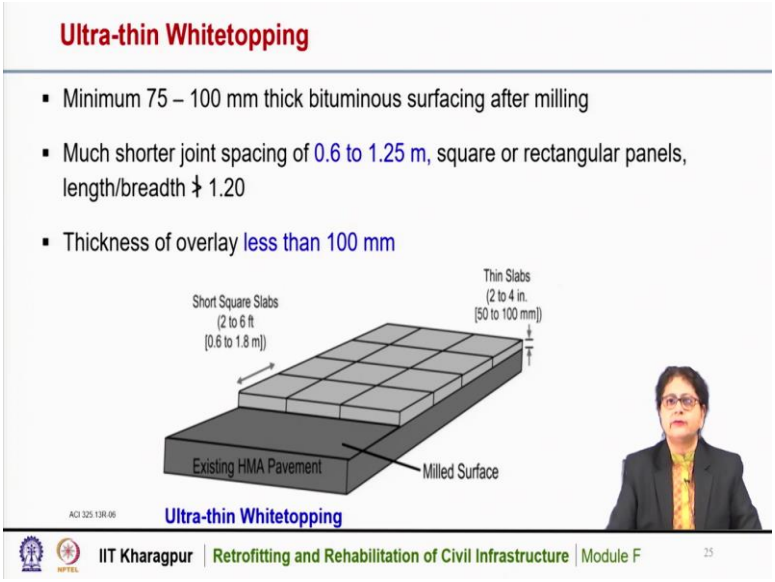


Here also after surface treatment or after milling, the minimum thickness of the bituminous surfacing is 75 to 100 millimetre, we can provide more but minimum this much thickness is required. In case of ultra-thin white topping, we may have even much shorter joint spacing as compared to thin white topping.

The joint spacing may be 0.6 metre to 1.25 metre, it may be square or rectangular as in case of thin white topping and the length to breath ratio should not exceed 1.2, it is desirable. And the thickness of overlay is generally less than 100 millimetre. So, considering the thickness, ultra-thin white topping has the least thickness, then for the thin white topping it is about 100 to 200 millimetre and in case of conventional white topping the thickness is generally more than 200 millimetre because it is designed as a new pavement.

So, the thickness is also more as compared to thin white topping or ultra-thin white topping. This is a schematic diagram of ultra-thin white topping, this is the existing bituminous pavement and over which ultra-thin white topping is to be placed. It has smaller joint spacing and the thickness is also less.

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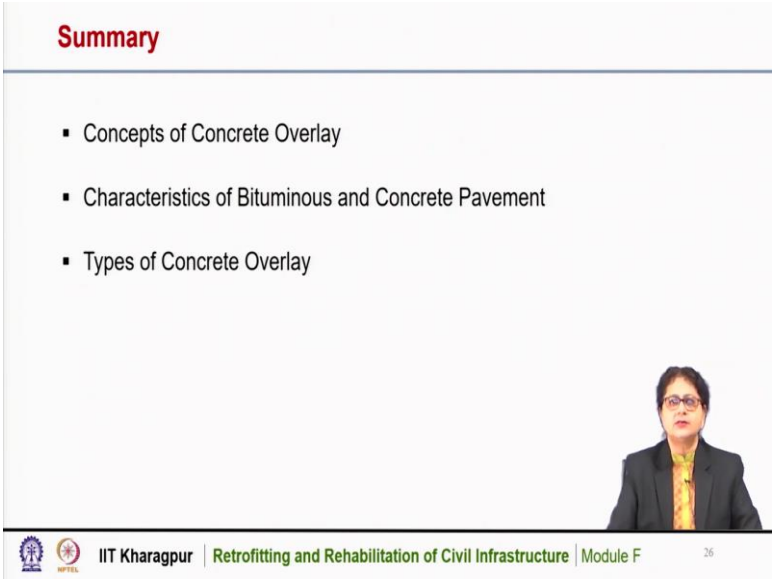


So, to summarise, we have discussed the concepts of concrete overlay. We have discussed briefly the characteristics of the two broad types of pavements, one is bituminous pavement and the other is concrete pavement. And we have also discussed the different types of concrete overlay and their applicability. Thank you.