

Course Name – Pavement Construction Technology
Professor Name – Dr. Rajan Choudhary
Department Name – Civil Engineering
Institute Name – Indian Institute of Technology Guwahati
Week – 11
Lecture – 41

A very warm welcome to all of you. I am Rajan Choudhary, a Professor in the Department of Civil Engineering at the Indian Institute of Technology, Guwahati, and the Course Instructor for the NPTEL MOOC Course Pavement Construction and Technology funded by the Ministry of Education, Government of India. Today's lecture will be a continuation of our lecture 26. Under module 11, where we were discussing pavement distress, there was a specific focus on the causes and treatments related to some specific pavement distresses. At the very beginning, I would like to acknowledge the use of text, information, graphs, and images sourced from various textbooks, codal standards, general articles, reports, newsletters, and public domain searches. Now, as we discussed in our previous lecture, it is very important to understand when some distress occurs on the pavement surface, specifically when some premature distress takes place; it is crucial to understand the cause of that distress, and only then will we be able to work out a possible treatment for that kind of distress.

We have IRC-82, which gives us the code of practice for the maintenance of bituminous roads. That is 82-2023, where the different types of distress have been clubbed under different categories. The four main categories that are formulated are surface defects, cracks, deformation, and disintegration. In the previous lectures, we have discussed the causes related to the surface defects, including bleeding, smooth surface, streaking, hungry surface, and under the cracks, hairline cracks, alligator cracks, edge cracks, shrinkage cracks, and reflection cracks.

In today's lecture, we will focus specifically on the causes and treatments of the distresses that come under deformation, including slippage, rutting, corrugation, shoving, shallow depressions, settlements, and upheavals, along with the distresses in the form of disintegration, which include stripping, loss of aggregates, raveling, potholes, and edge breaking. Now, coming to the first distress under the category of deformation, which is the slippage, we discussed these distresses and their possible locations where they can occur, as well as the severity levels of these distresses. Today, we will focus more on the causes of these distresses, and these are some of the common causes that have been experienced throughout these bituminous roads around the globe by different engineers, along with some of the common measures that have been taken by those engineers to address these distresses. It is always very important and vital that the engineer in charge takes a careful look at the cause of that distress. These are some of the possible causes; there may be something else in addition to this particular one.

So, he needs to investigate in a proper manner, and then, on the basis of the available information and his own judgment, he has to select a possible treatment for that particular distress. So, let us first begin with the distress that comes under the category of deformation, which is slippage cracking, and we discussed earlier that it mainly occurs due to a poor bond between the surface layer and the underlying courses. So, there is a slippage mechanism; you can see this is how a portion of the HMA surface has slipped and the bond has been lost between the underlying layer and the top surface course. So, specifically, it mainly occurs when the surface loses its bond with the underlying layers. So, this can possibly happen in case of omission or inadequacy of the tack coat because the tack coat is the one that is applied to build up a bond between the underlying bituminous cores and the overlay of HMA.

So, if there is an inadequate or an absence of a tack coat at some locations, there is a high possibility of slippage taking place. While we are doing construction over an existing bituminous layer, it is always advisable and recommended that the existing base be prepared by clearing any deleterious substances and removing all dust before applying a tack coat, followed by the overlay. So, if there is a presence of dust or moisture, then possibly you will not have a good bond of the overlay with your underlying layer, and if there are thin overlays and excessive deflections because the structure may be weak enough, then the possibility of this slippage may also happen. And another concern is when these particular overlays or the top layers are overstressed by traffic, and specifically where it happens. It happens when you have these curves; some braking actions are present.

So, there you have a greater amount of stress coming to the surface. So, a poorly bonded surface, specifically the one that already has a lack of bond with the existing one. When it is overloaded by normal traffic, it usually gets overloaded at intersections and curves where frequent acceleration and braking actions take place. And along with temperature changes, there are leading to premature cracking and material break-off. So, when these materials are highly stressed, they break, peel off, or get separated from the underlying layer, which can quickly grow, especially in cold conditions.

If water comes into this particular part where the breaking has taken place, then this further worsens the situation and makes your slippage cracks more severe. So, what could be a possible treatment for it? It involves the surface of this particular section, which has been distressed. So, it is important to remove this particular one, and while removing it, we can mill it, and we will always prefer that it is milled up to a certain lower depth. We go into the underlying course to a certain depth so as to get a sound surface with a good surface structure, specifically a rough surface structure. So what it says is that the treatment of slippage stress widely involves removing the slipped material, specifically what has already slipped, preferably with a milling machine.

There are small milling machines that can mill a given width, from a small width to a depth slightly below the point of slipping. Where this point already exists, we prefer to go because this is a polished surface. So, we will prefer to go for slightly more depth than this particular one to get a sound surface, in addition to that particular one, because when we do the milling, it gives us a rough surface structure as well. So, this is another improvement that enhances the bonding. So, once we mill it into the sound surface to a certain depth, if you mill it, you normally get a rough surface as well.

Then, you apply the tack coat followed by whatever premix material that matches the existing one, which is laid and compacted to achieve the required density. So, this is what a usual practice is that is normally done. So, an important aspect is that we need to mill it slightly below this particular area where the surfaces have already slipped off, and then apply a proper tack coat followed by whatever premixed material is compatible with the existing surface. In the other common distress under the deformation category, there is some change in the shape of the pavement structure, which is rutting. It is a very common distress usually observed in bituminous pavements.

So, rutting is the formation of ruts specifically, and as we discussed, it happens mainly in the wheel path because of the excessive repetition of traffic loads. And in this particular case, if these ruts can accommodate water or water gets accumulated here, and it is not able to drain off with the help of the camber, then it worsens this particular damage. Under what situations, or what are the factors that contribute to the rutting? First, it is the pavement structures or materials that cannot withstand the stresses. So, we design these layers while considering a given strength. So, that particular strength, which has been taken for these materials during the design of the crest, if the materials are not meeting those strength requirements, then they get overstressed, causing densification or shear failure in the pavement layers.

So, in that particular case, you can see that the densification has some underlying layer. So, if this is a subgrade, is there a granular course on top of whatever layers these may be? There may be multiple layers, but here we can see that there is some densification that has happened in this particular layer. So, if the underlying layer is not properly compacted, this may happen. Or within a layer, you can also see this kind of failure, where shear failure occurs because the material does not have adequate strength to withstand the wheel load stresses. So, then it will show this kind of shear failure.

So, this will ultimately create ruts or depressions along the wheel paths. Here, this particular rut, which has happened due to inadequate compaction at the subgrade, will, in due course of time, be reflected on your top courses. So, the rutting that appears on the bituminous courses has a reason that lies at the subgrade level. So, this is an important aspect of rutting, which is visible on the surface. It is important to understand, and for that

particular one, you need to have trenches; you need to dig down some pits; you need to take the course and see where actually the rutting is happening.

So, one of the reasons is that if these layers are overstressed or the layers do not have adequate strength as considered during their design. Vehicle overloading, as we mentioned earlier, is also one factor contributing to fatigue cracking; when the axle loads or overloading factors considered during the design are exceeded, it can lead to the failure of the pavement section in the form of rutting. Inadequate pavement thickness and poor compaction of the layer will lead to densification. Excessive use of plastic filler and rounded aggregates in the basin is due to a restriction on how much plastic fines should be present, in terms of the plasticity index of the granular courses. If that is not followed, in addition to that particular one, rounded aggregates do not have a good interlock; the internal friction gets reduced, especially in the case of rounded aggregates, as they do not pack well.

So in that case, there are more chances that these materials will fail under vehicular loading. So, that is why we have a restriction on the shape of these aggregates to be used in our base courses and sub-base courses. We also have a requirement for the crust faces when riverbed materials are used. So, that needs to be properly ensured. Weak subgrade and poor surface drainage occur because all our pavement crust layers are resting entirely on the pavement subgrade.

So, if that is weak, and if it is weak or if it is saturated, and as we have discussed earlier, the subsurface drainage and the drainage layers that we provide over the subgrade in our granular courses play a very important role in removing any water that can enter from the surface cracks or from the sides as well. So, if that subsurface drainage layer is not provided or is not functioning, then the chances are that these granular materials lose their strength in the presence of water. So, then again, you can experience this kind of shear failure and ruts. And when the rutting is specifically in bituminous courses, it is because thick bituminous pavements are constructed nowadays. The thickness may vary from 20 to 25 centimeters in that particular case, 200 to 250 mm.

Therefore, when these thick asphalt pavements are present, they can also experience some rutting within the bituminous layers. The most likely cause of this rutting layer is excessive asphalt content, which can occur if, for any reason, we design it with a higher asphalt content. This may happen if we have considered a lower compactive effort during the design of the mixes, and in the field, the compaction is higher, or the loads that are coming up are higher. So, then that particular one gets compacted, and this bitumen, which has been considered for a lower compactive effort, will become excessive in that case, or due to a certain lack of control during the production of those mixes, the binder content has exceeded. So, it is an excess asphalt content that will lead to these kinds of shear failures. Higher filler contents, because these fines, specifically the ones that are considered in

bituminous mixes, are typically in the range of around 80 to 100 percent passing through 75 micron sieve sizes; that material plays a very important role.

We can reduce the air void content by increasing the amount of these materials without incorporating the binder, but then in that particular case, the mixes become stiff and there is not that good cohesiveness in the mix. So, the filler content, both a lower filler content and a high filler content, is challenging specifically, and there are particular sizes of fillers that have sizes less than 10 microns, which can act as a part of the binder extender as well. So, this is another concern. So, the filler contents have to be properly controlled because the fines collected in the hot mix plant through your secondary collectors, when reintroduced, need to be properly ensured so that they do not exceed the designed limit. Overuse of rounded particles is the same concern in the case of bituminous courses; we also ensured their angularity, as well as the angularity of fine and coarse aggregates, in terms of the combined flakiness and elongation index.

So, stripping in underlying HMA layers, what happens if water in the underlying layers has entered and your subsurface drainage is not working, is that the water rises up, capillary rises occur, and then it rises in the form of water vapor, and when the traffic load comes over it, a high amount of pore water pressure is generated, which starts inducing the stripping of the film of binder from your aggregates. So the mix starts losing its strength. So, typically it starts from the underlying base courses, bituminous base courses, which are in contact with your granular courses. The use of a softer grade of binder is another concern because, depending on the climatic regions, the maximum temperatures expected in a region, along with the vehicular loads, determine the selection of a binder grade. If we select a softer grade of binder, then the mix will also show this kind of deformation.

So, if this happens, as I mentioned, there are a number of causes that are present. So, one needs to work out which particular cause is there, which is that particular layer in which the rutting has taken place. So, this you can see in this particular picture here; in this one, the surface course thickness more or less remains the same, but you can see that the thickness of your base course, the bituminous base course, is adversely changing. So this shows that rutting is taking place in your bituminous base course. So that needs to be addressed; only putting up an overlay may not serve the purpose.

So that is why, by cutting down the trenches and taking the course, you can work it out and see if any stripping has taken place. So one important part, if you are able to figure it out, is that this has happened in your bituminous base courses, which now need to be removed and milled off. So, milling and replacing any rutted affected layer must be completely removed because it is already distressed; now it will not serve the purpose, and we need to put a more stable mix over it. Patching, if some localized ruts are present, can be filled with the premix patching material and compacted to the required density. But if this rutting has

happened in the subgrade, then that definitely indicates that this subgrade is overstressed and you have a weak pavement structure.

So, simply putting up thin overlays will not serve this purpose. So, in this particular case, you need to work out the exact requirements for the structural evaluation to determine the existing strength of the pavement structure, and then you have to design an overlay to meet the design traffic for this particular case. So, this is the overlay thickness that has to be designed considering the strength of the existing pavement structure. Now, the other kind of deformation that can occur is in the form of corrugation, where again, whatever forces come on the bituminous surface top surfacing usually exceed the shear strength. And if it is happening in the HMA, we say that the shear strength has exceeded the strength of your HMA mixes, or it has exceeded the strength of your underlying courses.

You can have this wavy-like structure or ridges formed over the surface, which are perpendicular; you can see these ridges that are formed and which are perpendicular to the direction of travel or to the direction of the shear forces. The causes are very similar to the causes we experience in the case of rutting. So, it happens mainly due to the shear flow of the mix when the applied forces exceed the shear strength of your material. Now, where can it happen? If it happens in the HMA mixture, typically the reasons are quite similar to those we have for rutting. Excessive binder content is present, and high percentages of fines or excessive filler are present.

Smooth or rounded aggregates are present. Improperly crushed aggregates, as we have, should have at least one fractured face or two fractured faces for this percentage of aggregates. The use of a soft or incorrect grade of binder is present. Inadequate compaction is present.

This is another concern that is present. So, if these layers are not compacted in a compacted way, their density is less and their strength is less. So, when traffic comes over it, you can experience this kind of shear failure. Another concern may be the inadequate rolling or rolling of a tender mix, specifically when rolling is not present; densification is not achieved, or it is unclear what is happening. A tender mix is usually a mix that is difficult to compact, which flows when you are compacting it at higher temperatures or when the long grade of binder is present; these mixes are tender and difficult to compact. So, then they can contribute these kinds of ridge-like structures, especially, and this can even happen at lower layers during the construction itself.

So, additionally, vehicle braking on gradients, especially near intersections, often accelerates their development. So, you can find these corrugations specifically when there is a downward gradient, and where there are some bus stops and intersections, where frequent applications of brakes or acceleration activities are happening. Now, what to do or what the conventional treatment practices are that are followed in the case of

corrugations is scarifying the surface because it already has a baby structure, and ridges are formed. So, it has already become distressed. So, that needs to be first removed, scarified, and the part of the underlying base also needs to be addressed to get an intact surface.

So it has to move. So, that at least to a certain depth of the intake and then laying a new surfacing load, because this will help us to get a good bond with the existing pavement surface. Alternatively, high spots can be milled or cut with a blade; we have drag spreaders there. So, they can spread the mix, and they can cut the surface; whatever ups there are can be cut down. And this can be done with heating; we will discuss these heating arrangements when we discuss the recycling of the asphalt pavements. So, the surface can be heated up, and these high spots can be cut down or milled and corrected with a leveling course, and then on top, we put a leveling course.

Another effective method is spreading a sand-bituminous premix. If this corrugation is not high enough, we can use a sand bituminous mix placed with a drag spreader, where it can cut the high spots simultaneously. In all cases, the treated area is finally compacted thoroughly by rolling to restore the surface. So, finally, it has to match the existing surface. For severe corrugations in the lower pavement layers, as I said, this can happen even during construction if, with the movement of the construction vehicles and many times during the construction itself, the traffic starts flying, causing these layers to become overstressed.

So, the corrugations may also happen during the phase of construction in certain layers. So, in that particular case, a structural evaluation is to be carried out. And then, followed by the reconstruction, the overlay thickness has to be worked out properly. And one important aspect is that if this is happening, corrugation is occurring during that particular evaluation exercise, and if it is found that the subsurface drainage is not adequate enough, is not serving its purpose, or is choked, then during this particular strengthening phase, it must be taken into account how the subsurface drainage can be improved in the existing pavement. Now, the other distress that comes under the category of deformation is shoving; you can see there is a shift in this mix that has occurred on the edges.

So, this is clearly visible by the pavement marking that is there. So, there is some mix that has shifted towards the edges, and some bulging has happened here; you can also form. So, this sort of distress can be experienced, especially at intersections where they are located, or where some bus stops or truck lay-bys are, where slow-moving traffic is present and frequent applications of brakes are made. So, shoving is a plastic deformation in the bituminous layer that causes surface bulging, usually at intersections, sharp curves, and where heavy vehicles frequently accelerate or stop. The reason is specifically that the mix is unstable; the shear stresses acting on the mix are quite heavy compared to its stability.

So, the mix phase, and again, if this shoving is present in the bituminous mixes, the possible reasons are excessive binder, excessive fines, rounded aggregates, or the use of a softer

binder in the surface or a bituminous-bound base course. So, these are some typical issues we can see in the case of a bituminous mix failure: one reason may be the excess of binder, a second reason may be the use of rounded aggregate particles, excessive fines, or a softer grade of binder. So, this reduces the stability of the mix, and then the mix may experience deformation in the form of rutting, shoving, or corrugations. Poor bonding between the layers may lead to slippage to a certain extent, and if the bond is not strong enough between the underlying layer and the top layer, the chances of shoving are greater. Heavy, slow-moving traffic, especially on curves and gradients, leads to these kinds of failures in the bituminous mixes.

So, this is one of the reasons why on horizontal curves or at gradients where frequent stops or accelerations are made, we can experience this kind of distress in the form of showing. What is the treatment, specifically, since this distressed part has to be removed? So, it has to be carefully identified which particular section has been affected by it. So, that needs to be clearly removed, and we will prefer that it is removed to particular depths, a slight depth in the underlying course, where you get a good stable base. And then we applied the tag code, followed by the application of that premix material and its compaction. Now, another form of deformation is shallow depressions; at certain locations, we can find some small localized depressions, usually around 25 mm or 30 mm in depth.

So, some localized depressions may be present at certain locations. So, there are specifically some localized stresses, and these are localized settlements in the underlying layers of the pavement structure. If the pavements are thick enough, it may also be in the bituminous layers. And the common reason for this particular issue is the inadequate compaction of the subgrade or insufficient densification of the subsequent pavement layers during construction. So, there are some localized points where weak materials or saturated layers are not properly compacted.

So, they are weak. Or the bituminous courses at certain locations are not compacted because we usually try to compact them to an air void content of 6 to 8 percent after rolling. So, if those air void contents are greater than that particular one, they get compacted. We can feel these small amounts of depression; localized depressions may happen. Over time, if the underlying layer is not properly compacted, it will not provide the required support, which will lead to subsidence, and this subsidence in any underlying layer will be reflected sooner on the top course. Over time, these weak spots lose their uniform support capacity, causing the pavement to gradually deform and form depressions on the top layer.

So, shallow depressions in asphalt pavements are typically repaired. We can correct them by filling the affected areas with a suitable premix material followed by thorough compaction, so that the surface matches the surrounding material. So, this is how it can be corrected. These are shallow depressions, but when there are major settlements or upheavals, you need to be more cautious about them because the reason may be that there

is some major distress happening, due to which you can see that a big settlement has taken place. So, these are large surface deformations compared to shallow depressions and usually indicate deeper structural deficiencies in the pavement system.

So, what can happen if large fields are present and a good amount of embankment construction has been involved, but it has not been done properly? Then again, this kind of large settlement may occur, especially near bridge abutments or where there are utility cuts, because those fields are done in large quantities and there is a chance they are not compacted properly. So, what can be another reason for excessive moisture in the subgrade and inadequate subsurface drainage? So, your subgrade is saturated, and the drainage through your subsurface layers is not proper. So, then this combination always leads to this kind of major settlements or upheavals. Now, because when the water freezes specifically in colder regions, you can find that when you have soils or granular materials with a higher amount of plastic fines that are not well compacted, upheavals are observed. So, if settlements or upheavals are observed, the defective fill material should be excavated; we need to go deep down to the layer where this is actually happening, and that needs to be removed and replaced.

If it goes deep down, we have to ensure that the subsurface drainage is not affected and that it is properly maintained. So, the material that has to be used during the backfilling of it should match the materials of the existing one so that this defect can be properly addressed. If inadequate pavement thickness is responsible, and if one determines that this issue is occurring because the thickness of the pavement crust is inadequate for the traffic, then a structural evaluation definitely has to be done to determine the desired overlay thickness. Now, the other category of distress, which is our disintegration, under which the most common kind of distress observed is stripping. As the term indicates, it is the removal of the binder from the aggregate surface.

So, this is when the bond between the aggregates and binder is lost, stripping takes place, and it can occur because once this bond is lost, the material loses its strength, and then you can experience the distresses in the form of cracks, also in the form of rutting, and also in the form of shoving, because the strength or stability of the mix is lost as the binder has stripped from the aggregate surface. So, when can it happen? One reason is poor drainage because when the aggregates come in contact with the water. So, from where can the inadequate surface drainage come? If proper camber is not there from the top, then the water can percolate and will be in contact with the top surface for a longer period of time. If some fine cracks are present, it can also ingress through those cracks. And if subsurface drainage is not good enough, then water will rise from this capillary water; it will fringe, the vapors will be there, and a good amount of pore water pressure will be created under the traffic.

So, that will lead to stripping again, which will mostly happen from the bottom of your bituminous courses because there is a greater chance of water from the underlying courses. Inadequate compaction of HMA, if it is not compacted, as I mentioned, we expect to have 6 to 8 percent of voids when it is compacted. But if it is compacted to an inadequate density, at 6 to 8 percent air voids, these voids are generally not interconnected. So, you do not expect water to enter it, but say the voids may be 12 or 13 percent. So, then the water enters into your HMA mat, and that leads to the stripping of your bituminous binder from your aggregates.

Another concern is when you are using these aggregates and if there is a good amount of dust coating present over them. So, at the HMA plant, if you find that the dust coating is higher over the coarse aggregates, you should first go for a wet sieve analysis, and then it may be necessary to sprinkle water over the aggregates to remove that dust film. So that you get a good coating of bituminous binder over your aggregates. So, that may create a hindrance between the bond of your bitumen and the aggregates, and the binder may develop a bond with the dust coating, which may be easily removed in the presence of water. Second is high residual moisture in aggregates during mixing, which can specifically occur in certain aggregates during rainfall events.

So, in that course of time, if there is still moisture in those aggregates during the production process, then there are more chances of stripping occurring. Overheating of the binder or aggregates specifically leads to the aging of your binder, and the binder that has aged forms a coating on the aggregates, which is more susceptible to stripping. Use of weak and friable or hydrophilic aggregates is the other category because when these aggregates are weak enough, they get broken up and then expose the surfaces where there are more chances of water entering. So, more chances of stripping take place when these new faces get opened up.

Continuous water contact with the coated aggregates. So, this may be present from the underlying water as well as from the top. So, whenever this occurs, we can understand that if the coating is not proper, it may be due to the presence of dust, or if the water reaches this surface, and in the presence of water, the binder film gets stripped off. So, that leads to this stripping distress. So, that is why it is always recommended to remove, mill the stripped bituminous mix, and replace it when we see these kinds of distress on the surface, because the stripped mix has already lost its strength.

So, it is no longer recommended to keep that particular mix. It is preferred that the particular one that has already been stripped should be milled up and a fresh one should be laid. And during the construction, it is always recommended to employ a suitable anti-stripping agent, because there may be many aggregates that are not good enough for this stripping resistance. So, in that particular case, we can preferably use an anti-stripping agent; quite a good number of liquid anti-stripping agents are popular. But, their doses are

again important because low doses may not serve the purpose, may not be effective, and if higher doses are used, it often leads to a reduction of the strength of the mixes.

So, the doses are to be carefully decided during the mix design. And another is a very popular anti-stripping agent that is preferred. So, during these mixes, which are used for treating the surfaces that have stripped, in that particular case, for those aggregates, lime can be used as an anti-stripping agent; it has been very effective. Rejuvenating sealants, and once they have been removed, we have observed some stripping as if it has happened to a lower severity. We can go with some slurry seal or micro surfacing over those stripped surfaces. And if we are experiencing a major challenge with the subsurface drainage, and the structure evaluation is carried out, and an overlay is decided, in that case, we will prefer this whenever we go for a dense HMA overlay or an existing pavement that is experiencing severe stress in the form of stripping.

We prefer to put a layer specifically that can serve as a drainage layer so that it can be protected. So, a drainage layer, which can be in the form of a geocomposite layer or an aggregate granular layer, needs to be provided. So that whatever water is already trapped inside the existing pavements goes through that particular drainage layer and does not affect your overlay again. Now, the other distress that comes under the category of disintegration is ravelling, specifically where the progressive loss of fine aggregate particles and binder takes place from the bituminous surface.

You can see here that it looks like fines have been lost along with the binder. So, again, what can be one reason? One reason can be the inadequate or improper filler bitumen ratio. If this is very high, the filler bitumen ratio means that you do not have good cohesion in your mix. So, if this is very weak, the stability is very low; stability may be a concern. So, that is why during a mix design, we try to keep the filler bitumen ratio in a particular range. Overheating or excessive aging of bitumen makes your binder harder, ages your binder more, and weakens the adhesion between your aggregates and binder.

The use of weak, highly absorptive, or easily fractured aggregates results in these aggregates breaking up, as they are highly absorptive. So, the effective binder film thickness is reduced. So, then also this raveling can be experienced. Harsh climatic conditions can occur if surface voids, slight surface deformations, and cracks are present, and under these rainfall events, some freezing occurs, which can lead to fracturing, breaking your fines, and specifically, it can lead to ravelling. And it can also happen if some construction activities have been undertaken in cold or wet weather conditions when the compaction is not done properly, which retains water on those surfaces.

Inadequate camber, because this is another concern, leads us to construct wider pavements; 6-lane and 8-lane pavements are constructed. So, if the camber is not proper, then the water remains on the surface for a longer duration as it moves towards the sides with the help of

the camber. So, in that case, with this longer exposure of water, these bituminous mixes can introduce stripping from the top, which may lead to raveling. Another concern is heavy stress, specifically when it is greater at certain turns or where some braking or acceleration actions are taking place. So, what is usually done if you experience this raveling, where there is some loss of fines and aggregate? The one commonly suggested is that if the severity is low enough, we can definitely proceed with a treatment of a fog seal, which is a low application of a low viscosity emulsion.

If we find that this severity is high, there is a loss of fines that are in a higher category. So, then we go specifically for an application of a slurry seal or micro surfacing. The details of this will be discussed in the upcoming lecture, and if high severity is present, then you may consider using a thin HMA overlay or work with higher thicknesses of your micro surfacing or slurry seal to treat the raveling. Then, once these stresses are exaggerated or of higher severity in certain cases, these pothole formations are also observed on bituminous pavements, which are specifically small holes that extend mainly through the HMA surfaces and can go up to your subbase or base courses specifically. Now, when this usually happens is when you have thin HMA overlays; this is a very frequent problem that we can see in MDRs or other categories of roads that have a thin HMA layer only to withstand the heavy traffic loads.

So, in that particular case, those layers experience cracks, and very frequently, they also experience these pothole formations. Now, when these thicknesses are less, crack formation may occur, and as we have seen, crack formation, fatigue cracking, longitudinal cracking, and transverse cracking are present. When these cracks are formed, water enters through them, which will soften the base and weaken the pavement structure. So, it will reflect that a greater amount of stress will be generated, and it will further break down.

So, the cracks become wider. And these cracked pieces may, in due course of time, be picked up because closely spaced cracks will form, and they will be picked up by tires. Along with this, since water has gone into the underlying layers, fines will start coming out, creating a loss of support from the underlying layers and ultimately initiating the formation of potholes. So, this is an accumulation of factors that take place, starting with small depressions and small cracks, and then ultimately leading to the formation of these potholes. Extended exposure to water of bituminous layers under traffic, primarily due to poor camber, surface depressions, higher voids compacted to a lower density, and reduced cohesion, can cause stripping, raveling, and ultimately aggravate your rutting and cracking, resulting in potholes. So, when you have this combination of factors, specifically if some cracks are there, ruts are there, depressions are there, and the water stands over this particular one, then stripping and raveling take place, water enters through your cracks, weakening your sub-base.

And then finally, a greater amount of deflection is carried out as the crack intensity increases, causing the pavement to break, and these cracked pieces may be picked up by the traffic, ultimately leading to the formation of potholes. What can be the suitable treatment? The important part is that whatever the affected area needs, it has to be carefully marked, and the material has to be removed. And, nowadays, we have a good amount of cold patching mixes; we also have certain readymade mixes that can be stored for a longer period of time. And, if the weather permits, we can go for the hot-mix asphalt as well. So, it needs to be properly prepared; the pothole needs to be properly prepared, and we also have suitable equipment to fill up these potholes with these patching mixes and cold mixes, and then it needs to be compacted to match the existing surface.

So, this is how pothole patching can be done. Now, the other distress that is usually observed in the term under disintegration is age breaking; you can see here that the pavement ages very frequently. We can see on many roads that the ages break up, specifically pavement ages break up in an irregular manner. One reason behind it is that these edges are more exposed to water. So, there is infiltration of water from the pavement edges or sides. So, if the side slopes are not good enough, water will enter the pavement crust from the sides, and this will weaken the support.

So, infiltration of water from the pavement edges or sides weakens the foundation layers and causes the support from underneath the edges to be reduced because of the presence of water. Worn-out shoulders provide good support to your pavement edges, but if the shoulders are not properly maintained, then in that particular case, the side support is lost, which can further aggravate this particular problem. So, inadequate compaction is usually due to the problem whenever the edges are compacted, because the lack of confinement at the edges leads to a lower density of the edges. The material on the edges, most of the time, if proper measures are not taken, gets compacted to lower densities compared to the middle part of your carriageway.

So, this again leads to these edges breaking. And many times, when the pavement width is not sufficient, the wheels fly over the pavement edges, which are also not protected by the shoulders, causing these edges to get broken up. So, narrow pavement widths where the overall width of the pavement is insufficient to withstand the traffic stresses also contribute to edge failures. How can we rectify this particular one? We need to remove the edge as well as the shoulder materials where we observe this kind of distress, and they are removed to a particular depth where you get a sound base in that case. And then we need to reconstruct both the pavement at the edge parts and the shoulders, which need to be rebuilt simultaneously, ensuring thorough compaction throughout. So, it needs to be taken up in layers because if it has gone deep or for whatever thickness of bituminous it has gone down, that has to be milled up, and then the construction of the subgrade and this particular one, your carriageway, has to be taken up simultaneously.

A new bituminous surface matching the adjacent stretch is then laid. The shoulder should be constructed with an adequate slope. This is an important aspect again. Usually, whatever earthen shoulders are there typically have a camber that is around 1 percent more than the camber on your carriageway. So that the water can be quickly removed, and the material must be properly handled according to the required guidelines, the shoulder materials.

It should not be that the shoulder materials are of inferior quality. So, in that particular case, they will hold the water there. So, we need to have a proper camber and a properly designed shoulder material so that water is quickly removed from the pavement on these shoulders. If it stands there, the shoulders again will enter into your edges near the pavement edges, and again the edges may get weakened. So, to avoid the recurrence of age failures, regular maintenance is essential because if it is open land, open trenches are fine enough; if it is in urban sections, the side drains need to be regularly monitored and cleaned. So, it requires including periodic inspections of shoulder conditions and timely replacements because these shoulders, with the movement of the vehicle tires in case of emergencies, may get distressed, so they require regular maintenance as well, in order to protect the edges.

So, this is all about some of the common distresses, their possible causes, and the treatments that can be used for this particular one. As I mentioned, it is always important to carefully work out the possible causes of any kind of distress that has taken place through various investigations, and we already have a list of causes that can be present for a particular distress. So, on the basis of that experience, the different causes can be worked out, understood, and then from the possible treatments that have been done for those particular distress, one can be picked considering the actual field situation. So, this is all for today. Thank you so much.