Introduction to Transportation Engineering
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Lecture - 41
Overlay Design - IRC Method

Hello viewers, welcome to lesson 2 of module V. module V is on pavement evaluation and rehabilitation. In the previous lesson that was lesson 5.1 we discussed about the need for rehabilitation and various techniques that can be adopted for functional and structural evaluation of pavements. In this lesson we will be discussing about designing overlays for existing pavements using Indian Roads Congress method that is IRC: 81 – 1997 version.

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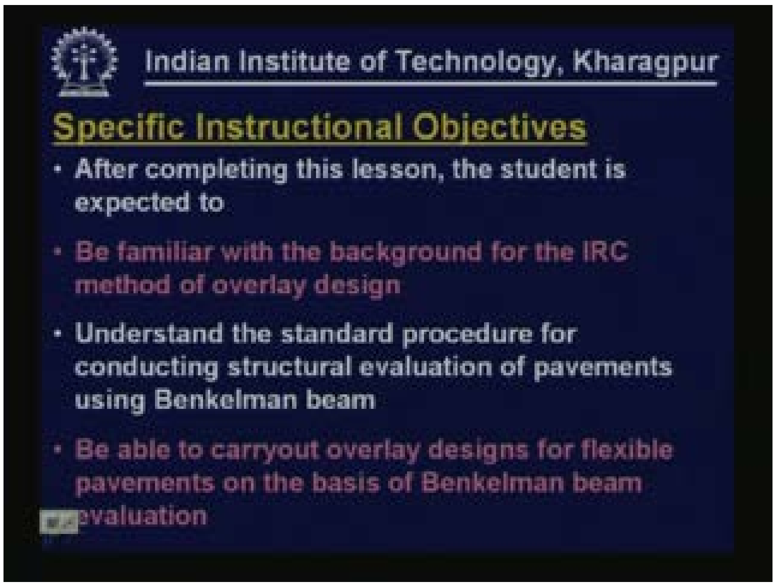

The specific objectives of this instruction will be after completing this lesson it is expected that the student would be familiar with the background for the IRC method of overlay design. it is also expected that the student would understand the standard procedure to be adopted for conducting structural evaluation of pavements using Benkelman beam because IRC: 81 – 1997 version is based on the structural evaluation of pavements using Benkelman beam evaluation technique. it is also expected that the students would be able to carry out overlay designs for flexible pavements on the basis of Benkelman beam evaluation.

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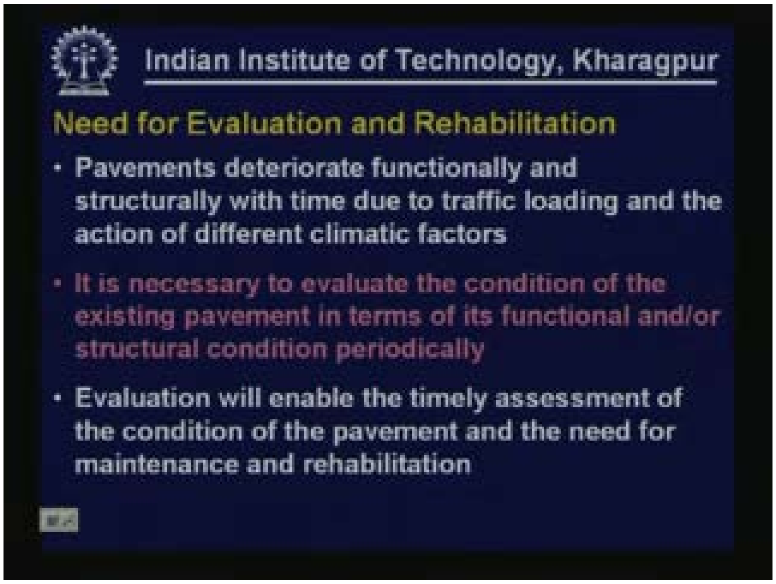

We have briefly discussed about the need for evaluating pavements in the previous lesson 5.1. We know that once constructed pavements gradually deteriorate in terms of its functionality and also in terms of its structural condition. The structural strength also gets reduced, there will be cracks, there will be deformation, there will be deterioration of materials in various forms resulting into reduced structural soundness of the structure.

The functional performance also gets deteriorated because of the surface distresses so the riding comfort, safety and other aspects that are important to the road users will also be affected thereby the functional performance gets reduced and simultaneously the structural performance also gets reduced. We are concerned about these two aspects. So to improve the structural conditions what is to be done, how to assess the requirement, how to assess the present condition are the things we are going to discuss. This discussion will be based on the guidelines that are provided in the Indian Roads Congress guidelines.

So as I have just mentioned pavements deteriorate functionally and structurally with time, this is because of application of traffic loads and also due to the action of different climatic factors like action of moisture, action of temperature and other parameters.

It is necessary to evaluate the condition of the existing pavement in terms of its functional and or structural condition periodically. Some agencies carry out only the function evaluation, some agencies carried only the structural evaluation but there are agencies which carry out that carry out both the functional evaluation and structural evaluation and evaluate the pavement in terms of its capability provide proper functional performance and also proper structural performance.

The evaluation will enable the timely assessment of the condition of the pavement at any given point of time like what is the condition of the pavement in terms of its functional performance and in terms of its structural performance and on that basis one would be able to assess what is the requirement if any and what is to be done to improve the condition of the pavement.

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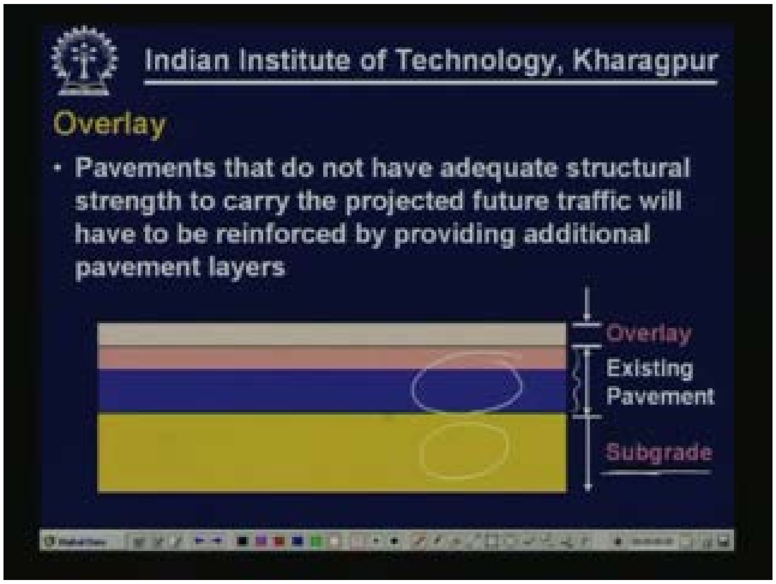

Overlay is that reinforcing layer that we provide over an existing pavement. That is because pavements that do not have adequate structural strength to carry the projected future traffic will have to be reinforced by providing additional pavement layer.

Normally there will be situations where we are trying to assess a given facility in terms of its ability to carry traffic satisfactorily or to serve satisfactorily for the next five years, ten years, fifteen years period. So if you can take into account all the traffic that has to be served over the next ten years design life period so we have to make an assessment in terms of its structural strength it has got at present whether it is capable of serving the projected traffic that is going to be there over the next ten years satisfactorily.

The pavements that do not have adequate structural strength will have to be reinforced by providing additional pavement layers. As you can see from this diagram (Refer Slide Time: 6:08) we have an existing pavement placed over a subgrade of given strength. It consists of two layers, it can be three layers or four layers also. So if you can assess what is the strength of these two layers placed over the subgrade then we can assess if we have a criteria which tells us what is the strength that is required to carry a given number of traffic loads satisfactorily. An important thing is we need to have a criteria which will tell us whether the existing strength is adequate or not and if it has to carry more traffic what should be the initial strength that criteria is very important. So we need to have a performance criteria which correlates the initial strength in terms of the parameters that we are using to evaluate the existing strength and its ability to carry further traffic.

So once we are able to assess the condition of the existing pavement and also in terms of the subgrade strength then using the criteria we can assess whether this pavement is capable of carrying more loads or not and we can also assess how many more loads it can carry so this is what we call as remaining life. And on the basis of assessing the remaining life of the pavement we can calculate the requirement for additional reinforcing layer as depicted here. So in this case the need for reinforcing was felt so the overlay that is provided is depicted here.

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The guidelines that we are going to discuss here are as per Indian Roads Congress: 81 and its 1997 version. These are guidelines for strengthening of flexible road pavements using Benkelman beam deflection technique, this is the title of the guidelines.

Guidelines for strengthening of flexible road pavements means we are referring to flexible roads, flexible pavements and these guidelines are meant for Benkelman beam deflection technique. The first version was in 1981 and the first revision what we are discussing is the 1997 revision. These guidelines are based extensively on the basis of the findings of MORTH Ministry of Road Transport and Highways, Government of India, a sponsored research project which has got the code R6 which was entitled "Development of Methods such as Benkelman Beam Deflection method for Evaluation of Structural Capacity of Existing Pavements and also for Strengthening of any Weak Pavement" this was the main objective of the research scheme, it was to develop Benkelman beam and other similar methods for evaluation of structural capacity of existing pavements. So the methodology is for evaluation of structural capacity of in service pavements and also for finding out the strengthening requirements of any weak pavements.

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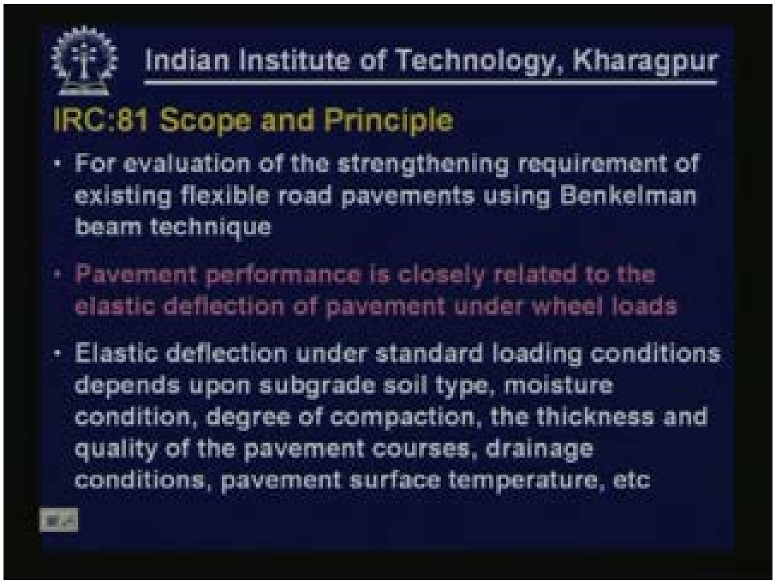

The scope of these guidelines: these are meant for evaluation of the strengthening requirement of existing flexible road pavements using Benkelman beam technique. So this is meant for flexible road pavements and is also meant for Benkelman beam pavement evaluation technique.

The pavement performance is closely related to the elastic deflection. It is believed that pavement performance is closely related to the elastic deflection that the pavement undergoes when it is subjected to a standard load.

Elastic deformation under standard loading conditions depends on various parameters such as the condition of the subgrade, its moisture content, degree of compaction and the condition of various other layers including granule layers, bituminous layers and also it depends upon various climatic conditions like temperature, position of drainage, thickness of various layers, quality of different materials and so on. So all the pavement related parameters affect the elastic deformation of a pavement when it is subjected to wheel loads.

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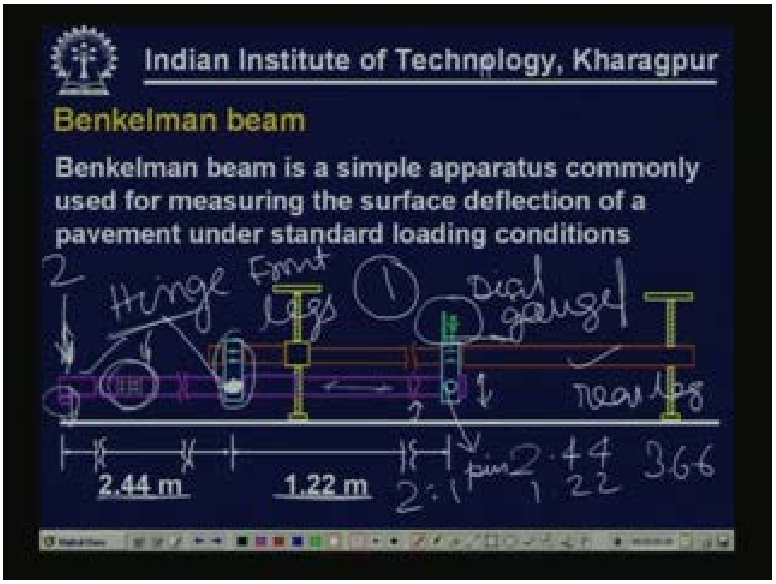

Benkelman beam is a very simple apparatus and it is commonly used for measuring the surface deflection of a pavement under standard loading conditions. A schematic arrangement of the Benkelman beam is shown here. This is the Benkelman beam (Refer Slide Time: 11:11). It is cut at several places because its full length cannot be shown in sketch. This is the probe point which would be resting on a pavement surface at a point at which we are trying to measure the deflection.

As you can see here since it is very long its extended portion is connected here by nuts and bolts so it can be dismantled and then for ease of carrying and other convenience it can be carried in two different parts but when we actually use it for deflection measurement we will connect them together so the full length of the beam is going to be attained.

The practical length of the beam that we are going to utilize is 2.44 + 1.22 that is 3.66 m. As you can see here from the probe point as I said that is the point at which we are going to measure the deflection of the pavement to a hinge so the beam is hinged here (Refer Slide Time: 12:22) and this is where we are measuring the deflection. We are using a dial gauge here so the movement of the end of this beam is measured with the help of this dial gauge and the probe of this dial gauge will be resting over the beam so as the beam moves up and down with reference to the upward and downward movement of the probe which is placed on the pavement surface as the pavement surface deflects and rebounds so the probe point also goes down and goes up, the corresponding end point also will go up and go down and that can be recorded with the help of this dial gauge which is positioned here. So what we are basically interested at is in the movement of this beam rather the movement of the end points pivoted and while the beam is pivoted about this hinge.

As you can see the distance from the probe point to the hinge is 2.44 m and from the hinge to the point at which you are measuring the deflection is about 1.22 m, you can see the ratio is 2:1. Therefore if the actual deflection of the pavement or actual movement of the probe is say about 2 mm the deflection that would be measured by the dial gauge will be 1 mm. So this beam is supported by a support frame with one rear leg, there is one leg here and there are two front legs here. so with the help of these three legs the support frame will be supported and the beam will be supported with the help of this arrangement here and it is hinged about this location.

In its normal condition during transport it will be connected to the main supporting frame with the help of a connecting pin here. But when we are going to measure the deflections we will remove this pin and allow this probe to rest on the pavement surface so that it can be freely rotating about this hinge point. So what we basically have here is three supporting legs, one supporting frame which supports the beam about this hinge point and the beam will rotate about this hinge. So as the pavement goes up and down at the probe point the corresponding end point will also will move accordingly which can be recorded using the dial gauge.

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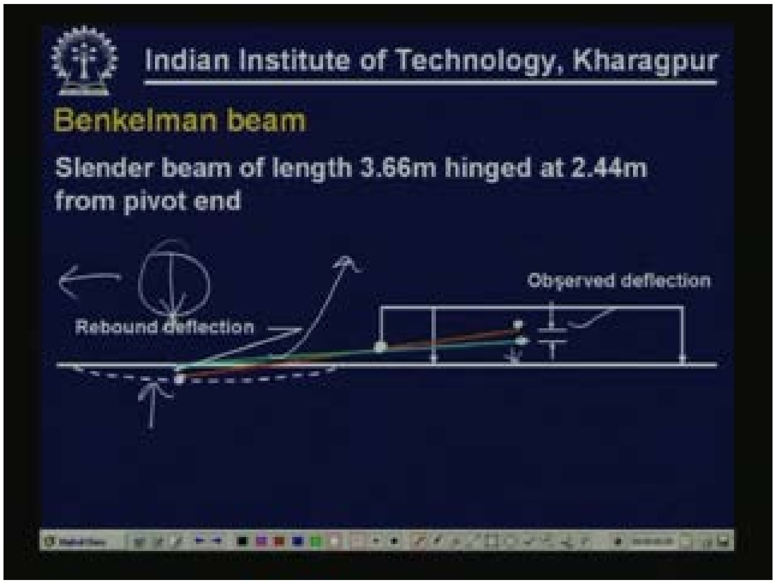

The principle is illustrated here:
This is a very slender beam very narrow beam and the total length as I mentioned is 3.66 m it is hinged at a distance of 2.44 from the pivot end. So initially what is done is a load is applied here and in its deflected condition the probe point of the beam rests on the pavement surface this is the corresponding position of the end of the beam which is rotating about this hinge so this deflection can be absorbed this portion of the beam can be absorbed using a dial gauge and when this load is removed this pavement surface rebounds and this would be positioned of the beam corresponding to the rebounded portion of the pavement surface so the end point will come down so this position will be recorded using the dial gauge so the absolute difference gives us an indication of what is the rebound deflection of the pavement.

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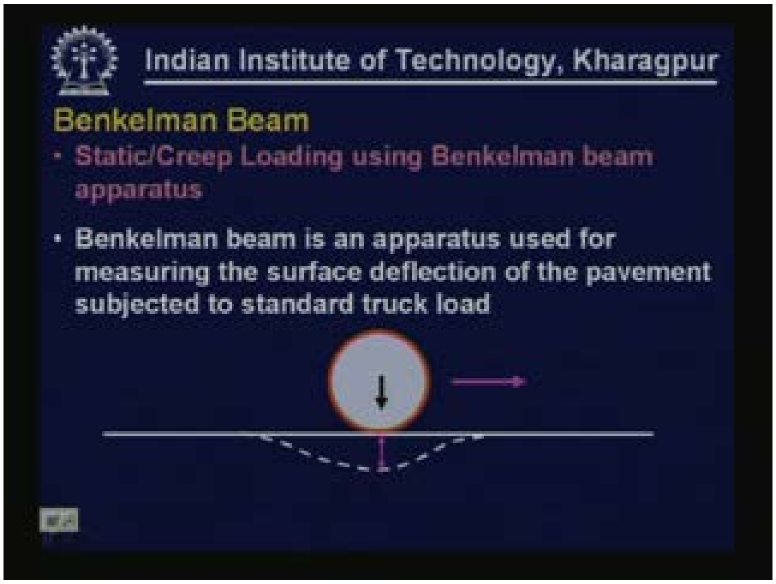

Using a Benkelman beam for measuring the deflections the load that is applied is either static or creep loading. As we have just discussed Benkelman beam is an apparatus used for measuring the surface deflection of the pavement subjected to standard truck load. What is important here is we are using load that is very similar to the load that is being applied on actual pavement surfaces although we are standardizing the load we are not going to apply any magnitude of load that is going to be there on the pavement surface but we are going to standardize this load as to how much load has to be applied that is the standard load which is applied through a truck.

As you can see here (Refer Slide Time: 00:17:42) what we want to measure here is either the maximum deflection when the load is applied or the maximum rebound deflection when the load is removed.

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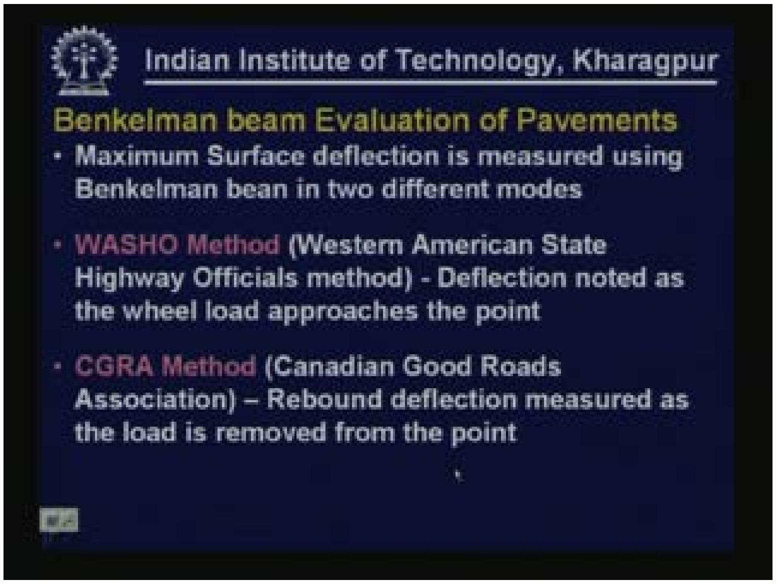

Maximum surface deflection is measured using Benkelman beam in two different modes. As per a WASHO procedure Western American State Highway Officials method the deflection is noted as the wheel load approaches the point. so the probe is kept on the pavement surface, wheel load gradually approaches the point so when the wheel load is directly above the point we see the maximum deflection that deflection is absorbed, that is what is absorbed in the case of a WASHO procedure. But if you are adopting Canadian Good Roads Association CGRA procedure the method of absorbing the deflection is slightly different. What to do here is we absorb the rebound deflection, it is measured as the load is removed from the point.

Initially the pavement will be subjected to the load. Then we know what is the reading corresponding to the deflected position of the load. When the load is removed away from the point the pavement rebounds, we will see the reading again and the difference should give us the rebound deflection. That is what we measure in the case of CGRA evaluation procedure.

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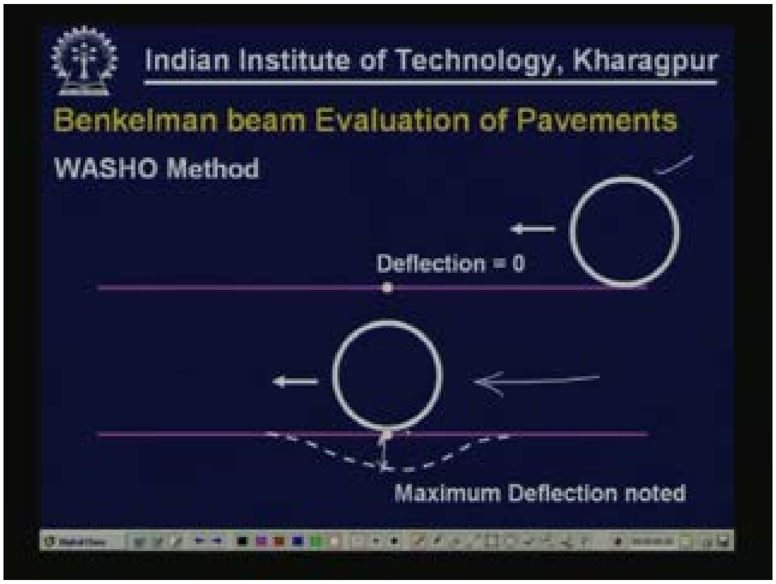

The WASHO method of measuring deflection using a Benkelman beam is depicted here. In this case initially the load is away, the probe point of the beam is kept here so we measure the corresponding deflection, so as the wheel load gradually moves forward and is directly above the point that is when we are expected to get the maximum deflection so we closely monitor the reading in the dial gauge. So when it is directly above the point that is the deflection we note in the case of a WASHO procedure.

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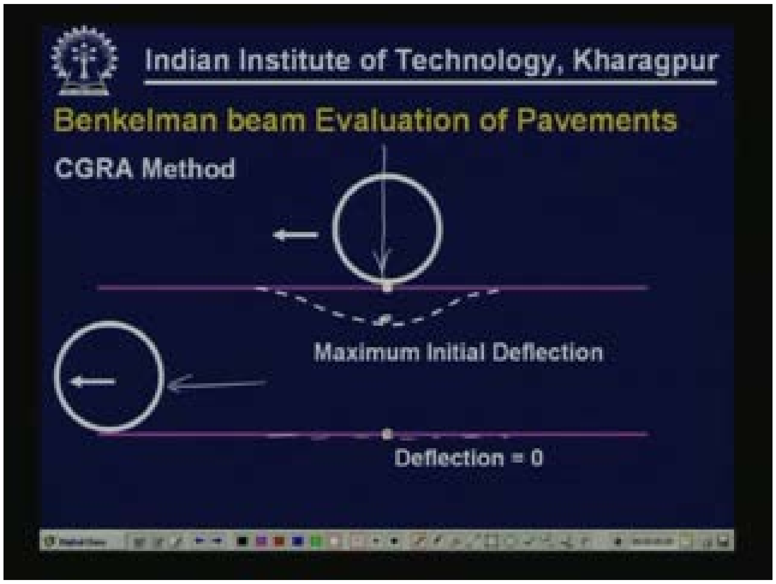

On the other hand, in CGRA procedure initially the load is directly above the point at which we are trying to measure the deflection so the probe point will be here so the dial gauge reading corresponds to the coefficient of the probe point corresponding to the deflected shape. When this load is removed away from the point the pavement surface rebounds and the corresponding absorption of the dial gauge is also made. So what we get here is the rebound deflection.

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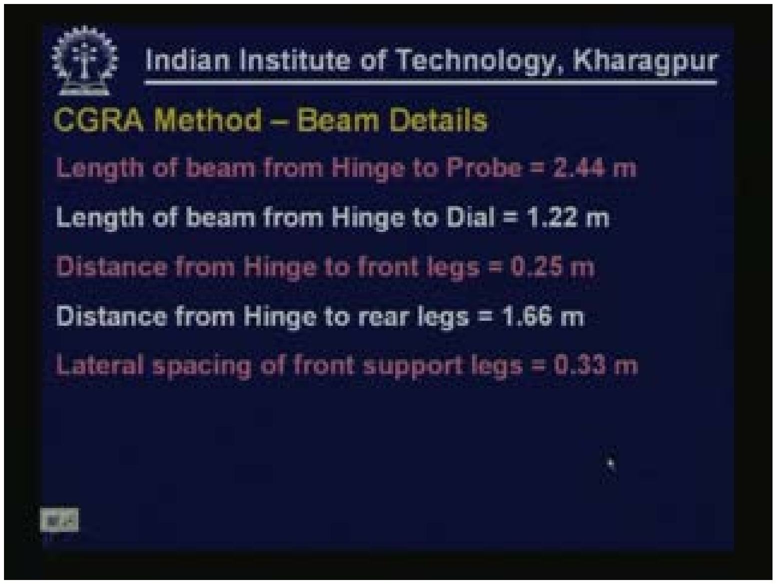

Indian Roads Congress: 81 guidelines suggest that we have to adopt CGRA procedure. One can also adopt WASHO procedure but the criteria that we adopt has to be corresponding to the pavement evaluation technique that we are adopting. If you are using CGRA procedure the corresponding criteria has to be there in terms of the deflection that we measure. If it is a WASHO procedure the deflection that we measure can be slightly different so the criteria also has to be different. So the criteria that is available for us is on the basis of CGRA evaluation of pavements.

The salient features of the beam are:

- The length of the beam from hinge to probe point is 2.44 m
- The length of the beam from hinge to dial is 1.22 m
- The distance from the hinge to the front legs is 0.25 m
- The distance from the hinge to the rear legs is 1.66 m
- The lateral spacing of the front legs the spacing between the two front legs is about 0.33 m

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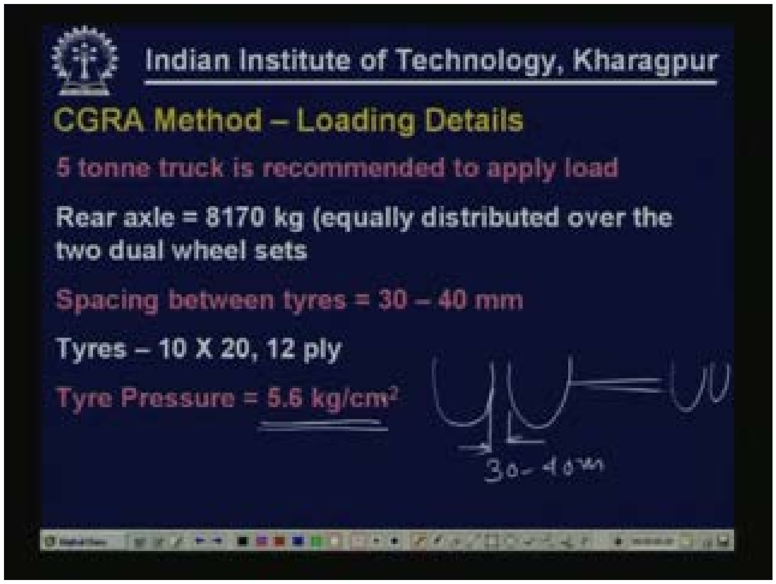

The loading that has to be applied is we have to use a 5 ton truck this is a standard truck so this is to be used to apply the load. What is important is the rear axle of the truck has to weigh 8170 kg. If you recollect this is the load that corresponds to standard axle load 18000 pounds or approximately equal to 80 kilo Newton rear axle.

This load has to be equally distributed over the two wheel sets. The standard truck that we are going to consider will have two dual wheel sets on either side so each one of these dual wheel sets will have to 8170 by two wheel load approximately. The clear spacing between the tires the dual wheel sets that we are going to use will have to be 30 to 40 mm and standard tires are to be used 10 by 20, 12 ply, the tire pressure is again very important 5.6 kg per cm square or 80 psi tire pressure has to be maintained.

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The other accessories we need to have besides the Benkelman beam are the gauge for measuring the pressure because we said that the tire pressure is very important in the entire exercise so we have to keep monitoring the tire pressure that the tires have. If they deviate from 5.6 so we have to again adjust that. We also need to have a temperature measuring instrument especially thermometers which are capable of measuring temperatures in the range of 0 to 100 degree centigrade because we have to measure the pavement temperature because in the case of bitumen surfaces the deflections get affected by the temperature of the pavement. So these deflections have to be standardized to correspond to a standard temperature so we should know what is the temperature at the time of measuring the deflections and for that we need to have thermometer.

We also need to have a small mandrel using which we can drill a hole into the pavement and into the hole we can put some glycerol and then we can put the thermometer to measure the temperature. So we have to have all this arrangement to put a small hole in the pavement temperature which is 4.5cm deep and put glycerol and then put the thermometer there and we should be able to measure the temperature of the pavement periodically.

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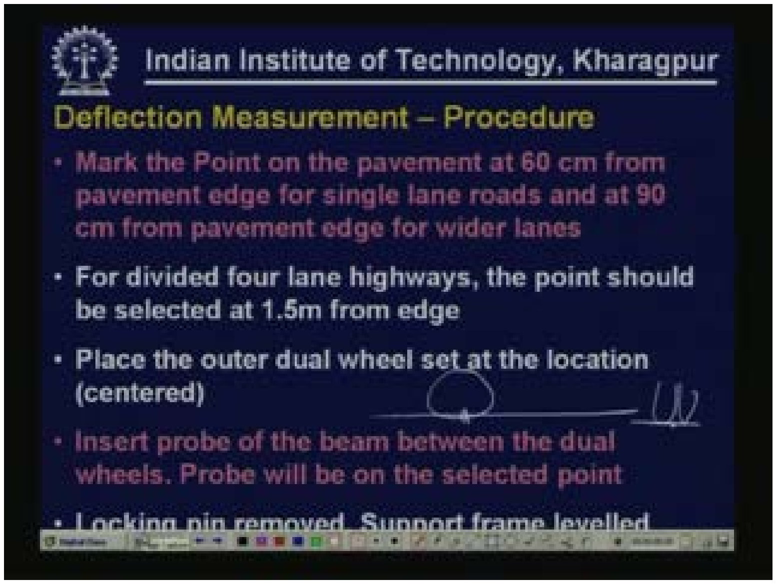

The procedure that has to be followed for measuring deflections using Benkelman beam is like this. The first thing that we were to do is mark the point on the pavement surface this has to be selected at a distance of 60cm from the pavement edge as per the guidelines given in IRC: 81 this is for single lane roads. So if you have single lane roads we assume that the wheel path is approximately at a distance of 60cm from the pavement edge so that is the path along which we are going to measure the deflections also. So for single lane road the points will be selected at a distance of 60cm from the pavement edge.

On the other hand, if you are using wider lanes then the wheel path can be considered to be at a distance of about 90cm from the pavement edge.

For divided 4-lane highways these are divided highways 4-lanes that means in each direction you have 2-lanes. In such cases the wheel path can be considered to be at a distance of 1.5 m from the pavement edge and that is the path along which we are going to measure the deflections. We have to place the outer dual wheel of the truck at the location so we have to center the outer wheel load. If this is the point (Refer Slide Time: 25:55) at which you want to measure the deflection so the outer dual wheel load will have to directly positioned about this point.

The probe of the beam has to be inserted between the dual wheels. The probe will be directly resting on the selected point.

The locking pin as shown in the previous diagram will be removed so that the beam is free to rotate about the hinge.

The support frame has to be leveled.

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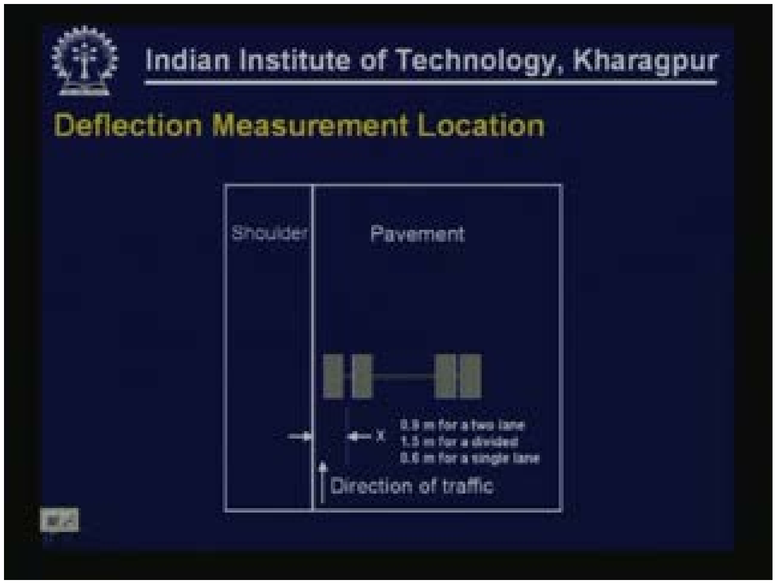

This sketch here shows how to select the location of the points for measuring the deflections. From the pavement edge it is 0.6 m, 0.9 m, 1.5 m for different types of facilities.

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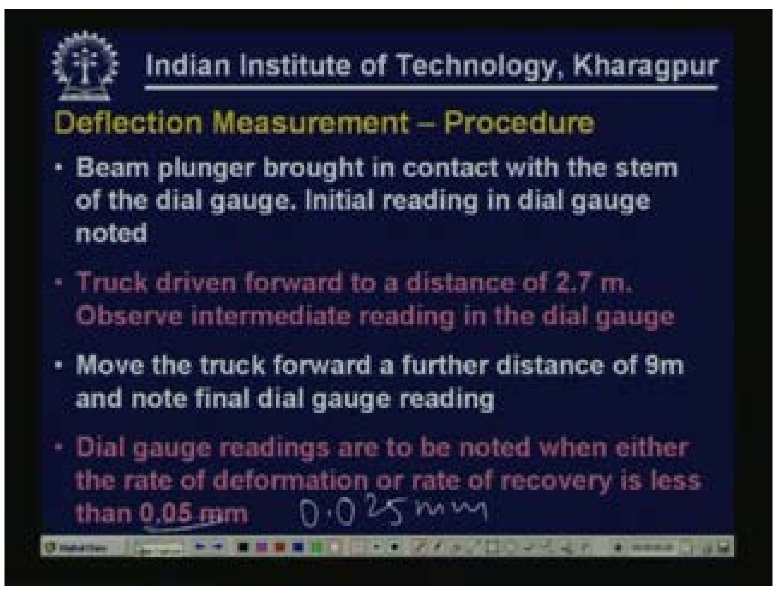

The beam plunger has to be brought in contact with the stem of the dial gauge. Beam plunger is the arrangement that we have at the end of the beam above which the plunger of the dial gauge will be resting. So as the beam rotates in this direction the plunger of the beam will be supporting the plunger of the dial gauge.

Initial reading in the dial gauge will be noted. as you understand load is already placed on the point, the probe of the beam is placed between the wheel loads so it is the initial deflected portion and the corresponding position of the end of the beam we are noting using a dial gauge because the pavement is already loaded it has already taken a deflected shape so the probe point is on the deflected shape, the end point goes up so that is what we are observing using the dial gauge.

Then we move the truck forward to a distance of 2.7 m from the initial point. Then we observe what is known as initial intermediate reading in the dial gauge. So as the wheel load moves away the pavement rebounds, the end of the beam comes down and that position will be noted by the dial gauge reading.

The truck wheel will then be asked to move away by a further distance of 9 m so starting from initial point of 0 the next position of the rear wheel road will be 2.7 m and the next position will be after the wheel load is moved by a further distance of nine meters. For this position if there is any change in the dial gauge reading we will note that as final dial gauge reading.

So there are three portions of the wheel loads such as wheel load directly over the point initial reading, wheel load placed at a distance of two point seven intermediate reading, and wheel load moved by a further distance of 9 m final reading in the dial gauge. These are the three readings that we are going to note down.

We have to note down these dial gauge readings when either the rate of deformation or the rate of recovery is less than .025 mm. So in its deformed condition the rate of recovery has to be less than this so either the rate of deformation or rate of recovery has to be less than this.

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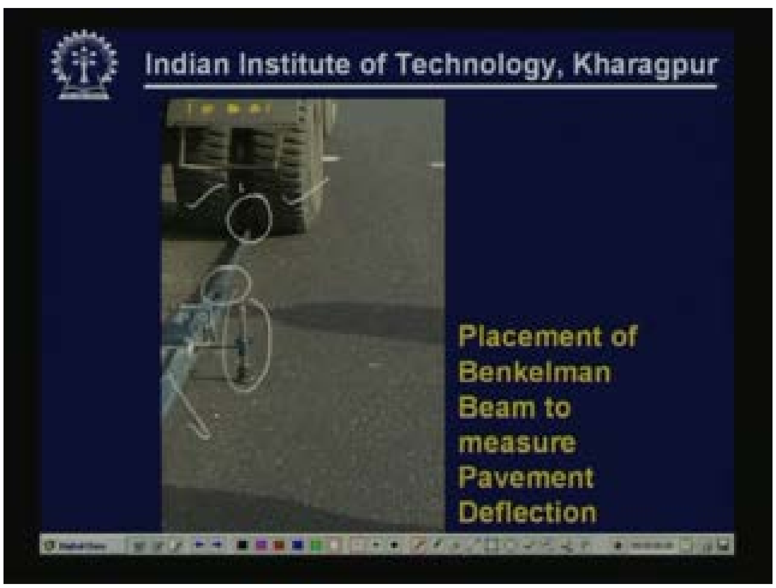

A photograph here shows the dual wheel set of the outer wheel with the probe point of the beam is inserted between the two dual wheels. You may not able to see it very clearly because it is on the shadow. These are the two front legs other leg you cannot see and this is the extension arrangement that we have and this is the support frame of the beam.

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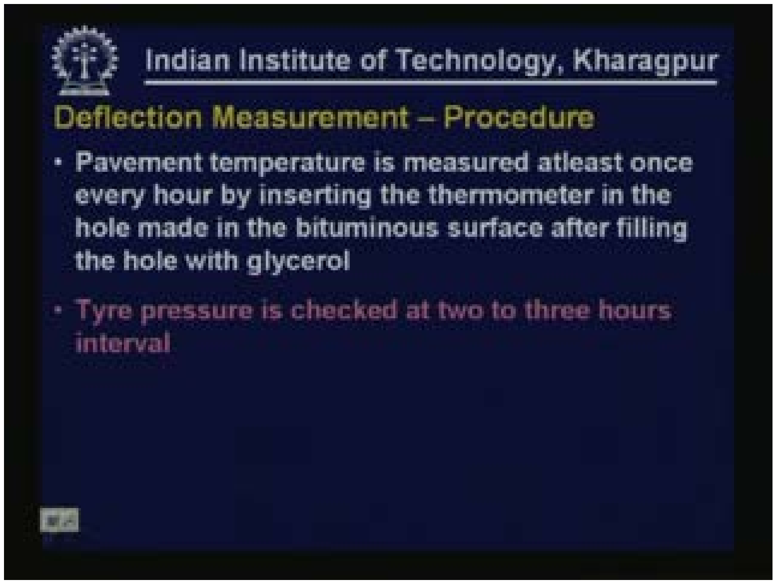

While carrying out the deflection survey we also have to measure the pavement temperature at least once every one hour by inserting the thermometer in the hole made in a bituminous surface and after filling the hole with glycerol. Hence we have to measure the pavement temperature at one hour interval. Tire pressure is also checked at two to three hours intervals and if it is not 5.6 kg per centimeter square we will have to adjust them.

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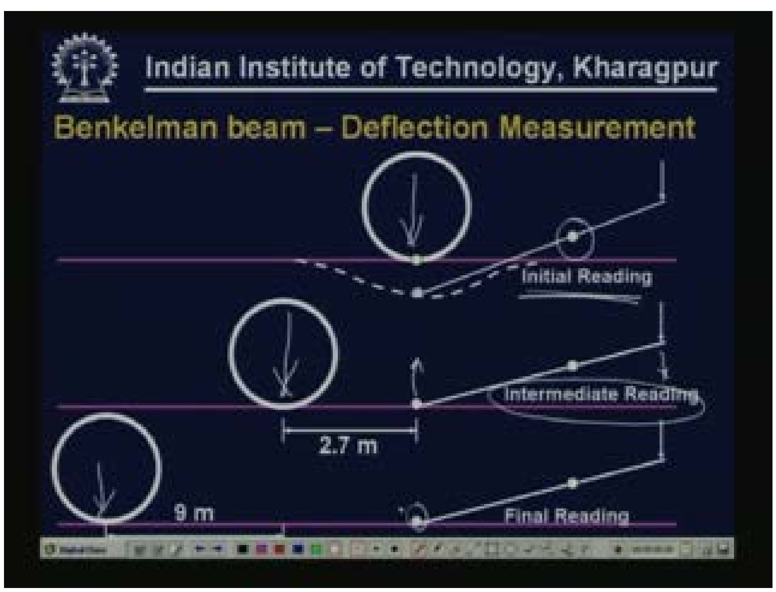

With three positions of the wheel load and the corresponding measurements that we take are represented here. In the topmost sketch we have here the wheel load is directly placed over the point and the probe point is at the bottom of the deflected wall, it is rotating about this hinge and this is the position of the end of the beam for this loading position so we get the initial reading.

When the load is moved to a distance of 2.7 m it rebounds. It may or may not fully rebound so it rebounds like this (Refer Slide Time: 31:47) so the corresponding intermediate reading is noted. In the final position the load is moved by a further distance of 9 m. In this position it can be expected that the probe point fully rebounds the pavement fully rebounds and the corresponding dial gauge reading is noted as the final reading.

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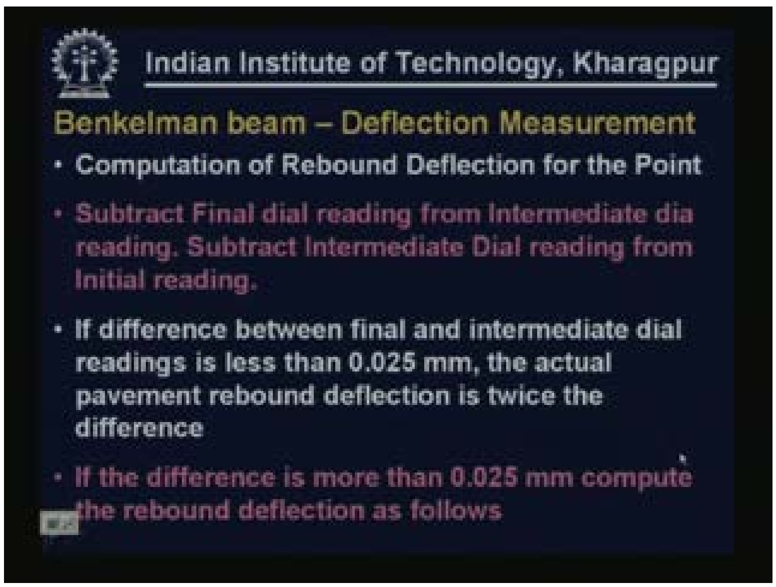

For a given stretch of may be 1 km, 2 km, 10 km we will be making number of deflection measurements. It is not just that we measure this deflection at one point and then design the overlay on the basis of that. We have to select a sample of points at which we are going to measure the deflections and on the basis of all the deflections that we measure at all these points we will work out a characteristic deflection which is representative of the entire pavement stretch under consideration and we will use that characteristic deflection for design and assessing the condition of the pavement.

At a given point how we calculate the rebound deflection is we subtract the final dial reading from the intermediate dial reading we also subtract the intermediate dial reading from the initial reading. If the difference between the final and the intermediate dial readings is less than 0.025 mm we should normally expect that the difference should be negligible because when the load is moved to a distance of 2.7 we should expect the pavement should have fully recovered, rebounded and when the load is moved to a further 9 m distance there should not be any further rebound that's the normal expectation. But it is quite possible that when the load is at 2.7 the pavement has not fully recovered it is still influenced where the load placed at 2.7 m distance and when the load is further moved to a 9 m distance that's the distance which is significantly large so that position should not have any influence on this point so that's the position we consider that the pavement has fully rebounded.

If the difference between the intermediate reading and the final reading is more than .025 mm we have to make some corrections to the deflection that we get. If the difference is more than 0.025 mm compute the rebound deflections as follows.

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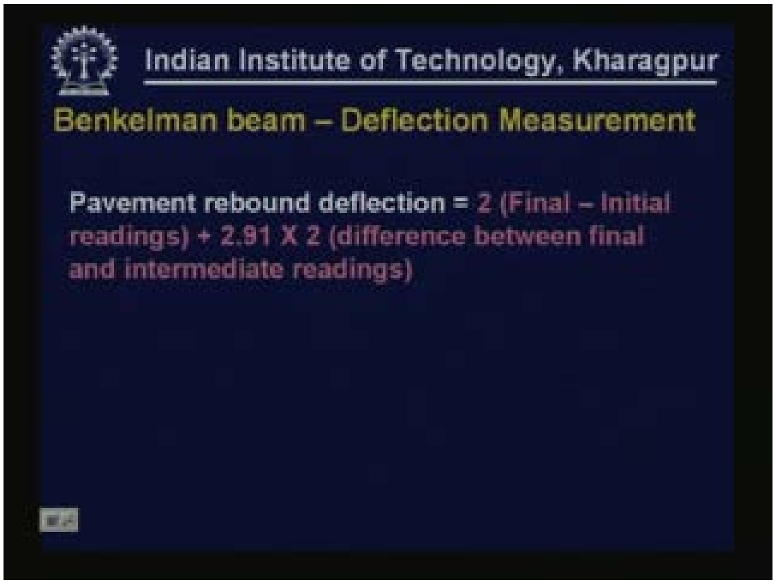

Pavement rebound deflection is twice this is when the intermediate and final readings differ by more than 0.025 mm. Pavement rebound deflection is given as twice final minus intermediate readings plus 2.91 times twice the difference between final and intermediate readings. This is when the intermediate and final readings differ from each other by more than 0.025 mm. If the difference is less the pavement rebound deflection is equal to twice final minus initial reading.

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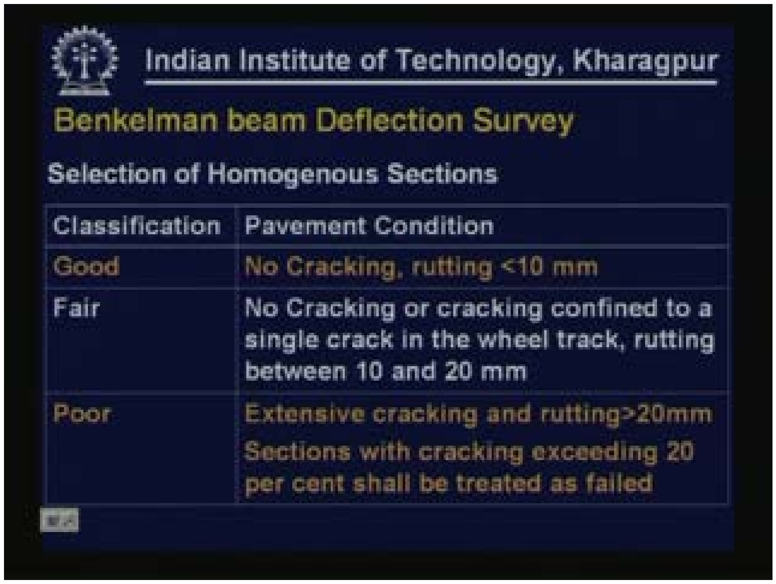

As I said we may have to be conducting Benkelman beam evaluation survey for let's say hundred kilometers and we cannot give one single value representing all the 100 km stretch so what we have to do is this complete stretch will have to be divided into smaller stretches having uniform characteristics it can be 1 km, 2 km stretches each 1, 2 or 3 km stretch will have to have uniform characteristics either in terms of the materials used, in terms of traffic pattern, in terms of the subgrade condition or especially in terms of the distress condition that we absorb on the pavement surface. So we have to identify, we have to initially conduct some visual examination and also carry out a few physical measurements to find out what is the present distress condition and on the basis of that classify that into different types of pavement stretches so each pavement stretch will be handled differently.

So, for selecting homogenous sections uniform sections the pavements will have to be classified in terms of good, fair and poor sections represented by pavement condition of good being no cracking, rutting less than 10 mm average, fair being no cracking or cracking confined to only single crack in the wheel track rutting in the range between 10 to 20 mm. It can also be classified as very poor if extensive cracking is absorbed and rutting is more than 20 mm. And sections with cracking exceeding 20% shall be treated as failed.

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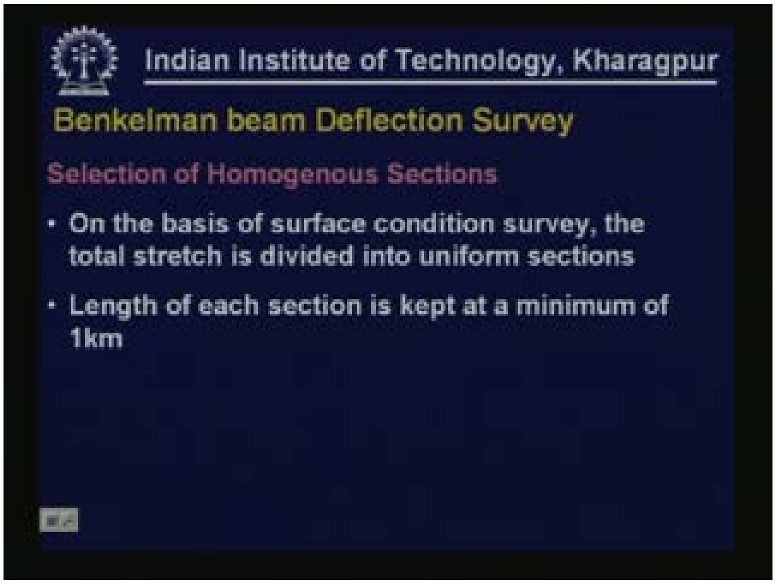

So we can classify the road in terms of cracking, rutting and select homogenous sections on this basis.

On the basis of surface conditions survey the total stretch and can be divided into uniform sections.

Length of each section is to be kept to a minimum of at least 1 km because would not want to design overlays for every 200 m.

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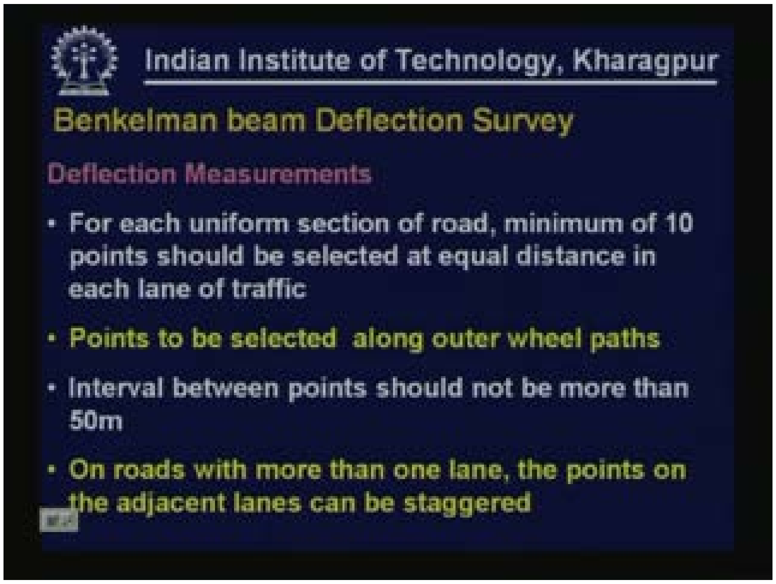

For each homogenous or uniform section of road a minimum of ten points should be selected at equal distance in each lane of traffic.

The points are to be selected along outer wheel path. Normally we have to select these points along the outer wheel path.

The interval between points should not be normally less than 50 m.

On roads with more than one lane the points on the adjacent lanes can be staggered.

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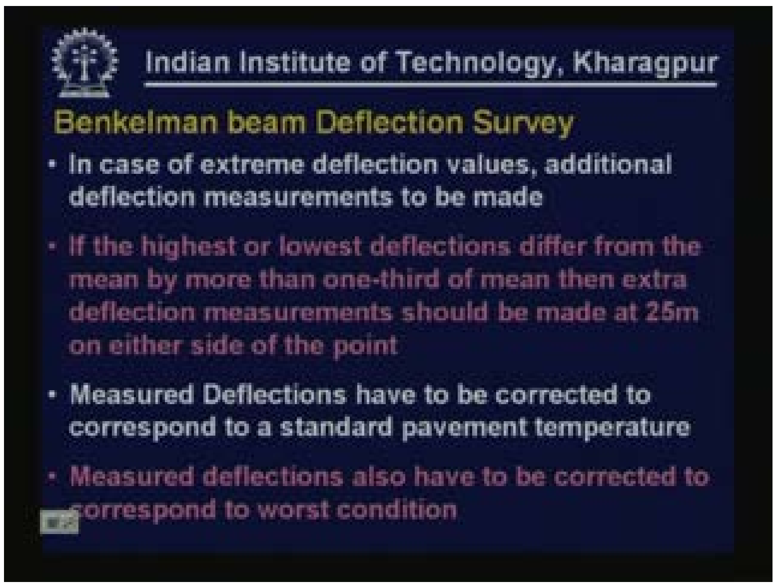

In case of extreme deflection values the additional deflection measurements are to be made. For example, if the highest or lowest deflection differs from the mean by more than one third of the mean then extra deflection measurements should be made at 25 m on the either side of the pavement. We have to be careful about extreme points or extreme deflections then we have to make additional deflections if this criteria is satisfied.

The measured deflections have to be corrected to correspond to standard pavement temperatures. As I said if you have a bituminous surfacing the pavement deflections are going to be affected by the temperature of the pavement, at higher temperature the bituminous surface is going to be weak then you get higher deflections. On the other hand if you do the deflection survey in very cold temperature the deflections will be low so this has to be normalized to a standard temperature.

The measured deflections also have to be corrected to correspond to the worst conditions because we are going to consider the structural condition of the pavement when it is in worst condition. This worst condition will normally be attained soon after monsoon.

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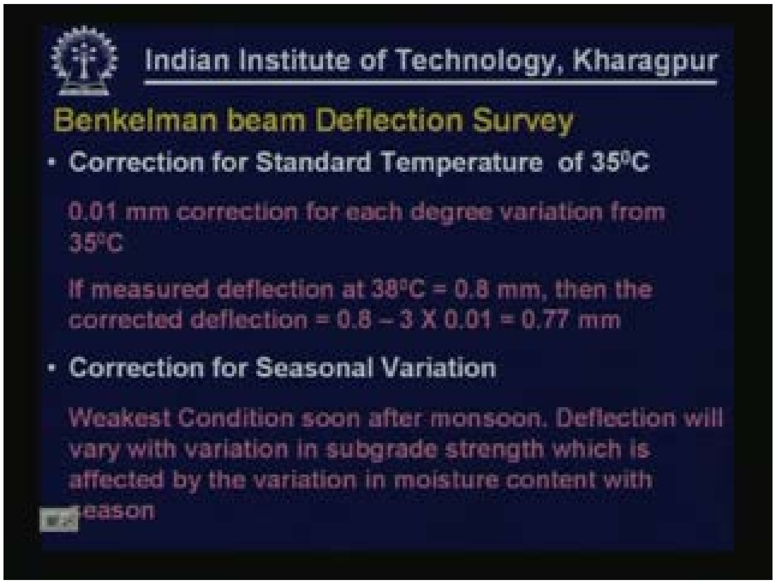

The correction for standard temperature has to be done for a temperature of 35 degree centigrade. The guidelines are the correction has to be 0.01 mm for each degree variation from 35 degree centigrade. For example, the deflections are measured at 38 degree centigrade pavement temperature. Because the deflection is measured at higher temperatures more than 35 degree centigrade so we have measured higher deflections so they have to be reduced to correspond to 35 degree centigrade so the corrected deflection will be 0.8 – 3 into 0.01 that's the correction for each degree of difference in temperature so the corrected deflection will be 0.8 – 3 into 0.01 that is 0.77 mm.

Similarly, correction for seasonal variation also can be done. This has to be done for the weakest condition which will be soon after monsoon. Deflection will vary with variation in subgrade strength which is affected by the variation moisture content with season and also it is a function of the type of soil that is there.

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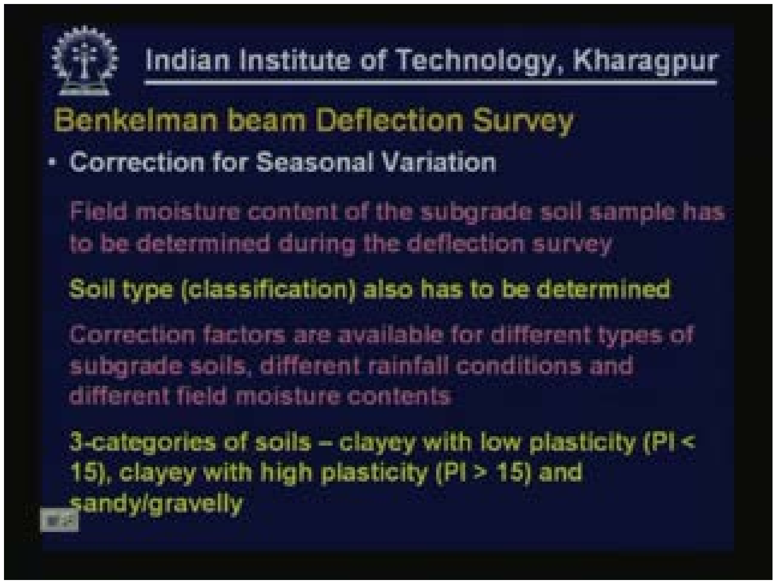

For correction of seasonal variation field moisture content of the subgrade soil sample has to be determined during the deflection survey. While we are conducting deflection survey we have to collect soil samples from the subgrade and determine the moisture condition. We also have to find out the type of soil. So, on the basis of the field moisture content moisture correction factors or seasonal correction factors are given in the guidelines. Hence correction factors are available for different types of subgrade soils, different rainfall condition and for different field moisture contents. Three categories of soils are considered namely clayey with low plasticity Pl less than 15, clayey with high plasticity Pl greater than 15 and sandy gravelly soils.

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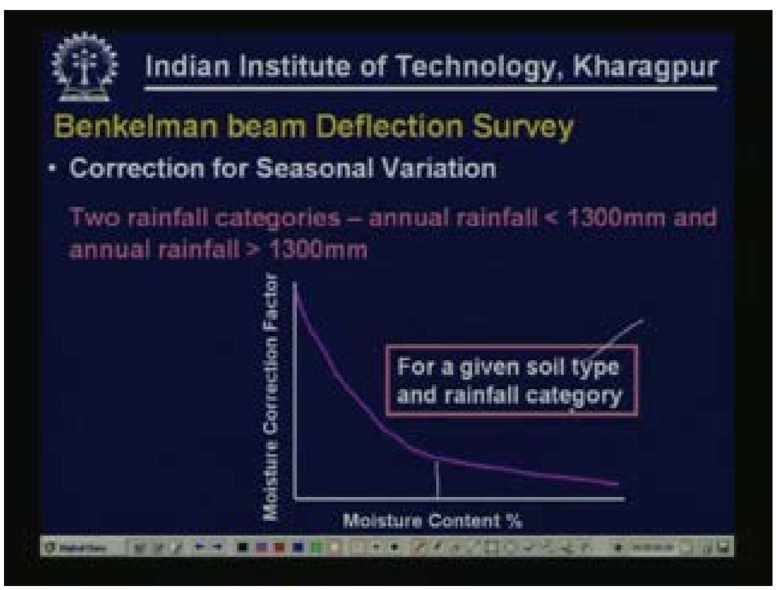

The correction for seasonal variation can be obtained from the charts that are given in the guidelines. For a given moisture content this is the field moisture content that is measured on the basis of the soil sample that is collected and for a given soil type and for a given rainfall category. Two categories are considered for rainfall, less than 1300 mm annual rainfall and greater than thirteen hundred millimeter annual rainfall. So for these two categories and for different types of soils a series of charts are available. So for a given soil type or for a given rainfall category and for the measured field moisture content the moisture correction factor can be obtained.

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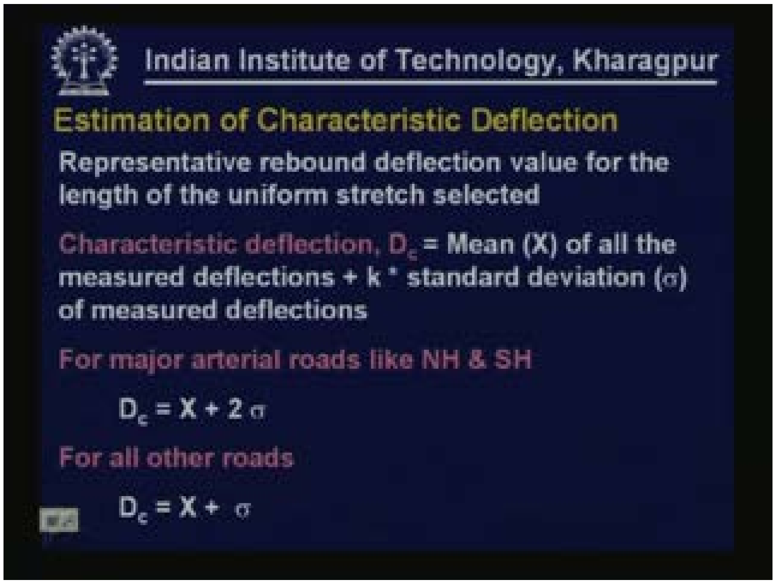

On the basis of number of deflections that we measure in a given stretch representative of a rebound deflection value for the length of the uniform stretch can be selected. This is known as characteristic deflection which represents the overall condition of the pavement. This is obtained Dc is obtained as mean of all the measured deflections plus some factor multiplied by the standard deviation of all the measured deflections.

For major arterial roads like national highways and state highways the characteristic deflection can be obtained as mean plus two times standard deviation. But for all other roads it can be mean plus one standard deviation.

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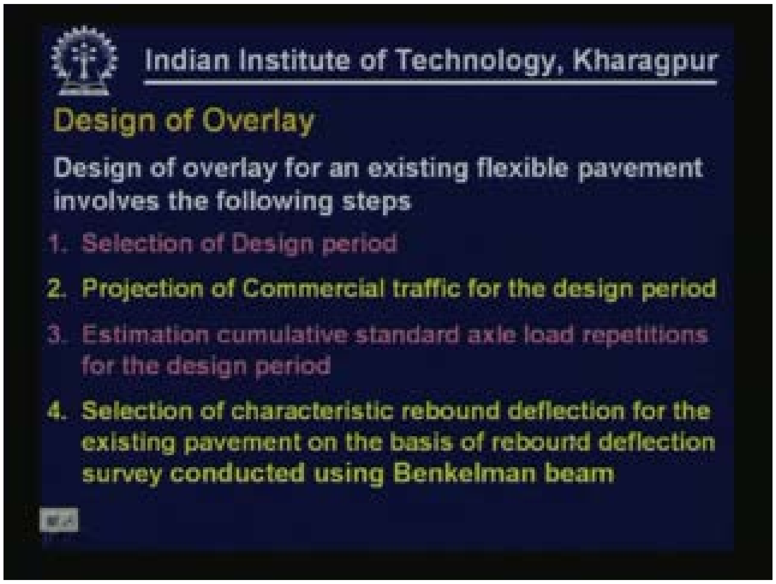

For designing overlays the following steps have to be followed:
First is you have to select the design period.
Next we have to project the commercial traffic that is going to be there during the design period. If you select design period to be ten years so after the pavement is constructed for a further period of ten years how many standard axle load repetitions this pavement is expected to have so we have to have that number.

We have to estimate the cumulative standard axle load repetitions for the design period. We have to select characteristic rebound deflections for the existing pavement on the basis of rebound deflections survey conducted using Benkelman beam. That is what we have discussed so far. Actually what is representative of the given stretch is the following:

- How to select the characteristic deflection
- How to conduct the survey
- How to get the sample of deflections and on the basis of that
- how to calculate the characteristic deflection

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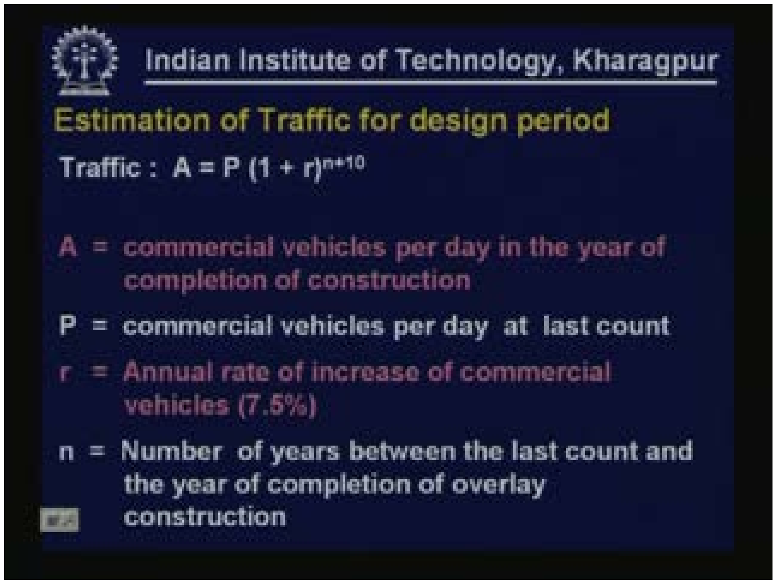

Traffic projection can be made in the following manner:
Traffic A which is commercial vehicles per day in the year of completion of construction then can be obtained from the traffic count that we have made sometime back let us say. So P is the commercial vehicles per day at last count, A is the annual rate of increase of commercial vehicles, if you have more authentic information about this we will use that value otherwise IRC suggests that you can use the value of 7.5%.

n is the number of years between the last count and the year of completion of construction of overlay because we might have obtained the value of P two years back and may be the overlay is going to be constructed after another three years so the time that has elapsed between the last count and the completion of construction of the overlay could be five years so the traffic intensity would vary by that time so we are going to estimate A value on the basis of the P that we have obtained about less than five years back using this expression.

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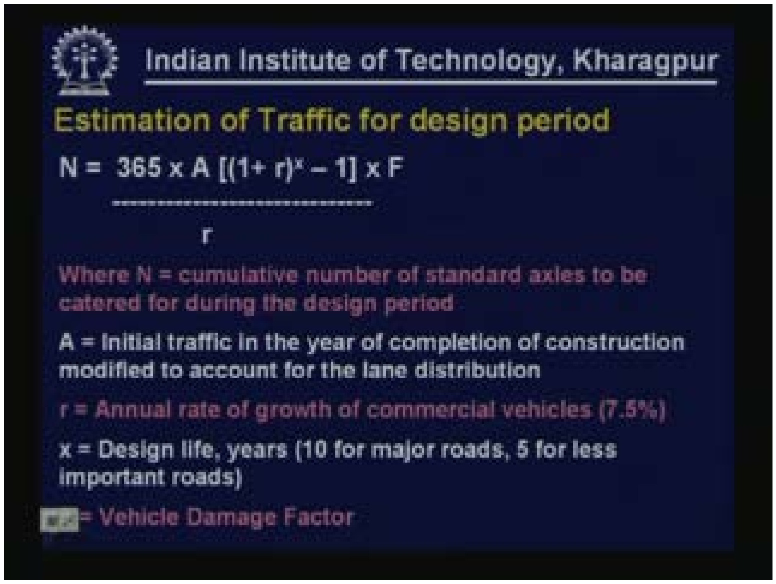

From the value of A that we have estimated N which is the cumulative number of standard axles to be catered by the pavement during the design period N is in terms of cumulative standard axles is given as: N = 365 A into 1 + r to the power x – 1 into F divided by r where r is the annual rate of growth of commercial vehicles authentic projections have to be made on the basis of various data one has to collect for projecting this. If it is not available a value of 7.5% can be taken. x is the design life period in years normally taken as ten for major roads and five for less important roads and F is the vehicle damage factor.

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The value of A has to be adjusted for lane distribution. For single lane having a width of about three point seven five meter the total 2-way commercial traffic multiplied by two has to be taken. Though this does not appear to be very logical but this is the guideline that IRC: 81 has. If you recollect the guidelines given in IRC thirty-seven which is for design of flexible pavement which has been revised subsequent to 1997 there the lateral dispersion factor taken for single lane roads is 1 that is we are going to take 100 percent of the total 2-way traffic. However, in the case of IRC eighty-one this provision of multiplying the total 2-way traffic by 2 still remains.

But for 2-lane single carriageway having 2-way traffic we are going to take 75% of the total 2-way traffic. For 4-lane single carriageway forty percentage of total 2-way commercial traffic we have 4-lanes total but at a single carriageway there is no division between the 2-lanes and the two directions it's a single carriageway it is not a divided facility and in that case we are going to take forty percent of the total two way traffic. We are interested only in commercial traffic. Similarly, if you have dual carriageway 75% of the commercial traffic in each direction for dual 2-lane carriageway is going to be considered. For each additional lane reduce the distribution factor by 20%.

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And for estimating the traffic we also need vehicle damage factors. We know that this has to be obtained from axle load survey. But if axle load survey data is not available indicative VDF values are; for different commercial traffic intensities 0 to 150 initial traffic, we can select a value of 1.5 for rolling and plain terrain, 0.5 for hilly terrain, for 150 to 1500 commercial vehicles per day 3.5 for rolling and plain terrain and 1.5 for hilly terrain. Similarly, if the commercial intensity traffic is more than 1500 it is 4.5 for rolling and plain terrain and 2.5 for hilly terrain. This is how we can select the vehicle damage factors. Thus we can estimate 'n' which is the cumulative standard axle load repetitions that the pavement has to cater to.

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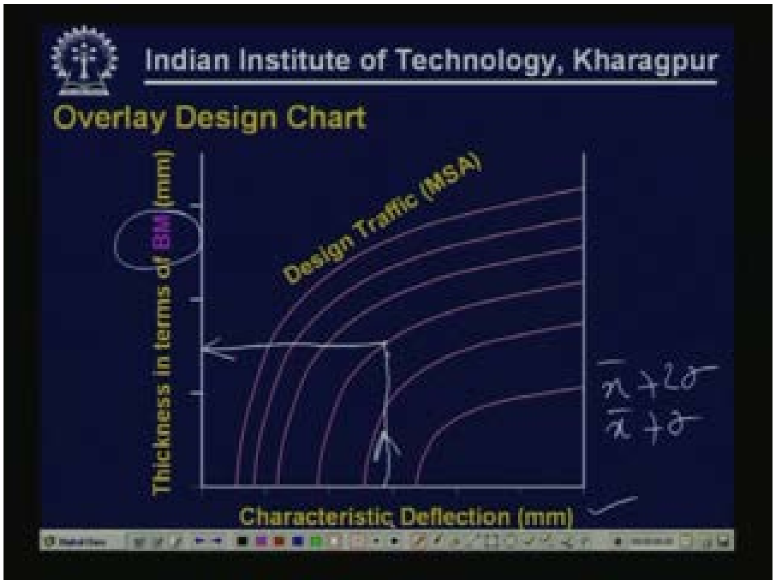

IRC: 81 has typical design charts using which we can select the overlay thickness. Characteristic deflection depending upon the importance of the facility mean plus two standard deviation or mean plus one standard deviation that value has to be selected. On the basis of characteristic deflection and on the basis of design traffic it is twenty million standard axles 10 million standard axles. We estimated that also and we get the thickness of the overlay to be provided in terms of bituminous macadam material in millimeters. This is quite simple. What we have to obtain is characteristic deflection from the Benkelman beam survey conducted corrected for temperature and corrected for season. So we select either mean plus two sigma or mean plus one sigma depending on the importance of the facility.

Obviously if we select mean plus two sigma we are using the same chart so we get higher bituminous macadam thickness. If you use mean plus sigma for lesser important roads we get lesser characteristic deflection so for this naturally we will get lesser overlay thickness. We have the overlay thickness in terms of bituminous macadam.

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We may not be using bituminous macadam. obviously bituminous macadam cannot be used for surface so this has to be replaced by the total beam requirement that has to provided in terms of DBM, also it can be BM, BM, BBM, BC or other types of bituminous layers. So using the conversion factors that are given here we can convert the total requirement of BM into different component layers.

For example, BM can be converted into other materials using equivalence factors that is 1 BM = 1.5 WBM or bituminous macadam or built up spray grout layer if you are going to replace some requirement of BM in terms of WBM, WMM or built up spray grout. Alternatively if you are trying to replace BM in terms of DBM AC or BC bituminous concrete or semi dense concrete equivalence is 1 BM = 0.7 DBM, AC or SDC.

Minimum thickness of overlay that has to be provided irrespective of all the calculations that we get is 50 mm BM with an additional surfacing course of 50 DBM or 40 BC.

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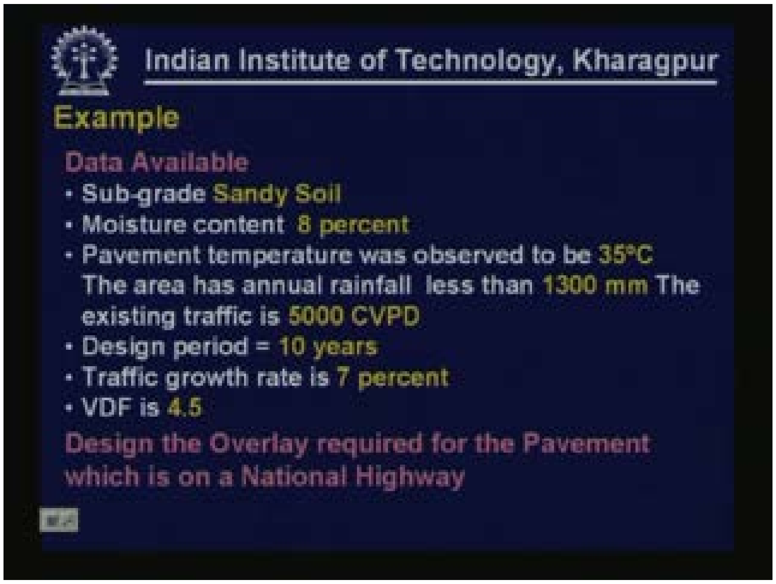

Let us take an example:
The data that is available is:

- Subgrade is of sandy soil
- Moisture content that was measured during the deflection survey was 8%
- Pavement temperature was observed to be 35 degree centigrade. You remember 35 is the standard temperature to which we have to adjust all the measured deflections. And incidentally if the temperature itself is 35 degree centigrade then we will not be making any correction for pavement temperature.
- The area has an annual rainfall less than 1300 mm
- The existing traffic is five thousand commercial vehicles per day
- Design period has to be ten years
- Traffic growth rate is given as 7%
- Vehicle damage factor on the basis of axle load survey is found to be 4.5.

We have to design an overlay for these pavements which is a national highway.

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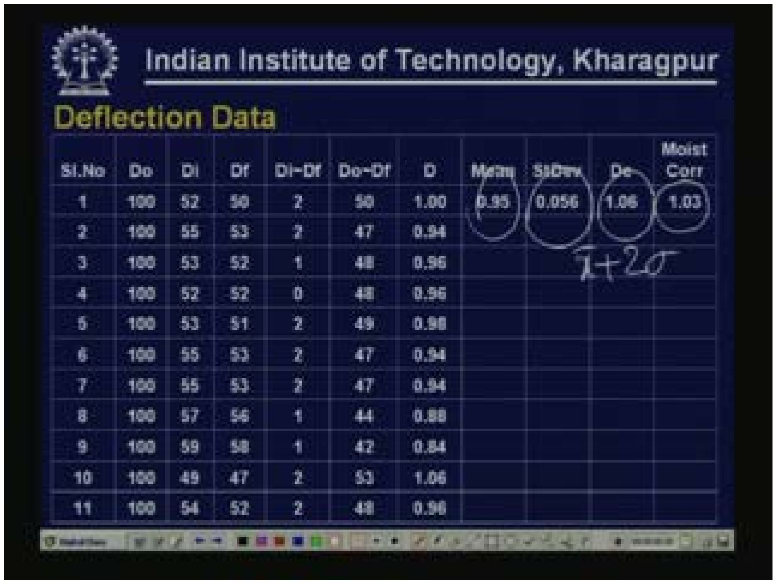

Sl.No	Do	Di	Df	Di-Df	Do-Df	D	Mean	St.Dev	De	Moist Corr
1	100	52	50	2	50	1.00	0.95	0.056	1.06	1.03
2	100	55	53	2	47	0.94				
3	100	53	52	1	48	0.96				
4	100	52	52	0	48	0.96				
5	100	53	51	2	49	0.98				
6	100	55	53	2	47	0.94				
7	100	55	53	2	47	0.94				
8	100	57	56	1	44	0.88				
9	100	59	58	1	42	0.84				
10	100	49	47	2	53	1.06				
11	100	54	52	2	48	0.96				

This is a typical deflection data that was measured. Initial deflection and intermediate deflection and then this is how we calculate the mean and standard deflection. This is the mean value, this is the standard deviation value, and from this, this is how we are getting character deflection as mean + 2 sigma. We are not making correction for temperature but we are making correction for moisture, this is the correction factor that is obtained.

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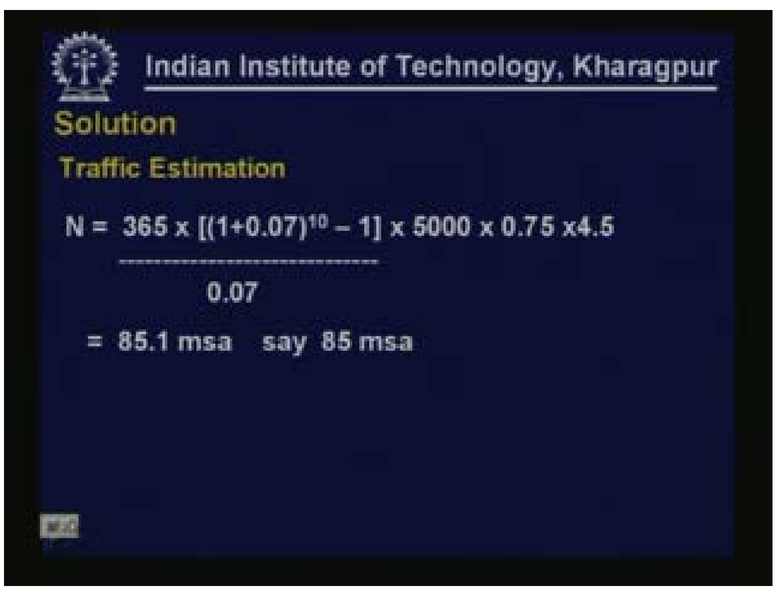

Traffic is estimated in this fashion:

A is given as 5000, lane distribution factor of 7.5 this is a 2-lane two way highway, vehicle damage factor is 4.5, growth rate is 0.07 so the traffic that the pavement has to cater to is eight point 85 million standard axles.

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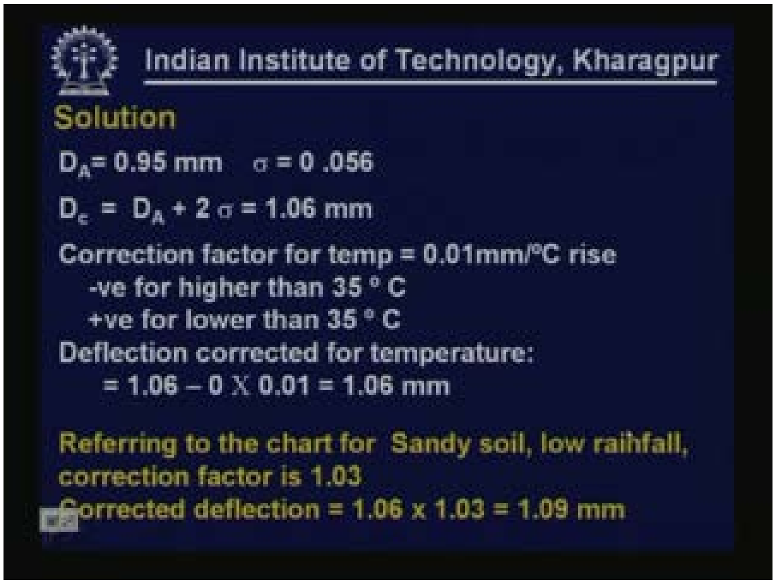

The corrective deflection works out to be 1.06, this is corrected for temperature there is no correction and this is corrected for moisture or season which is 1.03 which is the correction factor so the corrected deflection is 1.09.

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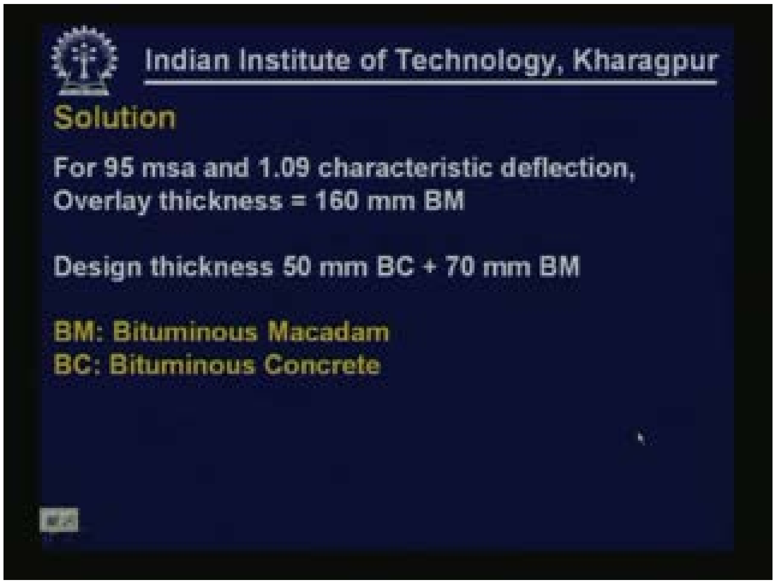

So for 95 million standard axles and 1.09 characteristic deflection using the thickness charts given in IRC the total overlay thickness works out to be 160 mm of bituminous macadam. So I split this into 50 mm of BC and 70 mm of BM. So you can verify whether this is correct or not. BM is bituminous macadam and BC is bituminous concrete.

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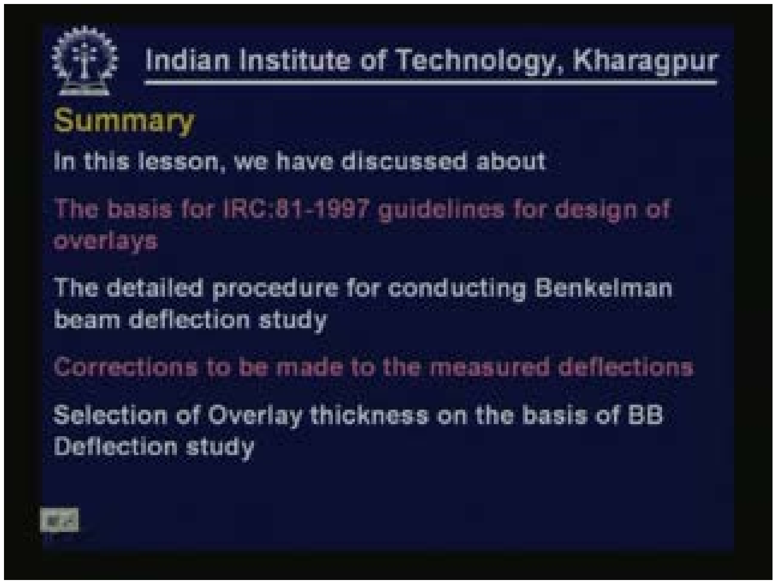

To summarize; in this lesson we have discussed about the basis for IRC: 81 - 1997guidelines for design of overlays. We also discussed detailed procedure for conducting Benkelman beam deflection survey. We also discussed about the corrections to be made to the deflections that are measured in terms of temperature correction, in terms of seasonal correction. We also discussed how to select overlay thickness on the basis of Benkelman beam deflection study and also on the basis of other information that we collect during the survey.

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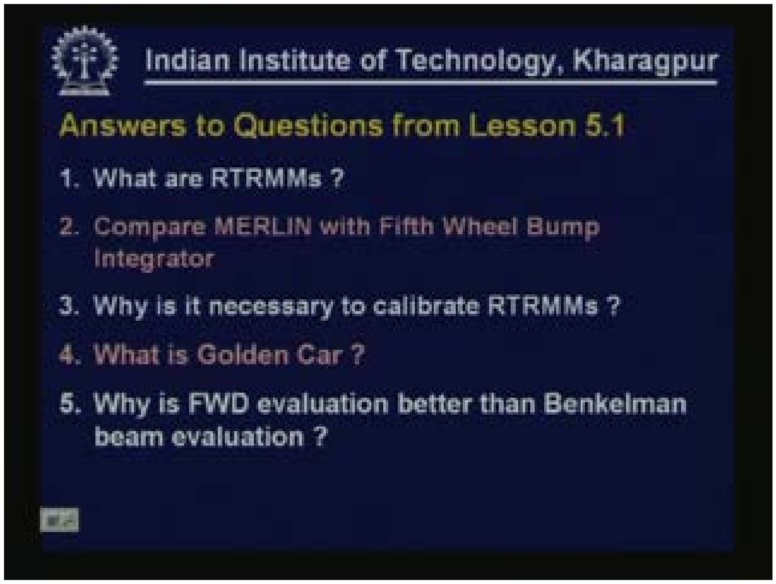

Let us take the answers to the questions that we asked from lesson 5.1. Lesson 5.1 was on evaluation of pavements.

1) What are RTRMMs?
RTRMMs are Response Type Roughness Measuring Machines. these are equipment that give an index of roughness of the pavement and this is the index that is sensitive to the road user's perspective.

2) Compare MERLIN with fifth wheel bump integrator:
MERLIN and fifth wheel bump integrator are entirely two different equipments. Fifth wheel bump integrator is a response type equipment which has got a suspension system and what we measure there is the cumulative stroke of the suspension system. In the case of MERLIN what we measure is how there is variation of the midpoint of a straight line drawn between two points on the pavement surface, how it is distributed so that distribution gives us the index of the roughness of the pavement. The roughness parameter that we obtain using a fifth wheel bump integrator can vary over time and can be different for different equipments. MERLIN is more or less standard so that's why it is normally used to calculate response type equipments.

3) Why is it necessary to calibrate RTRMMs?
Response type equipment as I just mentioned their response will be varying with time and similarly for a given road if we use different types of RTRMMs we get different roughness values. That's why these are to be standardized to correspond to a standard index. That's why we have to calibrate this RTRMMs.

4) What is golden car?
Golden car is hypothetical one fourth of an equipment which is used in the stimulation of its response to a given profile to calculate international roughness index. so the parameters of this; the body of the mass, body of the axle, suspension system and the stiffness of this tire are so

selected fine tuned so that the IRI value that is computed correlates well with the response type measurements. So the finely tuned tool parameters and the corresponding system is called as golden car. In fact this is a quarter car.

5) Why is FWD evaluation better than Benkelman beam evaluation?
In FWD evaluation we get information about the deflection bowl of the pavement whereas in the case of Benkelman beam we get only one deflection which is the maximum deflection whereas in FWD we get a number of deflections. So as a result we get more information about the pavement compared to the information that we get from Benkelman beam evaluation. So FWD is always better than BB evaluation.

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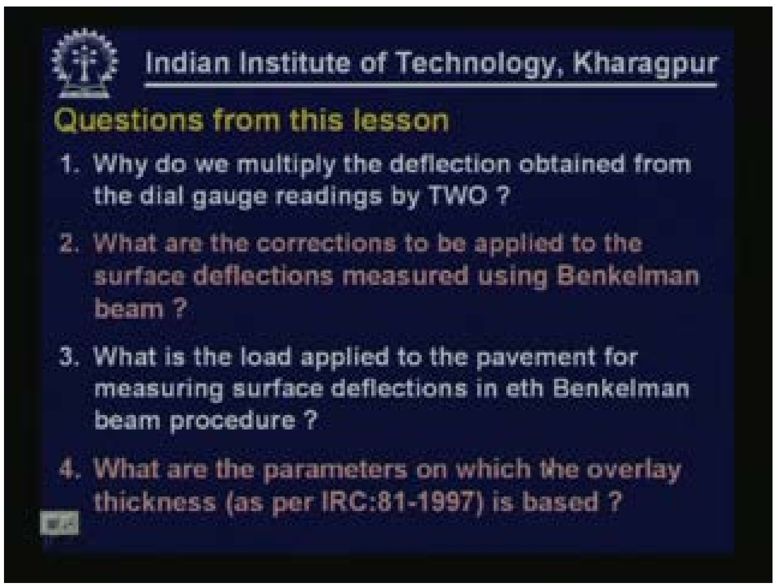

We will have a few questions from this lesson:
1) Why do we multiply the deflection obtained from the dial gauge readings by TWO?
This we have to do because the beam is hinged about a location which has got two is to one ratio in terms of length so that's the reason why we measure the deflections obtained from the dial gauge by 2.

2) What are the corrections to be applied to the surface deflections measured using Benkelman beam?
We have to apply temperature correction so that it corresponds to a standard temperature of 35 degree centigrade. We also have to apply seasonal correction on the basis of the moisture content that we obtain so that the deflection corresponds to the worst condition.

3) What is the load applied to the pavement for measuring surface deflections in the Benkelman beam procedure?
The load applied is through a truck. The rear axle has to be 8170 equally distributed on both the dual wheel sets, the tire pressure has to be 0.56 MPa.

4) What are the parameters on which the overlay thickness as per IRC: 81 – 1997 is based?
We can select the overlay thickness using characteristic deflection and also on the basis of the cumulative standard axle load repetitions, thank you.