Introduction to Transportation Engineering
Prof. K. Sudhakar Reddy
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture - 30
Pavement Materials – IV

Hello viewers welcome to lesson 4.7 which is on pavement materials part IV and in this lesson we will be covering bituminous binders.

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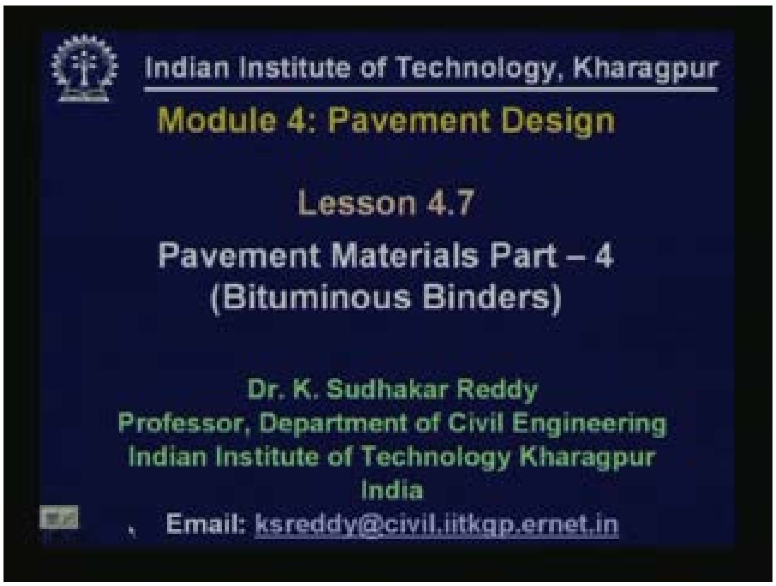

This lesson is being delivered under the module 4 which is on pavement design.

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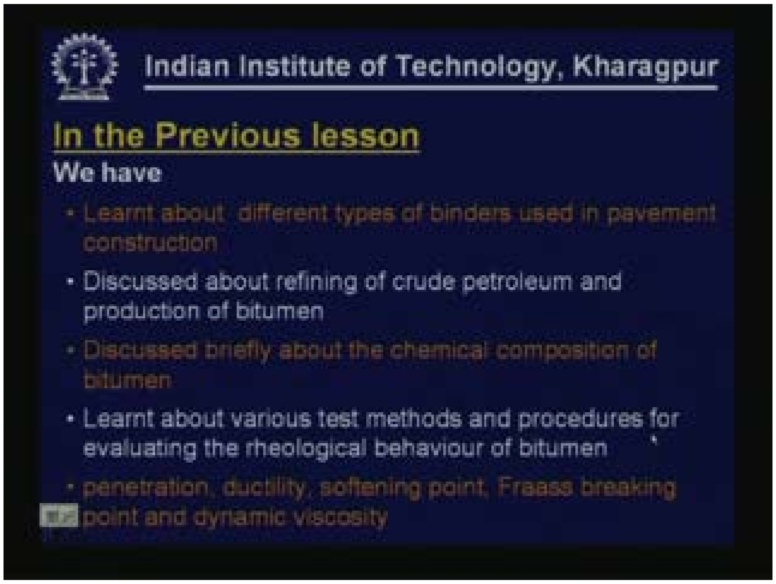

Just to recap what we discussed in the previous lesson which was lesson 4.6 which is also on bituminous binders we have learnt about different types of binders used in pavement construction rather we have listed various binders that are normally used in bituminous binders that is bitumen, tar, emulsion, cutback and modified binders. Then we discussed about the process of producing bitumen from crude oil by different refining processes. We also discussed briefly about the chemical composition of bitumen and we learnt about various methods that we adopt for testing the rheological behavior and other properties of bituminous binders.

Some of the tests we considered were penetration test, ductility test, softening point test, fraass breaking point, and dynamic viscosity. Obviously these tests do not completely cover the complete gamut of tests that we could do on bituminous binders. And we have in the previously lesson only covered certain aspects of testing and evaluation of normal bitumen. In this lesson we will go ahead and then discuss about a few other tests that we can do on bituminous material and the relevance of those test procedures.

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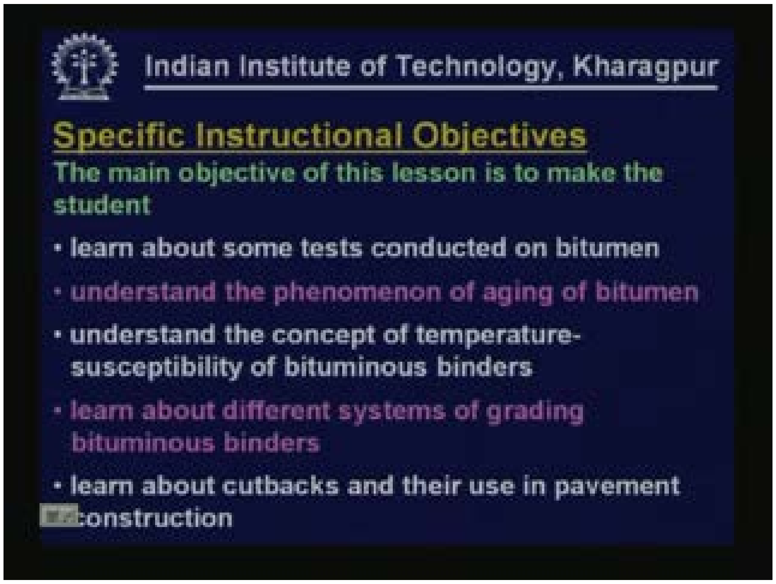

As I said the main objective of this lesson is to make the student learn about some additional tests other than what we have already discussed in the previous lesson. We will be discussing a few additional tests that we can conduct on bitumen, their relevance, test procedures. We will also try to understand the phenomenon of aging of bitumen. It is also expected that the student would be able to understand the concept of temperature susceptibility of bituminous binders and the student should also be able to learn about different systems of grading bituminous binders and we will also discuss about another type of bituminous binder which in fact is bitumen but in a different form that is about cutbacks, their use in pavement and the test that has to be conducted on cutbacks.

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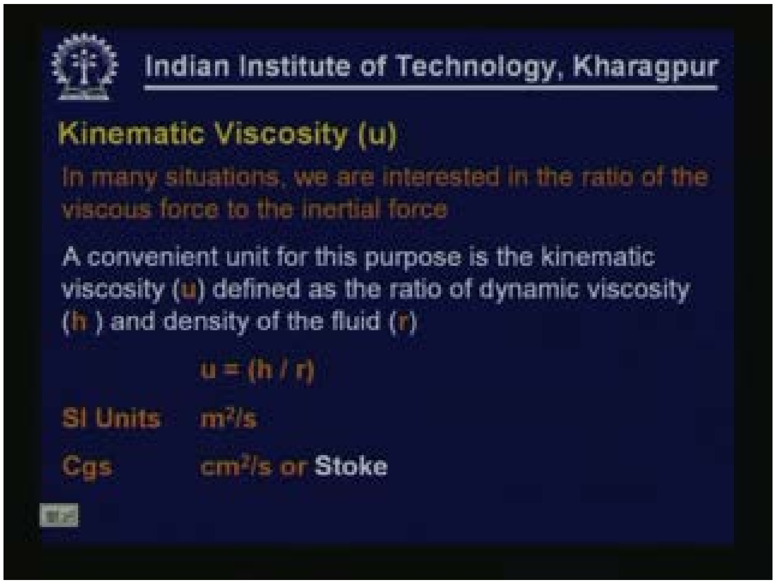

In the previous lesson we discussed about dynamic or obsolete viscosity which as I said was a fundamental parameter of bitumen that would tell us in great detail about the rheological behavior of bitumen. Rheology as we mentioned in the previous class is the study of flow and deformation behavior of any material. So as we know at different temperatures for different loading times bitumen does undergo flow. We are concerned about the rate of flow, the manner in which it flows at different temperatures and when it is subjected to different loading times and also we would like to know what is the implication of these deformation characteristics as far as the pavement performance is concerned.

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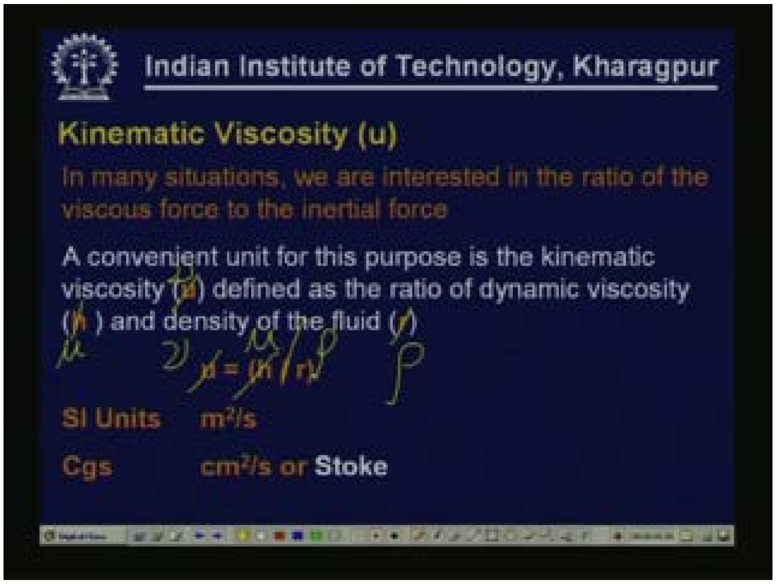

While it is a very useful parameter to talk about absolute viscosity but it does not take into account the inertial force. In many situations we are interested in the ratio of viscous force to the inertial force. A very convenient unit for this purpose is the kinematic viscosity defined as the ratio of dynamic viscosity. I think ‘mu’ was the parameter that we are using and the density of the fluid rho. So the kinematic viscosity can be defined as absolute viscosity a dynamic viscosity divided by the density of the fluid. The SI units for kinematic viscosity is meter square per second, the Cgs unit is centimeter square per second or more commonly stoke is the unit that is normally used and even more commonly it is centi stoke that is used. Obviously we know 1 stoke would be 100 centi stoke.

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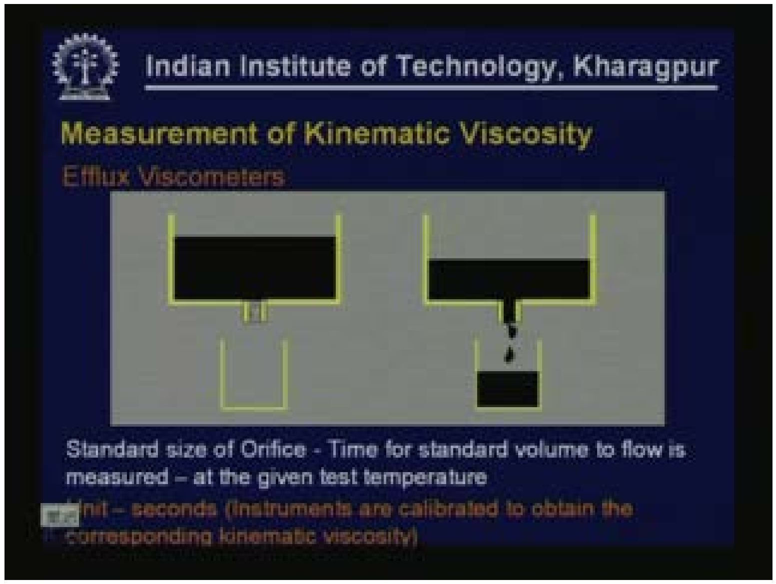

How do we measure kinematic viscosity? As I have said this is a very convenient unit if you want to express viscosity in terms of viscous force and the inertial force then kinematic viscosity is a convenient unit. We use efflux viscometers or capillary viscometers to measure kinematic viscosity.

What is done with these viscometers is in principle this. There is a standard orifice obviously there is viscometer which is a container it has a standard orifice and bitumen is collected which is maintained at a specified temperature so obviously we have to specify a certain temperature, at that temperature when the bitumen is maintained the stopper that is put in the orifice will be opened and the fluid is allowed to flow. The time required for certain quantity or certain volume of fluid to flow through this specified orifice is measured in terms of time unit. So viscosity in this case is expressed as the time taken for a standard volume of fluid to flow through a specified size orifice at a specified temperature.

But normally we can have specifications directly in terms of seconds as the viscosity unit or this time unit can be converted into kinematic viscosity or even the dynamic viscosity using appropriate calibration factors. These calibration factors will be different or dependent on the type of equipment that we are using, size of the orifice that we are using and other relevant parameters.

Hence on the left hand side we see the orifice being plugged and at the bottom there is a container which is placed to collect the fluid, on the right hand side once the orifice is opened fluid starts flowing if it is a viscous material it would naturally take more time but if it is a less viscous material the required quantity of binder can be collected within a shorter time period. But as I said, time can be in seconds viscosity can be expressed in seconds but normally this is expressed in terms of kinematic viscosity units with the stokes and centi stokes using appropriate calibration factors which again are a function of the equipment that we are using and size of the orifice.

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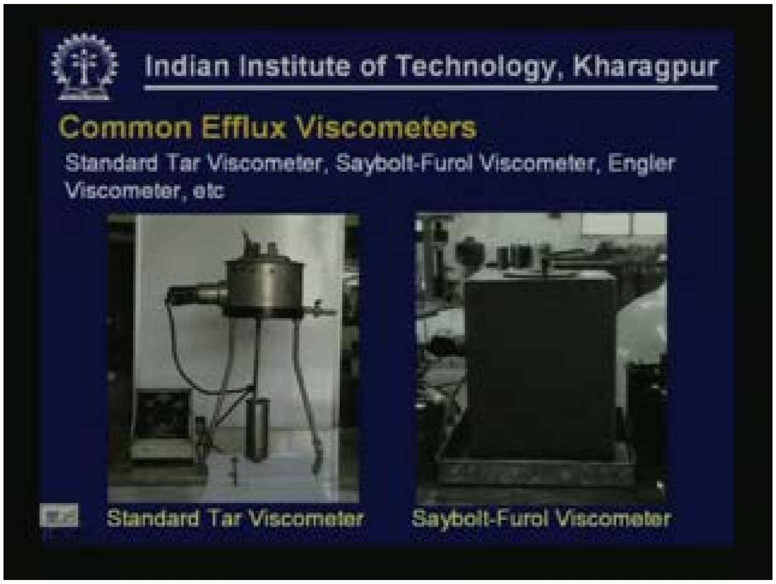

These two photographs show two typical viscometers. On the left hand side you have standard tar viscometer which is normally used to measure viscosity of tar and on the right hand side you have Saybolt-Furol viscometer which is used to measure the viscosity of bitumen emulsions and other types of binders.

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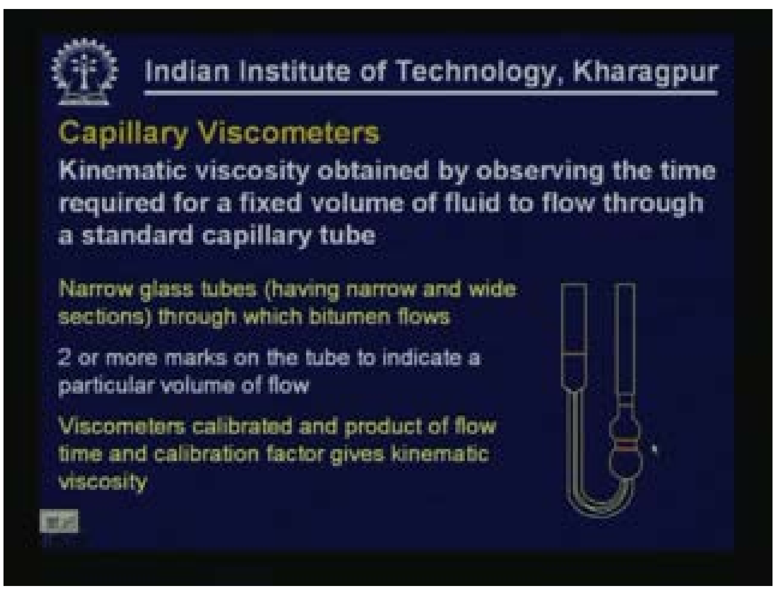

The next type of viscometers that we normally adopt for measuring kinematic viscosity is the capillary viscometer. what we have in this case is different types of capillary tubes and we measure the time taken for the binder or the fluid to flow through these capillary tubes and the time that is required for a certain quantity of fluid to flow through these tubes is measured, that is the viscosity unit that again has to be calibrated and then using the appropriate calibration factors we can get the kinematic viscosity.

There are various types of capillary tubes available, different sizes are there, there are marks that are provided on these capillary tubes which would indicate or rather serve as marks to identify when certain quantity of fluid has flown from one point to another point and the corresponding times can be noted and the time required for certain amount of fluid to flow from one mark to another mark can be obtained, the corresponding calibration factors are available from the manufacturer depending on the size of the capillary tube and the arrangement of bulbs and other arrangements that we have here.

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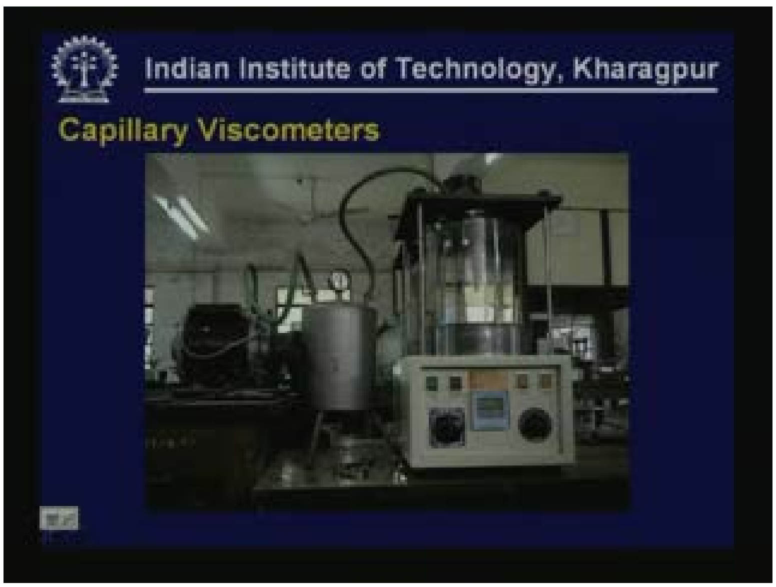

Here we see an arrangement that we normally use for a capillary viscometer. What we in fact see here is a temperature bath which is used to maintain constant temperature. The capillary viscometers which are basically glass tubes of different arrangements are placed inside this and then depending on the temperature that has to be maintained different mediums can be used including water. Normally a proper constant temperature arrangement has to be there.

In some cases depending on the viscosity of the fluid that is to be measured which again is a function of the test temperature at which you are conducting the test if it is a smaller temperature the viscosity of the fluid will be more then there is a vacuum arrangement that will have to be applied for certain test procedures. So there are various arrangements that are possible with and without vacuum, different types of capillary tubes are available and for each arrangement there is a separate calibration factor that is available. Once you get those timings from these testing arrangements for a given temperature we can get the corresponding kinematic viscosity.

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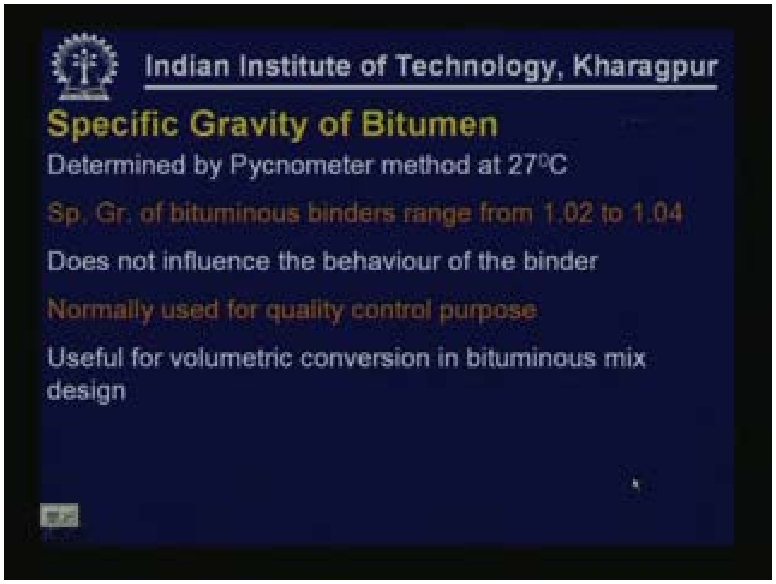

We are also interested in the specific gravity of bitumen. Normally this is determined using a Pycnometer and at a temperature of 27 degree centigrade. Normally specific gravity of bituminous binders or rather bitumen ranges from 1.02 to 1.04 it can be different from this also. In general the specific gravity of bituminous binders does not influence the mechanistic behavior of these binders. Normally we conduct this test for quality control purposes to ensure that we are getting the type of binders that we have been looking for.

We know for 60/70 typically the specific gravity could be in a different range, similarly 30/40 it can have different specific gravity of course from a particular source so this can be used as a quality control measure but more importantly this is used in converting the weight of bitumen into corresponding volume. As we have mentioned once in the earlier lesson this is because we are going to use the volumetric analysis of the bituminous mix for designing the bituminous mixtures. The bituminous mixes volumetric proportions that have been found to be better correlated to the performance of the pavements. Hence mixed design is normally in terms of volumetrics so that’s why we should be able to convert all the components that we were using in a bituminous mix into the corresponding volumes. For that reason we also need the specific gravity of bitumen.

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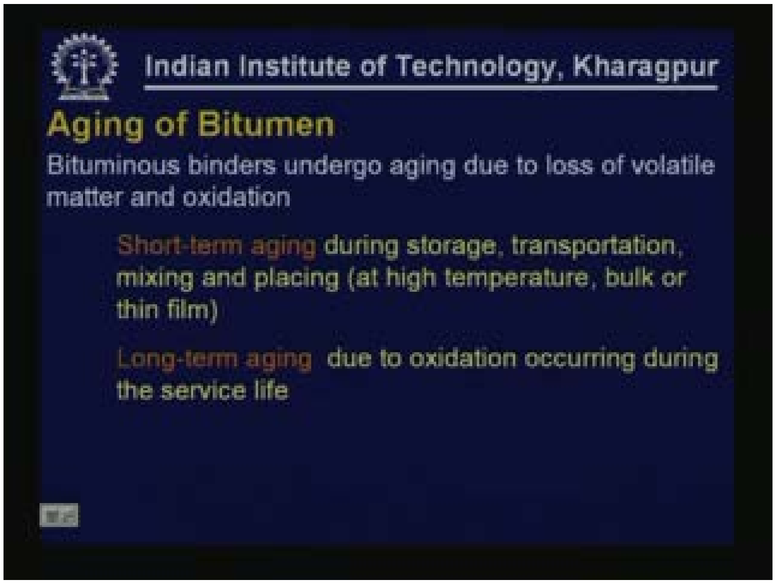

Aging of bitumen: this is a phenomenon that we need to understand because like all human beings or most materials bituminous binders are also going to be aging with time. So this is a time dependent process. But some of the changes that occur in bitumen with time are for good but most of them are not for good. So we try to understand what exactly happens as bituminous binders start aging with time.

Bituminous binders basically undergo aging due to the loss of volatile matter and oxidation. We know that there is certain quantity or certain amount of volatile matter present in bituminous binders with time and in certain conditions the volatile material is going to be lost. So that is one change that is going to happen to the bitumen with time.

The other changes the components of bitumen as discussed in a broad term asphaltenes, resins and oils get oxidized, oil could get oxidized to form resin and asphaltene similarly resin can get oxidized to form asphaltene so there is going to be some change in the chemical characteristics of the binder with aging. The aging usually happens in two different phases in the life of the bituminous binders that is used for constructing pavements. One is short-term aging. This happens over a very short time period. this happens because the bituminous heated to high temperature is mixed with aggregates and when it is coating the aggregates it is in a thin film the thickness could be of the order of may be 5 microns, 10 microns or 15 microns it is so thin and therefore it is coating the aggregates in the form of very thin films and it is heated to very high temperatures such as 150, 160, 170 so at that high temperatures and in thin films it is going to be oxidizing very rapidly. Also, during storage, during transportation usually it is at high temperature depending upon the area of surface that is exposed to air the amount of oxidation could be different. And the method in which you are going to mix it or how you are going to place it and things like that affect short-term aging.

Usually significant amount of aging occurs during this short-term aging. Because of high temperatures and because of the bitumen being in very thin films significant amount of change occurs during the initial short-term aging/ but there is some amount of aging that occurs after the short-term aging also. It is when the bitumen is in the pavement, while it is in service, the service life period say 5 years, 10 years, 15 years some amount of aging is going to occur. This aging that occurs during its service life period is known as long term aging. Thus long-term aging also occurs due to oxidation during the service life. This amount of oxidation that's going to be there the rate of oxidation that's going to be there would be a function of what the bitumen is exposed to, what is the air void content of the mix that is there so accordingly what is the air that is going to be present within the mix then that is going to be ((conducible)) for oxidation of the binder and there are also other climatic factors such as humidity and so on.

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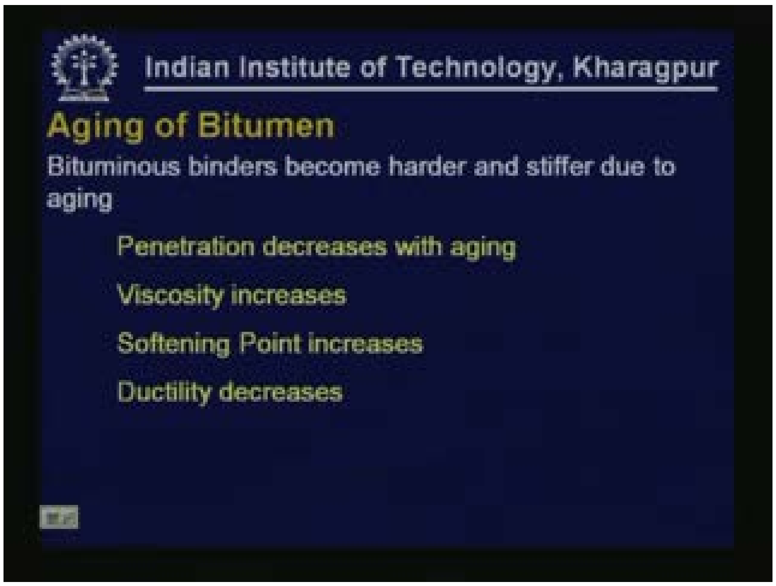

Because of aging bituminous binders become harder and stiffer. So with time the binders keep on getting harder and stiffer so because of this the penetration decreases with aging. We know smaller the penetration value harder the bitumen, larger the penetration value softer the bitumen so with aging the penetration value gets reduced that means the bitumen becomes harder, the softening point increases for bitumens having smaller penetration value but bitumens having larger softening penetration value which are softer the softening point will be smaller for obvious reasons. Also, the viscosity increases with aging and ductility decreases, it becomes brittle.

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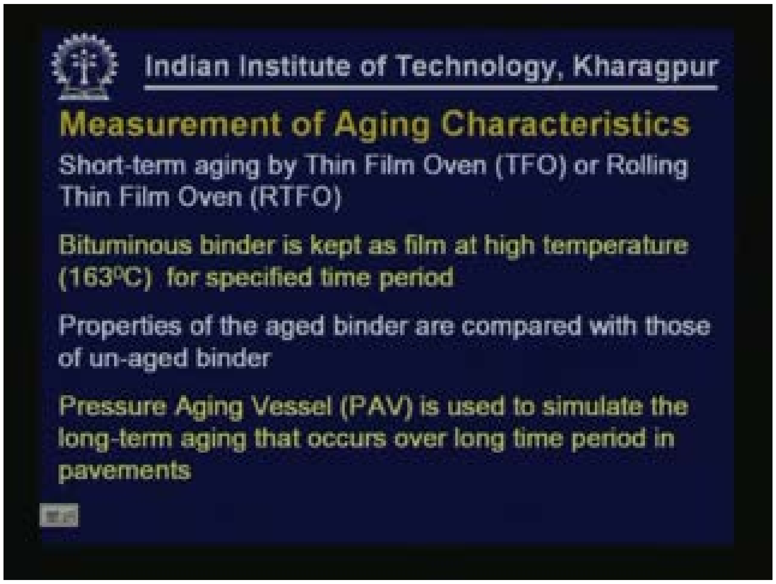

There are various methods by which we measure the aging characteristics of bitumen but the most commonly used methods are, especially short-term aging is measured by equipment called as thin film oven. As the name suggests the bitumen is going to be prepared in thin films and it is subjected to aging. There is a more recent version of thin film oven which is a rolling thin film oven which is slightly more advanced and the claim is that it simulates short-term aging better and the time required to simulate the short-term aging with rolling thin film oven is also going to be shorter.

In RTFO or TFO what we do is the bituminous binder is kept as a film at high temperature which is 163 degree centigrade for a specified time period. The specified time period will be different for RTFO and different for TFO. So the properties of the binders after aging and before aging are compared to assess the effect of aging on the binder. therefore normally we have specifications to assess how much is permissible, what reduction of penetration is permissible, what increase of softening point is permissible after aging, when it is tested in TFO, and when it is tested in RTFO obviously different specifications have to be there because these are different testing conditions so we test different properties of binder before TFO and after TFO then compare these two properties and see whether the bitumen has got too much susceptibility of aging or whether it is an acceptable aging process.

Pressure Aging Vessel is an equipment that is normally used to simulate the long-term aging that occurs over long period in pavements. Pressure Aging Vessel especially for Indian context is still a costly equipment although some agencies have it. What is done in this case is the binder is kept at maximum service temperature or at a temperature that is specified for a given site, given project location so obviously the temperature is going to be different for different project locations. And the binder is subjected to pressure for a certain time period and after that the properties of the binder are evaluated.

Therefore this process is expected to simulate the long term aging that is going to happen to the binder when it is used in pavement. Normally the binder that has been aged in either TFO or RTFO, usually the RTFO aged binder is used and it is the same binder that is used in PAV. thus first the binder is short-term aged in RTFO then it is put in a PAV Pressure Aging Vessel subjected to specified magnitude of pressure maintained at a specified temperature where this temperature is a function of the location at which the material is going to be used and then after this long-term aging the properties of the binder is going to be evaluated.

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What you see here are two actual views of thin film oven. On the left hand side you have thin film oven with the outside view with the door closed and on the right side you have the thin film oven, you have the interior details, we also have certain cups that are available, there are two shelves present where some discs can be placed in it and then bitumen will be put in that, then this arrangement is going to be rotating at a constant speed and because of that the binder is going to be spread in thin film, it in fact is not as thin as you will have in the case of the bitumen coating and aggregate it will not be as enough as 5 microns, 10 microns, 15 microns it will be much thicker than that but still it is a film and then this is subjected to 163 degree centigrade and then it will be continuously be rotated.

Compared to this what we do in the case of RTFO is besides formation of a film the film is going to be much thinner than this, there is going to be air that is going to blown on to the bitumen which would further accelerate the oxidation process.

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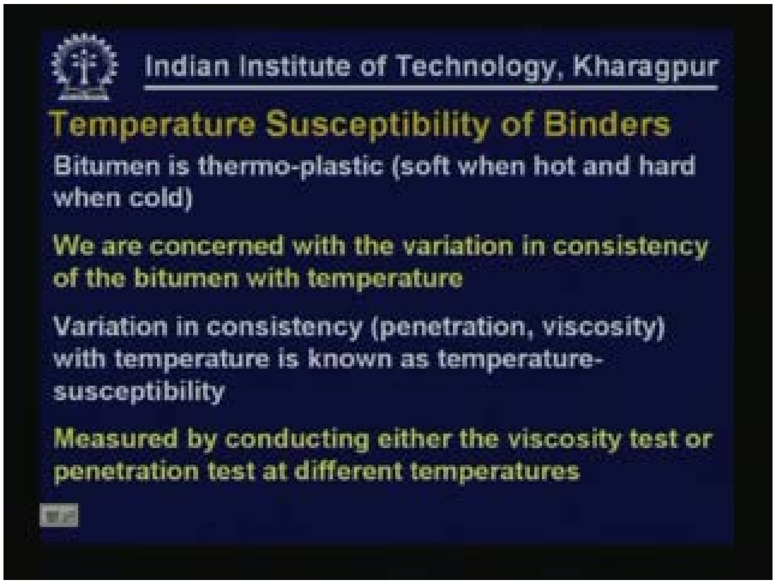

We will now discuss about the temperature susceptibility of binders. We know bitumen is thermo-plastic, it becomes soft when hot and hard when cold. What we are concerned about is the variation in the consistency that is consistency can be in terms of penetration, softening point, viscosity or any other parameter, stiffness, modulus value of the bitumen with temperature. The variation in consistency again either in terms of penetration viscosity or any other parameter with temperature is known as temperature susceptibility. This is normally measured or this can be quantified by conducting either the viscosity test or the penetration test or any other test which would give you a parameter like stiffness, modulus value and other parameters at different temperatures. If that parameter can be obtained at different temperatures that variation can be examined then we can quantify or express how temperature susceptible different binders are.

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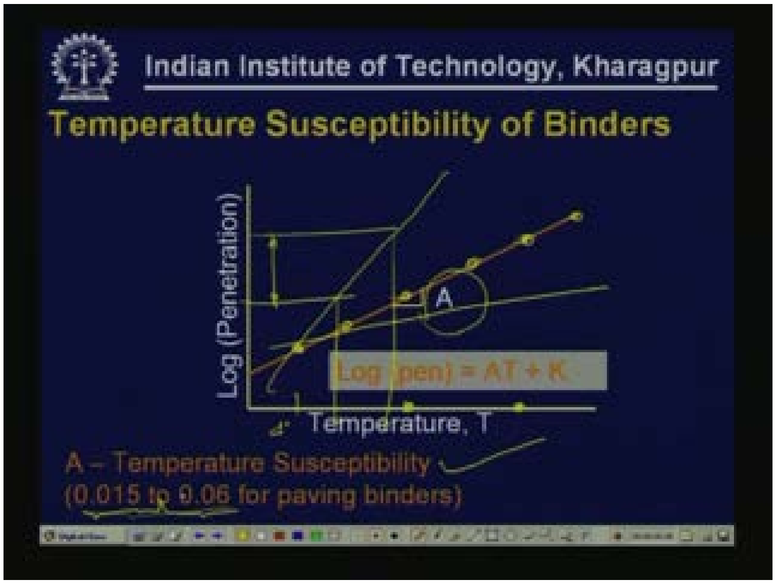

In this case we have chosen penetration to represent the temperature susceptibility of bitumen. What is done is penetration test is let us say conducted at different temperatures say at 4 degree centigrade the corresponding penetration is obtained, say 25 degree centigrade the corresponding penetration is obtained, and if we can conduct the penetration test at other temperatures let's say we obtain number of points like this and let's say we get a straight line.

Normally we expect to get a straight line if it is plotted on a semi-log scale the penetration being in on log scale. So the slope of this line A is called as temperature susceptibility of the binder. Typically for paving binders this value is going to be about .015 to .06. So, if we can get the value of A for a given binder we have some idea about what is going to be temperature susceptibility of the binder. Obviously flatter the line lesser the temperature susceptibility steeper the line it is obviously more susceptible because the property is going to vary for a given variation in temperature and the property is going to vary more significantly for a steeper line. So a larger value that is a value of .06 if you get a value of .06 it should to be considered to be highly temperature susceptible but a value of .015 obviously is not so temperature susceptible. But penetration index is a more convenient parameter to represent the temperature susceptibility.

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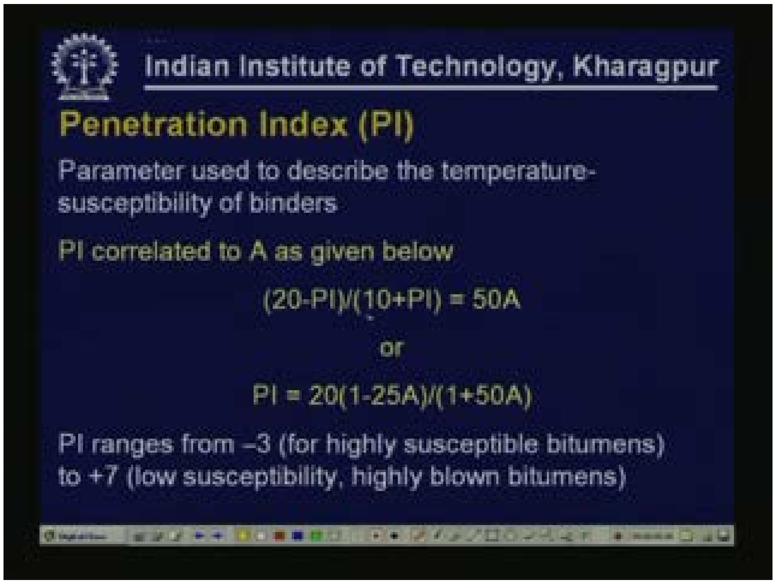

Penetration index has been correlated to the temperature susceptibility parameter A as we have seen in the previous slide as given below. That is 20 – Pi/10 + Pi = 50A or expressed in terms of Pi it is given as 20 into 1 – 25A/1 + 50A. Pi normally ranges from – 3 for highly susceptible bitumens, these are highly temperature susceptible bitumens if you get a value of – 3 + 7 low temperature susceptibility you get such high values especially for highly blown bitumens, when these bitumens are already blown and oxidized to significant amount they are not going to be so temperature susceptible compared to straightened bitumens.

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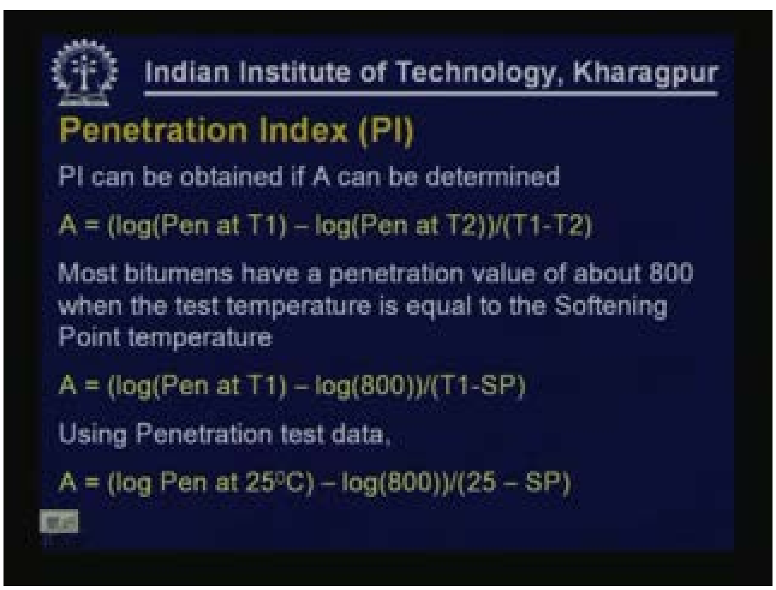

For determining penetration index it can be obtained by obtaining the value of A which is the temperature susceptibility on a penetration versus temperature plot. A can be obtained if you can conduct the penetration test at two different temperatures. So it is log penetration at temperature 1 – log penetration at temperature 2 divided by the temperature difference T1 – T2. Most bituminous binders have a penetration value of about 800. There is an observation that has been made on the basis of tests that are conducted rather that were conducted on a number of binders. But it's not that all binders are going to exactly have this value. This is the penetration value that can be expected if the test temperature is equal to softening point temperature.

We are getting similar penetration value for all binders irrespective of whether it is 60/70, 30/40 or 80/100 at softening point temperature because softening point temperature represents a specified degree of consistency. So irrespective of what binder it is what happens at its softening point temperature or what is the fluidity that is attained by all these binders is more or less similar. That is the reason why we get more or less similar values which is about 800 for all binders at the corresponding softening point temperatures. For example, 30/40 you have to test it at may be 52 degree centigrade, 80/100 you may be testing at 45 degree centigrade, so if that is the corresponding softening points then the penetration values that you can except for these two binders at those temperatures is about 800 where 800 means 80mm.

Therefore making use of this assumption or the experience one of the temperatures will be softening point and the corresponding penetration is 800. Also, making use of the penetration test result which is the penetration that we have obtained at 25 degree centigrade that temperature is again 25. Hence making use of the softening point test from which we get the softening point value the corresponding penetration value is assumed to be 800 and from penetration test we get the penetration test temperature of 25 degree centigrade and the corresponding penetration is what we report as the penetration of the binder. Thus making use of the results we get from these two tests we can calculate the value of temperature susceptibility and from this we can calculate the penetration index.

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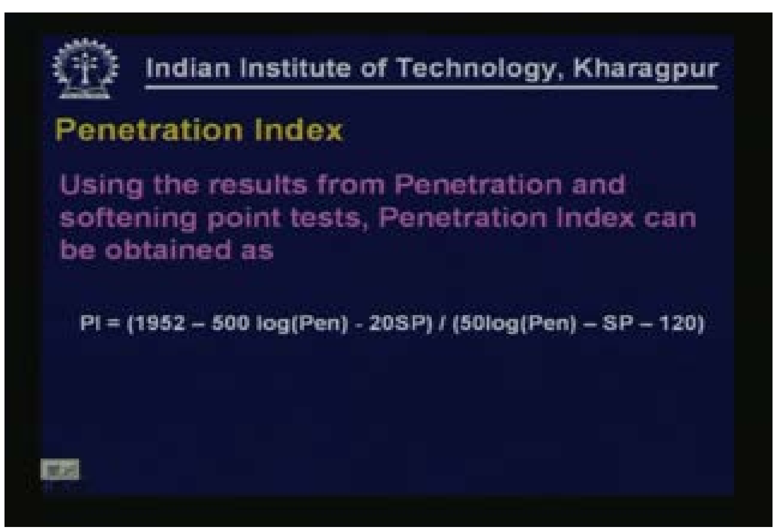

Thus using those results and further simplifying, it gives you penetration index value as 1952 – 500 times log penetration – 20 times softening point and the whole divided by 50 times log penetration minus softening point – 120. So, if we know the softening point value, if you know the penetration value the penetration index can be completed.

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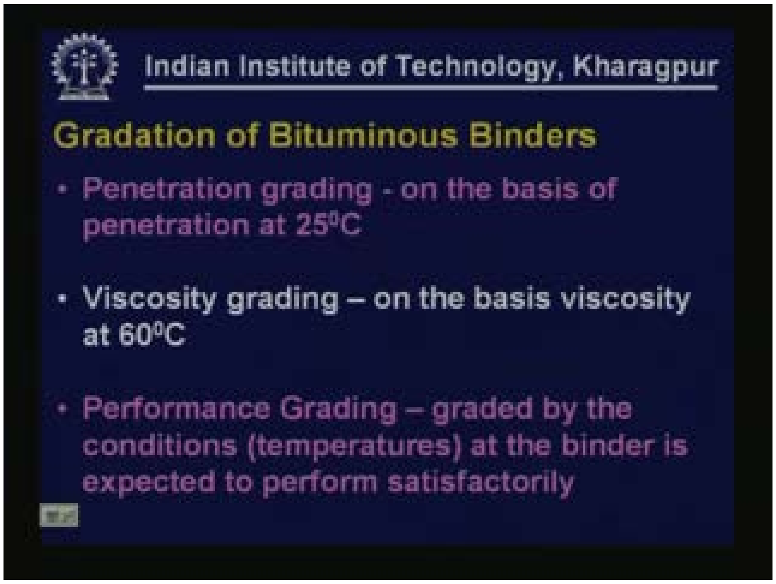

Let us now discuss about the gradation of bituminous binders. Any material when we select for construction then a certain grade of material has to be provided to it like class 1 bricks, class 2 bricks, 53 grade cement and so on and so forth. So every material has to be graded, that is, most materials have to be graded. The most commonly adopted grading system is penetration grading which is done on the basis of penetration bitumen at 25 degree centigrade. There is another grading that adopts viscosity value determined at 60 degree centigrade. So the grading is done on the basis of value of the viscosity obtained at 60 degrees centigrade.

there is another method of grading bitumens now known as performance grading also known as superpave performance grading because this has come out of an experimental study that has been conducted for developing superior performing pavements, superpave.

In performance grading the binders are graded by the conditions usually the service temperatures at which the binder is expected to perform satisfactorily. So obviously these are selected in such a way that they are going to be suitable for a given location. Hence, for a given project site if you identify what is the maximum temperature, minimum temperature the service temperatures then the performance grading is going to give you a binder which is going to be satisfactory under those conditions. Instead of giving you that at 25 degree centigrade this binder will have 80 penetration or at 60 degree centigrade temperature this binder is going to give you so much of viscosity and things like that this is a system which will help us in selecting a binder that will perform satisfactorily over a given range of temperature which are specific to given a project site.

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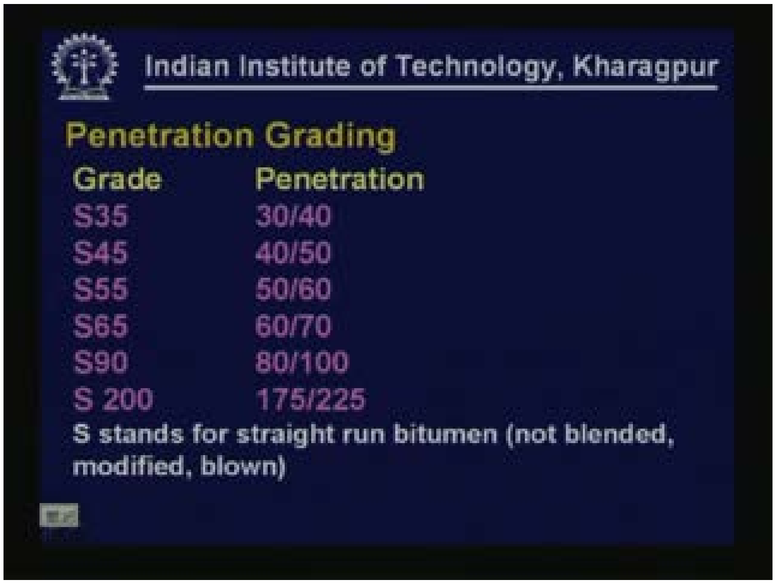

In penetration grading normally we have various grades. The S prefix that we have here on the left hand side stands for straight run bitumen. Obviously these are not blended, not modified, not blown bitumens but these are straightened bitumens which are not modified. So S35 is the average for the 30/40 range, S45 means the binder which is expected to have 40/50 penetration that means 4 to 5mm penetration of the specified needle, similarly S55, 65, 90 and 200 penetration.

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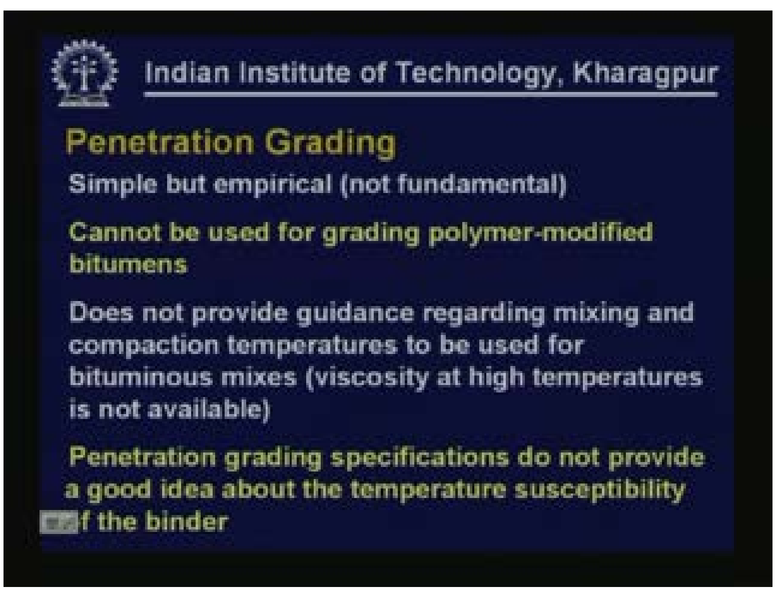

The problem with penetration grading is this is a very simple method because determining penetration is very easy but this is empirical. The property is not a fundamental parameter and it does not really tell us much about rheological behavior of the bitumens. And also we cannot grade polymer modified binders and other modified binders using penetration gradation. This is because two different binders having similar penetration have been found to be giving different performances while used in field. Thus from experience it has been found that penetration grading is not a good system to grade all types of binders. it also does not give us adequate guidance regarding the mixing and compaction temperatures to be used because on the basis of penetration at different temperatures, mixing and compaction are done at very high temperatures that is around temperatures 150, 135, 100, 110 and so on but normally we don't carry out penetration test at such high temperatures, we may conduct it at 25 degree centigrade or it may also be conducted at 4 degree centigrade and so on. With special effort we can still conduct penetration test may be at 60 but conducting penetration test at very high temperatures is not normally feasible.

So, viscosity corresponding to mixing operation or compaction operation is related to higher temperatures. So we do not normally get an idea on the basis of penetration test. We cannot formulate any specifications for mixing temperatures, compaction temperatures and other related parameters. Also, penetration grading specifications do not provide a good idea about the temperature susceptibility because we cannot normally conduct test penetration over a wide range of temperatures, as I just indicated few minutes ago. It is not normally possible to conduct penetration test at higher temperatures. so we cannot get the temperature susceptibility although we can conduct at 4 degrees we can conduct it at 25 degree centigrade where that will give you some idea about what is the temperature susceptibility but still over a much wider range of temperatures that is not possible.

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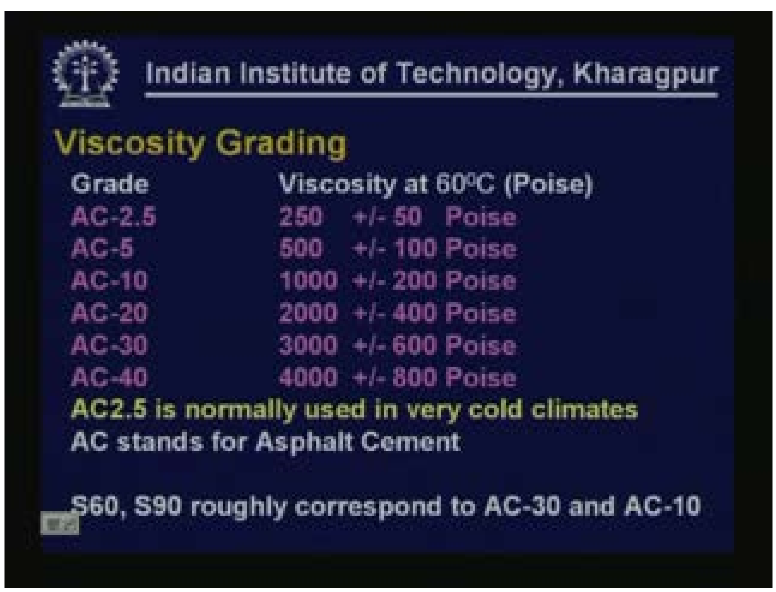

Viscosity grading is on the basis of viscosity measured at 60 degree centigrade. There are various viscosity grades that are available AC-20, 2.5, AC-5 etc. In India we still do not use viscosity grading but what we use is penetration grading. We have AC-5, AC-10, AC-20, AC indicates asphalt cement that is bitumen and if it is at AC-2.5 bitumen it means at 60 degree centigrade its viscosity is going to be around 250 +/– 50 Poise. AC-20 grade bitumen will have a viscosity of about 2000 +/– 400 Poise at 60 degree centigrade. S60, S90 are 60/70 bitumen, 80/100 bitumen that we normally use in India. In terms of the viscosity that we normally get for these binders they can correspond to AC-30 and AC-10 binders.

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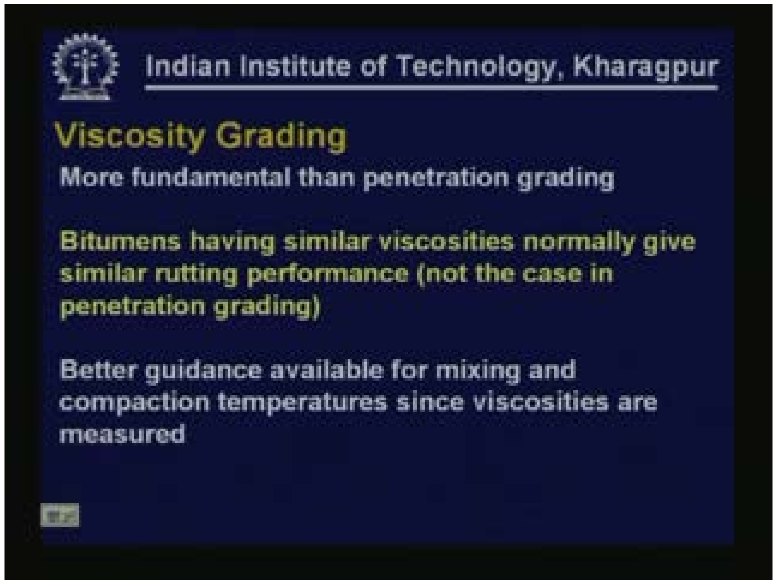

Viscosity grading is more fundamental when compared to especially penetration grading because we are using a more fundamental parameter which is viscosity. Bitumens having similar viscosities normally give similar rutting performance that is similar permanent deformation performance. That means there is a better correlation to what happens actually in field in terms of permanent deformation of those bitumen mixes to viscosity rather than penetration. As I said earlier two different binders having same penetration may not reflect similar type of rutting performance whereas two different bitumens having similar viscosities more or less will give you similar rutting performance. And we also get better guidance for mixing and compaction temperatures because viscosities can be measured at higher temperature also. Especially if we are using rotational viscometer or Brookfield's viscometer we can definitely measure viscosities at much higher temperatures. Then we can formulate guidelines in terms of viscosities for mixing compaction.

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Coming to performance grading this has been a result of a 50-million dollar 5 year long strategic highway research program popularly known as (SHRP) conducted in the United States of America. These are also called as superpave superior performance pavements performance gradation. In this the binders are graded by the temperature range high and low within which the binder has appropriate properties to perform satisfactorily against rutting mode of failure, against fatigue failure of bituminous mixes which is at intermediate temperatures, rutting mode is to be considered for high temperatures, this is service temperature, fatigue failure is to be considered at average service temperatures and low temperature cracking is nothing but low service temperature so these are basically the three modes of failure that are considered in formulating the specifications for performance gradation. So the binder is selected in such a way that for a given temperatures range these three failures can be tackled if the binder that has got appropriate properties within the temperature is selected. Performance grading is based on engineering principles and addresses common bitumen pavement problems like rutting, fatique cracking and in some specific areas low temperature cracking where minimum temperatures can go very low such as – 10, – 15 and so on.

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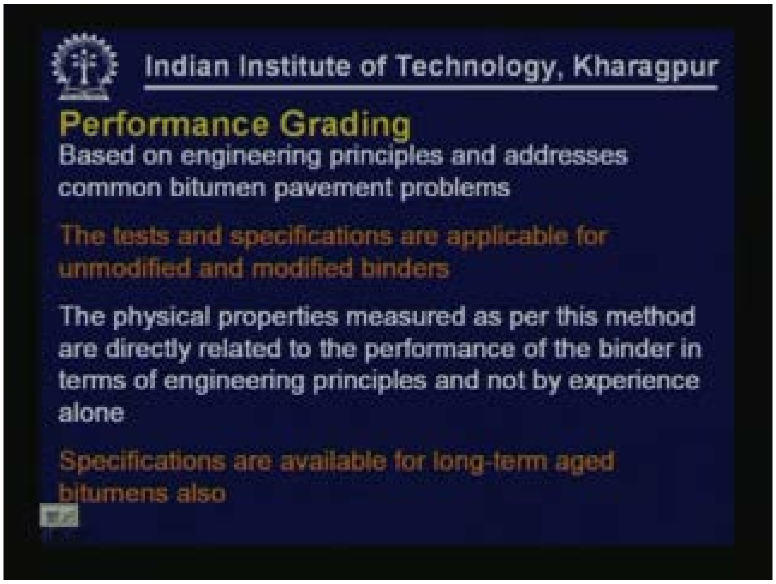

The test and specifications are applicable for unmodified and also modified binders. There is no mention of whether it is a 60/70 binder, 30/40 binder, modified binder, need binder etc but irrespective of the binder type it can be generalized.

The physical properties measured as per this method are directly related because in this specification, we will generally not be talking about softening point but the specifications will be in terms of more fundamental parameters. So this is a more complex system requiring more complex testing procedures. However, in spite of all the complex methodology and costlier equipment one needs to use this is considered to be very rational.

So these properties that we are expected to determine in this procedure or directly related or better related to the performance of the binder in terms of engineering principle and not just simply by experience. These specifications are available for long-term aged bitumens also. The complete range of temperatures experienced at a given site is considered for selecting an appropriate grade of bitumen for the site. This is the most important thing. The bitumen that is selected for a given project is going to be performing satisfactorily within a temperature range.

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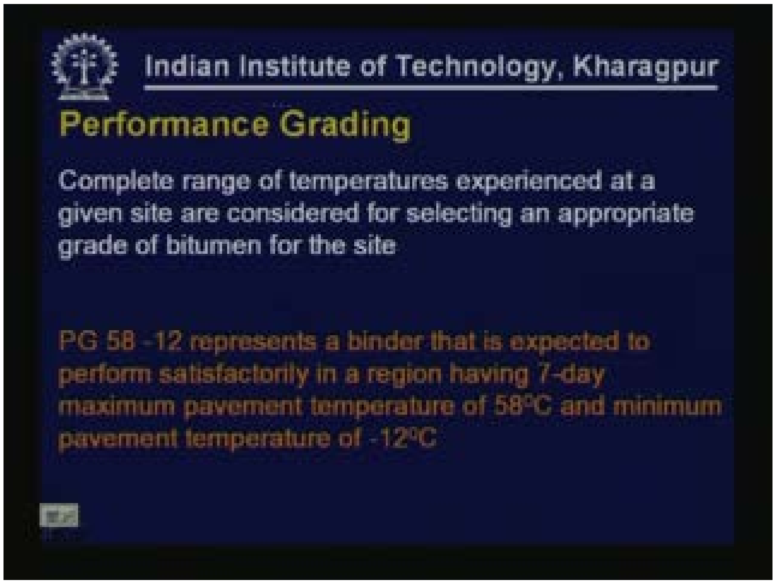

For example, if we designate a binder as PG 58 – 12 that is – 12 this represents a binder that is expected to perform satisfactorily in a region having seven day maximum pavement temperature of 58 degree centigrade and minimum pavement temperature of – 12 degree centigrade.

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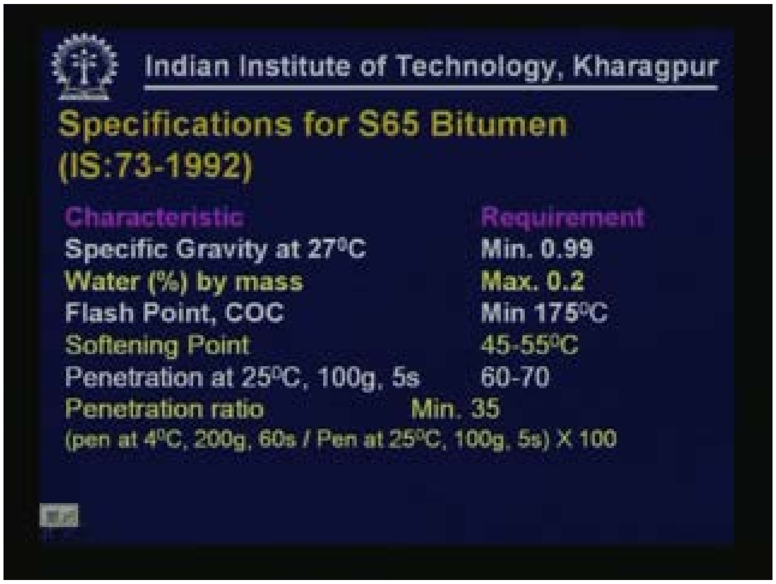

Let us examine a few specifications that Indian standard, IS: 73 specifies for S65. Similar specifications are available for other types of bitumens also. Considering the characters in the corresponding requirement specific gravity is a minimum of 0.99. as we know these are tests that are corresponding to purity of the binder, water percentage by mass should not more than 0.2%, flash point which is a test that we conduct for safety concern should be of a minimum of 175 degree centigrade, softening point normally ranges between 45 to 55 degree centigrade for 60/70 binder, this is a S65 bitumen that we are talking about and penetration obviously has to be between 60/70, penetration ratio should be a minimum of 35, the penetration ratio determined at 4 degree centigrade with 200g mass at 60 seconds time period and penetration at 25 degree centigrade with 100g at 5 seconds time period is expressed as percentage so this should be a minimum of 35. This ensures that the penetration value does not change significantly over this temperature range of 4 and 25.

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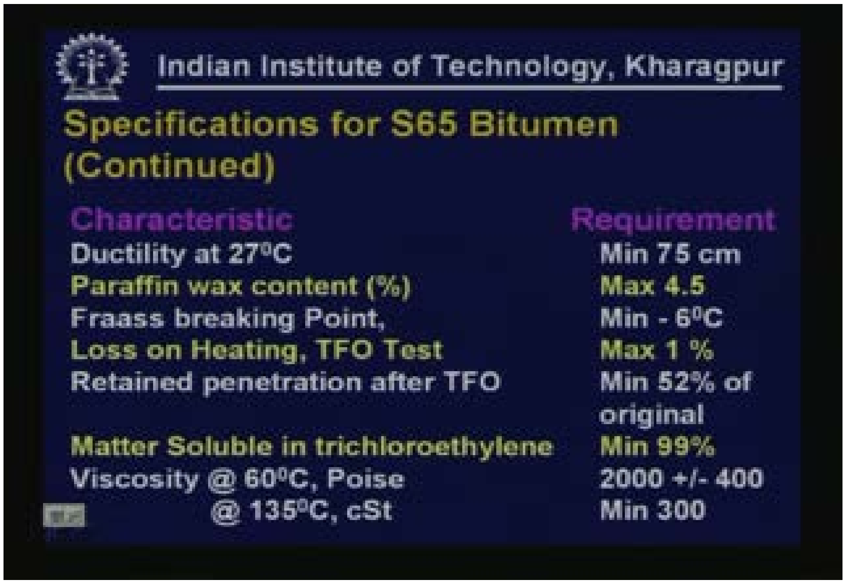

Other specifications for S65 bitumen are ductility minimum of 75 cm that means at a temperature of 27 degree centigrade we should be able to extend the bricket up to a minimum distance of 75 without the bricket breaking. Similarly, the Paraffin wax content should not be more than 4.5%, the Fraass breaking point is the temperature that represents the low temperature behavior of bitumens so it should be a minimum of – 6 degree centigrade, loss on heating that is after we put the bitumen in TFO operators the loss of mass which obviously should be the loss of volatile matter should not be more than 1%. The retained penetration is the ratio of penetration that is obtained after TFO test of the binder and when compared to the penetration of the original binder it should be a minimum of 52% for S65 binder.

Again coming back to the purity, matter soluble in trichloroethylene should be a minimum of 99%, and viscosity at 60 degree centigrade expressed in Poise should be 2000 +/– 400 and viscosity measured at 135 degree centigrade in centistoke should be a minimum of 300.

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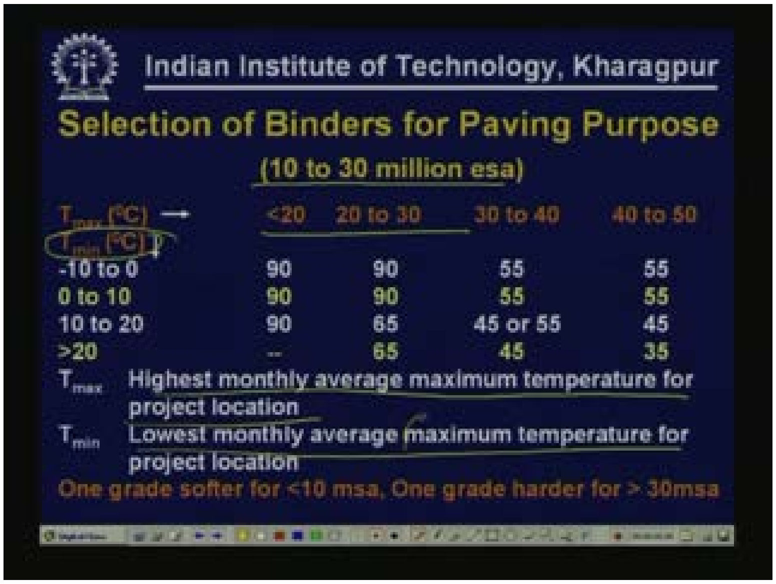

These are the guidelines that are normally available for selecting binders for different pavement purposes depending upon the traffic loading expressed in terms of 10 to 30 million equivalent standard axle loads. We have discussed about what are standard axles and other aspects in lessons that covered traffic related aspects. And here we are using T_{max} which is the highest monthly average maximum temperature for the project location and T_{min} which should be the minimum temperature for the project location. So for these conditions we can select the appropriate binder.

For example, for 0 to 10 degree temperature it is 90, 90 and for higher temperatures we are going for stiffer or harder grades of bitumen 40 to 50 degrees temperature and then even the low temperature is more than 20 these are generally hard conditions we are going for 35 grade 30/40 bitumen, if the traffic volume is less than 10-million standard axles this is for 10 to 30 then we can adopt whatever this table suggests, we can adopt one grade softer or if it is more than 30-million standard axles we can adopt one grade harder.

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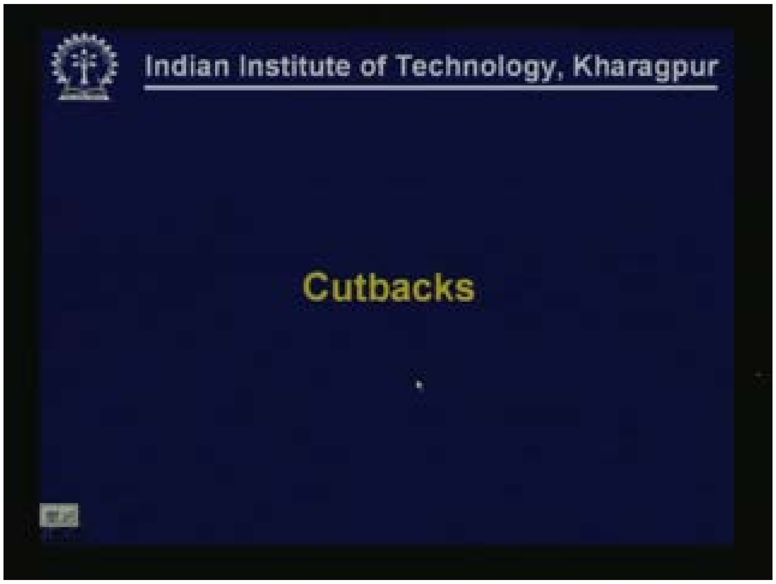

Next we will briefly discuss about cutbacks.

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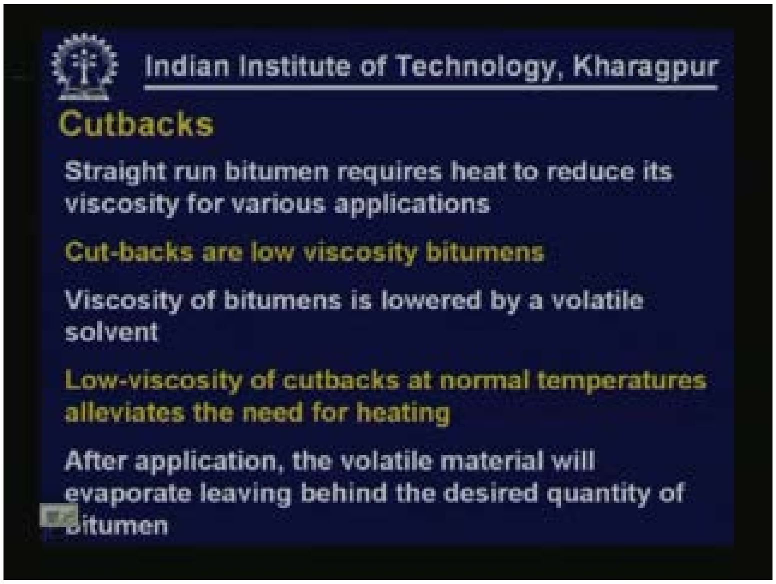

Straight run bitumen requires heat to reduce its viscosity for various applications. Because we have to heat bitumen at normal temperature we cannot spray bitumen, we cannot coat bitumen on to the aggregates. Cutbacks are nothing but low viscosity bitumens. These are obtained by lowering the viscosity of the bitumen using a volatile solvent. The low viscosity of cutbacks at normal temperatures elevates the need for heating. We don't need to heat cutbacks but we can apply the cutbacks straight away. But after application the volatile matter will have to evaporate and should leave behind the desired quality and quantity of bitumen. what we ultimately require is bitumen to be coating the aggregates, the volatile matter is only there to reduce the viscosity and enable us to use it apply it and once we apply it after certain time period the volatile matter should go away leaving behind the actual quantity of bitumen that we require.

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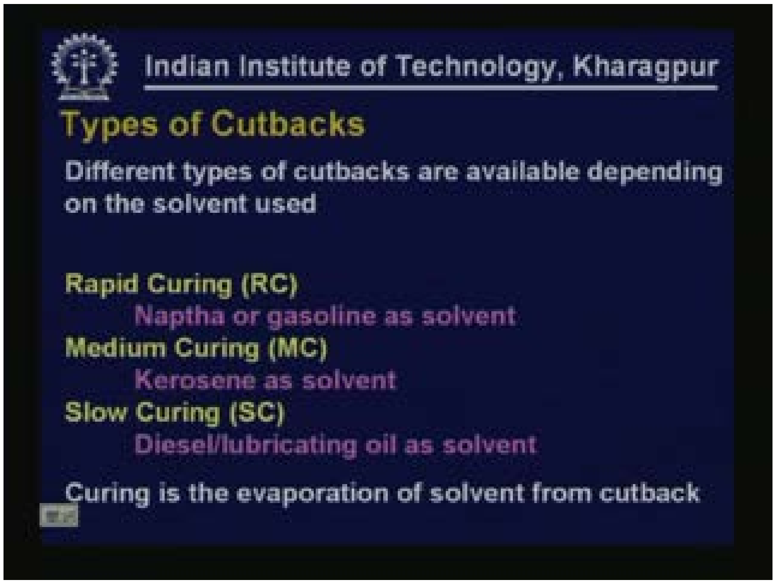

There are various types of cutbacks that are available depending upon how fast the volatile matter gets evaporated. In rapid curing naphtha or gasoline is used as a solvent. Medium curing kerosene is used as a solvent, slow curing diesel or lubricating oil is used as a solvent. As you can see the boiling points of these materials gradually go on increasing it takes more time for diesel to be evaporating compared to petrol. Curing is the evaporation of solvent from cutback.

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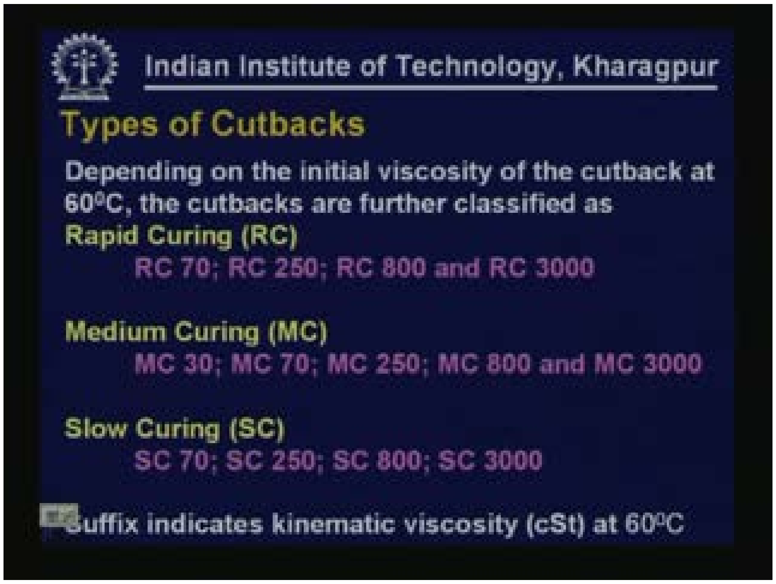

Also depending on the initial viscosity of the cutback at 60 degree centigrade the cutbacks are further classified as rapid curing. For example, RC 70, Rc 250, RC is obviously rapid curing 70, 250, 800, 3000 and so on. Similarly, for slow curing it is SC 70, SC 250, SC 800 and so on. The suffix the number indicates the kinematic viscosity of the cutback at 60 degree centigrade.

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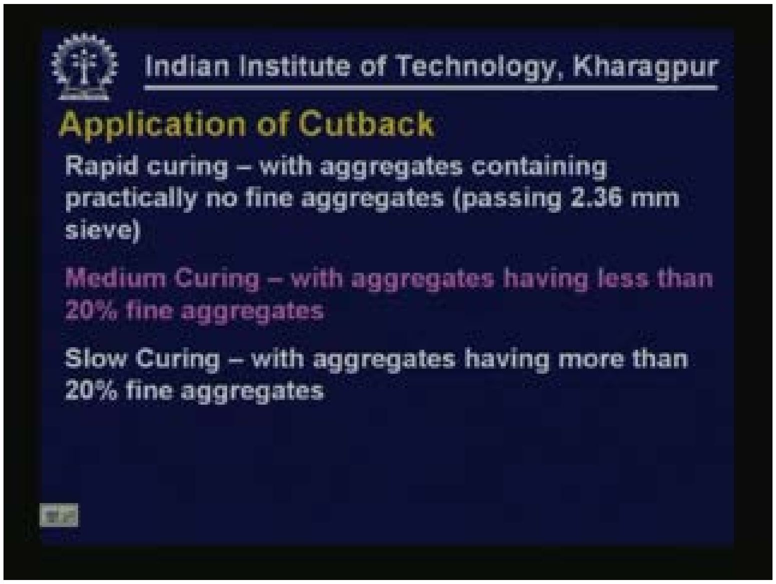

The application of rapid curing cutback is normally used with aggregates containing practically no fine aggregates, fine aggregates being the portion of the aggregates passing 2.36mm sieve. Medium curing aggregates are normally used with aggregates having less than 20% fine aggregates and slow curing cutback is used with aggregates having more than 20% fine aggregates.

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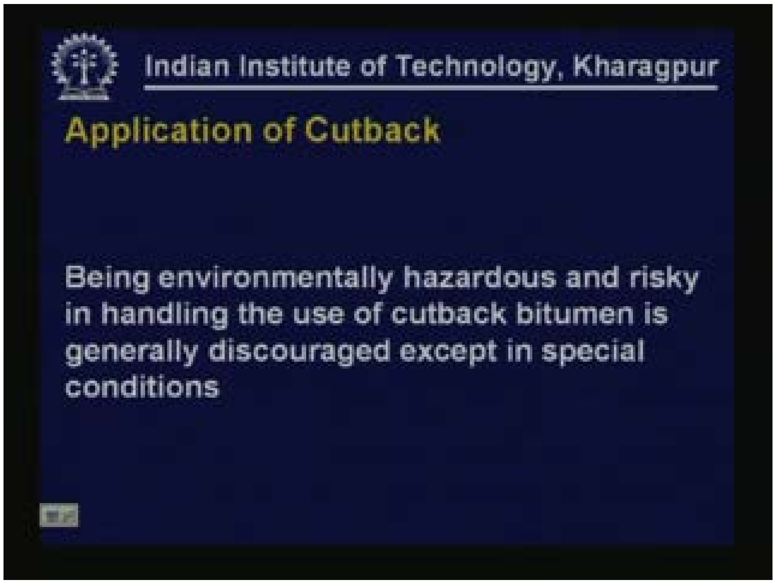

But being environmentally hazardous and considering the risk in handling this material because of the volatile matter that is there the user cutback is generally discouraged except in special conditions. So nowadays the user cutbacks especially in highway projects are not permitted unless special conditions persist.

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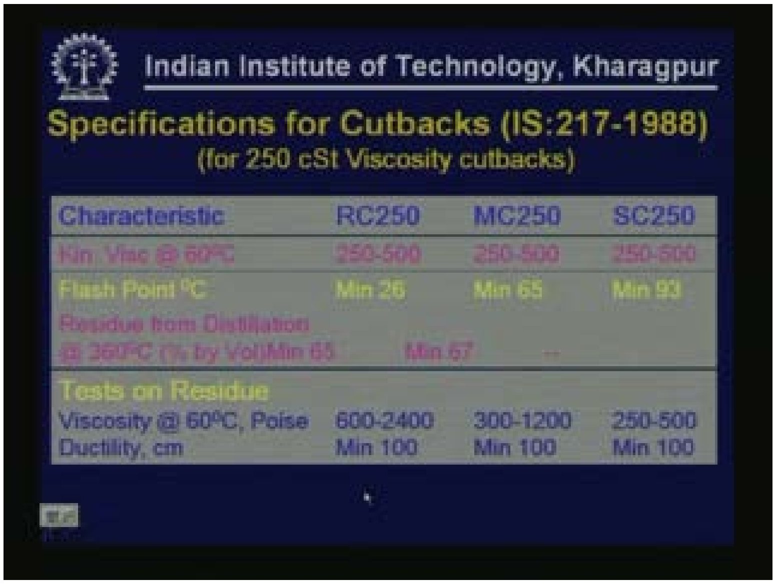

These are some of the specifications for cutbacks. This is in terms of kinematic viscosity at 60 degree centigrade, flash point and the residue that is obtained after distillation because we are interested in finding out what is the quantity of bitumen that is available and the property of the residue determined in terms of its viscosity.

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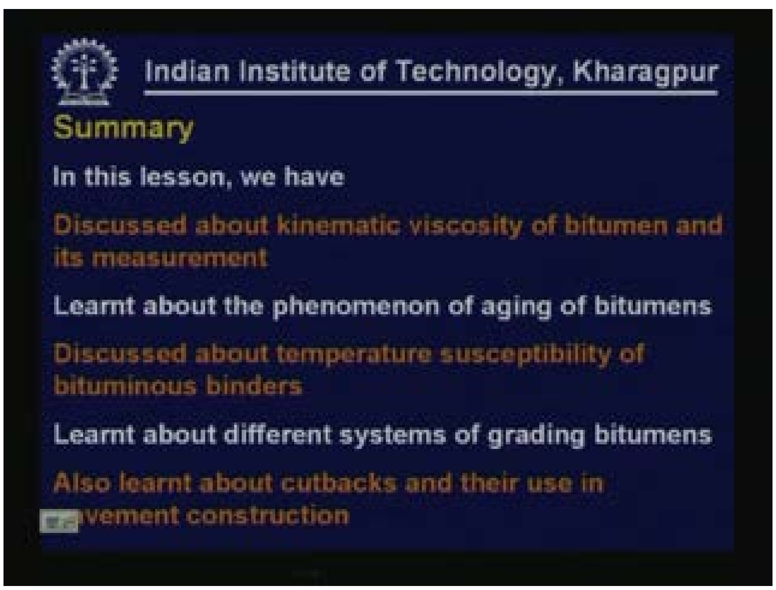

To summarize; in this lesson we have discussed about the kinematic viscosity of bitumen and its measurement because in the previous lesson we have talked about the absolute viscosity or the dynamic viscosity. In this lesson we have also discussed about the phenomenon of aging of bitumens. We also talked about temperature susceptibility of bituminous binders, we have learnt different systems of grading bitumen, we have discussed the rationality of different systems for grading bitumens. We have also learnt about cutbacks and their use in pavement construction.

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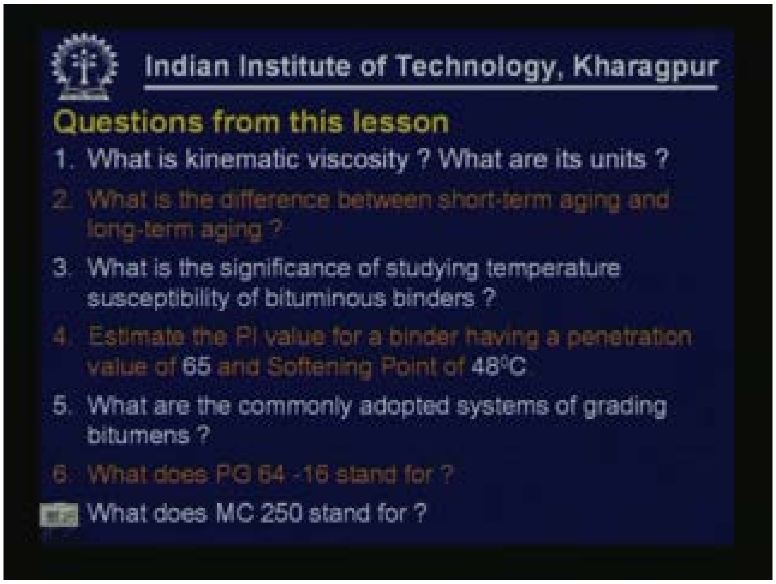

So let us take some questions from this lesson. Answers to these questions will be provided in the next lesson.

1) What is kinematic viscosity and what are its units?
2) What is the difference between short-term aging and long-term aging?
3) What is the significance of studying temperature susceptibility of bituminous binders?
4) Estimate the pi value that is penetration index value for a binder having a penetration value of 65 and softening point of 48 degree centigrade.
5) What are the commonly adopted systems of grading bitumens?
6) What does PG 64 – 16 stand for?
7) What does MC 250 stand for?

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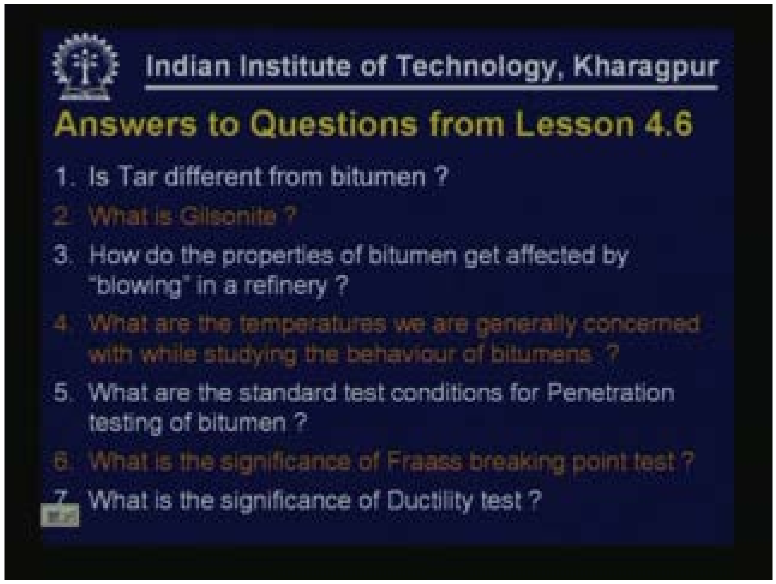

Now let us discuss the answers to the questions that we have asked in lesson 4.6.

Is tar different from bitumen?
Yes, tar is significantly different from bitumen in terms of its origin, in terms of the chemical composition, in terms of how it is produced and also in terms of its physical characteristics. So tar is a different material which is produced from distractive distillation of a coal tar rather bituminous coal whereas bitumen that is naturally occurring is produced from crude.

What is gilsonite?
Gilsonite is naturally occurring bitumen which is very hot and brittle and occasionally it is used to blend with other normal bitumens to increase its stiffness, reduce its penetration and increase its softening point.

How do the properties of bitumen get affected by blowing in a refinery?
By blowing what happens is there is oxidation of various chemical components of bitumen. As a result the penetration value gets reduced, softening point gets increased, viscosity gets increased and that’s how blowing affects the properties of bitumen.

What are the temperatures we are generally concerned about while studying the behavior of bitumens?
While studying the behavior of bitumens we were concerned about very high temperatures. for example, 135, 150 which are relevant for mixing, transporting and then other handling operations such as spraying etc. whereas as far as the performance of bitumen while in service is concerned the minimum service temperature could be – 10, – 15 and maximum service temperature is usually 60 degree centigrade and the average service temperature is about 25 degree centigrade. So we determine the properties of bitumens at these temperatures.

What are the standard test conditions for penetration testing of bitumen?

The standard conditions that we have to adopt are 100g mass, 5 second time period and 25 degrees centigrade temperature.

What is the significance of Fraass breaking point test?
This is the test conducted to evaluate the low temperature behavior of the bitumen. It is not very relevant for most parts of India unless we are facing with low temperatures as low as – 10, – 15.

What is the significance of ductility test?
This test gives us an indication as to how much the bitumen can be stretched at a fixed temperature, how far the bitumen films can be elongated at a given temperature. Thank you.