Pavement Materials
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Lecture 01
Introduction to Soil as a Highway Material

Hello friends, welcome to the course on pavement materials. Today is the first class and we are going to talk about the importance of the subject, the need for studying pavement materials, and we will also talk about some of the important points that we have to remember, while we are characterizing pavement materials in the laboratory.

Today, we will also touch upon the topic of soil, which is the first pavement material we are going to learn in this particular lecture module. This course in general is meant to expose you to various fundamental concepts related to the use and application of different pavement materials that we use in pavement construction. I hope that this course on pavement materials will be useful to all of you, especially those who are learning this particular subject from the perspective of their course curriculum.

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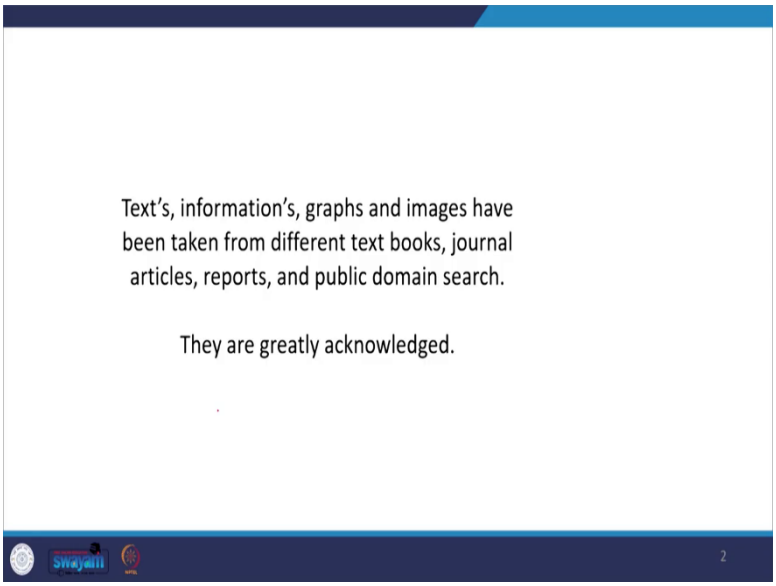

Before I begin, I would like to inform that various text information graphs and images that have been used to make this lecture and other lectures as well in this particular course have been taken from different textbooks, journal articles, reports, and general public domain search and I greatly acknowledge them.

Now, since this is the first lecture and we are just going to start talking about various aspects of pavement materials, I would like to take this opportunity also to thank my teachers, my colleagues from different institute's and also my students. In general, various discussions with

them have greatly enriched my knowledge in the area of pavement materials, and also this process is continuing with time.

I also would like to thank various other lectures on pavement materials that are available in public domain for example, already there is an NPTEL lecture by Professor K.S. Reddy from IIT Kharagpur. And I feel that you know, these lectures are very useful and my lecture or this particular subject, which we are going to learn is just an addition to the existing knowledge in the area of pavement materials. So, what are we going to learn in this particular module?

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We will talk about the need and concepts related to pavement material characterization. So, this is just an introduction to the subject. We will also talk about the introduction to soil as a pavement material as I mentioned soil is the first pavement material we are going to learn about in this lecture.

We will also further talk about the importance of particle size distribution for soils, we will learn about various consistency limits for example, liquid limit, plastic limit and the use of plasticity index. We will also talk about briefly different classification systems for soil and we will spend some time to discuss about the classification system we use in India.

We will further explore the various strength properties of soil that are required to study pavement as a system. We will talk about the expansive soils which are very critical soils and we will further talk about the various ways to stabilize some of these soils which in general cannot be used directly in pavement construction. So, today we will start discussing about these two topics first is the need and concepts related to pavement material characterization

and then introduction to soil as a pavement material. So, let us begin by understanding the term pavement material.

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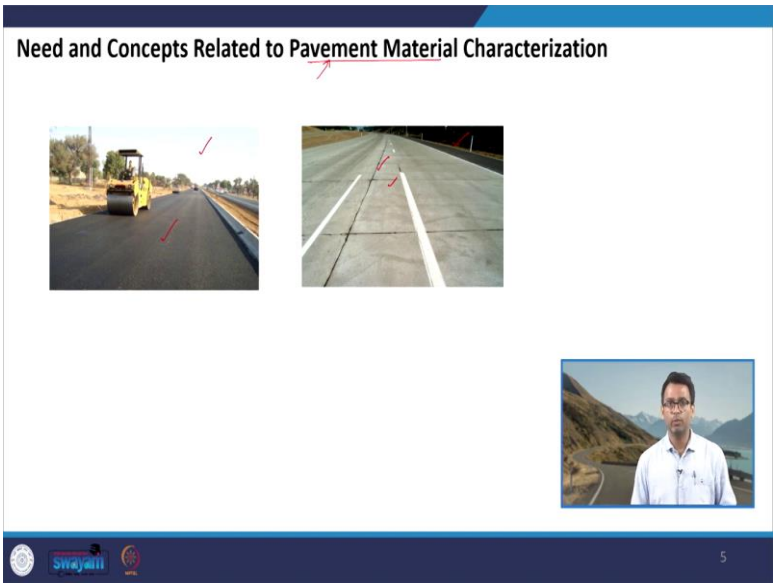

So, when you see the term pavement material, we have a predominant term here is pavement. So, we are learning about materials that are used in pavement. So, just to begin just to have a feel about this subject, let us try to see the two basic pavements that are typically used in construction. So, we have a flexible pavement here and we have a rigid pavement here. So, these are the general terminologies.

So, as you can see some of the differences you can make out from these two pictures are that the flexible pavement appears to be darker in color in comparison to the concrete pavement. So, sometimes flexible pavement is also called as a blacktop pavement. Then you can see in concrete pavement, some joints are visible very distinct joints and the presence of these joints you will also feel once you are riding on the surface of the concrete pavement whereas, the flexible pavement you do not see any such joints present in the surface.

Well, there are other differences between flexible pavement and rigid pavement which does not fall under the scope of the present lecture or present topic we are talking about. So, I just wanted to place this picture so that we can identify that these are two distinct type of pavement. So, if we are interested to know, our interest in this subject is to know the materials which are used to build up these pavements.

So, it is not only the surface of the pavement rather it is the entire cross section of the pavement we are interested in because there are several different materials used in different layers. So, if I just cut open this to pavements, so, how will this pavement look like?

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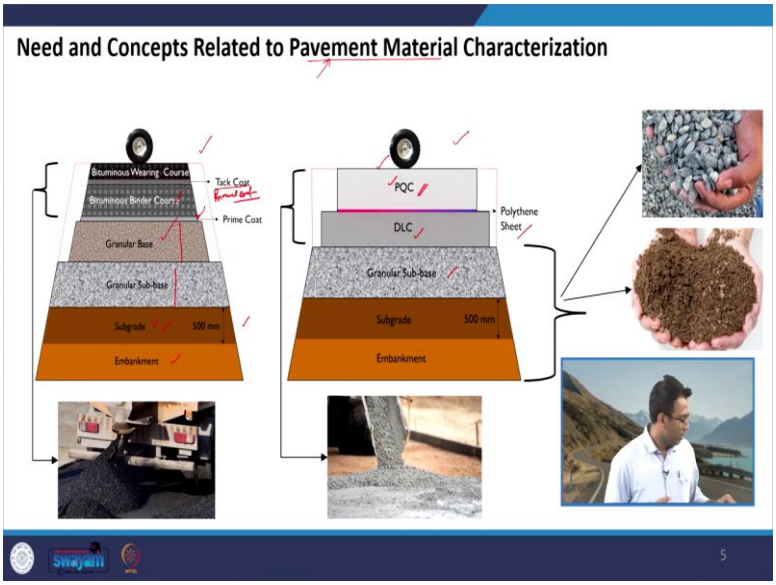

So, this will be a typical you know cross sectional structure, which you know we can assume for these two types of pavement. So, let me just you know very briefly explain about these cross sectional elements or the layers. So, when you see a flexible pavement, let us say the pavement is constructed an embankment. So, you will have an embankment here.

Subgrade sometimes is considered as a part of an embankment or it is an improved layer, which can be made up of similar material we use an embankment or some time we have to borrow this material from some other location if the existing material is not suitable for construction. So, we have a subgrade again made up of natural soil or improved soil.

Then we have granular sub base and granular base. So, these are granular materials made up of different sizes of aggregates. All these layers from below to top that we are seeing here, they all have different functions and that is why they are placed separately as a separate structure individual structure. Above the granular base typically in a flexible pavement we apply a spray application which is called as prime coat.

Above that we have bituminous layers, which can be composed of two or three different layers in general if it is a two layer bituminous system, then the bottom part is called as the bituminous binder course, over that we put another spray application tack coat, so we put a tack coat and then we put a bituminous wearing course.

On the other hand, if you see the cross sectional element of a concrete pavement, again the lower part remains the same that is we have embankment and we have subgrade above which

we are going to construct other layers. Typically, in concrete pavement, the need of other layers are not specifically so important, because the concrete slab itself has the ability to take off most of the load that is going to come on the surface.

However, because of other criterias for example, erosion of layer below or permeability requirement, other layers are also used in the construction of concrete pavement. For example, we have a granular sub base here above which we put a stabilized layer typically which is DLC or Dry Lean Concrete, then we put a polythene sheet to eliminate the friction between the two layers and then we have the PQC or the Pavement Quality Concrete placed at the top.

Now, if you see the materials that are used to make up all these layers. So, let us see the materials that are typically used in the common part in both the pavement that we have embankment, subgrade and then we have granular layers. So up to the granular layers, we have either the natural soil that are typically used in embankment and subgrade.

And then we have granular materials that are used for construction of granular sub base and as well as granular base, the bituminous layers on the other hand is basically a mixture, so this is a mixture of aggregates and bitumen. And then we heat the aggregates and bitumen together we prepare the mix and this mix is further laid for the construction of the surface layer in a flexible pavement system.

Then we have in the concrete pavement we have DLC and PQC both are made up of cementitious material, in DLC the amount of cement is considerably less in comparison to PQC but we can try to imagine both this material as a concrete mixture, so we have cement, water, aggregate, sand and other ingredients that are mixed together and then that are laid and then these layers are compacted.

So, before I begin to further slides and because we are able to see most of the materials here and we have talked about it. Let us try to see these materials with our eyes. So, here I have today with me because we are also going to talk about soil. So, I have different types of soil.

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You can see that I have this packet is a type of soil, it is more of clay in nature not very much recommended for the construction of foundation in pavements, but this is a type of soil.

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This is again another type of soil a little darker in color in comparison to the previous packet which I just showed you.

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We also have aggregates here as I mentioned that this is used for the construction of granular layer this is used for the production of bituminous mixtures, concrete mixtures and so on. So, these are some aggregates in my hand, though these are single sized aggregates, which I am showing you presently, but in practice in a particular layer, the aggregates can be present in various different sizes depending on the target gradation, we are going to talk about these aspects as we move forward.

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Then we have a packet of cement. So, you can see that this is cement that is used for the production of a concrete mixture or a dry lean concrete mixture.

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We also have bitumen. So, this is mostly I mean now, it is more of semi solid in nature, because the temperature of the room is around 25 to 26 degrees Celsius, but if you heat it, this will become fluid and if you cool it down, it will become solid in nature. So, this is more of a viscoelastic material. And we will be discussing about this material in detail in our lecture series.

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Then we have a bituminous mixture here. So, this mixture is something which you can see in the picture here. So, this is the bituminous mixture composed of aggregates of different sizes and bitumen mixed together and we also have some quantity of air voids within the volume.

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This is a cylindrical sample of a concrete mix; we also prepare cubicle samples. So, I have one cubicle sample with me.

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So, this is a cubicle sample you can see for a concrete mix.

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The DLC is also made up of concrete cement based materials, but the quantity of cement is less, this was a DLC which I just showed you. So, these are some of the materials, however, there are various other materials and my intention was to just to familiarize you with a visual idea of these materials.

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So, some of the basic materials that are used in construction, it includes soil, it includes bituminous binders, aggregates, cement, and there are various other materials, but these are some of the very primary materials that are used in construction. For example, soil is used in the construction in earthwork, in subgrade, in embankment.

Aggregates are used in different layers of the pavement in different form, they can be from natural sources, they can be from artificial sources. For example, we can have industrial slag that can be used as the replacement of the conventional aggregates, Under the bituminous

binders also we have certain categories such as we have normal bitumen or viscosity graded bitumen, we have emulsions, we have cutbacks, we have modified binders.

When you talk about cement we have just discussed that this can be used for the production of dry lean concrete for the production of pavement quality concrete and so on. We also have other materials, for example geosynthetics under which we have several products like geocell, geomembranes that have been used in various pavement constructions, we have various other stabilizing agents that can be used for stabilization of soil we have various chemical agents that can be used for modification of primary materials.

So, in pavements, presently the state of the art is that various different materials are being used are being developed and in the future these numbers are going to increase in a huge range.

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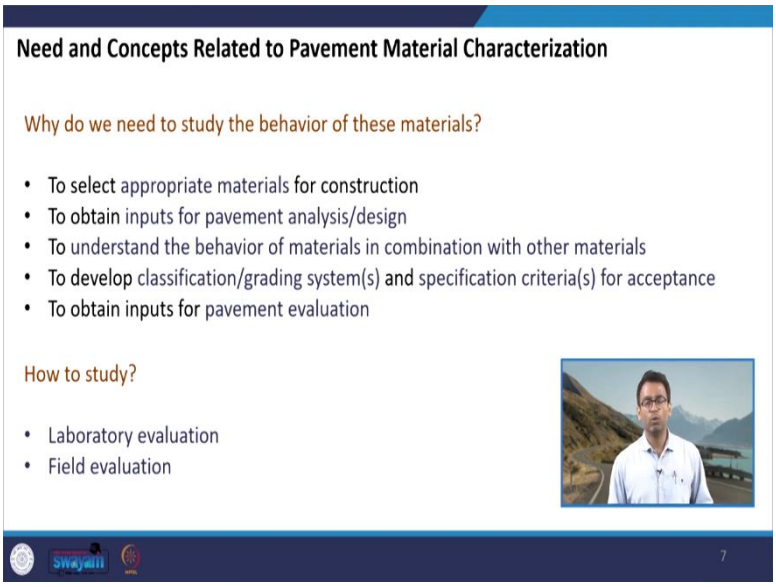

Now, coming to the need of studying pavement material or characterizing pavement materials. So, the question is, why are we interested to know about the properties of various pavement materials and why there is a need to characterize these materials before we can use it in the pavement construction.

So, there are various reasons which can be identified that indicates about the need of studying pavement materials. One is to select appropriate material for construction. So, this is like a pass-fail criteria. So, since for example, we can have aggregates from different sources, these aggregates from different sources, different types can have various mechanical strength, various different properties.

Now, for a specific construction, I want that my pavement should be able to resist the load which is going to come. But if the strength of the material is very low such that it is not able to take up the desired load, my purpose of constructing a pavement fails. Therefore, it is important to me as an engineer, that before doing/going for the construction, I have to test the appropriateness of these materials for the desired purpose for which the construction is being done.

We also need to study the material to obtain inputs for pavement analysis and design. For example, let us say if we are talking about flexible pavement design. In the flexible pavement design, we use resilient modulus as one of the properties for different layers, so that means that I have to have the value of resilient modulus of these layers, in order to design the pavement, in order to analyze the pavement, in order to find the thicknesses of different layers for a given project, where we have some specific amount of traffic, for which I am designing the pavement, where I have a specific number of years for which I am designing the pavement and so on.

So, for pavement analysis and design also we need to test these materials and obtain the inputs that are required during pavement analysis and then design. Then we also need to study this material to understand the behavior of the materials in one hand and also in combination with other materials because my pavement is actually a system, even one layer, let us say if you are talking about a concrete mixture, if you are talking about a bituminous mixture that is a system.

When I say system, it is a composite of different materials. So, sometimes I am also interested to know about the properties of this composite, correlating it with the properties of the individual components with which it is made. So, this is also one of the reasons that I want to study the behavior of individual materials. The study of materials is also required to develop classification and grading systems.

For example, in case of bitumen, we have VG 10, viscosity grading system VG 10, VG 30, VG 40 and so on. Similarly, if you talk about bitumen emulsions, we have different grades, depending on the setting time of the emulsion we have rapid setting emulsion we have slow setting emulsions. So, in order to classify or grade the individual materials under different categories, we need to test this material we need to study the properties or certain different properties of these materials.

Further, the study of materials is also required to get inputs for pavement evaluation. Now, let us say you already have a constructed pavement, let us say that after you have constructed

the pavement for 20 years and after 5 years you visit the pavement and you want to know what is the remaining life in that pavement. So, how will you know the remaining life?

One way is to cut open the pavement get the materials from the pavement tested in the laboratory. Try to see that what is the present property and then the property we use during pavement design. We will use a back calculation process to see that what is the remaining life of the pavement using the same pavement design procedure we adopted while designing the pavement.

Another method is to go for non destructive testing which is the most common way of analyzing the pavement presently, we will take deflection sensors, we will give some load to the pavement we will measure the deflection bowl, we will get the response and this response we will analyze using some available methodologies, using some available theories to back calculate the properties of the existing pavement and these properties will again be put in the pavement design process to calculate the remaining life of the pavement.

So, study of these material is also required for pavement evaluation. Now, we have identified various important reasons, there can be other reasons also in the list, but these are some of the important reasons for which we need to study the behavior of these pavement materials. Now, the question is once we know that there is a need, then how are we going to study these properties or the desirable properties.

The most common way to do it is to do a laboratory evaluation. You have the material with you, you have some list of tests available, some list of tests developed as per specification. We will subject the material to those testing, we will get the results and then we will be able to characterize this material. So, one way is to do laboratory evaluation.

We can also do field evaluation as I just mentioned that if we are interested to know the material properties of some existing pavement system, then we can do some non destructive testing using the results of the non destructive testing we can back calculate the material properties. If we are not in a position to do both this type of evaluation, then we can also use existing theories or correlations to predict the properties.

When I say existing theories it means, let us say you are interested to know the resilient modulus of a bituminous mixture. Now, to know the resilient modulus of the bituminous mixture you have to subject the mix to a specific testing procedure in an equipment which itself is very costly, the operation of which is very complicated. Therefore, and but somehow you want to know the property.

So, what you will do? We will search for alternate methods, maybe I will do some simple testing on the bituminous mixture using a method which is available with me and then I will try to see if there is a correlation between this test which the simple test, which I am going to do, and the resilient modulus, which I desire to find out or I desire to evaluate. So, using the existing correlations and theories we can also predict various material properties.

It is very important for us that, before we adopt any testing procedure to characterize the material, we should be very confident about the robustness of that particular equipment, so that the property which I am getting from subjecting the material to that particular testing should be able to guide us to use that material for this specific project. When I say specific project, try to imagine it in this way, that there can be the same material can be used in various different projects.

And various different projects have their own objectives, have their own requirements. Maybe you are using one type, in one project, you are using this material in a location which is subjected to let us say very high temperature, the temperature of the environment is very high. The same material you are using in some other location, where the temperature of the location is very low.

Now, if the response of this material is temperature dependent, then the material will behave differently in both the locations subjected to same loading conditions. Therefore, in the laboratory, I cannot use a single test to characterize this material for both the locations, which means, the experimentation itself which I am choosing should be project specific.

Now, this is very important, but not necessarily it is always considered as per the available specification, but we have to think about it, we need to ask questions regarding the existing specifications regarding the existing methodologies, and we have to see or we have to explore that, which are those tests methods, which are really useful to understand the behavior of the material for the purpose for which I am using it.

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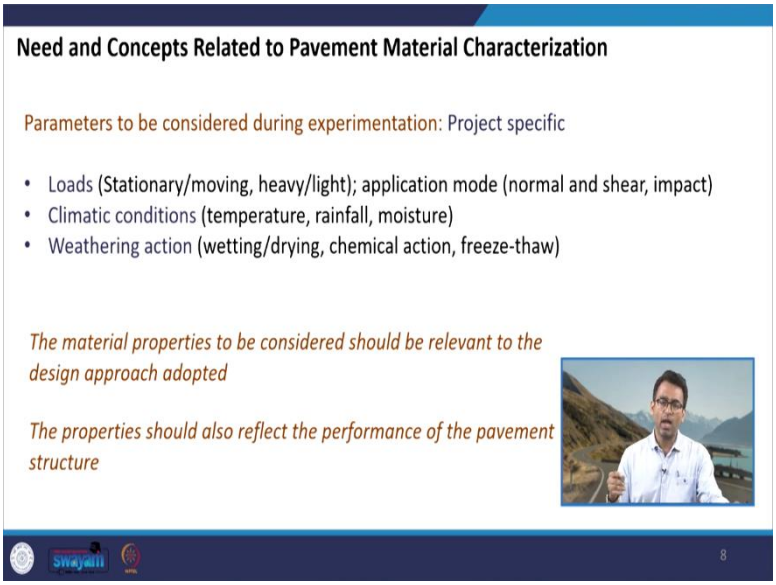

So, some of the critical parameters which I have to consider before doing the experimentation is load, load is one of the very important parameter. So, I have to understand that the material which I am going to use will be subjected to or the material which I am going to use in the pavement system. So, that pavement system will be subjected to which type of load.

Will it be subjected to stationary load? Will it be subjected to moving load? What will be the magnitude of the load? Will the load subject very or will the load impose very high stresses on the pavement layers and the materials? Will the load be not very high? Will it be light? And accordingly in the laboratory I have to see the response. Say the load is moving, and the material which I am going to use is very susceptible to change in frequency or the frequency of the loading or the magnitude of the load, let us say.

And I am using a stationary test to get some material property. So, this material property which I get using the stationary load, may not tell me the or may not tell me about the exact response or exact way this material is going to behave when it is actually used in the field. So, if there is a moving load and when material is susceptible or the response of the material is dependent on the frequency of loading, then it is better to test the material using similar level of frequency at which we are anticipating you know the material will be subjected to in the field.

Similarly, the magnitude of the load, if the load is going to be very heavy, I should be able to apply higher stresses in the laboratory to see how the material will respond to that particular magnitude of stress. Then, when we talk about load, we also have to see the application mode, are we studying the tensile property of the material, are we studying the compressive property of the material, are we studying the material under shear?

So, all these different modes of loading will change the response, some material are very good in compression, but very weak in tension, some materials have high shear strength, but may have lower compressive strength or lower tensile strength. So, we have to understand that this material or this mixture, which I am going to use for pavement construction, what mode of loading will that be subjected to in the actual field condition.

If I know that the critical load to which it will be subjected is shear. Then I have to test, I have to find out the property or the response of the material in the laboratory using a shear load. If the critical load which will be applied which will lead to the failure of the specimen is a compressive load, I need to test the material in the compressive mode. So, accordingly we have to think and we have to adopt those testing which will give me realistic property of the material corresponding to the project at which I am targeting.

We also have to look at the climatic conditions, climatic conditions mainly include the influence of temperature, for example, bituminous material, they are viscoelastic in nature. So, as I just mentioned that if you heat bitumen, it will become fluid, if you reduce the temperature it will solidify, it will behave as elastic material. So, we have to see that the material or for example, if we take the example of bitumen, we have to see what is the range of temperature at which it will be exposed in my project.

And accordingly I have to know the response of the material under that varying degree of temperature in the laboratory. And then once I have the response of the material, and I am confident that this material will behave desirably then I will be able to use it in pavement construction. We also have to see the effect of rainfall or moisture you can say. For example, you take soil, we will discuss that the properties of soil is highly dependent on the change in moisture content.

So, there is one particular moisture content at which the soil has the highest density that is the optimum moisture content, but maybe during monsoons my soil or the subgrade gets saturated and the moisture content changes, which means my pavement will become weak. So, I have to see that what is the moisture content at which I should expose my soil for testing in the laboratory.

And the same response which I get should be used during the pavement design. If we have a location where we are anticipating that the moisture level is not going to change, then using a very high moisture content or subjected or subjecting our sample to a higher degree of moisture may not be correct, because that will not lead to an economical design.

If I know that the material is not subjected to change in moisture content, then I should use the corresponding desirable property and we did not see the behavior of the material under worst conditions. So, you have we have to decide again all these parameters based on the specific project and the location. Then we also have to see whether we are using the materials in the location where there are cycles of wetting and drying, where there can be chemical action, where there can be cycles of freezing and point.

And accordingly I should also test the material in the laboratory because the response the behavior of the entire pavement structure can change depending on these parameters and these criterias. So, the material properties to be considered should be relevant to the design approach adopted as I mentioned. For example, in the design approach, if flexural strength is an input I should do the flexural strength testing, if resilient modulus is an input I should be able to find out the resilient modulus.

So, depending on the pavement design, I should take the appropriate test. For example, in US when doing the pavement design they take the dynamic modulus of the bituminous layer as an input while in India we use resilient modulus. So, why should I do a dynamic modulus test in the laboratory when resilient modulus is an input in the pavement design?

So, this is what I am trying to explain that the material properties to be considered should be relevant to the design approach adopted and these properties of course, should also reflect the pavement performance. When I say the performance of the pavement structure, I am mostly indicating about the critical failure mode, the type of distresses which is occurring. If it is a flexible pavement if you have fatigue cracking I should know that what are the parameters or what are the properties of different layers that can be related to this fatigue cracking and accordingly those parameters I should be testing in the laboratory instead of you doing N number of tests, which gives me no idea about the occurrence of fatigue cracking in the laboratory. So, our target properties should also be chosen such that these properties are related to the critical distresses that occur in the field.

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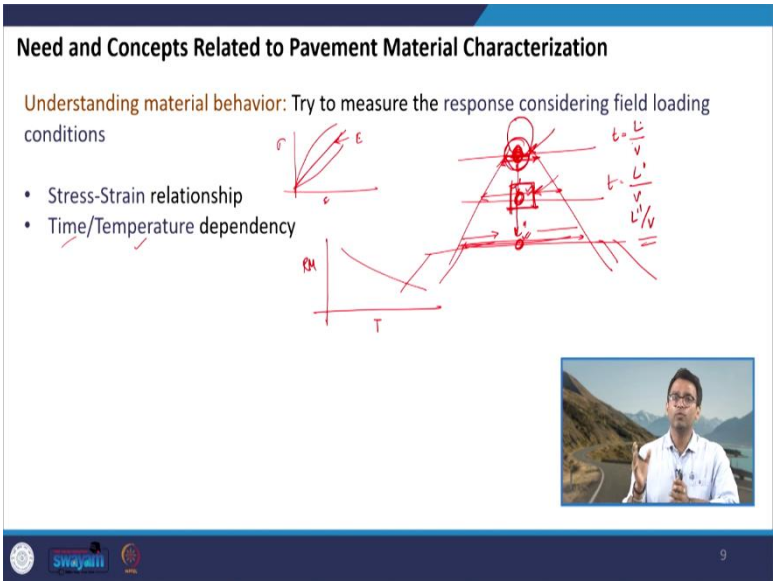

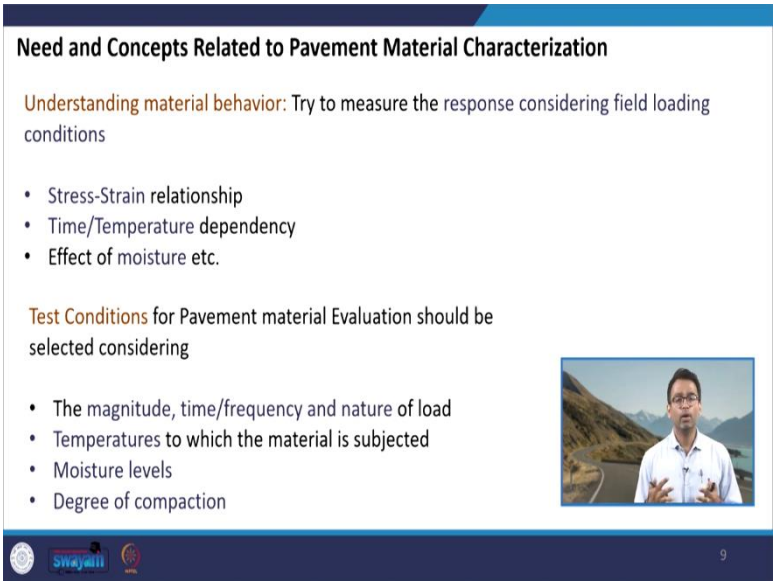

As I have been mentioning continuously that we have to measure the response considering the field loading conditions. And the responses can be seen in various different ways. For example, I can plot a stress strain relationship while doing the testing of the material. So that will, for example, if I am looking at the elastic modulus, then the stress strain property will give me the modulus.

Now, this can be linear sometimes it can be nonlinear or depending on the type of material we are talking about. We are also have to see time and temperature dependency specifically for those materials whose response change considerably with changing the time of loading or the temperature of loading.

When I say time of loading, here I am indicating the movement of the vehicles or speed of different vehicles. So, in fact in a pavement structure, you see that when a load moves, there

is a deflection bowl which is created, there is a stress bowl which is created and then materials in different layers are subjected to different loading times. So, if this is the length of tire imprint at the surface, then this material here is subjected to a loading period of L, if L is the tire imprint.

While material in this particular location is subjected to a time period of L', if this is L'. Material placed here is subjected to a time period of L''. So, you see, as you move down the duration of loading, it increases, but the magnitude of load will decrease, because the highest magnitude will be at the surface and then the magnitude will decrease as we go beneath.

So, when I am testing this material to get the response of this material, then the question is, in the laboratory, if I am doing a testing in which I can vary the magnitude of the load as well as the loading period, what loading period I should use, what magnitude of load I should use, and this magnitude of load and the magnitude of loading period should replicate the standard conditions in the field, so tell me about the behavior of the material when it is placed in the field.

Similarly, when I am testing a material here, I have to give a smaller loading time because the loading time is small here in the field, but the magnitude of the load is high. So, I have to select the stress levels, the strain levels, the loading period when I am testing material from this location accordingly and similarly for different layers.

Talking about temperature dependency, I have to see that how the property of the material changes with temperature, let us say I am talking about the bituminous mix, I might be interested that how the resilient modulus changes with temperature. And then there is a particular standard temperature at which I am doing the pavement design.

So, I am more interested to find out the resilient modulus at that particular temperature, but if I am targeting for the properties at a range of temperature, I also have to see the temperature susceptibility of that particular mixture. For example, granular materials, the properties are not very sensitive to the change in temperature. So, I might not be very interested to see the variation in properties by doing the test at different temperatures in the laboratory, I will do the test only at a standard temperature. And that should be sufficient to tell me about the properties. But for soils for example, the temperature may not be an important parameter, moisture content is an important parameter. So, I am interested to see the behavior of the soil at different moisture content.

The same is not true when I am talking about a bituminous moisture, I am not going to vary the moisture content to see how the material responds because that is a dense mix, the properties of the material does not considerably change with changing levels of moisture. So, these important points we have to remember while we are thinking about characterizing the pavement material in the laboratory.

So, finally, we can say that the test conditions for pavement material evaluation should be selected considering the magnitude, time, frequency and nature of the load, we should know the temperature to which the material is subjected in the field and accordingly the temperature should be selected. We have to select the moisture levels depending on the rainfall in that area, depending on the water table in that area.

We also have to select the degree of compaction depending on the field density conditions we are anticipating. So, all these factors have to be considered while doing the laboratory evaluation because the results of laboratory evaluation is going to influence finally my pavement design. And once the pavement design is done, then we have to be very confident that this pavement design which I have done for targeting for a specific design period should perform as I am anticipating it to perform because this requires a lot of effort in the laboratory, a lot of testing, a lot of use of materials. So, we have to think about optimizing the time optimizing the use of machines to characterize the samples in the laboratory. So, with this background on understanding the importance and need of studying pavement materials, let us start discussing about the first pavement material in our list and that is soil.

We will start by understanding soil more as a pavement material, because soil mechanics anyways is a very vast subject and we are not going to discuss in detail about all the concepts related to the soil from the perspective of soil mechanics, rather, we will focus our discussion on understanding the soil on understanding the properties of the soil from the perspective of using it as a pavement material.

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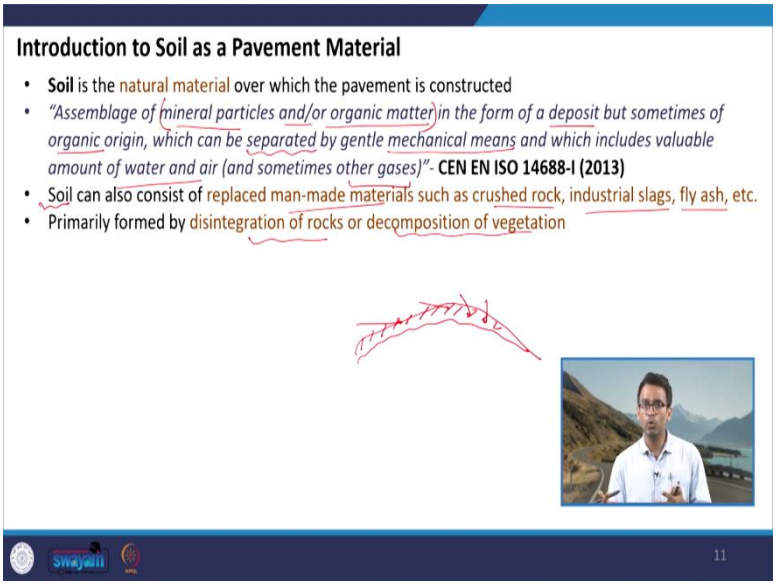

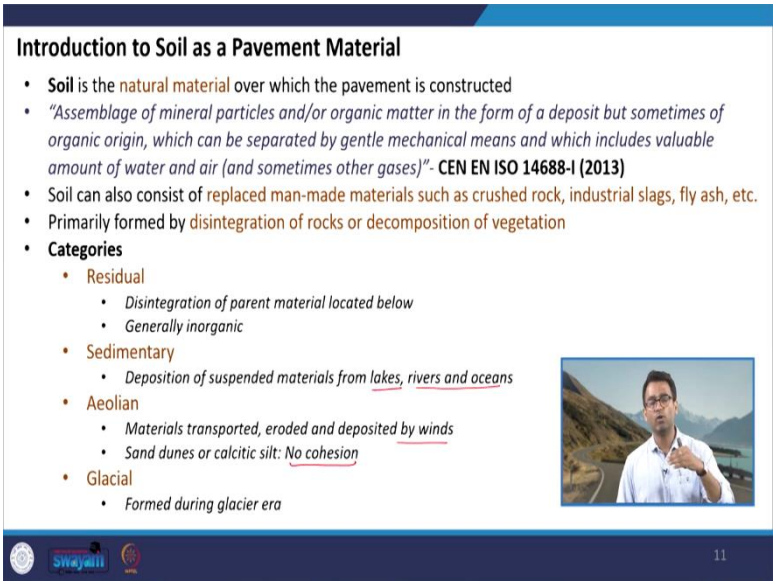

So, soil can be defined as a natural material over which the pavement is constructed. So, this is the simple definition of soil considering that we are going to use it in pavement construction. So, if you see the definition given in CEN EN ISO 14688. The definition states that soil is an assemblage of mineral particles. Now, these are some critical words which tells us, which gives us much indication about the properties of soil.

So, it is an assemblage of mineral particles and or or organic matter in the form of deposit but sometimes of organic origin which can be separated by gentle mechanical means and which includes valuable amount of water and air and sometimes other gases. So, this is a definition placed by this particular specification. And it tells us that soil basically consists of minerals, it can consist of organic matter.

Mostly it appears as a bulk but it can be separated by using, by through mechanical means, by subjecting the sample to mechanical forces. And soil in general it contains certain amount of water as well as air, if you see the volume of the soil. In addition to the natural soil, it can also consist of replaced manmade materials. For example, we can have crushed aggregates crushed rock, we can have industrial slags, we can have use of flashes, etc. So, the soil which I am going to use as a foundation layer in the pavement, so this is what I am referring to here.

It is primarily formed by disintegration of rocks or decomposition of vegetation. So, the existing rock which is there at the surface, it can decompose over a period of time let us say this is the existing rock. So, the top layer will decompose over a period of time, this decomposition can be due to weathering action can be due to movement of water can be due to chemical action and so on and for a considerable period of time.

So, this top layer it becomes weak, it changes its mineral composition, it changes its physical nature and it gets converted to a new material, which we are denoting as soil. So, it can be formed by disintegration of rocks or decomposition of vegetation also. The existing vegetation can decompose and it can take the form of soil and these are like organic soils.

Now, if you talk about the categories of soil. So, these are a few categories, which can be listed, so we have residual soils, as I mentioned, these are from the disintegration of the parent material, which is just located below and it is weak in nature in comparison to the parent material. It is generally inorganic in nature, because it is coming from the rock as the parent material.

Then we have sedimentary deposits, which can be in the form of suspended materials from lakes, rivers and oceans. For example, you have alluvial soils, you have marine soil, so alluvial soils are better in comparison to marine soils if you see them as a construction material, we have Aeolian soils which comes to movement or winds. So, these are material transported eroded and deposited by winds. For example, we have sand dunes, we have calcitic silt.

So, these materials usually for example, sand dunes, they do not have any cohesive properties though they have high angle of internal friction, but the cohesive properties between individual particle is negligible. So, again you have to see that how these properties are going to influence your structure if you use it as a foundation material. We also have glacial soils that come from the Ice Age. Now, these are kilometers of layers of several particles like cobbles, like gravels, like boulders, and these are typically seen in the northern hemisphere.

So, I think we have spent some time today discussing about different aspects and we have also started discussing about the soil as a pavement material. So, let us stop here and in the next class, we will continue our discussion of understanding the soil as a pavement material and further we will try to explore more properties that are important from the perspective of use of soil in pavement structure. Thank you.