Mechanical Characterization of Bituminous Materials
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Lecture-15
Asphalt Usage and Processing Part-1

So, hello everyone, what we are going to do in this lecture is to gently introduce what is asphalt? What are the various usages and how it is processed in the universe in the refinery? Most of us who are taken an undergraduate degree in civil engineering are familiar with production process for bricks, cement and steel. But, construction materials such as bitumen for which the production process is fairly complex. Involves considerable understanding from chemical engineering as far as refinery processing is something not understood by most of us. So in this lecture that will follow we will go through.

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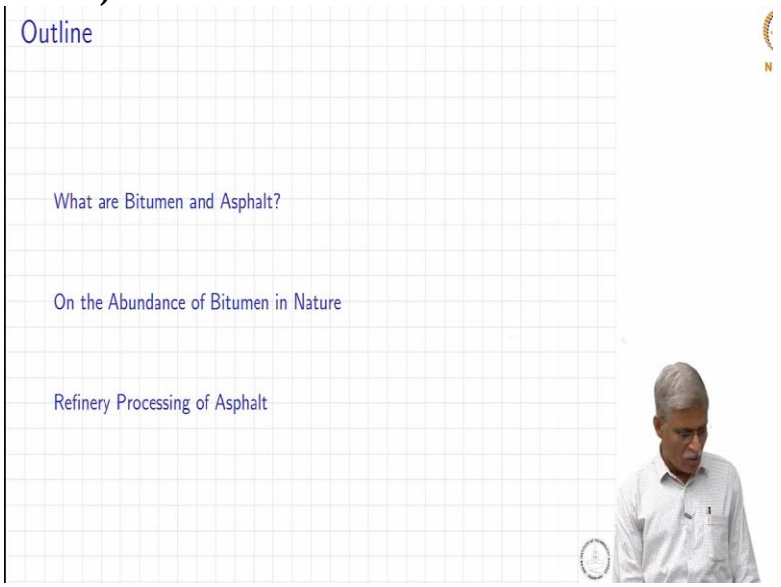

Discuss what is called us bitumen or asphalt. Then we will talk about some historic aspects of bitumen. This is probably one of the oldest construction material known to humanity. So, we need to also understand its associated history. And then we will talk about the refinery processing of asphalt. So, we know start talking about Bitumen and Asphalt. So we need to understand these words are used interchangeably in the practice.

Most of us who start working in highway engineering are always here first time the word tar road but this is not really tar road thar comes from the destructive distillation of coal. And if you live in India, the words bitumen is used a few go to United States, North America, the word as for these used and each of them have completely different meaning. And even in the Indian Roads Congress specifications, you will also see interchangeably the words bitumen and asphalt being used.

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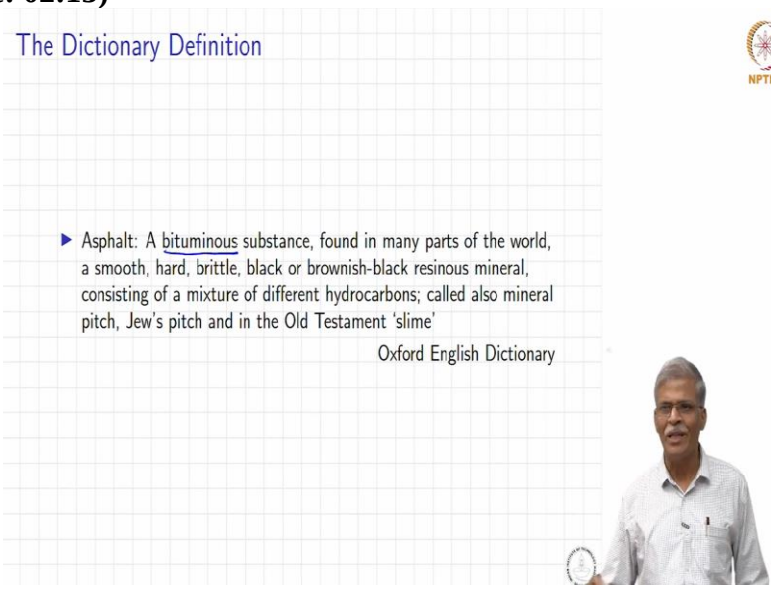

So it is necessary for us to first understand what is bitumen what is Asphalt. So if you go read the Oxford English Dictionary, this is the definition that you are going to see. And the interesting part here is asphalt will be defined in terms of bitumen. So, you can actually read the complete definitions for yourself.

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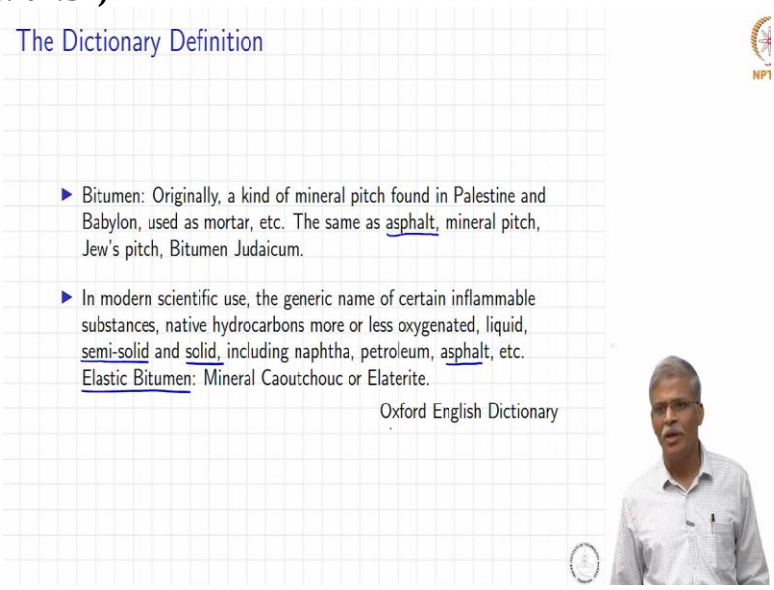

And if you go take a look at the definition of bitumen that is given in the same Oxford English Dictionary, you are going to see that it is defined in terms of asphalt so looks like they are using interchangeably the word at different places. And if you read a little more here, you will also see words such as elastic bitumen semi solid, solid and you will also see asphalt being used all over the place. So, there is nothing elastic about bitumen there is also nothing solid or semi solid about bitumen.

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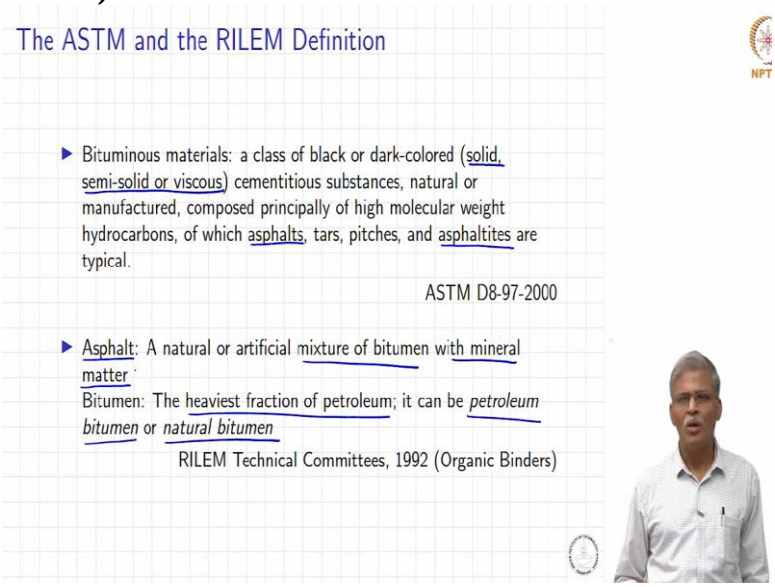

So let us look at what the ASTM standards say, the ASTM standards more or less it says the same thing. You can actually if you read it, it says a class of black or dark color solid or semi

solid or viscous. In fact, when these people mean semi solid what they really are talking about is a viscous material or what we will introduce as a viscoelastic material and you are also going to see that a bituminous material consist of asphalt and of course, this asphaltites something nothing but the lake asphalt that we see.

The reasonably close definition that you will see has come from the European Union standards, International Union for standards and testing and you are going to see about bitumen as the heaviest fraction of petroleum. It can be petroleum bitumen or it can be natural bitumen also and you should now look at very carefully the first line it says, asphalt is a mixture of bitumen with mineral matter. So, that means, what you mentioned is asphalt is nothing but asphalt concrete. And what is mentioned as bitumen is nothing but the binder that is used and the binder can be refinery processed or naturally available.

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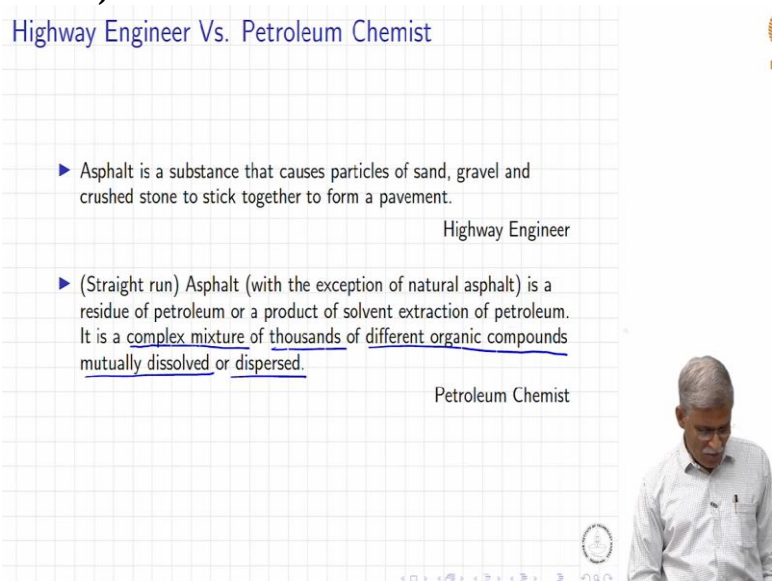

But if you read a very popular highway engineering book, the observations are completely different. They will be talking about like glue, that's what you will see. If you read from a petroleum chemist, the definitions will be completely different and I just want to underline few things they will say it is a complex mixture of thousands of different organic compounds, which are mutually dissolved or dispersed. So, what it means is depending on the field of study on the specialist who is writing this definition, the characteristic of this material seems to be keep changing.

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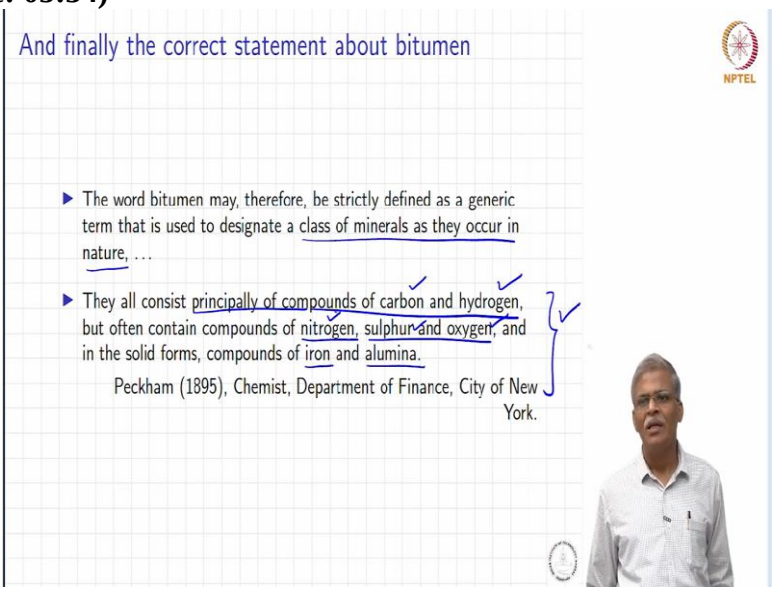

So, what exactly is the correct word the correct word that in my opinion, which most of us agree in this field, it is basically a class of mineral as they occur in nature, and we should be talking in terms of compounds of carbon and hydrogen. It also contains nitrogen sulfur and oxygen and little bit about iron and aluminum. And in fact in later lectures Dr. Nivita will talk to you something about the chemical composition and the influence of carbon, hydrogen as well as nitrogen, sulfur and oxygen on the response of the material. Okay. So, we will more or less strict to this definition because this in a sence seems to characterize the elemental composition of the material.

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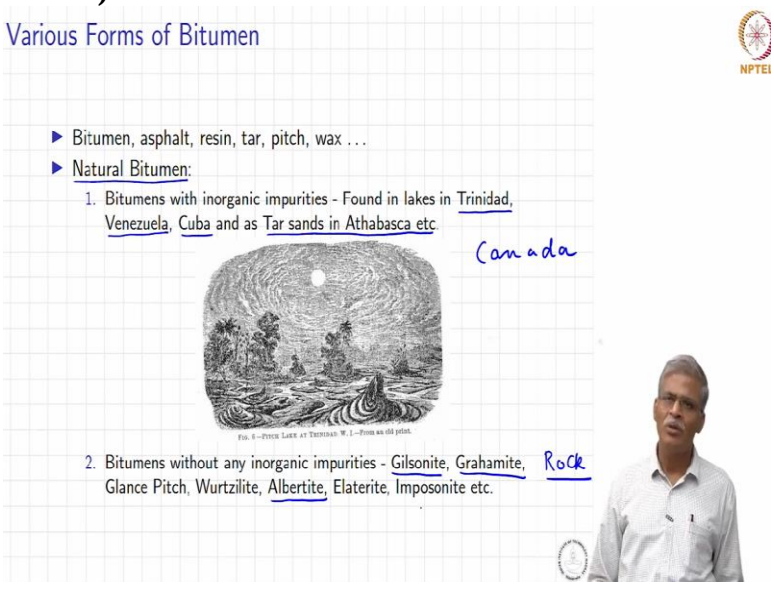

It is available in different forms and in different forms it has different names; resin, tar, pitch, wax or some of the names. It is available in natural form in the form in lake and they are what are really called us the lake asphalt and they are predominantly found in places such as Trinidad and Venezuela, Cuba and right now, there is a increased interest in the tar sands that are available in Canada.

And Canada is spending substantial amount of money to convert the higher ends basically petrol and diesel from the tar sands and eventually we are going to end up with substantial amount of bitumen that you can be used for road construction but that we will discuss about it later. It is also available in the form of rock. In fact, what you are going to see here is Gilsonite it is from Mount Gilson, Grahamite from the place called Graham and Albertite is from Alberta, Canada and all these are names that are associated to the geographical location.

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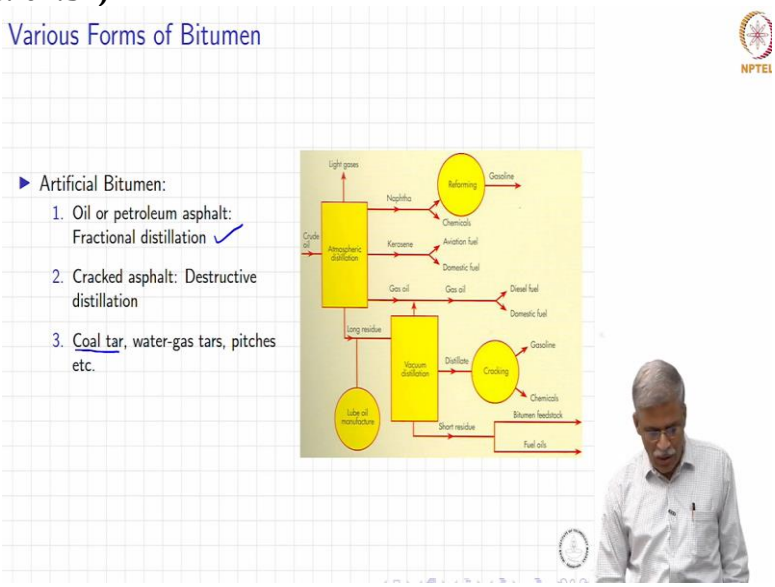

As far as the bitumen that we are going to be talking about in this course, this is more from the refinery process and we will be spending a lot of time talking about the refinery process. You can even classify coal tar as bitumen, pitch also has bitumen.

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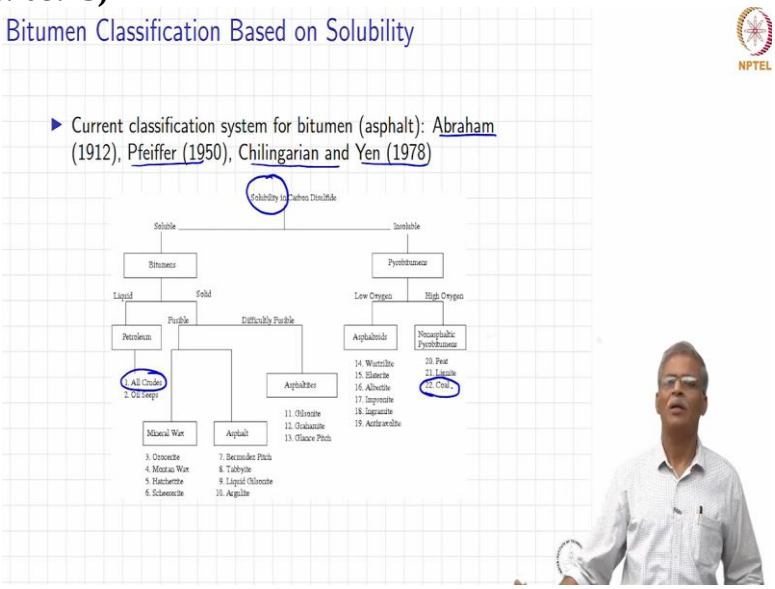

So, we will come to that in the next slide. The authoritative classification of bitumen more or less have come from the works of Abraham. In fact, he wrote 2 volumes of an influential text which was published in a different editions from 1912 to 1940. And detailed in discussions have been presented in the textbook. This is also due to the work of Pfeiffer as well as later by Chilingarian and Yen. Basically, the classification system that is followed is based on what is really called us the solubility system.

And more or less even today the bitumen classification is based only on the solubility. If we start from the solubility of carbon disulfide, which is what Abraham proposed originally, you have one at one end all croons and the other end coal. So, you have 22 set such subsets that can all be called as bitumen. So, in a sense, it may not necessarily be correct, but there is always a reason why you call it as a tar road because what thar is basically is also comes from the family of bitumen.

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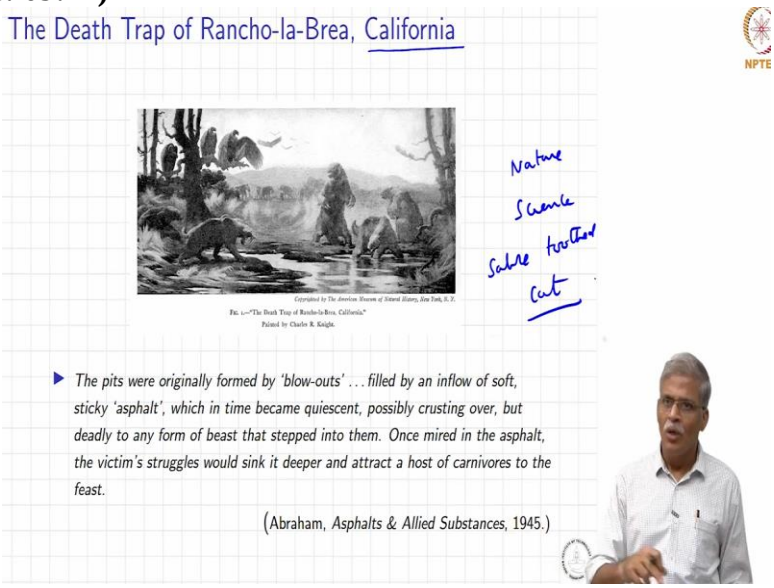

So, where is it available abundantly in nature because this is one of the historic material that has been known to humanity from the humalian period or even before that. This is an amazing would cut that you will see in the Abraham book 1945 edition. So, here he talks about the death trap of in California basically it is the bitumen that comes in oozes out forms as a lake. Due to the oxidation that happens during the daytime, the surface of the lake resembles that of is solid material, but just one feet below it, it is a viscous material. So, the most of the animals get trapped there.

And in fact, very recently, when I say very recently in the last 20 to 30 years, most of the papers that have been published in Nature or journals such as science, where they write papers on sabre toothed cat all have come from this particularly, it is a very interesting material, we will be talking about the preservative nature of this material and you will you are going to notice that it can actually preserve the skeleton as it is. So this is the death trap in California.

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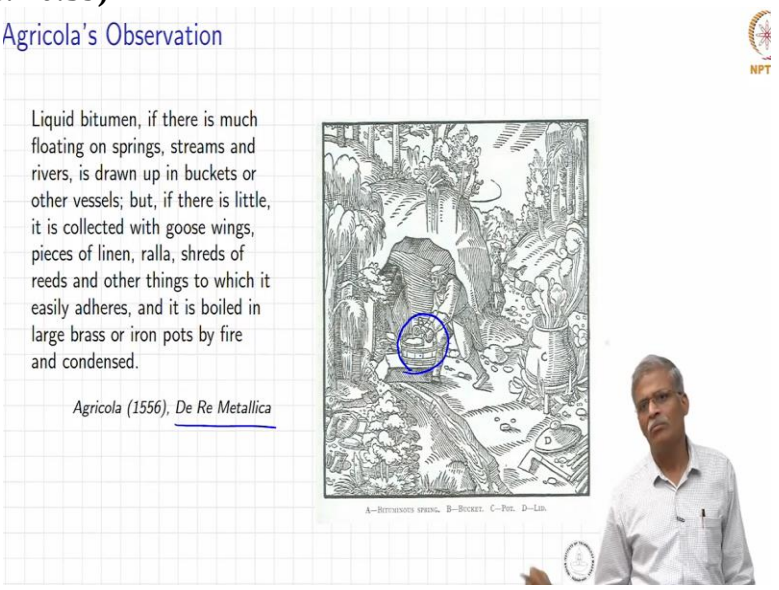

If you got come little more closer to our current time period, the very first book on metallurgy written by Agricola and it is called De Re Metallica 1556. And again, this is a woodcut that clearly tells you how bitumen is processed here. So, he gives a detailed description of how one should collect liquid bitumen from the lake and how it should really be processed.

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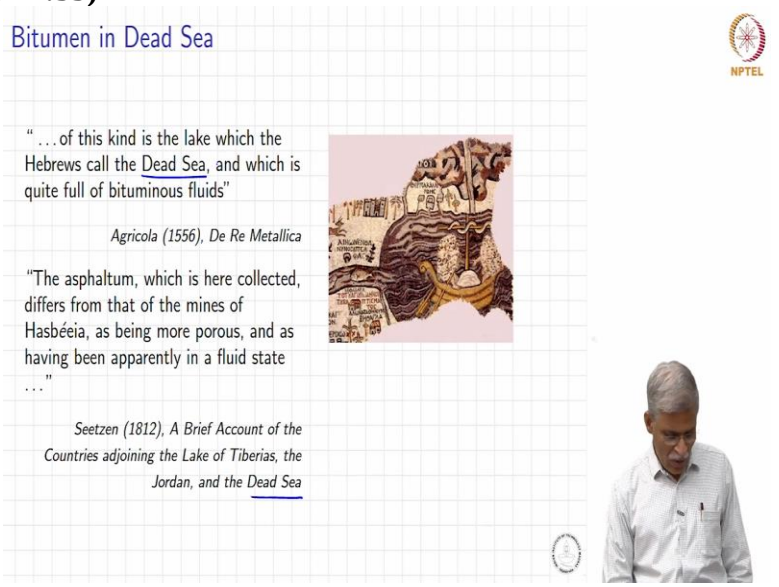

We come little more closer and you are going to see something about the bitumen that is available in Dead Sea. In fact, we can actually see that so, these are some of the interesting information related to bitumen that is available there.

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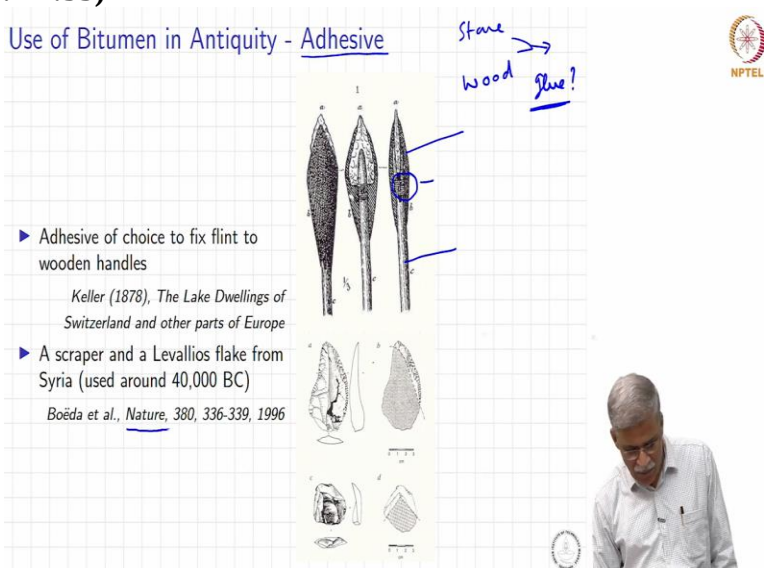

As I mentioned the earlier the very first construction Material known to human is stone and wood so, how do we know connect them together, you need a glue. So, which is the glue that was known at the time the glue that is available naturally. So, what they used to do is you can actually see that this is wood and this is a stone piece and you just stick them together with bitumen and then tie them around with wooden fiber. And now you have a weapon in your hand and this was probably the first use of bitumen as an Adhesive. Again, you can as I mentioned, these papers have been published in Nature and this is the time period that one should be aware of related to such studies.

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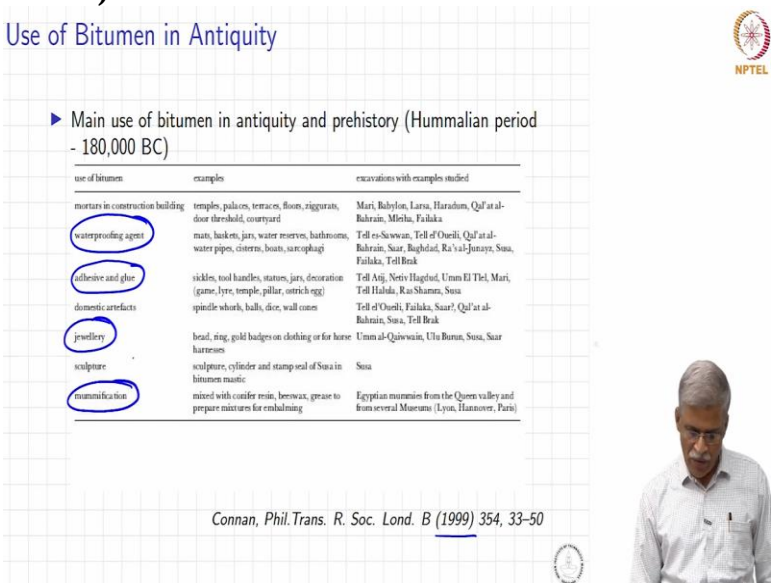

A very influential paper came in 1999 in the Royal Society, London by Connan and he was talking about the various uses of bitumen and in fact, you can actually see the mention of adhesive and glue waterproofing agent, jewellery, mummification and mortars in construction.

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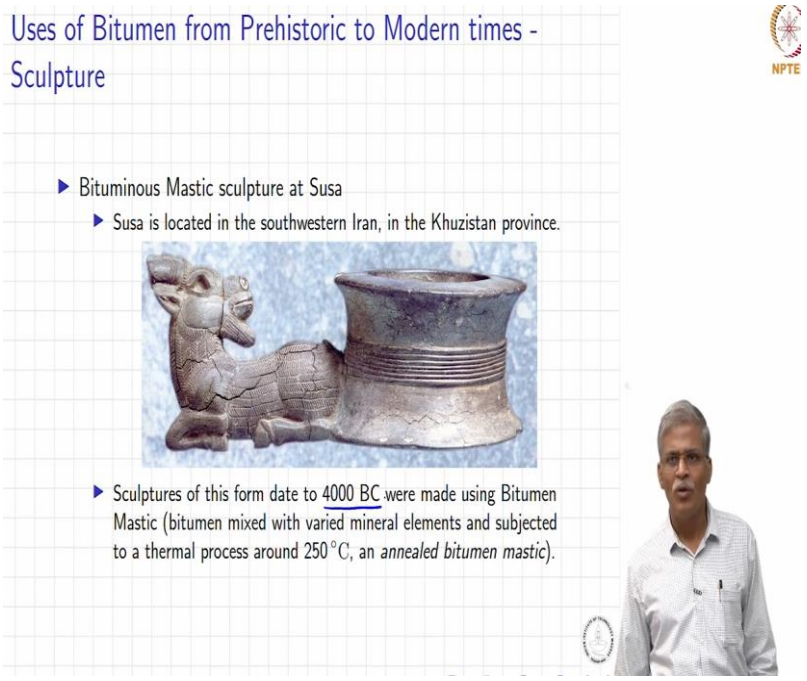

So, let us quickly take a look at some of them because this will give us some idea about the history, the nature and the significance of this amazing material. So, this is a bituminous mastic sculpture at Sousa, it is an Iran and what they used to do is to take mineral matter, mix it with a bitumen that is available and burn it in a thermal process. So, you basically get a rock in which one can do sculptures. This is the time period we need to know this is the time period in which we did not know how to wrap properly to do a sculpturing of our stone. So these were actually the original stones that were used for such kind of sculptures.

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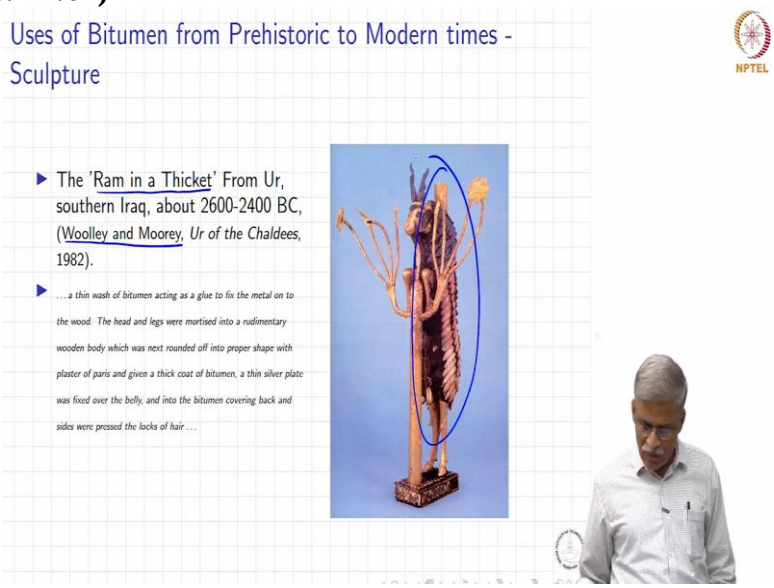

Then you will also see that it has been used as a body. In fact, what you see here is the Ram in a Thicket it is again given in one of the very influential archaeological investigations by Woolley and Moorey. And you actually see that the entire body that you see here is filled with bitumen and the gold was applied around it.

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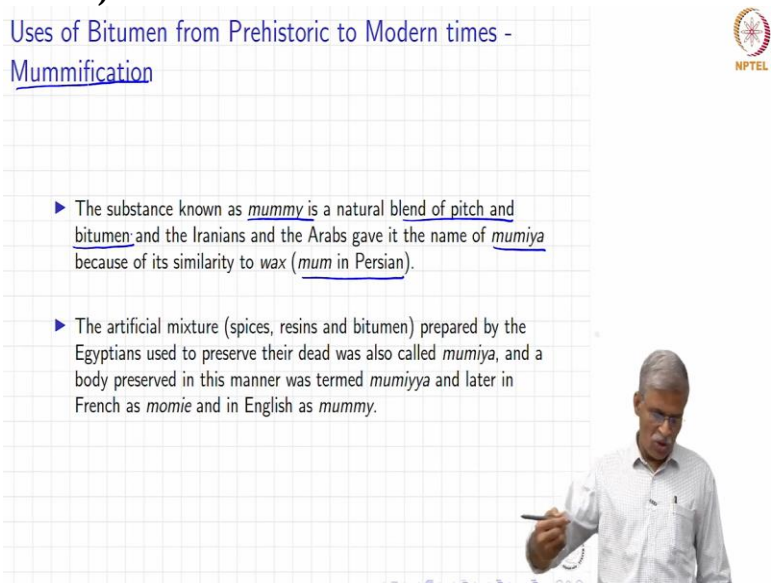

And the next and the interesting use which we really cannot ignore when we go in passing is something to do with the mummification. And in fact, the word mummy basically comes from the word mumiya in Persian mum is basically what we call us bitumen so it is a blend of pitch and bitumen. These artificial mixtures of spices, resins and bitumen by the Egyptians used to

preserve their dead was also called as mumiya. And when it came from French when it came to English, it becomes mummy.

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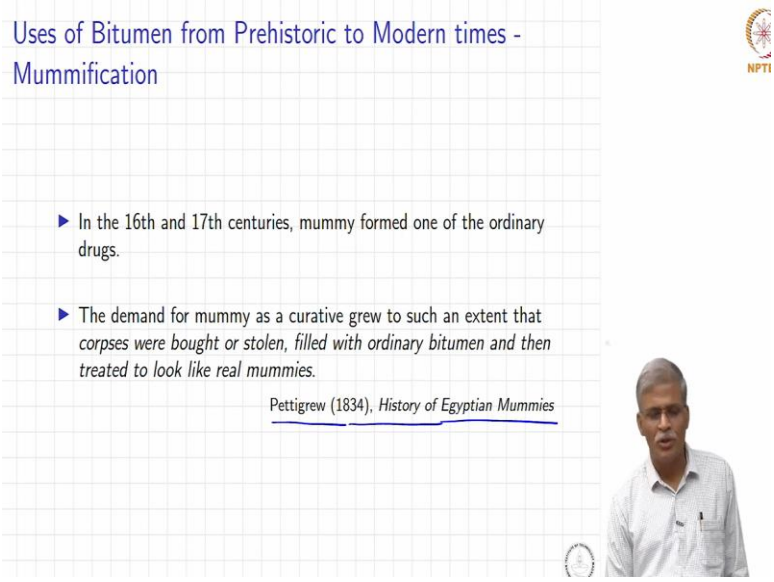

And there are interesting histories associated with some of the mummification. You can see some of this detail is in history of Egyptian mummies by Pettigrew, if you want more details, you can always get in touch with one of us and we will be very happy to provide more information.

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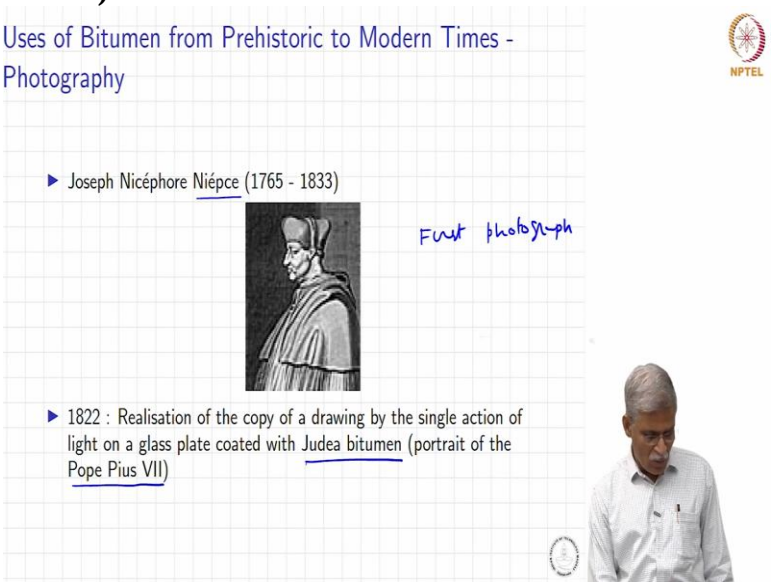

And we come a little more closer. So this is probably the first photograph. And in those days, they used to call it as Niepce camera. This is the name of the person who actually invented this technique. Of course, this is the first picture is obviously the picture of Pope Pius seven. So you take bitumen, dissolve it, Judea bitumen, dissolve it in a solvent, and then allow it for aging basically what you really called as the process similar to what we used to do in the old films. But you hear you allow it.

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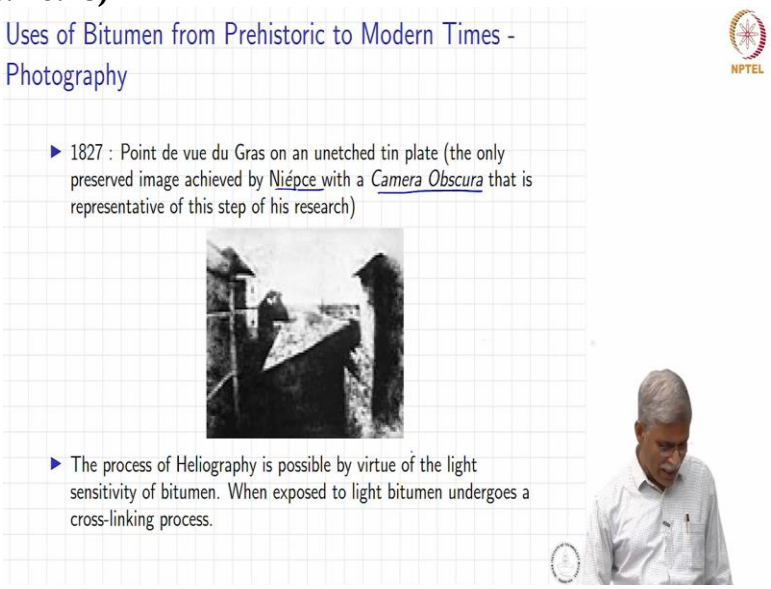

But the exposure time is months. And this is a picture of Niepce from the Niepce camera. And in fact, this was called us obscura camera. So this is the picture of the courtyard that is a scene from his window, the whole picture took more than 2 to 3 months to get etched on this plate. And then he used the process through which the he could get what is called as the positive of this film. And in fact, very recently, this whole process was revisited and published in a paper in which they could exactly follow the instruction given by Niepce and get similar picture.

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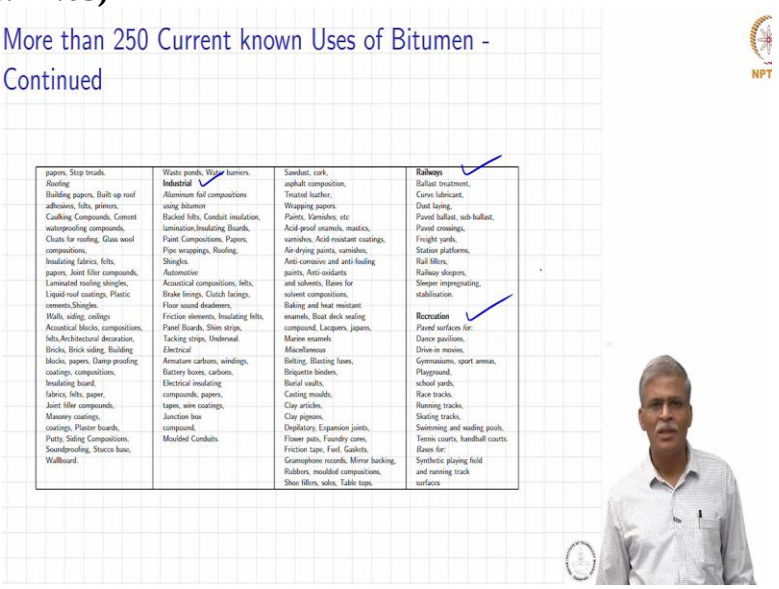

The exposure times were more than 3 months. So, there are more than 250 current more uses of bitumen from agriculture, buildings, hydraulic and erosion control, paving of course, and the story goes on and on, you can say industrial uses railways, recreation purpose. In fact, there is not even one field in which bitumen has never been used, it has always been used in all the things.

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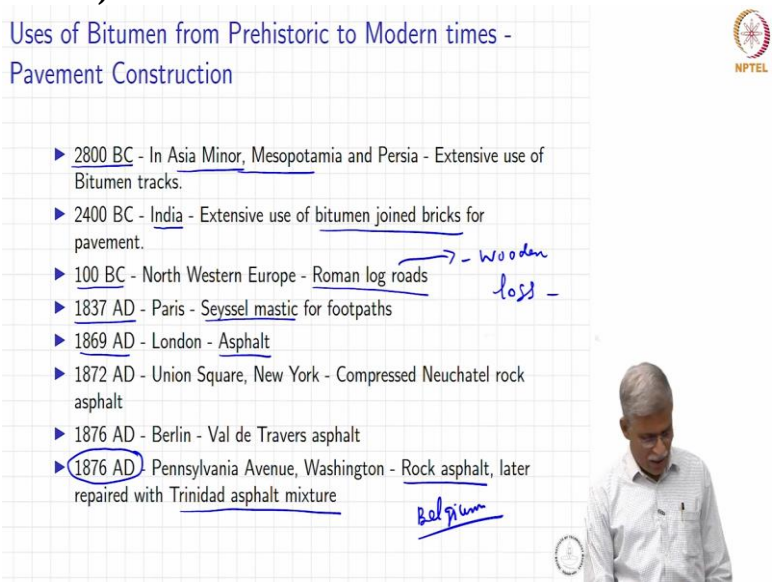

But as far as this course is concerned, our main interest is in the use of bitumen in road construction. So, I have given here in a snapshot some of the interesting history about the road construction more or less the very first construction of roads started in 2800 BC and of course,

this is in Mohenjdaro Harappa Civilization, Asia Minor. And in 2400 BC, we actually had bitumen joint bricks.

And when many archaeological investigations have precisely pointed out to such kind of roads that Europe log behind very much you could see those roads coming only in, what are really called as a log roads log roads are nothing but wooden logs. And these wooden logs were joined together by the use of bitumen. But the very first road came only in 1837 AD what is really called as Seyssel mastic 1869 in London.

But the correct road construction that more or less is followed even now, was just laid in front of the White House in Pennsylvania Avenue in which There was a mixture of rock asphalt with the Trinidad asphalt mixture. Now, why do I say that this is the technology that was more or less that we follow here because this was given by a Belgium engineer? So what he came up with the idea is to heat the stones heat the bitumen mixed them together, transported to the site, lay it, roll it and compact it more or less, this is the crux of your bituminous payment construction.

And such technologies originally started with this road construction in 1876. And we have more or less been following it. We have better missionaries, we have better understanding of this road construction technology but the crux of the technology started in 1876.

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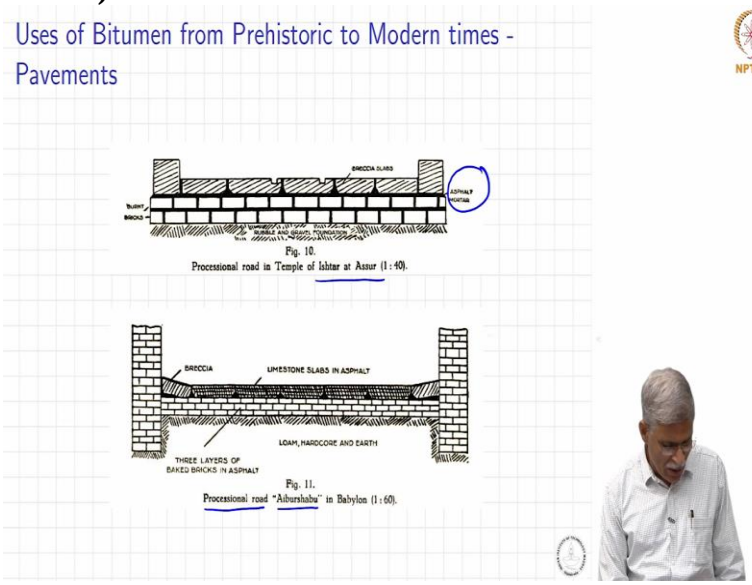

So let us take a look at some of the pavements cross sections how they have actually been used and where bitumen have actually been paste in that you can actually see the mention of asphalt mortar. So as far as discourse is concerned, when we use the word hot mix asphalt or asphalt, we are talking in general about a mixture of aggregate particles and binder. But if we specifically use asphalt rheological properties, you can assume that we are talking about the binder. But those clarity will come as we proceed through this course.

This was in Assur and you can actually see what is really called as a processional road and in fact, the processional roads or the roads from the temple, in which the priest of the kingdom used to walk with the royalty of the kingdom. And Aibursha bu is again a slogan that says to the king that whoever is your enemy let them meet death that is the more or less the meaning. And if you happen to watch some of this mummy and mummy roulette series of movies, you will seeing these kind of words that being used.

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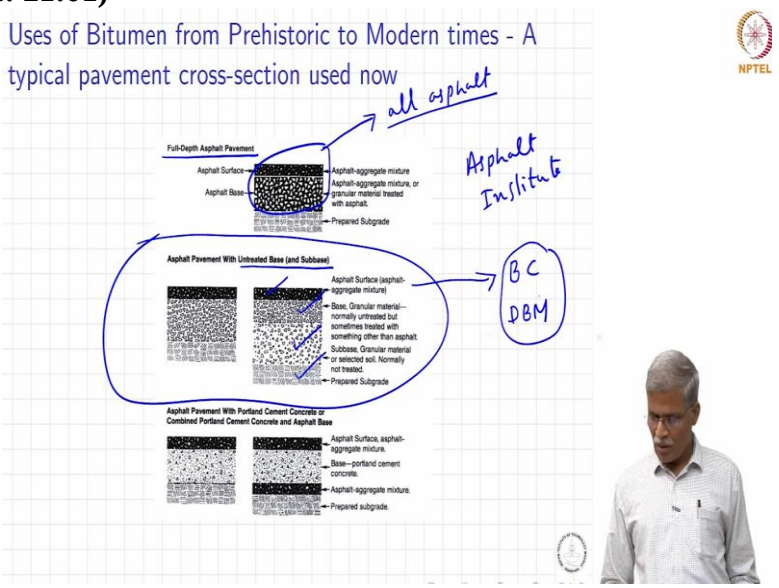

So let us come quickly to the modern construction. So right now, let us focus our attention on this particular one. So what you are going to see here is and an asphalt surface, a granular base, sub base, and a prepared subgrade. Institutions like asphalt Institute in America, in fact, as the name says, they are a consortium. They are basically created by a consortium of refineries with the sole interest of prepending asphalt and asphalt related material.

So they come out with what are really called us full depth asphalt pavement. So that means from the prepared subgrade everything is all asphalt. So obviously these constructions are very expensive, some of the runways use this kind of full depth payment. What our interest is in the second one, which is with untreated base, you can also have a mixed cross section, but these details will be clearly out of the scope of this course. When we offer a course on pavement analysis and design, we will be talking about what are really called an inverted cross section.

So, let us spend a little bit time on this cross section. So, you have an asphalt surface and within the Indian context this consists of 2 layers, what is called as bituminous concrete and dense bituminous macadam. They more or less consists of aggregate material of different size distribution the bitumen content is also slightly different. Then you have a granular base, sub base, and a prepared subgrade. We will be spending all our time in discourse talking only about the bituminous concrete as well as the dense bituminous macadam.