Pavement Materials
Professor Nikhil Saboo
Department of Civil Engineering
Indian Institute of Technology, Roorkee
Lecture: 60
Overview of Alternate Pavement Materials (Part-2)

Hello friends. Today finally is the last lecture in our lecture series on pavement materials. And today in continuation to the last class, we will be discussing further about alternate payment materials, where we will talk about the recent developments that have taken place in the areas of asphalt mixtures and cementitious materials.

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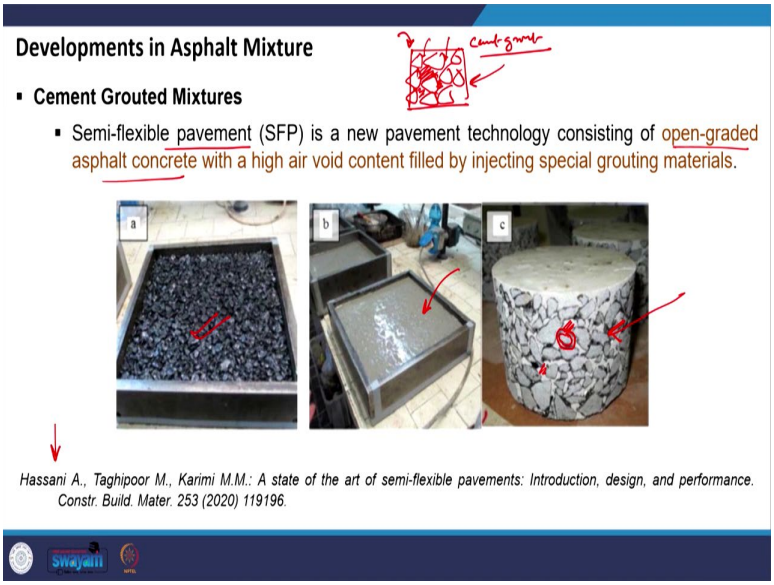

We have again an interesting type of mixture, which is cement grouted mixture. So, this cement grouted mixture is also denoted as semi flexible pavement in many research articles. And this is a new type of mixture or you can say it is a different kind of mixture, I would not say a new type of mixture, which contains open graded asphalt concrete skeleton, which means, we have let us say poorly graded structure which with large voids in it and these voids are filled using a cement grout.

So, this type of mix comprises of benefits both from bituminous mixture as well as concrete mixture. Let us say concrete mixture is good we know that concrete mixture is good in compression, but it is weak in flexure. So, and we know that bituminous mixture can provide good flexibility to the system.

So, therefore, those advantages of bituminous mixture can be found in the cement grouted mix as well as the advantages of the strong hydration products that makes that increases the load bearing capacity of concrete mixture can also be found in this cement grounded mix. So, this is how it looks like you see we have an open graded texture here.

This open graded texture is filled by a cement grout. Ideally the cement grout should be made such that it has self-filling capability or with light vibration, all the grout material should be able to fill these voids created by the asphalt skeleton. And then you when you take a core you can use see something like this where you can clearly see that you have aggregates, you have coated bitumen and in between the voids have been occupied by the cement grout.

So, again one of the very interesting technologies to explore. In fact, in India there are few test sections that has been constructed using a semi flexible pavement or the cement grout admixture.

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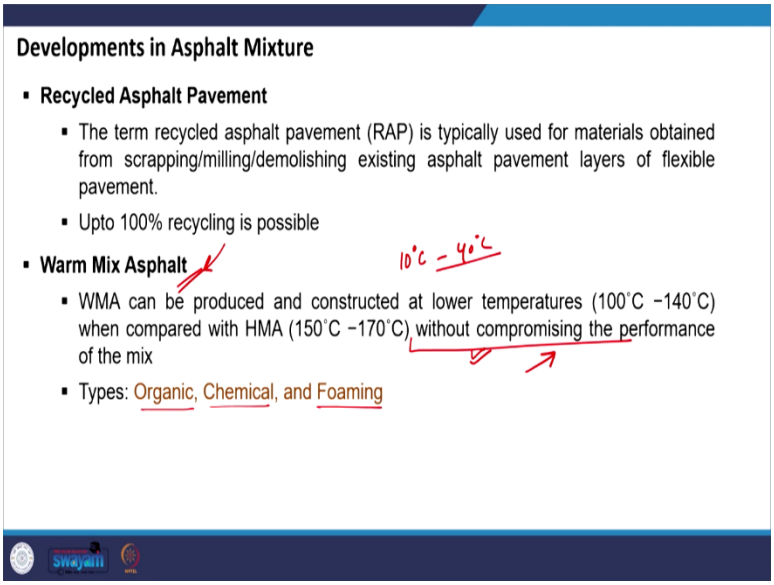

We have already discussed about rap. So, I have just placed it in the list because this is again one of the technologies. One of the mixtures where a lot of research is going on. People are trying to maximize the use of rap in asphalt pavement. As we have already discussed one of the disadvantages or one of the issues for maximizing the use of rap is the presence of highly oxidized binder.

So, various other materials like rejuvenators are being used to mitigate those disadvantages. And to maximize the use of rap in construction of asphalt pavement. We also have warm mix asphalt technologies. So, these are technologies or these are again warm mix asphalt. These are again as far as mixtures that

can be produced at lower temperatures the reduction in temperature can be from 10 to approximately 40 degrees Celsius.

So, which can be constructed at 10 to 40 degrees Celsius lower temperature in comparison to HMA and that too without compromising the performance. So, this is one of the benefit, because we also have cold bituminous mixture where we are able to construct the pavement even at ambient temperatures, but cold bituminous mixtures are having lower strength properties in comparison to hot asphalt mixtures but WMA it on one hand reduces the temperature requirement of production and compaction.

And on the other hand, it does not degrade or does not compromise with the performance of the mix. Warm mix asphalt can be broadly divided into three categories. We have organic, chemical and foaming based technologies. They all work on different principles and mechanisms and all are intended to reduce the production temperature of bituminous mixtures.

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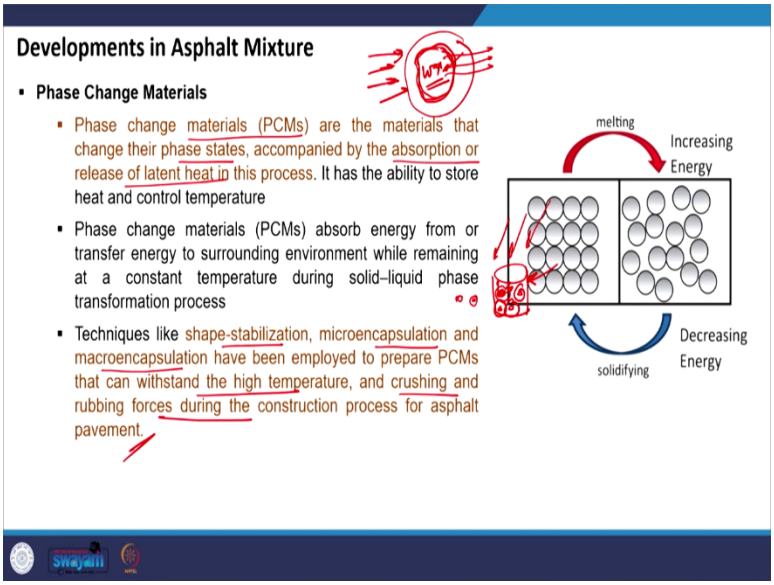

Then we have phase change materials. Again an interesting material to explore something, it is relatively new technologies that is being explored in the area of asphalt mixtures. So, we all see PCM is in different forms in our daily life. So, what is a PCM? Let us say you have a shell and inside this you have wax and we all understand what wax is. So, when you heat the system, the wax has a tendency to absorb this heat.

So, when you heat the system, when you increase the temperature, wax will convert from probably a solid form to a liquid form by absorbing this heat. So, since it is absorbing all the external heat, it does not allow the temperature of the surrounding to get increased, which means, the heat which is externally coming is being absorbed by the wax and it keeps the heat stored within it.

As the temperature lowers down then it will again start emitting the heat to the surrounding and it will again solidify depending on the again transition temperature range. So, these PCMs these are materials that can change their phase state accompanied by absorption or release of latent heat in this process. And it helps to alter the temperature of the pavement system during it is changed from solid to liquid phase and so on.

So, various type of PCMs have been experimented in asphalt mixture people have tried to use techniques like shape stabilization, microencapsulation in very small and in where this PCMs are kept in a very small encapsulated form just like fillers. It can be also incorporated in the form of macro encapsulation say like an aggregate system.

And the only issue in the manufacturing process or where the attention should be paid is that we have to develop a material that can withstand high temperature, that can withstand the crushing and rubbing forces during the construction process of the asphalt pavement. If it is stable enough during construction, so, try to imagine that you will have an asphalt mix where you will have this encapsulated phase change material.

When during summers when the temperature is very high, these materials it will absorb that heat and it would not let the temperature of the bituminous mixture to rise high because it is absorbing the heat within itself and during when the temperature is low, which means I want my pavement to be at higher temperature the same because again the phase will change.

So, the same material will release the heat and the temperature of the mix will increase artificially. So, this is how PCMs work and more details can be found in this particular paper.

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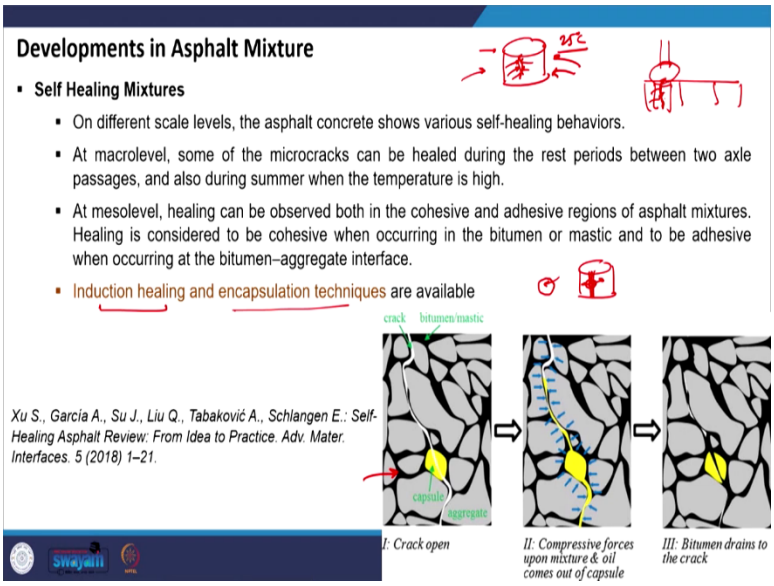

We also have self-healing mixture and self-healing is something which is a very inherent property in an asphalt mix, because we know that when the temperature of the mix increases, the binder will start to flow. So, let us say you have a bituminous mix which has cracked. So, let us say the temperature now is 25 degrees Celsius. So, try to imagine that when you keep this mix in the oven at high temperature say 60, 70 degrees Celsius, this crack which is found the bitumen will have a natural tendency to flow here and occupy this space.

So, bitumen in itself has a self-healing capacity and this capacity is can be artificially triggered using various techniques. For example, induction healing is one such technique. So, in the pavement, if there is some crack minor crack, you take the induction heating machine at the site. Heat this location once you heat. The bitumen will start flowing occupy the space and this crack can be filled. People have also used encapsulation technique that what happens let us say you have and this you have some form of binder encapsulated inside a shell.

So, you have an asphalt mix. When it cracks this encapsulation will break and once this encapsulation breaks, the liquid will start flowing and it will occupy the crack and it will fill the crack with the particular material. This is what is shown here. More details can be found in this particular paper.

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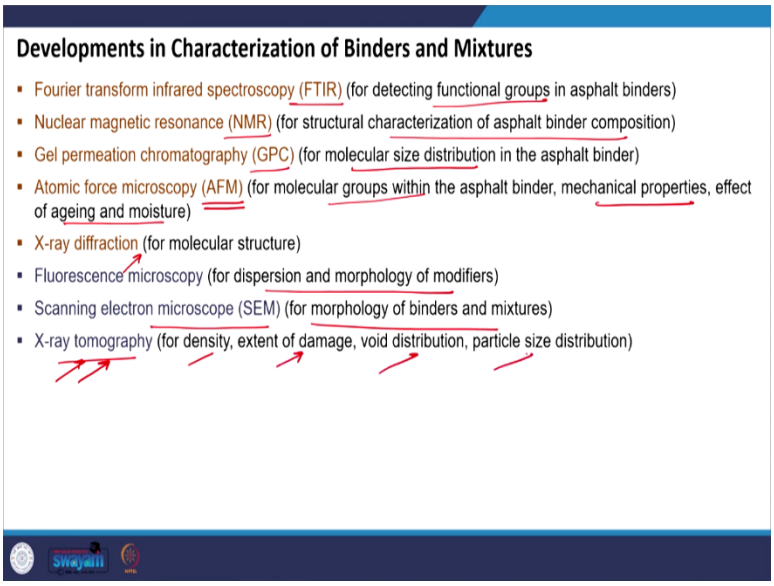

Now, having talked about the developments in the use of alternate materials. There have been parallel developments in the characterization of binders and mixtures as well. And various advanced technologies have been used to characterize the behavior, to predict the behavior of bituminous mixtures and when I say predict the behavior, I am talking about various performance characteristics, such as aging in the mixture, moisture resistance within the mixture, fatigue characteristic of bituminous mixtures and so on.

For example, FTIR have been used to get information about microscopic characteristics of the bituminous of asphalt binders by detecting the functional groups in the asphalt binders. NMR has been used for structural characterization of asphalt binder composition. GPC has been used to explore the molecular size distribution in the asphalt binder. For example, we have asphaltene and multi infraction.

So, how these different size fractions are distributed within the binder. AFM has been used, which is a technique which tells us about the surface property of the material at a microscopic level using which we can identify the presence of different molecular groups within the asphalt binder, we can study the mechanical properties and also the effect of aging and moisture.

X-ray diffraction techniques have been used to study about the molecular structure of the bitumen. Then we have optical base method. For example, we have fluorescence microscopy that have been used for dispersion and morphology of modifiers. An image I already showed you in the beginning of the presentation. SEM has been used. Again it tell us about the morphology of binders and mixtures. X ray tomography which is a very costly equipment has also been used to study characteristics of asphalt mixtures related to density, extent of damage, wide distribution, particle size distribution and so on.

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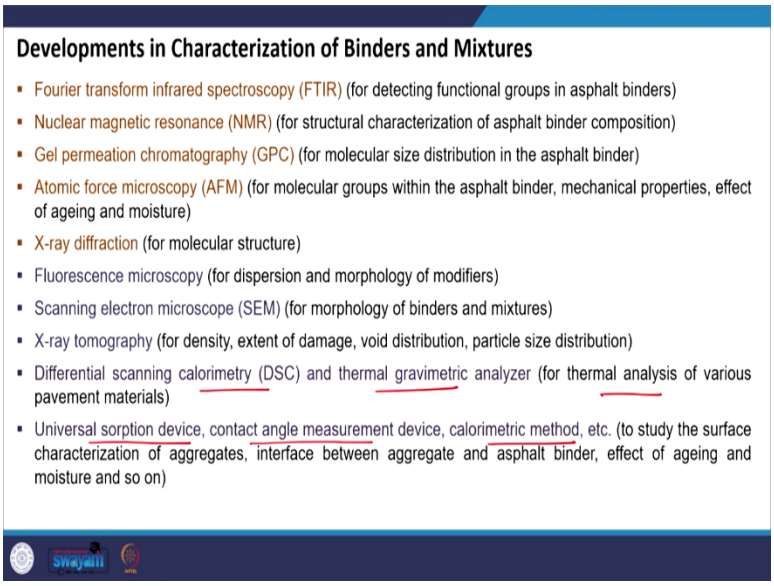

Then, we have other techniques as well to understand to explore about the thermal behavior of asphalt materials. For example, we have DSC differential scanning calorimetry. We have thermal gravimetric analyzer TGA so, that are being used for thermal analysis of various pavement materials. We also have other materials to study about the surface characteristics, interface characteristics between aggregate and asphalt binder.

And also the effect of aging and moisture. Some of these equipment's include universal sorption device USD. Contact angle measurement device for example, we have sessile drop method to study about the surface energy properties. Calorimetric method has also been used. And there are other characterization techniques available.

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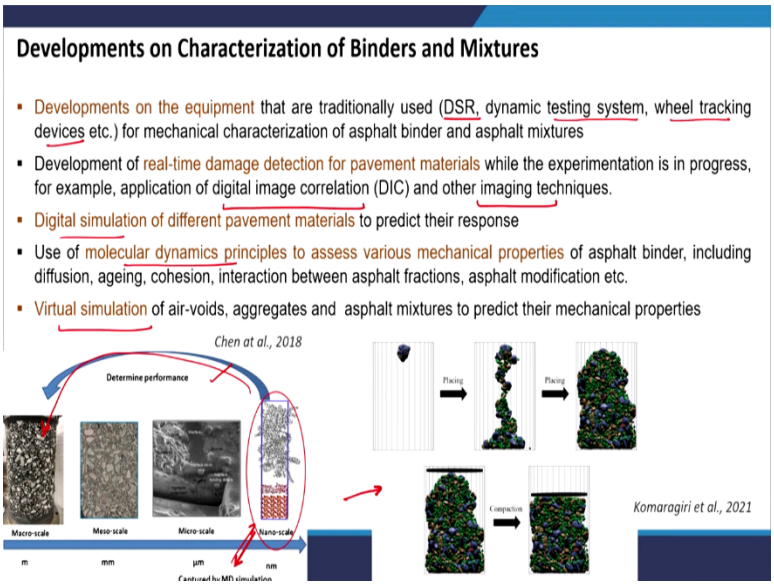

We also have technologies that are being used for real time detection of pavement materials while the experimentation is still in progress. For example, you are doing the experiment. In parallel you are seeing the development of let us say crack in the system the development of permanent deformation in the system and this incorporates using a digital image correlation device.

And or other imaging technique with the specific equipment we are using. Parallelly developments are also being made to improve the additional equipment's for example, DSR various new modifications in the dynamic (())(14:17) has been made to appropriately characterize asphalt binders and mastic systems. We have other dynamic testing systems.

For example, we have a servo hydraulic dynamic testing system. We have servo pneumatic dynamics testing system, which can be operated at varying frequency, in varying load configuration. We can apply compressive stresses, we can apply tensile and flexural stresses and so on. We have wheel tracking device for example, to study about the permanent deformation characteristics of the asphalt mixtures as well.

Then, usual, researchers have felt that the pavement material test ting requires a lot of time, lot of effort in the laboratory. So, to reduce those effort, various digital simulation methods have been developed where by doing some minimal tests in the laboratory, we can predict a lot of properties of the asphalt binders and mixtures. People have used the concept of molecular dynamic principle to assess the mechanical response of the asphalt binder.

Once we have the properties at the micro level researchers. Researches are being done to virtually simulate asphalt mixture, which means, artificially we can make an asphalt mixture for a given gradation

for a given binder type for given air voids and the response can also be virtually assessed using various other techniques. So, this shows that how the molecular dynamic simulation can be used.

So, if you have details at the nano level, you can use techniques to determine the properties or the behavior at the macro scale as well. This image shows that how artificially aggregate gradation can be generated, aggregate or bituminous mixture can be prepared for a given level of compaction. So, all these researches are being done and are being implemented as well. So, in the coming of near future it would not be surprising to see many such developments actually happening in the field.

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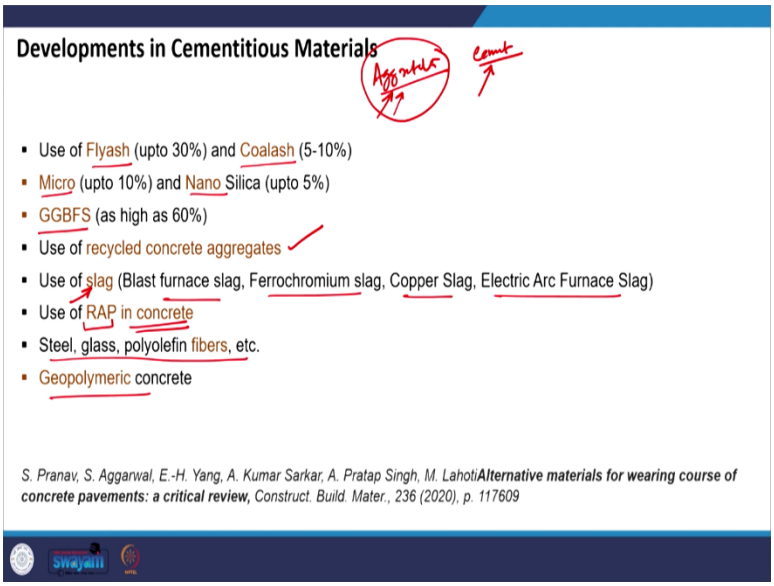

Talking about the development in cementitious material, you can divide these developments in two broad categories. One is the replacement of aggregates using alternate materials. For example, we have recycled concrete aggregates that have been used to produce concrete mixtures and DLC mixtures. People have used slag in different forms. For example, blast furnace slag, ferrochromium slag, copper slag, electric arc furnace slag and so on as replacement of natural aggregate.

People have also used reclaimed asphalt pavement aggregates to produce concrete mixtures. So, in the area of aggregates these are some alternate ways of producing concrete mixtures and the other part of the research is dedicated to find alternate sources of as for cement replacement, and we have already discussed about these technologies. For example, Flyash is being used up to 30 percent, coal ash has also been used. Micro and nano silica has been explored, though there are other considerations for using these materials successfully.

But, these are some alternate materials that have been explored. GGNFS, we have already discussed. For the production of concrete mixtures, various type of fibers have also been used. And finally, in our lecture, we have also discussed that how geopolymeric concrete can also be produced without the use of any cement in the entire mix.

So, again, this is one of the good references that can be seen. Well, friends with this, we come to the end of this particular course on pavement materials. I hope that this course was useful to you, I hope that you were able to learn and understand various concepts related to the use of pavement materials in pavement construction.

Well, I understand that there is always a scope of improvement in teaching as well as in the learning process. And I look forward to get valuable feedback from you on this course so that we can make it better with time. Taking this course under NPTEL was also a learning experience for me. And I am very grateful that I got this opportunity.

I am also thankful to my TS, Mayank Sukhija and Dhiraj Mehta, who were continuously supporting me during the making of the videos for this course. And I also would like to thank Mr. Binoy for facilitating smooth recording of these lectures. And without their support, it would have been very difficult for me to complete this course on time.

So, with this, I would like to conclude and I hope to see you the next time probably with a different course on pavement engineering. Thank you.