



**MAJLIS SYARAHAN
PROFESOR UiTM**

*Green Pavement Strategies
for Malaysia*

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Institut Kejuruteraan Infrastruktur dan Pengurusan Mampian (IIESM)

1 November 2023 (Rabu) | 9.30 Pagi
Dewan Sri Impian, Hotel UiTM Shah Alam
Bersiaran langsung di **LIVE** **TNCPIUITM**

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(Penyelidikan dan Inovasi)

Professorial Lecture UiTM
Profesor Ir. Dr. Ahmad Kamil Arshad
Green Pavement Strategies for Malaysia



Program

Program Kepimpinan Perpustakaan Siri 7

Dewan Sri Impian, Hotel UiTM Shah Alam

1 November 2023 (Rabu), Jam 9.30 pagi

Nama Profesor Ir. Dr. Ahmad Kamil Arshad
Tajuk Green Pavement Strategies for Malaysia
Jangka masa : 2 jam 12 minit

Transkrip:

- 1:07:55 : Assalamualaikum warahmatullahi wabarakatuh and good morning to everyone. Yang Berbahagia Prof. Nor Hadiani Ismail, Pengurus Majlis Profesor UiTM , Yang Berbahagia Prof. Dr. Nor Azura Mohamad Ghani, Pengarah Pusat Penyelidikan UiTM, Yang Berusaha Prof. Ts. Dr. Haji Ahmad Ruslan Mohd Ridzuan, Mantan Pengarah IIASM. Yang Berhormat Prof. Dr. Nor Hayati Abdul Hamid, Mantan Pengarah IIASM. Encik Tan Siaw Ling, Pengarah Pengurusan ISROC Sdn Bhd. Encik Sanjay Grover, Ketua Pegawai Eksekutif Kemaman Bitumen Company Sdn Bhd. Yang Berbahagia Datuk TS Haji Mohamad Taufiq Harun, Ketua Pegawai Eksekutif Kumpulan IKRAM Sdn Bhd. Dan Juga Yang Berbahagia Datuk Ir. Zul Ahmad Haji Sufian, Director of Industry Advisory, I would like to thank everyone for coming to this professorial lecture.
- 1:09:25 : And I would like also to thank the staff of ISERB for organizing this event. They have been very busy since yesterday. So, actually this lecture is dedicated to the staff of IASM also. With your permission, I would like to start this lecture in English, mixed with Malay. Okay, my professorial lecture is titled Green Pavement Strategies for Malaysia. It's not a new topic, but there are some new innovations which we can include in the topic.
- 1:10:40 : Next. Okay, this will be the outline of my talk. I have eight areas to go. I hope it can be completed within 40 minutes. So, it's about five minutes for each section. Okay, next. Before we go any further, we have to know what sustainable development is. So, this is the most popular sustainable development definition which is available everywhere. It's from the Brundtland Report in 1987 and it has been used everywhere, I think.
- 1:11:35 : In most environmental and sustainable talks throughout the world. So, sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Okay, so this definition is being applied throughout many areas.



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- 1:12:02 : So, for pavement, which is my area of research, there are several definitions from available literature. So, sustainable pavement is one that is safe, efficient, economic, environmentally friendly, meeting the needs of present-day users without compromising those of future generations. So, this is just an adjustment to the previous definition in the Brundtland Report, 1987.
- 1:12:40 : The second, which I think is related to my topic, green pavement, is from the FHWA, the Federal Highway Administration from the United States. Green highways, those that are environmentally responsible and sustainable in all aspects, including design, construction, and maintenance. And the third one is a pavement that minimizes the environmental impact through reduction of energy consumption, natural resources, and associated emissions while meeting all the performance conditions and standards.
- 1:13:23 : This is more of an academicians' definition. But I like the second definition, which is the green highway from FHWA. Okay, this slide is just to bring up some thinking or thought from me to the audience. So, this is the typical emissions standard of increasing the number of lanes for our highways once the capacity is met. That means that each time there is traffic congestion, our thinking or solution is likely to increase the number of lanes until there is no more land available. So, I put a question there, is that sustainable? Because you can't expand a highway until 20 lanes and so on to meet the increasing traffic in the country.
- 1:14:39 : So, we have to think of some other alternatives. Okay, next. This is another sustainability solution. This one is to improve the traffic condition so that it becomes sustainable. We are not satisfied with ground-level roads. We build another level, and then you build up until four or five levels of roads.



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- 1:15:11 : So, I put there a definition of insanity. This one is from Twitter. So, I like to quote from Twitter because these are the quotes from the younger generation. So, the younger generation feel that the older generation, like myself, I think have damaged this country's sustainability by building ever-increasing highways and also ever-increasing elevated structures for the highways. So, we can go on and on. This is another situation where another definition of sustainability, although it's related to the roads by the color of red.
- 1:16:13 : This is the Felda Bukit Goh bauxite condition at one time where certain entrepreneurs start to dig up the hills for the bauxite and causing the environmental pollution throughout the whole road network in Felda Bukit Goh. Okay. So, these are some of the examples of sustainability. Okay. This next slide shows what is happening in certain places. For example, this one is in Germany.
- 1:17:10 : So, after building the highway, they decided to, how do you say, take the highway out and build a more environmentally friendly road with greens around the area. So, after you build up the road, you destroy the road, and you build another, how do you say, a place where the public can use without increasing the traffic. So, this phenomenon is happening in many other places. Next. For example, in Utrecht, same thing, Germany. They are building, and also in Seoul.
- 1:18:06 : So, they demolish the whole building and do a much better environmentally friendly pedestrian walkway with rivers and green along the area. So, what I'm doing by giving these examples is that sustainability can mean different things to different people, and also can involve the destruction of what we have built and the new development of something which is better, but as the time goes on, it might involve another solution to the above. Okay, on pavement, what I'm saying is that we have an obligation to build and maintain our roads and highway infrastructure to meet the needs of present day users and those of future generation by using the definition in the report.



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- 1:19:26 : So, the challenge in pavement is to do it safely, efficiently, economically, and in an environmentally friendly way. So, it looks very complicated. Finding the balance is going to be an increasingly important consideration for pavement engineers in the years to come. So, we need to balance what is sustainable and what might not be sustainable, but the term sustainable is also a bit subjective. It may mean something to others, but it may also mean differently to another person. Okay.
- 1:20:20 : So, in this lecture, I will give what has been done, some ideas which have been implemented and been done at other places for the sustainability in pavement. So, in relation to sustainability in pavement, I have termed it as green pavement. The initiatives are called green pavement initiatives. So, if it is managed properly, it can produce economic benefits as well as cost savings throughout the conservation of non-renewable resources, especially our aggregate Bitumen in terms of pavement, elimination of disposal costs when we start to do rehabilitation work. We need to dispose our unused materials, reduction in energy requirements. When we construct, we need to reduce the requirements of energy and also we need to reduce the greenhouse gas emissions, especially during the transportation of materials.
- 1:21:37 : Okay. When we discuss on the sustainability, we need to see the overall life cycle of the pavement. So, a pavement life cycle may involve this circular process. First, it's material production for the pavement. You design the pavement, construction, use the pavement, preserve, maintain and rehabilitate the pavement and then at the end of the life, you can recycle back some of the materials into pavement production. That's why it's a circular type of process.
- 1:22:34 : So, sustainability must be considered in all phases of pavement life cycle. So, briefly, the life cycle which sustainability must be considered involves the following materials production. So, activities involved in the acquisition of materials such as the crushed aggregate and bitumen.



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- 1:23:08 : In pavement design, we need to consider the structural and functional requirements, the information on the subgrade traffic climate for design and also selecting and specifying materials which is suitable for the traffic and climate which is being used. Another cycle is the construction, the processes and equipment associated with the construction of the pavement. We must also consider the sustainability concepts.
- 1:23:46 : And finally, when we are using it, pavement characteristics that affect vehicle energy consumption and also emissions as well as the surrounding environment. After being used, we need to maintain. So, we need to apply sustainable treatments. They assist in pavement which slows down the rate of deterioration. And at the end of life, the final disposition and subsequent reuse, processing and recycling of any portion of pavement system that has reached its performance life. So, in all, we have to consider all the stages of the life cycle of the pavement in obtaining the sustainability for the pavement.
- 1:24:42 : Why we need to consider green pavement or sustainable strategies for the road pavement? There are some existing flexible pavements. For example, flexible pavements are impervious. So, it contributes to the flooding and erosion from the rain from the runoff on the pavement. It also plays a part in the contamination of our water supply system by collecting oil, gasoline and other pollutants as it washes into the neighborhood streams and rivers from our roadside drain. Another problem is that our flexible pavement is normally black or dark grey. So, it absorbs heat.
- 1:25:45 : So, in urban areas, there is a lot of build-up of roads with this black color and also dark grey color. This contributes to the creation of heat islands. That means areas around the roads are much warmer than its surroundings. Another reason why we need to consider is that the production of asphaltic concrete requires a lot of energy and resources. It also requires energy for the transportation of delivery at construction sites. So, basically, what I'm saying is that why we need to consider sustainability is that in construction of pavements and in uses, it requires a lot of energy to construct and also to transport the materials to the construction sites.



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- 1:26:48 : So, how do we overcome this? There are certain concepts for a pavement to be sustainable. The material should be durable throughout its life. That means it can last long. And also, it can be recycled. And then, apart from bitumen, we also need to consider alternative binder materials, if available. Currently, there are some alternatives in the market, which I will talk about later.
- 1:27:30 : Next, the energy required also for the production of asphaltic concrete needs to be lowered or reduced. And finally, when maintenance or rehabilitation is required, in-situ recycling should be a primary consideration. Okay. So, these are the concepts which we should follow when we are constructing sustainable pavements. So, the next slide, we will discuss some of these green pavement initiatives, what has been done to add some sustainability concepts into pavements. So, it includes material, use of alternative materials such as bio-asphalt and light-colored pavement.
- 1:28:34 : In design, we can improve it through perpetual pavement using mechanistic design and also use of permeable pavement. In construction, we can use warm-mix asphalt and cold-mix asphalt. And in maintenance, we use pavement recycling. Okay. This will be actually the bulk of my lecture. Okay. We look at the material initiative. So, there are three, bio-asphalt, light-colored surfacing, and recently, what is called phase-change materials. Okay.
- 1:29:29 : An alternative to bitumen is bio-asphalt. It's made from non-petroleum-based renewable resources. This can include sugar molasses from foods, rice, corn, and potato starches, natural tree and gum resins, natural latex rubber and vegetable oil, lignin, cellulose, and all sorts of materials which we can process to produce a bonding agent which is similar to bitumen. Okay. Most of these alternative materials are created by using thermochemical processes called fast pyrolysis. For example, corn starch, wood waste, and other types of biomass which are quickly heated without oxygen.



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- 1:30:32 : It produces a liquid bio-oil that can be used to manufacture fuels, chemicals, asphalts, plus products such as biochar to enrich soils. So, an example is made by Avello. This is a process by Avello which produces an alternative asphalt called bio-asphalt. Next. So, in France, I think Colas has produced it in 2004, which is called Vegecol. And then Shell also has another name, alternative bitumen, which is called Floraphalte.
- 1:31:18 : Next. So, this can be found easily in the internet. There have been field applications of this bio-asphalt in Shell and also in Vegecol in France. Next. Some other examples include Geo320 from Australia and also Replay from Soy beans. So, there are a lot of alternatives from different naturally available materials. Next. This is from a wood-based product of bio-asphalt, which is called plant-based lignin. It has been constructed in the Netherlands quite recently, in 2021.
- 1:32:22 : So, these are some available alternatives to bitumen, which are plant-based and also naturally occurring materials. But this needs to be through a process. Normally, it qualifies pyrolysis. Next. Next. Okay. We have just covered, just now, regarding urban heat, urban heat island, UHI, which is the increase in the areas where there are build-up of roads, especially in an urban area, due to the dark-coloured surface of asphalt or bitumen. Which absorbs heat and therefore increases the temperature of the surrounding area. So, when it is hot, you tend to increase the air condition to reduce the temperature.
- 1:33:34 : So, actually, the easiest way is to plant more trees at the surrounding areas. But mostly in urban areas, this has not been practical, especially in Malaysia, because currently there is a lot of storms around, so they tend to chop or remove the trees in the urban areas. So, what alternatives do we have? We can use light-coloured surfacing. Lighter shades of grey have significant impact on how much heat is absorbed and consequently radiated back into the air. So, to control the heat island effect, that means to reduce the temperature, lighter shades of paving material and planting trees should be considered for implementation in urban areas. So, if you look here, you can see that in urban areas, it is about 3 to 5 degrees higher than the outskirts or the rural areas.



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- 1:34:49 : So, you can see the increase due to the build-up of the road pavements. So, to reduce that, normally, this is shown in the reflectivity coefficient. So, a lighter material has a higher reflectivity coefficient, therefore it doesn't absorb the heat and reflect back to the atmosphere. A black-coloured material such as asphalt absorbs heat and causes the increase in temperature. So, one way is to apply light-coloured surfacing to the asphalt material. Next.
- 1:35:46 : You can see here, most areas have car parks which are black in colour. So, if you apply some lighter-coloured surfacing, you can reduce the temperature. This is a school parking area in the United States where they experimented with the use of nano-coloured surfacing, which reduced the temperature by about a few degrees. Okay, next. Okay, apart from trees and light-coloured pavement, for the academic world, research has been increasing on this phase-change material. These are substances that absorb and release thermal energy during the process of melting and solidifying.
- 1:36:54 : That means when you mix this compound or you apply the compound into the asphalt mix, it absorbs the heat from the asphalt, making it much cooler. So, it doesn't absorb the heat and increase the surrounding temperature. These are called phase-change materials. Research is increasing on these phase-change materials, but there are some problems on these phase-change materials. It absorbs heat. As it absorbs heat, it maintains the heat.
- 1:37:39 : Therefore, if it is in the asphalt, the asphalt tends to get softer, producing ruts. So, there needs to be further investigation on these phase-change materials because it tends to soften the asphalt material. So, this thing is ongoing at the universities, and hopefully they will find some solution on how to absorb the heat without affecting the asphalt material by softening it. I still have a lot more material to go through. I hope you will please bear with me. I won't make it complicated.



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- 1:38:38 : I just try to give some ideas because not all is from the pavement industry or the academicians. Some are generalists, meaning that they understand the conceptual change. Okay, design phase. Perpetual. Perpetual pavement is a term that describes long-life or durable pavement. So, in the concept of perpetual pavement, we try to design a long-lasting pavement that can last exceeding 40 years.
- 1:39:27 : We only need to do minor repairs on the surface. Due to the effect of the climate and environmental changes, but not due to the structural failure because it has been designed to accept a higher number of repetitions. So, perpetual pavement is the term we use for a long-lasting pavement. Normally, in the design of long-lasting pavement, mechanistic design procedure is being used. What we do is to provide enough stiffness at the upper pavement layers so that to preclude rutting. Also, the thickness is adequate to prevent fatigue cracking.
- 1:40:22 : That means the cracks don't generate from the bottom of the layer. So, Manny Smith and Long, some of the pavement experts at Caltech, I think, University of California. When you are designing for perpetual pavement, you try to limit the strain at the bottom of the asphalt layer so that they don't tend to initiate the cracks. Next. So, this is the perpetual pavement. But one problem is that it's a bit expensive, I think, because the asphalt layers are thick. Okay. Next. A bit on perpetual pavement also.
- 1:41:16 : What is unique on perpetual pavement is that this provides durable and long-lasting roadway. So, no major repair is required except for the surface of the pavement. Another thing is that the asphalt is recyclable, providing further cost-saving and environmental benefits. Okay. Next. Permeable pavement. Permeable pavement is a paving system that allows water to infiltrate through the pavement in order to more accurately reflect the pre-development hydrologic cycle. What we do is try to control the flooding in the area by using this permeable pavement. Okay, next.



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- 1:42:20 : The idea is that storm water enters through pores of the pavement and is stored in voids that exist in the layer of aggregate until it can percolate through the ground. Permeable pavement is more suited to car parks and hard-standing areas where the pavement strength and performance are not critical. Okay. We look at the permeable pavement. Next. So, this is the typical permeable pavement at the car parks.
- 1:42:54 : Okay. So, some of the problems of permeable pavement include clogging of the pores, which require frequent maintenance. So, research and development on higher-strength permeable pavement that are suitable for highways and heavy traffic areas are still in progress in terms of how to remove this clogging of the pores. Okay, next. We go into construction phase. There are two types of sustainable materials which can be used, warm-mixed asphalt and cold-mixed asphalt.
- 1:43:37 : So, what warm-mixed do is that they generally are produced at a lower temperature than the conventional hot-mixed asphalt, normally about 30 to 100 degrees Fahrenheit or 16 to 55 degrees Celsius lower than the typical hot-mixed asphalt. Okay, next. So, there are many types of different processes for warm-mixed asphalt. Some are foam asphalt, mineral additives, organic additives, and chemical-based methods. So, these are some which are available in the market. I believe maybe PLUS is considering the use of warm-mixed asphalt in their projects.
- 1:44:34 : I think they are trying to use this in trial run. Okay. Some of the benefits of warm-mixed asphalt is that it is cost-saving by using less fuel for heating, cleaner working environment, safer working environment, the possibility of retaining workability of the mix after long haulage, and possibility of placement in cooler weather. Okay, next. So, for example, you can see that hot-mixed is produced at a high temperature, say about 155 degrees Celsius, and warm-mixed at 110. The fume emission also is much lower for the warm-mixed asphalt.



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- 1:45:24 : Next. Okay, cold-mixed. Cold-mixed asphalt are used as emulsion that is mixed with aggregate at normal ambient temperature. So, we don't need to apply additional heat, so we conserve the energy. Okay. And also, there is little hydrocarbon emission, thus reducing the atmospheric production. Okay, next. So, most of this polymer modification has also been included in cold-mixed asphalt for the use of emulsion. Last time, it's not because of that.
- 1:46:07 : Now, we have also latex-modified cold-mixed asphalt. So, why we need to consider cold-mixed asphalt is because at remote sites, we can use the materials without heating. So, that is an advantage, especially in very remote rural areas. And then, another advantage is the safety for workers. Cold-mixed asphalt is much safer than the hot-mixed asphalt because of its lower temperature. Okay, next.
- 1:46:42 : Okay. Emulsions of cold-mixed asphalt are now much used for surface maintenance only. So, there is not much construction of wearing costs in Malaysia because possibly of durability problems, particularly due to the presence of moisture in the aggregate, which may cause the lack of bonding and emulsion aggregates. So, further research for its application as wearing costs in Malaysia should be also considered. Okay. Next. Okay. We go into another maintenance and rehabilitation phase, pavement recycling. Okay.
- 1:47:40 : So, some of the advantages of pavement recycling is reduced cost of construction, conservation of aggregates, preservation of existing pavement geometries, preservation of environment, and help to reduce reliance of landfill by reusing existing material instead of disposing them. Next. So, in the United States, the most recycled product in terms of tarnish actually is asphalt pavement because it has been a policy in certain government of the states to force the recycling of asphalt pavement in pavement rehabilitation such as in California.



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- 1:48:30 : Okay. Next. So, this is hot-in-place recycling. I think this is before that. Before that, I think this is more than 20 years ago, when it is being introduced by HCM in Malaysia. This is the road to Port Klang. So, at that time, the problem with HIPR, I think, is the cost of the machinery. At that time, it was about 1.5 million euros or about 6 million Malaysia. So, currently, it is more because at that time, currency is only about 1 euro is 4 ringgit.
- 1:49:31 : So, it is about 6 million. Now, it is increasing but unfortunately, I think the machinery has been sold and HIPR is not much carried out in Malaysia anymore. Next. The one which has been done a lot in Malaysia is the cold-in-place pavement recycling. This one is foam bitumen. I think foam bitumen also has some problems.
- 1:50:06 : In Malaysia, we focus more on the cement additive rather than foam bitumen in the cold CIPR. Okay. So, we have covered the whole phases of material production, design, construction, and also maintenance and rehabilitation phase. But, how do we know that what we are doing is sustainable or not? Most of the time, in recent years, green rating systems for pavement have been developed. So, green rating system is an understandable and quantifiable system to promote sustainable pavement technologies for the design and construction of new pavement, rehabilitation, reconstruction, and preservation management of pavement that needs to be created. A green rating system for roads will provide tools to make informed design and construction decisions on sustainability and environmental stewardship.
- 1:51:18 : It will also stimulate green construction and raise public awareness. So, how do we know that how our initiatives are sustainable or not throughout the whole pavement life cycle is to use the green rating system. So, a rating system to evaluate environmental sustainability of pavements would conceptually include sustainable design to encourage design and construction of long-life pavement, materials and resources to promote reuse and recycling, and also construction activities to reduce the environmental impact during construction.



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- 1:52:02 : Next. So, other aspects also include energy and environmental control to reduce energy use and minimize pollution, environmental impact to promote storm water management with forest pavement and so on, quiet pavement for noise reduction, faster construction to reduce user delays, and smoother roads for better vehicle efficiency. So, we also need to consider innovations to promote use of new environmentally friendly products and processes, and also include asset management to address infrastructure investment requirements and provide long-term stewardship.
- 1:52:42 : So, these are some of the considerations in a green rating system. So, there are many green rating systems available. For example, Green Roads by University of Washington. So, they followed some sort like the building energy rating system. They have certification level, evergreen, gold, silver, and certified, based on the lifecycle requirements of the project. Next. Also, Green Pave by Ministry of Transportation, Ontario, similar. They assess into four categories, pavement design, materials and resources, energy and atmosphere, innovation and design process. So, this is by Ministry of Transportation, Ontario.
- 1:53:41 : I believe that JKR also has introduced a green rating system for their roads. I think they just introduced and asked for comments. Okay, next. Okay, we have gone on the whole literature of green pavement. So, what I would like to finish this lecture is on what research has been carried out at UiTM on green materials for pavement. So, this is the last area to be discussed. So, at IIESM and Faculty of Civil Engineering, we have done some of this research. One mix asphalt with red, latex modified asphalt mixes with red, nano-silica modified asphalt mixes, asphalt emulsion mixes, and asphalt mixes using fibers. There are other things also, but I just like to discuss these five areas.



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- 1:54:59 : So, we encourage, we like to look the research with the incorporation of red into all special type of mixes. Because red, for me, can reduce the cost of producing asphalt mixes. So, this is one research area which we have done, one mix asphalt with red, about more than 10 years ago by my PhD student. At that time, one mix asphalt has just been introduced. The additive we use is Sasobit. And at that time, the Petronas, I think, opened a company to sell this Sasobit.
- 1:55:57 : But there was a lack of response, and therefore, I think it closed after a couple of years only. But we managed to get some samples of the one mix asphalt additive Sasobit, which is then being researched. And we found that it can reduce the mixing and complexion temperature substantially, lower than hot mix asphalt. But we, as one mix asphalt requires the additive, Sasobit additive, it increases the price. So, by incorporating red, you have two things. First, you can save some cost on new materials.
- 1:56:46 : And another thing is you conserve the use of aggregates, which is being reused. So, what we found is that test results showed that there is no substantial differences in volumetric properties, stability, and stiffness, and so on. So, it met the TSR requirement. Also, we found that normally Sasobit also enhances the rut resistance of the bitumen. Next. So, this is some of the findings.
- 1:57:27 : So, the TSR is very high also. And also, we use up to 50% red, I think, Sasobit 50%. We investigated the use from 30% to 50%. So, the higher use of red needs more care because some of the properties, when you put higher content of red, the properties may not be homogeneous. So, you need more care in the mix design. Lower red content, say below 20%, it doesn't affect much of the properties. And for me, it can be directly incorporated into the new asphalt mix. Okay, next. Latex-modified mixes with red.



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- 1:58:26 : Okay, I think in Malaysia, we have encouraged the use of latex-modified asphalt, but we use Kaplam rubber asphalt mix. But this one, latex-modified asphalt mixes, we got assistance from KBC to obtain their liquid latex, which is being produced commercially. So, liquid latex, I think, is much better because of its homogeneity with bitumen.
- 1:59:03 : It mixes better with bitumen because it doesn't form clumps and so on. So, polymers using latex is used to increase the performance of asphalt mixes. But normally, polymer-modified asphalt is always much costlier or much more expensive than conventional asphalt. So, you need to find ways to reduce. So, the use of red can reduce part of the increase in cost. That is why we prefer to do laboratory investigation by combining red and latex-modified asphalt.
- 1:59:50 : Next. So, what we found is that use of NRM modified bitumen together with about 25% red can provide a cost-effective solution to increase the performance of the hot mix asphalt. So, we can also see improvements in stiffness as depicted in the resilient modulus and also in the rutting by using dynamic creep test results. Okay, next. What is this in 2023? About 8 to 10 years ago, there is a hype on nanomaterials. What are nanomaterials? Nanomaterials is materials with one dimension of nanometer scale, which is 1 billionth of a meter, 10^{-9} meter.
- 2:00:45 : So, a lot of nanomaterials have been investigated by academicians and universities. Nano-clay, nanotube, nanofiber and so on. We also followed the trend. My student, Khairi Azman, did study on nanosilica. So, next. Nanosilica, when added, can increase resilient modulus value and reduce rutting depth because it produces a much stiffer material, as shown in the next slide. But I think its application in the field is quite rare. I think it's only in the realm of the academic world that we investigate these nanomaterials. At present, I think there is a shift away from these nanomaterials already.



Program

Program Kepimpinan Perpustakaan Siri 7

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Tajuk : Green Pavement Strategies for Malaysia
Jangka masa : 2 jam 12 minit

Transkrip:

- 2:01:44 : Okay, last. Second last. Asphalt emulsion mixers. I just like to raise certain things. Asphalt emulsion mixers, United Kingdom called them cold bituminous emulsion mixture, CDEM, or cold mix. United States says cold mix. So, there are advantages in its low requirement of energy. So, normally what's the problem with cold mix is how to obtain strength because it needs a bit of time to cure or to remove the water to attain strength. So, the most common method is to provide cement modified CDEM to improve its curing time.
- 2:02:44 : But the addition of cement can only be up to a certain percentage because we don't want it to be too stiff and it can produce fatigue cracks on the surface. Next. So, these are some of what we found. Emulsion content of about 6.5%. We produced the highest residual modulus. This is emulsion content, not the asphalt content. Asphalt content is a bit lower.
- 2:03:15 : Similarly, about nothing. Okay, the next area is under use of fibers. Fibers have been used to increase the strength, crack resistance, rut resistance, fatigue life, and so on for asphalt concrete. One example of use of fiber is to prevent binder drain down from SMA during mixing and transport. So, we have synthetic fibers such as Viatop, which is imported from Germany. But we can also consider certain natural fibers.
- 2:04:00 : UPM considers the use of palm oil fiber. We can also consider Kenaf fiber as a sustainable alternative to Viatop. So, in our research, we found that although the synthetic fiber or Viatop is slightly better in terms of performance, but the use of natural fiber is acceptable to the required specification as shown in this diagram. It meets the TSR value of 80%, but the rut depth is slightly more. Okay. So, that ends some of the research which has been undertaken at IIESM, particularly on asphalt mixers.
- 2:05:03 : I just talk this briefly because the papers can be found easily on the internet. Next. So, finally. Okay. These are some of my conclusions regarding the use of green pavement strategies. Sustainable pavements require the use of durable pavement, particularly on asphalt surfacing to ensure that the pavement is long-lasting.



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- 2:05:35 : So, asphalt modification and use of bitumen including latex, fibers, and nanomaterials can improve the performance of asphalt mixers. However, the modification of bitumen increases the cost of asphalt mixers, and therefore, alternative ways to reduce the overall cost of asphalt mixers must be investigated. Okay, next. So, what I am proposing is the use of RAP can offset the increase of cost of using the modified bitumen and therefore improve performance of asphalt mixers that can be produced at competitive cost to conventional asphalt mixers. Another waste material that can be used is the Recycled Concrete Aggregate or RCE. I didn't put inside, we have also investigation on that.
- 2:06:26 : Because aggregates from demolition of buildings can also be considered apart from RAP, although I feel that RAP is much slightly better than RCE. However, RCE can also be investigated further for use so that to reduce the cost of bitumen modification. Okay.
- 2:06:55 : The need to maintain existing highways and preserve our existing resources have led to technological innovations that can be incorporated in all phases of highway design, construction and maintenance. And finally, a sustainable highway pavement strategy can therefore be implemented using this innovation in the life cycle highway pavement, provided that the relevant stakeholders, government agencies, contractors and consultants are fully committed in implementing the strategy. So, we need to agree on this life cycle implementation of strategies by all parties so that the implementation can be successful.
- 2:07:47 : Okay. With that, I would like to end my lecture. I think it's about 20 minutes past the estimated time of 40 minutes. I think one hour I have spent. I would like to thank everyone for attending my lecture finally. I hope it gives some, I would say, some eye-opening on the use of materials at different stages of the life cycle to improve the sustainability of pavement. With that, I thank you. Thank you everyone for listening to my lecture. And after this, please enjoy your lunch.