Analysis and Design of Bituminous Pavements

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Lecture – 29

Enhanced Integrated Climatic Model - Part 02

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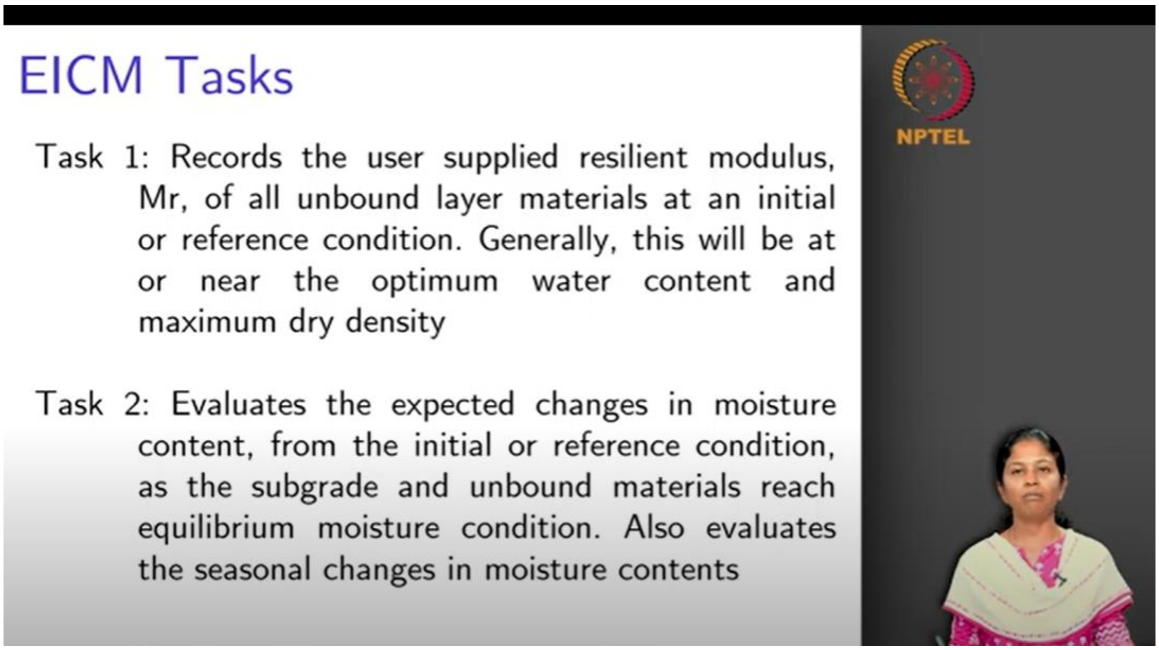

Welcome back. Now we will look into the individual tasks that this EICM model is going to perform. So now what is the first task that this EICM model is going to carry out? The task 1 is to record the use of supplied resilient modulus because we said that we are going to supply an M_R optimum value for a known water content and the model is going to compute for all other water contents. So it will record the use of supplied resilient modulus of all unbound layer materials at an initial or reference condition. So that is this particular condition. Generally, it will be at or near optimum water content and maximum dry density. So we know that we get the maximum dry density at the optimum moisture content. So this will be the water content for which we will compute the resilient modulus value and then specify it as a reference condition.

Task 2 is evaluating the expected changes in moisture content from an initial or reference condition as the subgrade and unbound materials reach equilibrium moisture content. So once we give the value of the optimum moisture content, depending upon the variations in environmental conditions, it is going to calculate the changes in moisture content for the subgrade and other unbound layers as a function of this initial. So with respect to my initial condition, how much is the variation? That is what we defined as S - Sopt. Say for example, it is a degree of saturation or W - Wopt. This is at any given condition. So this will be computed. It also evaluates seasonal changes in moisture content. So this is an input value that we are giving. Based on this input value, the climatic models we have discussed previously, it is going to, so here the CMS model and the precipitation model since we have moisture content and the infiltration drainage model will be used here.

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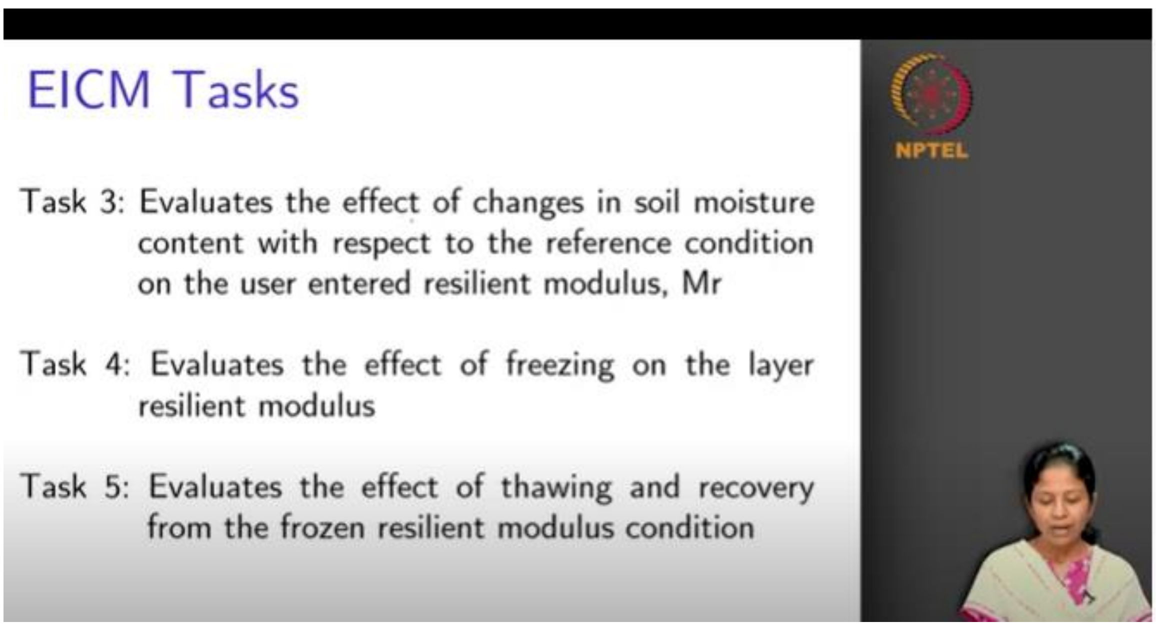

Now it evaluates the third task. So once we have the reference condition and the changes in moisture content, the third task is to evaluate the effect of changes in soil moisture content with respect to the reference condition or the user entered resilient modulus. So what are the changes in soil moisture content with respect to the reference condition? In the previous case, we have evaluated only the changes in moisture content. So here the soil moisture content is calculated accordingly and the effect on resilient modulus is calculated.

The fourth task is to evaluate the effect of freezing on the layer resilient modulus. So far we have been calculating the soil moisture content. Now we are going to quantify also the effects of freezing condition. So as the temperature in the layer varies, how much is the freeze and thaw that is observed in the pavement or observed in the granular layer to be precise. It also evaluates the effect of thawing.

So this is the freezing part separately, which is task 4 and task 5 is the thawing and recovery. In one of these slides in the previous lecture, I had shown that during freezing and thawing, how much is the variation in the strain. So immediately when the soil is frozen, the modulus increases and therefore we saw the strain to reduce and during the thawing period, there is a substantial reduction in the modulus value and therefore we can see the strain to be higher. We had seen that in one of the previous lectures. So similarly, it is going to evaluate the effect of thawing and recovery from the frozen resilient modulus condition.

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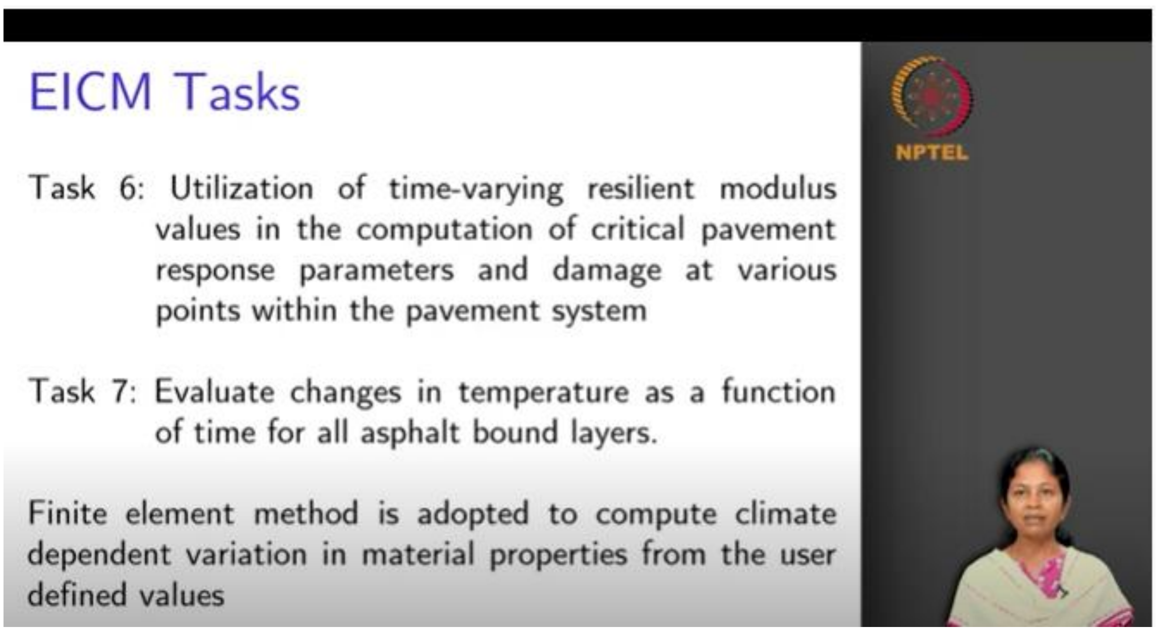

Task 6 is to utilize time varying resilient modulus in computation of critical pavement response parameters and damage at various points within the pavement system. So far we have been working on the granular layers. So it is going to compute the variation of resilient modulus with time and quantify its effect on the response parameters. And finally, it is going to evaluate change in temperature as a function of time for all asphalt layers. So, up to task 6 is for granular and subgrade layer.

And finally, for the bituminous layers, we are only going to compute the effect of temperature variation along the depth. So as we said earlier, a finite element method is adopted to compute climate dependent variation in material properties. So if we have to put it in a nutshell simplify the process, these are the different tasks, these 7 tasks are the simplified tasks that EICM is going to perform.

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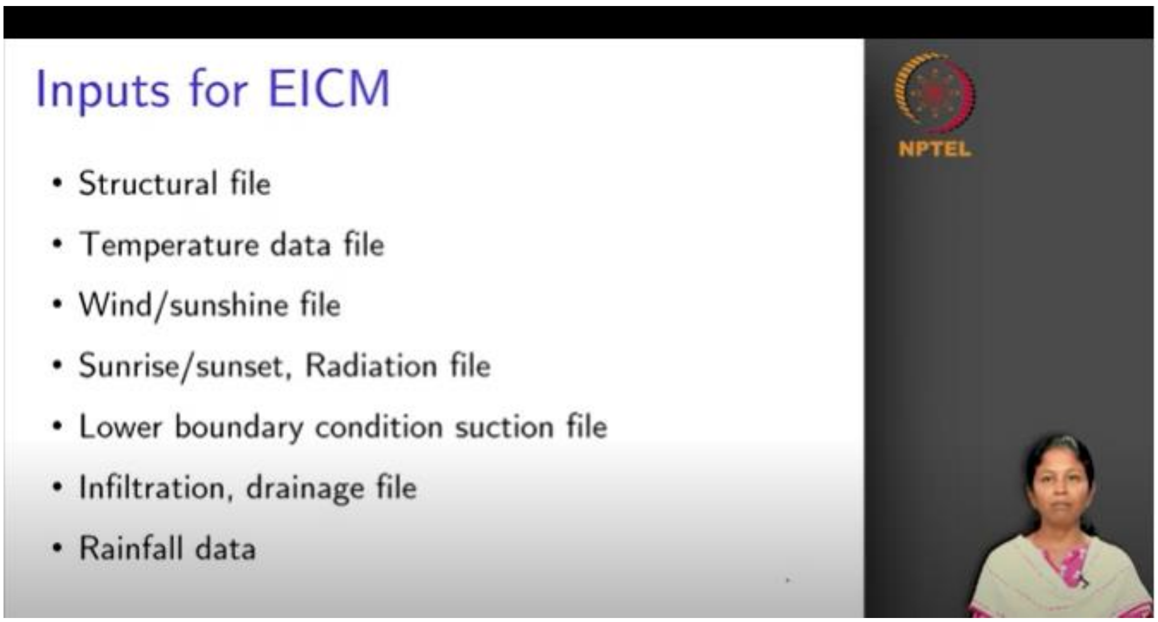

Now what are the inputs for the EICM model? So to perform all the tasks, what are the individual inputs that we have to give? One is the structural file which contains information about the cross section of the pavement. What are the individual layers, thickness, material properties and all other information required for different type of layers. The temperature data file, how air temperature varies, wind or sunshine data, sunrise or sunset and radiation data, the lower boundary condition suction file which is for the water table, infiltration and drainage file and rainfall data. These are the individual inputs which are required by the EICM model.

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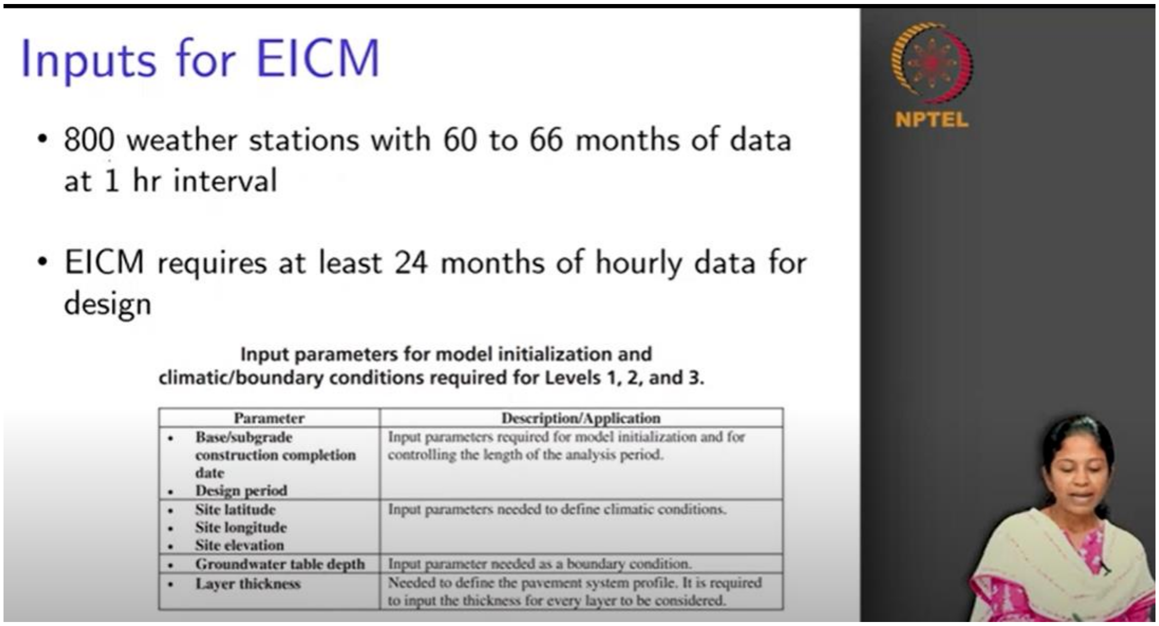

So there are about 800 weather stations in US. If you look into the incorporation of this EICM model into the design procedure, we were talking about the requirements of these many input parameters and these many tasks that are, this EICM is going to carry out. So to carry out the task, we have to give all the appropriate material properties. So in US, they have about 800 weather stations for which this climate data is already available. They have collected the weather information for all the 800 stations with a minimum of 60 to 66 months of data. So at least for 5 years, they have data at every 1-hour interval over this 5 year. So this information is already available in the design software that is used to implement the MEPDG which is nothing but the AASHTOware software. So this climate information is already available. In the next lecture, I will show you how it is done. Then for implementation of EICM, we need at least 24 months of hourly data. So this is something which is a minimum requirement to use this EICM model. Now let us see what are the input parameters that is required by this in detail for each of the different functions.

So these are the input parameters for model initialization and climate or boundary conditions. So we said we are going to specify a boundary condition. We have an upper boundary condition. We have a lower boundary condition. So what are the boundary conditions? Again if you look at MEPDG, they have a concept called level 1, level 2, level

3 data. So what are these level 1, level 2 and level 3 data? Level 1 is the most precise data with as minimum approximations as possible. So if I am giving a level 1 data, let us say we are trying to input the climate data. So all the parameters will remain constant, the required parameters will remain constant across level 1, level 2, level 3. But with what precision am I collecting these input parameters? That is the variable. So level 1 has the most accurate data or with a data with minimum approximations, most of it calculated in the laboratory or direct measurements carried out. So that is our level 1 data. But you should remember that collection of level 1 data is highly laborious, time consuming and so on. But that is a precise data that we have.

Next we move on to level 2 data. Level 2 data is partly data collected from field or partly the actual data and partly the data which is calculated from other constants or using some available models. So that is the level 2. And level 3 is the most approximate data. So either we would take it from the history information or take it from a nearby location or measure one or two parameters and use equations to compute all the remaining parameters. That is a level 3 data. So they give a provision for the user to input any of these three levels of data. We have to choose whether we are inputting a level 1, level 2 or level 3. And for most of the level 3 data, the default values which are available with the AASHTOware will be used. But we should note here that these default values are calibrated or calculated for a set of conditions which may not be exactly similar to our location of interest. So that is a caution that we have to exercise when we are using level 3 data.

Now let us look into the parameters and the description of each of these parameters. So we have the base or subgrade construction and completion date which is just used to make a note of the time period that we are interested in, the design period, the years for which we want to design the pavement for, the latitude, longitude and elevation, groundwater table depth and layer thickness.

So these input parameters are required for initialization of model just to say when time is equal to 0 and for controlling the length of analysis. So what is my tmax, the maximum time for which I am interested in computing all the parameters. Then the latitude, longitude or elevation are required to define the climatic conditions. So we said that the solar radiation and many parameters can be approximated using latitude. So we need this information also.

Third one is groundwater table depth. This groundwater table depth is an input parameter which is needed as a boundary condition. So we said the suction capacity is solely dependent on water table depth. So we need this input parameter also. And then layer thickness to identify the system profile.

So to compute thickness of individual layer, perform sub-layering and all other tasks. Now what are the input parameters? We will ignore PCC for now. What are the input parameters required for hot mix asphalt concrete material properties? So we need thermal conductivity, heat capacity and surface shortwave absorptivity. So what are these parameters? Thermal conductivity is nothing but given a thickness, I have a temperature T at this point, what is the rate at which this temperature T will be conducted throughout this system? That is nothing but the thermal conductivity. Similarly, heat capacity, so once I supply a heat, how much I am able to withstand the heat. How much I am able to hold on to that heat. And for how long I am able to hold on to that heat. That is nothing but heat capacity.

And surface shortwave absorptivity is, we said we have solar radiations which is falling on the pavement. So given a certain intensity of solar radiation falling on the pavement, how much this pavement is able to absorb the solar radiation. If it is, we know that pavement has a black surface, so it is able to absorb more amount of radiations compared to any other surface. So these are the 3 parameters required for bituminous layer. So direct measurements are recommended for this at level 1, you can see here, but default properties are also available for user convenience. So we can use any of these 2 methods to obtain this value. For level 2, the same properties, direct measurements or default values. Level 3, you can see they have directly said that we can use default values available. So this is for the hot mix asphalt.

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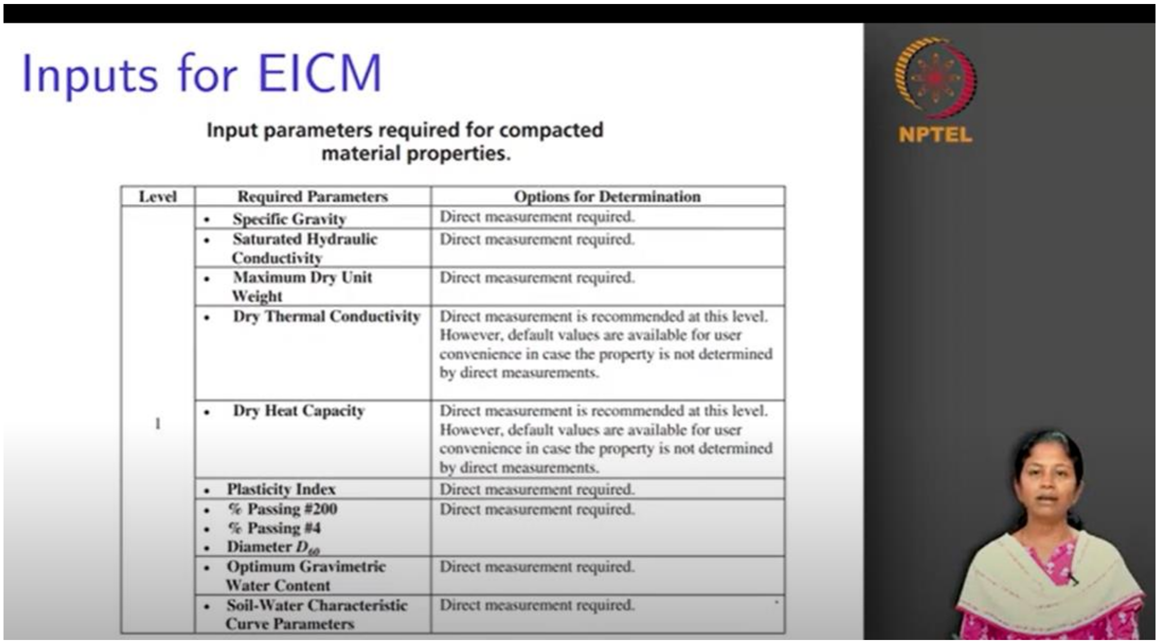

Next what are the input parameters required for compacted material property? We have another table wherein the input parameters required for in-situ condition is also given. So this is for compacted material property. So we want the specific gravity, this is for a granular layer and we want the saturated hydraulic conductivity. So what is the conductivity of the soil. How much water it is able to transmit under saturated conditions. Similarly, maximum dry unit weight we know that. Dry thermal conductivity, how much, what is the thermal conductivity of the soil when it is in a dry condition. And what is the dry heat capacity? So again in a dry condition, if heat is applied to this particular soil, how much heat it is able to withstand and how long it is able to withstand that heat. We know plasticity index and these are some properties with regard to the gradation. Percentage passing 200 sieve, number 4 sieve and D60. Again we had seen all this in a previous lecture. And we want optimum gravimetric water content, this was also defined and the soil water characteristics curve (SWCC). So we also have sufficient introduction to SWCC. Now what are the options for determination? We see that it is a level 1 type of data. So direct measurements are required for all these cases. For thermal conductivity, direct measurement is recommended, but if we do not have values, we can also use the default values or take it from any other literature. Similarly, for heat capacity, for all other cases, direct measurement is recommended.

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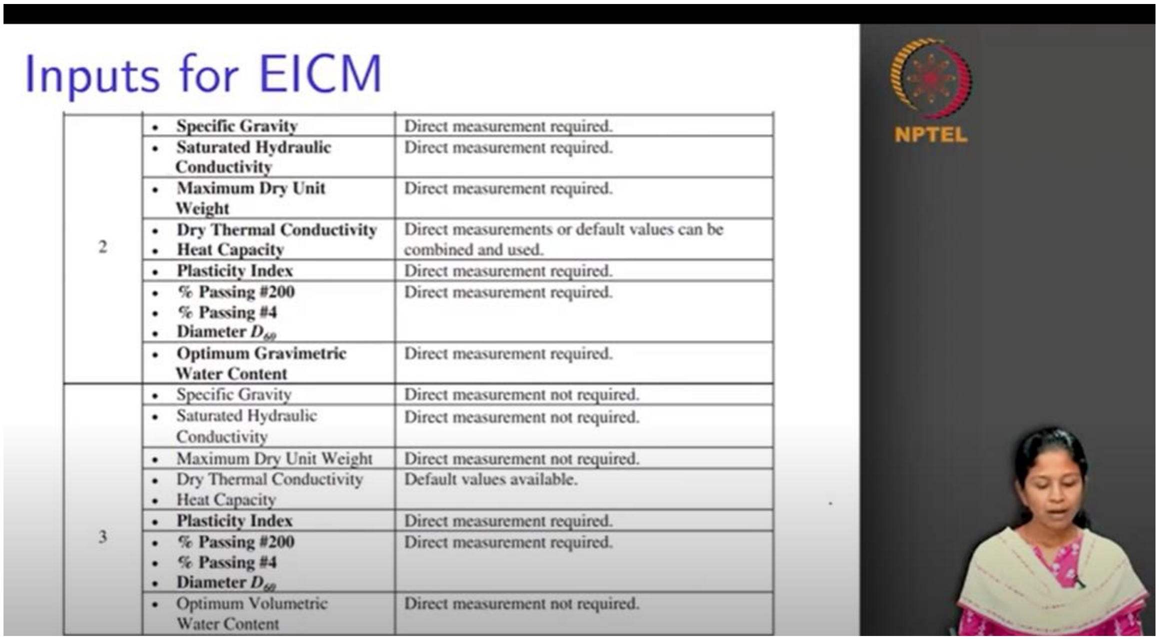

Next we move on to the level 2 of data. You can see whether it is level 1, level 2 or level 3, the input parameters required are the same. We saw a similar set of parameters for level 1 also. But the source from which we collect this information is going to be different. Even for level 2, direct measurement is recommended for all these parameters. For some, default values can be combined and used. Again direct measurement is required for all other cases. Previously when we are talking about granular material, its characteristics we said we need three input parameters. One is the specific gravity, second one is the water content present and third one is the dry unit weight. So once we know these three things, all other parameters can be computed. And to compute the soil water characteristics curve, we need additional parameters which is D60, percentage passing 200 sieve and the plasticity index of the soil. So these are the input parameters which have to be measured irrespective of the level of data. Then if we take level 3 alone, even the specific gravity is not required to be calculated. So you can see even this is taken from a history data or calculated using equations. So there is a lot of approximation involved here. But it is very convenient to be used when we do not have any data available with this. So it caters to different kind of users, people who have all the data collected and for cases where very limited data is available. So both kind of users will be able to use this particular design procedure.

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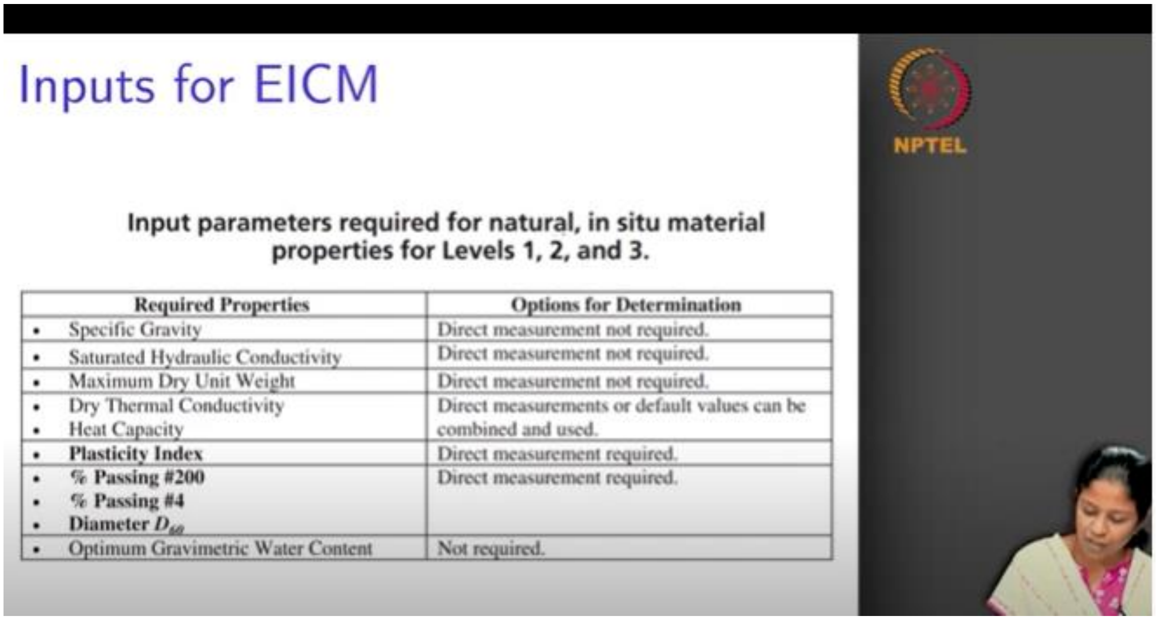

Then we move on to the in-situ natural and in-situ material properties that are required to be input for level 1, level 2 and level 3. For all the three levels, these are the data. So if it is in-situ, we do not need specific gravity and we do not need to measure conductivity. The other parameters can be measured or default value can be used. But for some parameters alone, it is required because we see that in in-situ condition, the material properties are measured at the water content which is present in the soil. Hence, there is no need for additional computation and that is why we do not need all these parameters. Even the optimum gravimetric water content is not required for this case.

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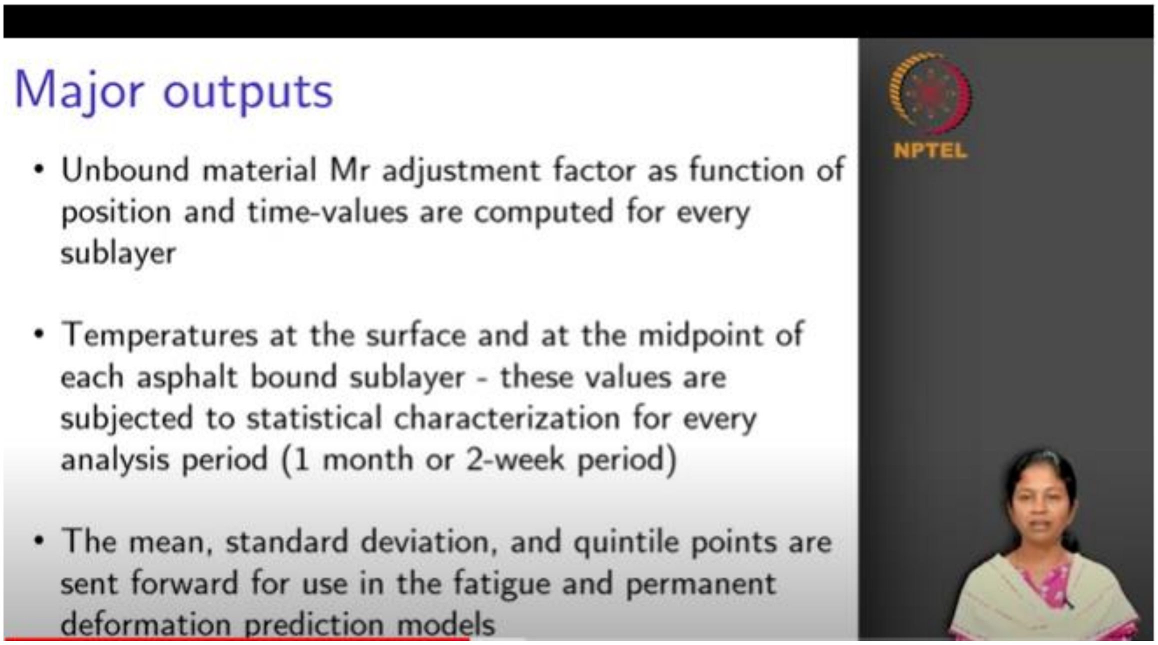

So these are some of the inputs which are used in the EICM model and we will see what are the major outputs. So the unbound resilient modulus which is adjusted for the climatic condition, so unbound M_R adjustment factor, the adjustment factor that we have to use as a function of position, the location in the pavement system and the time value for every instant of time is computed for every sublayer. So this is the first major output. We have the resilient modulus which is computed for depth in terms of sublayer, the time variation, different time and as a function of position in the pavement.

The second output is temperature at the surface and at the midpoint of each asphalt bound sublayer. Let us say I am dividing the layer into two sublayers, I will call it as sublayer one, and sublayer two. For each sublayer, there will be temperature variation throughout the depth. We are approximating the temperature variation to a mid-value because then it will become a highly iterative process. We have n number of layers. It is difficult to execute the process. So we will assume the midpoint and then average the value for a given sublayer instead of doing it for the whole layer. Then for this sublayer point, we said we will have a temperature distribution. So we will divide this into 5 quintiles and for each quintile, we will compute the damage separately. So this is how it is executed. So temperature at the surface and at the midpoint of each asphalt bound sublayer. So these values are subject to statistical characterization for every analysis period. The analysis period could be one month or a two-week period. So this is the second output that we will be getting from the EICM model.

Then the mean standard deviation and quintile points are sent forward for use in the fatigue and permanent deformation model. So we have distress prediction models. We will talk about that subsequently. So in the distress prediction models, we will be using the temperature information also. This is one of the inputs that is required in the model. So this information from the sub layering and the quintile at every given instance of time will be translated to the distress prediction model.

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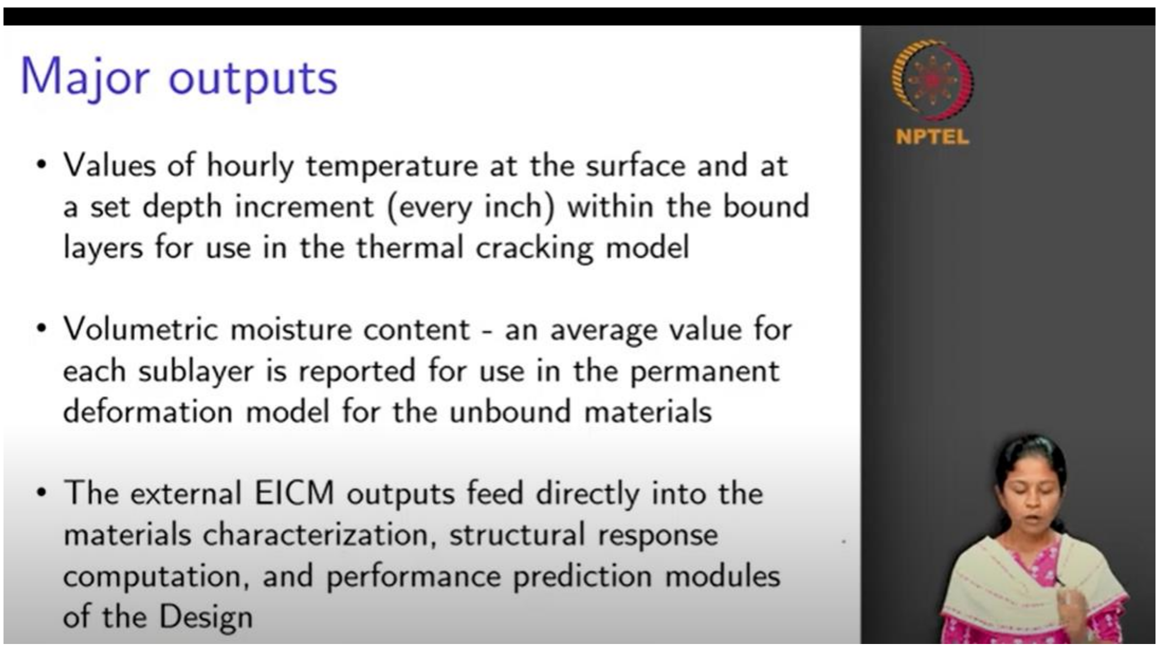

Then we will also get values of hourly temperature at the surface and at a given set of depth increment. Usually it is for every inch within the bound layers for use in thermal cracking model. So we also have a thermal cracking model which we will use for distress prediction. So for the thermal cracking model, we need the variation of temperature in the bituminous layers which is at the surface and at every depth. So how small is the depth interval here? As small as 1 inch for the thermal cracking model. So when we are talking about thermal cracking model, we will come back and refer to this temperature output.

Then we will also compute the volumetric moisture content. This volumetric moisture content is an average value for each sublayer. So like how we take the midpoint for midpoint value for temperature, here for the granular layer, we take the average value. So if it is a sublayer, we compute the value over this entire thickness, we take the average value and then we use it. So that is used in the permanent deformation model for the granular layers.

Then the external EICM outputs, all the other outputs are fed directly into the material characterization, structural response computation and performance prediction modules. So this information that are collected from here are input into the appropriate models and then it is used for material characterization, it is used for structural response computation and it is used for performance prediction. So this calculation from the EICM model serves as an input for at different stages in the pavement design process for the computation of strain, for the computation of damage also.

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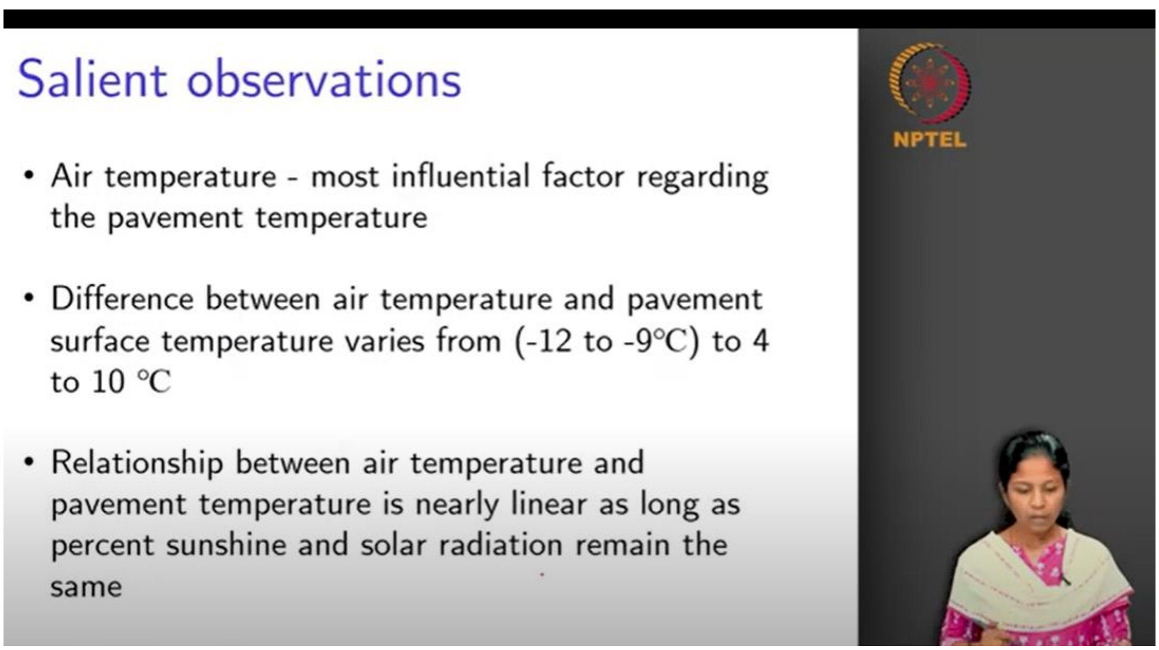

What are some of the salient observations that we have seen from this model? There are some observations that people have reported from the analysis of EICM data. We see that air temperature is the most influential parameter regarding the pavement temperature. This we had seen in the previous lecture with an illustration also. So we saw that among multiple parameters, there was a greater degree of correlation between air temperature and pavement temperature, but the degree of this correlation depended upon other parameters.

Also the difference between air temperature and pavement temperature varies from -12 to -9^{o}C and 4 to 10^{o}C. Again these numbers are calculated for climatic conditions in US. For India in the previous lecture I was talking to you about the regression equation that we developed to compute the pavement temperature. So when that equation was used, we observed that when the air temperature was about 17 to 18^{o}C, the pavement temperature was about 35 to 40^{o}C approximately. When the air temperature is 20^{o}C the pavement temperature is 40^{o}C. Whereas when the air temperature increased to 45^{o}C, the pavement temperature increased up to 70^{o}C. So the difference between air temperature and pavement temperature increased as the air temperature increased. So that was one observation that we were able to obtain from the air temperature pavement temperature correlation.

So the relationship between air temperature and pavement temperature is kind of linear as long as sunshine and solar radiation remain the same. The sunshine and solar radiation will remain the same or closer for locations lying on a given latitude. So that is why we use latitude as one parameter to account for these two effects in the pavement temperature model. So this is with regard to the relation.

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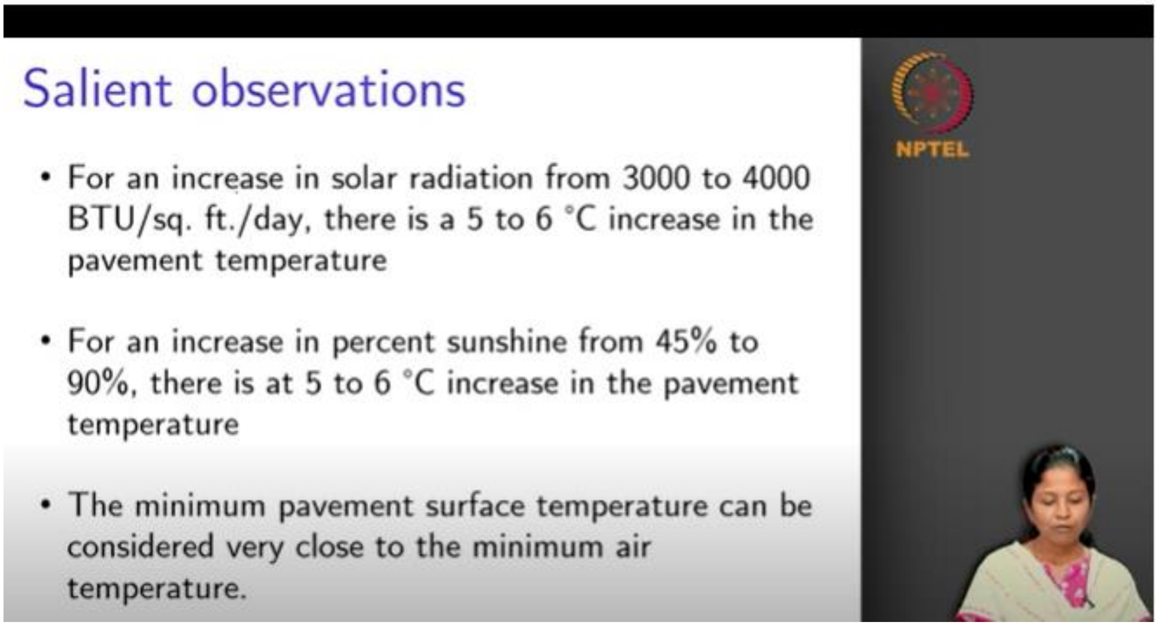

Also for an increase in solar radiation from 3000 to 4000 BTU/sq. ft./day, there is about 5 to 6°C increase in pavement temperature. So the influence of solar radiation and the degree to which it correlates to air temperature we had seen in the previous lecture through data from field and through models. And similarly for an increase in percentage sunshine from 45 to 90% there is about 5 to 6°C increase in pavement temperature. Also the minimum pavement surface temperature can be considered to be very close to minimum air temperature. In a few other models also we have seen that when air temperature is 0°C, when the air temperature is 0 the pavement temperature will also be close to 0°C. As air temperature increases, let us say air temperature becomes 20°C, pavement temperature will be 35°C or so. When air temperature increases to 45°C, pavement temperature will increase to 70°C, again approximate. So this air temperature and pavement temperature will be closer when the temperature is close to 0°C and as the air temperature increases the difference expands. So since the daily maximum temperature in a given year will be very high for Indian conditions compared to many other locations in US, it is very important that we predict the pavement temperature or we establish this air temperature, pavement temperature model very precisely. Next in a very brief note we will look into the validation of EICM model.

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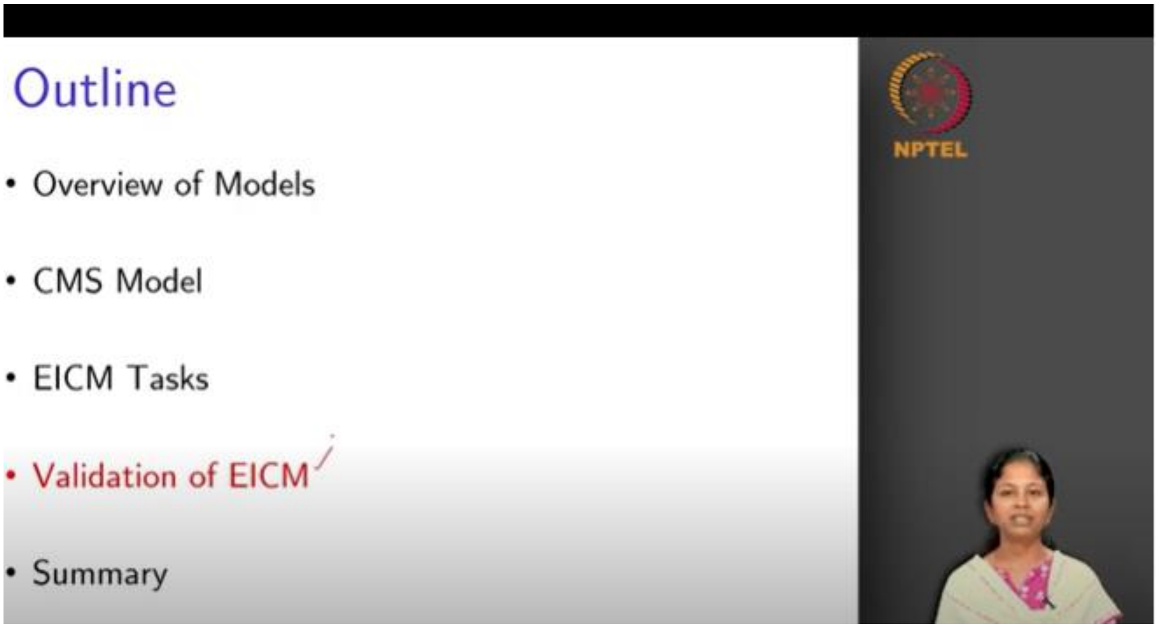

A lot of attempts have been made to validate the EICM model. If you look into this EICM model it has lot of equations. We all call, we call them as models and we said we have infiltration, penetration, precipitation, climate, material structures, etc. Each of these models use a number of equations, a number of variables and constants. So it is important that we calculate these values correctly and verify their values time and again. So depending upon the location for which it is used, the framework remains the same but depending upon the location for which it is used, people have tried to reevaluate the calibration constants.

In fact, the EICM model itself suggests that it is calibrated and validated for a set of data. They have tried to cover as much as locations in US possible to calculate the constants. But still if the model is to be borrowed for another location which does not fall within this sample set for which it was calibrated, then it is required that we reevaluate the calibration constants. So studies have attempted to do that. So here I will show you one illustration of how valid this EICM model is in predicting the material properties. Again for the sake of brevity, I have just shown here the illustrations for granular materials. But you can see there are lot of studies available which have attempted the same for even bituminous material properties also.

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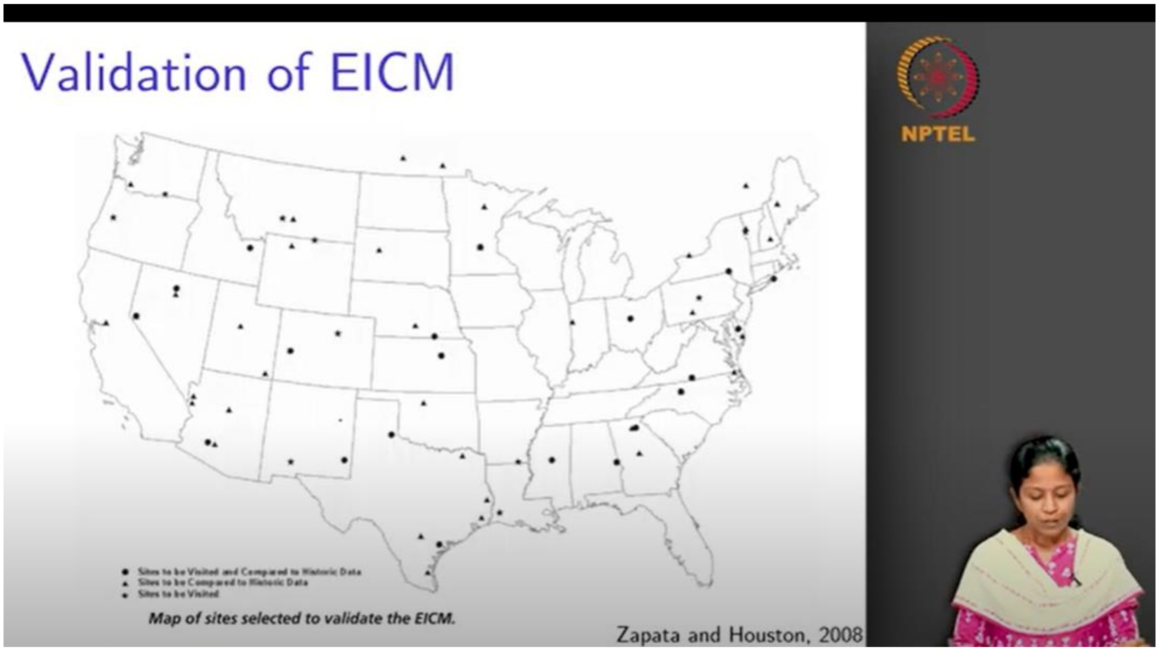

So this is a study by Zapata and Houston and it was published as an NCHRP report. And this report tried to validate the EICM model for granular layers. You can see in the whole map you can see they have indicated three different types of sites. One is sites which are to be visited and compared to historic data, sites to be compared to historic data and then the sites which are visited. So this is a map which indicates locations which were chosen.

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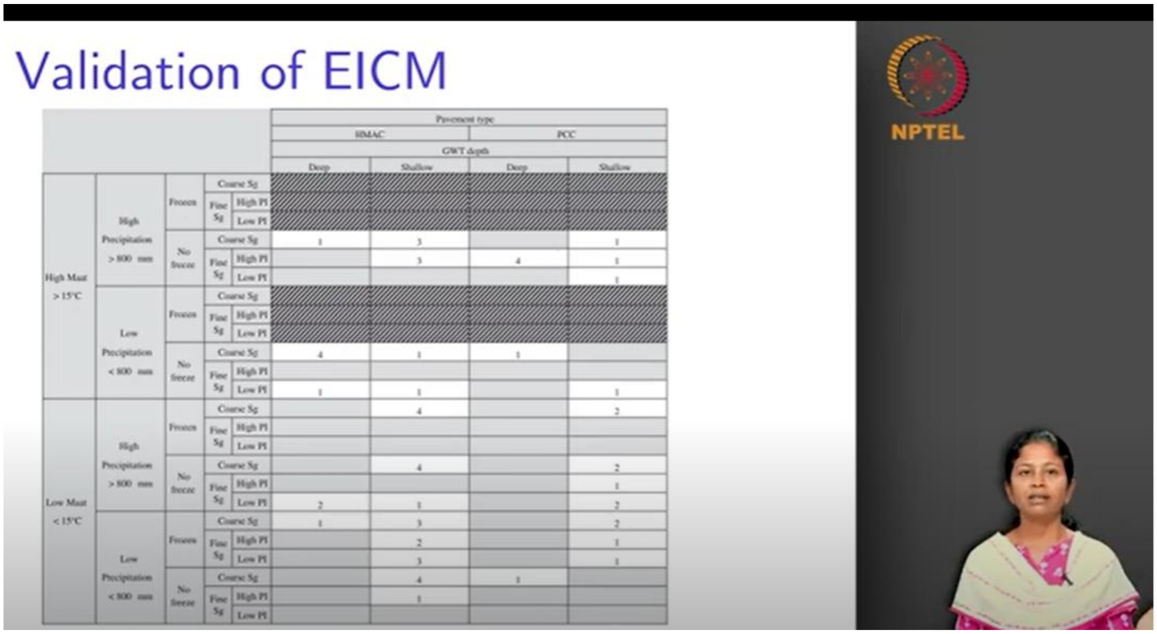

					Pavement type			
					HMAC		PCC	
					GWT depth			
					Deep	Shallow	Deep	Shallow
High Maat > 15°C	High Precipitation > 800 mm	Frozen	Course Sg					
			Fine Sg	High PI				
				Low PI				
		No freeze	Course Sg		1	3		1
			Fine Sg	High PI		3	4	1
				Low PI				1
	Low Precipitation < 800 mm	Frozen	Course Sg					
			Fine Sg	High PI				
				Low PI				
		No freeze	Course Sg		4	1	1	
			Fine Sg	High PI				
				Low PI	1	1		1
Low Maat < 15°C	High Precipitation > 800 mm	Frozen	Course Sg			4		2
			Fine Sg	High PI				
				Low PI				
		No freeze	Course Sg			4		2
			Fine Sg	High PI				1
				Low PI	2	1		2
	Low Precipitation < 800 mm	Frozen	Course Sg		1	3		2
			Fine Sg	High PI		2		1
				Low PI		3		1
		No freeze	Course Sg			4	1	
			Fine Sg	High PI		1		
				Low PI				

And then you can see they had categorized the locations based on the different conditions. So one is mean average air temperature. So locations which have mean average air temperature greater than 15°C and for locations which have as less than 15°C. So this location itself they have categorized into locations with high precipitation which is greater than 800 mm and low precipitation less than 800 mm. Similarly, for temperatures with lower temperature conditions also, they have the same two sets of data depending upon the precipitation level. Then in each of these locations they might be subjected to freeze and thaw effect or they might not experience the subzero temperature at all. So again they are classified into frozen and no freeze condition. And in a given condition the coarse grained soil, in fine grained soil high plasticity index and low plasticity index. So these were the different kind of locations for which they had collected data.

And if you look at pavement type, they looked at hot mix asphalt concrete pavements. They also looked at PCC pavements. And for these conditions what is the groundwater table depth? So a deep groundwater table or a shallow groundwater table. So this is how they categorized pavement into different categories and then they listed how many pavements was visited in each of these category for data collection. So you can see here for example one pavement which has, which is a hot mix asphalt, deep water table, coarse grained soil, no freeze, high precipitation and high MAAT. So like that they had collected data from different set of locations. So based on this data they were able to compare the parameters.

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And what are the parameters required to run EICM? So to validate the model they had collected all these input parameters from each of the layer. We can see here they have information on analysis conditions, the section state, identification number. So these are all the typical information that we collect for a location. Pavement lane properties, type, width, etc. Environmental, so once we know the latitude and longitude we are able to pull in the climate database. So that is why only latitude and longitude are specified. Similarly, the pavement structure, what is the layer number, what are the types, thickness, etc. The moisture content and the dry unit weight and then unbound material gradation. So what is the percentage of all these materials, gradation and all? And then what is the soil classification as per AASHTO and what are the Atterberg limits, liquid and plasticity limit and the gradation parameters. So this much of information it is required to input in the EICM model when we are trying to calculate the required parameters.

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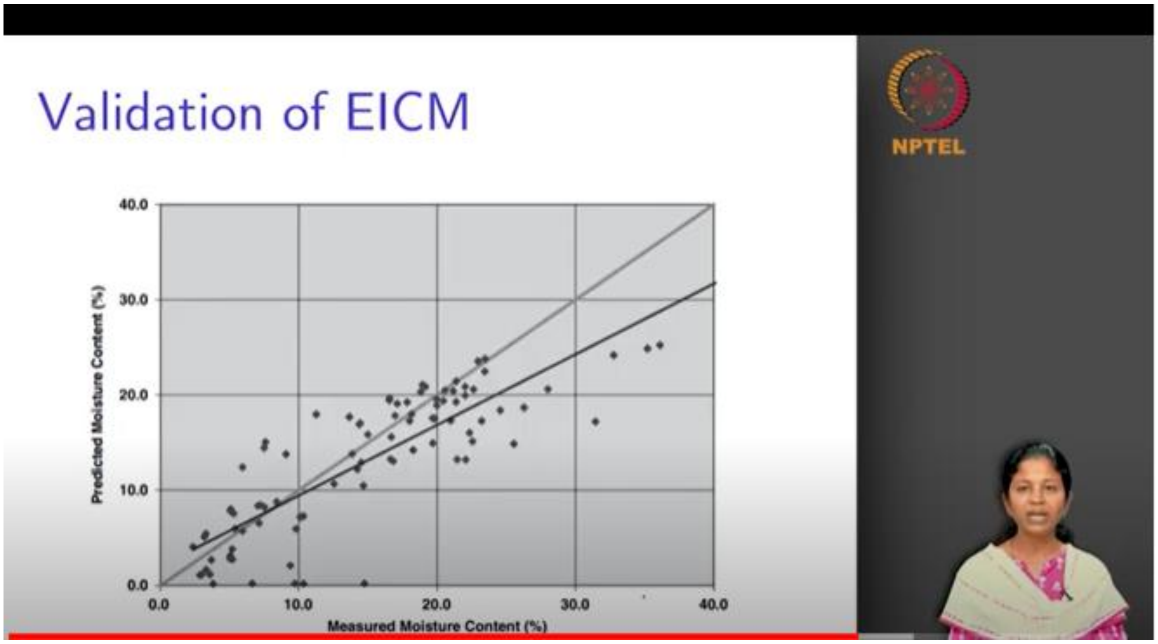

Now we can see, we said we are going to predict the moisture content rate at any given depth and for any given instant of time. So they had done two kinds of analysis. One is to collect the moisture content data directly from the field at different depth and the second one is to use the EICM model and predict the moisture content data. So this is the correlation that they observed between the measured moisture content and predicted moisture content. So more or less the software was able to predict the actual moisture conditions in the field to a closer extent. So this is one parameter which they have calibrated. Again they have similar kind of illustrations for different types of soils, different climatic conditions and so on.

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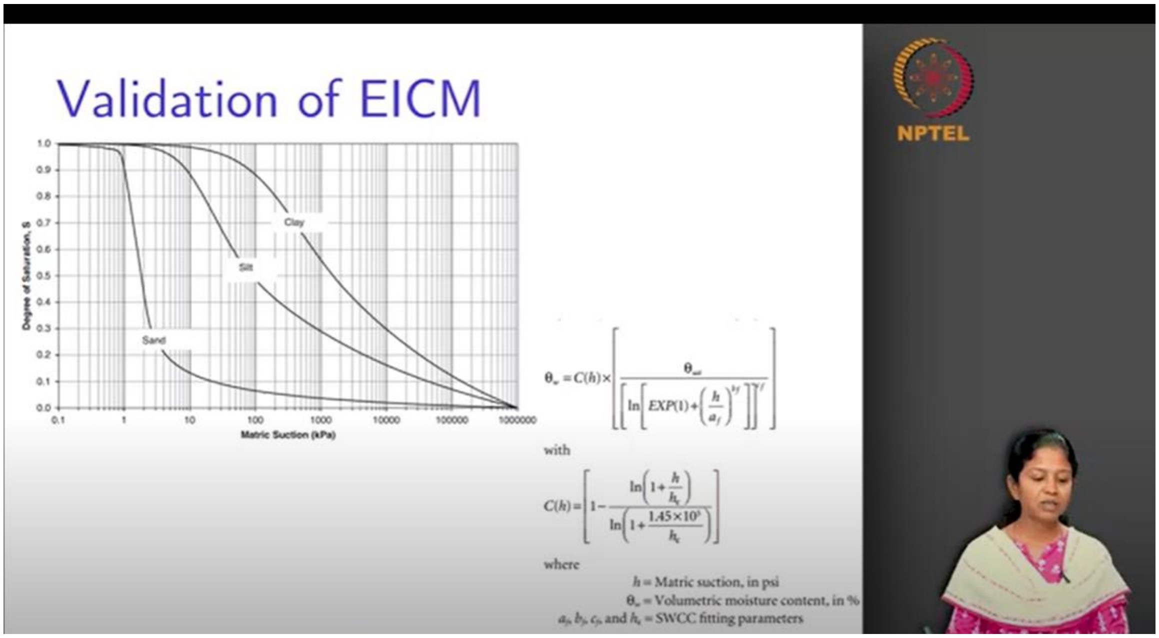

The next one is the soil water characteristic curve which helps us to identify the degree of saturation in the subgrade soil depending upon the suction capacity with respect to a given water table. So we had seen a similar equation previously which was the Gardner equation, a very simplified form but the actual equation used in MEPDG is by Fueldland and Zink. So this is the model which they have used.

$$\theta_w = C(h) \times \left[\frac{\theta_{vol}}{\left[ln \left[EXP(1) + \left(\frac{h}{a_f} \right)^{b_f} \right] \right]^{c_f}} \right]$$

$$C(h) = \left[1 - \frac{ln\left(1 + \frac{h}{h_{\mathcal{E}}}\right)}{ln\left(1 + \frac{1.45 \times 10^6}{h_{\mathcal{E}}}\right)} \right]$$

We can see here it is a function of volumetric moisture content. θ_w is nothing but the volumetric moisture content. This depends on θ_{vol} which is the saturation water content and constant C(h). This constant C(h) has h as the metric suction and all the other parameters are fitting parameters. So this h is nothing but the metric suction here, a_f, b_f, c_f

and $h_{\mathcal{E}}$ are fitting parameters or constants. So that is why we were saying depending upon the condition say even in this case if they evaluated for a coarse grained soil and a fine grained soil given all the other conditions to be same these fitting parameters will vary. There might be some slight variation in these parameters. So for another location with another soil type this parameter will vary. So that is why it is necessary to calibrate these models whenever it is to be used for a specific location. So this model and the fitting parameters were also calibrated and this SWCC was used to predict the moisture content.

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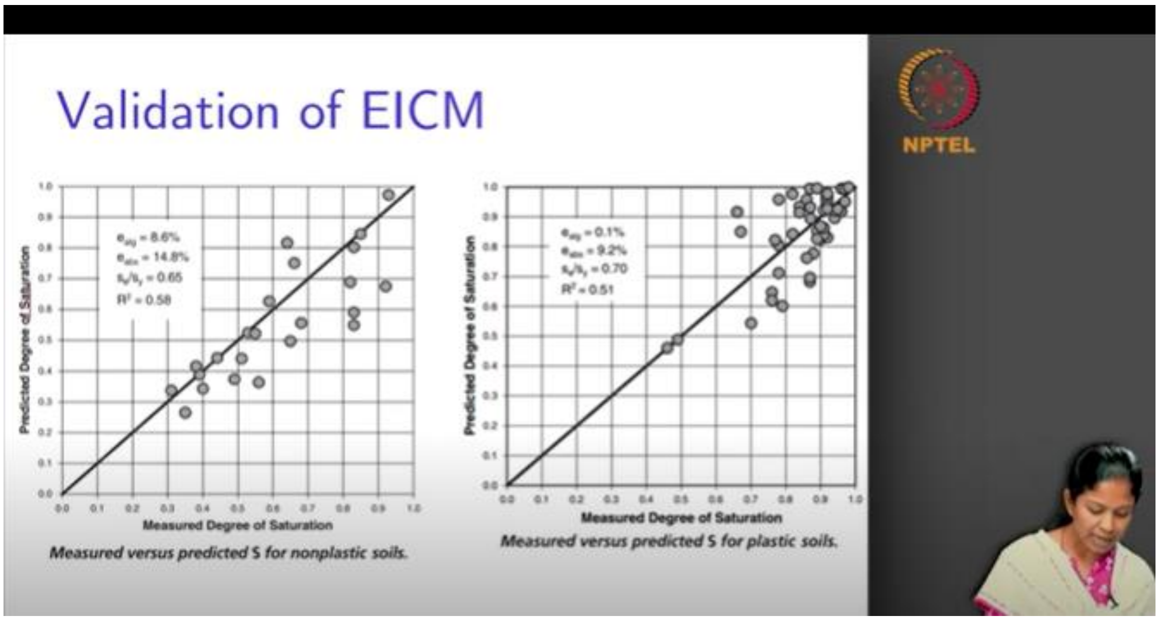

So you can see this is the predicted degree of saturation and this is the measured degree of saturation. Again they had done it differently for non-plastic soil and plastic soil because I said the fitting parameters will tend to differ. So hence two different set of parameters were used for the two types of soil. So we can see here the degree of saturation was also kind of predicted more closely using the EICM model. So this is just a glimpse of how the model fared for a given condition. So this is given in this study by Zapata and Houston. So all these data were from their study. You can look into the study for more details about the validation process, how the constants varied from one case to another.

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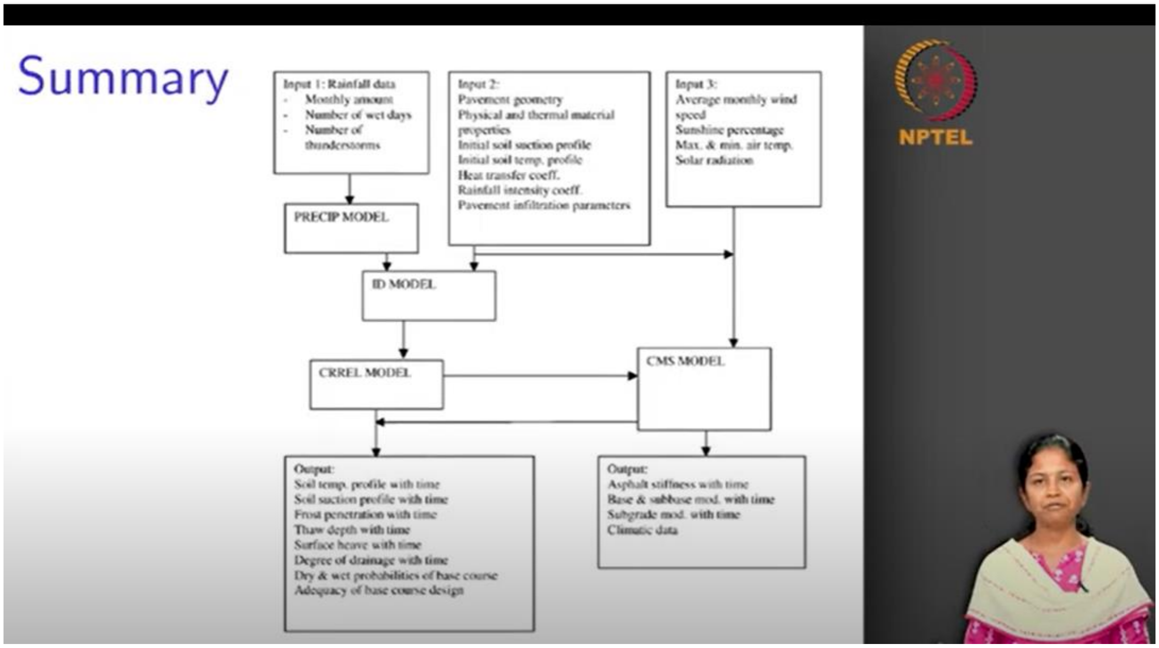

So finally to summarize about the EICM model we come back now and look into the same table, the table that we saw in the first or the second slide. We have different data, we have rainfall data, material property data and temperature related information. So we are going to use all of this information. We have two different kinds of temperature and moisture profiles that we will be computing. We will compute the temperature information on the surface. So we will write it here, one is the moisture information, other one is the temperature information. So this temperature information we will calculate at the surface. So we have all the environmental parameters. We will use the CMS model, we will use the heat balance equation, how much of radiation is received by the pavement, how much is reflected back, what is the influence of convection, what is the convection coefficient. We will use all of it and then we will compute the temperature at the surface. So this depends on the convection and radiation process. Similarly, the lower point we assume it to be a constant node and using the finite element procedure we will be calculating the variation along the depth.

So this is done for a given instant of time and similarly we can compute it for all other conditions. So again for this we will sublayer the pavement, take a value at the mid-depth. Again this value is going to follow a distribution, divide that into 5 quintiles and use the value of each quintile for prediction of modulus and also for damage computation. So this is with regard to the temperature information for the pavement. This temperature information depends on the conductivity and heat capacity of the soil as well. So this is with regard to pavement temperature. Similarly, if you look into the moisture effects we have precipitation and infiltration drainage model. So which will help us to calculate, let us ignore the bituminous layers here. Let us compute the moisture content at the surface of the first unbound layer. So then from this moisture content we will be able to predict the moisture content variation along the depth. Also we will have a subgrade here. We have water table. So from the water table because of the capillary action we will know what is h. Depending upon the variation in h we will be able to calculate the water content at any given instant. So this water content is calculated and then we use it to predict the resilient modulus. So this water content for calculation of water content and resilient modulus also is sublayer. Similarly depending upon moisture present here we will compute the moisture at every instant and from that also we will be able to compute the resilient modulus.

Also we have a frost and thaw model which will tell us what is the depth of frost and what is the depth of thaw. So during frost what is the heave that is happening? I had illustrated how heave happens during frosting with a pictorial representation in an earlier lecture. You can recall that and during thawing how much is the depth to which this thaw effect is observed and what is the settlement of the pavement because of this thaw effect. So this is in a nutshell the kind of output that we are interested in from the EICM model and we have understood the relevance of all these parameters and how it is going to influence the pavement design.

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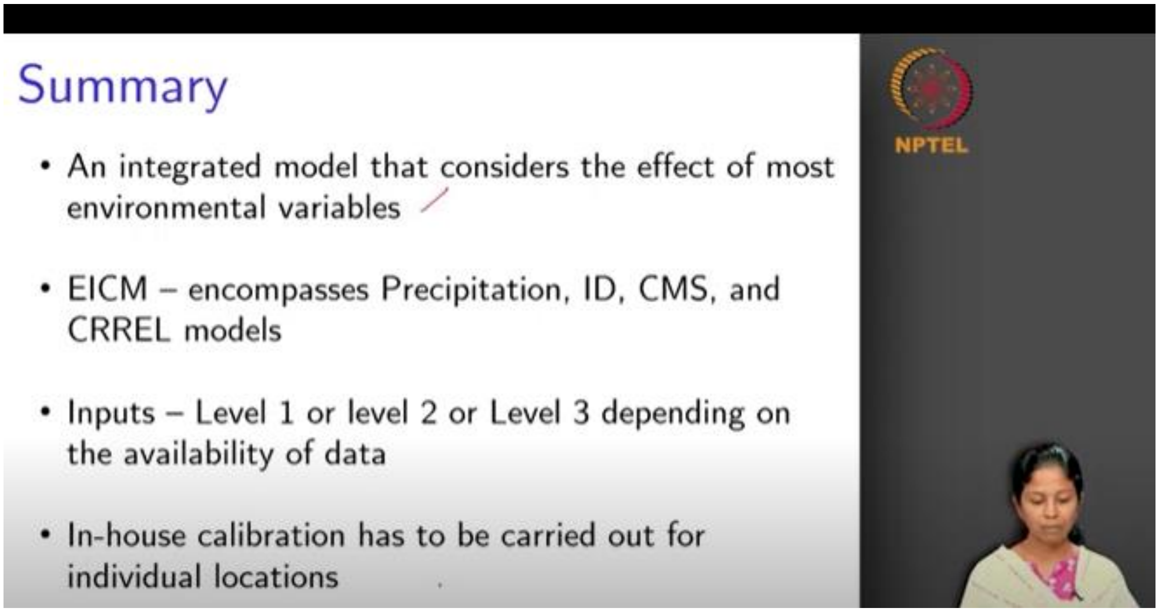

So finally it is an integrated model that considers the effect of most environmental variables. This EICM encompasses precipitation, infiltration drainage, CMS model and CRREL model. So we have inputs at level 1, level 2 or level 3. Again I forgot to mention here we will have this hydraulic conductivity, saturated hydraulic conductivity, then we have dry thermal conductivity and also heat capacity. So we have all these things. So these are the kind of input parameters we have to input.

So we can have a level 1 or level 2 or level 3 parameter depending upon the availability of data. So you should recollect that level 1 is the most accurate one and level 3 is more approximate. And for implementation of this EICM model or for translating it to any location of interest we should be developing in-house calibration constants. The form of the model in most cases the form of the model might be valid but even to be more precise we have to even check whether the form of the model itself is valid. But for as a first step we can still use the same model, re-evaluate the calibration constants and then use it for our location of interest.

So this is an overview in a very, very, very brief manner regarding the EICM model. So I thank you for your time. In the next lecture I will be talking about the different design procedures and how this climatic information is used in each of these design procedures. Thank you.