Sustainable Transportation Systems
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Lecture No. 43
Traffic Noise Emission Models

Hello, friends in the series of emissions related modelling techniques, today we will discuss about traffic noise emission modelling. So, as you know like we studied emission modelling in terms of material flow means something is being emitted in terms of air pollutants then it disperses and reaches to the receptor.

So, we want to know how much concentration of the air pollutant reaches to the receptor. Receptor can be a person or eco system or some building or city or whatever where we want to estimate the concentrations of air pollutants. So, emission modelling we have studied then dispersion modelling also we have studied.

Today we will study noise emission modelling and the reason behind this is because we want to know how much noise can propagate from the source to the receptor. So, that if the noise levels at the receptor is much higher than the acceptable standards, then we can do something to reduce the noise either we have to change something at the source or we have to design noise barriers you may recall that designed parts of the noise barriers how do we do that so, that the length of the total distance of the traveling of this noise becomes larger.

So, that the noise at the end becomes less and less, noise is nothing but the energy you can see like for example, if you are studying just under the bulb or tube light the light intensity or illumination is much higher if you go away from that the light or illumination decreases. Similarly, noise at the source it is energy and it is much higher at the source but as you go away from the source the noise levels decreases. So, today we will discuss about how to model the noise.

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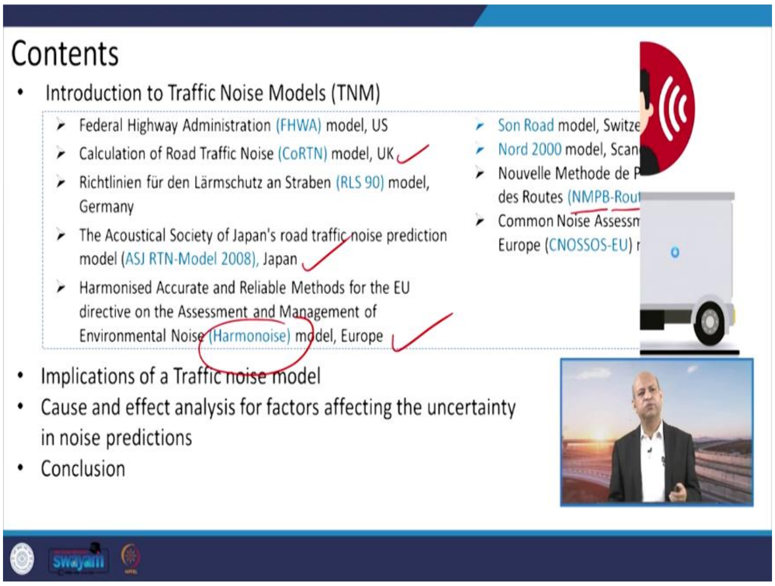

So, that traffic noise especially noise can be emitted by many sources like these diesel generators DG sets et cetera or maybe some loud music related sources et cetera, but our aim is only to a traffic noise basically because we are discussing sustainable transportation system.

So, our discussion will revolve around the traffic noise. So, we will look into different kinds of modelling techniques which are available in different techniques different countries like in USA, you can see this federal highway administration FHWA model so that is the model for noise estimating or noise prediction, calculation of road traffic noise CoRTN that is in the UK.

Similarly, in Germany also there is one model RLS 90 and then acoustical society of Japan's road traffic noise prediction model. So, that is ASJ RTN model 2008 2008 you can see in Japan it was developed, there is another model that is known as harmonized accurate and reliable methods for the EU directive on the assessment and management of environmental noise.

So, that is in short is known as harmonize model this is for European setting. In Switzerland they have their own model which is known Son road model and then Nord 2000 model is in the Scandinavian countries like Norway et cetera. And then there is this NMPB routes model for the France and in Europe, another model is common noise assessment methods in Europe, that is CNOSSOS-EU model.

So, different techniques are there for traffic noise modelling, as you have also seen like in air pollution emission inventory related models were several like IVE, MOBILE, MOVES, COPERT etc. Similarly, this noise emission modelling is different in different countries and they have their different kinds of strengths or limitations and as per the situation we will see in the short after.

We will see afterwards implications of these traffic noise model how do they help us in estimating the noise at the receptor and how they can be helped by policy decisions related to the noise levels and then the cause effect analysis of the factors which affect the uncertainty in noise prediction.

Because even though we have used certain mathematical equations, but there are several input parameters as you know in any kind of modelling technique, there are uncertainties because of several reasons that may be due to input parameters or that may be due to like calculation related limitations and other factors which we will discuss and then at last we will conclude the remarks or the lecture of today.

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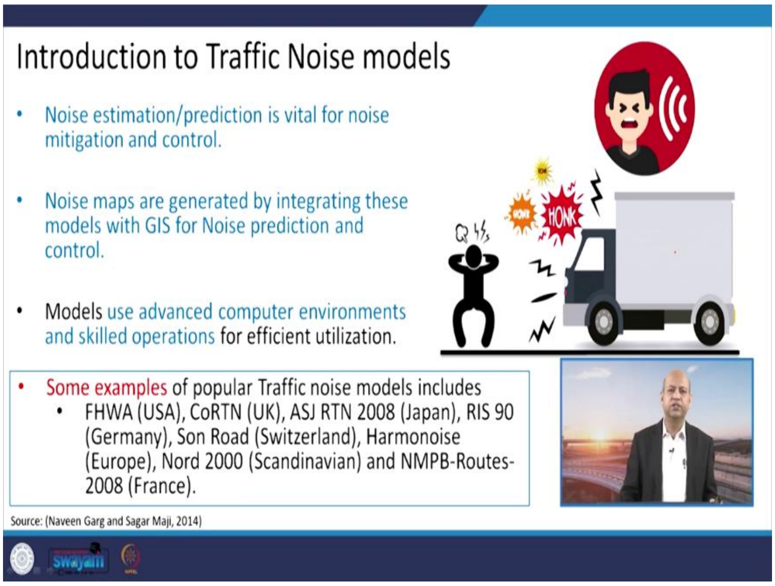

So, when we talk about the introduction of traffic noise models, then basically we want to see that what are the sources of the noise and how noise travels from one place to another and are there certain mitigation ways or to control the noise but before controlling or before mitigation, we should know how much noise is there at a particular place.

So, these models help us to estimating or predicting the noise because of these regular activities, then there are like noise maps can be developed as you might have seen grid based emission inventory or air quality dispersion those kinds of things. So, here also noise maps are generated by integrating these particular models which are used for traffic noise prediction or estimation with the GIS.

So, if we can integrate them with the GIS framework, the noise prediction and control becomes easy to analyse and to do whatever is needed as like interventions, whether it is policy related or technological related because then you have a map and which areas are more affected by noise, which area are okay. So, those particular areas can be tackled where lot of noise is there.

Then these models are nothing but as I said these are mathematical equations and they are used through programming. So, some computational environment is needed plus skilled operation operators are needed so that they know how to do programming how to run the model.

So, this is something which is kind of highly skilled kind activity with only those people who know the programming who know to convert those principles into certain equations and then doing input parameters the reading the file and then output is taking from this model in certain way which can be understood by policymakers. So, all these things are done by those particular experts who know how to do it.

And the examples of different noise models which we have just seen the list like FSWA for USA, then CoRTN UK and then as ASJ, RTN in Japan or RIS 90 of Germany then Son road of Switzerland, then HARMONOISE is of Europe NORD 2000 for Scandinavian countries, then NMPB routes 2008 which is France. So, those models we will discuss what are their parameters, what are their features

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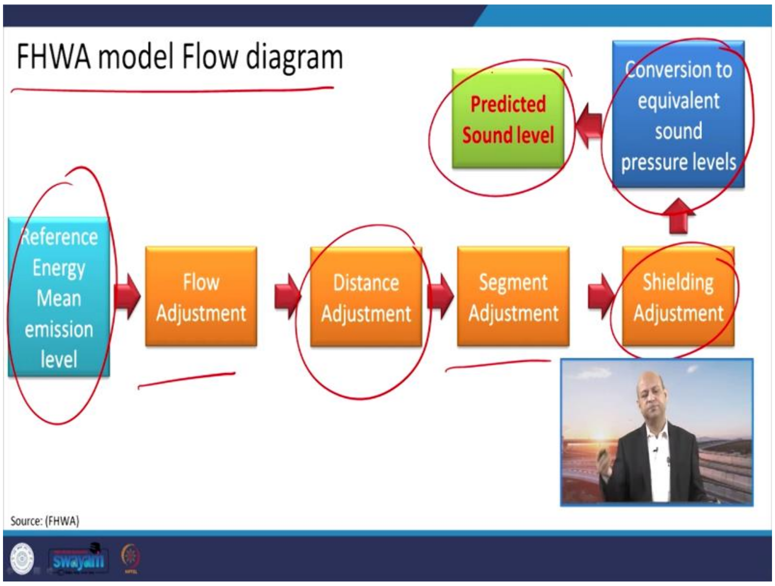

When we talk about this FHWA model the flow diagram, how does it you know different kinds of features how does it take. So, first of all the reference energy mean emission level. So, energy is nothing but that noise level what is the reference level in comparison to that we will know that how much noise is increasing or decreasing and how it is traveling then the flow adjustment we have to do because of like wind velocity direction all those things.

Distance related adjustment also we have to do because as you go away then noise decreases. And then segment adjustment depending upon the topography and other kinds of features and shielding adjustments means if you are using some sort of like noise barrier or some other kind of technique, then those kinds of adjustments have to be made or like ear plugs those kinds of things, then conversion to equivalent sound pressure level.

So, ultimately how much noise is being received by the receptor and because noise also fluctuates, but we want to estimate as an average value which is like equivalent, we will convert it into equivalent value of this noise.

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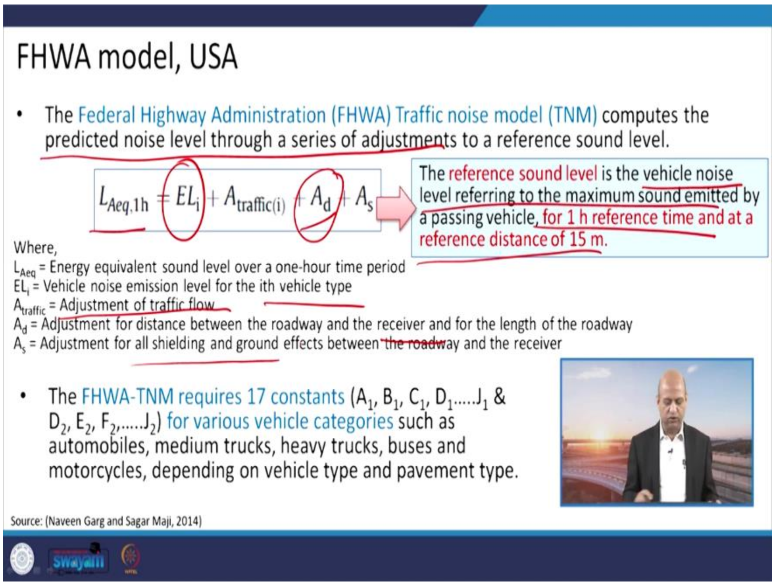

So, that predicted sound level is expressed in those terms which we will see like here this LAeq. So, this is energy equivalent sound level LAeq that is over a 1 hour time period. So, every parameter has certain definition and we should follow those definition those units, otherwise our calculations will be completely erroneous.

So, this is the empirical relationship which is used by Federal Highway Administration that is FHWA traffic noise model, in computational those kinds of activities.

$$L_{eq} = EL_i + A_{traffic(i)} + A_d + A_s$$

So, the prediction of noise level through the series of adjustments to a reference sound level that is very important which we have seen in the flow diagram.

So, the reference sound level is nothing but the vehicle noise level referencing to the maximum sound emitted by a passing vehicle. So, that we will take as the reference sound level. So, maximum possible sound created by a vehicle and this is for 1 hour reference time and at a reference distance of 15 meter that is also like in air quality monitoring you might have seen that when we talk about ground level measurement that is like 10 meter above the ground.

So, those kind of values have certain sanctity and we should be quite careful about that. So, this LAeq energy current sound level over a 1 hour time period. Similarly, this one terminology ELi this is vehicle noise emission level for the ith vehicle type means different kinds of vehicles will emit noise of different levels like two wheeler different three wheeler four wheeler and within four wheeler diesel vehicle have their engines may be working in differently and they can create a lot of noise in comparison to gasoline based noise.

So, and then heavy trucks or the those commercial heavy commercial vehicles they will produce different kinds of noise and then tyres also play a role then the surface of the roads they also play a role in creating noise. So, all those things are important. So, here this is basically the type of vehicle related the noise emission then Atraffic is just meant of the traffic flow because flow also changes from time to time.

So, some advertisement we have to do so, some factors are there basically. Similarly distance related adjustment factor we have to see because the distance between roadway and the receiver and for the length of the roadway that is reflected in this particular correction factor or adjustment factor.

Similarly, As is adjustment for all shielding and ground effects between the roadway and the receiver. So, whatever kind of barriers are there in natural way means men made whatever those kind of factors or adjustment related values we have to include. So, that values will give ultimately the 1 hour related equivalent sound level.

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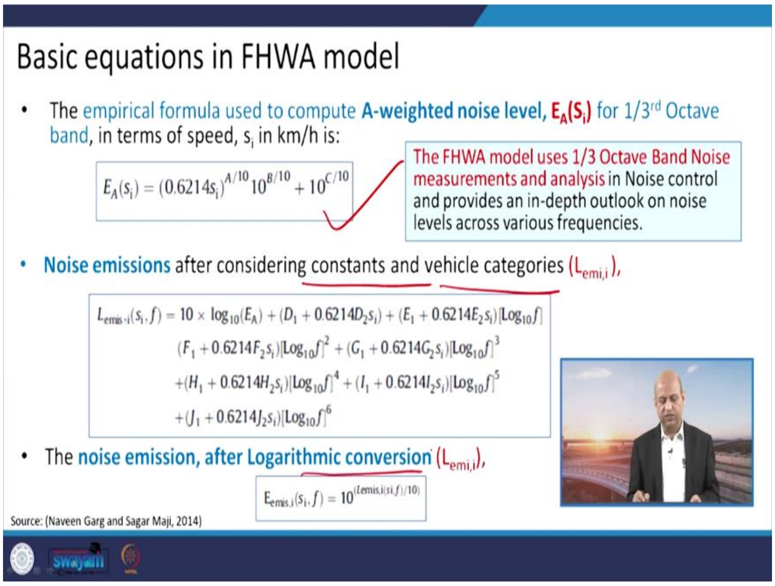

The basic equations which are used in this particular model are like you can see here.

$$E_A(S_i) = (0.6214 s_i)^{\frac{A}{10}} (10)^{\frac{B}{10}} + (10)^{\frac{C}{10}}$$

$$E_{emis,i}(s_i, f) = (10)^{(Lemis,i(si,f)/10)}$$

So, this emission of the noise is considered with the help of these constants and vehicle categories as we have seen different kinds of vehicle categories are there. So, these are empirical relationships use just convert them into programming and nowadays basically this model has already done this.

So, you only to do input values and the model will calculate automatically we are just giving you idea understanding of what is happening inside the model. So, that is why we are discussing these empirical relationships which are the part of the model. So, the noise emission then logarithmic conversion is there to convert into certain values that is equivalent related.

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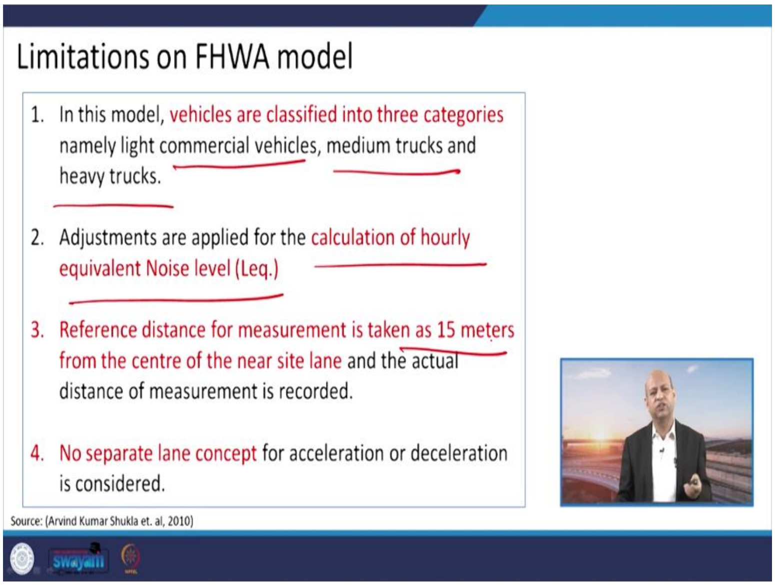

But there are limitations of this particular model and those limitations are like vehicles are classified in three broad categories. So, beyond that, we are not estimating or predicting any noise. So, that is a coarse categorization you can see otherwise, if you go further micro level kind of categorization, then estimation value estimated value may be different, but here this is like commercial vehicles, medium trucks and heavy trucks.

So, that means is small vehicles have not been considered or so. So, adjustments are applied for calculation of hourly equivalent noise level. So, means different time period is not available, then the reference distance measurement is taken as 15 meters from the centre or the near side lane you can see and the actual distance of the measurement is recorded.

So, again there are certain limitations in that we also, no separate lane concept for acceleration or deceleration is considered. So, whatever like you may recall in Gaussian model, we assumed that the pollutants are inert. Some very simple assumptions we generally use when we do some modelling because forever every kind of small thing we cannot do these use equations otherwise that would be very difficult and very resource intensive modelling effort.

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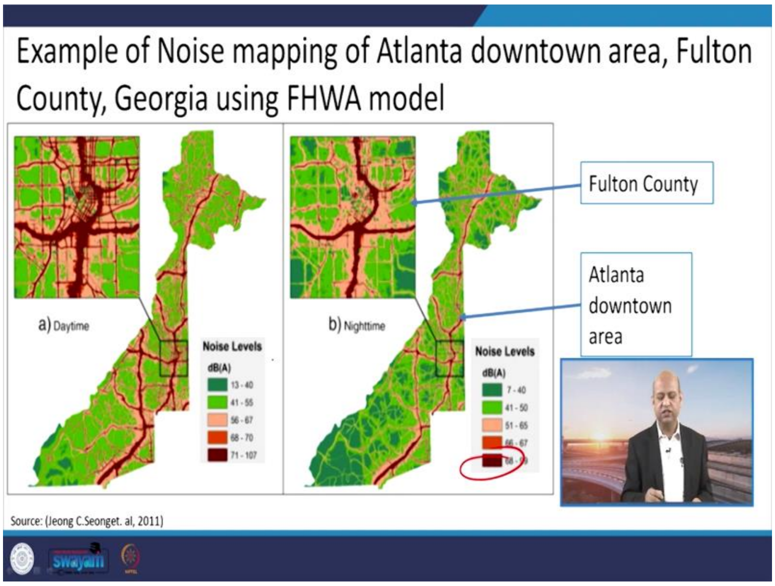

Then as I discussed like the mapping with the help of GIS based integration can be done so, here you can see this GIS based mapping is there for Georgia they have used this county Georgia in the USA. So, as you see the colour schemes. So, dark this brown or maroon is the maximum value of the noise.

This is the night-time this is the daytime you can easily see night-time noise levels is less than the compression in the daytime and the dark brown that is maroon is the most noise at the road level then as you go away from the road the noise level decreases. So, colour schemes are given here for knowing about different kinds of noise range or level.

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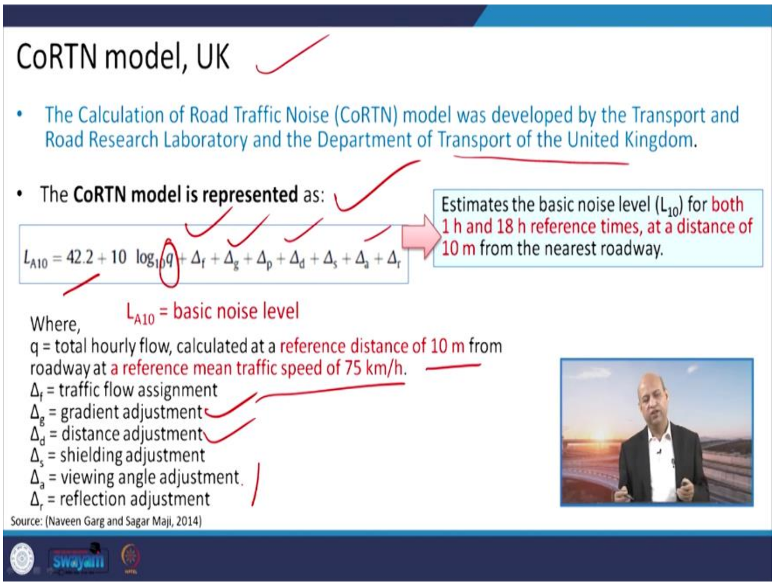

For UK this CoRTN model is there and this uses this particular equation this is developed by transport and road research laboratory and department of transport of the United Kingdom. So, they have developed this model for that particular purpose in this basic noise level that is L10 for both 1 hour and 18 hour reference times at a distance of 10 meter from the nearest roadway that is estimated and these empirical values are there you can see like small q is total hourly flow calculated as a reference distance of 10 meter from roadway at a reference mean traffic speed of 75 kilometre per hour.

$$L_{A10} = 42.2 + 10\ log_{10}q + \Delta_f + \Delta_g + \Delta_p + \Delta_d + \Delta_s + \Delta_a + \Delta_r$$

So, those kind of values are there, then different parameters are here you can see these are adjustment related factors whether traffic flow rate or gradient related. So, gradient is something new if you compare the other model otherwise traffic related adjustment factor was there in that also distance adjustment was there in that this model of FHWA and similarly, in this model of CoRTN and also distance related and shielding related are there. But additional adjustments are there like viewing angle reflection adjustment those are additional parameters in this particular model.

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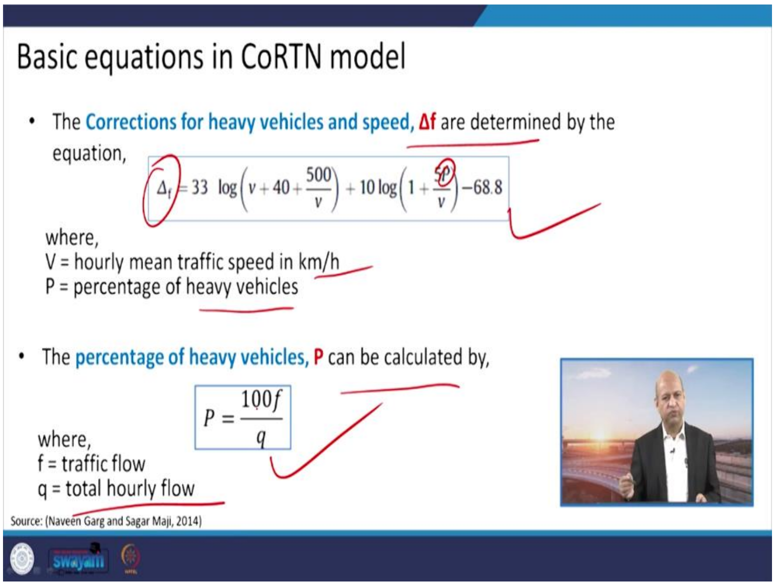

Then corrections for heavy vehicles and the speed.

$$\Delta_f = 33\log(v + 40 + \frac{500}{v}) + 10\log(1 + \frac{5P}{v}) - 68.8$$

So, delta f is calculated by this particular relationship. So, here v is hourly mean traffic speed in kilometre per hour P is basically the percentage of heavy vehicles. So, that is to be known for calculation purpose of delta f and then in percentage heavy vehicles P can be calculated by this particular equation where q is total hourly flow and f is flow at particular time period.

$$P = \frac{100f}{q}$$

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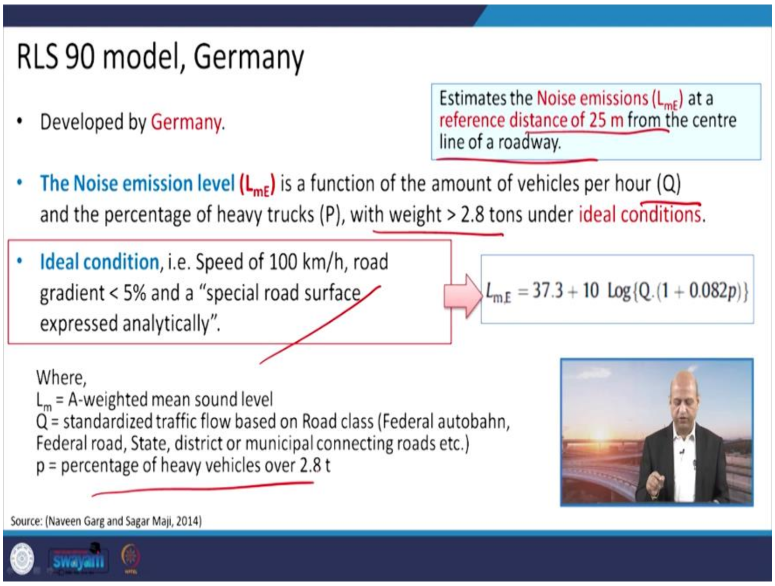

For Germany they have this another model RLS90 model and this is developed in Germany for their own purpose. So, this estimates noise emissions that is at a reference distance of 25 meters LmE and central line from the centre line 25 meter.

$$L_{m,E} = 37.3 + 10\ Log\{Q(1 + 0.082p)\}$$

So, different distances are there for different models accordingly, assumptions also change and the noise emission level LmE function basically of the amount of vehicle per hour flow amount means Q and the percentage of heavy truck as you have seen in the other model also and the weight is from like more than 2.8 tonnes under the ideal conditions.

So, that kind of truck is known as heavy truck their ideal condition is like speed 100 kilometre per hour and road gradient less than 5 % special road surface expressed analytically. So, those kinds of factors we have to take into account and then weighted mean sound level is calculated ultimately Lm and Lm,E.

$$L_m = L_{m,E} + R_{SL} + R_{RS} + R_{RF} + R_E + R_{DA} + R_{GA} + R_{TB}$$

$$L_{m,E} = 10 \log[10^{0.1L}{}_{m,n} + 10^{0.1L}{}_{m,f}$$

Then Q is standard traffic flow as we have seen as per their norms and P percentage of heavy vehicles of over 2.8 tonne.

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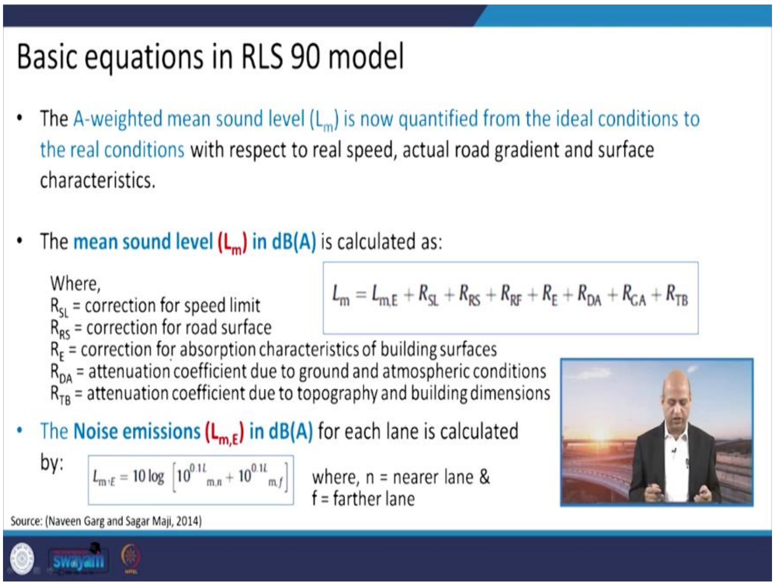

Basic equations in this particular model are again like there is one parameter and then there are some correction factors or adjustment factor. So, basic philosophy is same you can say all models only different kind of range and different kinds of parameters or adjustment factors are there those kinds of differences are there.

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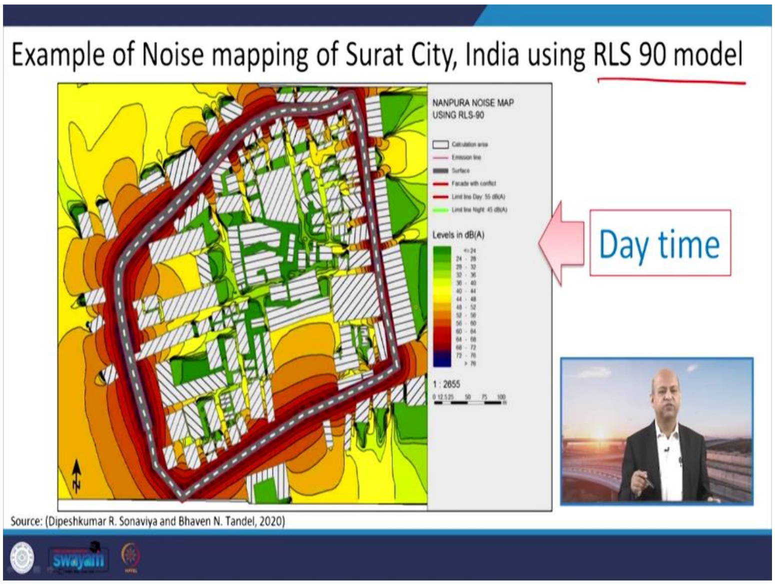

When we apply this noise mapping of Surat city in India using this RLS 90 model. So, in daytime this was kind of scenario was generated for different colour scheme you can see the different noise levels. So, this kind of output can be there.

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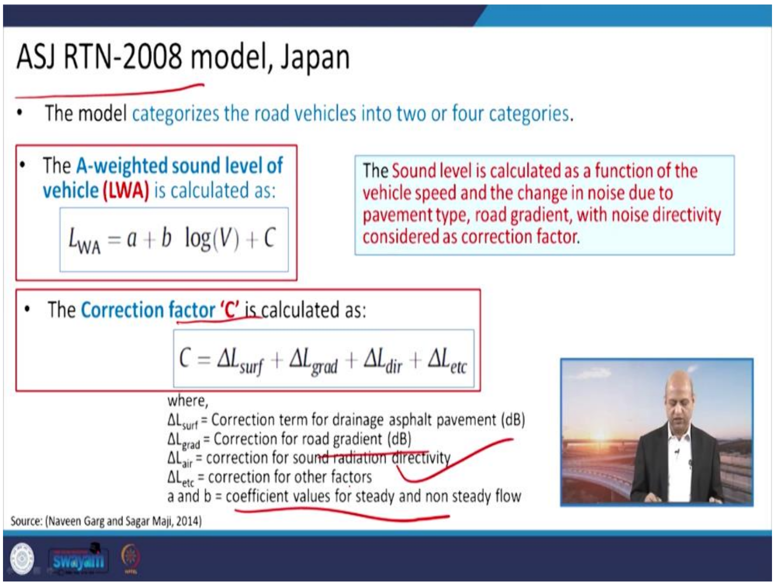

Then we if we talk about like Japan. So, they have their own model that is ASJ RTN 2008 and this is the relationship where a and b are basically coefficient values for steady and non-steady flow

$$L_{WA} = a + b \log(V) + C$$

and you can see these are the values like C correction factor and they have different kinds of correction factors related to like pavement material whether it is asphalt or something else and then road gradient is there and then radiation view angle correction for other factors are there.

$$C = \Delta L_{surf} + \Delta L_{grad} + \Delta L_{dir} + \Delta L_{etc}$$

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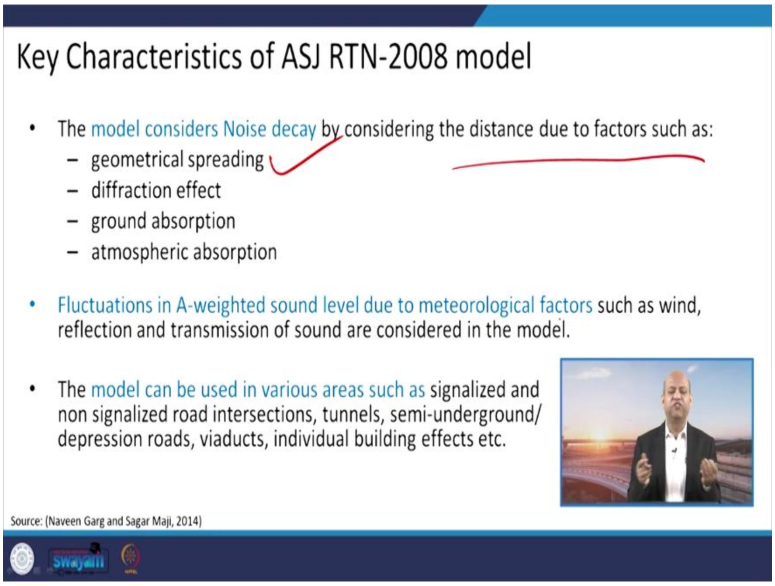

The key characteristics of this particular model are geometric spreading and then diffraction effect and ground absorption how much energy is absorbed or the noise energy sound energy you can say and atmospheric absorption is also. So, those kinds of things are considered this between the receptor and the source.

And then A-weighted sound level due to metrological factors such as wind or reflection and transmission of the sound are considered in this model and it can be used for various areas like signalized and non-signalized road intersections or tunnels or semi underground depression roads or viaducts individual building effects et cetera. So, versatility is there in this particular model.

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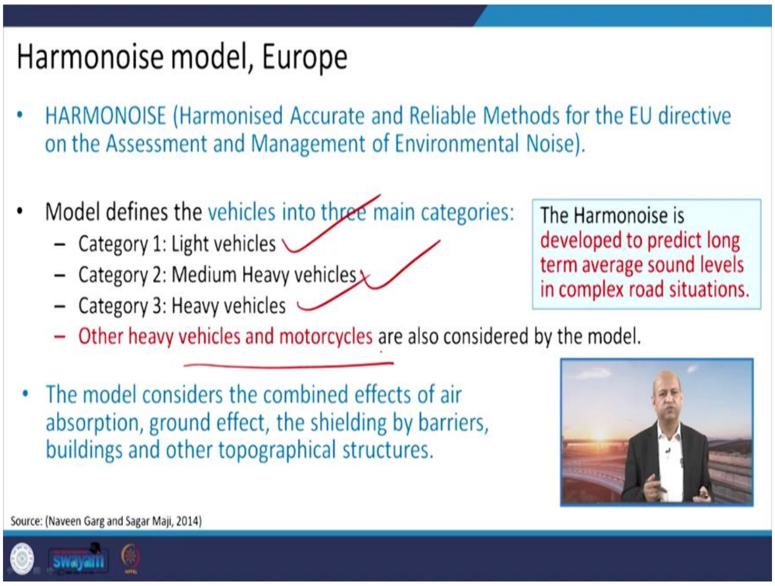

When we talk about another European model that is Harmonoise model which is means kind of more reliable and accurate this is in the particular name also. So, they have different categories. So, its versatility again has good depreciable things like light vehicles, medium heavy vehicles, heavy vehicles, other vehicles motorcycles even they are also considered in the in this model.

So, quite big ranges there for different kinds of vehicle category and it also considers the combined effect of air absorption or ground effect or the shielding which we have seen in other model techniques also.

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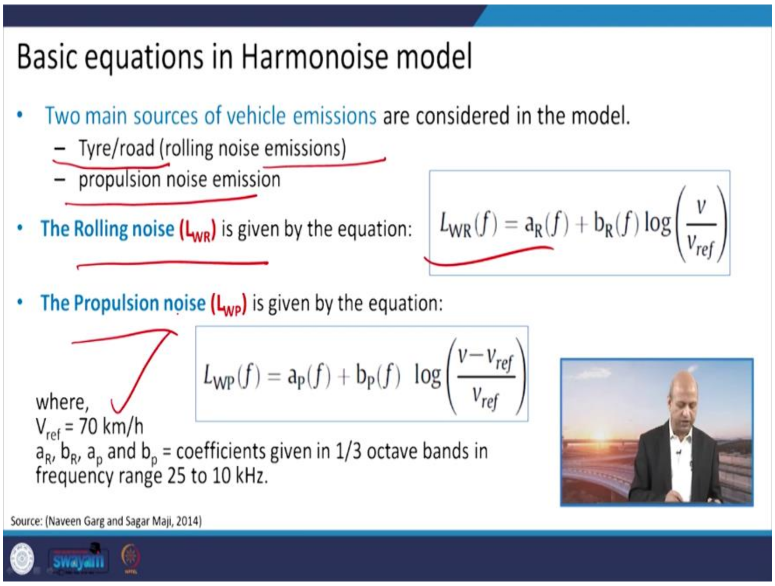

And the basic equations in this particular harmonized model are like rolling noise by this equation and propulsion noise.

$$L_{WR}(f) = a_R(f) + b_R(f)\log(\frac{v}{v_{ref}})$$

$$L_{WP}(f) = a_P(f) + b_P(f)\log(\frac{v - v_{ref}}{v_{ref}})$$

So, two types of noise we are considering basically the tire road related rolling noise emissions propulsion noise that exhaust emissions and those kind of thing and because of this movement related way. So, you can see these are the ways to represent and then the velocity or speed 70 kilometre per hour and these are the factors which are for different kinds of situations.

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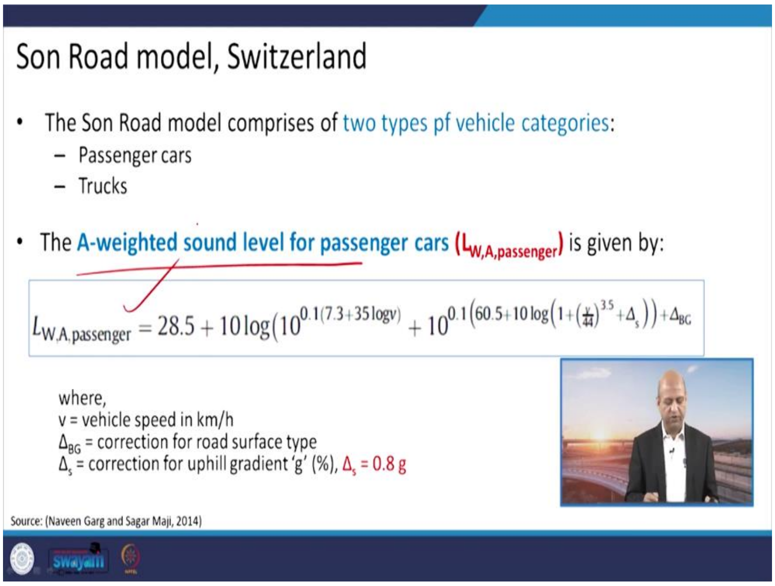

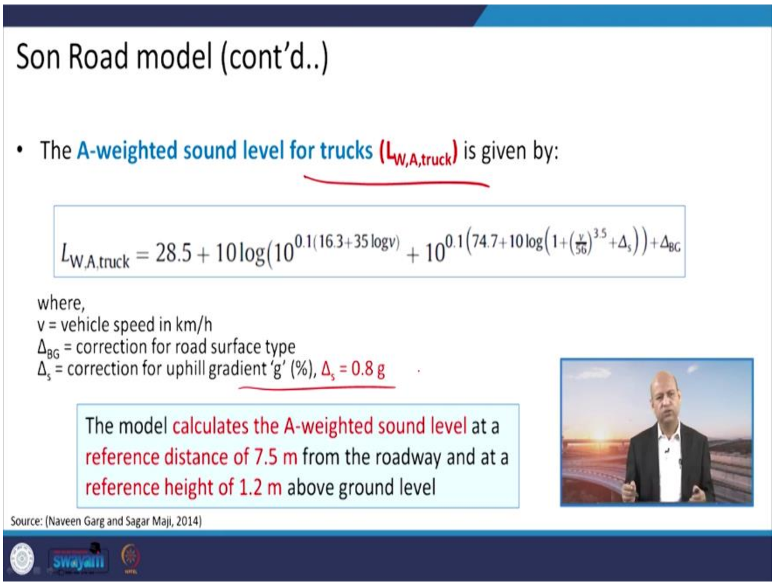

For Switzerland they have this Son road model and that is basically comprised of two types of vehicle categories only that is passengers, cars and trucks. So, it is quite coarse if you compare with other models which we just discussed. And then the A-weighted sound level for passenger cars is given by this empirical relationship

$$L_{W,A,passenger} = 28.5 + 10\log(10^{0.1(7.3+35logv)} + 10^{0.1(60.5+10\log(1+(\frac{v}{44})^{3.5}+\Delta_s)}) + \Delta_{BG}$$

$$L_{W,A,truck} = 28.5 + 10\log(10^{0.1(16.3+35logv)} + 10^{0.1(74.7+10\log(1+(\frac{v}{56})^{3.5}+\Delta_s)}) + \Delta_{BG}$$

we are again those parameters are similar kind of thing and for like trucks this is similar equation and then speed and then a correction factor is there those things are to be put for estimating the noise level.

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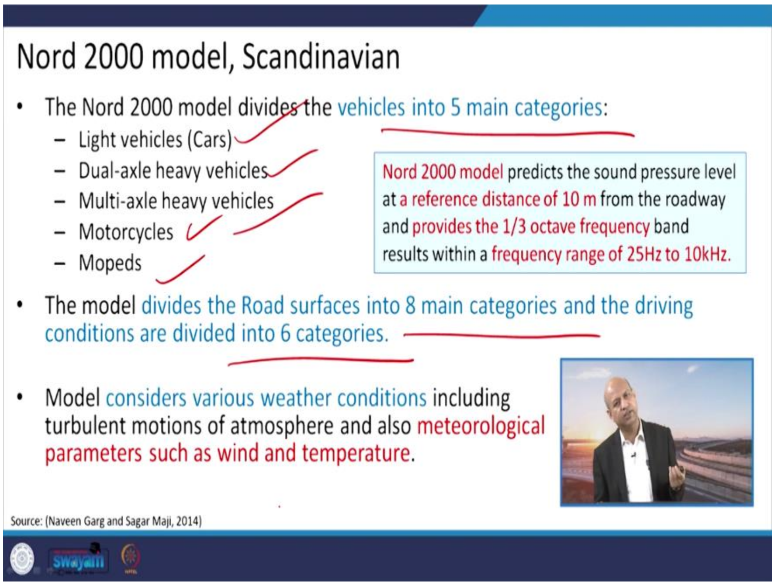

Nord 2000 model for Scandinavian countries that is like 5 main categories of the vehicle they are considering in this so again good model in that sense light vehicles like cars or dwell axle, heavy vehicles, multi axle heavy vehicles, motorcycles, mopeds also again very nice in that way it can go from very a small vehicle category individual vehicle category to the larger one and medium through medium.

So, 8 main categories they are dividing road surface into so again versatility is increasing and the driving conditions are divided into 6 categories. So, they are taking in many situation or many scenarios. So that is why they are estimations maybe better in comparison to others and this considers weather conditions also like turbulent motions of the atmosphere metrological parameters such as wind or temperature related issues, all those things are there because they can affect the energy propagation.

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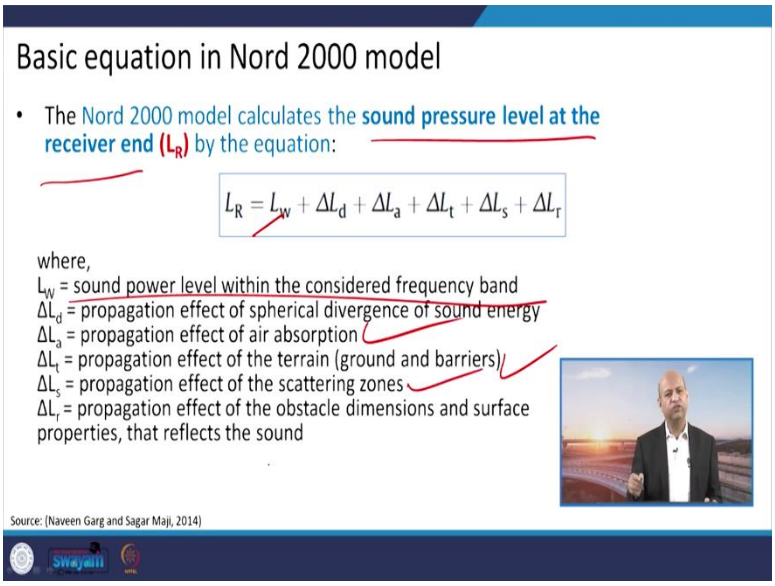

The basic equation is again of course similar kind of thing here.

$$L_R = L_w + \Delta L_d + \Delta L_a + \Delta L_t + \Delta L_s + \Delta L_r$$

LR is the sound pressure level at the receiver and LR and Lw is sound power level within the consider frequency band and then there are effects propagation effects for a spherical divergence and then ear absorption effect or terrain, ground and barrier related effect. If there are barrier than noise level will be reduced as you go further than scattering zones related. So, that we several correction factors are there.

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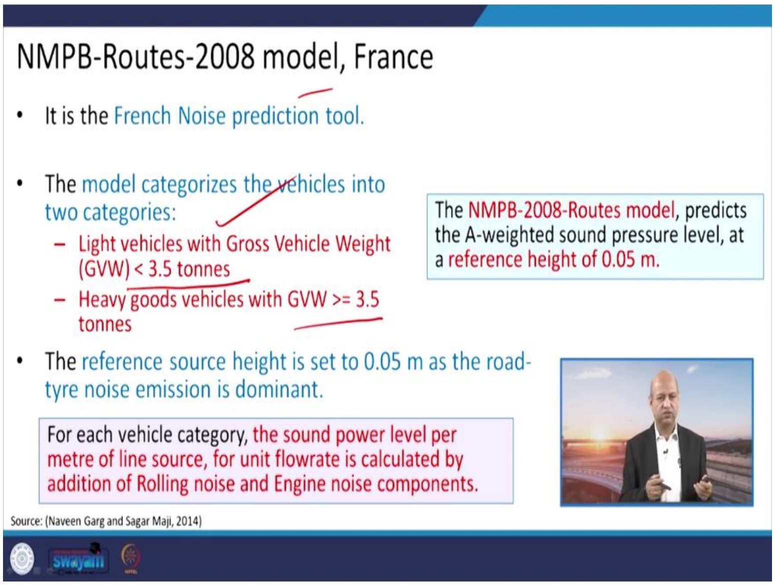

And if you consider the France, then they have their own model which is an NMPB routes 2008 model and this is basically French noise prediction model as I said and it categorizes the vehicles into again 2 broad categories light vehicles less than 3.5 tonnes gross vehicle weight the heavy goods vehicle that is more than 3.5 tonnes kind of weight. So, it is different than the German one if you remember.

$$L_{A,C} = L_W - (A_{div} + A_{atm} + A_{bnd,C})$$

For each vehicle category they have this sound power level per meter of the line source for unit flow rate and it is calculated by addition of rolling noise and the engine noise which is similar to this tire road and propulsion. So, this is similar that French model is similar to that particular model.

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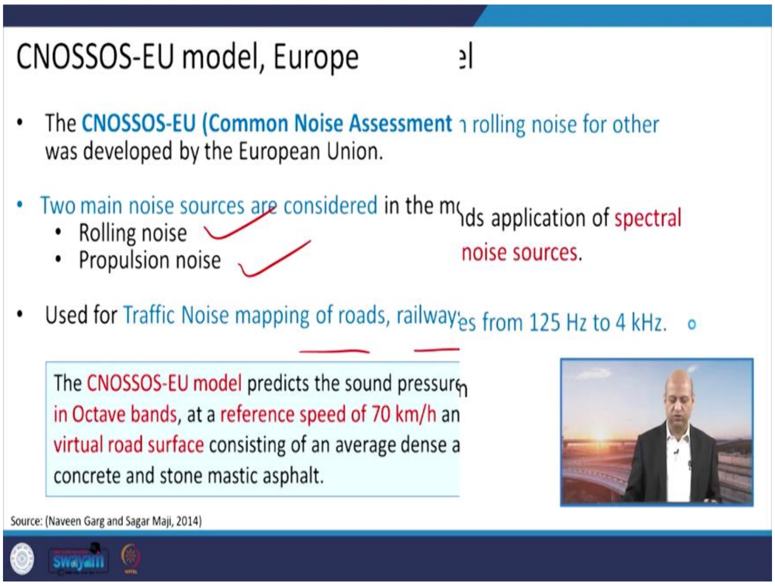

So, there is another model for Europe that is just CNOSSOS-EU model or CNOSSOS model that is common noise assessment methods in Europe that model is also again based on this rolling noise and propulsion noise same technique you can see and the mapping of roads railways aircrafts industry so, this is something extra you can say in comparison to other models.

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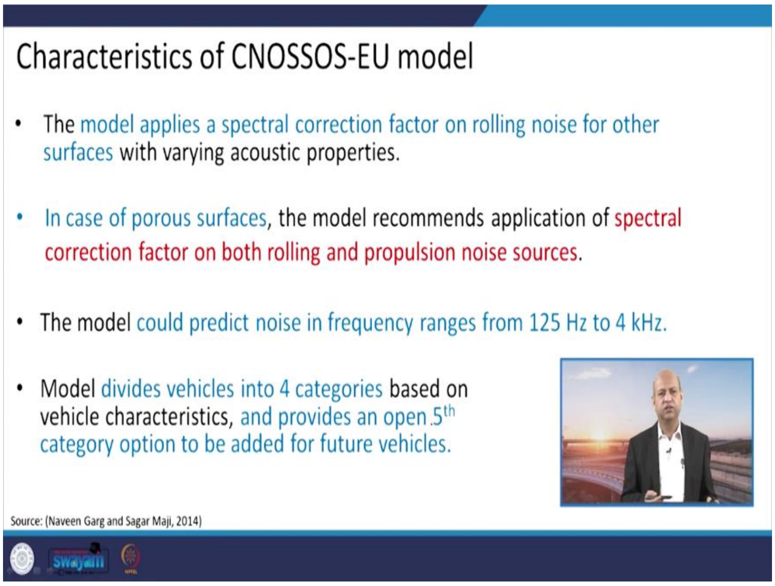

And the characteristics basically it spectral correction factors are needed for rolling noise estimations for other surfaces with varying kinds of acoustic properties because cement road as swelled road those kinds of different properties are there they will produce different kinds of noise.

And in case of like porous surfaces, the model recommends this application of spectral correction factor on both rolling and propulsion noise sources. So, that situation is to be kept in mind the model could predict noise in frequency ranges from 125 hertz to 4 kilo hertz you can say 4000 hertz. So, it divides vehicles into 4 categories based on their characteristics like their weight or their engine kind of technique or in those categories we can see.

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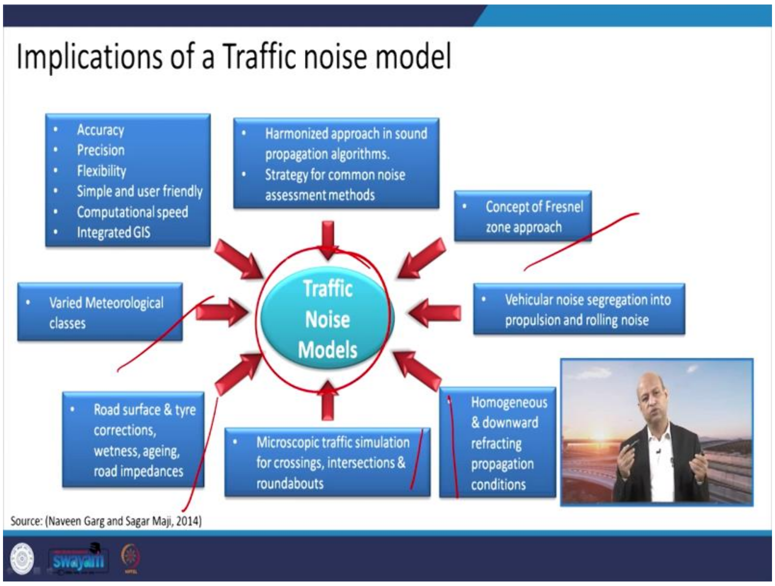

When we talk about implications of traffic noise models, so, this is the diagram which gives us like what kind of considerations must be there for a good traffic model. So, you can see like accuracy the precision means as good prediction is there then this is better flexibility means different kinds of categories it can be incorporated than simple and user friendly so, that very if it is very complicated user will be very less than computationally speeds should be fast and it should be integrated with the GIS.

So, similarly like varied metrological classes must be represented their road surface tire corrections or wetness aging road in this impedances then microscopic traffic simulation for crossings intersections and roundabouts that possibility must be there. And then homogeneous downward reflecting propagation conditions or vehicular noise segregation into propulsion and rolling noise that should be possible if you want to concentrate only the tire related noise then you can know.

So, one can switch off other thing that thing you can in the model you can take so that we can categorize the sources and concepts, zone related approaches harmonized approach in sound propagation algorithm a strategy for common noise assessment methods. So, all these things must be part of traffic noise model good and traffic noise model you can say.

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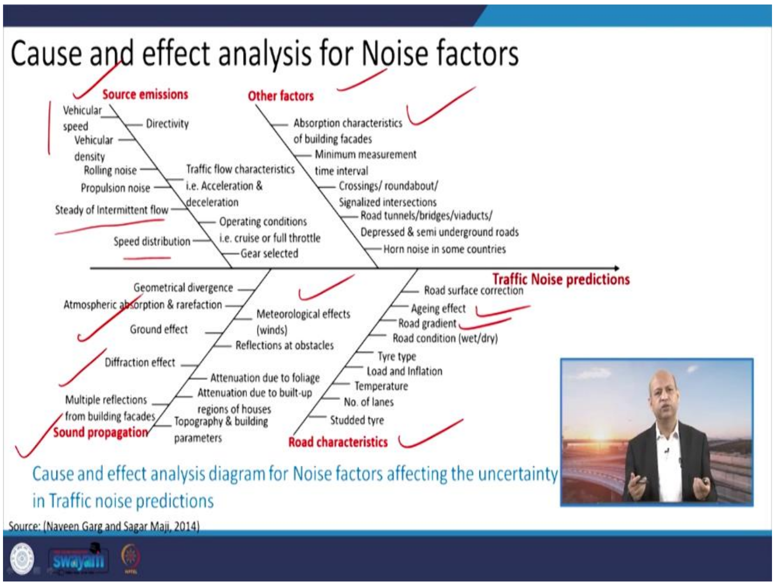

When we talk about cause and effect analysis for noise factors, then basically there may be like source emissions or other factors, sound propagation, and road characteristics. So, all these 4 things are there, which will influence the noise estimation. So in source emissions like vehicular speed, that will influence the noise produced then vehicular density noises like less vehicles are (())(29:29) speed is more than noise from the tires may be different rather than when it is slow traffic and then a study of intermittent flow is speed distribution all these things.

Similarly, like absorption characteristics of like building factors or minimum measurement time intervals, all these factors your aging effect we have seen road gradients, then here like metrological, parameters like winds et cetera and the ground effect diffraction and in fact all these things are cause and effect related damage analysis you can see all these are in cumulatively all these factors basically participate in how much noise will be produced and that way we should take into account includes empirical relationship so that our model based estimations or predictions are nearer to the real noise level.

Otherwise, if the estimated values of the noise levels at the receptor is erroneous if it is more than maybe you design barriers much more than the required so, a lot of money will be wasted, if it is under predicted then you are noise barrier which you will design based on the basis of that value may be underperforming and still if we have barrier we can have more noise at the receptor.

So, I mean to say as much parameters you can use for incorporation in the equations of the models then it is good but always there is a trade off as we have seen earlier also you cannot go beyond complexity of the level of the complexity. So, it should be simple also and resource related compulsion should not also be there.

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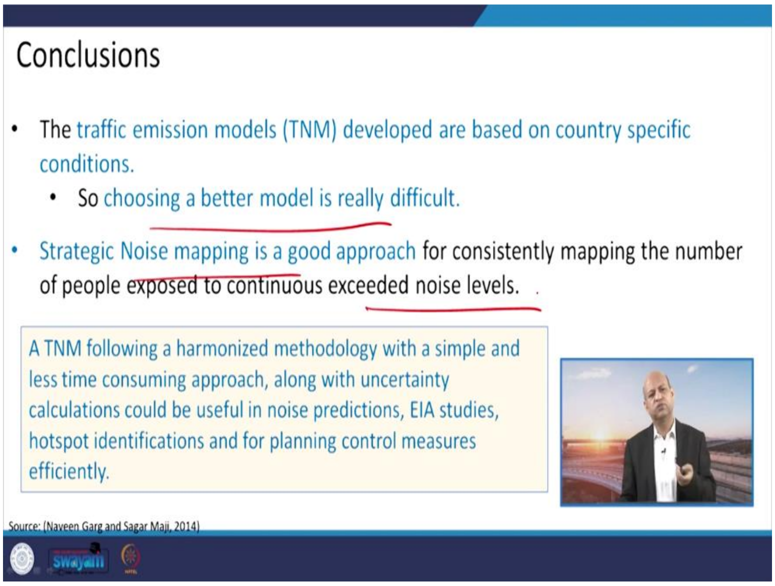

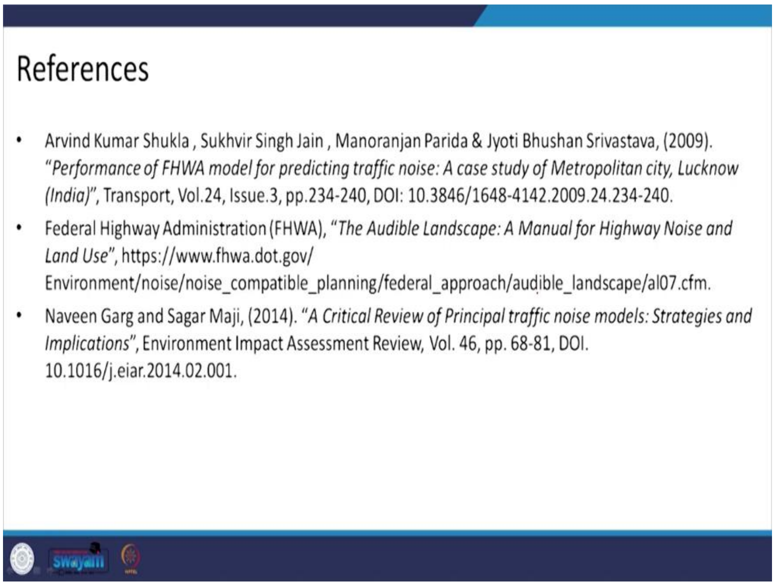

When we conclude So, we can say that the better models are really difficult to choose because there are so, many things related to gaps or uncertainties which always play the role and for strategic noise mapping it is good for like when we go for consistent mapping number of people exposed and the noise levels values to them.

So, the health effects other things also can be estimated easily. So, the uncertainties which are in calculation because of different factors there should be reduced and this can be used for several kinds of things like in EIA also we use these models to predict the noise level due to certain activity when some project is coming, some heavy machineries are being used. So, how much those stakeholders are workers which are working there in the on the site how much noise will be there, they will be exposed.

So, accordingly you have to give some tools so that they are exposed to less noise level. So that is why this is very important and this is all for today. So, thank you for your kind attention and you can go for additional information through these references. Thanks all. See you again.