Urban Transportation Planning
Prof Dr. V. Thamizh Arasan
Department of Civil Engineering
Indian Institute Of Technology, Madras

Module No. # 08
Lecture No. # 35
Transport Related Land-Use Models Contd.

This is lecture 35 on urban transportation planning. In this lecture we will continue our discussion on transport related land use models. Transport related land use models are required to predict the land use in urban areas in the horizon year, which will provide the input for transportation models namely trip generation model, mode choice model, trip distribution model and route assignment model, so that is why we are interested in transport related land use models. You may recall in the previous class we discussed about, certain general aspects related to urban land use. We tried to understand the spread of different types of land uses in urban areas, starting from CBD towards the peripheral areas. We observed that the road network occupies a larger area in and around CBD, and the proportion of road network in terms of area occupied, gets reduced gradually towards the peripheral areas. Similarly, commercial activates are very intense near c d b and gets thinned out when you go towards the peripheral. We found residential activities are also relatively less in CBD area, and increases as you move towards peripheral areas. Same is the case in respect of open space; open space is relatively less near CBD and increases towards peripheral areas. Then, we discussed about the methodology adopted in land use prediction in the case of Chicago area transportation study of USA, conducted in the year 1955.

We tried to understand how the available information was systematically put in order, and then step by step how the additional information was added to get the future land use pattern, in terms of unusable land, used land and vacant land. Then, we had a detailed discussion about land use transport interaction as a vicious circle. Transportation of inducing land use and land use in turn inducing demand for transportation. Then, we discussed about the different methodologies or approaches available for land use prediction. And finally we had a brief discussion about the basic aspects related to Lowry's model of land use prediction. To again check ourselves to the extent of

capturing the essence of the previous lecture, I would like to pose a few questions to you and would like to get your response.

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Recapitulation of lecture 34, the first question is very simple question, you need to tell me what is a master plan of an urban area, anybody master plan of an urban area, what is it. It is a plan prepared to represent the existing land use of an urban area, as well as the predicted land use pattern for the urban area, both will be available master plan. If, you look at the master plan, you will get the clear indication of the land use development that might take place in the near future, next one or two decades. They would have just allocated just different areas in a city or town for different types of land uses; like residential, commercial, industrial and land allocated for greeneries and so no. so, that is what is in this should be understood as the master plan for urban areas quite common, and who is preparing this master plan.

Obviously, urban development authorities have to prepare this master plan. They are responsible of master plan, who is the urban development authority for Chennai city, CMDA Chennai metropolitan development authority, have you heard about it CMDA, that is the urban development authority for Chennai urban area, and they prepare the master plan and get the approval of the state government, then it becomes a permanent authenticated record, and further development should strictly follow the master plan, one cannot ask the permission to construct industrial building in a residential location as per

the master plan, it is not possible similarly, one cannot get permission to construct a house in an area which is terminated as industrial area, so that is how the land use is regulated based on the master plan.

And I think the second question is already answered by me, still I would like to have some more additional points from you. The question is this, how is master plan useful for transportation planning. The master plan is the long term document and we are carrying out transportation planning also for a longer duration, so that way it would be a good document to correlate and plan for the future, exactly. See we are interested in predicting the land use pattern for horizon year fixed for transportation planning purpose, for future condition. Since master plan also provides information about the future land use pattern in an urban area, obviously master plan helps us a lot in predicting the future land use pattern which is going to be a very important input for prediction of travel pattern in the horizon year.

And third question is this; list the methodologies available for urban land use prediction. Transport related land use models are used finally, for urban land use prediction, what are the basic methodologies available as we discussed in the previous class, anybody would like to give the response. I will give a clue we discussed about three basic methodologies for prediction of future land use pattern. I will give you the name of the first one; stated preference approach, what are the other two. The other two methodologies are revealed preference approach and mathematical modeling approach. These are the three basic methodologies discussed for possible predication of a future land use pattern, as you may recall stated preference approach is based on the principle of getting statements or opinions of the dwellers of the urban area, about their decision in case of changes in land use pattern, changes in transport system characteristics and so on, and that is used as input to predict the future possible changes in the land use of an urban area. In the second case which is revealed preference approach, we just observed the preferences revealed by the urban dwellers people change residence form one location to other locations for different reasons.

Commercial establishments shift their business over different parts of the city for various reasons, even other service type of industries also ship their locations. You just observe analyze the causal factors, and with this frame work you try to predict the future changes in the land use of your city or town. The third obviously is mathematical model, we just

fix the causal factors and derive variables and use the variables to formulate a model to predict the future land use pattern. In that context only we discussed about Lowry's land use model. And you need to list the three broad sectors of activities, used to represent the principle special properties of an urban area, obviously as per Lowry's principle, what are the three broad sectors of activities, taken or considered as the basis for modeling by Lowry's.

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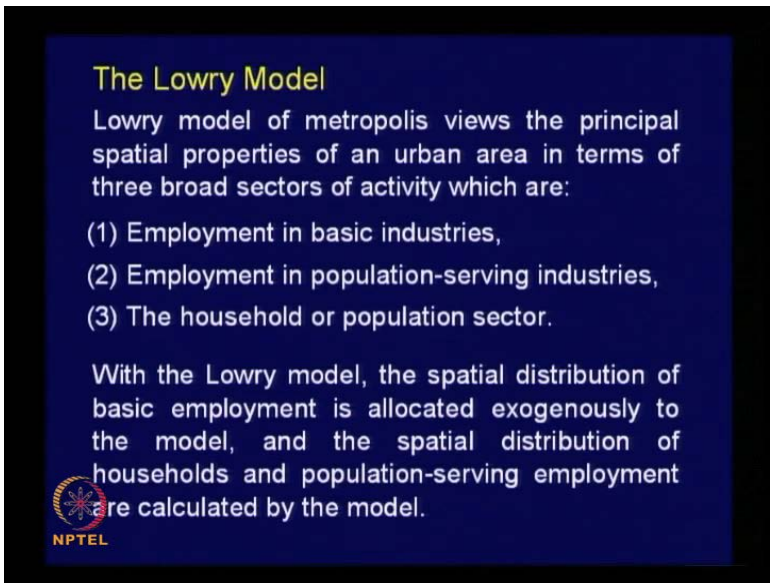

No response, I will show you the three aspects; first employment in basic industries, then employment in population service industries, third the household or population sector. So that is how Lowry just considered the special distribution of all activities into three basic aspects. And we all know, now at this stage as per Lowry's model, the special distribution of basic employment, is allocated exogenously to the model. What you understand by allocating exogenously, the allocate special distribution of basic employment. I think you are clear about the term basic employment. All activity centers holds market interest spreads beyond the urban area or basic employment activity centers. These activity centers are not located with the use of Lowry's application model, it is already prefixed before you apply Lowry's model.

Now, the question is how to prefix these basic employment activity centers or basic employment centers, how will you fix it, what is the basis. This is where your master plan will be very useful in addition to. The forecast made for population growth and the

growth of other related socioeconomic activates in the urban area. There will be several sources available for you to predict the total possible number of households in your horizon year. The total possible industries of different categories in the horizon year, all these things are to be collected from various secondary sources, and fix these things prior to application of your Lowry's model. All the canters related to basic employment should be fixed, by getting data from different sources.

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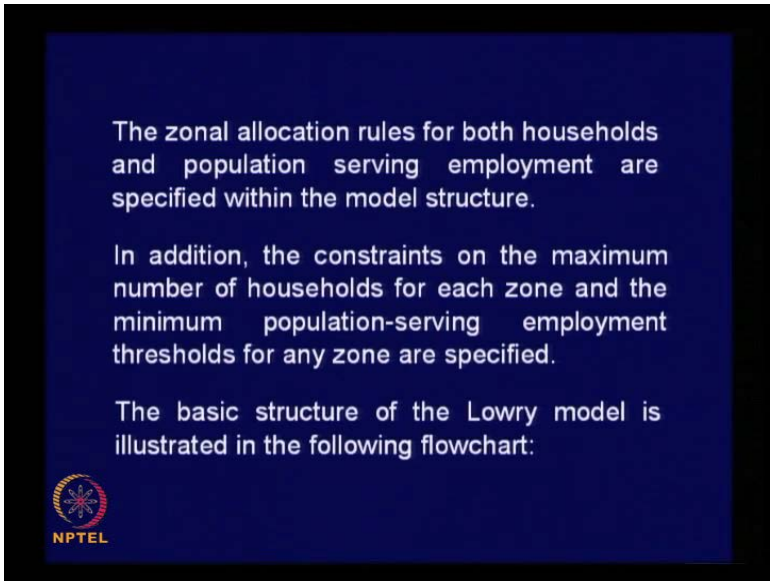

The zonal allocation rules for both households and population serving employment are specified within the model structure, this is where the model is going to help you. The model structure helps you to allocate households as well as population serving employment in various zones of urban areas that is what the model does. In addition, the constraints on the maximum number of households for each zone, and the minimum population serving employment thresholds for any zone classified as input to the Lowry's model. While you are predicting or distributing the households and population serving employment you should not exceed the holding capacity of zones, while fixing the households. Those constraints will be given as input to the Lowry's model. Similarly, the minimum required service employment should be available at each of the zones, so that is also given as a constraint. Of course, the basic structure of the Lowry's model is illustrated in the form of a flow chart to reinforce our understanding.

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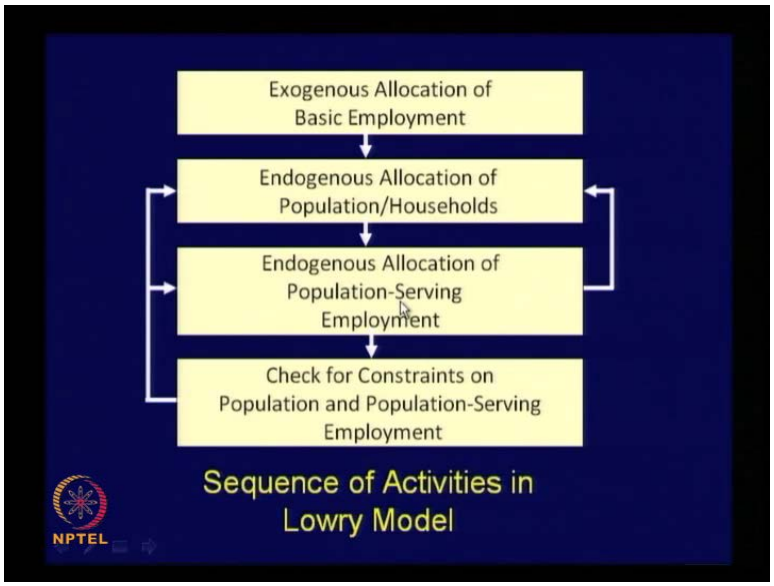

This is our basic structure of the Lowry's model of land use. First exogenous allocation of basic employment, basic employment means; the activity centers related to basic employment, that is the meaning. So, you fix exogenously from outside the model all this basic employment centers. Then endogenous allocations of population slash households. You can just treat allocation in terms of population or in terms of household, its left to us. Mostly, it is done in terms of households, because households is the basic unit for other purposes, so planners prefer households to be a measure for distribution of population using Lowry's model, this is done using the model. Then endogenous allocation of population serving employment; we discussed about examples of population serving employment in the previous class, you may now understand what we really mean by population serving employment.

The employment centers which are needed for day to day activities of people living in the urban areas; like shopping areas, other service centers, bank, post office, health services etcetera, that is how we should understand the endogenous allocation of population serving employment. And then finally, check for constraints on population, with the understanding of the maximum limiting value, and populating serving employment with the understanding of their minimum required value, check both these aspects. So, that is what being done in Lowry's model, and of course we go back whenever required from this step to another step and so on depending upon the need or if

while checking if there are any problems, you have to go back and forth and see that there is a balance or the constraints are satisfied.

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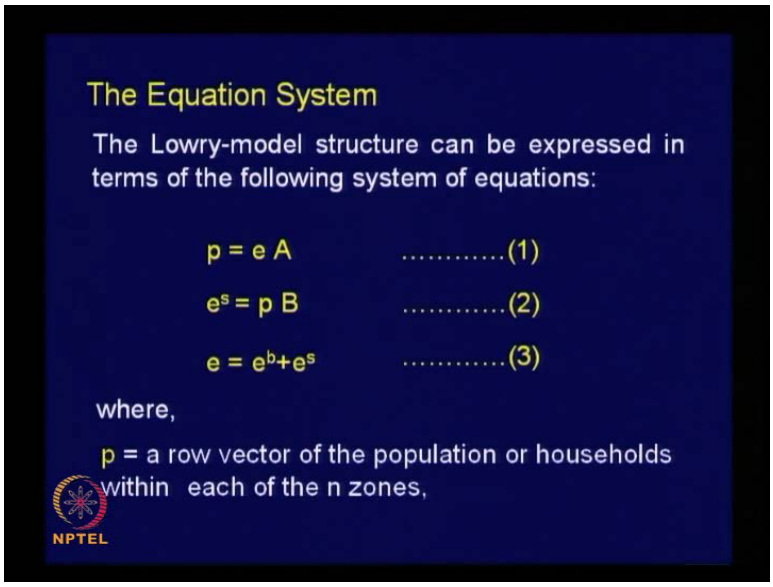

Then, the equation system of Lowry's land use model, and a set of equations were used by Lowry; equation number 1 is this, p is equal to e into a, later on I will explain what are these notations mean actually. Then e s is equal to p into b, and e is the sum of e b and e s, e b plus e s, where p is nothing, but a row vector of the population or households within each of the end zones, just the population zone wise is given in the form of a vector. It will be normally a row vector, because there will be one value for one zone. So, it is a row vector. Then we have to explain about e a, b, e b and e s.

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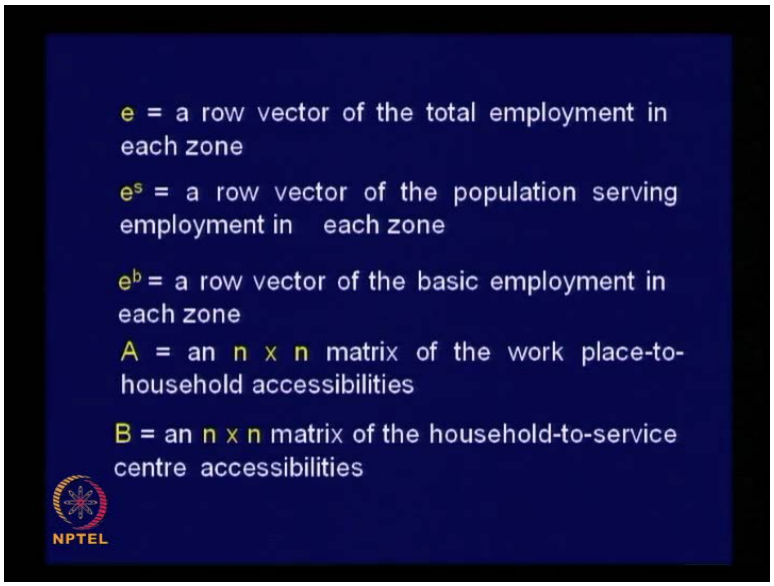

Small e is again a row vector of the total employment in each zone, both basis employment as well as population serving employment put together is total employment. Then e s again a row vector of the population serving employment in each zone, e b a row vector of the basic employment in each zone. And A is an n by n matrix of the work place to household accessibility. This is the most important aspect. We should be able to define accessibility and hear it is in abstract form indicated with letter a, it is a n by n matrix. Later on we will find out why it is an n by n matrix of the work place to house hold accessibilities. And B is again an n by n matrix of the household to service center accessibilities. These with which people can reach out to the service places are to be expressed numerically using some accessibility calculation method. So, that is what is given in abstract terms as capital B.

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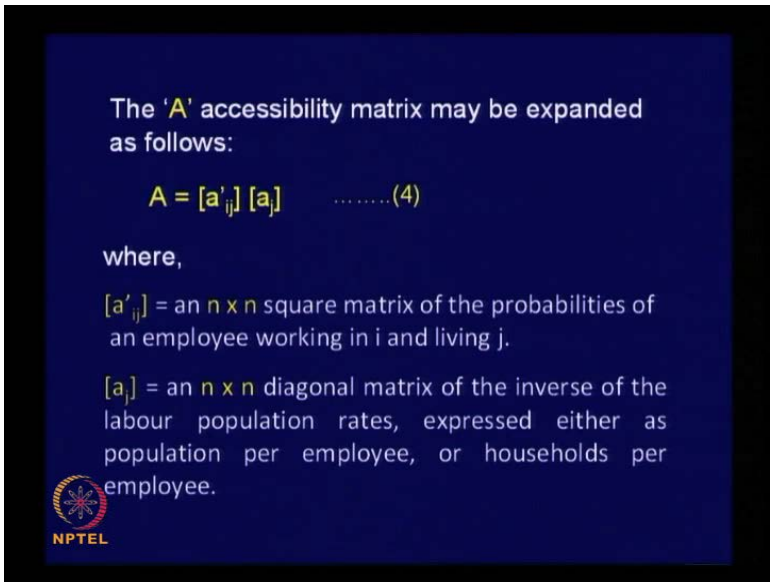

The A accessibility matrix may be expanded as follows; A as we know is an n by n matrix, and A can be written as a dash i j into a j. Where a dash i j is equal to an n by n square matrix of probabilities of an employee working in i and living in j. are you able to understand the explanation for a dash i j. It is an n by n matrix which his square of the probabilities on an employee working in i and living in j. Will you be able to get this information for base year conditions for example, suppose you are asked to get the values of a dash i j as an n by n, if you have 200 zones, it will be 200 by 200 matrix; will it be possible. Let us say about 10 percent of the employees are working in zone 100, living in zone 20. Zone 20 has certain number of employees. Let us say 10 percent of them as per the base year condition are employed in zone 100, even though it is a proportion, it's nothing, but probability, it can be taken as the probability values for the base year condition. So, that is how we need to understand the values of a dash i j, its nothing difficult. And when you do it for all the zones, you will be getting obviously an n by n matrix one to one, one to two and one to n and so on. If you do that you will get an n by n matrix giving the probability of an employee working in i but, living in j.

And a j is an n by n diagonal matrix of inverse of the labor population rates, inverse of the labor population rates, expressed either as population per employee or households per employee. We are familiar with the term employees per household. We have been discussing about this variable in trip production modeling. here Lowry uses the inverse of that, households per employee, because the service employment and basic

employment etcetera, when Lowry started distributing, he found that this method of expressing the employment rate is more convenient, its only for convince and nothing else instead of expressing as employees per household, he found it convenient to have this number as households per employee, or may be certain number of population per employee, may be about let us say, 0.8 households per employee. Then, how many employees per household, 1 by 0.8. So, that is how inverse of that was taken for substitution in this particular case.

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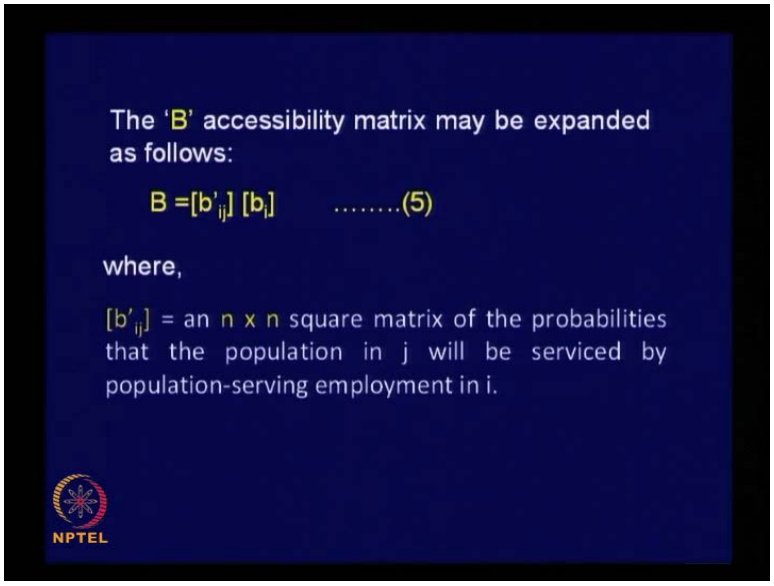

Then, B accessibility matrix may be expanded as follows, similar to A accessibility matrix, only difference is B accessibility matrix is related to population serving employment. A accessibility matrix is related to basic employment that is the only difference, otherwise this model structure the structure of the equation as could see is same as for A accessibility matrix. B is written as b dash i j into b i, where b dash i j is again an n by n square matrix of the probabilities that the population in j, will be serviced by population serving employment in i; are you able to understand population in j being served by population serving employment in i. Earlier we talked about distribution of population serving employment zone wise along with distribution of population of households. Now, as per this statement population serving employment will be into me other zone, it may still serve population in other zones, that is the reality, what are the service employments normally availed of or used by urban dwellers, basically can you divide the services as service for education, service for heath, service for purchase of

household items, service for may be commercial activities; like banks, and service for communication may be telecomm centers, post offices and so on.

when you think of these different kinds of services, these services need not be located in every zone, and if you consider petty shopping as a kind of service, then petty shop service should be available in every zone, assuming that the size of that zone is going to be approximately a circle of radius about say 1 to 3 kilometers depending upon the intensity of activity. So, we must understand the population serving employment centers need not be located in every zone, and center located at one zone will be normally serving several adjoining zones, depending upon the type of service a kindergarten may be serving 1 or 2 zones, where as a element school may serve, more number of zones and high schools might service still large number of zones, that how you must understand the location of population serving employment centers. And b i is again an n by n diagonal matrix of the population serving employment to population ratios, as we saw in the previous case, its n by n diagonal matrix of the population serving employment to population ratios.

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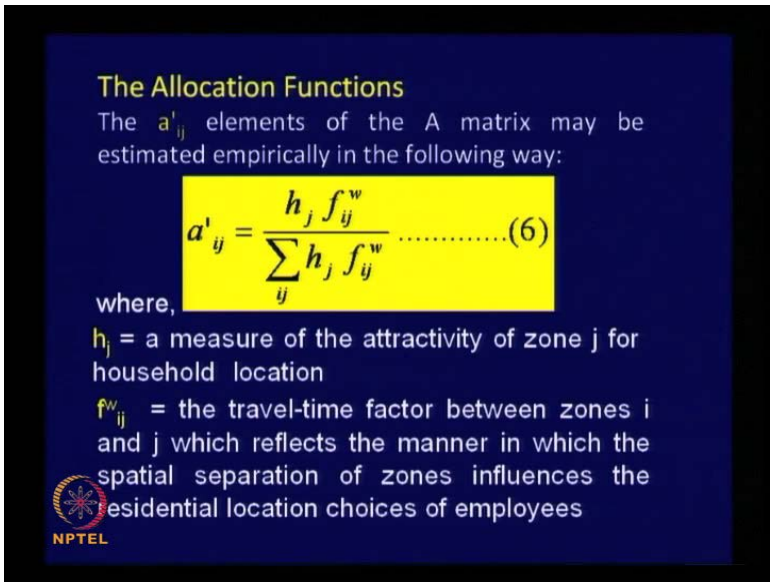

Then, the allocation functions, are we need to further understand as to how we really get the value of a dash i j as well as b dash i j, because we have simply defined a dash i j as something related to accessibility. Should i have to go back and show you what you have done. So how do we define it is a n by n square matrix of the probabilities of people

living in one zone and working in another zone, and that is going to be related to the accessibility aspects. A matrix, the a dash i j elements of a matrix may be estimated empirically in the following way. This is the equation to get the value of a dash i j, where h j is a measure of the attractively of zone j for household location, and f w i j, superscript w stands for just work place nothing else, and f i j as you know it is sort of friction factor related to accessibility. The travel time factor or friction factor between zones i and j, which reflects the manner in which the special separation of zones influences the residential location choices of employees.

You need to have to worry too much about each word in the sentence. Please understand f i j as a factor representing the travel assistance, which is related to the accessibility of work place from home for employees, working in activities related to basic employment. And look at the denominator, it is the sum of the same for all the zones, are you able to recollect some kind of equation similar to this, which we have already done; friction factor. In trip distribution analysis we have seen a similar structure, utility equation also we have done, and friction factor particularly we have done in connection with gravity model of trip distribution.

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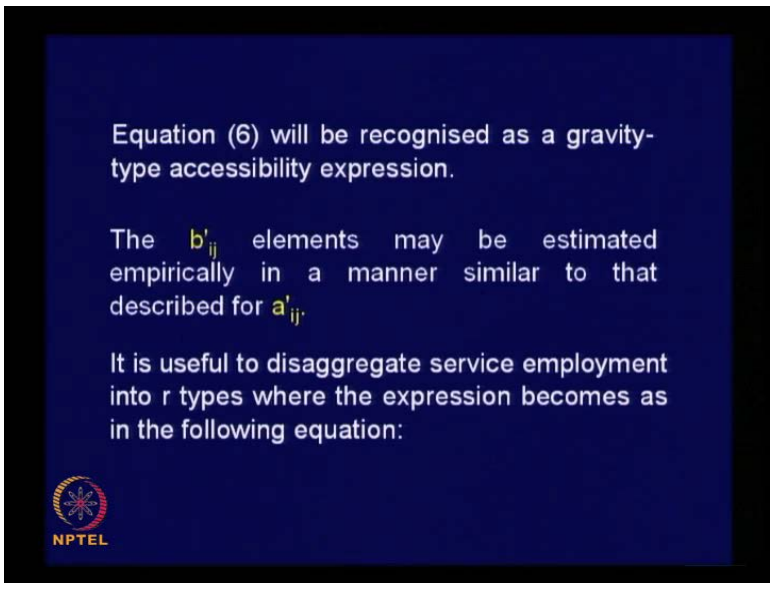

Equation 6 will be recognized as a gravity type accessibility expression; because we just measure the accessibility to a particular zone with respect to the accessibility of that zone to all other zones. It is relative measure of accessibility. The b dash i j elements may be

estimated emphatically in a manner similar to that described for a dash i j. It is useful too disaggregate service employment into r types, where the expression becomes as in the following equations. As i told you earlier it is better to segregate service employment into different types, because of the fact that each service will be different and the area covered by each service type will be different from one another, as i said as an example high school, elementary school, kindergarten area covered by each of these institutions is going to be different. So, you cannot put all of them together and then develop a model. So, just develop the equations based on the type of service.

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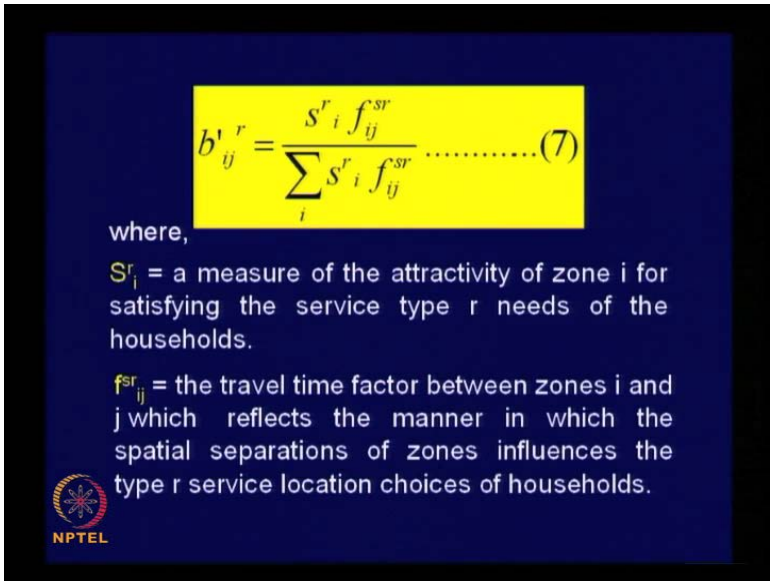

so, we can write b dash i j r, r refers to the type of service, is equal to s r I, f a j, s r divided by the sum of the same as we have shown in the numerator, shown in the denominator. S i r is nothing, but a measure of the attractively of zone i for satisfying the service type of needs of a household, attractivity of zone i for satisfying the service type or needs of the household is the measure, and you must understand we will be distributing the different types of service centers, based on the attarcitivity of different zones for this particular service.

And f s r i j is a travel time factor between zone i and j, which reflects a manner in which special separations of zones influences the type of service location, choices of households. I will repeat f s r i j is nothing, but the travel time factor between the zones i and j, which reflects he manner in which the special separation of zones influences the

type or service location choices of households. It is with respect to the households and the type or service employment.

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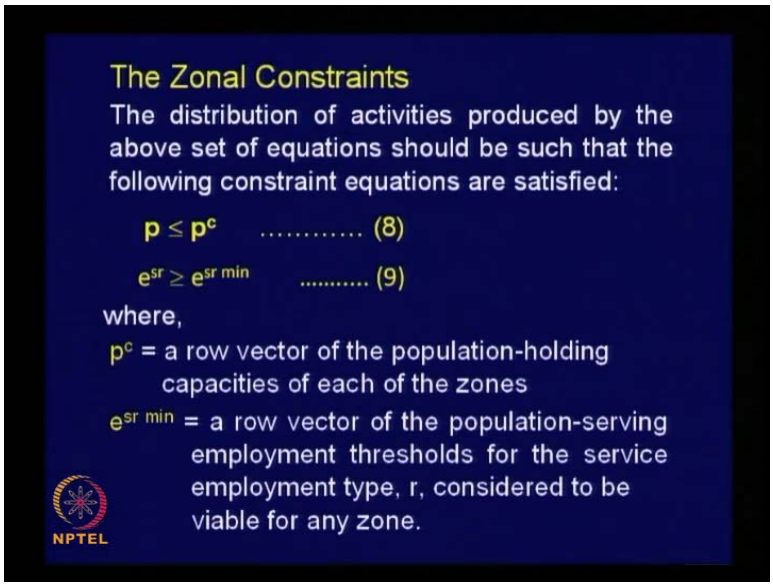

Then, about the zonal constraints, the distribution of activities produced by the above set of equations should be such that the following constrain equations are satisfied, as I indicated to you earlier the first constraints is this, p should be less than and equal to p c, c stands for capacity, p stands for population, the allocated households or populations should not be, should be less than or equal to the capacity of the zone and e s r should be greater than or equal to e s r minimum, if there are any questions you are welcome to raise, there is no problem. Where pc is the row vector of the population holding capacities of each of the zones, and e s r minimum is equal to a row vector of the population service employment thresholds for the service employment type are considered to be viable for any zone, that is the e s r minimum. So, these constraints are to be satisfied by the model.

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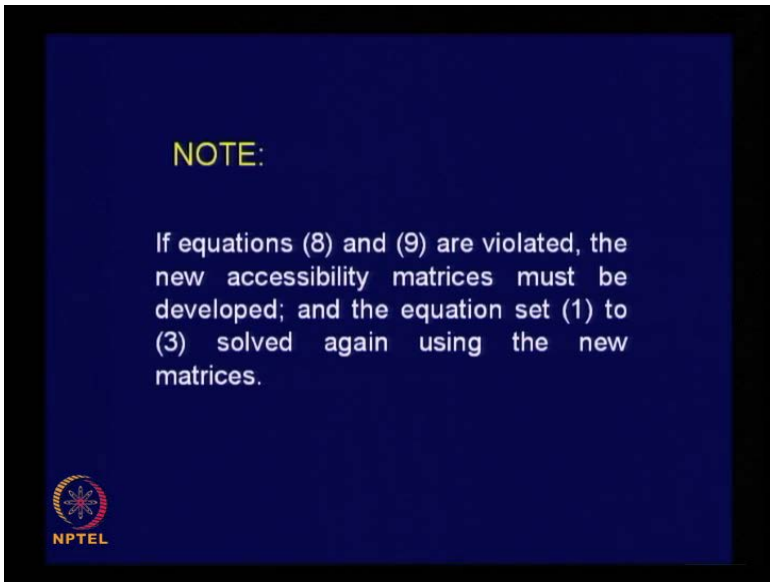

This is a very important note, if equations 8 and 9 ways to be the constraints, two constraints are violated, the new accessibility matrices must be developed and the equation set 1 to 3 solved again, using the new matrices. So, that is how you must make use of the set of equations developed by Lowry. I could guess that you would not have grasped the set of equations and related analytical implications at this stage; I have just listed the number of equations and given explanation for the notations, unless we take a numerical example and try to have a feel of application of Lowry's model. It is not possible for you to really capture the whole of the concept related to Lowry's model of land use. I have been showing number of slides in every class to you.

I will just tell a small story about presentation of slides. There was a very busy vice president of an international company, located in Mumbai; the organization employed more than 1000 employees. The vice president normally used to be well dressed, very punctual, systematic and very strict. The employees were really afraid of him, he was a terror to everyone including his close associates and still the perfect vice president was afraid of one person. Can you guess who the person might be, any suggestion, take the microphone and give your response; sharmila wants to respond to the question. No; may be his wife. Exactly, he was scared of his wife, very much scared and he used to travel frequently to different major cities around the world for the purpose of business promotion, and he used to prepare power point slides to explain the company's vision, mission and strengths and weaknesses, and trade objectives and so on, so that companies

business flourishes. on one occasion he had planned to travel to New York, then to Paris, then to London and then back to India, and his wife packed off everything for him; his trip, and the baggage was ready and when he was about to move out of the house, his wife told him in a very stern voice; my dear you know that my sister lives n London, she is on a family way, I have just kept a pickle bottle in the baggage, please see that despite your business, you must finish off this business of handing over the pickle to my sister, it is very important.

And this message has gone very strongly into the mind of the vice president you can imagine. He first started off to New York and made a nice presentation about the companies profile, and the end of the presentation he was very happy that he got good response, he was feeling that his companies objectives will be achieved through this kind of presentation at least in cities like New York then he flew to Paris, and there also things went on very well, he made nice presentation about his company's business plan and there were partners ready to participate in their business, and his presentation was very successful and he achieved his objective. Then he had to take the flight to London and unfortunately the flight was delayed by two hours, and those two hours as you can guess is very important for him to finish off the activity assigned to him by his wife. Unfortunately the flight was delayed; he arrived in London just to go to the venue of the first meeting, where he had to make the presentation. There were two venues in London in which he had agreed to make the presentation about his companies profile and business objectives and he went to the first venue and made a detailed presentation, and after finishing his presentation he proceeded to the second venue. When he was proceeding towards his second venue, the taxi driver stared talking to him and he just enquired about the company and slowly started explaining the material presented in each of the slides by the vice president. Driver had also been in the hall and observed what this person presented and he was able to reproduce almost the whole thing.

As you may know, normally the vice president will be presenting the same set of slides in all the venues and the vice president was surprised and asked him how is he able to capture the matter so nicely and reproduce. Then he said I am an MBA graduate, then he asked why then you are a taxi driver, why do not you get employed in a company in a managerial job he coolly said, this job is more lucrative than being a manager in a company in London. Then he understood and suddenly there was a spark in the mind of

the vice president. He asked the driver just to stop the taxi and said that now onwards I will be the taxi driver and you are the vice president of the company, and he also gave all the back ground information about the company and handed over all the materials as well as the power point slide, pen drive to the taxi driver, and told him clearly the second venue it is going to be a small gathering and none of them will know about his face or he is the stranger as far as the second venue is concerned nobody will identify, and said that you are going to present or make the presentation in the second venue, and I have an important business to attend to I will finish it off and come and join. So when they went to the second venue the taxi driver was the vice president, he was received a red carpet welcome, garland everything went on very well, and the vice president was observing everything, and he waited until the person started with the first slide.

And when he was observing he found that the taxi driver is doing much better than him and then he was very happy, he went to his sister in laws house to hand over the pickle bottle and he did it and he was in a hurry to come back to the venue, as you know there will be come tension always, and his sister in law was offering coffee tea things like that he was in hurry to go he said thanks and left the house quickly, and came back to the venue, by then the presentation was over. And the question answer session started and the few questions was answered by the driver excellently or the vice president was happy about it, and suddenly one experienced person asked an important question, and the driver was shocked, he could not find an answer, and he observed the vice president was just in the rear entrance in the hall. He said oh this is very simple question, even a taxi driver can answer this question I will call my taxi driver let him answer the question, he said and the vice president came in and answered the question, and he answered the question very well there were too many questions to him and he managed to answered all the questions well, and finally in the second venue also the company's objective was very well achieved, this is how the power point presentation skill has to be understood. You can make a presentation, but it comes to the subject matter we should be very careful. The moral of the story is that slides cannot help a person to be a real substitute for a knowledgeable person on a subject matter.

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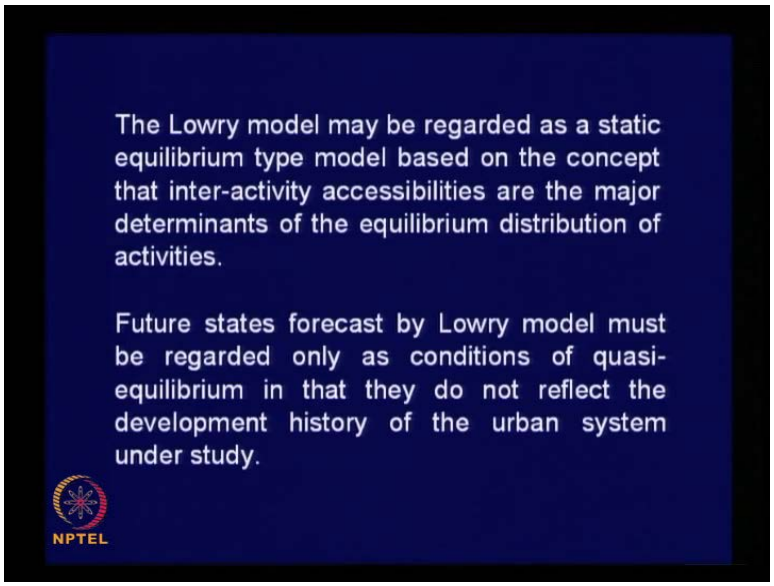

Then, there are two important points to be remembered about Lowry's model. The first one is, the Lowry model may be regarded as a static equilibrium type mode, based on the concept that interactivity accessibilities are the major determinants of the equilibrium distribution of activities, what do you understand by interactivity accessibilities, you have activity centers, accessibility between activity centers is what is stated here as interactive accessibilities, spread over space in different zones. And Lowry's model measures this interactive accessibilities in terms of f i j travel time factor, and that activity accessibility measure is used as the basis for predicting the horizon year activity distribution also, which may or may not be correct. In certain cases, the travel time factor may change between zonal pairs. So, that changes are not accounted for by Lowry, because anywhere we have to work with the information available for base year condition.

So, we should be aware of it. Another important aspect to be understood with regard to Lowry land use model is this, future states forecast by Lowry model must be regarded only as conditions of quasi equilibrium, in that they do not reflect the development history of the urban system under study. The historical aspects related to development is not brought into the model, what do you understand by development history. See the interactions between certain zonal pairs might have grown at a faster rate. In certain cases, the growth might have not been that fast, and current interactions can be understood in terms of the ease or difficult related to accessibility between zonal pairs,

and the future possible changes in terms of ease or difficulty related to accessibilities between zonal pairs may not be reflected fully, taking into account the historic aspects by Lowry's model, he will fox the bas year information as input for the model.

So, these are the two basic constraints related to Lowry's model, and still Lowry's model is considered to be one of the best prediction models, as far as future land use prediction is concerned, only thing is we should be aware of the two constraints or two drawbacks which are minor not major drawbacks, but still we should be aware of it. If, there are certain historical aspects that need to be brought in while you, finally predict land use pattern, you should make modifications to the results that you get out of Lowry's model also, that is the implication that is the point made here.

And we will stop here, and take up an example of application of Lowry's model in the next class. To summarize what we have seen today, we started our discussion with understanding of the three factors that were taken as the basis for Lowry's model of land use, to explain the facial distribution of activities namely; employment in basic industries, employment in population serving employment industries, and then population or household sector. These are the three basic inputs or basic factors used in Lowry's land use model. Then with the help of the flow chart we tried to understand the structure of the Lowry's land use mode, and different steps involved in the process.

Then, we looked at the set of equation systems used in Lowry's model related to population total employment, employment service sector and employment in basic industries and so on. And also we saw the related equations, which give the information about accessibility between zonal pairs, as A accessibility matrix, B accessibility matrix and so on. We will stop here and continue the rest with the rest of it in the next class.