CBCS SCHEME

USN 1CR19CV003

18CV745

Seventh Semester B.E. Degree Examination, Jan./Feb. 2023
Urban Transport Planning

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Define Urbanization. List and explain the urban class groups. (06 Marks)
b. What is Para-transit system and what are the factors influencing Para transit system. (07 Marks)
c. Compare between Bus and Light Rail system. (07 Marks)

OR

2 a. What are the causes of urbanization? (06 Marks)
b. List and explain the different effects of urbanization. (07 Marks)
c. Write merits and demerits of Metro and BRTS system. (07 Marks)

Module-2

3 a. Define study area. What are the factors to be considered while selecting external cordon line? (06 Marks)
b. Explain Home interview survey. (07 Marks)
c. What are the four basic movements for which survey data are required? (07 Marks)

OR

4 a. Define Zoning. What are the points to be kept in view when dividing the area into zones? (07 Marks)
b. Define sampling. (06 Marks)
c. Explain Road Side Interview Survey. (07 Marks)

Module-3

5 a. Explain Trip and its classification. (04 Marks)
b. What is Multiple Linear Regression Model? What are the assumptions made in MLR analysis? (08 Marks)
c. Let the trip rate of a zone is explained by the household size done from the field survey. It was found that the household size are 1, 2, 3 & 4. The trip rate of the corresponding household is as shown in below table. Fit a linear equation relating trip rate and household size.

Household Size (x)

	1	2	3	4
Trips Per Day (y)	1	2	4	6
	2	4	5	7
	2	3	3	4

(08 Marks)

OR

6 a. Explain the factors governing trip generation and attraction. (06 Marks)
b. What is aggregated and disaggregated analysis? (06 Marks)

c. Trips originating from zone 1, 2, 3 of a study area are 78, 92 and 82 respectively. Those terminating at zone 1, 2, 3 are given as 78, 96 and 78 respectively. If growth factor is 1.3 and cost matrix is shown below, find the expanded growth trip table.

O/D	1	2	3	O_i
1	20	30	28	78
2	36	32	24	92
3	22	34	26	82
d_j	78	96	78	252

(08 Marks)

Module-4

7 a. Explain Gravity model. (04 Marks)

b. What are the factors affecting Modal Split? (08 Marks)

c. The total trips produced in and attracted to the three zones A, B and C of a survey area in the design year are tabulated below.

Zone	Trips Produced	Trips attracted
A	2000	3000
B	3000	4000
C	4000	2000

It is known that the trips between two zones are inversely proportional to the second power of the travel time between zones which is uniformly 20 minutes. If the trip interchange between zones B and C is known to be 600. Calculate the trip interchange between A & B, A & C, B & A and C & B. (08 Marks)

OR

8 a. Draw the flowchart for modal split carried out after trip distribution. (07 Marks)

b. Explain opportunity model. (07 Marks)

c. Explain Desire line diagram with neat sketch. (06 Marks)

Module-5

9 a. Explain purpose of trip assignment. (06 Marks)

b. Explain all-or-nothing assignment. (07 Marks)

c. What are the difficulties in transport planning for small and medium cities? (07 Marks)

OR

10 a. Explain Minimum Path-tree. (06 Marks)

b. What is Lowry Derivative Model? (07 Marks)

c. Explain Capacity Restraint Techniques. (07 Marks)

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Q1

a) Urbanization is a process whereby populations move from rural to urban area, enabling cities and towns to grow. It can also be termed as the progressive increase of the number of people living in towns and cities. It is highly influenced by the notion that cities and towns have achieved better economic, political, and social mileages compared to the rural areas.

Majority of people move to cities and towns because they view rural areas as places with hardship and backward/primitive lifestyle. Therefore, as populations move to more developed areas (towns and cities) the immediate outcome is urbanization. This normally contributes to the development of land for use in commercial properties, social and economic support institutions, transportation, and residential buildings. Eventually, these activities raise several urbanization issues.

According to the Census definition of India, an urban area consists of (Census of India, 2011). 1) All Statutory Towns: All places with a Municipality, Corporation, Cantonment Board or Notified Town Area Committee, etc. so declared by State law; and 2) Census Towns: which places and satisfy following criteria:- a minimum population of 5000 ; at least 75% of male working population engaged in non agricultural pursuits; and a density of population of at least 400 persons per sq km. Furthermore, Population Census in India classifies urban settlement into six size classes as per the limits indicated below (Kundu, 2001): Population Size

- Category 100,000 and more Class I
- 50,000 to 100,000 Class II
- 20,000 to 50,000 Class III
- 10,000 to 20,000 Class IV
- 5,000 to 10,000 Class V
- Less than 5,000 class VI

b) Para-transit system

"Paratransit vehicles are a for-hire flexible passenger transportation that does not necessarily follow fixed routes and schedules.

They provide two types of services: one involving trips along a more or less defined route with stops to pick up or discharge passengers on request. The other is a demand-responsive transport which can offer a door-to-door service from any origin to any destination in a service area.

Factors influencing Para-transit:

- Longer travel time, Higher cost and Lack of connectivity, Reduced Ridership of major public transport systems
- High cost of introduction and maintenance of mass public transportation
- Short Trip lengths: The average trip length in medium and small size cities is less than five kilometer
- High percentage of low income groups
- Creates employment opportunities
- They provide first mile-last mile connectivity
- Ideal feeder system for the MRTS, Metro/Mono Rail, BRTS etc

c) BRT Buses

- By use of exclusive or reserved rights-of-way (bus ways) that permit higher speeds and¬ avoidance of delays from general traffic flows.
- Include reverse lane operation on limited access roadways, and/or prioritization of at¬ grade bus movements through signalized intersections.
- A standard BRTS bus can carry 5000 pphpd and with an overtaking lane, this number¬ could reach 8000.

Light Rail Transit

- Commonly referred as “streetcars” or “trolleys.” Most systems are powered by overhead electric wires.
- Run on either exclusive or shared rights-of-way with or without grade crossings, or¬occasionally in mixed traffic lanes on city streets.
- Tracks can be laid in any of three generic right-of-way (ROW) categories.
- Cars are typically articulated, about 28 m long by 2.65 m wide, with about 75 seats.
- Trains vary from 2-4 cars, with a 4-car train capable of carrying about 300 seatedpassengers, and a total of up to 750 passengers.

Q2**. Causes of Urbanization**

a) 1. Industrialization

Industrialization is a trend representing a shift from the old agricultural economics to novel non-agricultural economy, which creates a modernized society. Through industrial revolution, more people have been attracted to move from rural to urban areas on the account of improved employment opportunities.

2. Commercialization

Commerce and trade play a major role in urbanization. The distribution of goods and services and commercial transactions in the modern era has developed modern marketing institutions and exchange methods that have tremendously given rise to the growth of towns and cities.

3. Social benefits and services

There are numerous social benefits attributed to life in the cities and towns. Examples include better educational facilities, better living standards, better sanitation and housing.

4. Employment opportunities

In cities and towns, there are ample job opportunities that continually draw people from the rural areas to seek better livelihood.

5. Modernization and changes in the mode of living

Modernization plays a very important role in the process of urbanization. As urban areas become more technology savvy together with highly sophisticated communication, infrastructure, medical facilities, dressing code, enlightenment, liberalization, and other social amenities availability, people believe they can lead a happy life in cities.

6. Rural urban transformation

The increase in productivity leads to economic growth and higher value-added employment opportunities.

b) Merits:

Efficiency: Cities are extremely efficient. Less effort is needed to supply basic amenities like electricity and water. Research and recycling programs are possible only in cities.

Employment opportunities: Plenty of job opportunities in all sectors- banking, retailing, industries, IT, export companies, educational institutes, medical, Pharmaceutical, research and development.

Transport and communication facilities: easy connectivity to all locations. Good infrastructure andtransportation facilities to reach any destination faster.

Educational facilities : schools, colleges, universities are established in cities to develop human resources.Increase in the standard of living : Better health care facilities, advanced communication , high concentration of resources, access to social and cultural activities make city life sophisticated and comfortable.

Improvement in economy: High Tech industries earn big part of their money in dollars thusboosting country's economy

Demerits

Problem of over population – this result in accommodation problem resulting in growth of slums.

Disintegration of joint families-Joint family can't be maintained in cities on account of high costof living: People prefer to live in the nuclear type of families.

High Cost of living: it is very difficult for lower income groups to maintain a decent standard ofliving.

Increase in Crime rates: Urban areas are known for high rate of crimes. Theft, Dacoity, Murder,Cheating, Pick pocketing, rape etc. are common in urban localities.

Environmental impacts of urbanization

- Problem of Pollution: caused by industries or by excessive movement ofvehicles.
- Rise in temperature: Due to construction of high rise buildings and apartments,industries lead to loss of vegetation, thus increasing temperature drastically.
- Water related issues: Ground water depletion due to high water consumption and water pollution due to industry effluents and improper dumping of waste generated from industries.

c)

Table 7. Comparison between Metro Rail System and Bus Rapid Transit System

	Metro Rail System	Bus Rapid Transit System
Commercial speed (km/h)	24–55	25–30
Catchment area	Low	High
Average cost/trip (₹)	45–50	10–15
Required minimum trip length	10–15 km	5 km
Space required	2 lanes for elevated corridor	2–4 lanes
Parking	Needs parking facilities for feeder services	Needs parking facilities for feeder services
Air pollution reductions (along its influence area)	Significantly decreases due to shifting of vehicles to MRTS (particularly private vehicles)	Expected to improve slightly if BRTS is able to shift private vehicle to its system
Noise pollution reductions	Noise levels may slightly increase, if background levels are less than the noise generated by metro rail	No significant improvement in ambient noise levels expected

(Table 7 Continued)

	Metro Rail System	Bus Rapid Transit System
Environmental conditions (inside the system)	Noise and vibration levels along with SPM/PM_{10} levels are very low	Noise and Vibration levels comparatively higher, SPM/PM_{10} levels inside generally higher than ambient levels
Road safety	Reduces accidents in urban arterials and in its influence zone	Less safe for pedestrians and NMT movement
Congestion reduction	Reduces the congestion problem in its influence zone and other city arterials	With increase in frequency congestion increases resulting in decrease in LOS (level of services)
Infrastructure cost	Very high	Apparently low
Cost/km of corridor	₹285 crores/km—Underground (~57 million US$) ₹115 crores/km—Elevated (~23 million US$)	Comparatively lower (₹5–7.5 crore/km) (~1–1.5 million US$)
Passenger carrying capacity (PPHPD)	More (30,000–60,000)	Less (15,000–20,000)
Vulnerability to natural and man-made disasters	High	Less
Corridor alignment	Mostly 'Elevated', 'Underground' along the Congested and CBD areas, Very small portion at surface levels	Mostly At-Grade, in some cases Elevated section
Passenger fare	Generally economical in long distances (>10 km)	Economical in short distance travels (3-5km), Comparable with MRT for distances between 5–10 km
USP of the system	Time saving, safe, punctuality, comfortable, environment friendly	Time Saving for Bus commuters, 'Door to Door Service' 'Economical' (travel distance up to 10 km)
Public perception (Indian experience)	Mostly favourable	Mostly apprehensive (bus commuters–mostly favourable)

Q3.

a) To collect all information like travel pattern, land use, economic activities and transport facilities, one need to know the boundary for the study area or planning area, and hence it is essential to define the study area first. Transportation planning can be at the national level, the regional level

or at the urban level. For planning at the urban level the study area should embrace the whole contribution, containing the existing and potential continuously built up areas of the city.
The imaginary line representing the boundary of the study area is termed as the external cordon line.

The area inside the external cordon line determines the travel pattern to a large extent and as such, it is surveyed great detail. The land use pattern and the economic activities are studied intensively and detailed survey (such as the home-interview) are conducted in this area to determine the travel characteristics. On the other hand, the area outside the cordon line is not studied in such details.

Selection of External Cordon Line:

- The selection of the external cordon line for urban transportation planning should be done carefully with due to consideration to the following factors
- The external cordon line should circumscribe all areas, which are already built up, and those areas, which are considered likely to be developed during the planning period.
- The external cordon line should contain all areas of systematic daily life of the people oriented towards the city center and should in effect be the commuter shed.
- The external cordon line should-be continuous and uniform in its courses so that movements cross it only once. The line should intersect roads where it is safe and convenient for carrying out traffic survey.
- The external cordon line should be compatible with the previous studies of the areas studies planned for the future

b) Home-interview survey

Home-interview survey is one of the most reliable type of surveys for collection of origin and destination data. The survey is essentially intended to yield data on the following information:

- Household information - information on household characteristics includes type of dwelling unit, number of residents, age, sex, race, vehicle ownership, number of drivers, family income and so on.
- Journey data - information on the travel pattern includes number of trips made, their origin and destination, purpose of trip, travel mode, time of departure from origin and time of arrival at destination and so on.

Based on these data it is possible to relate the amount of travel to household and zonal characteristics and develop equations for trip generation rates. It is impractical to interview all the residents of the study area. Since travel patterns tend to be uniform in a particular zone. The size of the sample is usually determined on the basis of the population of the study area.

Following techniques are generally adopted for Home Interview Survey.

- Person to person full interview technique - Full interview technique involves interviewing as many members of the household as possible and directly recording all the information.
- Home questionnaire technique - In the Home questionnaire technique, the interviewer collects only details of the household characteristics, leaving forms for household

residents to complete in regard to travel information. The completed forms are collected by the interviewer after a day.

- Telephone survey - In the former the questionnaire is sent out by post before the survey data and the replies are elicited by telephone. This method can be successful only in areas of high telephone ownership.
- Postal survey - In the postal survey method, the questionnaire is mailed and the households are requested to send their replies by post in reply-paid envelopes.

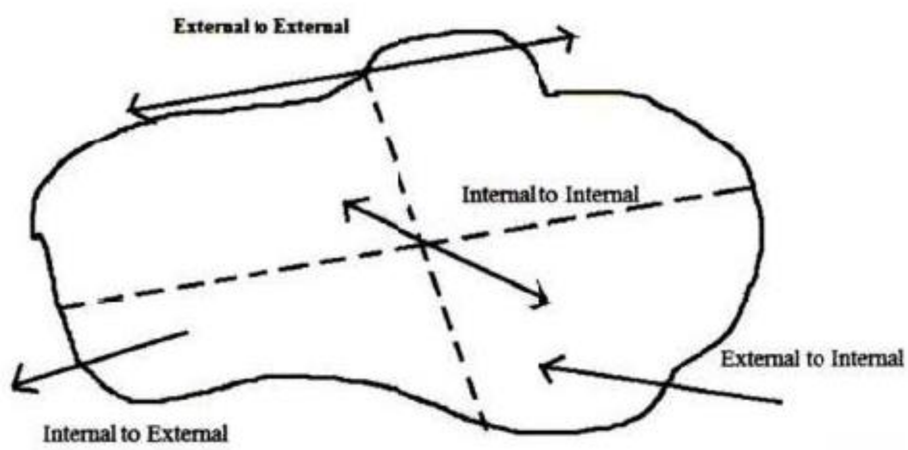
c) Types of Movements for which survey data is required:

- Internal to internal.
- External to internal
- Internal to external.
- External to external.

For large urban areas, the internal to internal travel is heavy whereas for small areas having a small population (say less than 5000) the internal to internal travel is relatively less.

Most details of internal to internal travel can be obtained by home interview survey.

The details of internal- external, external internal and external- external travels can be¬ studied by cordon surveys.



OR

Q4.

a)

- The defined study area is sub-divided into smaller areas called zones. The purpose of such a subdivision is to facilitate the spatial quantification of land use and economic factors which influence travel pattern. The data collected on individual household basis cannot be conveniently considered and analysed unless they are aggregated into small zones.

- Sub-division into zones further helps in geographically associating the origins and destinations of travel. Zones within the study area are called internal zones and those outside the study area are called external zones. In large study projects, it is more convenient to divide the study area into sectors, which are sub-divided into smaller zones.
- A convenient system of coding of the zones will be useful for the study. One such system is to divide the study area into 9 sectors. Each sector is sub-divided into 10 zones. A sub-zone bearing a number 481 belongs to sector 4 and to zone 8 in that sector and is sub-zone 1 in that zone.
- Zones are modelled as if all their attributes and properties were concentrated in a single point called the zone centroid. The centroids are connected to the nearest road junction or rail station by centroid connectors. Both centroid and centroid connectors are notional and it is assumed that all people have same travel cost from the centroid to the nearest transport facility which is the average for a zone. The intersection from outside world is normally represented through external zones. The external zones are defined by the catchment area of the major transport links feeding to the study area.

The following points are kept in view when dividing the area into zones:

a) Land use is the most important factor in establishing zones for a transportation survey. The traffic generated within the zones can be predicted, quantified and measured accurately; only when origin and destination reflects the land use properly.
b) The zones should have a homogenous land use so as to reflect accurately the associated trip making behavior.
c) Anticipated change in land use should be considered when sub-dividing the study area into zones.
d) It would be advantages, if the subdivision follows closely that adopted by other bodies (e.g. census department) for data collection. This will facilitate correlation of data.
e) The zones should not too large to cause considerable errors in data. At the sometime, they should not be too small either to cause difficulty in handling and analyzing the data. As a general guide, a population of 1000-3000 may be the optimum for a small area, and a

population of 5000-10000 may be the optimum for large urban areas. In residential areas, the zones may accommodate roughly 1000 households.

f) The zones should preferably have regular geometric form for easily determining the centroid, which represent the origin and destination of travel.
g) The sectors should represent the catchment of trips generated on a primary route.
h) Zones should be compatible with screen lines and cordon lines.
i) Zone boundaries should preferably be watersheds of trip making.
j) Natural or physical barriers such as canals, rivers, etc. can form convenient zone boundaries

b) The need for sampling is based on the realisation that in transport studies one is often dealing with very large populations. To attempt to survey all members of these populations would be impossible.

The object of sampling is to obtain a small sample from an entire population such that the sample is representative of the entire population.

It is therefore of some importance to ensure that the sample is drawn with care to ensure that it is indeed representative.

The accuracy of sample parameter estimates, however, is totally dependent on the sampling being performed in an acceptable fashion. Almost always, the only acceptable sampling methods are based on some form of random sampling.

There are many types of sampling methods, each of which is based on the random sampling principle. The most frequently encountered methods are:

- Simple random sampling
- Stratified random sampling
- Multi-stage sampling
- Cluster sampling
- Systematic sampling

c) Road-side interview survey:

- Road-side interview survey is one of the methods of carrying out a screen-line or cordon survey. The road side interview survey can be done either by directly interviewing drivers of the vehicles at selected survey points or by issuing prepaid post cards containing the questionnaire to all or a sample of the drivers.
- The survey points are selected along the junction of the cordon-line or screen-line with the roads. The cordons may be in the form of circular rings, radial lines of rectangular grids.
- For small towns, population less than 5000, single circular cordon at the periphery of the town should suffice. The internal travel being light, the external cordon survey in that case will give the origin-destination data.
- A population in the range 5,000 to 75,000 two cordon lines is necessary, the external cordon at the edge of the urban development and the internal cordon at the limits of the central business district. Road side interviews at the intersection of roads with these two cordon lines should be able to fairly assess the patterns of travel in such cities.
- For large cities, the cordon-lines and screen lines may be more complicated, and the homeinterview technique cannot be dispensed with. Cordon line and screen line surveys

by the road side interview technique serve to check the accuracy of the home interview survey data.

- For dual carriageways or roads with very little traffic the traffic in both the directions is dealt with simultaneously. In other cases the traffic in two directions will be interviewed at different times. If the survey covers most of the day it may be sufficient to interview traffic in one direction only and to assume that the journeys in the opposite direction are the same as in the direction interviewed.
- It is impractical to stop and interview all the vehicles. Convenient sampling methods to be adopted, for instance, one in a fixed number of vehicles (every tenth, or fifteenth or twentieth) or select the nest vehicle as soon as each interview is completed.
- A sample form is shown below.

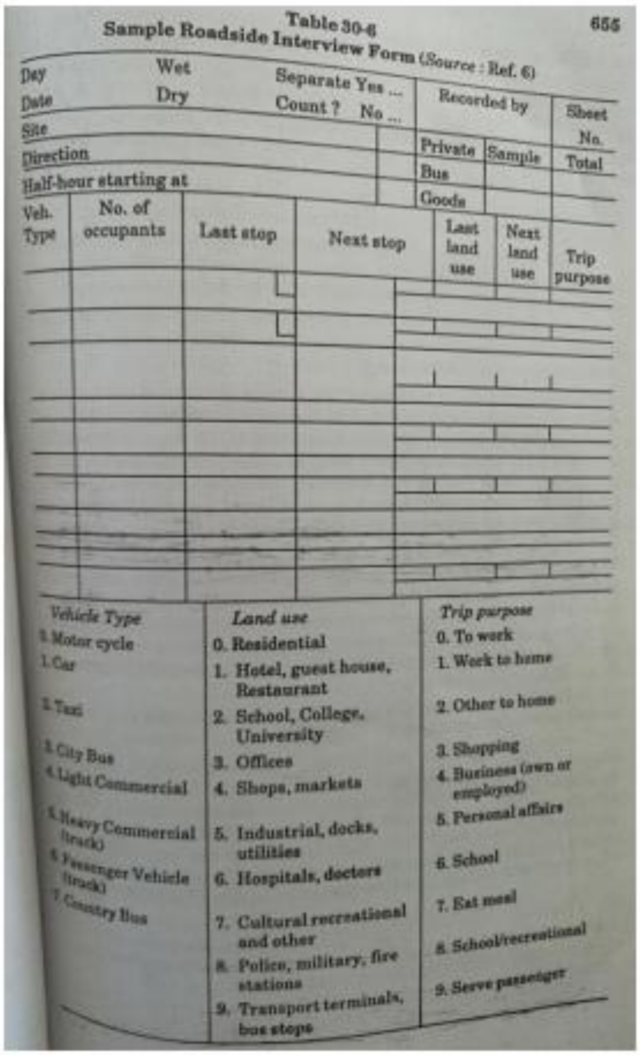


Table 30-6 655

Sample Roadside Interview Form (Source : Ref. 6)

Day | Wet | Separate Count ? Yes ... No ... | Recorded by | Sheet No.

Date | Dry

Site

Direction | Private | Bus | Goods | Sample | Total

Half-hour starting at

Veh. Type	No. of occupants	Last stop	Next stop	Last land use	Next land use	Trip purpose

Vehicle Type	Land use	Trip purpose
0 Motor cycle	0. Residential	0. To work
1 Car	1. Hotel, guest house, Restaurant	1. Work to home
2 Taxi	2. School, College, University	2. Other to home
3 City Bus	3. Offices	3. Shopping
4 Light Commercial	4. Shops, markets	4. Business (own or employed)
5 Heavy Commercial (truck)	5. Industrial, docks, utilities	5. Personal affairs
6 Passenger Vehicle (truck)	6. Hospitals, doctors	6. School
7 Country Bus	7. Cultural recreational and other	7. Eat meal
	8. Police, military, fire stations	8. School/recreational
	9. Transport terminals, bus stops	9. Serve passenger

Q5.

a) A generation is the home end of any trip that has one end at home (home based trips) and is the origin of a trip with neither end home based (non home based trip). i.e., Trip generation is defined as all the trips of home based or as the origin of the non home based trips.

An attraction is the non-home end of a home based trip and is the destination of a trip with neither end home based.

Types of trip [Classification of Trips]

Trips can be classified by trip purpose, trip time of the day, and by person type.

- Home Based Trip and Non Home-based trips If either origin or destination of a trip is the home of the trip maker then such trips are called homebased trips Typical home-based trips are the journey to work, shopping, and school. The amount of home-based trips varies from 80 to 90 percent of total travel.
- Non- Home-based trips are those trips that do not have either the origin or destination end at a household Examples of non-home-based trips are trips between work and shop and business trips between two places of employment.
- Home Based Trip: One of the trip end is home. Example: A trip from home to office.
- Non Home based trips: None of the trip end is home. Example: A trip from office to Shopping Mall.

The above definitions are further classified by the following examples. Consider a trip from home to work and the return trip from work to home. Both these trips are home based trips, because one end of the trip is at home. Both these trips are considered to have been generated at the home zone and attracted to the work zone. We thus have two work-purpose trip end generations in the home zone and two work- purpose attractions in the work zone.

b) The most common technique employed in establishing trip generation is multiple linear regression which fits mathematical relationships between dependent and independent variable. In the case of trip generation equation, the dependent variable is the number of trips and the independent variable are the various measurable factors that influence trip generation like land use and socio-economic characteristics. The general form of the equation can be expressed in the following form:

$$Yp=a1X1+a1X2+a3X3+\ldots\ldots.anXn+U$$

Yp= number of trips for specified purpose p

X1, X2, X3,……., Xn=independent variables relating to for example, land-use, socio economic factors etc.

a1, a2, a3,……, an= Coefficients of the respective independent variables X1, X2, X3,……., Xn, obtained by linear regression analysis

U= Distribution term, which is a constant and representing that portion of the value of Yp not explained by the independent variables

The equation of the above form is developed from the present-day data pertaining to independent variables and dependent variables and the dependent variables, using statistical techniques of “least squares “fitting. The equation thus developed is used for determining the future values of trips, knowing the estimated future values of the independent variables.

<u>Assumptions in Multiple Linear Regression Analysis and their validity in trip generation analysis:</u>

The statistical theory of Multi linear regression analysis is based on the following important assumptions:

- All the variables are independent of each other.
- All the variables are normally distributed.
- All the variables are continuous .
- A liner relationship exists between the dependent variable and the independent variable.
- Influence of independent variable is additive that is the inclusion of each variable in the equation contributes a distinct portion of trip numbers.

c) The linear equation will have the form y=bx+c where y is the trip rate, and x is the household size, a and b are the coefficients. For a best fit, b is given by:

$$\begin{aligned}
b &= \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
a &= \bar{y} - b\bar{x} \\
\Sigma x &= 3 \times 1 + 3 \times 2 + 3 \times 3 + 3 \times 4 = 30 \\
\Sigma x^2 &= 3 \times (1^2) + 3 \times (2^2) + 3 \times (3^2) + 3 \times (4^2) = 90 \\
\Sigma y &= 5 + 9 + 12 + 17 = 43 \\
\Sigma xy &= 1 \times 1 + 1 \times 2 + 1 \times 2 \\
&+ 2 \times 2 + 2 \times 4 + 2 \times 3 \\
&+ 3 \times 4 + 3 \times 5 + 3 \times 3 \\
&+ 4 \times 6 + 4 \times 7 + 4 \times 4 \\
&= 127 \\
\bar{y} &= 43/12 = 3.58 \\
\bar{x} &= 30/12 = 2.5 \\
b &= \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \\
&= \frac{((12 \times 127) - (30 \times 43))}{((12 \times 90) - (30)^2)} = 1.3 \\
a &= \bar{y} - b\bar{x} = 3.58 - 1.3 \times 2.5 = +0.33 \\
\bar{y} &= 1.3x - 0.33
\end{aligned}$$

Q6.

a) Factors influencing Trip Generation and Attraction:
   - Income: Family income which represents its ability to pay for a journey affects the number of trips generated by a household. A general trend is that the higher the income the higher is the trip generation rate.
   - Car ownership: A car represents easy mobility, and hence a car owing household will generate more trips than a non-car-owing household. By the same reasoning, the more cars there are in the household, the more the number of trips generated. Of course,

number of cars owned is itself related to the income of the family, which has been listed earlier as a factor.

- Family size and composition: The bigger the family, the more trips there are likely to be generated. Apart from the size, the composition of the family itself is important. For instance, if both the husband and wife are employed, the trips generated will be more than when only the husband is employed. If there are many school-going children, the number of school-purpose trips will be large. The age structure of the family also governs the trip rates. Old persons are not expected to generate as many trips as younger ones.
- Land use Characteristics: Different land uses produce different trip rates. For example, a residential area with a high density of dwellings can produce more trips than one with a low density of dwellings. On the other hand, low density areas may represent dwellings of the well-off society, which may produce a large number of private car trips. The rateable value of the dwelling and type of dwelling units affect the trip generation rates. The most important assumption made in transportation planning is that the amount of travel is dependent on land use.
- Distance of the zone from the town center: The distance of the zone from the town center is an important determinant of the amount of travel that people might like to make to the town center. The farther the town center, the less the number of trips are likely to be.
- Accessibility to public transport system and its efficiency: The accessibility to a public transport system and its efficiency determine to some extent the desire of persons to make trips. An easily accessible and efficient public transport system generates more trips.

b) Multiple linear regression analysis of two types:

1. Aggregated, or zonal least-square regression, where each traffic zone is treated as one observation.
2. Disaggregated, or Household least-square regression, where each household is treated as an observation.

Zonal Regression Method (Aggregated Analysis)

- In the case of zonal regression, the study area is divided into a number of zones. Each traffic zone is treated as one observation. The aggregated analysis which is most widely used is based on the assumption that contiguous households exhibit a certain amount of similarity in travel characteristics.
- The dependent variable is some measure of the zonal trip ends and the independent variables are typically the number of households, number of workers, number of cars, total incomes etc. Alternatively, the variables are expressed as mean values for the zones.
- This assumption allows the data in a zone to be grouped and the mean values of the independent variable used in further calculation. Sufficiently large survey data is needed to get reliable results.

Household least squares regression analysis (Disaggregated Analysis):

- The logical extension to the arguments favouring a reduction in zone size is to develop data base that makes no reference to zone boundaries. One consideration is to treat this at household level.
- The dominating Influence of the head of household implies that the trip making activity of the household members can only be accurately predicted through a knowledge of total household characteristics.
- It would appear, then, that the household can reasonably be considered as a behavioural trip-making unit and therefore, treated as the basis for the trip end estimating procedure.
- In the household regression analysis, each household is considered as a separate input data, so that the wide observed variation in household characteristics and household trip making behaviour is incorporated into the models. The attempt, here, is to explain the total variation between households, as against the variation between zones, explained by zonal models.
- The variables considered are between the number of trips per household per day and the household characteristics such as family size (persons), employees per household, car ownership per household, household income etc.
- Compared to aggregated analysis, disaggregated analysis produces better results and is considered more likely to be stable over time and to provide more reliable future estimates.

c) Given growth factor = 1.3, Therefore, multiplying the growth factor with each of the cells in the matrix gives the solution as shown below.

O/D	1	2	3	Oi
1	26	39	36.4	101.4
2	46.8	41.6	31.2	119.6
3	28.6	44.2	33.8	106.2
Dj	101.4	124.8	101.4	327.6

Q7

a) Gravity model

- One of the well-known synthetic models is the Gravity Model. Based in Newton's concept of gravity, the model as proposed by Voorhees assumes that the interchange of trips between zones in an area is dependent upon the relative attraction between the zones and the spatial separation between them as measured by an appropriate function of distance.
- This function of spatial separation adjusts the relative attraction of each zone for the ability, desire or necessity of the trip maker to overcome the spatial separation. Whereas the trip interchange is directly proportional to the relative attraction between the zones, it is inversely proportional to the measure of spatial separation.

  A simple equation representing the above relationship is of the following form:

$$T_{i-j} = \frac{KP_i A_j}{d_{ij}^n}$$

Where,

T_{i-j} = Trips between zones i and j

P_i = Trips produced in zone i

A_j = Trips attracted to zone j

d_{ij} = Distance between zone i and j, or the time or cost of traveling between them

K = A constant, usually independent of i

n = An exponential constant, whose value is usually found to lie 1 & 3

k = Total number of zones

The following formulation was also used in earlier studies dispersing with the proportionality constant:

$$T_{i-j} = P_i \times \frac{\dfrac{A_j}{(d_{i-j})^n}}{\dfrac{A_j}{(d_{i-j})^n} + \cdots\cdots + \dfrac{A_k}{(d_{i-k})^n}}$$

b)

FACTORS AFFECTING MODAL SPLIT

The following are the primary factors affecting the modal choice of travellers :

(1) Characteristics of the trip

(2) Household Characteristics

(3) Zonal Characteristics

(4) Transport system Characteristics

CHARACTERISTICS OF THE TRIP

(1) TRIP PURPOSE - The trip purpose to certain extent influence the choice of mode of travel. For example, home-based school trips have a high rate of usage of public transport. Whereas for home-based shopping trips have a higher rate of private car

(2) TRIP LENGTH - The trip length also influences the choice of m[illegible] of travel. For longer distance travel, people prefer public mode[illegible] transportation, whereas, for short distance travel, people use private vehicles. Trip length can also be measured by the trav[illegible] time and the cost of travelling.

HOUSEHOLD CHARACTERISTICS

(1) INCOME - The income of a person is a direct determinant [illegible] the expenses he is prepared to incur on a journey. Higher income groups are able to purchase and maintain private car[illegible] and thus, private car trips are more frequent. Lower income[illegible] groups usually prefer public transport.

(2) CAR OWNERSHIP - Car ownership is determined by the inco[illegible] and for this reason, both income and car ownership are int[illegible] elated in the analysis of modal choice. Families which own a car prefer private car for trips and families without car pre[illegible] to travel through public transport.

(3) FAMILY SIZE AND COMPOSITION - The number of persons in [illegible] family, number of people earning, unemployed and other socio-economic factors of family greatly influences the mo[illegible] choice. Some of these factors are responsible for certain trip[illegible] in public transport.

ZONAL CHARACTERISTICS

(1) RESIDENTIAL DENSITY - The use of public transport increases as the residential density increases. This is due to the fact that the areas with the highest residential density are generally inhabited by people with varying ranges of income, domin[illegible]

c)

Sol^n

$$T_{i-j} = \frac{K P_i P_j}{d^n}$$ — resistance

$P_3 = 3000$

$P_6 = 2000$

First find out 'K' value (constant) as;

$T_{3-6} = 600$ — given.

$$600 = \frac{K \times 3000 \times 2000}{20^2}$$

$$K = 1/25 = 0.04$$

$\therefore$ Now;

$$T_{A-B} = \frac{0.04 \times 2000 \times 4000}{20^2}$$

$$\boxed{T_{A-B} = 800}$$

$$\rightarrow T_{A-C} = \frac{0.04 \times 2000 \times 2000}{20^2}$$

$$\boxed{T_{A-C} = 400}$$

$$\rightarrow T_{B-A} = \frac{0.04 \times 3000 \times 3000}{20^2}$$

$$\boxed{T_{B-A} = 900}$$

$$\rightarrow T_{C-A} = \frac{0.04 \times 4000 \times 3000}{20^2}$$

$$\boxed{T_{C-A} = 1200}$$

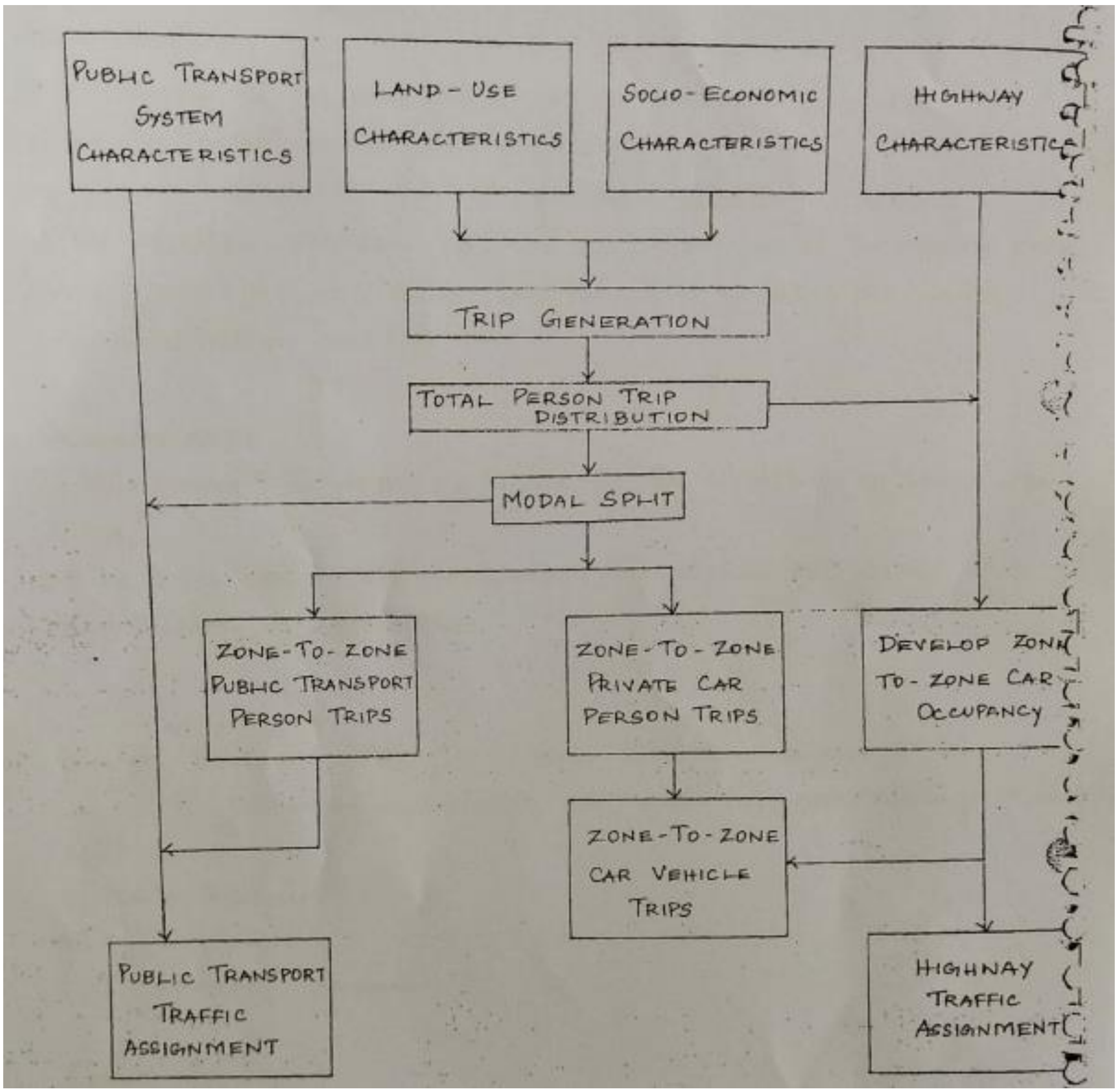
$$\rightarrow T_{C-B} = \frac{0.04 \times 4000 \times 4000}{20^2}$$

$$\boxed{T_{C-B} = 1600.}$$

NOTE: Different formulas are given in gravity model, by looking at given data in problem we will choose which formula to be used.

Q8.

a)



b) Opportunity Model

Opportunity models are based on the statistical theory of probability as the theoretical foundation. The concept has been pioneered by Schneider and developed by subsequent studies. The two well-known models are:

1. The intervening opportunities models

2. The competing opportunities model
   The opportunity models can be represented by the general formula:

$$T_{ij} = O_i \, P\,(D_i)$$

Where,

$T_{i\text{-}j}$ = Predicted number of trips from zone i to j.

O_i = Total number of trips originating in zone i.

$P(D_j)$ = Calculated probability of a trip terminating in zone j.

D_j = Total trip destinations attracted to zone j.

3.1 Intervening Opportunities Model

In the intervening opportunities model, it is assumed that the trip interchange between and origin and a destination zone is equal to the total trips emanating from the origin zone multiplied by the probability that each trip will find and acceptable terminal at the destination. It is further assumed that the probability that a destination will be acceptable is determined by two zonal characteristics: the size of the destination and the order in which it is encountered as trips proceed from the origin. The probability functions in above equation $P(D_j)$, may then be expressed as the difference between the probability that the trip origins at *i* will find a suitable terminal in one of the destinations, ordered by closeness to *i*, up to and including *j*, and the probability that they will find a suitable terminal in the destination up to but excluding j. The following equation represents mathematically this concept:

$$T_{i-j} = Q_i\left(e^{-LB} \cdot {}_{-e}{}^{-LA}\right)$$

Where,

$T_{i\text{-}j}$ = Predicted number of trips from zone i to j

Q_i = Total number of trips originating in zone i

L = Probability density of destination acceptability at the point of consideration

A = Number of origins between i and j when arranged in order of closeness

B = Number of destinations between i and j when arranged in order of closeness

It may be noted that:

$$A = B + D_j$$

3.2 Competing Opportunities Model

In the competing opportunities model, the adjusted probability of a trip ending in a zone is the product of two independent probabilities, *viz.*, the probability of a trip being attracted to a zone and the probability of a trip finding a destination in that zone. A form of this model is given below:

$$T_{i-j} = \frac{P_j \dfrac{A_i}{\sum A_j}}{\sum \left(\dfrac{A_j}{\sum_j A_j} \right)}$$

c) The Origin & Destination study gives basic data for determination of desired directions of vehicular flow or passenger trips in terms of “desired lines”. Straight lines joining the points of origin and destination of each trip are called desired lines.

The O & D studies of vehicular traffic determines their number, their origin and destination in each zone under study. The data of number of passengers in each vehicles, purpose of trip, intermediate stops made and reasons, actual direction of travel, selection of routes and length of trip etc. also collected.

Methods of O & D studies are:

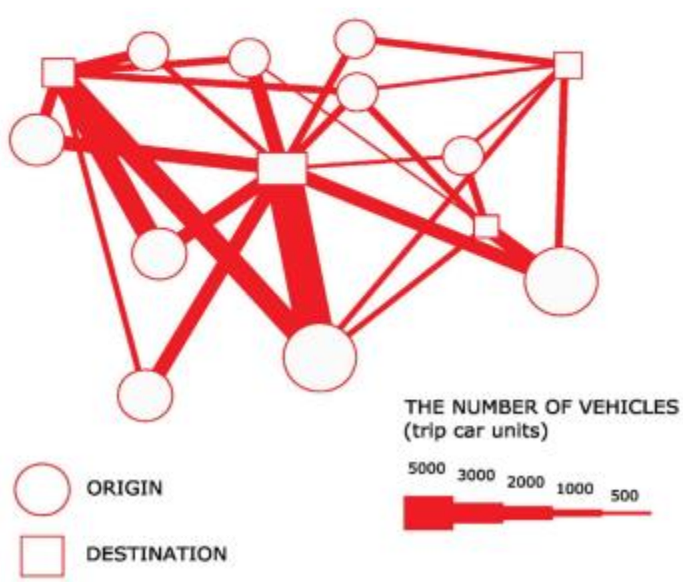
- Road side interview method
- Home interview method
- License plate method
- Return post card method
- Tag on car method

The specific uses to which O & D study data:

- To determine the amount of by-passable traffic that enters a town and thus establishes the need for bypass.
- To establish preferential routes for various categories of vehicles.
- To develop trip generation and trip distribution models in transport planning process.
- To determine the extent to which the present highway system is adequate and plan for new facilities like expressways, truck laybyes etc.
- To assess the adequacy of parking facilities and plan for future.

Presentation of O& D data:

- O& D data can tabulated in the form of matrix having origin zone on one axis and destination zone on the other axis. The matrix will show the number of trips between these zones.
- Pictorially presented in the form of desired line chart. The width of desired lines represent the number of trips between these points and hence drawn to a suitable scale.



Q9.

a)

Traffic assignment is stage in the transport planning process wherein the trip interchanges are allocated to different parts of the network forming the transportation system.in this stage of transportation planning the route to be travelled is determined and the inter zonal flows are assigned to the selected routes.

The applications of traffic assignment are

1. To determine the deficiencies in the existing transportation system by assigning the future trips to the existing system.
2. To evaluate the effects of limited improvements and additions to the existing transportation system by assigning estimated future trips to the improved network.
3. To develop construction priorities by assigning estimated future trips for the intermediate years to the transportation system proposed for those years.
4. To test alternative transportation system proposals by systematic and readily repeatable procedures.
5. To provide design hour traffic volumes on highway and turning movements at junctions.

b)

All-Or-Nothing assignment

In this method the trips from any origin zone to any destination zone are loaded onto a single, minimum cost, path between them. This model is unrealistic as only one path between every O-D pair is utilized even if there is another path with the same or nearly same travel cost. Also, traffic on links is assigned without consideration of whether or not there is adequate capacity or heavy congestion; travel time is a fixed input and does not vary depending on the congestion on a link. However, this model may be reasonable in sparse and uncongested networks where there are few alternative routes and they have a large difference in travel cost. This model may also be used to identify the *desired path*: the path which the drivers would like to travel in the absence of congestion. In fact, this model's most important practical application is that it acts as a building block for other types of assignment techniques. It has a limitation that it ignores the fact that link travel time is a function of link volume and when there is congestion or that multiple paths are used to carry traffic.

c)

- Intelligent Transportation Systems
- ITSs encompass technologies that have been with us for some time, new technologies, and those that are still in the research or testing phase. ITSs are useful for maximizing the effectiveness of the existing transportation system through management and operational

efficiencies. In small and medium-sized communities, applications focus on communications,

- such as weather or road-condition advisories; incident management; traffic management; and traveler information. The problems facing small and medium-sized communities include all four of the resource issues identified above. Because of their limited resources, these communities must make good decisions about investing in new technologies. Some of the critical factors are the ability of the new technology to be viable over time; to be compatible not only with other technologies in the agency, but also with those of other agencies; and to solve problems facing the agency cost-effectively.
- Air Quality
- Air quality has been an issue for some small and medium-sized communities for some time, but not for the majority. Changes in regulations that occurred as a result of the presidential directive of July 16, 1997, create a new situation for many of these communities. The tightening of controls on ground-level ozone and particulate matter (PM2.5) creates the possibility of many more small and medium-sized communities having to meet the requirements of the Clean Air Act.
- Access to and Preservation of Rights-of-Way
- Access to and preservation of transportation rights-of-way become more important, with the emphasis on maximizing the benefits of existing investments. Access management is a broad term encompassing an array of traffic design and land use techniques used to preserve and enhance the capacity of existing highways while significantly improving safety. Local officials are challenged to balance the demands of property owners, who want to maximize access, with the needs of safety and operational efficiency.
- Safety
- Safety is an ongoing problem for small and medium-sized communities, affecting all modes. Whereas motor vehicle accident rates may be lower, severity rates are often higher, particularly fatality rates.
- Growth
- Growth has great effects on the quality of life. For some, it means effects on the environment and threats to existing lifestyles because of overcrowding. For others, quality of life relates more to economic development, and congestion is seen as a threat to growth. These issues are most commonly associated with large urban areas, but have become significant issues in small- and medium-sized communities as well.

Q10.

a)

Path building Criteria, Moore's Algorithm and Skim Tree

Path building criteria – the first step is to create the highway network with nodes and links. Later the network description is coded. The next step is to select the minimum path between the zones and assign predicted trips to these paths. Traffic volumes are thus accumulated for each section of the network. The minimum path may be that route of travel which has least accumulation of time, distance or other parameters. The 'tree' is determined starting from the zone centroid and progressively selecting the shortest path to the terminal zone centroid. When traffic is accumulated for each link it may so happen that certain individual links get overloaded. In that event, certain adjustments will have to be made in accordance with travel time flow relationship.

A procedure commonly employed in traffic assignment studies is what is called as **'Moore's Algorithm'**. Moore developed a method for dealing with telephone calls on the basis of shortest

path, and this method has been exploited in many computer programs designed to assign the t
in a street network.

A simple example below illustrates the method of building the minimum path tree (skim tre

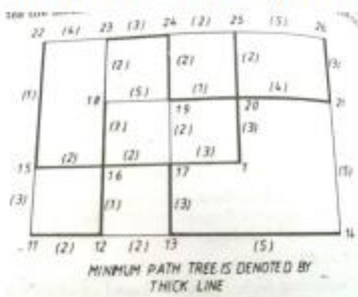


Fig. 33-1. Minimum path 'tree'.

work shown in Fig. 33·1 consists of a zone centroid 1 and a number of links and nodes. The travel time on each link is indicated in figures in backets. It is required to build the minimum path tree from centroid 1.

Starting from Centroid 1, we go to each connecting node and note the time of travel to the node. Thus

$T_{1-20} = 3$

$T_{1-17} = 3$

The node close to Centroid 1 in time is considered next. In this example, the time taken to reach both the nodes being the same, the node having the lower number, *viz* Node 17 is taken up. From Node 17, the cumulative time to travel from Centroid connected directly to Node 17 is noted. Thus :

$T_{1-17-19} = 5$

$T_{1-17-16} = 5$

$T_{1-17-13} = 6.$

The next closest node to Centroid 1, *i.e.* Node 20, is now considered and the cumulative time to travel from Centroid 1 to all nodes connected directly to it are noted. Thus :

$T_{1-20-19} = 4$

$T_{1-20-25} = 6$

$T_{1-20-21} = 7.$

... two possible routes

It will be seen from the above that there are two possible routes to reach Node 19, *i.e.* 1–17–19 and 1–20–19. The latter is shorter in time and is, therefore, chosen and the former is discarded. This process is repeated until all nodes have been covered by the shortest path. The minimum path 'tree' is indicated in Fig. 33-1.

b) Selection of Land Use Transport Model While selecting a model, a number of considerations become important. These are:
   1) Simplicity – the model should have a simple casual structure which should be easy to comprehend. A simple model will generally consume less time and resources.
   2) Modest data requirements – data requirements must be modest. In fact, some of the good models make use of data routinely available with the planning department.
   3) Adaptability – the model should be adaptable to any given location.
   4) Comprehensiveness – the model should be comprehensive and should synthesise the relationship between activities, housing and transportation adequately well.
   5) Operationality and rapidity – the model should be operational, capable of easy interpretation and should be able to test rapidly a wide range of policy options.
   6) Computer cost – the model should be operational at relatively cheap computer cost.

Lowery Derivative Model

The Lowery derivative models have many of the above attributes. They are simple to use, require modest data, are comprehensive and economical, have good response to change in input variables and have simple causal structure. They have therefore been used extensively and successfully in a number of studies. The fundamental structure of the model is illustrated in Figure.

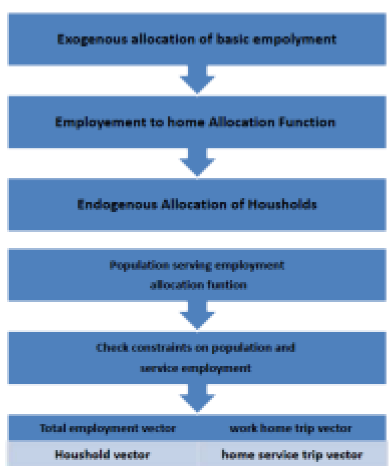


Figure (1): Structure of Lowery Model.

The Lowery model relates the three principle components of the urban area:

1. Population.
2. Employment.
3. Communication between population and employment.

c) **3. Capacity restraint assignment techniques**

This is the process in which the travel resistance of a link is increased according to a relation between the practical capacity of the link and the volume assigned to the link. This model has been developed to overcome the inherent weakness of all-or-nothing assignment model which takes no account of the capacity of the system between a pair of zones. This method clearly restrains the number of vehicles that can use in any particular corridor. The whole system, if assigned with volumes which are beyond the capacity of the network, then it redistributes the traffic to realistic alternative paths.

Steps:

- Here the procedure is similar to all-or-nothing assignment as far as the initial data input are concerned. The additional data fed is the capacity of each link. The best paths are determined in the same way as in all-or-nothing assignment by building the minimum path trees.
- Traffic is then assigned to the minimum paths, either fully or in stages.
- As the assigned volume on each link approaches the capacity of the link, a new set of travel time on the link is calculated.
- This results in a new network with a different minimum path tree, differing significantly from the earlier minimum path tree. As a consequence, assigning the inter-zonal volumes to the new tree produces a new volume on each link.
- This iterative process is repeated until a satisfactory balance between volume and speed is achieved.

Some of the capacity restraint methods are:

Smock Method:

In this method all-or-nothing assignment is first worked out. In an iterative procedure, the link travel times are modified according to the following function.

Smock model is used to compute link travel time as:

$$T_A = T_0 e^{\left(\frac{V}{C} - 1\right)} \qquad (27)$$

Where, $T_A \leq 5T_0$

T_A = adjusted travel time which is used to determine the minimum paths or routes.

T_0 = Original travel time

e = exponential base

V = assigned volume

C = computed link capacity

In the second iteration, the adjusted travel time (T_A) is used to determine the minimum paths. The resulting link volumes are averaged and these are again used to calculate the adjusted travel time for next iteration.

b) Bureau of Public Roads (BPR) Method:

The formula used to update the link travel time is:

$$T_N = T_0\left[1 + 0.15\left(\frac{Assigned \quad Volume}{\Pr actical \quad capacity}\right)^4\right]$$

$$T_N = T_0\left[1 + 0.15\left(\frac{V}{C}\right)^4\right] \tag{26}$$

Where, T_0 = free flow time or base travel time at zero volume

T_0 = 0.87 * travel time at practical capacity

V = assigned volume

C = practical capacity