According to New Revised Credit System Syllabus

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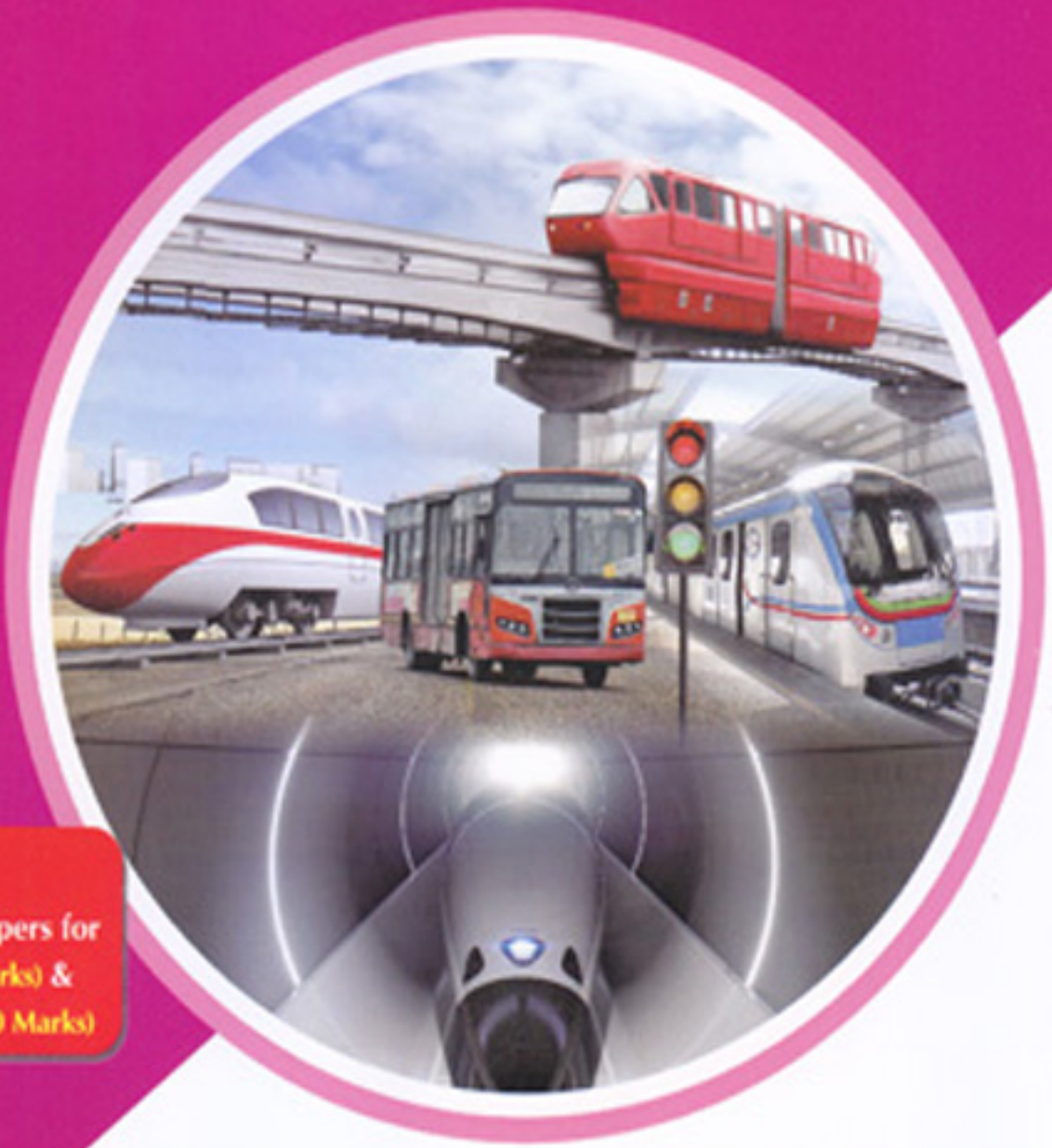
Final Year Degree Course In
CIVIL ENGINEERING (Semester - II)

ADVANCED TRANSPORTATION ENGINEERING



Includes
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NIRALI PRAKASHAN
ADVANCEMENT OF KNOWLEDGE

A TEXT BOOK OF

ADVANCED TRANSPORTATION ENGINEERING

(ELECTIVE – IV)

FOR

SEMESTER – II

FINAL YEAR (B.E.) DEGREE COURSE IN CIVIL ENGINEERING

Strictly According to New Revised Credit System Syllabus of Savitribai Phule Pune University

(w.e.f. 2018-2019)

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PREFACE

It gives us great pleasure to present the book **"Advanced Transportation Engineering" (Elective – IV)** for the students of **Final Year (BE) Degree Course in Civil Engineering** of the Savitribai Phule Pune University. This book is strictly as per the **New Revised Credit System Syllabus 2015 Pattern** and **Effective from the Academic Year 2018 - 2019.**

As per the New Revised Examination Scheme, which has been implemented from the previous academic year, the In-semester examination allots 30 marks for the first three units and the End Semester Examination allots 70 marks for the entire syllabus, out of which first three units carry total 20 marks and the units 4, 5, 6 will have total 50 marks. The theory course will have 3 credits.

The book is written such that all the basic concepts are explained in simplified manner. It is presented in a more conceptual manner rather than mathematical, as required by the new examination system. It is our objective to keep the presentation systematic, consistent, intensive and clear through explanatory notes and figures.

Main feature of this book is, Complete Coverage of the New Credit System Syllabus with Exercises and Model Question Papers of In Sem. and End Sem. Exams.

We are sure that this book will cater to all needs of the students for this subject.

We take this opportunity to express our sincere thanks to Shri. Dineshbhai K. Furia, Shri. Jignesh C. Furia, Mrs. Nirali M. Verma, Shri. M. P. Munde and the entire team of Nirali Prakashan including Mrs. Deepali Lachake (Co-ordinator) and her colleagues who really have taken keen interest and untiring efforts in publishing this text.

The advice and suggestions of our esteemed readers, to improve the text, are most welcomed, and will be highly appreciated.

Pune **Authors**

SYLLABUS

Unit I : Transport System Planning **(6 hrs.)**

Transportation planning process and types of surveys. Travel demand forecasting - trip generation, modal spilt analysis, trip distribution and route assignment analysis, Transportation System Management (TSM), application in Comprehensive Mobility Plan (CMP) and DPR.

Unit II : Urban Transport Technology **(6 hrs.)**

Classification- light, medium, mass and rapid transit system, Introduction to Intelligent Transportation System (ITS) and its components, Public Transport Policy. Introduction to BRT, Mono rail, Metro rail, Bullet train and Hyperloop. Concept of Integrated Inter Model Transit System and freight transportation.

Unit III : Transport Economics, Financing & Environmental Impact Assessment **(6 hrs.)**

(a) Transport Economics & Financing: Road user cost - Vehicle operations cost, running cost, value of travel time, road damage cost, accident cost. Economic evaluation – Benefit cost method, Net present value method, First year rate of return method, Internal rate of return method & comparison of various methods.

(b) Environmental Impact Assessment: EIA requirement of highway projects, procedure and guidelines, pollution cost and concept of congestion pricing.

Unit IV : Traffic Engineering **(6 hrs.)**

Traffic studies, basic traffic theory, traffic analysis process, level of service, intersection studies- turning movements, grade separated intersection, signal design-IRC method and Webster's method, parking study and analysis, bicycle and pedestrian facility design, instrumentation of traffic monitoring.

Unit V : Study of Flexible Pavement **(6 hrs.)**

Philosophy of design and design criteria, design of flexible pavement using IRC 37-2012, Distresses in flexible pavement, evaluation of pavement –Benkelmen beam, Falling Weight Deflectometer (FWD), Pavement Management Systems (PMS).

Unit VI : Study of Rigid Pavement **(6 hrs.)**

(a) Study of Rigid Pavement: Philosophy of rigid pavement, comparison of rigid pavement over flexible pavement, types of rigid pavements, design of rigid pavement using IRC 58-2015 including design of joints, distresses in rigid pavement.

(b) Overlay Types and their Design as per IRC: Types of overlays, design of overlay using IRC 81-1997.

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UNIT - I

TRANSPORT SYSTEM PLANNING

1.1 TRANSPORT POLICY

- The problems such as congestion, pollution and accidents are some of the major issues in front of the transport planners.
- The supply side i.e. the lane width of the transportation system greatly influences the congestion, pollution and accidents.
- There is a wide range of solutions suggested to these problems from building of new roads to banning cars and from improving bus service to the use of telecommunications as an alternative to travel.
- Many of these solutions are expensive and may not be very effective moreover, they may introduce new problems.
- It is the task of politicians and skilled professionals who advise them, to identify the most appropriate solutions to today's and tomorrow's transport problems.
- These solutions forms basis for a transport policy which can be designed for a nation, individual city or town or a rural area.

1.2 TRANSPORTATION PLANNING PROCESS

(Nov. 16, May 17)

- The transportation planning process comprises seven basic elements, which are inter- related and not necessarily carried out sequentially.
- The information acquired in one phase of the process may be helpful in some earlier or later phase, so there is a continuity of effort that should eventually result in a decision.

The Elements in the Transportation Process are:

1. Situation definition
2. Problem definition
3. Search for solutions
4. Analysis of performance
5. Evaluation of alternatives
6. Choice of project
7. Specification and construction

These elements are described and illustrated in Fig. 1.1, using a scenario involving the feasibility of constructing a new bridge.

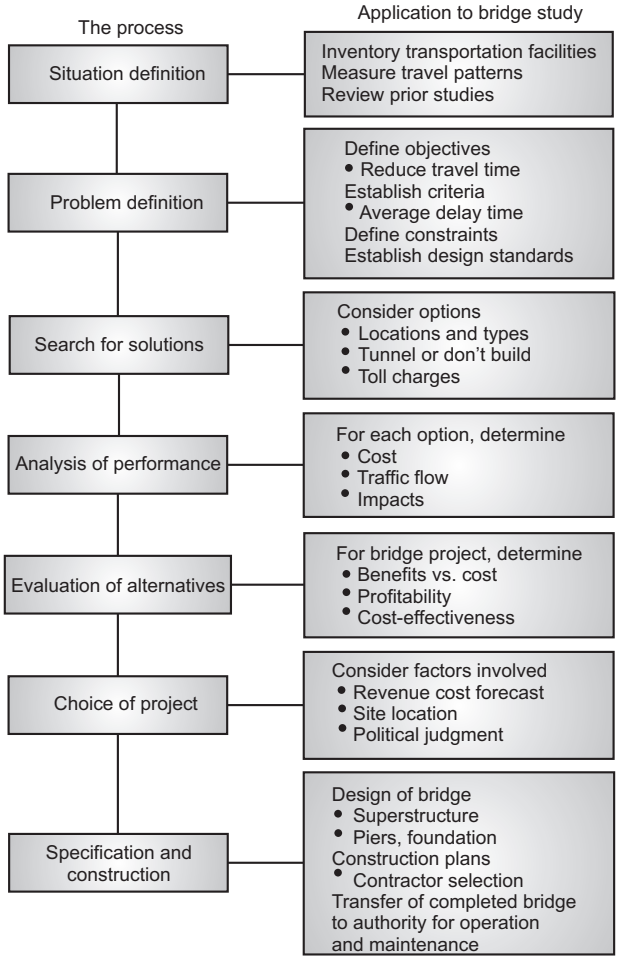

Fig. 1.1: Basic elements in the transportation planning process applied to consider the feasibility of a new bridge

1.3 TRAFFIC SURVEY

- Survey deals with the study of summary of present travel pattern, existing pattern of transport system and facilities which take into consideration the economic activities.
- Study area for the transportation facility is initially decided. Facilities can be planned at city/town level, state and national level.
- Imaginary lines are drawn at the various levels mentioned above which represent the boundary of the area to be studied. These imaginary lines are called as external cordon lines or simply the cordon lines.
- Any area thus, selected as study area for planning of transportation facility, it is subdivided into smaller areas called zones and process known as zoning.
- To find the average characteristics of the individual households, the data collected is aggregated into small

zones and analyzed. Such small zones further help into physical and geographical association of origin and destinations of the trips.

- Survey data is collected from the movement of trips which generally occur in the below mentioned pattern.
  1. Inter-zonal movement.
  2. Internal to external zone movement.
  3. External to internal zone movement.
  4. External to external zone movement.

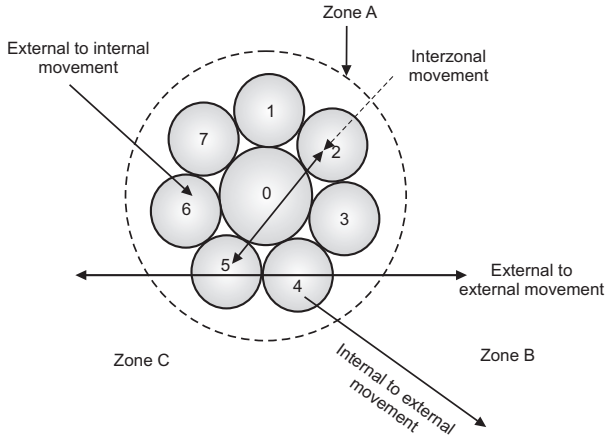

Fig. 1.2

1.4 TYPES OF SURVEYS

Following are the different types of survey:

1. Postal survey
2. Registration number plate survey
3. Road side interview survey
4. Public transport survey
5. Taxi survey
6. Commercial vehicle survey
7. Home interview survey

1. Postal Survey:

- Drives are given the prepaid post cards at the points where the survey is being carried out and are requested to fill the information and return the post.
- This method avoids traffic which leads to delay when the drivers in other methods are stopped road side for interview.
- Response for this method may not be good. Not recommended in the developing countries like India.
- Postal method is simple and cheap to carry out the survey.
- It is observed a good response of more than 50%.

2. Registration Number Plate Survey:

- In this method, the registration number on the vehicles are noted down in a table for those leaving or entering the cordon lines.
- Vehicle registration numbers are matched with the vehicles existing out of the cordon line or study area being studied thus identifying the path of the vehicle.
- Advantages of this method are that, it does not interrupt the moving traffic.
- But this method does not yield any useful information such as trip purpose, origin or destination of the trip.
- Large numbers of observers are needed to carry out the survey.
- The procedure is tiresome, if done manually, so electronic equipment's like camera, computer and various software's are used.

3. Road Side Interview Survey: (May 17)

- Road side interview survey is directly done by interviewing drivers of the vehicles at selected survey points or by issuing prepaid post cords.
- Survey is generally conducted on the external cordon line of a town having population 5000 or less.
- When the town or cities are large in size having population varying from 5000 to 75000, the two cordon lines are necessary.
- The external cordon at the end of the urban development and the internal cordon at the Central Business District (CBD).
- It is practically impossible to stop every vehicle without disrupting the traffic hence the samples depend on number of interviewers.
- Best way is to sample one in a fixed number of vehicle as follows every seventh, fifteenth, twentieth vehicle.
- As the interview takes several minutes, vehicles should be stopped in interview bay.
- A 24 hours count will not be needed as survey is often restricted to 12 hrs or 10 hrs.

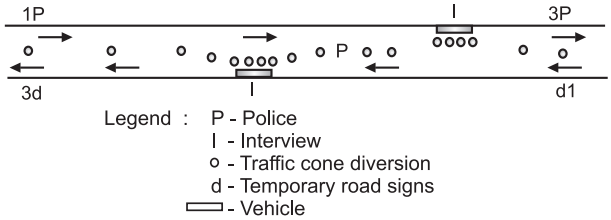

Fig. 1.3: Layout four road side interview

4. Public Transport Survey:

- To determine number of bus passengers passing through external cordon line.
- Direct interview or postal survey can be done direct interview may lead to delay and requires large number of interviewers.

- Passengers on any public transport facility can be interviewed on the external cordon to get the data while travelling to avoid other complications:

5. Taxi Survey:

- Large urban areas, usually have a sizeable amount of travel by taxis. So separate taxi survey is necessary.
- The survey consists of issuing log sheets and questionnaires to the taxi drivers and requesting them to complete the same.

6. Commercial Vehicle Survey:

- This survey is conducted to derive the information and travelling patterns made by all commercial vehicle based within the study area.
- Forms are issued to drivers with a request to record particular of the trips made and the future trips to be made.

7. Home Interview Survey: (Nov. 16, Feb. 17)

- Home interview survey is one of the most reliable types of survey for collecting origin and destination data.
- The survey intends to yield data on the travel pattern of the residents of the household.
- Because a wide variety of data (like trips made, their origin and destination, purpose of trip, travel made, time of departure from origin and destination purpose of trip, travel mode, time of departure.

Table 1.1

Population of Study Area	Sample Size
Under 50,000	1 in 5 households
50,000 – 150,000	1 in 8 households
150,000 – 300,000	1 in 10 households
300,000 – 500,000	1 in 15 households
500,000 – 1,000,000	1 in 20 households
Over 1,000,000	1 in 25 households

- In the above method, it is necessary to take prior permission from the selected households explaining the nature importance and objectives of the survey and expecting their co-operation.
- The household interview technique is very expensive and it is possible to collect the needed information at a rate of 8 – 10 interviews per day per interviewers.
- Sometimes, telephonic interview were used in the past to satisfy the above techniques.
- The data collected from the home interview can be classified under two groups: household, information and journey data.
- The data collected includes information such as address, size of household, age, sex, earning members, occupations, place of work, number of motor vehicles, household income etc.

1.5 ORIGIN DESTINATION MATRIX (Feb. 17)

- O-D survey is necessary not only to know the origin and destination of any trip but also, to know the number of trips made in a particular zone.
- Origin is the location where the trip originates and destination is the location or place where the trip terminates.
- Origin destination matrix is used to identify the amount of traffic that enters the town and immediately exits for the other town in order to bypass it.
- Origin destination matrix is used to develop trip generation and distribution models.
- Origin destination matrix is used to determine the existing capacity of present transportation system and plan for new if required.
- Origin destination surveys produces a large amount of data which needs to be arranged in such a way so that one can understand it.

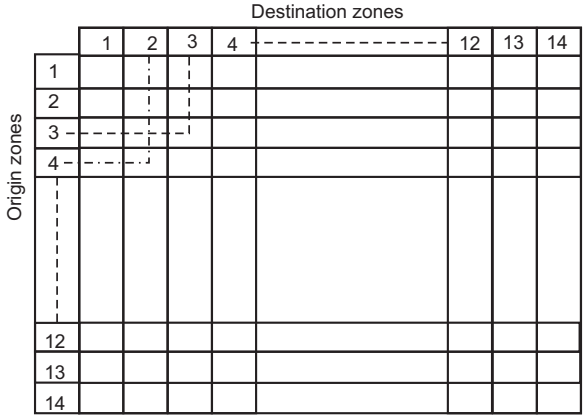

Fig. 1.4

- The above matrix represents the destination zone on horizontal axis and origin zone on vehicle axis.
- The numbers in the cells on vertical and horizontal axis indicate the numbers of zones.
- In the above matrix, $t_{4\text{-}2}$ indicates that trips are originating from zone four and terminating in zone two.

1.6 TRAVEL DEMAND FORECASTING

- Travel demand is expressed as the number of persons or vehicles per unit time that can be expected to travel on a given segment of a transportation system under a set of given land-use, socioeconomic, and environmental conditions.

- Forecasts of travel demand are used to establish the vehicular volume on future or modified transportation system alternatives.
- The methods for forecasting travel demand can range from a simple extrapolation of observed trends to a sophisticated computerized process involving extensive data gathering and mathematical modelling.
- The travel demand forecasting process is as much an art as it is a science. Judgments are required concerning the various parameters that is, population, car ownership, and so forth that provide the basis for a travel forecast.
- The methods used in forecasting demand will depend on the availability of data and on specific constraints on the project, such as availability of funds and project schedules.

1.6.1 Transportation Demand

- Transportation demand is the demand for trips that exists in any area.
- All of these demands, however may or may not be materialized into physical trips and some of it remains latent and is referred as hidden demand.

Nature and Analysis of Transportation Demand:

- These demands are the demands of persons to be transported not because he/she wants to move but, because he/she wants to achieve some other purpose such as reaching school, or office, or a movie theatre.
- In other words, need for achieving some goal creates the need of travel.
- Land use refers to the pattern of land usage in an area. Land use affects the transportation demand through generation and distribution of trips.
- The effect of land use on transportation demand is not necessarily. A one way effect but rather a part of cycle in which land use changes transportation needs which in turn change land use.

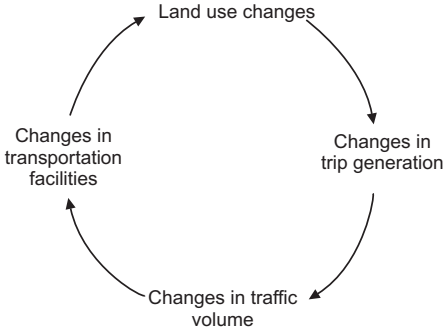

Fig. 1.5

- Trip purpose refers to the purpose for which the trip is being undertaken.
- Travel demand behaviour changes with the trip purpose. For example, a person hardly exercises any choice for work trips, i.e. does not necessarily decide every time whether to go to work or not.
- A person obviously does not decide where to go to work (generally it is fixed over a period of time for a large section of the population) even the choice of route and mode are not daily decisions.
- On the other hand, for recreational trips, on individual make a large number of decisions, such as whether to go or not, where to go and how to go.
- Consequently, the travel demand behaviour for work trips varies considerably from that of recreational trips.
- Hence, given the effect of trip purpose on travel demand behaviour, the analysis of travel demand is done separately for different trip purpose.
- Generally, a trip materializes after the trip maker makes certain decisions. These decisions can be broadly classified as follows:
  - ➢ Decision to travel.
  - ➢ Decision on the choice of destination.
  - ➢ Decision on the choice of mode.
  - ➢ Decision on the choice of route.
- In this analysis and demand procedure, first the entire study area is divided into various zones.
- These zones are generally obtained from land use pattern of the area. Next, for each zone numbers of trips generated in that zone are estimated using trip-generation models.
- Outputs of these models are then used to determine the number of trips between all zone pairs using trip distribution models.

1.6.2 Factors Influencing Travel Demand

- The three factors that influence the demand for urban travel are:
  1. The location and intensity of land use.
  2. The socioeconomic characteristics of people living in the area.
  3. The extent cost, and quality of available transportation services.
- These above factors are incorporated in most travel forecasting procedures. Land-use characteristics are a primary determinant of travel demand.
- The amount of traffic generated by a parcel of land depends on how the land is used. For example, shopping centres, residential complexes, and office buildings produce different traffic generation patterns.

- Socioeconomic characteristics of the people living within the city also influence the demand for transportation.
- Lifestyles and values affect how people decide to use their resources for transportation.
- For example, a residential area consisting primarily of high-income workers will generate more trips by automobile per person than a residential area populated primarily by retirees.
- The availability of transportation facilities and services, referred to as the supply, also affects the demand for travel.
- Travellers are sensitive to the level of service provided by alternative transportation modes.
- When deciding whether to travel at all or which mode to use, they consider attributes such as travel time, cost, convenience, comfort, and safety.

1.7 SEQUENTIAL STEPS FOR TRAVEL FORECASTING

- Prior to the technical task of travel forecasting, the study area must be delineated into a set of Traffic Analysis Zones (TAZ) that form the basis for analysis of travel movements within, into, and out of the urban area.
- The set of zones can be aggregated into larger units, called districts, for certain analytical techniques or analyses that work at such levels. Land use estimates are also developed.
- Travel forecasting is solely within the domain of the transportation planner and is an integral part of site development and traffic engineering studies as well as area wide transportation planning.
- Techniques that represent, the state of the practice of each task are described in this chapter to introduce the topic and to illustrate how demand forecast can be determined.
- Variations of each forecasting technique are described in the literature.

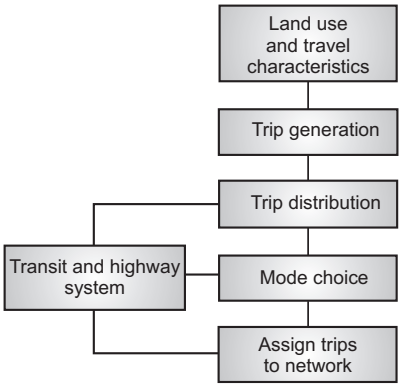

Fig. 1.6: Travel forecasting process

- The approach most commonly used to forecast travel demand is based on land use and travel characteristics that provide the basis for the "four-step process" of trip generation, trip distribution, modal choice, and traffic assignment illustrated in Fig. 1.6.
- Simultaneous model structures have also been used in practice, particularly to forecast intercity travel.

1.8 DEFINITION OF SOME COMMON TERMS

- **Trip :** It is a one-way movement between an origin and destination, independent of length or distance, without any significant stop, except the time spent during the transfer of mode. It is conducted for a specific purpose.

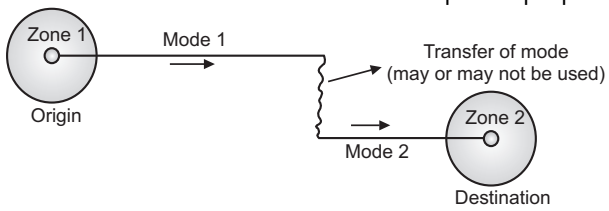

Fig. 1.7

- **Origin :** The zone in which trip begins (the start of the trip).
- **Destination :** The zone in which trip terminates (end) (i.e. end of the trip).
- **Trip End :** Either end of the trip where trip originates or where the trip ends.
- **Internal Trip :** A trip having both Origin and Destination within the study area.
- **Intra-Zonal Trip :** A trip with both Origin and Destination in the same zone.
- **Inter-Zonal Trip :** A trip travelling between two different zones.
- **Through Trip :** The trip having both origin and destination outside the study area.
- **Trip Mode:** The means of transport by which trip is made i.e. car, taxi, auto, bus etc.
- **Generation :** The trip end where the trip starts (generates).

  Examples:

  (a) Home : For home based trip (Home to Work).

  (b) Work : For non home base trip (Work to Shopping).
- **Attraction :** The trip end where the trip terminates (end).

  Examples:

  (a) Work : For home base trip (Home to Work).

  (b) Shopping : For non home based trip (Work to Shopping).
- **Trip Purpose :** Trips are made for different purposes and a classification of trips by purpose is necessary.

  Examples: Work, school, business, social or recreational, others.

1.9 TRIP GENERATION

- Trip generation is the process of determining the number of trips that will begin or end in each traffic analysis zone within a study area.
- Since, the trips are determined without regard to destination, they are referred to as trip ends.
- Each trip has two ends, and these are described in terms of trip purpose, or whether the trips are either produced by a traffic zone or attracted to a traffic zone.
- For example, a home-to-work trip would be considered to have a trip end produced in the home zone and attracted to the work zone.
- Trip generation analysis has two functions:
  1. To develop a relationship between trip end production or attraction and land use and
  2. To use the relationship to estimate the number of trips generated at some future date under a new set of land use conditions.
- To illustrate the process, two methods are considered; Cross-classification and rates based on activity units and another commonly used method is regression analysis.

1.9.1 Classification of Trips

It has been found that better trip generation models can be obtained, if the trips by different purposes are identified and modeled separately.

The trips can be classified as given below.

- **Home Based Trip:** A trip which has one end of the trip at home of the person making the trip.

  Examples: Home to work , Home to shopping school.
- **Non-Home Based Trip:** The trip which does not end or start from home.

  Examples: Work to shopping.

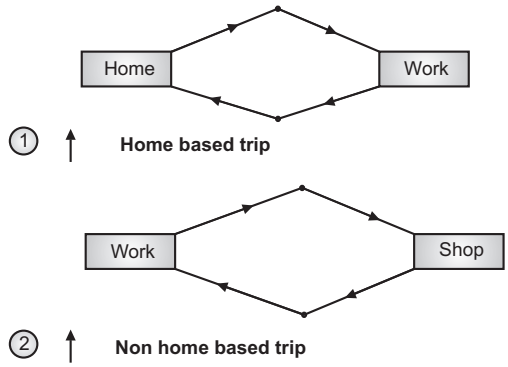

Fig. 1.8

- **Time Based Trips :** The proportion of journey is different by different purposes, usually varies with time of the day. Thus, the classification is often given as Peak and Off Peak Period Trip.
- **Person-Type Based Trips :** The travel behaviour of an individual is mainly dependent on its socio-economic attributes. Following are the categories which are usually employed :
  - ➢ Income Level- Poor, Middle Class, Rich
  - ➢ Car Ownership- 0,1,2,3
  - ➢ Household Size- 1,2,3,4... etc

1.9.2 Factors Governing Trip Generation and Attraction Rates (Nov. 16)

The factors governing trip generation and attraction rates are as follows :

- **Income :**
  - ➢ Higher the income, the higher is the trip generation rate.
- **Car Ownership :**
  - ➢ More cars in a household, more trips family size and composition, the bigger the family, the more trips there are likely to be generated.
  - ➢ Composition of the family, age group, school going childrens employed persons also affects trip generation.
- **Land Use Characteristics :**
  - ➢ High residential area with high density of population more trips.
  - ➢ Residential area with less density of population but rich peoples (High Income Group) more trips
  - ➢ Distance of the zone from the town centre, farther the town, less number of trips.
- **Mode Employed :**
  - ➢ The trip maker also takes a decision as to what mode of transport he/she will use for a given trip.
  - ➢ This decision, however, is only available to those who have access to different modes and are not captive users of any particular mode.
- **Route Travelled :**
  - ➢ The trip maker on any given trip takes a definite decision on which route to take so as to reach the destination.
  - ➢ Again this decision is available to trip makers who have access to modes which can use different routes as per the wishes of the trip maker.
  - ➢ Such modes would generally include personal automobiles or two wheelers.

1.9.3 Multiple Linear Regression Analysis

- Multiple linear regression analysis is a well known statistical technique for fitting mathematical relationships between dependent and independent.

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