Chapter 1

Introduction to transportation engineering

1.1 Overview

Mobility is a basic human need. From the times immemorial, everyone travels either for food or leisure. A closely associated need is the transport of raw materials to a manufacturing unit or finished goods for consumption. Transportation fulfills these basic needs of humanity.

Transportation plays a major role in the development of the human civilization. For instance, one could easily observe the strong correlation between the evolution of human settlement and the proximity of transport facilities. Also, there is a strong correlation between the quality of transport facilities and standard of living, because of which society places a great expectation from transportation facilities.

In other words, the solution to transportation problems must be analytically based, economically sound, socially credible, environmentally sensitive, and practically acceptable and sustainable. Alternatively, the transportation solution should be safe, rapid, comfortable, convenient, economical, and eco-friendly for both men and material.

1.2 Transportation system

In the last couple of decades transportation systems analysis has emerged as a recognized profession. More and more government organizations, universities, researchers, consultants, and private industrial groups around the world are becoming truly multi-modal in their orientation and are opting a systematic approach to transportation problems.

1.2.1 Diverse characteristics

The characteristics of transportation system that makes it diverse and complex are listed below:

1. *Multi-modal:* Covering all modes of transport; air, land, and sea for both passenger and freight.
2. *Multi-sector:* Encompassing the problems and viewpoints of government, private industry, and public.
3. *Multi-problem:* Ranging across a spectrum of issues that includes national and international policy, planning of regional system, the location and design of specific facilities, carrier management issues, regulatory, institutional and financial policies.

4. *Multi-objective:* Aiming at national and regional economic development, urban development, environment quality, and social quality, as well as service to users and financial and economic feasibility.
5. *Multi-disciplinary:* Drawing on the theories and methods of engineering, economics, operations research, political science, psychology, other natural, and social sciences, management and law.

1.2.2 Study context

The context in which transportation system is studied is also very diverse and are mentioned below:

1. *Planning range:* Urban transportation planning, producing long range plans for 5-25 years for multi-modal transportation systems in urban areas as well as short range programs of action for less than five years.
2. *Passenger transport:* Regional passenger transportation, dealing with inter-city passenger transport by air, rail, and highway and possible with new modes.
3. *Freight transport:* Routing and management, choice of different modes of rail and truck.
4. *International transport:* Issues such as containerization, inter-modal co-ordination.

1.2.3 Background: A changing world

The strong interrelationship and the interaction between transportation and the rest of the society especially in a rapidly changing world is significant to a transportation planner. Among them four critical dimensions of change in transportation system can be identified; which form the background to develop a right perspective.

1. *Change in the demand:* When the population, income, and land-use pattern changes, the pattern of demand changes; both in the amount and spatial distribution of that demand.
2. *Changes in the technology:* As an example, earlier, only two alternatives (bus transit and rail transit) were considered for urban transportation. But, now new systems like LRT, MRTS, etc offer a variety of alternatives.
3. *Change in operational policy:* Variety of policy options designed to improve the efficiency, such as incentive for car-pooling, bus fare, road tolls etc.
4. *Change in values of the public:* Earlier all beneficiaries of a system was monolithically considered as users. Now, not one system can be beneficial to all, instead one must identify the target groups like rich, poor, young, work trip, leisure etc.

1.2.4 Role of transportation engineer

In spite of the diversity of problem types, institutional contexts and technical perspectives there is an underlying unity: a body of theory and set of basic principles to be utilized in every analysis of transportation systems. The core of this is the transportation system analysis approach. The focus of this is the interaction between the transportation and activity systems of region. This approach is to *intervene, delicately and deliberately in the complex fabric of society to use transport effectively in coordination with other public and private actions to achieve the goals of that society.* For this the analyst must have substantial understanding of the transportation systems and their interaction with activity systems; which requires understanding of the basic theoretical concepts and available empirical knowledge.

1.2.5 Basic premise of a transportation system

The first step in formulation of a system analysis of transportation system is to examine the scope of analytical work. The basic premise is the explicit treatment of the total transportation system of region and the interrelations between the transportation and socioeconomic context.They can be stated as:

P1 The total transportation system must be viewed as a single multi-modal system.

P2 Considerations of transportation system cannot be separated from considerations of social, economic, and political system of the region.

This follows the following steps for the analysis of transportation system:

- **S1** Consider all modes of transportation
- **S2** Consider all elements of transportation like persons, goods, carriers (vehicles), paths in the network facilities in which vehicles are going, the terminal, etc.
- **S3** Consider all movements of passengers and goods for every O-D pair.
- **S4** Consider the total trip for every flows for every O-D over all modes and facilities.

As an example, consider the the study of intra-city passenger transport in metro cities.

- Consider all modes: i.e rail, road, buses, private automobiles, trucks, new modes like LRT, MRTS, etc.
- Consider all elements like direct and indirect links, vehicles that can operate, terminals, transfer points, intra-city transit like taxis, autos, urban transit.
- Consider diverse pattern of O-D of passenger and good.
- Consider service provided for access, egress, transfer points and mid-block travel etc.

Once all these components are identified, the planner can focus on elements that are of real concern.

1.3 Major disciplines of transportation

Transportation engineering can be broadly consisting of the the four major parts:

1. Transportation Planning
2. Geometric Design
3. Pavement Design
4. Traffic Engineering

A brief overview of the topics is given below: Transportation planning deals with the development of a comprehensive set of action plan for the design, construction and operation of transportation facilities.

1.3.1 Transportation planning

Transportation planning essentially involves the development of a transport model which will accurately represent both the current as well as future transportation system.

1.3.2 Geometric design

Geometric design deals with physical proportioning of other transportation facilities, in contrast with the structural design of the facilities. The topics include the cross-sectional features, horizontal alignment, vertical alignment and intersections. Although there are several modes of travel like road, rail, air, etc.. the underlying principles are common to a great extent. Therefore emphasis will be normally given for the geometric design of roads.

1.3.3 Pavemenet analysis and design

Pavement design deals with the structural design of roads, both (bituminous and concrete), commonly known as (flexible pavements and rigid pavements) respectively. It deals with the design of paving materials, determination of the layer thickness, and construction and maintenance procedures. The design mainly covers structural aspects, functional aspects, drainage. Structural design ensures the pavement has enough strength to withstand the impact of loads, functional design emphasizes on the riding quality, and the drainage design protects the pavement from damage due to water infiltration.

1.3.4 Traffic engineering

Traffic engineering covers a broad range of engineering applications with a focus on the safety of the public, the efficient use of transportation resources, and the mobility of people and goods. Traffic engineering involves a variety of engineering and management skills, including design, operation, and system optimization. In order to address the above requirement, the traffic engineer must first understand the traffic flow behaviour and characteristics by extensive collection of traffic flow data and analysis. Based on this analysis, traffic flow is controlled so that the transport infrastructure is used optimally as well as with good service quality. In short, the role of traffic engineer is to protect the environment while providing mobility , to preserve scarce resources while assuring economic activity, and to assure safety and security to people and vehicles, through both acceptable practices and high-tech communications.

1.4 Other important disciplines

In addition to the four major disciplines of transportation, there are several other important disciplines that are being evolved in the past few decades. Although it is difficult to categorize them into separate well defined disciplines because of the significant overlap, it may be worth the effort to highlight the importance given by the transportation community. They can be enumerated as below:

1. **Public transportation:** Public transportation or mass transportation deals with study of the transportation system that meets the travel need of several people by sharing a vehicle. Generally this focusses on the urban travel by bus and rail transit. The major topics include characteristics of various modes; planning, management and operations; and policies for promoting public transportation.

2. **Financial and economic analysis** Transportation facilities require large capital investments. Therefore it is imperative that who ever invests money should get the returns. When government invests in transportation, its objective is not often monetary returns; but social benefits. The economic analysis of transportation project tries to quantify the economic benefit which includes saving in travel time, fuel consumption, etc. This will help the planner in evaluating various projects and to optimally allocate

funds. On the contrary, private sector investments require monetary profits from the projects. Financial evaluation tries to quantify the return from a project.

3. **Environmental impact assessment** The depletion of fossil fuels and the degradation of the environment has been a severe concern of the planners in the past few decades. Transportation; inspite of its benefits to the society is a major contributor to the above concern. The environmental impact assessment attempts in quantifying the environmental impacts and tries to evolve strategies for the mitigation and reduction of the impact due to both construction and operation. The primary impacts are fuel consumption, air pollution, and noise pollution.

4. **Accident analysis and reduction** One of the silent killers of humanity is transportation. Several statistics evaluates that more people are kiled due to transportation than great wars and natural disasters. This discipline of transportation looks at the causes of accidents, from the perspective of human, road, and vehicle and formulate plans for the reduction.

5. **Intelligent transport system** With advent to computers, communication, and vehicle technology, it is possible in these days to operate transportation system much effectively with significant reduction in the adverse impacts of transportation. Intelligent transportation system offers better mobility, efficiency, and safety with the help of the state-of-the-art-technology.

In addition disciplines specific to various modes are also common. This includes railway engineering, port and harbour engineering, and airport engineering.

1.5 Summary

Transportation engineering is a very diverse and multidisciplinary field, which deals with the planning, design, operation and maintenance of transportation systems. Good transportation is that which provides safe, rapid, comfortable, convenient, economical, and environmentally compatible movement of both goods and people. This profession carries a distinct societal responsibility. Transportation planners and engineers recognize the fact that transportation systems constitute a potent force in shaping the course of regional development. Planning and development of transportation facilities generally raises living standards and enhances the aggregate of community values.

1.6 Problems