CHAPTER 1

Introduction to Transport Engineering

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1.1 Overview

What is transportation?

- Transportation is all about moving goods and people from one place to another.
- It is a Safe, efficient, reliable, and sustainable movement of persons and goods over time and space.

What is Transportation Engineering?

Transportation engineering is the application of technology and scientific principles to the planning, functional design, operation and management of facilities for any mode of transportation in order to provide for the safe, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods (transport). It is a sub-discipline of civil engineering.

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Transportation engineering encompasses a wide variety of issues and areas, including the design of streets, highways and intersections; mass transit systems; urban planning; traffic control systems and devices; travel demand and traffic flow; sizing of transportation facilities; operations and management for roadways; highway sign visibility; traffic congestion and safety hazards; and the management and economics of transportation systems.

The planning aspects of transportation engineering involve urban planning and technical forecasting decisions. Technical forecasting of passenger travel usually involves an urban transportation planning model, requiring the estimation of trip generation (how many trips for what purpose), trip distribution (destination choice, where is the traveler going), mode choice (what mode is being taken), and route assignment (which streets or routes are being used). More sophisticated forecasting can include other aspects of traveler decisions, including auto ownership, trip chaining (the decision to link individual trips together in a tour) and the choice of residential or business location (known as land use forecasting). Passenger trips are the focus of

transport engineering because they often represent the peak of demand on any transportation system.

The design aspects include the sizing of transportation facilities (lanes and facility capacity issues) as well as designing the geometry of the roadway. Likewise, the operations and management involve traffic engineering, so that vehicles move smoothly on the road or track.

A review of descriptions of the scope of various committees indicates that while facility planning and design continue to be the core of the transportation engineering field, such areas as *operations planning, logistics, network analysis, financing*, and *policy analysis* are also important to civil engineers, particularly to those working in highway and urban transportation.

Transportation engineering, as practiced by civil engineers, primarily involves ***planning, design, construction, maintenance***, and ***operation*** and ***Management*** of transportation facilities. The facilities support air, highway, railroad, pipeline, water, and even space transportation. The design aspects of transport engineering include the sizing of transportation facilities (how many lanes or how much capacity the facility has), determining the materials and thickness used in pavement designing the geometry (vertical and horizontal alignment) of the roadway (or track).

Before any planning occurs the Engineer must take what is known as an inventory of the area or if it is appropriate, the previous system in place.

This inventory or database must include information on:-

1. Population
2. Land Use
3. Economy Activity
4. Transportation facilities and services
5. Travel patterns and volumes
6. Laws and ordinances
7. Regional financial resources
8. Community values and expectations

These inventories help the engineer create business models to complete accurate forecasts of the future conditions of the system.

Operations and management involve traffic engineering, so that vehicles move smoothly on the road or track. Older techniques include signs, signals, markings, and tolling. Newer technologies involve intelligent transportation systems, including advanced traveler information systems (such as variable message signs), advanced traffic control systems (such as ramp meters), and vehicle infrastructure integration. Human factors are an aspect of transport engineering, particularly concerning driver-vehicle interface and user interface of road signs, signals, and markings.

Undoubtedly, transportation engineering is an emerging discipline encompassing the analysis, planning, design, construction, operation, and management of integrated transportation systems.

The characteristics of transportation Systems

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

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.

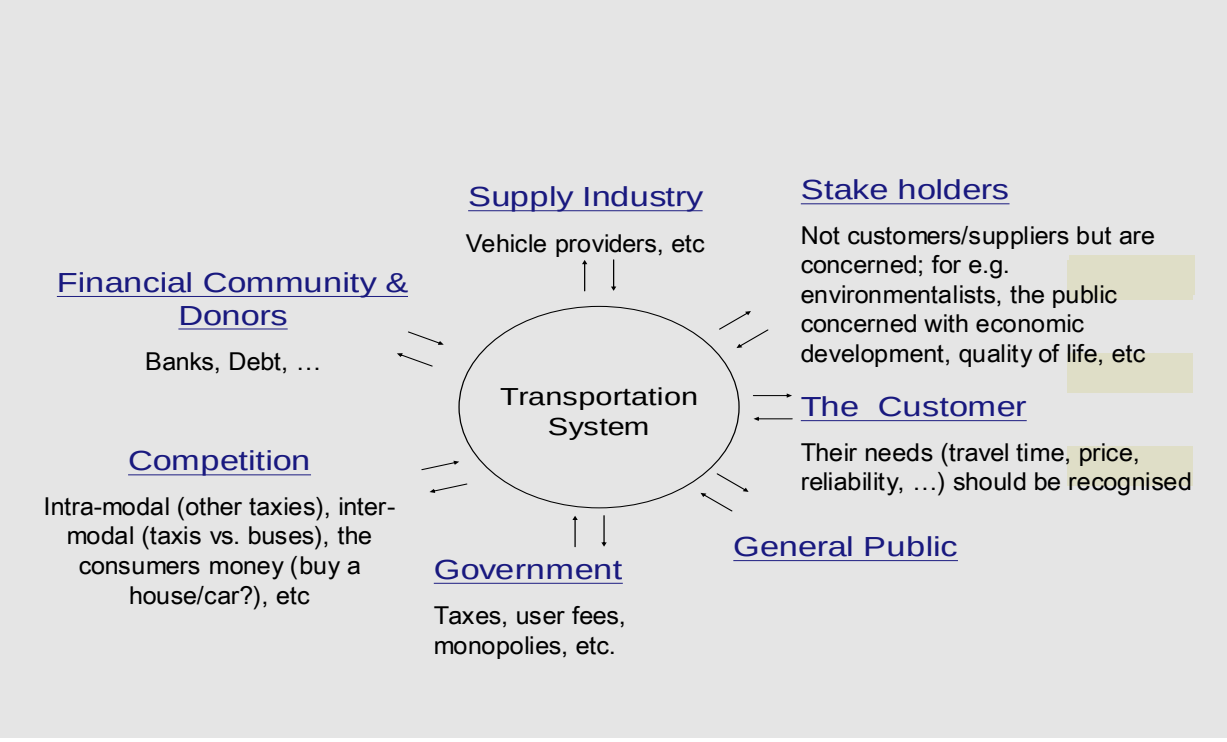

Fig 1 Task Players in Transportation

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, and 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.

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

1. ***Planning range*****:** Urban transportation planning, producing long range plans for 5-25 years for multimodal 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

Therefore as we understand from above 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.

1.2 History of transportation engineering

- Humans had migrated by their feet
- Use domesticated animals to carry goods
- Built machines and devices, like sleds and travois, to help them carry more.
- Establishing trading routes
- Well-used paths became more and more permanent.
- These paths became the first roads
- Maintain the roads and look at ways in which they could be made easier to travel
- The first transportation engineers.

Generally a transportation system has three elements this are:-

i. ***Infrastructure***: which includes Road, canal, rail, air Transfer points Supporting elements (signs, signals, safety)
ii. ***Vehicles***: which includes Planes, trains, autos, buses, ships, trucks
iii. ***Operators/Content*** : which includes Drivers, pilots, freight, passengers

Major Disciplines of Transportation Engineering

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

i. 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.

ii. 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.

iii. Pavement analysis and design

Pavement design deals with the structural design of roads, both flexible and rigid pavements. 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.

iv. 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 behavior 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.

Additional disciplines of transportation

a) **Public transportation: -** Study of the transportation system that meets the travel need of several people by sharing a vehicle.
   - Characteristics of various modes;
   - Planning,
   - Management and operations; and
   - Policies for promoting public transportation

b) **Financial and economic analysis: -** tries to quantify the economic benefit which includes saving in travel time, fuel consumption, etc.

c) **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.

d) **Accident analysis and reduction:-** looks at the causes of accidents, from the perspective of human, road, and vehicle and formulate plans for the reduction.

e) **Intelligent transport system:-** offers better mobility, efficiency, and safety with the help of the state-of-the-art technology.

Factors in Transportation Development

- Economic Factors
- Geographical Factor
- Political Polices
- Military
- Technological Factor
- Competition
- Urbanization

- ***Economic Factors***

  Almost all transport development is economic in origin. The chief preoccupation of the first human was the procurement of food, shelter and sometimes clothing. As they become more highly developed their needs increased, often beyond what their local economy could supply. Means of transporting goods from distant places had to be devised, adding to the costs of the goods thereby secured. The need for transporting individuals over wider areas also arose. Increasing transportation productivity and lower unit costs have occurred over the years as the system of transportation becomes more highly developed and complex.

- ***Geographical Factor***

  Geography is closely related to economics. The geographical location of natural resources determines the transport routes that gives access to those resources and create economic utility, that is, time and place utility, by taking them from a location where they have little values to processing and consuming areas where their values is vastly increased.

- ***Political Polices***

  Political polices frequently play a deciding role in transport development. Basically is in a way to form integrated political system and control.

- ***Military***

  The military might of a nation is primarily intended to support its political polices and to provide for national defense. Consequently, often it has direct influence on transport development.

- ***Technological Factor***

  Progress in direct and supporting technologies has played an obvious role in transportation, for instance introduction of new economical transportation mode to the exist system calls for the development of transportation

- ***Competition***

  The competitive urges have given a powerful impetus to transport development. Railroads compete with railroad also with trucks, barges, pipelines and airlines. Airlines have counted heavily on speed but have also been forced to greater safety and dependability to meet ground transport competition. No less real is the competition between products and industries tributary to transport. Bituminous material competes with concrete as the road surface. Diesel won steam but may face competition with electricity.

- ***Urbanization***

  The rapid growth of urban areas by an even more rapidly expanding population is a phenomenon that cannot be overlooked among transport development factors. Accessibility to land and the intensity of land use are closely related to transport availability.

Role of transportation in society

- Economic role of transportation:

  Transportation contributes two kinds of utilities:
  - place and
  - time utility
- Social role of transportation
  - Growth of Urban Centers
  - Size and Pattern of Settlement
  - Formation of settlements
- Environmental role of transportation
  - Safety
  - Air Pollution
  - Noise pollution
  - Energy consumption
- Other impacts
  - Aesthetics
  - Social life and social pattern

1.3 Modes of Transport

- **Road transportation**. Road infrastructures are large consumers of space with the lowest level of physical constraints among transportation modes. However, physiographical constraints are significant in road construction with substantial additional costs to overcome features such as rivers or rugged terrain. Road transportation has an average operational flexibility as vehicles can serve several purposes but are rarely able to move outside roads. Road transport systems have high maintenance costs, both for the vehicles and infrastructures. They are mainly linked to light industries where rapid movements of freight in small batches are the norm. Yet, with containerization, road transportation has become a crucial link in freight distribution.
- **Rail transportation**. Railways are composed of traced paths on which are bound vehicles. They have an average level of physical constrains linked to the types of locomotives and a low gradient is required, particularly for freight. Heavy industries are traditionally linked

with rail transport systems, although containerization has improved the flexibility of rail transportation by linking it with road and maritime modes. Rail is by far the land transportation mode offering the highest capacity with a 23,000 tons fully loaded coal unit train being the heaviest load ever carried.

- **Pipelines**. Pipeline routes are practically unlimited as they can be laid on land or under water. The longest gas pipeline links Alberta to Sarnia (Canada), which is 2,911 km in length. The longest oil pipeline is the Tran Siberian, extending over 9,344 km from the Russian arctic oilfields in eastern Siberia to Western Europe. Physical constraints are low and include the landscape and pergelisol in arctic or subarctic environments. Pipeline construction costs vary according to the diameter and increase proportionally with the distance and with the viscosity of fluids (from gas, low viscosity, to oil, high viscosity).
- **Maritime transportation**. Because of the physical properties of water conferring buoyancy and limited friction, maritime transportation is the most effective mode to move large quantities of cargo over long distances. Main maritime routes are composed of oceans, coasts, seas, lakes, rivers and channels. However, due to the location of economic activities maritime circulation takes place on specific parts of the maritime space, particularly over the North Atlantic and the North Pacific. The construction of channels locks and dredging are attempts to facilitate maritime circulation by reducing discontinuity. Comprehensive inland waterway systems include Western Europe, the Volga / Don System, St. Lawrence / Great Lakes system, the Mississippi and its tributaries, the Amazon, the Panama / Paraguay and the interior of China. Maritime transportation has high terminal costs, since port infrastructures are among the most expensive to build, maintain and improve. High inventory costs also characterize maritime transportation. More than any other mode, maritime transportation is linked to heavy industries, such as steel and petrochemical facilities adjacent to port sites.
- **Air transportation**. Air routes are practically unlimited, but they are denser over the North Atlantic, inside North America and Europe and over the North Pacific. Air transport constraints are multidimensional and include the site (a commercial plane needs about 3,300 meters of runway for landing and takeoff), the climate, fog and aerial currents. Air activities are linked to the tertiary and quaternary sectors, notably finance and tourism,

which lean on the long distance mobility of people. More recently, air transportation has been accommodating growing quantities of high value freight and is playing a growing role in global logistics.

- **Intermodal transportation**. Concerns a variety of modes used in combination so that the respective advantages of each mode are better exploited. Although intermodal transportation applies for passenger movements, such as the usage of the different, but interconnected modes of a public transit system, it is over freight transportation that the most significant impacts have been observed. Containerization has been a powerful vector of intermodal integration, enabling maritime and land transportation modes to more effectively interconnect.