# Transportation Engineering

For

## Civil Engineering

By


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# Syllabus for Transportation Engineering

**Transportation Infrastructure:** Highway Alignment and Engineering Surveys; Geometric Design of Highways-Cross-Sectional Elements, Sight Distances, Horizontal and Vertical Alignments; Geometric Design of Railway Track; Airport Runway Length, Taxiway and Exit Taxiway Design.

**Highway Pavements:** Highway Materials-Desirable Properties and Quality Control Tests; Design of Bituminous Paving Mixes; Design Factors For Flexible and Rigid Pavements; Design of Flexible Pavement Using IRC: 37-2012; Design of Rigid Pavements Using IRC: 58-2011; Distresses In Concrete Pavements.

**Traffic Engineering:** Traffic Studies on Flow, Speed, Travel Time - Delay and O-D Study, PCU, Peak Hour Factor, Parking Study, Accident Study and Analysis, Statistical Analysis of Traffic Data; Microscopic and Macroscopic Parameters of Traffic Flow, Fundamental Relationships; Control Devices, Signal Design By Webster's Method; Types of Intersections and Channelization; Highway Capacity and Level of Service of Rural Highways and Urban Roads.

## Previous Year GATE Papers and Analysis

### GATE Papers with answer key

**thegateacademy**.com/gate-papers

### Subject wise Weightage Analysis

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"For it matters not how small the beginning may seem to be. What is once well done, is well done forever."

**Henry David Thoreau**

CHAPTER 1

# Traffic Flow and Highway Capacity

## Learning Objectives

After reading this chapter, you will know:

1. Order of Road Development
2. Modern Road Development in India
3. Classification of Roads
4. Engineering Survey for Highway Location
5. Drawings and Report
6. Highway Capacity

## Order of Road Development

1. **Roman Roads**
   Roman started 1st time construction of roads in large scale in 312 B.C they constructed "Appian Way" length over 580 km.
   Main features of Roman roads are:
   - They were built straight regardless of gradients.
   - Total thickness of the construction was as high as 0.75 to 1.2 meters.
   - The wearing course consists dressed large stone blocks set in lime mortar.

2. **Tresaguet Construction(1716-1796)**
   "Pierre Tresaguet" developed roads in France during 1764 A.D
   Main features are:
   - Thickness was of the order of 30 cm.
   - Consideration was given to subgrade moisture condition and drainage of surface water.
   - The top wearing course was made of smaller stones having a cross slope of 1 in 45 to the surface, to provide surface drainage.

3. **Metcalf Construction (1717 – 1810)**
   John Metcalf was working in England and he followed the instruction of Robert Phillips.

4. **Telford Construction: (1757-1834)**
   His work started in early 19th century.
   Main features are:
   - He provided level subgrade of width 9 meters.
   - A binding layer of wearing course 4 cm thick was provided with cross slope of 1 in 45.
   - Thickness of foundation stone varied from 17 cm at edge to 22 cm at the center.

5. **Macadam Construction:**
   1815 onward he started in England but his new concept came in 1827. This was the 1st method based on scientific thinking.
   Main features are:
   - Macadam was first person who suggest that heavy foundation stones are not at all required to be placed at the bottom layer. He provided stones of size less than 5 mm to a uniform thickness of 10 cm.
   - The importance to subgrade drainage and compaction were recognized and so the subgrade was compacted and prepared with cross slope of 1 in 36.
   - The pavement surface was also given the cross slope of 1 in 36.
   - Total thickness was kept uniform from edge to centre to a minimum value of 25 cm.

6. **Water Bound Macadam (W.B.M)**
   In this method the broken stones of the base course and surface course are bound by the stone dust in the presence of moisture.

## Modern Road Development in India

British government passed a resolution in 1927 in response to which Jaykar committee was constituted in 1927.
Jaykar committee proposed that an extra tax should be levied on petrol.

**Recommendation Made by Jaykar Committee**

1. The road development in the country should be considered as a national interest as this has become beyond the capacity of provincial governments and local bodies.
2. An extra tax should be levied on petrol from the road users to develop a road development fund called Central Road Fund.
3. A semi-official technical body should be formed to pool technical know-how from various parts of the country and to act as an advisory body on various aspects of the roads.
4. A research organization should be instituted to carry out research and development work.
   Most of the recommendation made by Jaykar committee was accepted and following steps were taken.
   - The Central Road Fund was formed in 1929.
   - A semi – official technical body known as Indian road congress (IRC) was formed.
   - In 1939 the Motor Vehicle Act was started in 1950 CRRI (Central Road Research Institute) was started.
   - Other measures taken are:
   - National Highway Act was brought in 1956.
   - Highway Research Board was setup in 1973.
   - National Transport policy committee in 1978.
   - IRC has played important role in the formulation of the last three 20 years road development plan in India.

1. **First 20 Years Road Plan (Nagpur Road Plan) [1943-63] Features**
   (a) The Nagpur road formulas were prepared on basics of "Star and grid" pattern.
   (b) The total road length of 5,32,700 km with a density of 16 km of road length per 100 $km^2$ area would be available by 1963.
   (c) All the roads were classified into 5 categories
   - NH
   - SH
   - MDR
   - ODR
   - VR

   (d) The length of the railway tracks in the area was considered with the road length. Hence net road length is called by subtracting length of railway tracks from the length of metaled road.

   **Result:** Through the total achievement was higher than the targeted value, but the lengths of NH and SH achieved were lesser than the plan targets.

2. **Second 20 Years Road Plan (Bombay Road Plan) [1961-1981]**
   (a) At the end of plan, the target road length aimed was 32 km per square km area.
   (b) Maximum distance of any place in a developed or agricultural area would be 6.4 km from a metaled road and 2.4 km from any category of roads.
   (c) Every town with a population above 2000 in plains and above 1000 in semi-hill areas should be connected by metaled road.
   (d) 1600 km Express ways have been considered in this plan within proposed target of NH.
   (e) Length of railway track is considered independent of the road system and hence it is not subtracted to get the road length.
   (f) A development factor of 5% is provided for future development.

   **Result:** The total achievement was higher than targeted but NH and SH were constructed lesser than targeted.

   It should be noted that allowance for development of agriculture and industry during the next 20 years was made in Nagpur.

3. **Third 20 Years Road Plan (Lucknow Road Plan) [1981-2001]**
   (a) Roads are classified in to primary, secondary and territory road systems.
   (b) All villages with over 500 populations should be connected by all-weather roads.
   (c) The overall road density was targeted as 82 km per 100 square km area.
   (d) The NH network should be expanded to form square grids of 100 km sides.
   (e) Express way should be constructed along major traffic corridors to provide fast travels.
   (f) There should be improvement in environment quality and road safety.

(a) **Primary Road System** (According to Third Plan)
- Express way of total length 2000 km.
- NH based on the concept of 100 km square grids 100+200=300 km of NH length are provided per $100 \times 100 = 10000$ square km area.
- Length of NH, km
  $= \frac{\text{Area in sq km}}{50}$

(b) **Secondary Road System**

This includes

- SH (State highways) m, max. of $\left[\left(\frac{\text{Area}}{25}\right), (62.5 \times \text{No. of town} - \text{NH})\right]$
- MDR(Major district roads)
  (i) Length of SH in km
  $= \frac{\text{Area of State}}{25}\ \text{km}^2$
  or
  Length of SH in km = 62.5 × No. of towns in state – Length of NH
  (ii) Length of MDR in km
  $= \frac{\text{Area of state (km}^2)}{12.5}$
  Length of MDR in km = 90 × No. of towns in state
  (iii) Total length of Road, NH + SH + MDR + ODR + VR = 0.82 × A(km$^2$)

(c) **Territory Road System**

This includes = (0.82×A−[NH+SH+MDR]) =ODR+VR

- ODR (Other District Road)
- VR (Village Roads)

## Classification of Roads

1. Classification of rural roads
   The roads are classified on the following basis
   (a) Traffic volume – Heavy, medium or light
   (b) Load transport – Class A , Class B
   (c) Location and junction

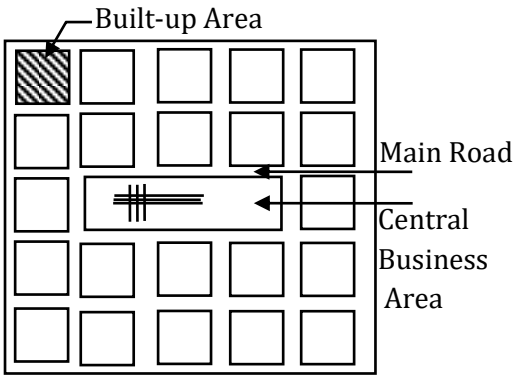
   Nagpur Road plan classified roads on following 5 categories based on location and junction.
   - National Highway (NH)
   - State Highway (SH)
   - Major District Roads (MDR)
   - Village Roads (VR)
   - Other District Roads (ODR)

   Modified classification is proposed by third plan as discussed

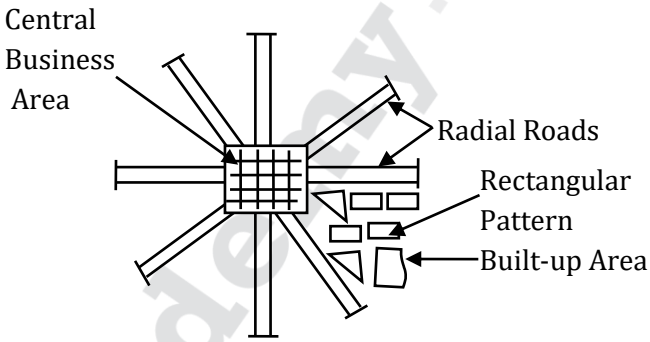
2. Classification Urban roads
   The Length of the urban roads is not included in the target of Third twenty year plan (1901-2001) the urban roads are classified as:
   - Arterial roads
   - Sub-arterial roads
   - Collectors streets
   - Local streets

**Road Patterns:**

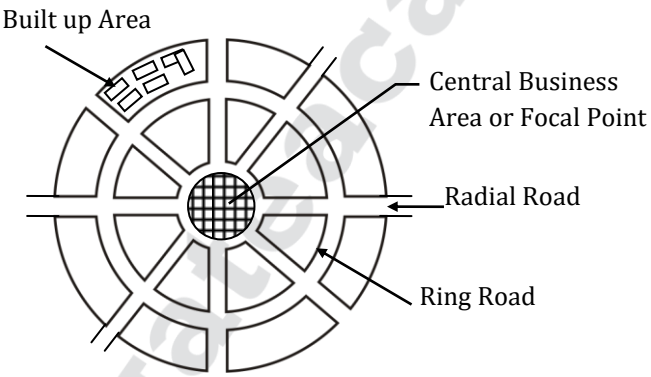
(a) Rectangular or Block pattern
(b) Radial or star and Block pattern
(c) Radial or star and Circular pattern
(d) Radial or Star and Grid pattern
(e) Hexagonal pattern
(f) Minimum travel pattern



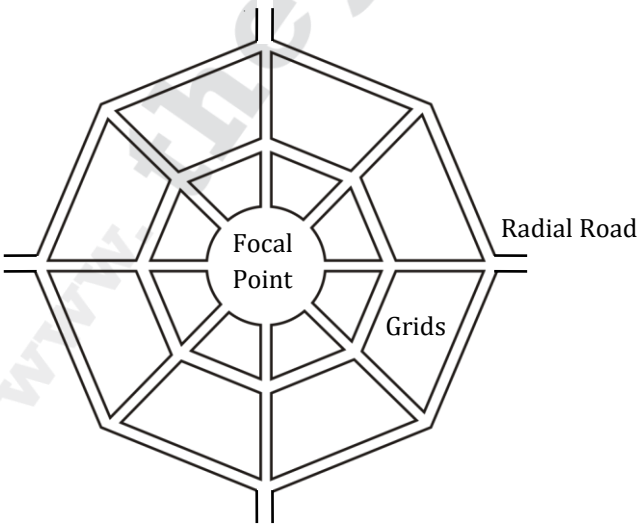

**(a) Rectangular of Block Pattern**



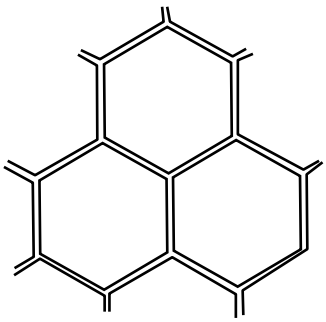

**(b) Radial or Star and Block Pattern**



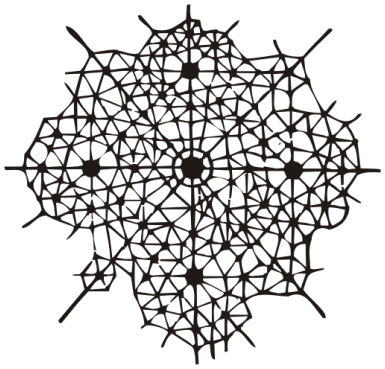

**(c) Radial or Star and Circular Pattern**




**(d) Radial or Star and Grid Pattern**



**(e) Hexagonal Pattern**



**Legend:** City Centre – Encircled dot, Sector centers – •, Suburban centers – •, Neighborhood centers – •, Represented of a "Minimum Travel" city (Assumed population of 2 million)

### Planning Surveys

For assessing the road length requirements, following studies are made.

1. Economic studies
2. Financial studies
3. Traffic or road use studies
4. Engineering studies

### Saturation System for Calculating Optimum Road Length

In this system the optimum road length is calculated for area, based on the concept of obtaining the maximum utility per unit length of road. Hence this system is called saturation system or maximum utility system.

### Factor for Obtaining the Utility per Unit Length of Road are

1. Population served by the road
2. Productivity served by the road network
   - Agricultural products
   - Industrial products
3. Village having population range between 1001 and 2000 may be grouped together and be assigned one utility unit per village.
   For population less than, 500 utility unit = 0.25
   For population less than, 501 to 1000, utility unit = 0.50
   For population 1001 to 2000, utility unit = 1.00
   For population 2001 to 5000, utility unit = 2.00

## Engineering Survey for Highway Location

Before highway alignment is finalized in highway project, the engineering surveys are to be carried out. The stages of engineering surveys are:

1. **Map Study**
   If the topographic map of the area is available, it is possible to suggest the likely routes of the road. In India topographic maps are available from the survey of India, with 15 or 30 meter contour intervals. The main features like rivers, hills valleys etc. are also shown on these maps.