

RPSC 2024

Rajasthan Public Service Commission

Assistant Engineer

CIVIL ENGINEERING

Highway Engineering



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HIGHWAY DEVELOPMENT AND PLANNING

ORDER OF ROAD DEVELOPMENT

1. Roman Roads

Roman started 1st time construction of roads in large scale. In 312 BC they constructed *Appian way* of length over 580 km.

Main features of Roman roads are:

1. They were straight regardless of gradients.
2. Total thickness was as high as 0.75 to 1.2 meters.
3. The wearing course consists of dressed large stone-blocks set in lime mortar.

Do you know?

They were built after the soft soil was removed and a hard stratum was reached.

2. Tresaguet Construction (1716-1796)

- “Pierre tresaguet” developed roads in France during 1764 A.D.

Do you know?

The main feature of Pierre Tresaguet proposal was that the thickness of construction needed was of the order of 30 cm.

Main Features are:

1. Thickness was of the order of 30 cm.
2. Consideration was given to subgrade moisture and drainage of surface water.
3. The top wearing surface was made up of smaller slope having a cross slope of 1 in 45 to the surface to provide surface drainage. Shoulder sloping was also provided of the order of 1 in 20.

3. Metcalf. Construction (1717-1810)

- “John Metcalf” was *working in England* and he followed the instruction of *Robert Phillip*.

4. Telford Construction (1757-1834)

His work started in early 19th century in England.

Main Features are:

1. He provided level subgrade of width 9 meters.
2. A binding layer of wearing course 4 cm thick was provided with cross slope of 1 in 45.
3. Thickness of foundation stone varied from 17 cm at edges to 22 cm at the centre.

5. Macadam Construction (1756-1836)

He put forward an entirely new method of road construction as compared to all the previous methods. The first attempt to improve the road condition was made by him in 1815. *This was the 1st method based on scientific thinking.*

Main Features are:

1. Macadam was the first person who suggested 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.
2. The importance to subgrade drainage and compaction was given so the subgrade was compacted and prepared with cross slope of 1 in 36.
3. The size of broken stone for the top layers was decided on the basis of stability under animal drawn vehicles.
4. The pavement surface was also given the cross slope of 1 in 36.
5. 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.

Macadam method	Telford method
(i) The subgrade was given a cross slope of 1 in 36 to facilitate subgrade drainage.	The subgrade was kept horizontal and hence subgrade drainage was not proper
(ii) The bottom layer of pavement or the subbase course consisted of broken stones of less than 5 cm size to uniform thickness equal to 10 cm only.	Heavy foundation stones of varying sizes, about 17 cm towards the edges and 22 cm towards the centre were hand packed and prepared to serve as subbase course.
(iii) Base and surface courses consisted of broken stones of smaller sizes to compacted thickness of 10 and 5 cm respectively and the top surface was given a cross slope of 1 in 36.	Two layers of broken stones were compacted over the foundation stones before laying the wearing course, 4 cm thick with a cross slope of 1 in 45.
(iv) The total thickness of pavement construction was kept uniform from edge to centre to a minimum value of only 25 cm.	The total thickness of construction varied from about 35 cm at the edge to about 41 cm at the centre.

Modern Road Developments in India

- British government passed a resolution in 1927, in response to which Jayakar Committee was constituted in 1927.
- Jayakar committee proposed that an extra tax should be levied on petrol to develop a fund called "Central Road Fund".

Recommendations made by Jayakar Committee are :

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 roads.
 4. A research organization should be instituted to carry out research and development work and to be available for consultations.
 - Most of the recommendations made by Jayakar committee were accepted and following steps were taken.
1. The Central Road Fund was formed in 1st March 1929.
 2. A semi official technical body known as Indian Roads Congress (IRC) was formed in 1934.
 3. In 1939 Motor Vehicle Act was started & in 1950 CRRI (Central Road Research Institute) was started. Motor vehicle act has been revised in the year 1988.

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Other Measures Taken are:

4. National Highway Act was brought in 1956.
5. Highway Research Board was setup in 1973, with view to give proper direction and guidance to road research activities in India.
6. National Transport Policy committee in 1978.
7. IRC has played important role in the formulation of the last three 20 years road development plans in India.

1. First 20 years Road Plan (Nagpur Road Plan) (1943-63)

- A conference of the Chief Engineers of all the states and provinces was convened in 1943 by the Government of India at Nagpur, an initiative of the Indian Roads Congress to finalise the first road development plan for the country as a whole.
- In this first 20 years road development plan, popularly known as the Nagpur Road Plan, all roads were classified into five categories and a twenty year development programme for the period 1943-63 was finalized.

Features

1. The Nagpur road plan formulae were prepared on the basis of "star and grid" pattern.
2. The total road length of 5,32,700 km with a density of **16 km of road length per 100 km²** area would be available by 1963.
3. All the roads were classified in to 5 categories. (i) NH (ii) SH (iii) MDR (iv) ODR (v) VR
4. The length of the railway tracks in the area was considered within the road length. Hence net road length is calculated by subtracting length of railway track from the length of metalled road.

Sl. No.	Category of road	Nagpur Plan targets, km	Achievement by 1961, km
1.	National Highway	26,715	22,636
	(a) NH	6,680	
	(b) National Trails Total NH	33,395	
2.	State Highway	86,825	62,052
3.	Major District Roads	80,145	1,13,483
	Total main roads (metalled roads)	2,00,365	1,98,171
4.	Other District Roads	1,33,580	1,11,961
5.	Village Roads	1,98,755	3,88,841
6.	Unclassified Roads	—	10,149
	Total	5,32,700	7,09,122

- The total length of the first category or metalled roads for National and State Highways and Major District roads in km is given by the formula

$$NH + SH + MDR(km)$$

$$= \left[\frac{A}{8} + \frac{B}{32} + 1.6N + 8T \right] + D - R$$

- Where,
- A = Agricultural area, km²
 - B = Non-agricultural area, km²
 - N = Number of towns and villages with population range 2001-5000
 - T = Number of towns and villages with population over 5000
 - D = Development allowance of 15 percent of road length calculated to be provided for agricultural and Industrial development during the next 20 years.
 - R = Existing length of railway track, km

- The total length of second category roads for Other District Road and Village Roads in km is given by the formula

$$ODR + VR(km) = [0.32V + 0.8Q + 1.6P + 3.2S] + D$$

- Where,
- V = Number of villages with population 500 or less
 - Q = Number of villages with population range 501-1000
 - P = Number of villages with population range 1001-2000
 - S = Number of villages with population range 2001-5000
 - D = Development allowance of 15% for next 20 years.

Do you know?

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

Central Road Research Institute

- In the year 1950 the Central Road Research Institute (CRRI) was started at New Delhi for

research in various aspect of highway engineering.

- The CRRI is one of the national laboratories of the Council of Scientific and Industrial Research the institute is mainly engaged in applied research and offers technical advice to state governments and the industries on various problems concerning roads.

National Highway Act

- In 1956 the National Highway Act was passed. The main features of the act are:
 - The responsibility of development and maintenance of the National Highway (NH) to be provisionally taken by the central government.
 - The central government to be empowered to declare any other highway as NH or to omit any of the existing national highways from the lists.

2. Second 20 years Road Plan (Bombay Road Plan)-(1961-1981)

Features

- At the end of plan, the target road length aimed was **32 km per 100 square km area.**
- Maximum distance of any place in a developed or agricultural area would be 6.4 km from a metalled road and 2.4 km from any category of roads.
- Every town with a population above 2000 in plains and above 1000 in semi-hill areas and above 500 in hilly areas should be connected by metalled road.
- 1600 km Express ways have been considered in this plan within proposed target of NH.
- Length of railway track is considered independent of the road system and hence it is not subtracted to get the road length.
- A development factor of 5% is provided for future developments.

Result

- The total achievement was higher than targeted but NH and SH were constructed lesser than targeted.

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- (a) Villages having population range between 1001 and 2000 may be grouped together and be assigned one utility unit per village.
- (b) For population less than 500, utility unit = 0.25
- (c) For population less than 501 to 1000, utility unit = 0.50
- (d) For population 1001 to 2000, utility unit = 1.00
- (e) For population 2001 to 5000, utility unit = 2.00
- After deciding the optimum road length for plan period. The final step is the phasing of the road development plan by fixing up the priorities for the construction of different road links.

Engineering Surveys 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:

- (a) **Map Study:** Topographic maps are available from the Survey of India with 15 to 30 meter contour intervals. Valley, ponds or lakes etc., can be avoided and approximate position of bridges etc., can be planned.
- (b) **Reconnaissance:** This is used to examine the general characteristics of the area for deciding the most feasible routes for detailed studies.
- (c) **Preliminary survey:** This is carried out to collect all the physical information which are necessary in connection with the proposed highway alignment. This work consist of
 1. Primary traverse
 2. Topographical features
 3. Levelling work
 4. Drainage studies & hydrological data.
 5. Soil survey
 6. Material survey
 7. Determinations of final centre line.
- (d) **Final location and detailed survey:** The centre line of road finalized is translated on the ground during location survey.

Detailed survey is done to fix temporary bench mark and levelling work is used for drainage and earthwork calculations.

Practice Questions : Level-1

- Q.1** Nagpur road plan formulae were prepared by assuming
- (a) rectangular or block road pattern
 - (b) radial or star and block road pattern
 - (c) radial or star and circular road pattern
 - (d) radial or star and grid road pattern
- Q.2** Select the correct statement
- (a) Nagpur road plan formulae take into account the towns with very large population.
 - (b) Nagpur road plan has a target road length of 32 km per 100 square km.
 - (c) Second 20-year plan has provided 1600 km of expressways out of the proposed National Highway.
 - (d) Second 20-year plan allowed deduction of length of railway track in the area while calculating the length of roads.
- Q.3** I.R.T.D.A. (Indian Roads and Transport Development Association) was set up at Bombay in
- | | |
|----------|----------|
| (a) 1907 | (b) 1917 |
| (c) 1927 | (d) 1937 |
- Q.4** Indian Road Congress (I.R.C.) was founded and constituted with its head quarters at New Delhi, in
- | | |
|----------|----------|
| (a) 1924 | (b) 1927 |
| (c) 1930 | (d) 1934 |
- Q.5** For administration of the movement of road transport, a Motor Vehicle Act was enacted in
- | | |
|----------|----------|
| (a) 1927 | (b) 1934 |
| (c) 1939 | (d) 1947 |

Practice Questions : Level-2

- Q.6** The shape of the camber, best suited for cement concrete pavements, is

- (a) straight line
- (b) parabolic
- (c) elliptical
- (d) combination of straight and parabolic

Q.7 In speed and delay study, if the average journey time on a stretch of road length of 3.5 km is 7.55 minutes and the average stopped delay is 1.8 minutes, the average running speed will be, nearly

- (a) 36.5 kmph (b) 37.5 kmph
- (c) 38.5 kmph (d) 39.5 kmph

Q.8 Three new roads A, B and C are planned in a district. The data for these roads are given below:

Road	Length (Km)	Number of villages with population		
		Less than 2000	2000-5000	More than 5000
A	20	8	6	1
B	28	19	8	4
C	12	7	5	2

The order of priority for these three roads should be

- (a) A, B, C (b) B, C, A
- (c) C, A, B (d) C, B, A

Common Data Question Q.9-Q.10

The area of a certain district in India is 15000 sq. km. and there are 10 towns in the district.

Q.9 According to Lucknow road Plan, what will be length of NH and SH respectively

- (a) 200 km and 325 km
- (b) 300 km and 325 km
- (c) 300 km and 600 km
- (d) None of these

Q.10 What will be the total length of Rural Roads (Tertiary system)

- (a) 12900 km (b) 13200 km
- (c) 11900 km (d) 12800 km

ANSWERS

1. (d) 2. (c) 3. (c) 4. (d) 5. (c)
6. (a) 7. (a) 8. (d) 9. (c) 10. (a)

Hints & Solutions

8. (d)

Assuming utility units, for population

- < 2000 1.0
- < 2000 – 5000 2.0
- > 5000 3.0

utility per unit length,

$$\text{for A} = \frac{8 \times 1.0 + 6 \times 2.0 + 1 \times 3.0}{20} = 1.150 \quad \text{(III)}$$

$$\text{for B} = \frac{19 \times 1.0 + 8 \times 2.0 + 4 \times 3.0}{28} = 1.679 \quad \text{(II)}$$

$$\text{for C} = \frac{7 \times 1.0 + 5 \times 2.0 + 2 \times 3.0}{12} = 1.92 \quad \text{(I)}$$

9. (c)

$$\text{Length of NH, km} = \frac{15000}{50} = 300 \text{ km}$$

$$\text{Length of SH, km} = \frac{15000}{25} = 600 \text{ km} \quad \text{(I)}$$

$$= 62.5 \times 10 - \frac{15000}{50}$$

$$= 325 \text{ km} \quad \text{(II)}$$

Adopt length of SH (higher of the two)
= 600 km

10. (a)

$$\text{NH} + \text{SH} + \text{MDR} + (\text{ODR} + \text{VR}) = 15000 \text{ km}$$

$$\left. \begin{aligned} \text{Length of MDR} &= \frac{15000}{12.5} = 1200 \\ &= 90 \times 10 = 900 \text{ km} \end{aligned} \right\}$$

Adopt 1200 km

$$\text{NH} + \text{SH} + \text{MDR} = 300 + 600 + 1200 \text{ km} \\ = 2100 \text{ m}$$

Tertiary system or Rural Roads consists of ODR and VR.

$$\therefore \text{Length of Rural Road} = 15000 - (2100) \\ = 12900 \text{ km}$$



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