structure to minimize vehicle operating costs and maintenance expenditure. A number of bridges would be required to be constructed/ reconstructed. Special attention has to be given to those State Highways which would require to be upgraded to National Highway in the future on the basis of traffic densities and growth It is essential that the State Governments make arrangements to prepare suitable road and bridge inventories covering the existing physical status and structural condition of the main network comprising the State Highways and major district roads and then update them at regular periodic intervals. Regular traffic counts on these roads would be necessary in order to decide on the inter-se priority of development of various sections.

- Rural roads are essential for achieving the objective of integrated rural development. The priority for rural road development in the Eighth Plan would be as under :-
  (a) Linking of all villages with a population of 1000 and above on the basis of 1981 census.
  (b) Special efforts to accelerate village connectivity in respect of backward regions and tribal areas.
- It would be appropriate to integrate rural road construction and maintenance under Minimum Needs Programme (MNP) with local area development planning. State Governments may pool the resources, made available under MNP and special employment programmes and undertake rural road construction under the respective local area development plan.

1.9.10 Ninth Five Year Plan (1995 - 2000)

The following goals and objectives have been kept in view while framing the outline of the Ninth Plan :

(a) Phased removal of deficiencies in the existing NH network in the tune with traffic needs for 10-15 years with emphasis on high density corridors for four-laning.
(b) Bring in highway-user oriented project planning in identifying package of projects section-wise rather than isolated stretches.
(c) Greater attention to rehabilitation and reconstruction of weak/dilapidated bridges for the safety of the traffic.
(d) Modernization of road construction technology for speedy execution and quality assurance.
(e) Engineering measures to improve road safety and conservation of energy.
(f) Continued emphasis on research and development
(g) Integrating the development plans with Railways and other modes of transport.
(h) Providing employment opportunities to the labour force in rural areas.
(i) Special attention for development of roads in the North-Eastern Region.
(j) Encouraging private sector participation in development of roads.

1.9.11 Tenth Five Year Plan (2001-05)

The following broad goals and objectives for road sector development have been set for the Tenth Plan :

1. Balanced development of the total road network comprising three functional groups viz. the primary system (National Highways (NH) and expressways), secondary system (State Highways and Major District Roads) and rural roads.
2. Development of roads to be considered an integral part of the total transport system supplementing other modes, integrating the development plans with railways and other modes of transport.
3. Completion of the National Highways Development Project comprising the Golden Quadrilateral and the North-South and East-West corridors.
4. Phased removal of deficiencies in the existing NH network in tune with traffic for the next 10-15 years with emphasis on four-laning of high-density corridors.
5. To plan and take preliminary action for expressways to be built in future in those sections where these can be economically justified.
6. To make long distance travel safer and faster so as to give a boost to the economy.
7. Priority is to be accorded to areas like overloading of trucks, control of encroachments and unplanned ribbon development, energy conservation and environment protection.
8. Greater attention to be paid to rehabilitation and reconstruction of weak/dilapidated bridges for traffic safety.
9. Special attention is to be paid to the development of roads in the North-Eastern region.
10. Particular emphasis needs to be given to the commercialisation of highways particularly the National Highways and State Highways and bringing in the concept of user-charges for sustainable financing of the road sector. Further steps must also be taken to encourage private sector participation in the highway sector. It is necessary to implement the policy of levying toll on all four-lane roads on the National Highway network. States must adopt a similar strategy in respect of State Highways etc.
11. High-density corridors within the network of National and State Highways and Major District Roads should be identified. Such corridors and major inter-state roads should be developed on a priority basis.
12. To improve the quality of life in rural areas and ensure balanced regional development by achieving the PMGSY target of providing connectivity through all-weather roads to all habitations with a population of over 500 persons (as per the 2001 Census).
13. To encourage industry and export by providing sufficiently wide roads leading to industrial centres, ports, mining areas and power plants.
14. To encourage tourism by improving roads leading to centres of tourist importance.
15. To provide wayside amenities along highways.

16. To reduce transportation costs by providing better riding surface and popularising the use of containers and multi-axle vehicles in the haulage of goods.
17. Utmost attention to the proper upkeep and maintenance of the existing road network.
18. To ensure road connectivity where rail link is not available or possible.
19. Integrating the development plan with railways and other modes of transport and to :
    (a) Identify feeder roads to important railway routes and undertake needed improvement including periodic maintenance;
    (b) link minor important ports with minimum two-lane NHs/SHs;
    (c) link all Inland Container Depots/container freight stations with minimum two-lane NHs/SHs.
20. Use of modern management techniques for scientific assessment of maintenance strategies/priorities.
21. Development of a road data bank and computerised project monitoring system and promotion of the use of information technology in the highway sector.

1.9.12 An approach to Eleventh Five Year Plan (2007-2012)

1. The Tenth Plan stressed the need for improving mobility and easy accessibility. Accordingly, the National Highway Development Programme (NHDP) consisting of four laning of the Golden Quadrilateral (NHDP I) with a length of 5,846 km and the North-South and East-West Corridor (NHDP II) with a length of 7472 km coupled with Pradhan Mantri Gram Sadak Yojana (PMGSY) for rural roads were taken up. The PMGSY programme has been recently expanded to achieve the Bharat Nigam target of connecting 1000 + habitation (500 + for hilly and tribal areas) by 2008-09 with all-weather roads. This programme will help bring India's villages into the market economy. It will also help us to tackle social sector problems like illiteracy, high IMR and MMR) which are dragging India down because while roads connect villages to markets, they also connect them to schools and hospitals. The "Special Accelerated Development Road Programme for the North Eastern Region (SARDP-NE)", will help in developing and integrating these regions with the rest of the country.

2. The problems of development of our roads network are diverse and future requirements are formidable magnitude. Therefore, the strategy for development of roads would would have to vary keeping in view the nature of problem and the development required. It is proposed to undertake an expanded programme for highway development going beyond NHDP I and II to include NHDP III to VII. This programme will involve substantial resources from public private partnership based on build, operate and transfer (BOT) model which has many advantages over the

traditional contracts (See *Box* on PPPs). All contracts on provision of road services for high density corridors to be taken up under NHDP III onwards would be awarded only on BOT basis, and the traditional construction contracts will be awarded only in specified exceptional cases. A model concession agreement has been developed to facilitate speedy award of contracts. This is a very significant innovation in the areas of public-private partnership. This would leave a substantial part of National Highways network which would also require development during the Eleventh Plan period. These sections are characterised by low density of traffic. Some of these stretches fall in backward and inaccessible areas and others are of strategic importance. The development of these categories of National Highways would be carried out primarily through budgetary resources.

3. The present traffic mix consisting of non-motorised and low-powered vehicles compels low speed Furthermore, most of the National Highways pass through habitations and ribbon development is a perennial problem. It is, therefore, necessary to establish a network of access controlled Expressways across the country for which advance planning would be undertaken during the Eleventh Plan. The actual construction (except for 1000 kms already taken up) would be undertaken during the Twelth Plan period and would be prioritised according to the density of traffic.
4. Vehicular traffic needs more than just the arterial routes to be of world class. Adequate attention has not been given in the past to other roadways, which are the responsibility of the state governments. Priority would be accorded for ensuring integrated development of road networks including State Highways, Major District Roads and Other District Roads. The increased emphasis on rural roads would also continue and a major proportion of the 1.72 lakh unconnected habitations would be connected with all weather roads under the PMGSY.
5. The maintenance of roads has not been given adequate importance by the states mainly due to paucity of resources. This has resulted in poor riding quality of the road network which is highly uneconomic. A rupee spend on maintenance saves two to three rupees in vehicle operating costs, besides improving traffic flow. Therefore, there is a need to accord higher priority to the needs of maintenance by providing more allocation or considering it as a part of Plan. In fact, the 12th Finance Commission has recommended additional grants to the States, to the tune of Rs. 15,000 crore for maintenance of roads and bridges for the four-year period 2006-07 to 2009-10.
6. The National Highway Authority of India (NHAI) has an enormous task before it to implement a road programme. The Authority is being restructured to give it greater professional skills combined with a measure of autonomy and accountability.
7. Indian roads are considered very accident prone and claim a large number of casualties representing an enormous human and economic loss. This problem is compounded by the phenomenal growth in road transport fleet, particularly personalized vehicles and the consequent problems of increase in vehicular pollution and road safety. Steps need to be taken to improve the public transport system and safety of road transport operations.

1.5 Classifications of roads

2.1.1 Classification Based on the Weather Condition

The different types of road are classified into two categories, depending on whether they can be used during different seasons of the year.

1. All-weather roads
2. Fair-weather roads

All-weather roads : All weather roads are those which are negotiable during weather, except at major river crossing where interruption to traffic is permissible upto a certain extent, the road pavement should be negotiable during all weathers.

Fair-weather roads : Roads which are called fair-weather roads on these, the traffic may be interrupted during monsoon season at causeways where stream may overflow across the road.

2.1.2 Classification Based on the Road Pavement

Based on road pavement, roads are classified as paved roads and unpaved roads.

1. Paved road
2. Unpaved road

Pavement roads : If they are provided with a hard pavement course which should be at least water bound macadam (WBM) layer.

Unpaved roads : If they are not provided with a hard pavement course of at least a WBM layer. Thus, earth road and gravel road may be called unpaved roads.

2.1.3 Classification Based on the Pavement Surfacing

Based on the type of pavement surfacing providing, the roads are divided into two categories as :

1. Surfaced road
2. Unsurfaced road

Surfaced Roads : Surface roads which are provided with a bituminous or cement concrete surfacing.

Unsurfaced Roads : Unsurfaced roads which are not provided with bituminous or cement concreting.

2.1.4 Classification Based on the Road Plan

- **Classification of Rural Roads** : (I.R.C-1980)

The road plan classified the roads in India based on location and function into following categories.

1. Expressways
2. National Highways (NH)
3. State Highways (SH)
4. Major District Roads (MDR)
5. Other District Roads (ODR)
6. Village Roads (VR)

Expressways : Expressways are a separate class of highways with superior facilities and design standards and are meant as through routes having very high volume of traffic. The expressways are to be provided with divided carriageways, controlled, grade separations at cross roads and fencing. These highways should permit only fast moving vehicles. Expressways may be owned by Central Government or a State Government, depending on whether the route is a National Highway or State Highway. Example : Mumbai-Pune Expressway.

National Highways (NH) : National highways are highways running through the length and breadth of India, connecting major ports, foreign highways, capital of large states and large industrial and tourist centres including roads required for strategic movements for the defence of India. Example NH-1 Delhi-Ambala-Amritsar, NH-50 Nasik-Pune.

State Highways (SH) : State highways are arterial roads of a state, connecting up with the national highways of the adjacent states, district head quarters and important cities within the state and serving as the main arteries for traffic to and from district roads. The NH and SH have the same design speed and geometric design specifications. Examples :

SH-61 Belha Pabal Shikrapur Astapur Road

SH-70 Mahad-Pandharpur Road.

Major District Roads (MDR) : Major district roads are important roads within a district serving areas of production and markets and connecting those with each other or with the main highways of a district. The MDR has lower speed and geometric design specifications than NH / SH. Example, MDR-2 Kendur Dhamani Hirare Ranjangaon Road.

Other District Roads (ODR) : Other district roads are roads serving rural areas of production and providing them with outlet to market centres, taluka head quarters, block development head quarters or other main roads. These are of lower design specifications than MDR.

Village Roads (VR) : Village roads are roads connecting village or groups of villages with each other to the nearest road of a higher category. Example.

VR-183-Hiware-Jategaon Road

2.1.5 Classification of Urban Roads (I.R.C. - 1977)

The road systems within urban areas are classified as Urban Roads and will form a separate category of roads to be taken care by the respective urban authorities. They are divided into following types

1. Arterial roads
2. Sub-arterial roads
3. Collector streets and
4. Local streets

Arterial Roads : The city roads which are meant for through traffic usually on a continuous route are called arterial streets. Arterial streets are generally spaced at less than 15 km in developed business centres whereas in less important areas, these may be 8 km apart. Arterial roads are also divided highways with fully or partially controlled access. Parking, loading and unloading activities are carefully regulated. Pedestrians are permitted to cross them at intersections only.

Sub-Arterial roads : The city roads which provide lower level of travel mobility than arterial streets are called as sub-arterial streets. Their spacing may vary from 0.5 km in central business districts to 3 to 5 km in sub-urban areas. Loading and unloading are usually restricted. Pedestrians are allowed to cross these highways at intersections.

Collector Streets : The city roads which are constructed for collecting and distributing the traffic to and from local streets, and also to provide an access to arterial and sub-arterial streets, are also called collector streets. These are located in residential, business and industrial areas. These roads are accessible from the building along them. Parking restrictions are few that too during peak hours.

Local Streets : The city roads which provide an access to residence, business and other building are called local streets. The traffic carried either originates or terminates along the local streets. Depending upon the importance of the adjoining areas, a local street may be residential, commercial or industrial. Along local streets, pedestrians may move freely and parking may be permitted without any restriction.

1.6 Road patterns

The road network can be laid in various patterns. These patterns can vary. The patterns in which the road network is laid could be (1) Rectangular or block pattern, (2) Radial or star and block pattern, (3) Radial or star and circular pattern, (4) Radial or star and grid pattern, (5) Hexagonal pattern, (6) Minimum travel pattern. These patterns are illustrated in the next subarticles. The Nagpur road plan formulae were prepared on the assumption of star and grid pattern. Connaught place in New Delhi has radial and circular pattern, whereas Chandigarh has rectangular or block pattern. If the city is being planned from scratch, some pattern can be given. In most of our cities, some of the pattern is already existing and one has to go with them.

Rectangular or Block Pattern : In this pattern, the whole area is divided into rectangular blocks of plots, with streets intersecting at right angles. The main road which passes through the centre of the area should be sufficiently wide and other branch roads may be comparatively narrow. The main road is provided a direct approach to outside the city.

The rectangular plots may be further divided into small rectangular blocks for construction of buildings placed back to back, having roads on their front. The rectangular pattern has been adopted for the city roads of Chandigarh. The construction and maintenance of roads of this pattern is comparatively easier but from traffic point of view, this pattern is not very much convenient because at the intersections, the vehicles face each other.

Radial or Star and Block Pattern : In this pattern, the entire area is divided into a network of roads radiating from the business outwardly. In between radiating main roads, the built-up area may be planned with rectangular blocks.

Radial or Star and Circular Pattern : In this system, the main radial roads radiating from the central business area are connected together with concentric roads. In these areas, boundary by adjacent radial roads and corresponding circular roads, the built-up area is planned with a curved block system. An example of this road pattern is the road network of co naught place in New Delhi.

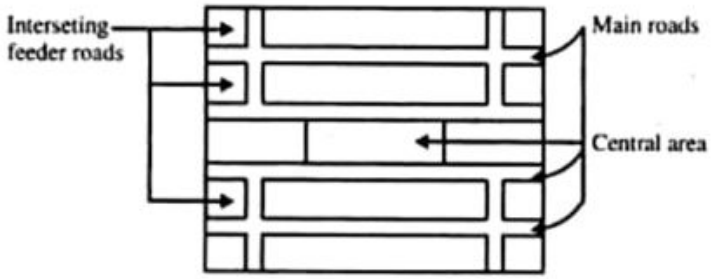


Fig. 2.1 : Rectangular or block pattern

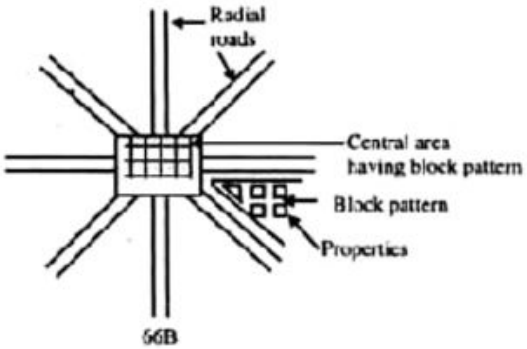


Fig. 2.2 : Radial or star and block pattern

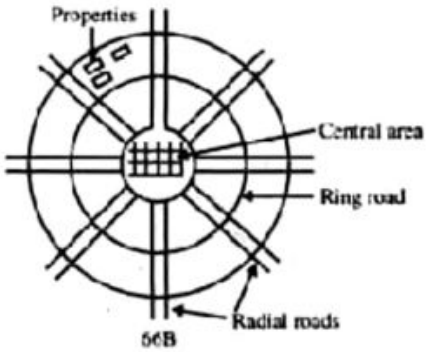


Fig. 2.3 : Radial or star and circular pattern

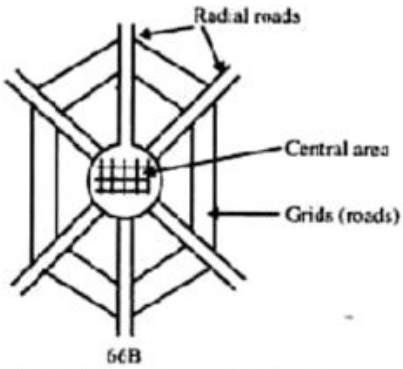


Fig. 2.4 : Radial or star and grid pattern

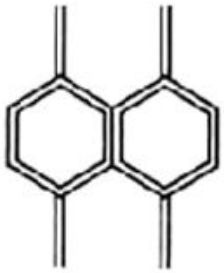
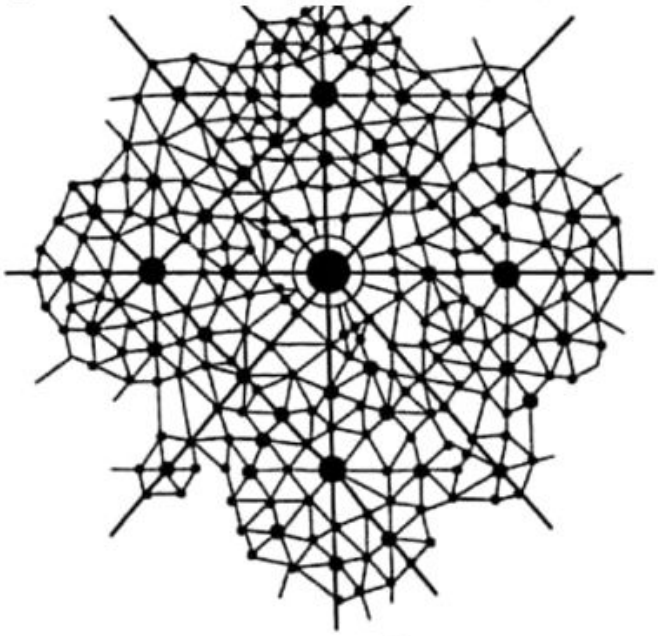


Fig. 2.5 : Hexagonal pattern

Hexagonal Pattern : In this pattern, the entire area is provided with a network of roads forming hexagonal figures. At each corner of the hexagon, three roads meet The built-up area bounded by the sides of the hexagons is further divided in suitable sizes.



Minimum Travel Pattern : In this road pattern, city (city centre) is contented by sector centres, suburban centres and neighbourhood centres by the road which required minimum to connect the city centre.

1.7 Camber

Camber or cant is the cross slope provided to raise middle of the road surface in the transverse direction to drain of rain water from road surface. The objectives of providing camber are:

_ Surface protection especially for gravel and bituminous roads
_ Sub-grade protection by proper drainage
_ Quick drying of pavement which in turn increases safety

Too steep slope is undesirable for it will erode the surface. Camber is measured in 1 in n or n% (Eg. 1 in 50 or 2%) and the value depends on the type of pavement surface. The values suggested by IRC for various categories of pavement is given in Table .

1.7.1 Types of cambers.

The common types of camber are parabolic, straight, or combination of them

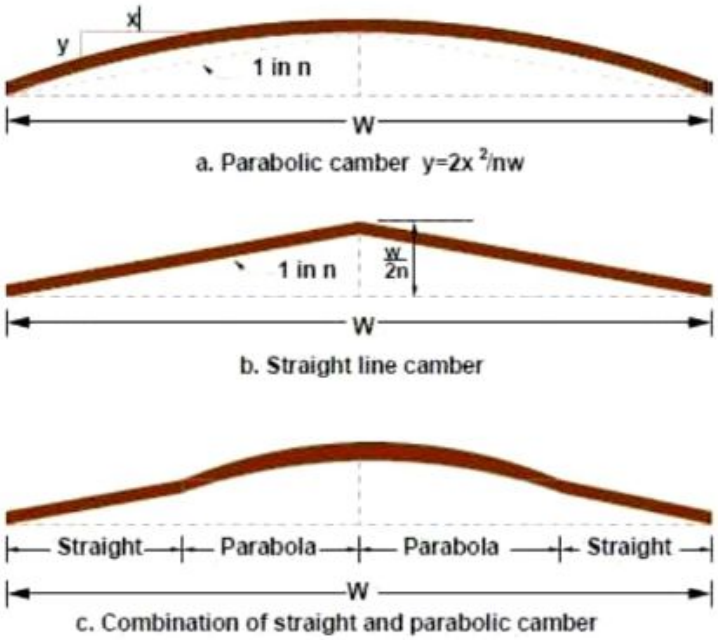


Table 12:1: IRC Values for camber

Surface type	Heavy rain	Light rain
Concrete/Bituminous	2 %	1.7 %
Gravel/WBM	3 %	2.5 %
Earthen	4 %	3.0 %

1.8 Width of carriage way

Width of the carriage way or the width of the pavement depends on the width of the traffic lane and number of lanes. Width of a traffic lane depends on the width of the vehicle and the clearance. Side clearance improves operating speed and safety. The maximum permissible width of a vehicle is 2.44 and the desirable side clearance for single lane traffic is 0.68 m. This require minimum of lane width of 3.75 m for a single lane road .However, the side clearance required is about 0.53 m, on either side and 1.06 m in the center. Therefore, a two lane road require minimum of 3.5 meter for each lane The desirable carriage way width recommended by IRC is given in Table