REPORT CONTAINING RECOMMENDATIONS OF THE IRC REGIONAL WORKSHOPS ON HIGHWAY SAFETY

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FOREWORD

It is unfortunate that the accident rate in our country is one of the highest in the world. It is also rather disturbing that the percentage of fatal accidents is also increasing steadily and now stands at more than 15 per cent as compared to 10 per cent only a decade back. Over 20,000 lives are lost every year on our roads besides injuries to thousands of people and huge economic losses in terms of damage to vehicles and property. The need for ensuring greater safety on our highways is, therefore, of the utmost importance.

The Indian Roads Congress have been deeply concerned with the subject of Highway Safety. In pursuance of a decision of the Council in their 85th meeting held at Hyderabad on the 3rd January, 1976 the Indian Roads Congress organised Workshops on Highway Safety in six regions of the country at Chandigarh, Trivandrum, Lucknow, Bombay, Calcutta and Gandhinagar.

With a view to have interaction between the various disciplines necessary for tackling problems of highway safety, specialists from other walks of life, such as administrators, planners, professors, police and transport officers and scientists apart from highway engineers, were invited to participate in these workshops. A number of useful suggestions were thrown up in these workshops which are now being brought out in the form of a Special Publication.

K.K. SARIN

Director General (Road Development) & Additional Secretary to the Govt. of India

New Delhi
November, 1984

CONTENTS

LIST OF TABLES

LIST OF FIGURES

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1

Introduction

1

INTRODUCTION

1.1. The rapid socio-economic development taking place in the country since Independence has brought in its wake a large expansion of the transportation system. Of the available modes of transport, road transport, because of its easy availability, flexibility in operation, adaptability to individual needs, door to door service and reliability, has become increasingly popular and its share in the total transportation load has been steadily increasing. Over the past 30 years, the number of registered motor vehicles has increased by 14 times, the freight traffic by 4.6 times and passenger traffic by 5 times as could be seen from Tables 1.1. and 1.2. According to the projections of the National Transport Policy Committee, the mechanised road transport is poised to handle freight and passenger traffic of the order of 185 billion tonne km and 800 billion passenger km respectively by the turn of the century. In a situation like this, it is becoming increasingly important to ensure that all possible measures are taken for making road transport safe and free-flowing.

TABLE 1.1. GROWTH OF REGISTERED MOTOR VEHICLES IN INDIA

('000 Nos.)

Type of vehicle	1950-51	1980-81	Per cent increase
Cars, jeeps, taxis	159	1054	563
Buses	34	140	312
Trucks	82	494	502
Two and three wheelers	27	2461	9015
Other vehicles	4	548	13600
Total :	306	4697	1435

TABLE 1.2. GROWTH OF ROAD AND RAIL TRAFFIC IN INDIA

Particulars		Rail	Road	Total
A. Freight traffic				
(Billion tonne-km)	1950-51	44.1 (88.9)	5.5 (11.1)	49.6 (100)
	1981-82	174.2 (62.6)	104.0 (37.4)	278.2 (100)
Per cent increase		290	1800	460
B. Passenger traffic				
(Billion passenger km)				
	1950-51	66 (74.2)	23 (25.8)	89 (100)
	1981-82	221 (41.2)	316 (58.8)	537 (100)
Per cent increase		230	1270	500

Note : Figures within brackets show the relative share between Rail and Road in per cent.

1.2. Accident Scenario

The phenomenal growth of road transport has brought along with it the serious problem of traffic accidents. There has been an increasing trend in the number of road accidents as well as casualties from year to year. Over the last 20 years, the number of accidents has gone up by 1.8 times, the number killed by 4.2 times and the number injured by 2.5 times as indicated in Table 1.3. On an average, over 400 reported road accidents take place every day leading to about 70 persons being killed and 300 injured. Besides this, a sizeable number of accidents, mostly of minor nature go unreported each day.

1.3. A further analysis of the data reveals certain specific features of road accidents in the country. The five metropolitan cities of Bombay, Banglore, Calcutta, Delhi and Madras

TABLE 1.3. ROAD ACCIDENTS IN INDIA

Year	Number of accidents	Number of persons killed	Number of persons injured
1960	55,500	5,100	33,700
1968	102,200	10,800	58,400
1976	121,800	17,200	88,100
1980	148,000	24,000	114,000
1981	153,400	26,500	118,000
Per cent increase compared to year 1960	180	420	250
Average growth rate per annum (per cent)	4.9	8.2	6.1

account for about 30 per cent of the total accidents in the country as could be seen from Table 1.4. As regards the types of persons killed, occupants of motor vehicles constitute about 41 per cent, pedestrians 40 per cent and cyclists 7 per cent. If data for the metropolitan cities alone are considered, the proportion of pedestrian and cyclist casualties are much higher. Fault of driver of motor vehicles has been found to be responsible for about 50 per cent of the accidents while the corresponding figures in respect of pedestrians and cyclists are about 9 per cent and 4 per cent respectively. Another revealing feature is that majority of the fatal accidents are due to fault of drivers of heavy vehicles.

TABLE 1.4. ACCIDENT RATE IN A FEW SELECTED CITIES IN INDIA

City/particulars	1979	1980	1981
A. Number of accidents			
Bombay	22,601	22,979	23,161
Bangalore	4,377	4,215	4,279
Calcutta	9,970	9,158	8,268
Delhi	4,497	4,044	3,626
Madras	4,722	5,163	5,878
All India	142,171	148,000	153,400
Total for 5 cities	46,167	45,500	45,212
	(32.5)	(31.0)	(29.5)

B. Number of persons killed			
Bombay	751	733	673
Bangalore	315	316	366
Calcutta	365	357	400
Delhi	763	663	750
Madras	267	310	339
All India	22,595	24,000	26,500
Total for 5 cities	2,461	2,379	2,528
	(11.0)	(10.0)	(9.5)
C. Number of persons injured			
Bombay	8,377	7,891	6,879
Bangalore	3,388	3,429	3,581
Calcutta	3,607	3,158	2,921
Delhi	4,207	3,807	3,278
Madras	2,764	2,996	3,348
All India	102,961	114,000	118,000
Total for 5 cities	23,343	21,281	20,007
	(22.7)	(18.7)	(17.0)

Note : Figures in parenthesis indicate percentage

1.4. Compared to some of the developed countries, the number of accidents in India in absolute terms may be low, but the accident rate in terms of unit number of motor vehicles brings out a disturbing picture. For example, in the years 1979, the number of fatalities per 10, 000 vehicles ranged between 2 and 5 in countries like Japan, U.K. and U.S.A., while in the case of India, it was as high as 55 as indicated in Table 1.5. Looking from another angle, while there were only 2 to 5 fatalities per 100 accidents in these countries, the figure was as high as 16 for India, a matter of serious concern indeed.

TABLE 1.5. RATE OF ROAD ACCIDENTS IN A FEW SELECTED COUNTRIES

Country	No. of accidents per 10,000 vehicles	No. of fatalities per 10,000 vehicles	No. of fatalities per 100 accidents
India	346	55	15.9
Japan	100	1.8	1.8
U.K.	153	3.9	2.5
U.S.A.	140	3.3	2.4
France	94	4.6	4.9
W. Germany	137	4.9	3.6

1.5. The high and growing accident rate in the country and the consequent loss to life and property have a serious impact on the national economy. A detailed analysis of road accident cost recently completed as a part of the Road User Cost Study in India* showed that the overall cost of road accidents in the country during the year 1978 amounted to Rs. 2367 million, based on an estimated cost of Rs 49,804 per fatal accident and Rs 29,510 per accident leading to serious injuries - see Table1.6. This works out to roughly 0.35 per cent of the GDP. If under-reporting of accident cases and limited demand on claim Tribunals are taken into account, the actual accident cost would be much higher. This is a serious matter which the country can ill afford to neglect.

TABLE 1.6. ESTIMATED COST OF ROAD ACCIDENTS IN INDIA (1978)

Sl. No.	Accident category	Number of accidents	Rate per accident (Rs)	Estimated cost of accidents (Rs million)
1.	Fatal	21,409	49,804	1070.2
2.	Serious injury	24,410	29,510	720.3
3.	Minor injury	73,231	321	23.1
4.	Damage to buses	40,764	5,467	222.9
5.	Damage to trucks	45,164	6,111	276.0
6.	Damage to cars	41,251	1,200	49.5
7.	Damage to two-wheelers	15,279	300	4.6
			Total :	2366.6

*Road User Cost Study in India, Final Report, Vol. V, Central Road Research Institute, New Delhi, 1982.

1.6. Accident Causative Factors

"Road accidents do not just happen but are caused" is a common cliche in the area of traffic safety. Thus, if accidents are caused by some agents, surely they could be identified and appropriate remedial measures developed and implemented for their prevention to the extent feasible and for the reduction of the ill effects and trauma of the accidents still happening. As brought out

earlier, analysis of the data on accidents in the country exemplify that driver of the motor vehicle is the single major factor responsible for the accidents. This must be the result of his misjudgement, or his inattentiveness to perceive the situation ahead because of his poor reflexes, fatigue, inexperience or being under the influence of intoxicants. There are, however, other factors which contribute directly or indirectly to the accidents. These are:

(i) the road,
(ii) the vehicle, and
(iii) the road users

1.7. If road factor is analysed, it may be seen that it has several ramifications. First is the planning of the road in relation to the land use pattern, and here the town and country planners have an important role to play. Second is the geometric design of the road and provision of skid-free pavement surfacing for safe movement of vehicles which fall under the purview of highway engineers. Third is the provision of suitable traffic guidance and control system like signs signals, pavement markings and delineators which concern traffic engineers and traffic management specialists. Fourth is the landscaping of the road environment and provision of resting facilities for vehicle drivers so that they are kept alert while driving and this aspect is looked after by landscaping engineers and architects.

1.8. As regards the vehicle, its fitnesss or roadworthiness is most important from traffic safety angle. Control over its fitness and its conformity with the legal provisions is exercised by transport officials and the police.

1.9. The road user group can be broadly classified into three categories, namely, the pedestrians, the drivers of non-motorised vehicles and the drivers of motorised vehicles. The first two catogories are not governed by any specific traffic regulations and generally drivers of slow vehicless do not feel obliged to acquire any formal knowledge of the traffic rules and regulations. For these groups of people, concerted effort is warranted in educating them of the correct behaviour on the road, and on this educationists and mass media have a vital role to

play. As regards the drivers of motor vehicles, it is a question of adherence to he stringent licensing procedures as prescribed by law and enforcement authorities responsible for the driving rules and regulations. Here, licensing authorities and the police come into the picture.

1.10. Thus, the problem of traffic safety cannot be looked at in isolation but as a system requiring attention at several fronts and involving action by several disciplines.

1.11. Highway Safety Workshops Organised by the Indian Roads Congress

Traffic accidents having grown into serious dimensions as brought out earlier, the Indian Roads Congress, the national body of highway engineers, has been looking into this problem with deep concern and has been taking a series of actions on the professional front directed towards bringing an awareness amongst politicians, administrators, engineers and other concerned authorities, developing recommendations and measures on accident prevention, and dissemination of knowledge in the field. A panel discussion on "Highway Safety Through Engineering Techniques" was organised during the Annual Session of the Congress held at Madras in December, 1970. Another panel discussion on highway safety was held at Amritsar in January, 1982. However, the major thrust on the subject was made with the organisation of a series of inter-disciplinary Highway Safety Workshops in different parts of the country. Six such Workshops were held, the first at Chandigarh in January, 1977 the second at Trivandrum in October, 1977 the third at Lucknow in November 1978 the fourth at Bombay in December, 1979 the fifth at Calcutta in November, 1980 and the sixth at Gandhinagar (Gujarat) in September-October, 1982. The most important feature of these workshops was the active particpaction of the operating officials and specialists of the various disciplines connected with traffic operation and traffic safety such as the police, transport and licensing officials, town planners, research workers and highway engineers. The idea was that the safety problem which requires attention and action of the various departments and organisations should be discussed in all its facets so that effective and workable solutions could be evolved for direct

application. As envisaged, these Workshops generated very useful discussion, and a number of important recommendations arising therefrom have been circulated amongst the State Governments and other concerned authorities from time to time.

1.12. Scope of this Publication

This Publication is intended to serve as a ready reference book for guidance of adminstrators, engineers and other officials who are concerned with traffic safety and in the implementation of the traffic safety programmes. Section 2 gives the consolidated summary of the recommendations of the six Highway Safety Workshops organised by the Indian Roads Congress. Some of the recommendations are self-explanatory in nature and can be implemented directly. For many others, explanatory notes have been included in Section 3 of this publication for providing a detailed discussion of the related aspects and guidelines on the actual implementation of the corrective measures. This Section has been prepared from the current knowledge on the subject and from what is considered as good engineering practice. As the experience grows, this section would need to be reviewed and updated in the years to come.

2

Summary of Recommendations

2

CONSOLIDATED SUMMARY OF RECOMMENDATIONS OF THE IRC HIGHWAY SAFETY WORKSHOPS ORGANISED AT CHANDIGARH, TRIVANDRUM, LUCKNOW, BOMBAY, CALCUTTA AND GANDHINAGAR

2.1. Engineering Measures to Improve Road Safety

2.1.1. Road geometrics

(i) Uniform design standards recommended by the Indian Roads Congress for planning and designing the alignment of roads should be adopted.

(ii) While designing the alignment, kinbs in the horizontal and vertical directions should be avoided, horizontal curves provided with as large radii as feasible, and the alignment both in the vertical and horizontal directions sulitably co-ordinated so as to provide aesthetically pleasing profile with built-in safety.

(iii) Necessary sight distance as appropriate to the situation should be provided at horizontal/vertical curves and at intersections. Availability of the required sight distance should be periodically checked for removal of all obstructions.

(iv) On existing roads, locations/sections having substandard geometrics such as narrow pavement, inadequate sight distance, sharp curvature, etc. should be identified and effective steps taken for their rectification. Besides spot improvements of the defective locations, a thorough study of these should be made while taking up major improvements to the road/pavement, and the correction of the geometric deficiencies should be made as a part of the project itself.

2.1.2. Road intersections

(i) In the design of road intersections, adequate care should be taken to minimise the number of conflict points for increasing safety.

(ii) As 3-arm intersections are generally safer than 4-arm

intersections, while laying new roads, it will be desirable to design the road network in such a way that the intersections, by and large, will have three arms.

(iii) Wherever a new road is built, the intersections with the existing roads should be properly designed and executed as a part of the new road project taking into consideration the traffic flow requirements.

(iv) Islands provided within the intersection area and elsewhere should be suitably painted and in rural areas they should be of the mountable type.

(v) Approaches to intersections should be provided with properly laid out guidance system in the form of signs and pavement markings.

(vi) Traffic signals, where provided, should be properly co-ordinated to minimise delays, as such a coordination, besides reducing overall fuel consumption results in better behaviour of drivers. The signals should also be maintained in good working order.

(vii) The lighting of road intersections should be of higher intensity than along straight stretches so as to provide the necessary visual warning to approaching road users. Street lighting in urban areas should be so provided and maintained that pavements always remain well-lit so as to make driving possible only with parking lights.

2.1.3. **Pedestrian facilities**

(i) Pedestrians should be considered as a traffic unit in the design of roads in urban areas.

(ii) As pedestrians are often involved in fatal traffic accidents, footpaths of adequate width with suitable surfacing should be provided on all busy urban roads, kept free from encroachment by hawkers and maintained properly.

(iii) Wherever necessary, railing barriers for pedestrians should be provided to control the movement of pedestrians.

(iv) Pedestrian crossings should be made adequately conspicous through the provision of zebra crossings preferably with flashing beacons. Such crossings near schools should be given special attention.

(v) On busy roads having heavy volvme of pedestrian traffic across the road, pedestrian underpasses/overbridges should be provided.

2.1.4. **Separate tracks for slow moving vehicles**

(i) Cycle traffic on important urban roads should be segregated from other fast traffic by providing separate cycle tracks/lanes. These tracks/lanes should be continuous and should be maintained in good order.

(ii) Cycle traffic should be properly segregated at junctions also.

(iii) Separate tracks for other slow vehicles should be provided wherever possible, and so warranted.

2.1.5. **Bus bays and terminals**

(i) Lay-byes of appropriate designs recommended by the Indian Roads Congress (IRC : 80-1981 for rural highways and IRC : 70-1977 for urban roads) should be provided at pick-up bus stops on all busy roads.

(ii) Properly planned bus terminals should be provided in the cities at suitable locations.

(iii) The bus terminals should be planned in an integrated manner keeping in view the various demands of the passengers.

2.1.6. **Medians**

(i) Physical separation of opposing traffic streams greatly facilitates reduction of accidents. For this purpose medians should be provided, wherever appropriate and possible.

(ii) Medians should be wide enough to enable povision of pocket lanes for right turning traffic.

(iii) Median openings should be provided judiciously keeping in view the problem of road safety (see IRC : 62-1976 for guidance on access control and median openings).

2.1.7. **Shoulders**

(i) Shoulders of adequate width and suitable specifications should be provided and properly maintained to ensure smooth flow of traffic.

(ii) In black cotton soil areas hard shoulders, at least on main highways to start with, should be provided.

2.1.8. **Embankment of roads**

(i) Side slopes of embankments should not be very steep as otherwise serious accidents are likely to occur (see IRC : 36-1970 for guidance on safe side slopes).

(ii) At hazardous locations such as approaches to narrow bridges, high embankments etc. guard rails of suitable design should be provided for better safety.

2.1.9. **Speed-breakers**

Speed breakers of the steep hump type now being provided on some of the roads are dangerous and should be done away with.

2.1.10. **Bridges and culverts**

(i) Approaches to bridges and culverts should be laid out carefully so that these could smoothly join the roadway on the structure.

(ii) The width of bridges upto 30 m length should preferably be kept equal to width of roadway as the sudden reduction in the width of bridge leads to traffic hazards.

(iii) Wherever widening of single lane to two-lane carriageway is undertaken, the widening/reconstruction of narrow culverts equal to full formation width should be simultaneously taken up. For this purpose, it would be preferable to include the provision for culverts in the estimate for widening of road itself. However, wherever

this is not possible, bold warning sign boards on both sides of narrow culverts should be installed.

2.1.11. **Road-rail grade crossing**

Unmanned road-rail grade crossings should be provided with automatic audio visual signals such as the one developed by the RDSO of the Railways. Such devices would increase the safety at these places.

2.1.12. **Flood level indicators**

Flood level indicators should be installed and maintained at all submersible bridges and causeways for providing adequate information to the road users at such locations.

2.1.13. **Repair of roads**

(i) Prompt maintenance under condition of flood and land-slide should be planned in advance and adequate equipment and personnel made available.

(ii) Repairs to roads in urban area should be carried out during the non-peak hours.

(iii) Repair to potholes, shoulder drop-offs, etc. caused during rainy season should be done soon after the rainy season so that minimum inconvenience is caused to traffic. The financing procedures to meet the cost of such repairs should be streamlined by the State Governments, so that these repairs can be attended to without delay.

2.1.14. **Service road**

Provision of service roads with controlled access to the arterial road should be provided to enable the reduction of numerous road intersections and thereby increase safety (see IRC : 62-1976 for guidance on access control).

2.1.15. **Skidding/surface characteristics**

(i) Road pavements on horizontal curves and intersections are subject to large centrifugal forces, and vehicles on such sections are prone to skidding. Also, skidding can occur due to polishing of aggregates and at locations where bleeding of bitumen shows up due to the use of

excessive bitumen. Such locations should be identified and necessary measures such as provision of skid-proof surfacing should be taken. Guidance in this regard can be had from the IRC Highway Reseasch Board State-of-Art Report on "Pavement Slipperiness and Skid Resistance".

(ii) Skid—prone locations yet to be corrected should be notified to the motorists by posting appropriate warning signs.

2.1.16. **Traffic control devices**

(i) Traffic control devices such as signs, signals, and road markings of the required standards should be employed to regulate and control the traffic to promote greater safety (see IRC : 67-1977 for traffic signs and IRC : 35-1970 for road markings).

(ii) Delineators of scientific design and preferably of reflectfive type should be used wherever necessary in such a manner that these can guide the traffic efficiently (see IRC : 79-1981).

(iii) Suitable control devices must be made available to the enforcement authorities for the purpose of better control of traffic on road for temporary diversions.

(iv) Warning signs and devices should be installed well in advance at both ends of the road section under repair/improvement in order to reduce accident risks.

(v) Warning signs should be clearly visible at night also.

(vi) At all hazardous locations, reflectors should be provided for warning the road users of possible hazards.

(vii) The estimates of the projects should include the cost of installation of traffic control devices.

(viii) The cost of road markings should form a part of road maintenance grant.

(ix) All cities and State Highway Departments should have a 'Road Sign' workshop.

2.1.17. **Location of trees**

Where as it is desirable to save trees, if they are a safety hazard, such trees should be removed. Moreover trees should be painted in white colour upto a height of 1.25 m above the ground with 300 mm middle band in black colour to warn the road users of their presence.

2.1.18. **Elimination of surprise elements**

As far as possible surprise elements should be removed from the roads, and construction of permanent/semi-permanent structures, statues, etc. within the road land boundaries for other than road purposes should be completely discouraged.

2.2. **Traffic Enforcement**

2.2.1. **Speed limit**

Speed limit in mixed traffic condition should be judiciously imposed and adequately enforced at locations where high speed travel is hazardous. The speed limit should be appropriate to the situation and be arrived at after a study of the distribution of the speed of vehicles.

2.2.2. **Parking regulation**

(i) The provision of parking space required for public buildings like cinema theatres should be effectively enforced for ensuring better traffic management and control.

(ii) Off-street parking facilities should be provided at the fringes of central business districts of each city to prevent indiscriminate parking of vehicles on the congested streets.

(iii) Location of moter vehicle repair workshops should be properly planned and regulated and their locations should form integral part of the zonal plans.

(iv) At octroi and other check posts, laybyes for trucks should be provided.

(v) On rural highways, truck parks and rest areas should be provided at suitable locations.

(vi) Truck terminals with adequate capacity and infrastructure should be provided at suitable locations in the cities.

These can be developed with the financial participation of the truck owners and booking agencies.

2.2.3. **Weights and dimensions of vehicles**

(i) The Motor Vehicles Act has recently been amended to provide for uniform application of the regulations regarding maximum weights and dimensions of road vehicles. These provision are also included in IRC : 3-1983. These should be enforced strictly.

(ii) Carrying of long rods and over-sized loads is hazardous, and should be strictly controlled. Such loads should be permitted to be carried only in specially designed vehicles provided with necessary safety measures.

2.2.4. **Vehicle code**

(i) Uniform vehicle code should be worked out and enforced at national level to ensure better safety of vehicles. This document should give due importance to quality of various parts and also include safety fixtures.

(ii) Seat belts should be made a compulsory fitment in passenger cars and the driver and the front-seat passengers should be made to wear these while in motion.

(iii) Slow-moving vehicles including cycles must have reflectors fixed both in front and rear.

(iv) All trucks and other public carrier vehicles must carry reflective signs to be installed in front and rear on the highway, in case of breakdown so as to warn the other traffic about the obstruction.

2.2.5. **Fitness of vehicle**

(i) There should be periodic inspection by the registering authority of mechanical condition of all types of automobiles on the road, and unfit vehicles should be kept off the road.

(ii) Automobiles, particularly public service vehicles should be subjected to surpirse spot checks for road-worthiness to ensure their proper mechanical fitness.

(iii) The tyre rating should be limited to the registered laden weight so that in case of overloading tyres could give way.

(iv) Electrical direction indicators should be made compulsory for all motor vehicles including autorickshaws.

(v) Only those buses which are completly fit should be allowed to be used as school buses.

(vi) Safety aspect of cycle rickshaws, specially that of its braking system, should be improved.

2.2.6. **Visibility at night**

(i) For better visibility at night, rear and front of trucks and buses plying on rural highways should be painted bright yellow.

(ii) For better visibility, the autorickshaws should be painted yellow.

(iii) Adequate measures should be taken to ensure proper functioning of vehicle lights for enhancing visibility during night.

2.2.7. **Bald tyres**

The use of bald tyres leads to traffic hazards and therefore should be checked, particularly for commercial vehicles.

2.2.8. **Use of helmets**

Use of helmets by scooter/motor cycle/moped drivers and riders has been made compulsory only in a few States. Such enforcement should be done in the remaining States also.

2.2.9. **Licensing of drivers**

(i) The drivers should be subjected to rigorous written and in-field/on-road tests for ascertaining their driving ability besides physical fitness and psychological compatibility. Minimum educational standards for drivers should also be prescribed.

(ii) It is desirable to prescribe the maximum age limit for

heavy vehicle drivers. Maximum hours of work for professional drivers should also be enforced.

(iii) It is recommended that licences with respect to all drivers should carry a photograph of the driver for quick identification. Such licences should always be carried on person by all drivers, while driving.

(iv) A national register of drivers to whom licences for driving heavy vehicles have been issued, should be maintained so that no driver can get a licence from any other State once the same has been cancelled or impounded by the authority in another State.

(v) Each driver should carry with him an identity card giving the particulars such as name and address of the next of kin and biological data of the person such as blood group, rhesus factor, chronic disease, heart condition, drug allergies, etc. to enable quick and unambiguous medical treatment in times of emergency.

2.2.10. **Driving hours**

Driving hours should be restricted to avoid fatigue.

2.2.11. **Punishment for traffic offences**

(i) Exemplary punishment should be given to repeated traffic offenders.

(ii) Spot punishment system introduced in Bombay should be studied for viability and may be adopted in other cities as well if found suitable.

(iii) Separate traffic mobile courts composed of magistrates with working knowledge of the automobile and sufficient driving experience should be set up in all the cities for promptly dealing with the traffic violations, since prompt action will have better impact on violators.

2.2.12. **Enforcement personnel**

(i) With ever increasing traffic on roads, there is a need to strengthen the enforcement staff and also to train them adequately. The number of mobile courts for traffic

offences should also be augmented for the speedy disposal of traffic violation cases.

(ii) There is also need to get assistance to police by setting up other agencies like traffic wardens.

(iii) Police officers in metropolitan cities could also be empowered to collect fines on the spot for minor violations as this arrangement has been found to be very effective in making the road users abide by the law and regulations.

2.2.13. **Equipment**

(i) Availability of latest traffic control and measuring equipment is an essential prerequisite towards effective enforcement. For this purpose, wireless equipment, radar speedometers, brake efficiency meters, etc., should be made available to the enforcement authorities in major cities.

(ii) As drunken driving has proved to be a major source of traffic accidents, blood alcohol meters like breath analysers should be made available for enforcement.

(iii) Adequate number of weighing machines and portable weigh bridges should be made available to check overloading.

(iv) Latest traffic control equipment with closed circuit T.V., automatic traffic controllers, etc. should be introduced in major metropolitan cities in a gradual manner.

(v) Traffic aid posts should be established at regular intervals on all important rural highways. Highway patrols should be instituted on main highways and cranes should be available to remove vehicles involved in accidents or stalled.

2.2.14. **Uniformity in enforcement**

As far as possible, the enforcement of traffic regulations and the agency/agencies handling enforcement should be of uniform pattern throughout the country.

2.2.15. **Motor vehicle act and rules**

(i) The Motor Vehicle Act should be revised to cover both fast and slow moving traffic and also pedestrians.

(ii) Motor Vehicle Rules should be made uniform in all the States of the country.

(iii) Besides maximum punishment as prescribed in the current Act, minimum punishment is also required to be stipulated therein.

2.2.16. **Hoardings and ribbon development**

(i) There should be strict control on the display of advertisements along the roads, specially at intersections (see IRC : 46-1972 for guidance in this regard).

(ii) There should be effective and speedy removal of encroachments on road land and footpaths.

(iii) Central legislation for prevention of ribbon development and removal of encroachments should be expedited. Powers should be given to the Engineering staff for the removal of encroachments.

2.3. **Traffic Education**

2.3.1. **Road safety propaganda**

(i) All categories of road users including pedestrians should be made to understand the importance of road safety through available media such as newspapers, radio and television.

(ii) Ministry of Information and Broadcasting, Government of India should bring out a series of films on road safety.

2.3.2. **Training of drivers**

Heavy vehicle drivers should be subjected to thorough training before issue of licences and also during their service period.

2.3.3. **Driving school**

(i) Functioning of driving schools should be regulated to provide for proper training by competent personnel.

(ii) Properly equipped driving schools should be instituted for effecting better training of drivers. It would be very helpful, if a few model schools are set up by the Government.

2.3.4. **Safety education to children**

(i) Children should be educated on the need for road safety by introducing this as a subject of study in the curriculum.

(ii) Essay and painting competitions should be conducted for children to make road safety programme more popular.

(iii) Expenditure to be incurred on education campaigns should come under Plan provisions.

(iv) Traffic training parks suitably planned and adequately equipped should be provided in all cities to train children on the proper road user behaviour.

2.3.5. **Courtesy to pedestrains**

Apart from engineering and enforcement measures, intensive education of drivers to extend courtesy to pedestrains should be given.

2.3.6. **Traffic training classes**

Traffic training classes may be run by social workers for the purpose of educating the road users. Such classes may be made compulsory for those committing minor violations.

2.3.7. **Road safety education cell**

Road safety education cell should be formed in each city and should be manned by competent persons.

2.3.8. **Quality improvement programme**

Personnel manning various traffic safety and traffic education cells should be sent for refresher courses from time to time.

2.3.9. **Highway safety code and driving manual**

Uniform highway safety code and driving manual should be

prepared for the country and road users must be familiar with the provisions made in these codes.

2.3.10. **Seminars and safety campaigns**

(i) Periodical seminars and group discussions should be held wherein experts in different fields of traffic and transportation could highlight the importance of road safety and measures for achieving the same.

(ii) All types of road users should be covered in the safety campaigns in order to ensure better safety on roads.

(iii) All local authorities, particularly civic and education authorities should be involved in road safety campaign.

2.4. **Accident Investigation**

2.4.1. **Accident reporting**

(i) The Accident Reporting froms A 1 & 4 evolved by the Indian Roads Congress (see IRC : 53-1983) should be used by all the States for recording and reporting accident data. This will facilitate identification of the problems and the required solutions thereof.

(ii) The Police staff should be trained in filling these forms in an objective manner, and in the storage, analysis and retrieval of the information.

(iii) There should be a system of checking the filled-up forms for compatibility and completeness on a sample basis.

(iv) Data of all accidents including minor ones should be collected.

(v) For fatal accidents, reporting should be comprehensive involving all disciplines and causes must be investigated in depth.

2.4.2. **Investigation**

(i) Investigating police officials should be given training in the latest methods of scientific accident investigation and such officials should be adequately equipped.

(ii) Up-to-date techniques should be employed for analysing the accident data with the idea of identifying accident-

prone spots and working out priority oriented improvement schemes.

2.4.3. **Specialists investigation**

Fatal accidents should be investigated jointly by specialists from all concerned disciplines to make suitable recommendations. The Traffic Engineering Cells should co-ordinate this work.

2.4.4. **Accident mechanism**

Urban areas being more vulnerable to road accidents the mechanism of accidents in such areas should be studied in greater detail.

2.4.5. **Accident bureaus**

(i) Separate accident bureaus should be set up in each State to effect proper collection, compilation and analysis of accident data. These bureaus should work in close liaison with the Traffic Engineering Cells.

(ii) These bureaus should include specialists like traffic engineers, enforcement officials, medical experts, experts in forensic science, economists, statisticians and social workers.

2.5. **General Recommendations**

2.5.1. **Traffic engineering cell**

(i) Traffic engineering cells manned by specialists in the field should be created in all state P.W.D.'s for effective design of roads and road facilities with adequate emphasis on safety. There should also be a traffic engineering cell in the Roads Wing of the Union Ministry of Shipping and Transport to study problems in so far as they relate to National Highways.

(ii) In all metropolitan cities, there should be a properly staffed Traffic Cell having all disciplines, i.e. traffic police, highway engineers, doctors, town planners, traffic managers, etc. Such a cell should be adequately equipped to reach the accident sites, provide first aid to the injured and remove them to hospital, remove

the involved vehicles from the road pavement, record accident detail and then analyse for improvements required, etc.

(iii) For proper manning of the above cells, the staff of the State P.W.D's and Municipalities/City Corporations should be encouraged and even sponsored by these organisations to attend courses of long duration in traffic engineering and traffic planning offered by various universities and institutions in India.

2.5.2. **Comprehensive traffic and transportation planning**

(i) Comprehensive traffic and transportation planning should be undertaken in all cities to effectively forecast the anticipated future traffic and to design the required traffic facilities for the future design year to ensure maximum safety. At the same time, immediate improvement plans for optimising the existing facilities to ensure safe and efficient movement should be planned as an integral part of the long term solutions and implemented on priority basis.

(ii) Decentralization of activities and decongestion from the central business districts should be undertaken to reduce the traffic congestion in the cities.

(iii) For medium sized cities, traffic operation plans including traffic engineering improvements to increase the capacity and traffiic regulation and control measures to ensure safe and efficient movement should be prepared.

(iv) Schools/colleges should not be allowed to be opened along heavily trafficked roads. As regards existing schools/colleges opening into highways, necessary facilities like foot-over bridges/subways and other traffic control measures should be provided.

(v) For improving efficency and safety of movement of heavy traffic, access-controlled high speed expressways should be provided on heavily trafficked sections of trunk routes in the country.

2.5.3. **Staggering of working hours**

Staggering of working hours should be considered in order to reduce the congestion at peak hours.

2.5.4. **Unified transportation authority**

In metropolitan cities, unified transportation authority should be created to plan, execute and maintain roads and traffic improvements. Such an authority should employ inter-disciplinary staff so that aspects such as regulation and control could also be tackled in a comprehensive manner.

2.5.5. **Municipal services**

Cuts are made in roads in urban areas to lay pipes, cables etc. which are not properly repaired. A centralised control should be exercised in granting permission for any road cutting and to ensure that these cuts are repaired properly without any delay.

2.5.6. **Medical care**

(i) A good number of road fatalities could be averted by timely medical attention. Efforts should be made to properly equip and operate such medical care units in all cities and on important highways.

(ii) All hospitals should be made to attend to accident cases. The medico-legal problem should be looked into and tackled.

(iii) Para medical forces should be formed from within the public, police and other organisations in order to extend adequate post-accident care to accident victims.

2.5.7. **Safety benevolant fund**

A safety benevolant fund for accident victims should be raised from the public and should be properly supplemented by the Government.

2.5.8. **Funds for road safety measures**

(i) There is a need for allocating more funds for carrying out road safety measures.

(ii) A non-lapsing Central Road Safety Fund on lines similar to the Central Road Fund should be instituted at the Centre for carrying out road safety programmes in the country.

2.5.9. **National road safety council**

(i) To tackle the road safety problem at the National level in a sustained and balanced manner, a National Road Safety Council should be constituted at the centre with adequate financial and statutory provisions.

(ii) A top level Co-ordination Committee consisting of representative of police, transport, road, finance, medical and other departments should be set up in each State under the chairmanship of State Chief Secretary for looking into the highway safety problem in the State.

3

Explanatory Notes

3

EXPLANATORY NOTES

3.1. Road Condition and Traffic Safety

3.1.1. It is generally accepted that road accidents do not just happen, but are caused. The causative factors may be the road, the driver, the vehicle, other road users and the environment, either singly or collectively. The evaluation of the contribution of the individual factors to an accident is difficult, and quite often it is the easiest and the quickest way to conclude that the accident was caused by the driver, who, as is expected should have instantaneously reacted to the changes in the other elements of the entire complex and adjusted his manoeuvre correspondingly to compensate for the changes. This is one reason that the available statistics on road a ccidents in the country attribute a majority of the accidents to fault of drivers. This is not to say that all drivers are entirely faultless. There are cases of driving under the influence of intoxicants, or drivers with poor sensory reflexes and driving skills who normally should not have been permitted to drive, or arrogant drivers not abiding by the traffic rules or driving recklessly for sheer thrill, etc. where the drivers should be held solely responsible for the accident. However, there can be many other cases where situations are allowed to exist on the rodway which are conducive for drivers to commit mistakes, e.g., presence of a sharp curve following a long tangent section, poor lighting, hidden dip in the profile, sudden narrowing of the roadway because of a cross-drainage structure in an otherwise wide road, or aspects distracting or weakening the attention of the drivers and creating a delusive notion of traffic condition, etc.

3.1.2. The above situations may not by themselves constitute the basic cause of accidents, but by the elimination of such unfavourable roadway features and by creating safe driving conditions, traffic safety can be improved considerably. In other words, the road design should rather be to assist disciplined drivers and to make their work easier so that there is the least possibility of their making mistakes than to force them to

change their condition of driving to get over unfavourable road features.

3.1.3. Valuable data on the effect of the various road parameters on accident rate relating to roads in India have now become available from the Road User Cost Study* completed by the Central Road Research Institute in collaboration with the Ministry of Shipping & Transport and the World Bank. The data pertain to two studies, one on a 114 km length of Bombay-Pune road (two-lane black-topped highway traversing plain, rolling and hilly terrains, and carrying ADT of 4747 vehicles), and the other on 34 routes in different parts of the country (covering a good range of the variables). Regression equations have been developed relating the accident rate to the different geometric variables. The more generalised equations derived from the second study have been:

$$AR(1) = -.0.9134 + 0.0545RF + 0.5560J - 0.222W + 0.001177\ QADT \quad (R^2 = 0.766) \ldots..(1)$$

$$AR(1) = 0.2171 + 0.002884CV + 0.4126J - 0.3447W + 0.001274\ QADT \quad (R^2 = 0.759) \ldots..(2)$$

Where AR (1) = Accident rate per km per annum
RF = Rise and fall in metres per km
CV = Average horizontal curvature in degrees/km
J = Number of junctions per km
W = Pavement width in metres
QADT = Average traffic volume in vehicles/day

These equations can be used for predicting the accident rate of a road section or for comparing the accident potentialities of a number of alternatives having different geometric and traffic features bound by the same limits as those used in developing these equations. These, however, cannot be used for micro level analysis, for example, what will happen to the accident rate when a sharp curve of radius 100 m is flattened to 350 m.

For getting a broad appreciation of the significance of the

*Road User Cost Study in India, Final Report, Vol. V, Central Road Research Institute, New Delhi, 1982

various road parameters on the accident rates, the above two equations have been used to plot the diagrams in Fig.3.1. For plo-

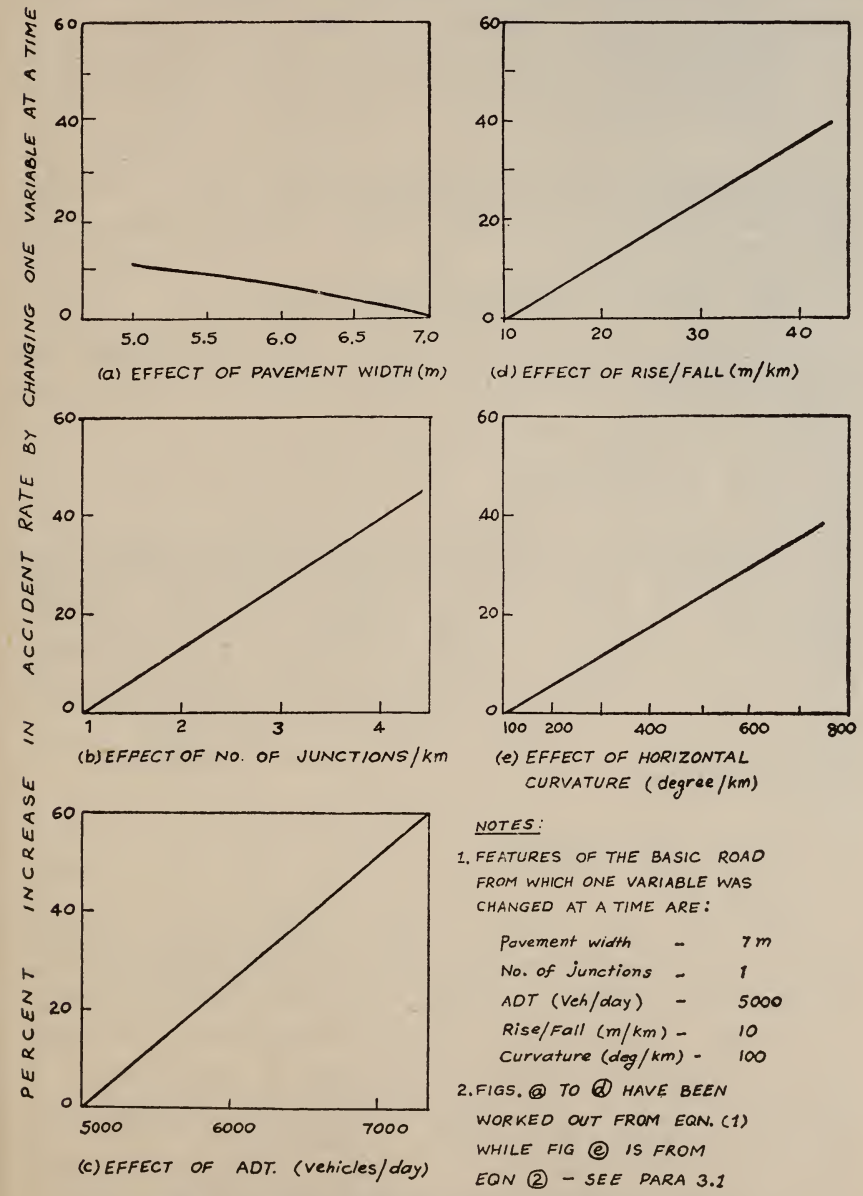


Fig. 3.1. Effect of road parameters on accident rate
(From Road User Cost Study in India)

tting these diagrams, a basic road having the following features have been assumed:

Pavement width	. . . . . 7 m
No. of junctions	. . , ... 1
ADT (veh/day)	 5000
Rise/fall (m/km)	 10
Curvature (degree/km)	. . . , ... 100

To study the effect of one feature, value for that feature is varied while those of others are kept constant. The diagrams are by themselves self-explanatory.

3.2. Geometric Design for Improved Safety

3.2.1. In this para, the following aspects of road design influencing traffic safety are discussed:

(i) Road alignment
(ii) Road cross-section; and
(iii) Sight distance

These aspects which generally fall under geometric design should be regarded as integral part of road design right from the initial construction of the road. For existing roads, the approach should be to identify the defects and deficiencies and take appropriate remedial action in a systematic manner. Where the corrective action is expected to be delayed, the presence of the deficiency should be notified to the motoring public through appropriate signs.

3.2.2. Road alignment

General

(1) The alignment of a road pre-determines the path taken by a vehicle in moving from one point to the other and comprises the elements of horizontal curve for effecting changes in direction and grade for negotiating the differences in elevation. These elements are determined on the basis of the design speed and the type of terrain traversed. From safety angle, the effort should be to design and develop the alignment in such a way that it is like a free flowing ribbon tied to the natural topography and unfolding the different features of the road and the landscape to the drivers sufficiently in advance so that he is least fatigued

and his interests are kept alive on the roadways ahead. In other words, the alignment affording pleasant driving and devoid of surprise elements will not tax the driver to make him commit mistakes, and this is conducive to safe driving. Considerations needing attention in this regard are discusesd here in under.

Uniformity in design

(2) The alignment should follow uniform design standards. Drivers get conditioned by the road on which they are travelling and from past experince they expect certain things ahead. For example, a driver on a good alignment will expect flat and free-flowing curves, and in case an isolated sharp curve is present it will be a surprise element which will prove to be more dangerous than a curve of same radius in a generally poor alignment. Consistency in road alignment is, therefore, an important pre-requisite for traffic safety. In places where change in standard is unavoidable, such as where a hill road emerges on to the plains, it is desirable to effect the same gradually by providing successive sections of gradually increasing standards till the road users get adjusted to the new conditions. At unavoidable locations having sharp changes in standards, safety can be improved by providing adequate warning about the same through installation of relevant warning signs and posting of speed limit restrictions.

Horizontal curves

(3) Horizontal curves are generally associated with high accident rates. The accident rate is influenced not only by the sharpness (curvature) of the curves but also by the frequency of their occurrence. Sharper the curve, greater is the proneness to accidents. A road section with an isolated sharp curve has a greater accident rate than one with more number of curves. The accident rate shoots up with increasing curvature of an isolated curve.

(4) Hazard at horizontal curves arises because of several factors acting singularly or in combination. Important amongst these and the actions that could be considered for improving safety are briefly discusted below :

(i) At a horizontal curve, the driver has to act on his steering wheel in time, and if he is not prepared for the change in direction or is

taken by surprise, his vehicle will leave the intended path and either hit a stationary object or trip off the roadway. This surprise element has already been discussed in the earlier paragraphs.

(ii) At curves, a vehicle is subject to centrifugal force the intensity of which depends on the travelling speed and the degree of curvature. Design requirement warrants that a portion of this force (equal to the force developed at 75 per cent of the design speed) should be counteracted by superelevation (superelevation rate should be subject to maximum of 7 per cent for plain and snow-bound hilly terrains, and 10 per cent for non-snow-bound hilly terrain) and the balance by side friction subject to a maximum ratio of 0.15. Absence of, or inadequate superelevation will mean greater pressure on side friction which may lead to skidding, particularly where the pavement is wet or has a smooth and slippery surfacing. From these considerations, therefore, it should be ensured that the curves are provided with proper and adequate superelevation and skid-free surfacing.

(iii) On curves, compared to straight sections, vehicles occupy more space in the lateral direction, and it is also more difficult to judge the clearance between opposing vehicles. Any misjudgment in this regard will mean serious head-on collision. On curves, therefore, suitable system for guiding the vehicles in their respective paths should be provided, and this can be in the form of centre line and edge line pavement markings. Reflective studs will be advantageous particularly on un-lit rural highways. The edges of roadway on the curves should also be notified by means of delineators or white washed guard stones.

(iv) The problem of inadequate visibility may arise on the inside of the curve in case any obstruction to sight like building, wall, high crops, etc. exists. This aspect is discussed in more detail in para 3.2.4.

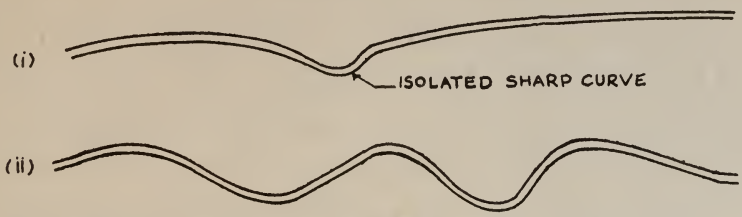
(5) Some of the safety problems arising at horizontal curves are illustrated in Fig. 3.2.

Long tangent sections

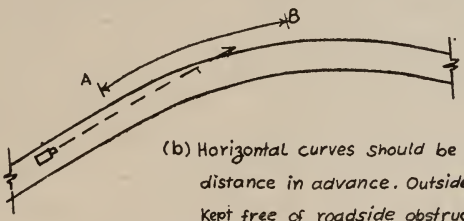
(6) Long tangent sections exceeding 3 km in length should be avoided as far as possible. Such sections make distant objects in the line of the road appear nearer and consequently create a psychological feeling in the driver to speed up, thus creating a hazardous situation.

Vertical profile

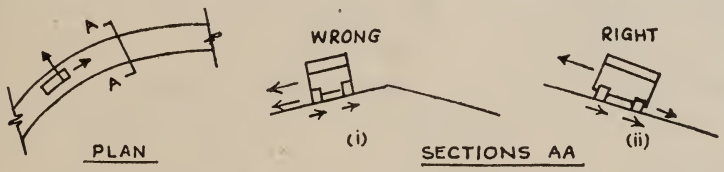
(7) The most important feature of vertical profile affecting safety is the availability of adequate sight distance. Good



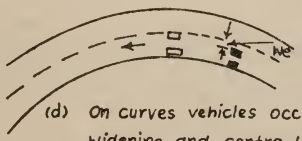
(a) Isolated sharp curve in a good alignment is more dangerous (see i) than a series of curves in a generally poor alignment (see ii)



(b) Horizontal curves should be visible for sufficient distance in advance. Outside of the curve should be kept free of roadside obstructions. Distance AB equal to 3 seconds travel time from start of curve is particularly critical.

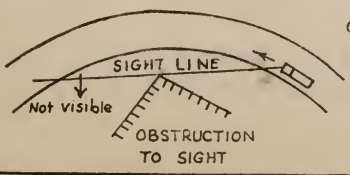


(c) Dynamics of motion along a curve. In (i), camber acts as reverse superelevation and adds to sideway force to make it dangerous. In (ii) superelevation counteracts part of the sideway force to keep friction within limits.



We = Extra width occupied by vehicle because of tracking of rear wheels

(d) On curves vehicles occupy more space in lateral direction. Pavement widening and centre line marking will help keep the vehicle in its own lane.



(e) Visibility at inside of curves becomes an element of design. At least stopping distance should be ensured.

Fig. 3.2. Some of the safety problems arising at horizontal curves

engineering practice requires that the summit curves should be designed to provide the needed sight distance (safe stopping sight distance being the absolute minimum), while the valley curves should be designed for headlight distance required for safe driving during hours of darkness (see para 3.2.4. for more details). The other factors affecting safety are (a) the rate of grade, (b) the length of grade, and (c) the frequency of grade changes. The first two factors influence the extent of speed differential between trucks and cars travelling upgrade since speed of trucks is more affected by grades exceeding 3 per cent. Accident rate increases and the capacity reduces as the speed differential increases. Where the speed differential is expected to be more than about 25 km/h on two-lane highways, it wtll be desirable to provide a separate climbing lane in the upgrade direction, particularly where the proportion of trucks is high. Some of the problems arising in vertical profile and the manner of their correction are illustrated in Fig. 3.3.

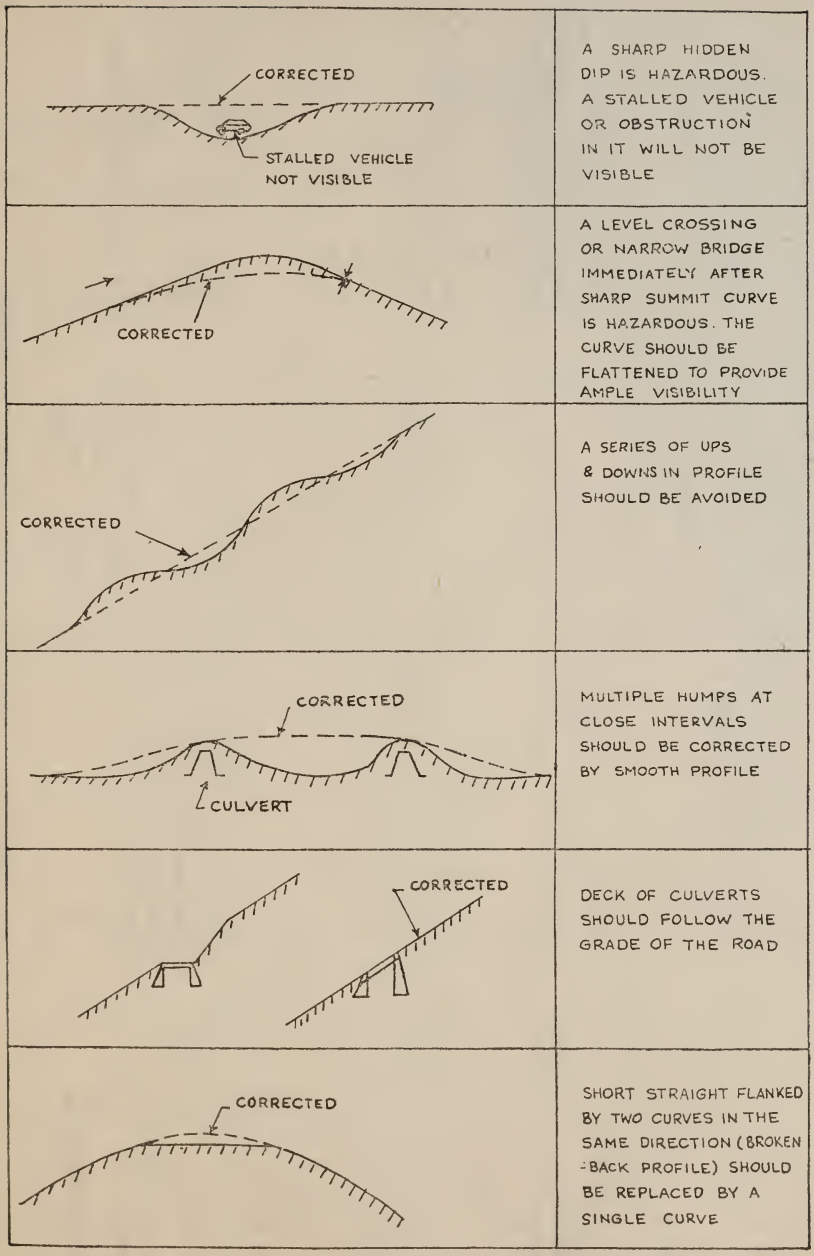
Alignment Co-ordination

(8) A driver gets a three-dimensional view of the road ahead in the landscape and, therefore, from angles of safety and providing confidence in driving, the horizontal alignment and the vertical profile should be co-ordinated to provide for aesthetically pleasing view of the road besides full information on the features (ups and downs, direction changes, etc.) of the road ahead. An alignment not so co-ordinated and which presents a warped appearance or conceals important features of the road ahead (e.g. a hidden dip or similar visual discontinuity) makes driver judgment difficult and increases the chances of accident. Some of the guidelines in alignment co-ordination are :

(i) The degree of curvature should be properly balanced with the gradient, e.g., flat horizontal curve should not be at the expense of steep and long grades, and vice-versa.

(ii) Vertical and horizontal curves should cioncide as far as possible, and where this is difficult, the horizontal curve should be somewhat longer than the vertical curve.

(iii) Sharp horizontal curves should be avoided at or near the apex of a pronounced summit/valley vertical curve from safety considerations.



3.3. Corrections to vertical profile for improved safety

Fig. 3.4. Illustrates some typical cases of good and bad alignment co-ordination.

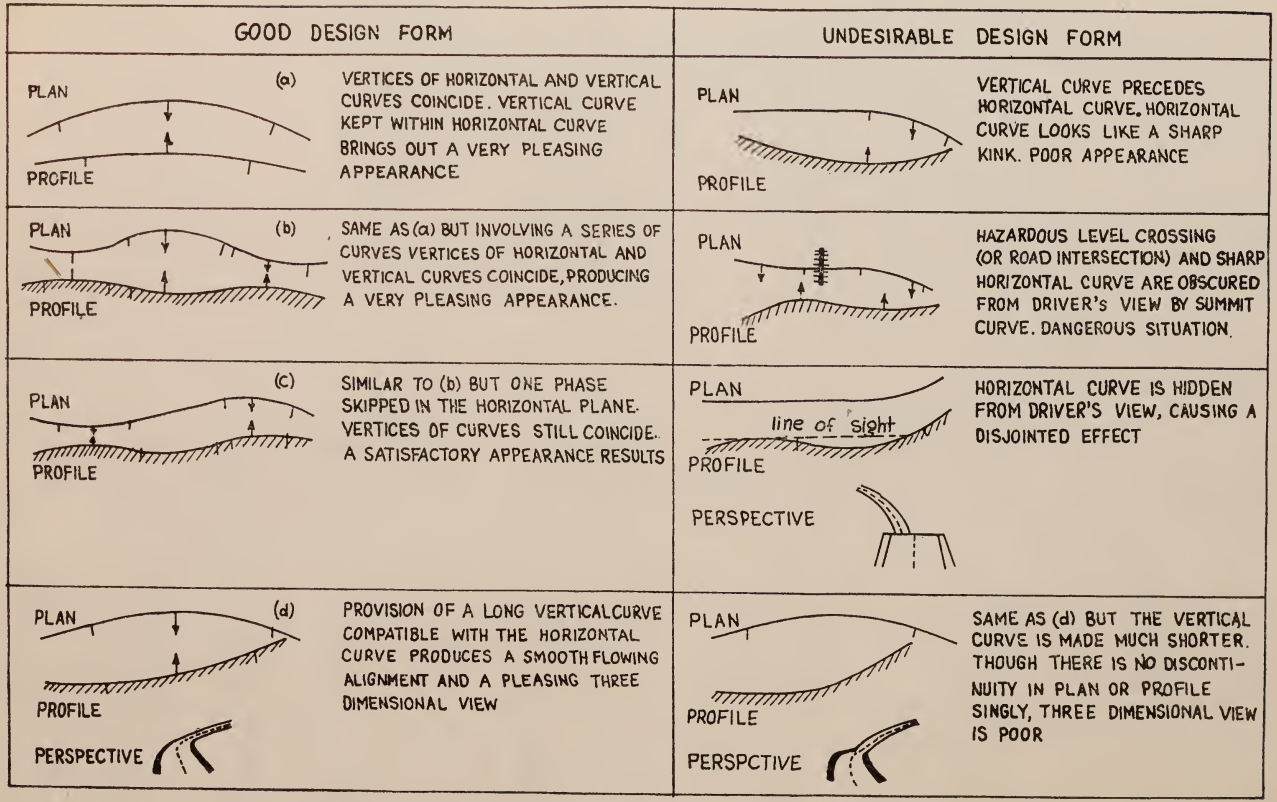


Fig. 3.4. Sketches illustrating good and bad alignment co-ordination

3.2.3. **Road cross-section**

(1) The elements involved in road cross-section are the width and the number of traffic lanes, the width of median where provided, the type and width of shoulders, the crosfall, the embankment side slopes and the side drains. The design criteria and values for all these elements for adoption under different situations have been standardised by the Indian Roads Congress which should be followed in all cases. However, the points requiring specific attention from safety angle are highlighted below :

(i) The facilty with which a vehicle can move freely and safely along a road is influenced by the width and number of traffic lanes, and the volume and composition of traffic. The carriageway widths have been standardised as 3.75 m for single lane, 5.5 m for intermediate lane, 7 m for two lanes and 3.5 m per lane for multi-lane highways, and each type of cross-section has been assigned a capacity value in terms of P.C.Us. For all rural highways having traffic volumes within the capacity of two-lanes, it will be preferable to go in for 7 m wide carriageway instead of the intermediate lane, particularly where the proportion of commercial vehicles is more than 50 per cent. Further, safety can be improved by widening the road sections with traffic volumes close to or exceeding the capacity.

(ii) At locations where the carriageway is widened from single to two lanes, two to four lanes, or *vice versa*, an important requirement is that the increase or decrease in width should be brought about gradually with a splay of 1 in 15 to 1 in 20 for rural highways and 1 in 10 to 1 in 15 in the case of urban roads. Also, the transition should be provided with guidance system in the form of signs and pavement markings. Typical cases are illustrated in Fig. 3.5.

(iii) Approaches to a narrow bridge in an otherwise wide road creates hazardous situation. Such cases require special attention, and the treatment to be given is discussed in detail in para 3.4.3.

(iv) The type aud condition as also the level and crossfall of shoulders relative to the carriageway are important from the point of view of traffic safety. On single lane roads, the outer side wheels of vehicles generally travel for considerable distance on the shoulders for overtaking crossing manoeuvres. On two-lane roads, vehicles may have to use the shoulders in emergencies, or drive along the pavement edges. Soft earthen shoulders have been found to be responsible for overturning of many heavily loaded trucks due to wheels sinking into the shoulders during the rainy season. Further, the slushy condition causes the mud from the surface of the wheels to spread on to the pavement surface presenting a constant threat for skidding. A good design practice, therefore, calls for provision of hard shoulders upto a width of atleast one metre and regular

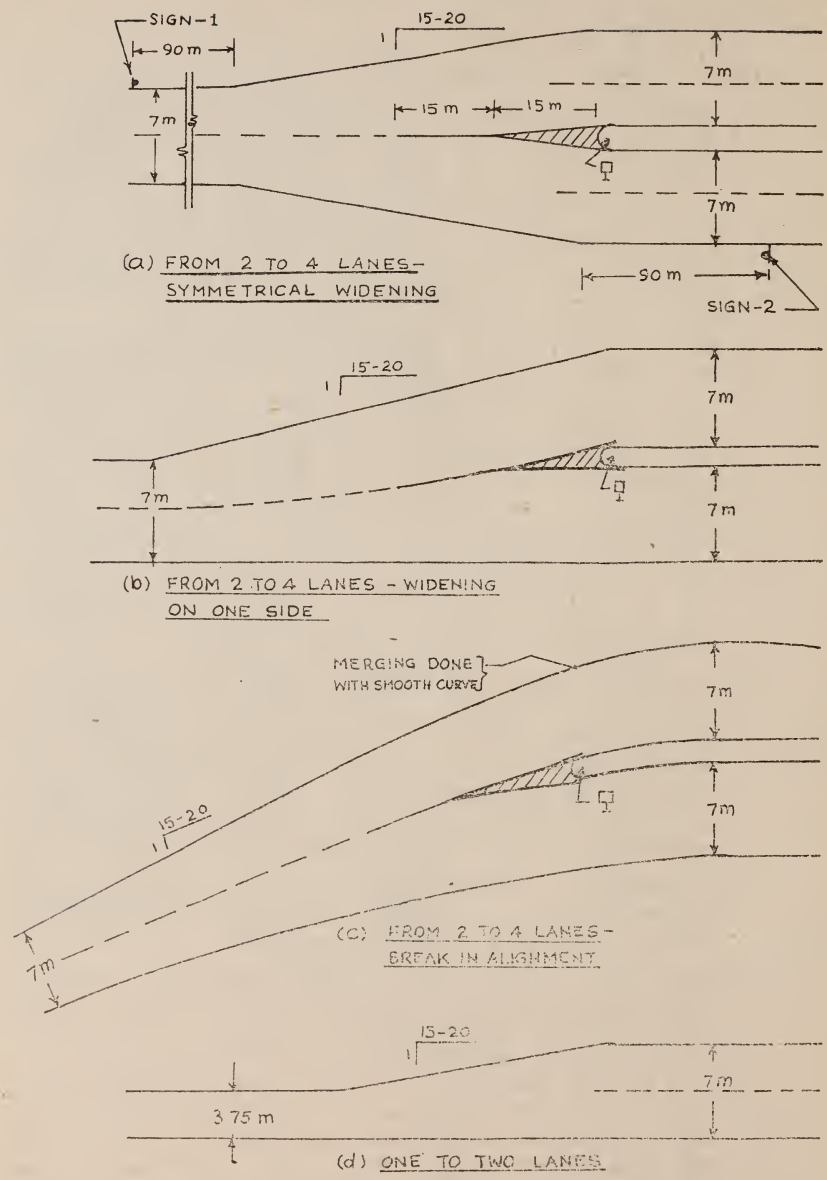


Fig. 3.5. Treatment at typical cases of pavement widening

maintenance thereof. Quarry spalls, gravel, hard moorum,or other locally available granular material can be used for the purpose of improving safety at low cost. Another aspect is that the space to a distance of at least 1.5 m from the edge of the carriageway should be kept free of all obstructions so that drivers feel confident to make full use of the carriageway width and thus contribute to improved capacity and safety. Some of these points are illustrated in Fig. 3.6.

(v) Medians improve the capacity and safety on high volume roads by physically separating the opposing traffic streams, reducing headlight glare (by planting shrubs in the median space), and providing positive delineation of the right edge of the carriageway. Medians also protect right turning traffic at crossings. As a general rule, rural highways of four or more lanes and urban roads of six or more lanes should be provided with median. For four lane urban roads, provision of median should be judicious taking into account such considerations as safety, directional distribution of traffic (medians not advisable when tidal flows of traffic are present), proportion of slow vehicles roadside developments, etc.

Medians should be highly visible both during day and at night from safety considerations. For this purpose, median kerb and surface area in-between should be provided with an effective contrast in colour and texture.

The number of median openings is an important factor affecting safety; the higher the number of openings per unit length the higher is the accident rate. Median openings, should generally be limited to intersections with public roads, and the distance between successive openings should not be less than 750 m for rural highways and 500 m for urban arterials.

(vi) In cut sections, for draining the roadway, it is a general practice to provide open drains on the hillside just at the edge of the shoulders. For such cases, 'v' shaped drains (with a slope not exceeding 3:1), though hydraulically not as efficient as the trapezoidal section, is advantageous from safety angle since out of control vehicles can make use of the drain and get retrieved from an otherwise dangerous situation - see Fig. 3.7.

(vii) It will be desirable to have embankment slopes as flat as possible so that any wayward vehicle leaving the roadway will have a better chance of survival. From safety considerations IRC:36-1970 recommends side slopes of 4:1 for low embankments upto 1.5 m height

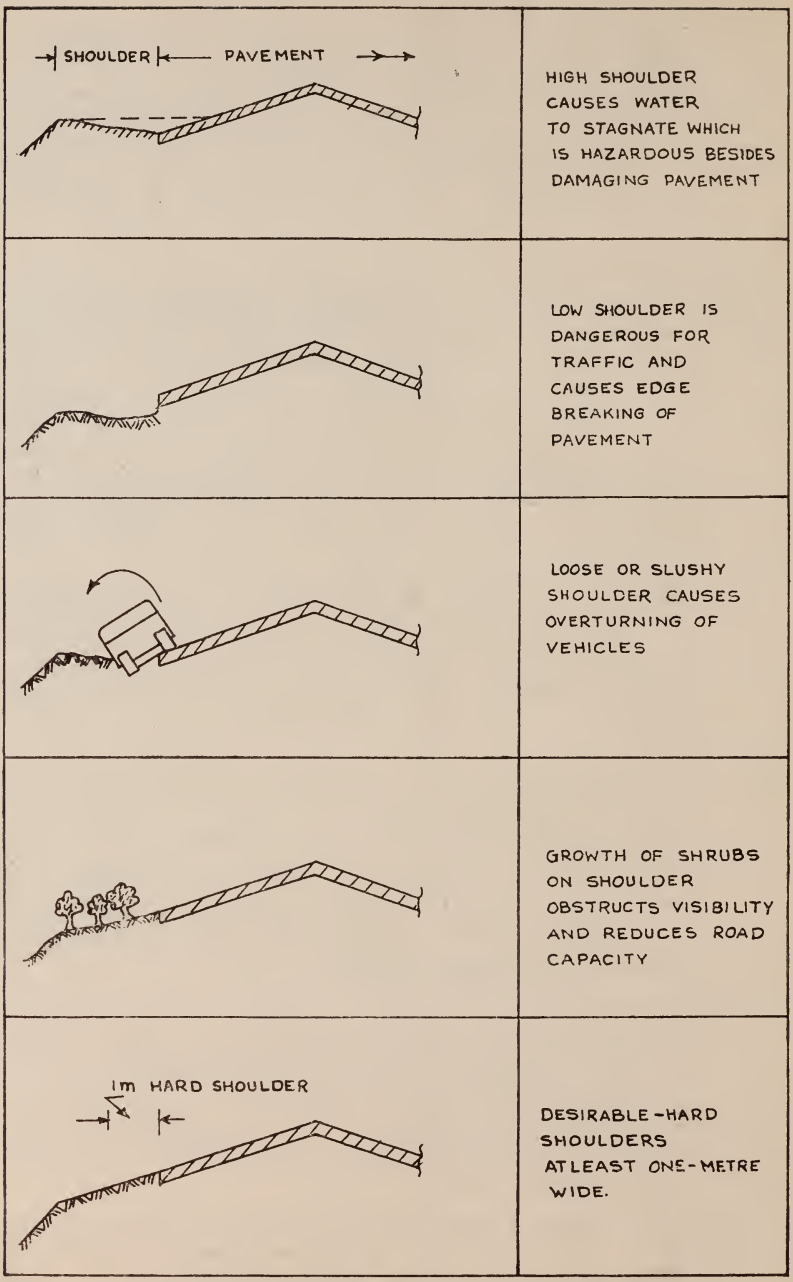


Fig. 3.6. Traffic safety problems relating to shoulders

Where embankment height is more, a cross-section for side slopes, starting from 2:1 at top and ending at 4:1, at the ground is suggested-see Fig. 3.8. Adoption of such slopes will no doubt involve extra cost, but weighing the benefits likely to accrue from improved safety, it would be preferable to provide such slopes particularly at critical locations such as sharp curves.

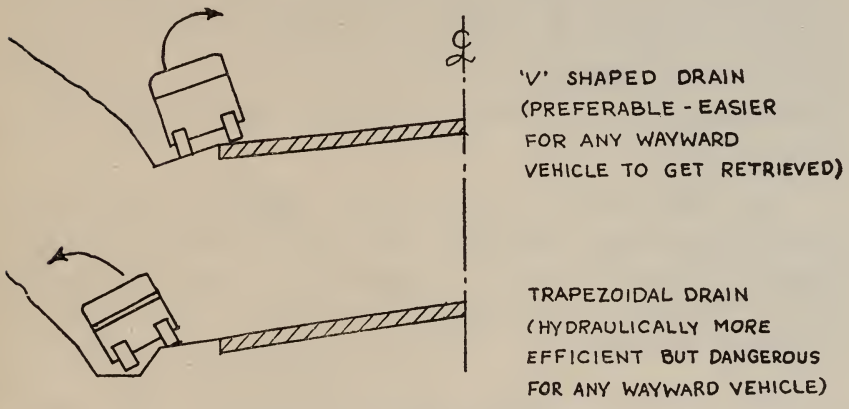


Fig. 3.7. Side drains for hill roads

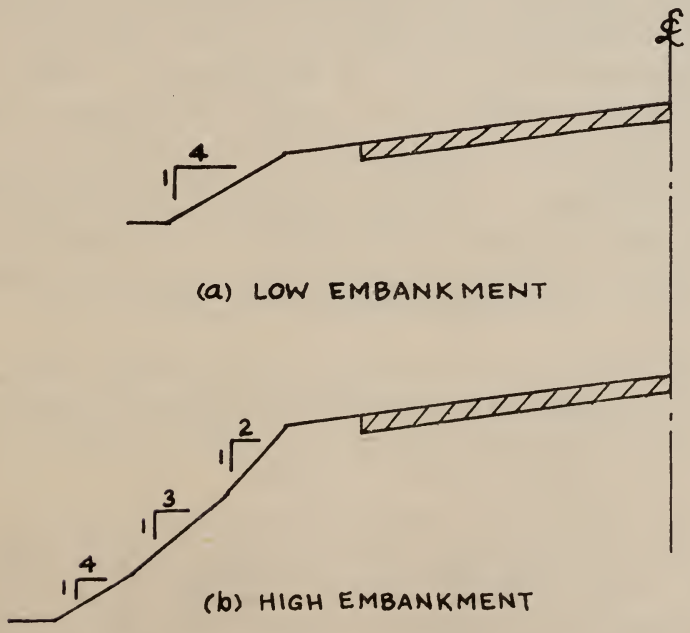


Fig. 3.8. Embankment slopes for traffic safety

3.2.4. **Sight distance**

(1) Sight distance, or ability to see ahead is one of the most important factors affecting safe and efficient movement of vehicles on roads. The road must provide for sufficient sight distance in which a driver can control his vehicle, or come to stop to avoid striking an obstacle on the roadway, or safely complete the manoeuvre of overtaking a slower vehicle without hitting an on-coming vehicle in the opposite lane. IRC : 66-1976 explains the types of sight distances and lays down minimum standards for various design speeds.

(2) Obstruction to sight or reduced visibility arises in two cases, (i) along the alignment where there is break in the grade line, and (ii) in the lateral direction along inside of horizontal curves due to obstructions like walls, cut slopes, buildings, wooded areas, high farm crops, etc. These cases are illustrated in Fig. 3.9.

(3) The needed visibility in the longitudinal direction can be ensured by providing suitably designed vertical curves. For 2-lane highways, the effort should be to provide visibility corresponding at least to intermediate sight distance. In cases where the terrain is characterised by a series of ups and downs, a profile closely following the natural ground surface which creates a "roller-coaster" kind of profile should be avoided. Similarly, on long straight sections, local hidden dips which merge with the continuity of the road when viewed from a distance should be avoided. A vehicle stopped in such a dip for repairs or other reasons can be seen only at the last moment, thus creating a hazardous situation. Fig. 3.3. shows some typical cases.

(4) On valley curves visibility is not a problem during day time. But for night travel the design must ensure that the roadway is illuminated by vehicle headlights for sufficient length to enable the vehicle to brake to a stop, if necessary.

(5) On the inside of horizontal curves, visibility can be improved by cutting back the obstructions to sight, lowering the height of hedges, replacing solid compound walls by see through-grills, cutting back the hill slope or benching as considered appropriate.

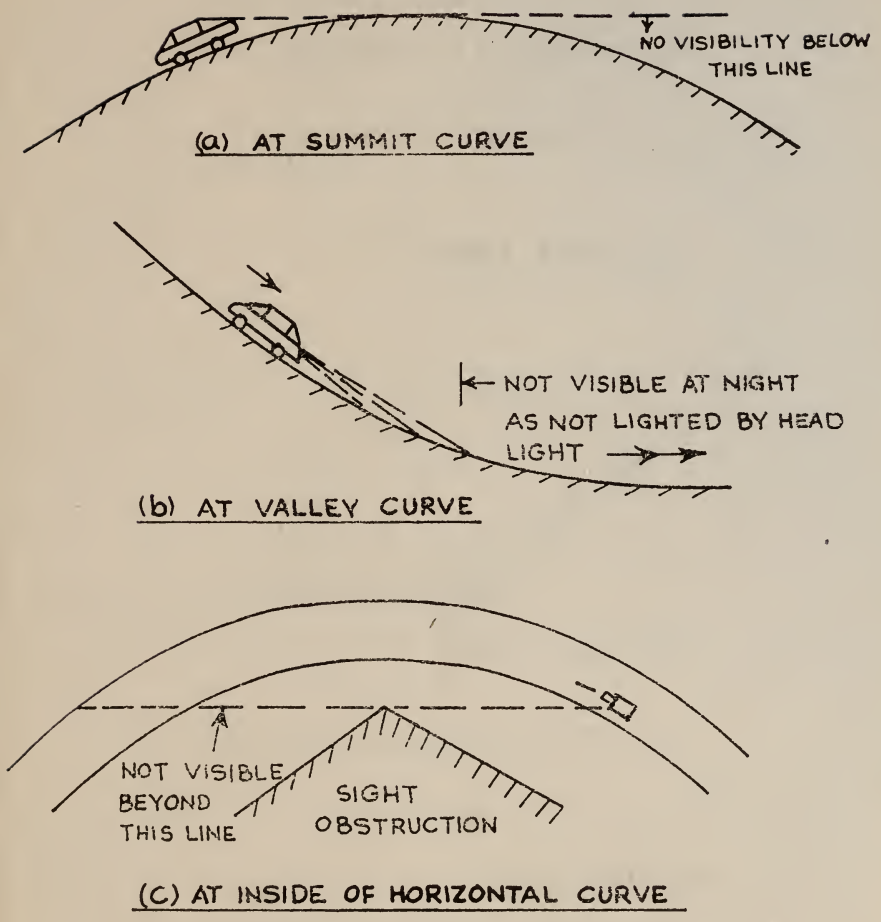


Fig. 3.9. Problems of visibility along and across the road

(6) Where a horizontal and summit curve overlap, the line of sight will not be over the top of the crest but to one side, and in part my be off the roadway. Design in such cases should provide for required sight distance both in vertical direction along the pavement and in horizontal direction on the inside of the curve.

(7) Fig. 3.10. illustrates the criteria for measurement of sight distance.

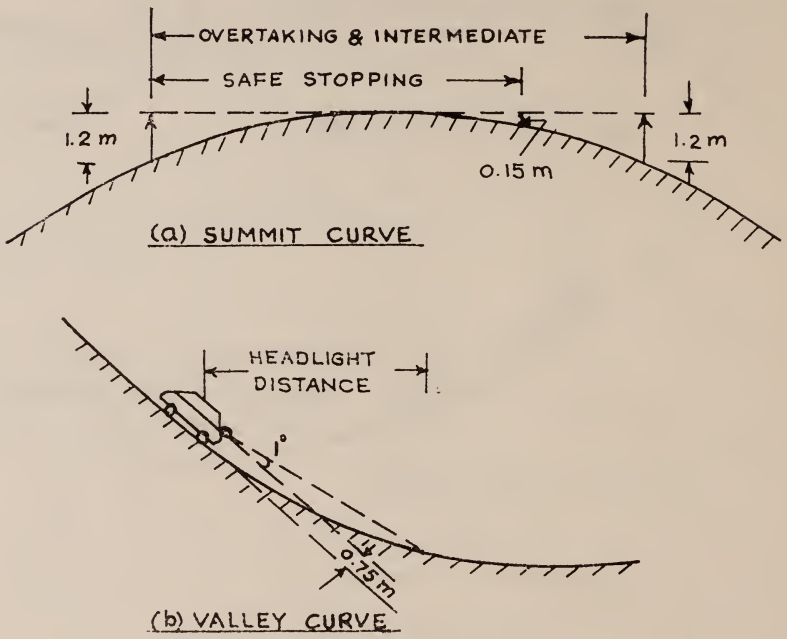


Fig. 3.10. Criteria for measuring sight distance

3.3. Road Intersections

3.3.1. General picture of accidents at intersections

It is generally accepted that road intersections are a major cause of accidents. Statistics both for the country and abroad show that roughly one-third of all road accidents occur at intersections. The recent study of accidents on Bombay-Pune Road (N.H. 4) and on a number of other highways conducted as a part of the Road User Cost Study showed that the presence of intersections is highly significant as an accident causative factor. Table 3.1. highlights this fact making use of the equation derived for Bombay-Pune Road.

TABLE 3.1. EFFECT OF FREQUENCY OF INTERSECTIONS ON ACCIDENT RATE

Sl. No.	No. of intersections/km	Personal injury accidents per million vehicle km/annum	
		Number	Per cent increase over the case at Sl. No. 1
1.	1	0.66	—
2.	2	1.14	73
3.	3	1.62	145
4.	4	2.10	218

Note : (i) The equation used to arrive at the above figure is :

$$AR(3) = -0.1526 + 0.0216\,RF + 0.0031\,CV + 0.4793\,J$$

Where : AR (3) = Personal injury accident rate in number per million vehicle km/annum

RF = Vertical profile denoting rise and fall in m/km

CV = Average horizontal curvature in degree/km

J = Number of intersections/km

(ii) In working out the above Table, values for RF and CV have been assumed to be 1 and 100 respectively corresponding to plain terrain.

3.3.2. Factors affecting safety at intersections

(1) Safety at an intersection results from the operation of a complex system of variables. Quite often, an accident takes place because of the interaction of a number of contributing variables. To have an objective study of accidents and for finding the appropriate remedial measures, it is necessary to identify the variables and the possible contribution of each variable. The variables can be grouped under two broad headings, namely, human variables and physical variables.

Human variables

(2) The behaviour of road users follows a three-phase process of perception, decision and action. These phases not only succeed each other but are also concurrent. A fault in one or more of these phases often foretells the occurrence of accidents. Risk arises when wrong actions are performed either because of

incorrect or incomplete information leading to wrong decisions, or wrong decision in spite of proper information implying incorrect judgment.

(3) For driving correctly at intersections, the drivers must perceive certain essential information such as : (i) the need for changes in speed, choice of lane/route across the intersection area and anticipation about possible approach of other road users; (ii) the traffic control devices setting out guidance or regulation about speed, turning, etc; (iii) traffic on the other approach roads covering the types and their positions with regard to the intersection area and to himself, their speed, the lanes/routes the other road users will use and signals given by other road users concerning slowing down, stopping or turning; (iv) the position and speed of the road user himself; and (v) special circumstances such as slippery pavement, diversion, etc.

(4) Generally, the total quantity of information that can be picked up or absorbed by a road user in a given period of time is limited. The chances of obtaining complete information decreases when a situation becomes complicated, such as in difficult road situation with various kinds of traffic, crossing pedestrains and numerous traffic signs. Besides this, there could be external situations imposed by objects obstructing visibility, or decreased visibility because of insufficient lighting, or glare, or the driver's attention being diverted by irrelevant information like advertisements, shop window displays, etc. Instances are not far to seek where intersections overload the driver with information with the result that drivers disregard significant information such as warning signs.

(5) Another important factor in safety at intersections is the familiarity of the situation. Generally, chances of a road user missing the crucial information or under-estimating the risks are greater for those who are new or unfamiliar with local situations. Under-estimation of risk may also occur when a familiar situation has changed and if this situation is inconspicuous and not clearly notified.

Physical variables

(6) Basically, hazard at an intersection arises as a result of conflict between two or more traffic streams, or between a vehicle and other road users, or between vehicles in the same stream. Several physical factors influence the type and intensity of the conflicts. A clear understanding of the different types of conflicts is, therefore, essential not only for safety evaluation of an intersection but also for developing appropriate remedial measures. The types of conflicts and influence on traffic safety are discussed in para 3.3.3.

(7) Important physical variables influencing hazards at intersections can be grouped under the following broad heads :

(i) **Location**	:	Location in the network; with respect to other intersections; and in relation to topography and other environmental features.
(ii) **Type of intersection**	:	type in relation to the intensity and mixed nature of traffic; the type of area whether rural or urban; the presence of pedestrains; cyclists and other slow-moving vehicles; speeds of approaching vehicles, etc.
(iii) **Intersection geometry**	:	the size and shape of the intersection area; the angle or obliquity of approaching legs; the presence of traffic islands, flaring, etc. in the intersection area.
(iv) **Visibility**	:	sight distance available within the intersection areas as also between the intersecting legs.
(v) **Traffic**	:	intensity and mixed nature of traffic; proportion of slow traffic; pedestrain volumes, etc.
(vi) **Traffic control devices**	:	the presence of signs, signals and pavement markings.
(vii) **Other conditions**	:	roadside conditions; ribbon development; advertisement hoardings; weather, light and road surface conditions.

(8) The physical variable enumerated above act either singly or in combination. How these act on safety at intersections, and what measures can be taken to improve the safety situation are discussed in para 3.3.4.

3.3.3. **Traffic conflicts at intersections**

(1) Movement of a vehicle along or across an intersection area invariably involves a conflict. The conflicts are of varied types, and the intensities of collision produced by them are also different. The attempt in any safety improvement programme should, therefore, be not only to reduce the number of conflicts but also convert more intense conflicts into ones of minor nature. It should be understood that it is not possible to remove all conflicts since even interchanges have merging/diverging conflicts, and in some cases (e.g. cloverleaf design) weaving conflicts.

(2) The different types of vehicular conflicts at an intersection are illustrated in Fig. 3.11. alongwith the possible types of collision produced by each of these. Of these, conflicts arising out of merging, diverging or weaving manoeuvres can be considered to be of minor nature (since the resulting collision is not of serious type) while those from straight moving and right turning movements are of more serious type. Compared to straight moving, right turning movements are more potential for serious collisions since the vehicles will have to take a longer curved path within the intersection area, have to look for potentially conflicting vehicles in all directions, and are involved in greater number of conflicts in their path. A closer attention and necessary provisions for right turning movements are therefore important for improved safety at intersections. Table 3.2. brings out the parameters to be considered for reducing the intensity of vehicular conflicts.

(3) The number of conflict points at an intersection area affects traffic safety, the larger the number of conflict points greater is the probability of collision. Fig. 3.12. brings out the number and type of conflicts at typical intersections. This highlights the point that having intersections with fewer legs or making one or more of the crossing roads one-way can drastically reduce the conflict points for improved safety.

(4) The occurrence of conflict points at close sequence as shown in Fig. 3.12 (a) creates hazardous situation of serious nature, and this can also psychologically affect the capabilities and judgement of drivers. The area of conflict, i.e. the space available in

CONFLICT	POSSIBLE TYPE OF COLLISION
A. LESS DANGEROUS	
MERGING (Joining a stream at small angles)	SIDE SWIPE
DIVERGING (Separating from a stream at small angles)	REAR END, SIDE SWIPE
WEAVING (Crossing at small angles over a distance)	SIDE SWIPE
B. MORE DANGEROUS	
SINGLE CUTTING (Straight moving)	HEAD - ON
MULTIPLE CUTTING (Straight moving)	HEAD - ON
DIVERGING, CUTTING & MERGING (Right turning)	HEAD-ON, SIDE SWIPE
DIVERGING, CUTTING & MERGING (Right turning)	REAR END, HEAD-ON, SIDE SWIPE

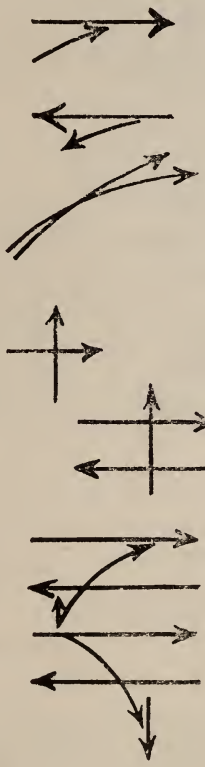


Fig. 3.11. Vehicular conflicts at intersections

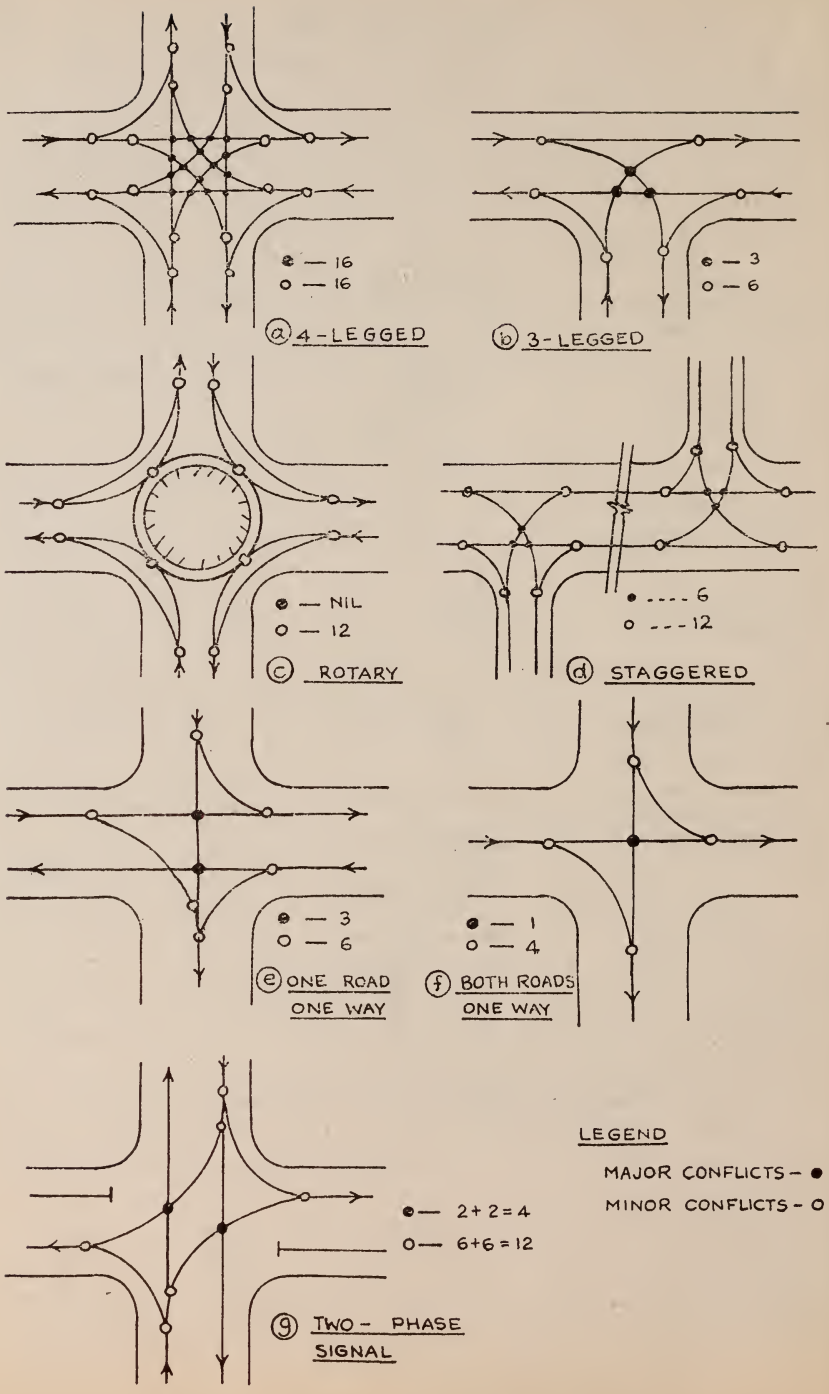


Fig. 3.12. Conflict points at typical intersections

TABLE 3.2. PARAMETERS TO BE CONSIDERED FOR REDUCING THE INTENSITY OF VEHICULAR CONFLICTS

Sl. No.	Conflict	Crucial parameters for improved safety	Application in design
1.	Merging	Should be at small angles and low relative speeds. Presence of sufficient gaps in the main stream necessary.	Design of acceleration lanes and merging tapers.
2.	Diverging	Should be at small angles and low relative speeds. Diverging arm notified sufficiently in advance.	Design of deceleration lanes and diverging tapers.
3.	Weaving	Merging, crossing and diverging should be at small angles and low relative speeds over sufficient distance called weaving length.	Design of rotary intersections, and in cases when merging and diverging roads closely follow each other as in cloverleaf interchanges.
4.	Cutting (straight moving)**	Gaps in main stream should be adequate, delineation of manoeuvre area and control of priority for movement from each arm.	Design and capacity evaluation of at-grade intersections.
5.	Cutting and merging, or diverging and cutting (right turning)**	Adequate gaps in the main stream, safe storage space to wait for acceptable gap, turning radius for safe movement, delineation of manoeuvre area, and control of priority for movement.	Design and capacity evaluation of at-grade intersections.

Note : **Where the safety requirements cannot be satisfied, these movements (i) can be converted into less dangerous weaving by adopting rotary design, or (ii) can be separated in time by signal control, or (iii) can be separated in space by grade separation, as appropriate.

the lateral direction for carrying out a manoeuvre, if more than necessary, can add further dimensions to the problem. A driver negotiating a manoeuvre adjusts his speed and position in anticipation of a particular path for a potentially conflicting vehicle, and in case the latter has a large area to manoeuvre, the calculations of the former will get seriously upset, and this may result in a serious accident. From safety angle, therefore, it is essential not only to separate the possible conflicts but also to reduce the potential conflict area. This can be achieved through channelisation. This point is illustrated in Fig. 3.13 (a to d) with the progressive development of a 'T' intersection. Even where traffic volumes do not demand channelisation, the principle can be applied to reduce the non-functional intersection area for obviating the possible wavering of vehicles. Such cases arise at oblique intersections of a minor road with a major road as illustrated in Fig. 3.13 (e).

3.3.4. **Measures for improved safety at intersections**

(1) Risk of accidents at intersections can be reduced and their consequences minimised by taking suitable engineering measures discussed in the following paragraphs. While some apply to new intersections others apply to both new and existing ones. In all cases, it will be a good practice to examine the design in the light of a check list, a sample of which is suggested in Table 3.3.

(2) In the development of road network for an area, due attention should be paid to the following points from traffic safety angle:

(i) The roads in the network should follow an hierarchical pattern with respect to function so that priorities of each arm of the intersection could be understood and suitably provided for by way of introducing 'GIVE WAY' or 'STOP' signs for traffic entering the intersection from minor roads.

(ii) The number of intersections should be reduced to the barest minimum. On rural highways, the intersections should not be spaced closer than 750 m. On urban arterials, the corresponding minimum distance should be 500 m.

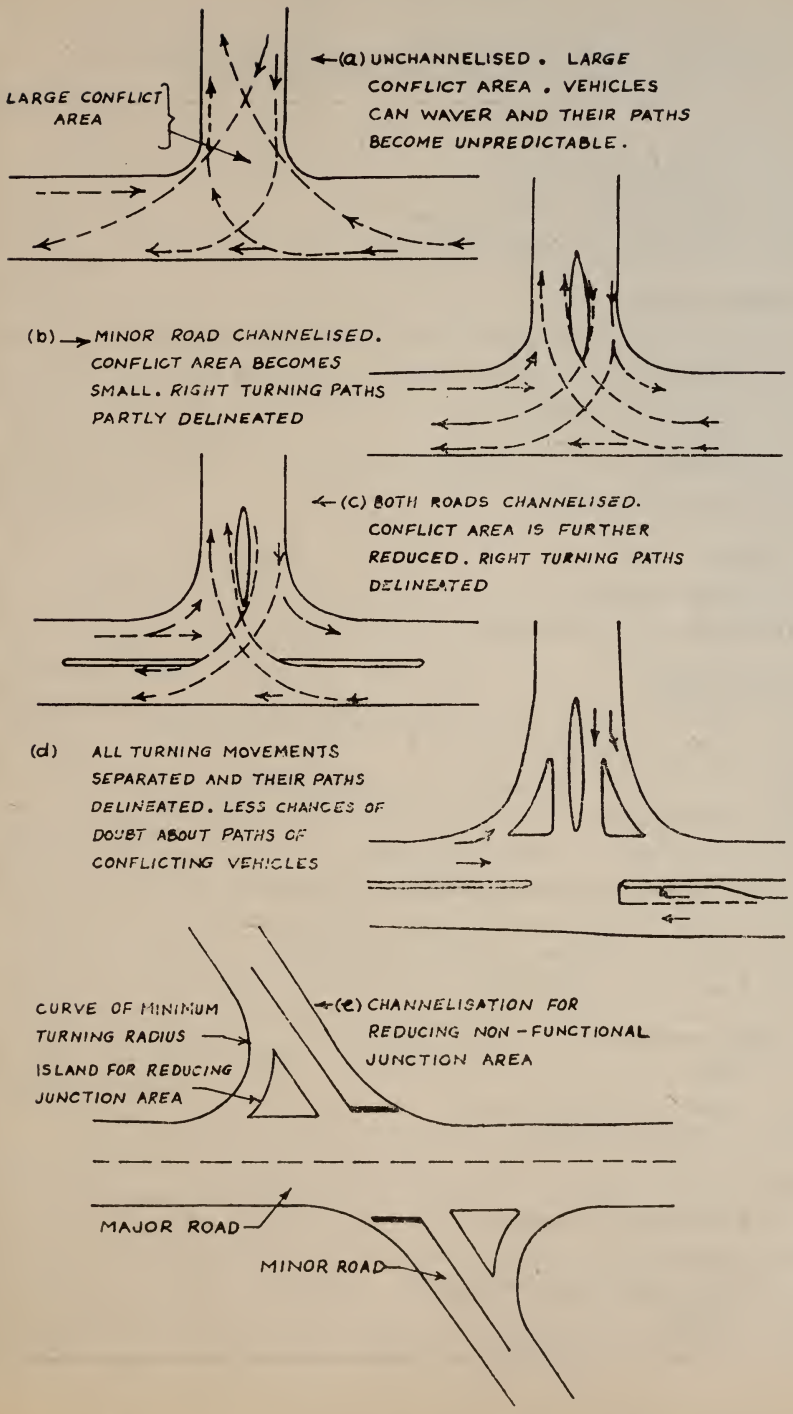


Fig. 3.13. (a to e) Channelisation for separting conflicts and for reducing conflict area

TABLE 3.3. CHECK LIST OF POINTS TO BE LOOKED INTO FROM SAFETY ANGLE IN THE DESIGN OF INTERSECTIONS

1. **Location**
   - (i) Importance in network
   - (ii) Grade/curvature of crossing roads
   - (iii) Distance from adjoining intersections

2. **Choice of design**
   - (i) Compatibility with traffic volume, directional distribution and mixed nature, and importance of intersecting roads
   - (ii) Speeds of approach roads
   - (iii) Type of area, urban or rural
   - (iv) Possibility of lighting the intersection area
   - (v) Uniformity in design

3. **Visibility**
   - (i) Overall visibility
   - (ii) Clearance of sight triangles

4. **Layout design**
   - (i) Number of conflict points and possibility of reducing these
   - (ii) Separation of conflict points
   - (iii) Conversion of major conflict points into minor ones
   - (iv) Turning radius
   - (v) Size and shape of channelising islands
   - (vi) Type of kerb for islands (mountable/non-mountable)
   - (vii) Painting of kerb faces in black and white bands
   - (viii) Presence of non-functional intersection area
   - (ix) Flaring of approach arms

5. **Traffic control devices**
   - (i) Signs
   - (ii) Signals and flashing beacons
   - (iii) Pavement markings

6. **Miscellaneous**
   - (i) Advertisement hoardings
   - (ii) Drainage
   - (iii) Skid resistant pavement surfacing
   - (iv) Lighting

(iii) Having more of 'T' intersections which have fewer number of conflict points in place of 4-way intersections.

Choice of type of intersection

(3) A variety of designs are possible from simple layouts having only left turning curves to complex channelised layouts, or rotary, or signal control. Each type is appropriate to a particular situation of traffic and environmental parameters. A wrong choice may mean congestion and delay at one end to confusion and inconvenience on the other, and this means greater proneness to accidents. For example, a signal controlled junction on a lightly trafficked road or an isolated signal or rotary on a high speed highway will be a cause for increasing the accident rate. Also, a complex channelised layout should be avoided on unlit rural highways.

Intersection geometry

(4) Geometric features include the location and direction of the intersecting arms, the location, size and shape of channelising islands, the turning radius, etc. Some of the satisfactory and unsatisfactory geometric design features at intersections are illustrated in Fig. 3.14.

(5) Very often the intersection area is flared out to accommodate the different manoeuvres and channelising islands. The angle of flaring to suit the approach speeds, the delineation of the path or channels right from the approaches in logical sequence are important. Leaving a large unmarked area at the junction will cause wavering of vehicles and increase accident potential. No traffic island should come on the normal vehicle path, and if used should be of sufficient size (minimum 6 m^2 area) and their faces painted in black and white bands to make them adequately conspicuous.

(6) The left turning curves should follow the path of the inner rear wheel and should not be so sharp as to cause the turning vehicle to encroach on the lanes intended for other vehicles. This can be achieved by providing 2-centred or 3-centred compound curves. For high speed rural highways like National Highways, 2-centred designs of 17-23 m and 20-30 m (with left infiltration lanes) have been successfully used in many places.

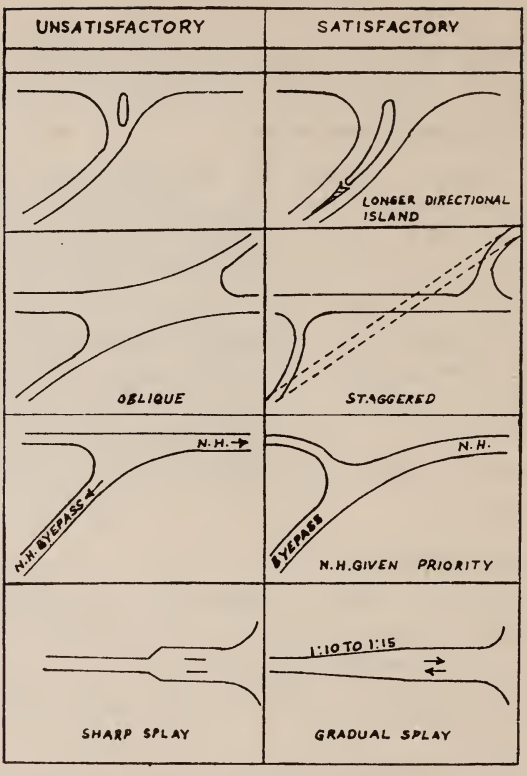


FIG. 3.14 SATISFACTORY AND UNSATISFACTORY DESIGN OF AT-GRADE INTERSECTIONS

(7) Controlling the entry speed of right turning vehicles is another requirement in design from safety angle. Fig.3.15 illustrates the case relating to a 'T' intersection.

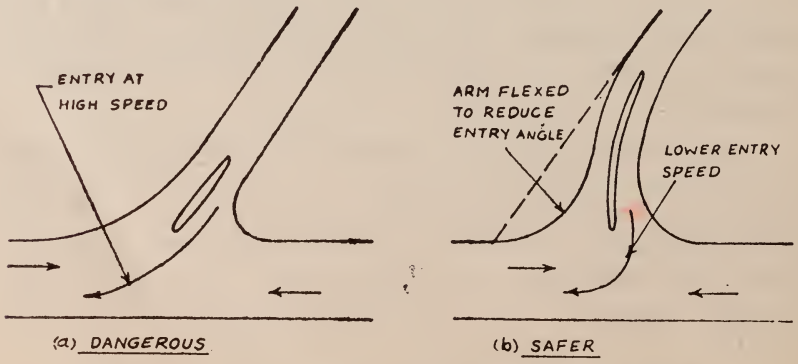


Fig. 3.15. Controlling entry speed of right turning vehicles

(8) Proper treatment at the branching points of byepasses of major highways is very important from safety angle. The section byepassed should invariably be flexed and subordinated to the byepass so that the fast through traffic on the major highway is not misguided into the byepassed or abandoned road. Fig. 3.16. illustrates the case.

(9) Acceleration and deceleration lanes are intended to avoid acceleration or deceleration by the entering and leaving vehicles taking place on the lanes meant for through traffic. These should be provided only where at least one of the roads is a high speed highway, and there are at least 200 turning vehicles per hour. On low-volume intersections, if provided, these lanes will only serve to increase the meandering area for vehicles and add to the hazards. However, the right turning pocket lane carved out of the median has been found to be very useful in reducing the accident rate.

Visibility

(10) A major factor affecting safety at intersections is the visibility or sight distance. There are two considerations which are important to the driver as he approaches an intersection. First is the overall visibility of the junction layout to provide the driver with a clear picture of the type of intersection, the facilities provided for the various movements, the presence of channelising islands and other traffic control devices. Poor alignments can produce 'hidden, intersections with erroneous visual impressions which may lead to incorrect decision by the users.

(11) Locations with straight alignment and near-level grades are the best for intersections. Locations on long and flat valley curves have superior overall visibility, but the down grades should not be steeper than 1 per cent to cause vehicles to accelerate. Locations at top of summit curves have poor visibility but have the advantage of reduced speeds of approaching vehicles. At such locations, rotaries are preferable. However, locations on either side of a summit curve will prove to be highly dangerous. Where such a situation cannot be avoided, the junctions should be located at a distance equal to at least the safe stopping sight distance

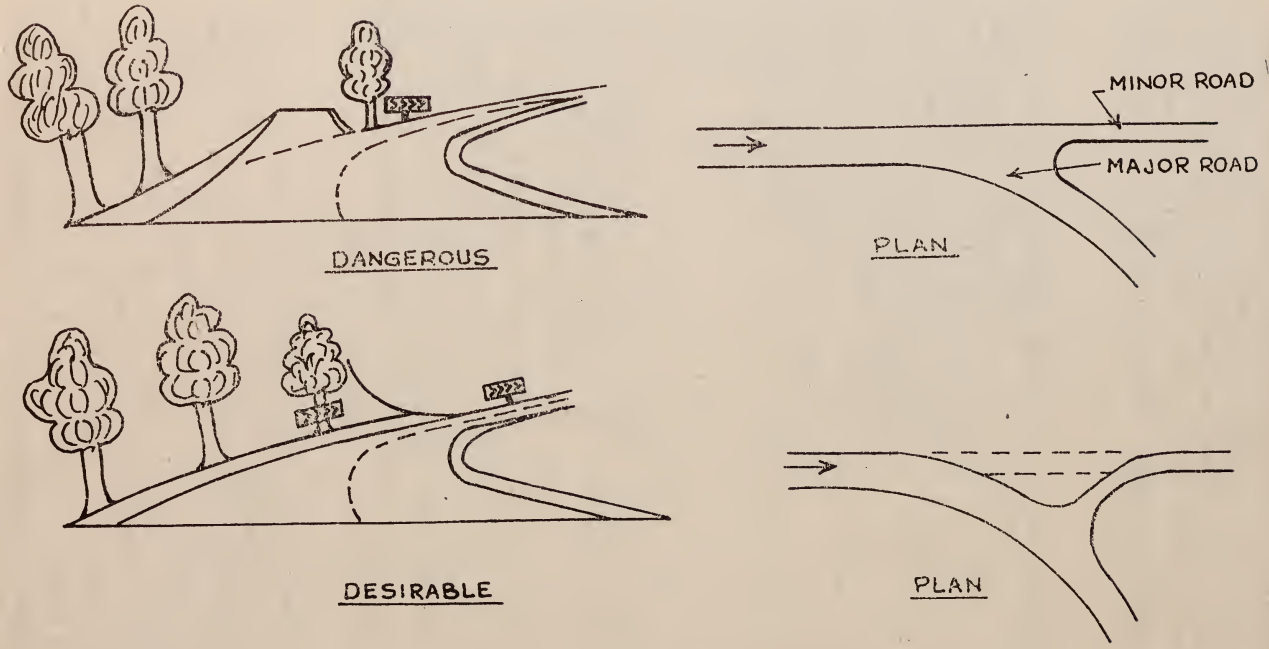


Fig. 3.16. Treatment at branching point of byepasses to avoid misdirection to through traffic

away from the summit and where the grade is the flattest and not steeper than 2 per cent.

(12) The second improtant requirement towards safe negotiation of an intersection is the right triangle visibility. After a driver becomes aware of approaching an intersection, he must be able to observe and comprehend the speed and direction of approaching traffic to his right and left. The driver must be able to see sufficient distance along the cross road to allow him to judge if he can make a crossing by suitably adjusting the speed or he must come to a stop.

(13) There are two specific conditions that are relevant to minimum sight triangle. These are :

(i) 'Uncontrolled intersections' where the intersecting roads are of more or less equal importance and there is no established priority.

(ii) 'Priority intersections' like an intersection between major and minor roads where the major road has the priority for movement while the entry from the minor road is controlled by 'STOP' or 'GIVE WAY' signs and stop line markings.

Sight distance requirements in both these cases are illustrated in Figs.3.17 and 3.18.

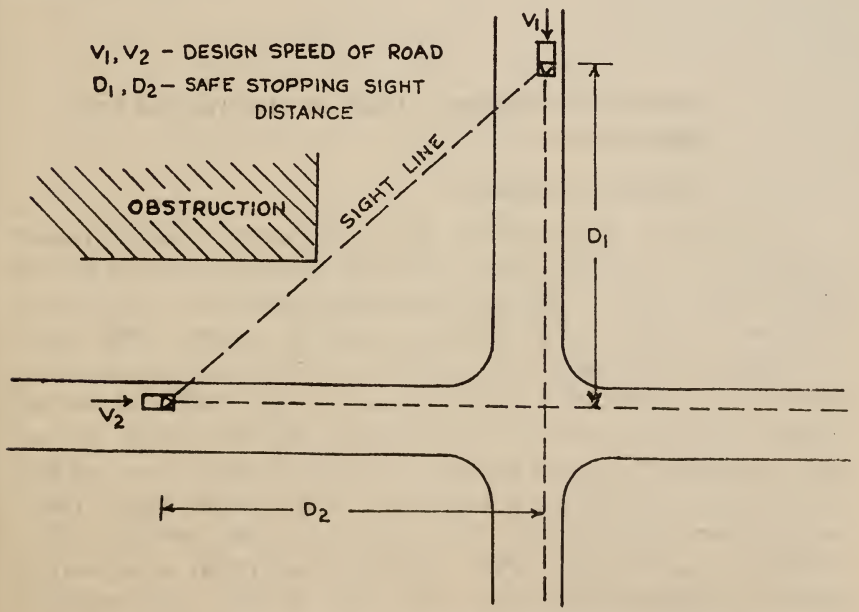


Fig. 3.17. Minimum sight triangle at uncontrolled intersection

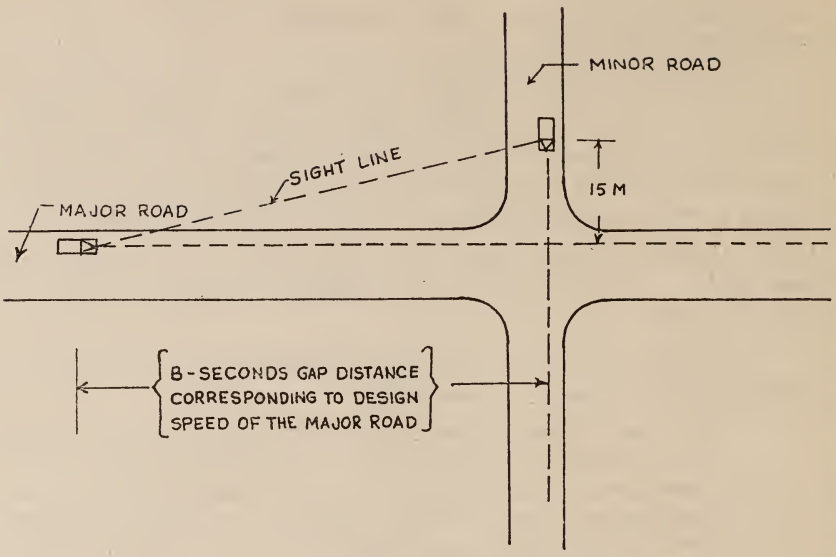


Fig. 3.18. Minimum sight triangle at priority intersection

3.4. Roadside Developments, Roadside Hazards and Road Appurtenances

3.4.1. Ribbon development

(1) Ribbon development along highways i.e. development of commercial business and residential activity on either side of the highway close to the road boundaries generates a lot of local traffic and throws up pedestrians and slow-moving traffic on to the highway resulting in criss-cross movements, restriction to sight distance, distraction to drivers of through traffic, all leading to utter confusion and serious hazard. Encroachment of road land, sometimes even the roadway area by hawkers, vendors and petty shops, and parking of trucks and other vehicles on the roadway for long periods add further dimensions to the problem. The problem is particularly acute and highly hazardous at sections of highways approaching major cities and towns. This aspect is dealt with in greater detail in para 3.4.2.

(2) Measures for the prevention of ribbon development along highways is discussed at length in I.R.C. Special Publication No. 15-1974 'Ribbon Development Along Highways and its Prevention'. Some of the measures which can pay quick dividends are :

(i) Construction of parallel service roads for segregating local and slow traffic from the main highway.

(ii) In the absence of adequate land, provision of railing barriers and maintaining the footpaths in good order for encouraging pedestrians to use them.

(iii) Development of off-road facilities like truck parks at intervals for the purposes of rest, refreshment, vehicle repairs, etc., for truckers.

(iv) Strict enforcement of no-parking restrictions on the roadway and removal of encroachments on the road land.

(v) Proper location of bus stops on lay-byes (see para 3.4.5) or in off-road terminals.

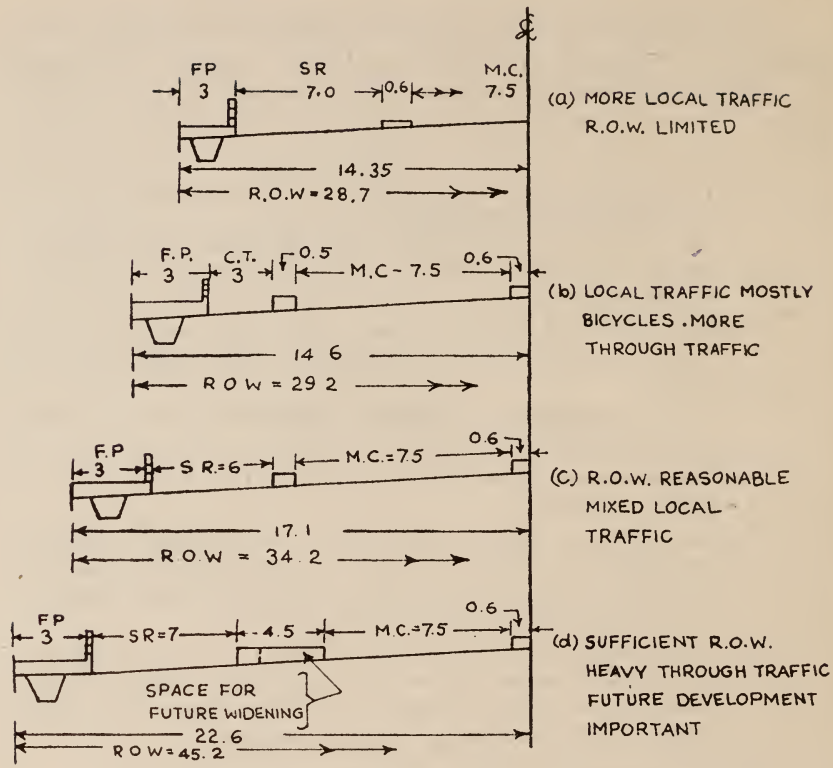
(vi) Controlling the location and frequency of fuel-filling stations in accordance with IRC: 12-1983 "Recommended Practtice for Location and Layout of Roadside Motor-Fuel Filling & Motor-Fuel Filling-cum-Service Stations (Second Revision)".

(vii) Check barriers for various purposes should as far as possible be combined into single ones so as to control their proliferation where constructed these should conform to the type designs recommended in IRC: 41-1972 'Type Designs for Check Barriers'.

3.4,2. Highway sections approaching cities and towns

(1) Sections of highways approaching cities and towns are more vulnerable to ribbon development and encroachment. This is for the reason that such locations generate a lot of business with vehicles, drivers and passengers coming from long distances. The local developments drastically reduce the free passage of vehicles, and such situations will prove to be highly hazardous for drivers who till then have been driving at high speeds on the rural sections of the highway.

(2) For such sections, besides taking action on the prevention of ribbon development, removal of encroachments, etc. as discussed in para 3.4.1., the roadway itself should be suitably widened and provided with safety measures (like pedestrian crossings and railing barriers). The widening treatment will depend on the available right-of-way, the proportion and type of local traffic, etc. Fig. 3.19. shows a few typical cross-sections along-



LEGEND:

F.P. – FOOTPATH (MIN. WIDTH 2 m)
S.R. – SERVICE ROAD (MIN. WIDTH 5.5 m)
C.T. – CYCLE TRACK (MIN. WIDTH 3 m)
M.C. – MAIN CARRIAGEWAY
R.O.W. – RIGHT-OF-WAY
– RAILING BARRIER

NOTES:

1. THE WIDTH OF FOOTPATH, CYCLE TRACK AND SIDE DRAIN MAY BE ADJUSTED AS PER REQUIREMENT AND AVAILABLE R.O.W. ALSO, SEE IRC: 86 FOR MORE DETAILS
2. ALL DIMENSIONS ARE IN METRES.

Fig. 3.19. Typical cross-sections for highway sections approaching cities/towns

with suggestions on their application. These may be taken for guidance only, and may be adjusted according to actual needs and available right-of-way. In the design of the main carriageway, service road, cycle track and footpath, guidance can be had from IRC:86-1983 'Geometric Design Standards for Urban Roads in Plains'.

3.4.3. **Approaches to bridges**

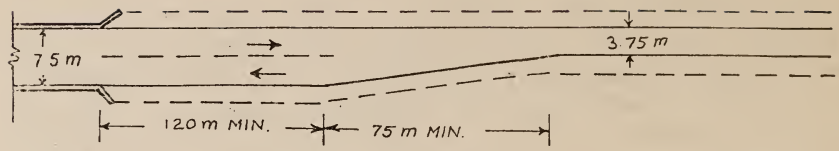
(1) The present practice in India is to curtail the shoulders at all bridge structures except culverts. However, there are numerous locations on the highways where bridges do not have even the widths equal to the flanking road carriageways.

(2) A motorist driving along an open highway (presence of shoulders and absence of lateral obstructions gives him confidence to drive fast and even along the carriageway edges), when he suddenly meets with a bridge structure (absence of shoulders, and presence of lateral obstructions like kerbs and parapets) he has to adjust his speed and lateral position quickly, as otherwise he may collide with the kerb or parapet or other protruding members of the structure. The situation becomes more critical and highly hazardous if the bridge roadway is narrow and there is already a vehicle on it. Failure to comprehend the situation and make adjustments in position and speed has quite often been the cause of serious accidents including tripping of vehicles into the water course below. Some of the measures for avoiding such critical situations are:

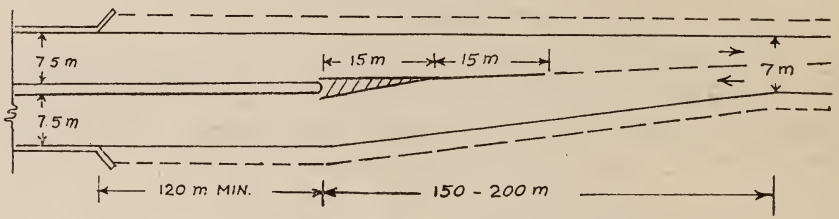
(i) Ensuring adequate visibility of the bridge structure from the approaehing roads for a distance equal to at least 1.5 times the safe stopping sight distance.

(ii) Avoiding road intersections for a distance of at least 200 m from either end of the bridge.

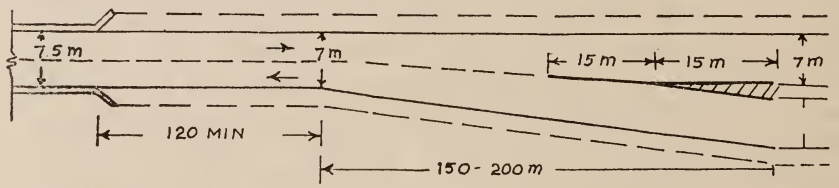
(iii) Providing suitable transitions to the roadways where their widths differ. Three common cases occur: (a) road built to single lane while the bridge is of two-lanes; (b) road built to 2-lanes while the bridge is of 4-lanes; and (c) road built to 4-lane divided cross section while the bridge is of 2-lanes in the first instance to be widened at a future date. Suggested treatments for these cases are shovn in Fig.3.20.



(a) SINGLE LANE ROAD – TWO LANE BRIDGE



(b) TWO LANE ROAD – FOUR LANE BRIDGE



(c) FOUR LANE ROAD – TWO LANE BRIDGE

Fig. 3.20. Transition at bridge approaches

(iv) In the case of narrow bridges, posting of advance warning signs and painting of the ends of the parapets in bands preferably with reflectorised paint.

(v) Providing guard-rails (discussed in more detail in para 3.4.8.)

(vi) In the case of underpasses, piers and abutments built close to or within the traffic lanes may cause accidents due to their sudden appearance. These should be protected with guard-rails or concrete barriers not only to reduce the severity of impact but also to redirect any erring vehicle to its normal path.

3.4.4. **Railway level crossings**

There are a large number of railway level crossings along the highways in the country, and a good proportion of these are still unmanned. While the phased programme of converting all the unmanned crossings in to manned ones and the heavily

trafficked ones into overbidges/subways should be accelerated, all possible measures should be taken for improving safety at the crossings still existing at level. The measures should include:

(i) Provision of adequate visibility including clearance of the sight triangles as at road intersections.

(ii) Removal of obstructions or irrelevant information like advertisements from the immediate vicinity of the crossing.

(iii) Provision of warning signs including advance warning signs in accordance with IRC:67-1977 'Code of Practice for Road Signs'.

(iv) Provision of flashers or automatic stop signals linked with railway signals to give warning of approaching trains. At unmanned crossings automatic audio-visual signals as the one developed by the RDSO should be provided.

(v) The design of the crossing and the approach roads should be in accordance with IRC:39-1970 'Standards for Road-Rail Level Crossings'.

3.4.5. Pick-up bus-stops

(1) Bus system is an important means of transportation both in the rural and urban areas in the country. People swarming the roads near the bus stops is a common sight. Besides risks arising out of passengers alighting or boarding a moving bus which can be controlled only through discipline, there can be other factors causing serious accidents at bus stops. These may be as a result of:

(i) Visibility obscured by standing vehicles, and a through vehicle running over waiting or alighting bus passengers.

(ii) Bus stopping on the main carriageway itself thus blocking part of the roadway and causing serious obstruction to other vehicles; and

(iii) Bus stop located too near and preceding an intersection, and the bus not having sufficient distance to merge with the main traffic to negotiate turning movements.

(2) For avoiding these hazards, certain measures are necessary both in the design and operation of bus stops. Important among these are :

(i) Bus stops should be located at places where there is adequate visibility and the grades are flat or gentle;

(ii) There are two ways of providing bus bays, viz. one by carving out an additional width adjoining the main carriageway, and the second

by having an exclusive lay-bye separated from the main carriageway. As far as possible, except for very lightly trafficked roads, the second alternative of having a separate lay-bye should be adopted. This will provide for safe refuge area for passengers and obviate the possibility of waiting people swarming the main carriageway;

(iii) The bus bay area should be properly drained and maintained in good order;

(iv) The bus stops and bays should be sufficiently away from an intersection, and should have easy entry and exit. Guidance in location and design of pick-up bus stops can be had from IRC : 80-1981 'Type Designs for Pick-up Bus Stops on Rural (i.e. Non- urban) Highways'; and

(v) No-parking regulation for a distance of 100 m from either side of bus bay turning curves should be strictly enforced.

3.4.6. Avenue trees

Roadside trees have been a traditional complement of all old roads including main highways in the country. Planted with an eye on the provision of shade to pedestrain and animal-cart traffic, they have been accepted as a part of the road. However, with the advent of fast motorised traffic, trees too close to the roadway are proving to be a serious traffic hazard. Experience shows that the trees should be located at a minimum distance of 10-12 m from the centre of extreme traffic lane to provide recovery area for any wayward vehicle running off the road. This clearance distance for planting trees should be adopted for all new roads. For existing roads, there should be a phased programme for removing trees falling within the clearance area with side by side plantation of new trees beyond the clearance zone. First priority for removal should be for trees falling along outside of horizontal curves (since vehicles are more prone to trip off the roadway at these places) and those on inside of curves obstructing visibility. Trees allowed to remain should be painted in white colour for a height of 1.25 m above roadway level with 300 mm middle band in black colour to warn road users of their persence. For better night visibility, it will also be preferable to fix on their face a piece of red reflectorised tape, disc or paint.

3.4.7. Kilometre stones, sign posts and utility poles

(1) Position of kilometre stones, sign posts and utility poles is another factor relating to road accidents. Vehicles going off the

carriageway may strike them resulting in accident.

(2) Kilometre stones on embanked roads should be fixed at the edge of the roadway outside the shoulder on specially erected platform. In cutting, they should be fixed clear of the shoulder and the side drain. For more details, reference may be made to IRC : 8-1980.

(3) For road signs, the minimum lateral clearance from carriageway edge should be 600 mm for kerbed roads and 2 m for unkerbed roads (see also para 3.6.4.).

(4) For utility poles, the clearances should be as per IRC : 32-1969.

3.4.8. **Guard-rails**

(1) Guard-rails are used where vehicles accidentally leaving the roadway would be subjected to considerable danger or where there are abrupt changes in roadway widths as at approaches to bridges, or for protecting the components of subway structures like piers and abutments located in the proximity of the travelled way. The purpose is to restrain and redirect out-of-control vehicles away from the danger zone and opposing traffic flows.

(2) Warrants for installation of guard-rails have been developed in countries like the U.S.A., and if these are applied directly to roads in the country it will be found that most of the highways will require guard-railing for most of their lengths. This is neither feasible, nor necessary since speeds of vehicles in the country are relatively low. At the same time, there are vulnerable areas where guard-rails have a very useful role to play. The approach should, therefore, be to identify the critical areas or the combination of critical parameters, and prepare a priority-wise list for phased action.

(3) The critical parameters are the high probability of a vehicle leaving the roadway (e.g. at outside of sharp horizontal curves, approaches to a narrow bridge, etc.) and the degree of danger awaiting such a vehicle (e.g. deep valley, deep water course or ditch, etc.). This means that outside of a sharp horizontal curve falling on the valley side, and high approaches to a

narrow bridge will claim a high priority. Another way of according priority is to analyse the locations where accidents are caused due to vehicles tripping off the roadway.

(4) Common designs of guard-rails are shown in Fig. 3.21. In their installation, they should be located somewhat away from the useful shoulder line and at about the same elevation. It is desirable to flare the guard-rails outwards for a short distance at the end of tariffic approach and anchor the ends of guard-rails in order to lessen possible direct impact and to provide a full view to the driver. A typical guard-rail treatment at a bridge approach is shown in Fig. 3.22.

3.4.9. **Roadside facilities**

(1) Long distance drivers need rest and recreation enroute. A driver who has rested will be fresh and alert, and is less likely to commit mistakes. From safety angle, therefore, it is desirable to provide the necessary facilities on all through highways.

(2) **The facilities may be in the form of :**

(i) Roadside lay-byes at scenic spots for the travellers to park their vehicles and relax for sometime with provision for drinking water and light refreshments;

(ii) Off-road rest areas for night halt. Such places should have facilities for over-night halt, food and vehicle repair; and

(iii) Truck parks with facilities for night halt, food, vehicle repair; and parking for long distance truckers.

Detailed guidelines on the provision of these facilities are contained in the IRC Special Publication No. 21 "Landscaping of Roads".

(3) Besides providing rest and recreation for road travellers, the above mentioned facilities will help traffic safety from the following angles :

(i) Discourage parking of vehicles on the roadway itself; and

(ii) Discourage the mushroom growth of roadside tea/eatable shops and vendors.

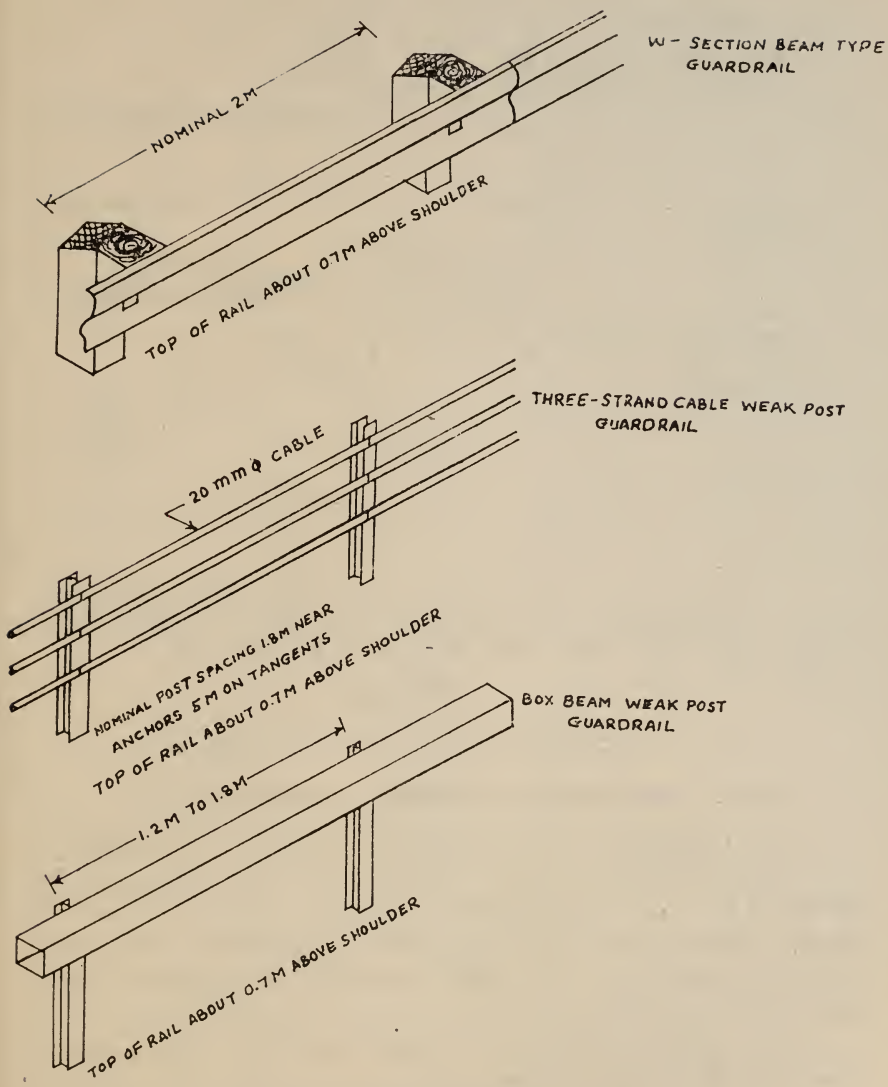


Fig. 3.21. Common designs of guard-rails

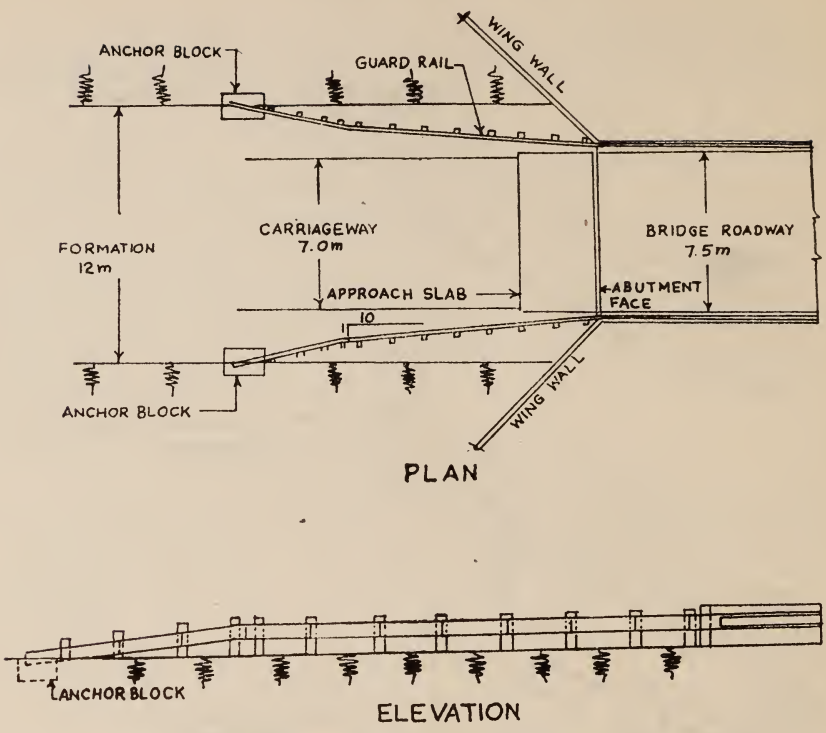


Fig. 3.22. Typical guard-rail treatment at bridge approaches

3.4.10. Arrangements for traffic at construction sites

(1) On occasions it may become unavoidable to suspend or direct traffic from a section of a highway for improving/repairing the highway or cross-drainage structures, or a breach caused by floods. Disproportionately large number of accidents are known to have occurred at such sites due to poor geometrics or inadequate guidance to the motorists.

(2) Basic principles to be kept in mind at such locations from the point of view of safety are ;

(i) Traffic must be guided properly if it is required to follow an alternate path;

(ii) Display of clear warning about any hazards that may be present, including posting of advance warning signs; and

(iii) Geometrics of alternative facility or diversion should be such as to allow smooth and safe flow of traffic.

(3) Fig. 3.23. illustrates the typical arrangements that could be made during widening/reconstruction of cross-drainage structures. Adequate warning signs, pavement markings and geometrics, as shown in the figure, if strictly adhered to, could result in drastic reduction of severe accidents. At both ends, the diver-

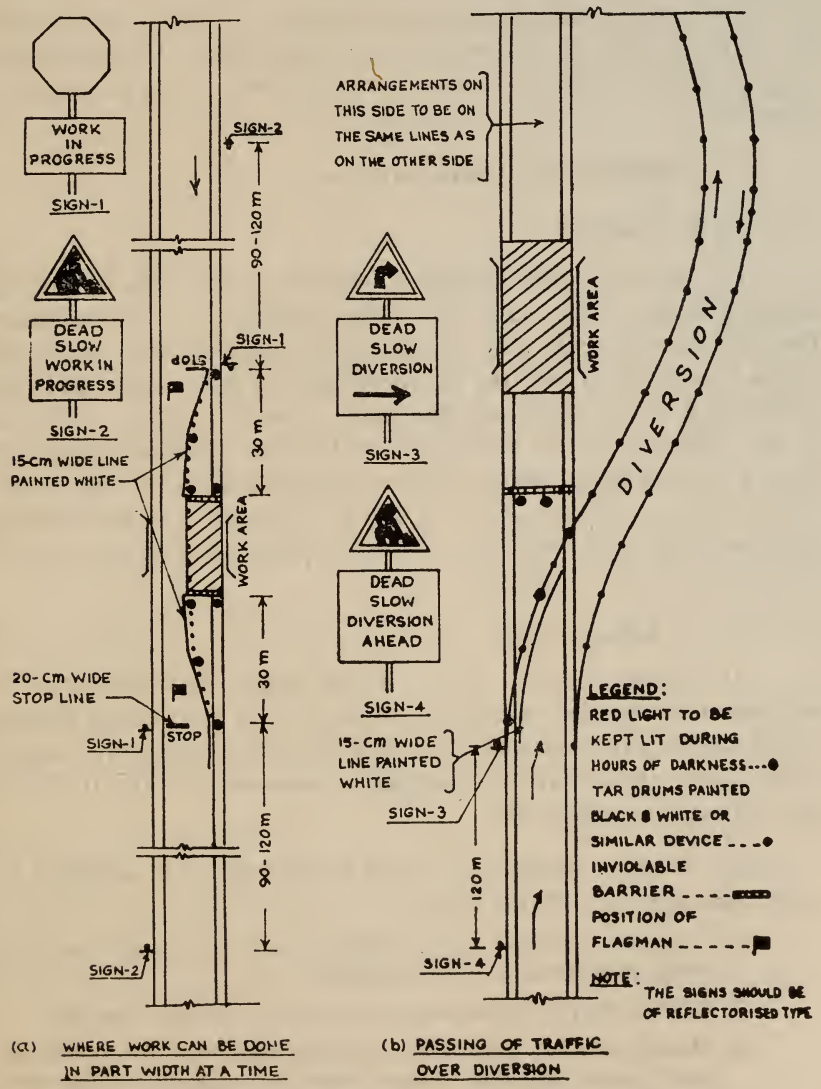


Fig. 3.23. Arrangements for traffic when a cross-drainage structure is to be reconstructed

sion should be joined to the main carriageway with smooth transitions keeping in view the grade and visibility requirements.

(4) Another important requirement from safety angle is that at the end of day's work, all the construction equipment should be parked outside the main roadway. If this is not possible, they should be parked at the extreme edge of the shoulders and provided with red lamps on both sides during the hours of darkness.

3.5. Road Surface Characteristics

3.5.1. General

The two important attributes of road surface characteristics affecting traffic safety are the riding quality and skid resistance. The riding quality refers to the surface evenness of the pavement which in conjuction with the characteristics of the vehicle and the quality of driving determines the riding comfort. Skid resistance is the frictional force developed at the tyre—pavement interface when a tyre on being prevented from rotating, skids on the pavement surface. Longitudinal friction is needed for acceleration and deceleration whereas lateral friction becomes important while negotiating horizontal curves.

3.5.2. Riding quality

(1) Riding quality has a direct impact on traffic safety in the sense that an uneven surface or a road with poor riding quality causes undue jerks and vibrations and this leads to early fatigue of the driver and impairs his judgment manoeuvrability, all leadidg to hazardous situations.

(2) Riding quality of a road pavement can be assessed by a number of ways. These are :

(i) Subjective assessment by a panel of raters on a 5-point scale while riding on a vehicle at constant speed;

(ii) Measurement of surface irregularities under a straight edge; and

(iii) Measurement of unevenness by special equipment like profilograph which plots the road surface profile, or a bump integrater which cumulates the unevenness in terms of cm/km while riding at a constant speed employing a fixed diameter wheel. Besides safety, since riding quality is an important factor affecting vehicle operating cost,

it will be a good practice to assess the riding quality at least once in a year for planning maintenance and other remedial measures.

(3) Surface unevenness of a pavement, to a great extent is influenced by the unevenness built in at the time of construction. It is, therefore, important that all care is taken about surface regularity at the time of construction/reconstruction. For guidance in this regard, reference may be made to IRC : SP : 16-1977 'Surface Evenness of Highway Pavements' which lays down the norms and makes suggestions on their achievement.

3.5.3. Skid resistance

(1) Skid resistance has not been a major factor for roads in the country in view of the predominant use of open graded surfacings and relatively lower speeds. However, this aspect is gaining importance in view of the progressive use of smoother surfacings and the development of high speed highways.

(2) Identification of potential slick spots can be made in a number of ways. Some of these are :

(i) Predominance of single vehicle accident indicates skidding possibilities:

(ii) Higher proportion of accidents during wet weather indicates skidding potential;

(iii) Absence or inadequacy of superelevation at horizontal curves may lead to skidding accidents;

(iv) Bleeding bituminous surfaces have high skid-risk potential;

(v) Horizontal curves on heavily trafficked roads provided with asphaltic or cement concrete surfaces, particularly attended with oil spillage from vehicles have high potential for skidding.

(3) Measures for correcting the slick spots include the provision of skid-proof surfacing, correction to superelevation at horizontal curves, sand blotting of bleeding surfaces, etc. For more details, reference may be made to I.R.C. Highway Research Board Special Report No. 2-1976 'State-of-the Art: Pavement Slipperiness and Skid Resistance'.

3.6. Traffic Regulation and Control

3.6.1. General

(1) Traffic regulation is concerned with matters relating to

the control of vehicles, drivers and other road users, and the manner of their using the road space. In India, the traffic is mixed in character, and the spectrum of vehicles range from fast moving passenger cars to slow moving animal carts, hand carts, etc. each competing for the available road space. Well thought-out regulation and control measures are therefore of paramount importance for the safe and efficient movement of vehicles and pedestrians having different physical and speed characteristics.

(2) Traffic regulation and control measures can be dealt with under three broad heads, namely :

(i) Legislative measures;
(ii) Engineering measures; and
(iii) Traffic control devices.

For best results, it is important that all these measures should complement and supplement one another, and should be backed by effective enforcement.

3.6.2. **Legislative measures**

(1) In India, the Motor Vehicles Act 1939 as amended from time to time along with the local legislations provide the basis for regulating vehicles, drivers, and traffic movement. Under these, adequate provisions have been made to control and manage vehicular traffic through traffic laws covering different aspects such as dimensions and weights of vehicles, speed limits, restrictions on the use of certain vehicles on specified routes, parking places, traffic signs, etc. Some of these measures are discussed in the following paragraphs.

Regulation of speed

(2) Imposition of speed limit is a powerful tool in traffic regulation and safety, and the general experience has been that it brings down the number of those who drive at high speeds and reduces accident rate. Regulation of speed may be warranted in the following situations :

(i) In urban areas, because of the mixed traffic, too frequent intersections and large pedestrian flows, particular care is warranted in the vicinity of schools and colleges.

(ii) In rural areas for the control of heavy commercial vehicles.

(iii) At small villages (not covered under urban area) located along rural highways for the protection of pedestrians and other slow traffic.

(iv) At locations where geometric deficiencies do not permit higher speeds, such as at sharp horizontal curves and at locations having restricted visibility.

(3) A variety of factors influence the value of speed limit to be applied. Important among these are :

(i) **Running speed of traffic**—normally, the 85th percentile speed of vehicles is selected for speed limit. Speeds survey would yield data to determine this.

(ii) **Road conditions**—the geometry of the road, gradient, sight distance, street lighting, safety measures for pedestrians, etc. are some of the aspects that should be studied before selecting the speed limit.

(iii) **Environment of the road**—the extent of roadside development, the frequency and nature of access points, the presence of schools, play fields, cinema houses, and places of worship attracting large crowds are some of the conditions governing the speed limit.

(iv) **Traffic**—the volume and mixed nature of traffic also govern the speeds limits. For heavy commercial vehicles, lower speed limits. should be applied because of their potentiality for more serious accidents.

(v) **Accident rates**—Analysis of past accident rates will give positive indication whether there is any need of imposing speed limits, and if so the actual limit.

(4) The speed limits suggested in the Motor Vehicles Act for rural areas are reproduced in Table 3.4. The speed limits recommended by the Indian Roads Congress (IRC : 70-1977 'Guidelines on Regulation and Control of Mixed Traffic in Urban Areas') for application to mixed traffic conditions in urban areas are given in Table 3.5.

(5) Posting of speed limits alone is not just sufficient, and there should be strict enforcement. A variety of equipment like enoscope and radar speed meter are available for detecting speed violation, and these have become popular with the enforcement authorities.

Regulation of vehicles

(6) Regulation of motorised vehicles covers the following aspects :

(i) Vehicle registration

TABLE 3.4. SPEED LIMITS PRESCRIBED IN THE MOTOR VEHICLES ACT, 1939

Class of vehicle		Maximum speed km/h
(1) Vehicles without trailers		
(i) Light motor vehicles or a motor cycle	...	No limit
(ii) Medium or heavy passenger motor vehicle	...	60
(iii) Medium or heavy goods motor vehicle	...	60
(2) Articulated heavy motor vehicle	...	50
(3) Vehicle drawing not more than one trailer		
(i) Vehicle being a light motor vehicle, and trailer being two-wheeled having a laden weight not more than 800 kg	...	60
(ii) Vehicle being a light motor vehicle, and trailer having more than 800 kg	...	50
(iii) Vehicle being a medium motor vehicle	...	50
(iv) Vehicle being a heavy motor vehicle	...	40
(v) Vehicle being a heavy motor vehicle used by the fire brigade	...	50
(4) Any case not covered by above	...	30

TABLE 3.5. SPEED LIMITS RECOMMENDED FOR DIFFERENT TYPES OF VEHICLES IN URBAN AREAS

Road category	Speed limit—km/h	
	Group I	Group II
	Light and medium vehicles	Heavy vehicles
(1) Major roads of arterial/sub-arterial character mostly in open and thinly built-up areas	50	40
(2) Roads with moderate traffic situated in semi-built-up areas	40	30
(3) Congested roads in built-up areas	30	20

(ii) Construction and equipment of vehicles
(iii) Size, weight and loads of vehicles
(iv) Lighting of vehicles
(v) Inspection of vehicles
(vi) Control of transport vehicles
(vii) Insurance

On some of these aspects, State Governments are empowered to make rules for effective enforcement.

Regulation concerning the driver

(7) Regulations concerning the driver as provided in the Motor Vehicles Act cover the following aspects :

(i) Licensing of the driver
(ii) Requirements of physical fitness
(iii) Age of driver
(iv) Disqualification and endorsement of licences.

The present regulations are adequate to ensure physical fitness and driving ability on the part of the driver, but what is crucial is the strict enforcement. The drivers are expected not to drive in a rash and negligent manner and failure to observe this is deemed to be an offence. Driving under the influence of liquor or drugs, and driving when mentally or physically unfit are also punishable offences.

Regulation of non-motorised traffic

(8) Cyclists constitute a large number amongst those driving a non-motorised vehicle in urban areas. By and large no licence is required to ride a bicycle, and the cyclists do not feel obliged to acquire any formal knowledge of traffic rules and regulations. The result is that a large number of accidents have been taking place in the city streets which can be attributed to the cyclists not having proper traffic sense or the bicycles not fitted with the necessary safety equipment like bell, light, reflector or brake. For ensuring smooth and safe flow of cycle traffic under mixed traffic conditions as obtaining on our roads, the following rules could be considered for enforcement :

(i) Making it compulsory for the bicycles to be provided with head lamp, back reflector, bell and brakes;

(ii) Making it obligatory for the cyclists to use the separate cycle tracks, where provided;

(iii) Prohibiting the cyclists from carrying any other person on the vehicle, or loads other than what can safely be accommodated in the front basket or the rear carrier;

(iv) Prohibiting the cycles from being towed by any other vehicle;

(v) Ensuring that not more than 2 cycles remain abreast except on cycle tracks; and

(vi) Making it obligatory for the cyclists to keep to the extreme left of the carriageway where no separate cycle tracks have been provided.

(9) As regards hand-pulled and animal-drawn carts, the following regulations, if enforced, would be useful from safety angle :

(i) Making it obligatory for them to carry a lantern at night and to fix red reflectors at the rear;

(ii) Prohibiting the use of any cart from carrying pipes or rods longer than 5 m. Ends of these loads should be provided with red flags during day time and red lamps during hours of darkness;

(iii) Making it obligatory for the carts to ply only on the slow carriageway wherever provided. Where such a facility is not there, the carts should be made to keep to the extreme left of the carriageway; and

(iv) Prohibiting the plying of the carts on fast busy roads at least during the hours of peak traffic.

Regulations of pedestrians

(10) In urban areas, a substantial number of fatalities in accidents pertain to pedestrians. It is, therefore, important to regulate the movement of pedestrians for which purpose enforcement of the following may be helpful :

(i) Making it obligatory for the pedestrians to walk on the footpaths where such facilities have been provided; and

(ii) They must be made to cross the roads by subway or pedestrian overbridges where such facilities have been provided. At other locations they should be permitted to cross the road only at pedestrian crossings.

Prohibiting certain types of vehicles on certain roads

(11) Most of the problems of congestion arises during the peak hours, and it will be worth considering the prohibition of the vehicles which create the maximum congestion. This, how-

ever, will be successful only where a suitable alternative route is available. The measures can be :

(i) Prohibiting the plying of heavy commercial vehicles and slow-moving carts during the peak hours; and

(ii) Prohibiting the plying of heavy commercial vehicles along routes where schools are located, during the opening and closing hours of the schools.

Parking regulation

(12) The phenomenal growth of motor vehicles in towns and cities has brought into sharp focus the problem of parking. A vehicle parked on the road occupies some road space which could otherwise have been used by a moving vehicle, and also causes obstruction to visibility which is particularly crucial at intersections. Safety, comfort and convenience of road users demand a proper and effective regulation of parking.

(13) The parking problem which is becoming acute particularly in the CBD areas can be looked at from two angles:

(i) Controlling the parking demand through town planning measures and augmenting the parking supply through engineering measures; and

(ii) Regulating the effective utilisation of the available parking spaces.

As regards the first aspect, the measures include control on the construction of multi-storeyed commercial and office complexes, cinema halls, etc., which generate huge parking demand, and insisting on providing their own parking spaces. Guidance on the need for parking spaces for different types of buildings can be had from IRC: SP: 12-1973 'Tentative Recommendation on the Provision of Parking Spaces for Urban Areas'. Side by side, the supply-demand position of parking spaces should be assessed periodically by parking surveys, and further augmentation in the form of off-street parking spaces, multi-storeyed parking garages, etc. should be thought of.

(14) For the effective utilisation of the available parking spaces with traffic safety in view, the following regulations are normally imposed:

(i) Exclusive parking spaces for taxis and other public service vehicles;

(ii) Reservation of kerb space for bus stops and prohibiting the parking of other vehicles for a distance of 100 m on each side of the stop;

(iii) Restrictions on parking near intersections, for a distance of at least 100 m on each side;

(iv) Designation of parking spaces along the roadway edges at certain locations;

(v) Prohibition of parking along heavily trafficked roads during peak hours; and

(vi) Parking control by fees.

3.6.3. Engineering measures

(1) Engineering measures of traffic regulation include segregation of traffic by their operational characteristics, provision of suitable facilities for the safe movement and crossing of pedestrians and cyclists, measures for safe and quick movement of vehicles, etc. Some of these are discussed in the following paragraphs.

Segregation of traffic

(2) Movement of mixed traffic in the same stream causes friction between vehicles of different operational characteristics, and reduces the speed and capacity. Further, in a mixed stream, motor vehicles are subject to frequent stop-start or deceleration -acceleration operations resulting in wastage of fuel and intense atmospheric pollution. All this can be obviated by segregating the slow moving vehicles from the fast moving ones. Segregation can be effected by providing separate carriageways, atleast 5.5 m wide, for slow traffic. The actual cross-section to be adopted will depend on the available land width. Where land is limited, it will be worthwhile to combine the space for bicycles, other slow-vehicles and local traffic into a single carriageway on each side with separate lanes for fast moving through traffic instead of a common carriageway for all. Fig.3.19, shows a few typical cross-sections effecting traffic segregation.

One-way streets

(3) Adoption of one-way system of street operation for dealing with large volumes of mixed traffic on narrow streets

has proved to be successful in many cases. One-way street system results in better utilisation of the available streets, improved safety because of reduced conflicts at intersections, elimination of head-on collisions and headlight glare from on-coming vehicles, higher operating speeds for vehicles, and involves least cost compared to other alternatives. This system is eminently suited where grid-iron pattern of roads exists, and for other cases should be considered only where parallel streets of adequate capacity are available at intervals not exceeding 200 m and it is possible to merge the two one-way streets at a suitable point into two-way streets.

Provision for through traffic passing through cities and towns

(4) In cities and towns falling in the route of through highways like the National Highway, a major safety problem is created because of the through traffic moving on the congested urban streets. There are two ways of tackling this problem:

(i) Segregating the local and slow-moving traffic by constructing service roads, footpaths etc., so that the through traffic can flow unhindered. This however is possible only when the urban link has a land width of at least 30 m, and

(ii) Constructing a byepass for the through traffic.

In either case, it will be desirable to carry out an economic analysis for choosing the best alternative.

Facilities for commercial traffic

(5) Many of the busy arterial roads in the heart of cities/towns are dotted with warehouses, wholesale markets and commercial establishments where loading/unloading of goods constitutes an important activity. In the absence of any lay-byes, the trucks park on the main carriageway for long periods, thus usurping the precious space of the moving traffic. Further, the unloaded goods and those waiting to be loaded are stacked on the footpaths intended for pedestrians. All this contributes to serious congestion, confusion and traffic hold-ups leading to hazardous situations. Some of the measures for obviating these problems are :

(i) Restricting the loading/unloading of trucks only during the night time when the traffic is low;

(ii) Shifting wholesale markets generating a lot of inflow/outflow traffic to outskirts of the city with in-built facilities;

(iii) Providing truck terminals far away from the city centre with suitable approaches, thereby decentralising the bulk of loading and unloading activities from the congested areas of the city; and

(iv) Insisting at construction stage on all new business premises to provide for off-street loading/unloading facilities.

Bicycle traffic

(6) In the recent past, there has been a phenomenal growth of bicycle traffic in and around cities and towns, and cyclists constitute one of the major groups of accident victims. The movement of cyclists on the main carriageway along with the fast traffic gives rise to traffic conflicts at intersections as well as along narrow congested streets. Some of the solutions for alleviating the situation are :

(i) Segregating the cycle traffic by constructing separate cycle tracks. IRC : 11-1962 'Recommended Practice for the Design and Layout of Cycle Tracks', provides guidelines on the warrants, design and construction of cycle tracks.

(ii) At intersections, particularly the major ones, necessary provisions should be made for the safe movement of cycle traffic. This may be in the form of separate phase for cyclists at multi-phase signalised intersections; provision of cycle boxes ahead of the stop line and separate turning lanes for them; and posting of police with loud speakers for warning erring cyclists and motorists.

Pedestrian traffic

(7) Pedestrians constitute the single largest group of accident victims in urban areas. This is for the reason that the pedestrian volumes are increasing leaps and bounds, and that a substantial proportion of them are not familiar with the traffic rules and regulations. Apart from education and enforcement, certain engineering measures will be highly helpful in improving the safety of pedestrians.

(8) The requirements of pedestrians are sufficient space for walking along the road and earmarked areas for crossing the road with safety. Raised footpaths of adequate width, provided with uniform surface and kept free of vendors, hawkers and other encroachments will provide safe passage for pedestrians along the road and discourage them from spilling on to the main carriageway. IRC : 86-1983 provides guidelines on the design of footpaths

under different situations. Where the streets are narrow and the pedestrian flows are heavy due to commercial/shopping activity, it will be advantageous to reserve these for the exclusive use of pedestrians or as pedestrian precincts.

(9) For the safe crossing of roads by pedestrians, all important intersections should provide for pedestrian cross-walks. Besides this, pedestrian crossings should also be provided at locations which generate pedestrian traffic such as cinemas, schools, etc. The crossings should be visible for adequate distance from either side and provided with "Zebra" markings and pedestrian crossing signs so that the driver of an approaching vehicle will be alerted about the pedestrians crossing the road. The cross-walk can also be made priminent by providing flashing beacons.

(10) Crossing of a busy and wide arterial road by a large number of pedestrians may necessitate the provision of pedestrian sub-ways or over-passes. Such facilities are expensive and should therefore, be provided only when there is sufficient justification for the same. The justification could be the combined effects of pedestrian accidents, and delay to both vehicular traffic and pedestrians. When such facilities are constructed, it will be desirable to post policemen at these locations atleast to guide the pedestrians to cross the road only through these and not otherwise.

(11) Provision of railing barriers at the footpath edges will be helpful in preventing pedestrians from spilling on to the main carriageway, particularly on busy roads and intersections. They also help in preventing pedestrians from crossing the road at their will and force them to cross only at pre-determined and well notified cross-walks. The railings should be of aesthetically pleasing design and should not be too low to permit easy cross-over.

3.6.4. **Traffic control devices**

(1) A traffic control device is any sign, signal, marking or device placed or erected for the purpose of regulating, warning or guiding traffic. Basic requirements of traffic control devices are to :

(i) compel attention;

(ii) permit time for easy response;

(iii) makes its meaning clear at a glance; and

(iv) command respect.

The basic requirements are achieved by appropriate design, placement, maintenance condition, visibility, and uniformity of application.

Road signs

(2) A road sign is a device mounted on a fixed or a portable support to give, in the form of symbols and/or descriptions, warning, direction or guidence to traffic. Road signs have a profound influence on road safety. It has been often found that posting of an appropriate sign has improved safety at an accident-prone spot to a great extent.

(3) The Ninth Schedule of the Motor Vehicles Act, 1939 has been amended to introduce the new system of symbolic signs in conformity with the international signs. Complete details of the signs including guidelines on their erection are contained in IRC : 67-1977 'Code of Practice for Road Signs'. The new system of signs should become fully operational by first June, 1985. For new roads, the complete sign system should be planned at the design stage and installed before opening the roads to traffic. On existing roads, a careful survey should be done to assess the requirements and the signs should be installed and maintained in good condition without loss of time. On rural highways and unlit roads, increasing use of reflectorised signs should be made for improved visibility at night. It is also important to educate the road users of the new system of signs and the message given by them for easy recognition and compliance.

(4) Road Signs are classified into three categories given below :

Mandatory/ Regulatory	...These inform the road users of laws and regulations. Violation of these is a legal offence.
Cautionary/ Warning	...Warn road users of the existence of certain hazardous conditions.
Informatory	...For information and guidance of road users.

So far traffic safety is concerned, mandatory signs are the most important followed by cautionary signs, while informatory

signs although not directly connected with safety, provide useful information for the road user. It should be understood that a wrong or wrongly placed sign is more dangerous than no sign at all.

(5) It is very important that the road user is able to recognise the signs easily and in time. These should be placed on the left hand side of the road in plain/rolling terrain and on the valley side of the road in hills. Care should also be taken that these are not placed in such a way as to obstruct vehicular traffic. On kerbed roads, the edge of sign should be atleast 60 cm away from the edge of the kerb whereas on unkerbed roads the edge of the signs should be at a distance of 2 m from the edge of the carriageway.

(6) The signs should be properly oriented for the drivers to see them at proper time. On horizontal curves, the signs should be placed at right angles to the line of travel of the approaching traffic. On grades, it is desirable to tilt the sign forward or backward to improve the viewing angle.

Traffic signals

(7) Traffic signals fall under two broad categories, namely, fixed time signals and vehicle actuated signals. The Indian Roads Congress is in the process of finalising detailed guidelines on the design and installation of fixed time traffic signals.

(8) Traffic signals are eminently suited for control of traffic at intersection on heavily trafficked urban roads. Where a number of signals fall on the same roads, all these should be synchronised for easy movement of through traffic without delay.

(9) Traffic signals should be installed only where they are warranted. Their use should be avoided on high speed highways or in the proximity of pronounced down grades.

Road markings

(10) Road markings are lines, patterns and words applied on the carriageway or kerbs, on to objects within or adjacent to the carriageway for control, warning, guidance or information of road-users. Because of their position in the normal field of attention

and visual focus, they serve as a very effective means in conveying the intended message to the drivers without diverting their attention from the roadway. Detailed guidelines on the design and application of road markings are contained in IRC : 35-1970 'Code of Practice for Road Markings (with Paints)'.

(11) From safety angle, the most crucial locations for application of pavement markings are at intersections, and at summit curves with limited visibility for marking no-passing zones. Examples of these are illustrated in Figs. 3.24. and 3.25. respectively.

(12) The road markings should be periodically renewed to maintain their functional efficiency.

Road delineators

(13) The role of delineators is to provide visual assistance to drivers about alignment of the road ahead, especially at night. Delineators are classified under three types :

(i) **Roadway indicators** : Located at the edge of usable shoulder, these are intended to delineate the edges of the roadway so as to guide drivers about the alignment ahead.

(ii) **Hazard markers** : These are to define obstructions like guard-rails and abutments adjacent to the carriageway, for instance at culverts and bridges which are narrower than the roadway width at approaches.

(iii) **Object markers** : These are used to indicate hazards and obstructions within the vehicle flow path, for example channelising islands close to intersections.

For details on the design and placement of road delineators, reference may be made to IRC : 79-1981 "Recommended Practice for Road Delineators".

3.7. Accident Recording and Analysis

3.7.1. General

Accidents are incidents on the road involving damage to property, injuries to people, or less of life, or a combination of all these. Accidents have been happening and will continue to happen as long as there is movement on the roads, but the major concern of the people as well as the concerned authorities is how

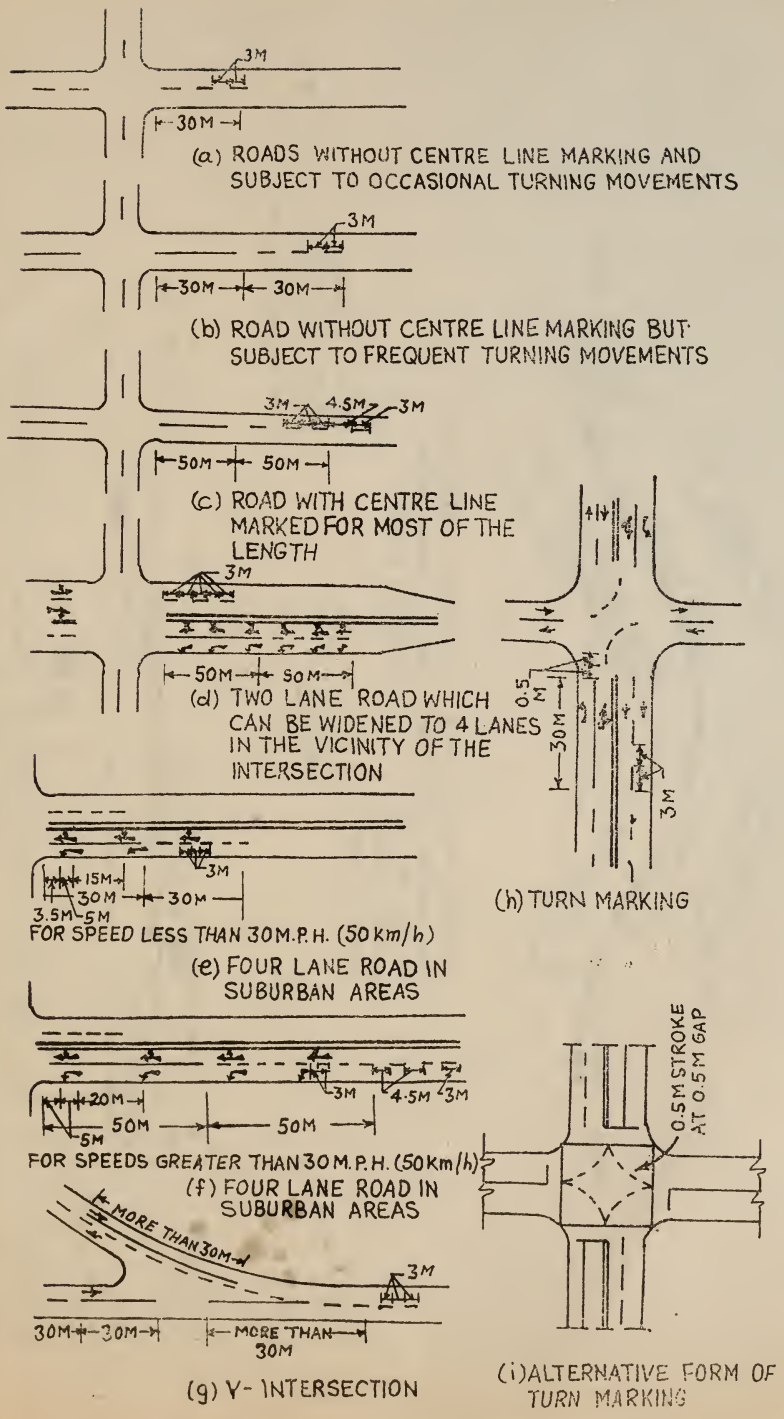


Fig. 3.24. Pavement markings at road intersections

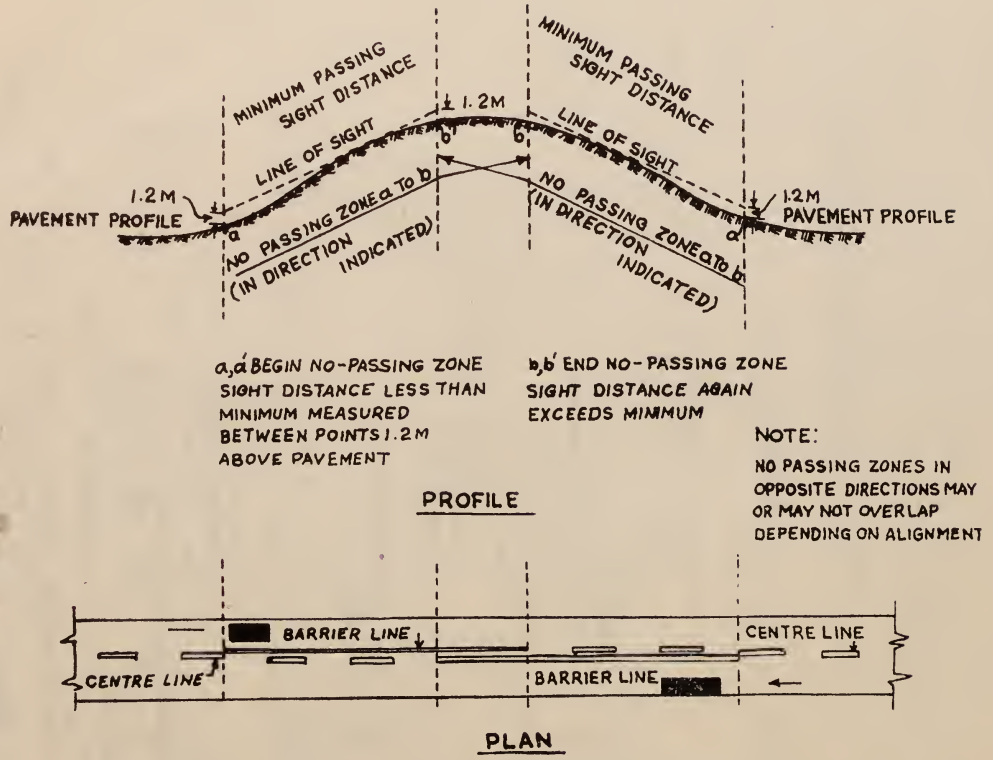


Fig. 3.25. Method of marking no-passing zone on summit curve

to reduce the number of accidents, and even if they happen, how to reduce their intensity and the resulting trauma. This calls for a clear understanding as to why the accidents happen, how they happen, the parameters involved alongwith their relative contribution, etc. and will require properly recorded accident information as a first step in the analysis. The importance of accurate accident information and its objective analysis in any traffic safety programme either at the macro or the micro level, therefore, needs no special emphasis. It should also be borne in mind that the correctness or appropriateness of any remedial measure derived from accident analysis will, to a great degree, depend on the correctness and completeness of the accident information. In view of the voluminous data to be processed, it will be advantageous for the authorities concerned with accident analysis to make use of computer facilities.

3.7.2. **Accident recording**

(1) In India, the Police are primarily responsible for recording road accidents. Details of individual road accidents are recorded by them on Road Accident Form A-1 which was originally introduced in 1939. On the basis of Form A-1, the Police prepare a summary of road accidents occurring during the year in the Road Accident Form-4. These summaries are subsequently utilised by the State and Central Statistical Cells to develop overall accident statistics.

(2) However, the information emenating from these Forms have not been complete or sufficient to make a scientific analysis for the cause of the accidents. To improve the situation, the Indian Roads Congress has finalised revised Forms A-1 and 4 with a view to collecting more specific and detailed information, vide IRC : 53-1982 'Road Accident Forms A-1 and 4'. These forms, if filled in properly, provide the necessary information on the drivers, vehicles and others involved in the accident, the geometric and surface features of the road, environmental parameters at the time of the accident, etc. for facilitating parametric analysis. The format of the Forms has been designed to facilitate computer processing. For ensuring proper filling of these forms, the IRC has plans to organise training courses for police personnel on all-India basis.

3.7.3. Accident analysis

General

(1) A major objective of accident analysis is to discern the factors that have been responsible for the accident and their relative contribution so that appropriate corrective action could be taken.

(2) The analysis will depend on the purpose for which it is made, and the quality and completeness of the data. Generally, the analysis is done for any of the following purposes:

(i) Review of administrative and policy regulations at the macro level;

(ii) Identification of hazardous road sections/locations; and

(iii) Spot improvement of individual locations.

Analysis for a administrative and policy purposes

(3) Here, the analysis may be for the following purposes:

(i) Keeping an eye on the accident trend from year to year, comparing accident rate with other countries, or between States or between cities so that any alarming situation can be dircerned for further investigation and corrective action. For this purpose, the accident or fatality rate can be expressed in terms of the number of accidents or fatalities for every 100,000 population or 10,000 registered vehicles.

(ii) For policy decisions including making amendments to the Motor Vehicles Act for tightening control over or correcting any deficiency as the major accident causative factors. For this purpose, it will be necessary to make an analysis for the dominant causes of accidents. For instance, if human failure has been the major cause, concerted attention could be directed towards education, stricter control over driver licensing and better enforcement. Similarly if vehicle failures contribute to a good proportion of the accidents, attention could be paid to stricter control over fitness of vehicles and measures for improving vehicle equipment. If road factors happen to be dominant, standards for geometric design and road surface characteristics, and policy on traffic control devices may warrant a review.

(iii) For planning decisions and further investments with regard to improving safety measures relating to major target groups of accident victims. For this purpose, the analysis should be for the type or types of persons (e.g. pedestrians, cyclists, etc.) killed or injured in road accidents. For example, if it is found for a city that pedestrians constitute the major group of victims, concerted action could be taken to improve pedestrian facilities and educate them on road safety through mass media.

Analysis for identification of hazardous road sections/locations

(4) The main objective of this analysis is to identify and locate road sections or locations which have shown to be more prone to accidents than others. The idea is that once such sections/locations are identified, further detailed studies including spot inspections could be made to find out the causes of accidents and the deficiencies in the roadway for evolving appropriate remedial measures. The analysis can be on the lines of one or more of the following:

(i) Comparison of accident rates of a series of road sections in the network carrying relatively uniform traffic flow, in terms of accidents per km. The example in Table 3.6. illustrates the analysis.

(ii) Comparison of accident rates of road sections in the network carrying different traffic intensities, in terms of accident rates per million vehicle—km. The example in Table 3.7. illustrates the analysis.

TABLE 3.6. COMPARISON OF ACCIDENT RATES OF ROAD SECTIONS CARRYING UNIFORM TRAFFIC

Road Section	Length (km)	No. of accidents per year	Accident rate per km	Remarks
A	20	10	0.5	
B	100	25	0.25	
C	160	20	0.125	
D	40	32	0.8	Most Hazardous

TABLE 3.7. COMPARISON OF ACCIDENT RATES OF ROAD SECTIONS CARRYING DIFFERENT TRAFFIC INTENSITIES

Road Sections	Length (km)	A.D.T.	No. of accidents per year	Accident rate per million vehicle—km	Remarks
A	20	700	10	1.96	Most Hazardous
B	100	1200	25	0.57	
C	160	500	20	0.68	
D	40	2000	25	0.86	

(iii) Preparing an accident spot map by showing the location of each accident with the help of pins of different shapes or colours representing different types of accidents (i.e., fatal, personal injury, non-injury, etc.). Such maps which are normally maintained for a calendar year furnish a quick visual index of the locations of accident concentration. A simple street map to a scale of 1 in 5000 showing streets and a few topographical features will be generally satisfactory for urban areas. For rural areas, a map to a scale of 1 in 50,000 (1 in 25,000 in congested areas near cities) may be adequate. By this way, black spots or locations having clustering of pins denoting fatal/personal injury accidents can be identified for further investigation and corrective action.

Spot improvement of hazardous locations

(5) The objective in this phase is to analyse for the major cause of accidents for evolving appropriate corrective measures at already identified hazardous sections/locations. The following procedures will be helpful in the analysis :

(i) Analysis for the predominant type of accident will give a broad indication about the probable causes of accidents. This is illustrated in Table 3.8.

(ii) Analysis for the type of collision with the help of collision diagram. Collision diagram is a sketch of the hazardous location in which the different types of collisions that had taken place are indicated by respective symbols. A study of the diagram will help to discern the predominant type of collision so that appropriate remedial measures could be taken. The remedial measures suggested in Table 3.9. can be used as a guide.

TABLE 3.8. POSSIBLE CAUSES OF ACCIDENTS FROM PREDOMINANT TYPE OF ACCIDENT

Sl. No.	Predominant type of accident	Possible causes
1.	Single vehicle accident	Slippery road surface, sharp horizontal curve, absence of superelevation, surprise geometric element, absence of proper roadway delineation.
2.	Accidents during wet weather	Slippery road surface, absence of superelevation at horizontal curve.
3.	Accidents during nights	Poor lighting condition, sharp horizontal curve combined with steep grade, poor delineation of roadway edges, tired or drunken driver.
4.	Collision against fixed objects	Trees and other fixed objects in proximity of roadway edge, narrow bridge/culvert in an otherwise wide roadway, surprise geometric element.

TABLE 3.9. REMEDIAL MEASURES SUGGESTED FOR DIFFERENT TYPE OF COLLISION

Sl. No.	Type of collision	Possible remedial measures
1.	Rear-end collision at intersection	Provision of deceleration lane and right-turning pocket lane Provision of left infiltration lane Removal of sight obstructions Installation of advance warning signs about proper lanes for different destinations Increasing amber time in case of signal control
2.	Head-on, right angle and right turn collision at intersection	Removal of sight obstructions and enforcement of parking regulation Installation of stop lines/signs on minor arms Prohibition of right turns where possible Provision of channelising islands Conversion into rotary where space is available Installation of traffic signals where minimum warrants are met Creation of one-way streets
3.	Side swiping collision at intersection	Installation of pavement markings Widening of pavement Elimination of roadside obstructions such as caused by parked vehicles and other bottlenecks Installation of channelising islands
4.	Pedestrian-vehicular collision at intersection	Installation of pedestrian cross-walk lines Erection of pedestrian railing barriers Provision of pedestrian refuge island Prohibition of kerb parking Clearing foot-path of all encroachments Provision of pedestrian subways/overbridges where minimum warrants are satisfied Installation of signal control
5.	Head-on collision	Provision of pavement lane markings, and reflector studs in case of unlit highways Installation of no-passing restrictions at locations having poor visibility Installation of centre-dividing strip Creation of one-way streets
6.	Collision with fixed object	Application of red reflectors to fixed objects Banding of roadwide trees Removal of fixed objects where possible
7.	Vehicle running off roadway	Installation of pavement edge lines Installation of warning reflectors, guard-rail or delineators Correction of superelevation at horizontal curves Providing skid resistant surfacing
8.	Collision with parked vehicle	Parking prohibition Change from angle to parallel parking Arranging off-street parking facilities Creation of one-way streets

(iii) On-spot investigation of hazardous locations can be highly useful in the identification of adverse road and environmental features which can be related to the driver's reactions and the difficulties he possibly encounters so that appropriate corrective measures could be developed. The investigation should also include observations for conflicts (i.e. situations involving one or more vehicles where there is an imminent danger of a collision). This may be done by a study of traffic flows at site or by making fast runs through the area under investigation. Such a study can help to identify the high risk vehicle manoeuvres and the locations where they would occur so that appropriate remedial measures could be thought of.

3.8. Education

3.8.1. General

(1) Statistics of road accidents in the country clearly bring out that in majority of the cases, human failure has been the main cause. This human failure may be due to ignorance, carelessness, downright callousness or indifferent attitude. For correcting the situation in this crucial area, education and propaganda or any measure to inculcate a better road sense in the minds of road users have a vital role to play.

(2) The objective of education concerning road traffic should be to impress upon the minds of all road users the complexities of modern day traffic and the dangers underlying the simple process of moving from one place to another. Obviously different types of road users require different types of instructions and guidance though the basic discipline and an understanding of the rights and privileges of other road users should be common. But one thing is certain that the earlier a person begins his education in life, the better road user he will prove to be in future. The best way to begin educating a person, therefore, is in the beginning itself, i.e. at the primary school level when the mind of the child is still impressionable, and whatever discipline or attitude is imbibed at that time will last him for his life.

3.8.2. Education of the children

(1) Education of children should start from the primary classes. Their text books should contain a chapter or two on the rules of the road and the correct methods of crossing and walking along the streets. Coloured illustrations depicting both the correct

and wrong methods besides leaving a lasting impression will create the curiosity to know why a particular method is right or wrong. This may be supplemented by showing them occasionally short films covering various aspects of traffic problems and accidents.

(2) As the children grow up, they should be encouraged to get themselves enrolled in the School Safety Patrols wherein they will be required to take training in controlling traffic at various intersections and pedestrian crossings with the help of traffic police. This will help them to come at grips with the realities of the traffic problems, and these will leave an indelible mark on their personalities.

(3) Another very effective method to teach the children about traffic problems is the traffic Training Park. This park simulates the traffic conditions on the roads and the children are required to go from one point to another on their cycles or other conveyance. On the way, all sorts of traffic conditions such as right turns, left turns, etc. are met with and the child is required to negotiate them, giving proper signals, etc., as per rules and conventions. The instructor watches the competents, and marks are allotted with the winners getting acclamations and prizes. In this way, game is combined with education, and very soon the children acquire proficiency in traffic rules and regulalions.

(4) As a part of the national effort in the traffic education of children, the Indian Roads Congress will shortly be bringing out two publications, one an illustrated booklet on Road Safety For Children, and the other on 'Guidance to teachers involved in road safety education.'

3.8.3. Education of adults - other than drivers of motor vehicles

This group includes pedestrians, cyclists and drivers of non-motorised vehicles. The difficulty with this group is that there are no adequate laws to regulate them, and by and large, they are ignorant of the existing traffic rules and regulations. They also require no licence to make their presence on the roads. What is required is that they should be educated about the traffic rules and regulations, the safe way of their using the road facilities and better road behaviour. Road safety propaganda

through mass media (see para 3.8.5.) can play a vital role in this regard.

3.8.4. **Education of adults-drivers of motor vehicles**

(1) Drivers of motor vehicles, whether light or heavy, know or atleast they are expected to know the rules and regulations pertaining to traffic. Their problem generally is rashness, sometimes drunkenness and lack of respect for the life and safety of more vulnerable people like pedestrians and cyclists. Many accidents can be avoided if the motorists were less impetuous and were trained the art of 'defensive driving' i.e. driving with a very watchful eye on the mistakes that may be or are likely to be committed by the other road users. For their education, it is desirable that every aspirant for driving licence should be required to undergo training in a recognised driver training school, and the instructor should inculcate in him the desirability of adopting an attitude of defensive driving and extending due courtesy to other road users. It will also be helpful if a few model driving schools are set up by the Government to serve as an example for others.

(2) Among the drivers of motorised vehicles, drivers of two-wheelers (motor cycles, scooters and mopeds) constitute the most vulnerable section because of their instability against even a small impact. Some studies have shown that this group of drivers/riders is 14 times more vulnerable to fatal accidents than a traveller by any other mode of conveyance, and also that almost all deaths and most of the severe injury accidents are caused by injuries on the head and face. This category of road users should, therefore, be educated about their greater vulnerability and the necessity of their wearing safety helmets.

3.8.5. **Road safety propaganda**

All available types of mass media, e.g., leaflets, hoardings, cinema films and slides, radio/T.V. talks, lectures or advertisements, etc. can be utilised for the purposes of road safety propaganda. Audio-visual media such as cinema and television have definitely more impact and reach a larger number of persons than other avenues. For children, besides a chapter or two in their text books, comics can be very profitably utilised. Commercial

advertisements in-between popular programmes in radio/T.V. will also have a better impact and can reach larger bodies of people. Similarly, short films on the tragedy of road accidents with the participation of well-known personalities from the show-business can be made and shown in cinema halls and television for greater impact on the people.

3.9. Enforcement

3.9.1. Enforcement of traffic laws and regulations has to cover a wide spectrum of people with different backgrounds, etc., and for best results the methods adopted should not only create a deterrent to violators or potential violators of traffic laws but also attempt to raise the level of voluntary compliance among the road users. To achieve this objective, the great mass of road users should be made to believe that the traffic laws are reasonable and intended for the overall welfare of the society, and that in case of their breakage, court action will be prompt and result in adequate and uniform penalties.

3.9.2. Bulk of the responsibility for enforcement and control of traffic lies with the traffic police. The mere presence of the policemen induces people to behave in a better way. The enforcement measures adopted by the police should be of two kinds, namely,

(i) punitive measures based on challans, fines, arrests and prosecutions for major offences, and

(ii) non-punitive measures such as active and conspicuous patrols, warnings, education, etc.

As regards the punitive measures, the prosecution should be quick and the punishment uniform. This can be achieved with the help of mobile courts which have proved to be very useful in Delhi and a few other cities.

3.9.3. Among the non-punitive actions, the following innovative ones which are being adopted in some cities can have a positive impact :

(i) Instead of challaning or imposing fines on cyclists for the absence of essential equipment like bell or light, it will be more purposeful to take a vendor of these equipment along with the police squad and

compel the cyclists to purchase the missing part. Similar action can be considered for scooterists driving without helmet.

(ii) Similarly, for other minor offences, the offenders can be made to compulsorily attend traffic training classes to be run by social workers.

These are some of the examples which show how police enforcement can be based upon persuation rather than on force and still be more purposeful than imposition of fines.

Appendix

Standards, Codes and Manuals of the Indian Roads Congress which contain Guidelines on Aspects Relating to Traffic Safety

I. **Road Vehicle**

IRC : 3-1983 'Dimensions & Weights of Road Design Vehicles'

II. **Geometric Design of Roads and Appurtenances**

IRC : 8-1980 'Type Designs for Highway Kilometre Stones'

IRC : 11-1962 'Recommended Practice for the Design and Layout of Cycle Tracks'

IRC : 12-1983 'Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling & Motor-Fuel Filling-cum-Service Stations'

IRC : 32-1969 'Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads'

IRC : 36-1970 'Recommended Practice for the Construction of Earth Embankments for Road Works'

IRC : 41-1972 'Type Designs for Check Barriers'

IRC : 52-1981 'Recommendations about the Alignment Survey and Geometric Design of Hill Roads'

IRC : 54-1974 'Lateral and Vertical C arance at Underpasses for Vehicular Traffic'

IRC : 66-1976 'Recommended Practice for Sight Distance on Rural Highways'

IRC : 69-1977 'Space Standards for Roads in Urban Areas'

IRC : 73-1980 'Geometric Design Standards for Rural (Non-urban) Highways'

IRC : 80-1981 'Type Designs for Pick-up Bus Stops on Rural (i.e. Non-urban) Highways'

IRC : 86-1983 'Geometric Design Standards for Urban Roads in Plains'

IRC : SP : 23-1983 'Vertical Curves for Highways'

III. **Design of Road Crossings**

IRC : 39-1970 'Standards for Road-Rail Level Crossings'

IRC : 65-1976 'Recommended Practice for Traffic Rotaries'

IV. **Road Surface Characteristics**

IRC : SP : 16-1977 'Surface Evenness of Highway Pavements'

IRC Highway Research Board Special Report No. 2—1976" State of the Art : Pavement Slipperiness and Skid Resistance

V. **Traffic Control Devices**

IRC : 2-1968 'Route Marker Signs for National Highways'

IRC : 30-1968 'Standard Letters and Numerals of Different Heights for Use on Highway Signs'

IRC : 31-1969 'Route Marker Signs for State Routes'

IRC : 35-1970 'Code of Practice for Road Markings (with Paints)'

IRC : 67-1977 'Code of Practice for Road Signs'

IRC : 79-1981 'Recommended Practice for Road Delineators'

VI. **Parking**

IRC : SP : 12-1973 'Tentative Recommendations on the Provision of Parking Spaces for Urban Areas'

VII. **Ribbon Development and Access Control**

IRC : 62-1976 'Guidelines for Control of Access on Highways'

IRC : SP : 15-1974 'Ribbon Development along Highways and its Prevention'

VIII. **Traffic Regulation and Control**

IRC : 70-1977 'Guidelines on Regulation and Control of Mixed Traffic in Urban Areas'

IX. **Roadside Advertisement**

IRC : 46-1972 'A Policy on Roadside Advertisements'

X. **Roadside Facilities and Environmental Considerations**

IRC : SP : 21-1979 'Manual on Landscaping of Roads'
'Environmental Consideration in Planning and Design of Highways in India (1979).

XI. **Accident Recording**

IRC : 53-1982 'Road Accident Forms A-1 and 4'

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