

## **PLANNING AND DESIGN PARAMETERS-FMR**

### **1.1.1. Road Design**

Road design, in its entirety, is divided into two distinct groups:

- (1) Geometric, which embraces the grade line or profile, the alignment, including curvature, and the widths of the several component parts, including intersections, and
- (2) Structural, which embraces the thickness of pavements, bases, and stability of foundations.

The data required for an appropriate geometric design are:

- (1) Traffic density,
- (2) Character of traffic, and design speed.

The data required for an appropriate structural design are:

- (1) Maximum expected wheel load to use the road and volume of traffic,
- (2) Soil classification,
- (3) Minimum field compaction, i.e., per cent of dry weight, and
- (4) Modulus of sub grade reaction.

### **1.1.2. Basic Consideration**

In preparing the design of a new road or the redesign of an old one, the road engineer must give attention to the following basic considerations:

- (1) The design must be suitable for the traffic volume, both daily and at the design peak hour, for the design speed, and for the character of the vehicles to use the facility.
- (2) The design must be consistent and must avoid surprise changes in alignment, grade, and sight distance.
- (3) The design must be pleasing to the user of the road and to those who live along it.
- (4) The design must be complete. Although the test of the function and attractiveness of the design will be reflected in the use of the road, the designer can insure the effectiveness of his design, to a large degree, by allowing for the necessary roadside treatment and providing for control devices, such as lane markers and road signs.
- (5) The design should be as simple as possible from the standpoint of the builder. Excessive changes in cross-sectional design or the use of a variety of types within a project, will, in many cases, increase the cost and difficulty of construction beyond the commensurate value of such "uniqueness".
- (6) The design should be such that the finished road can be maintained at the least cost.
- (7) The design must be safe for driving and should insure confidence for the majority of drivers.

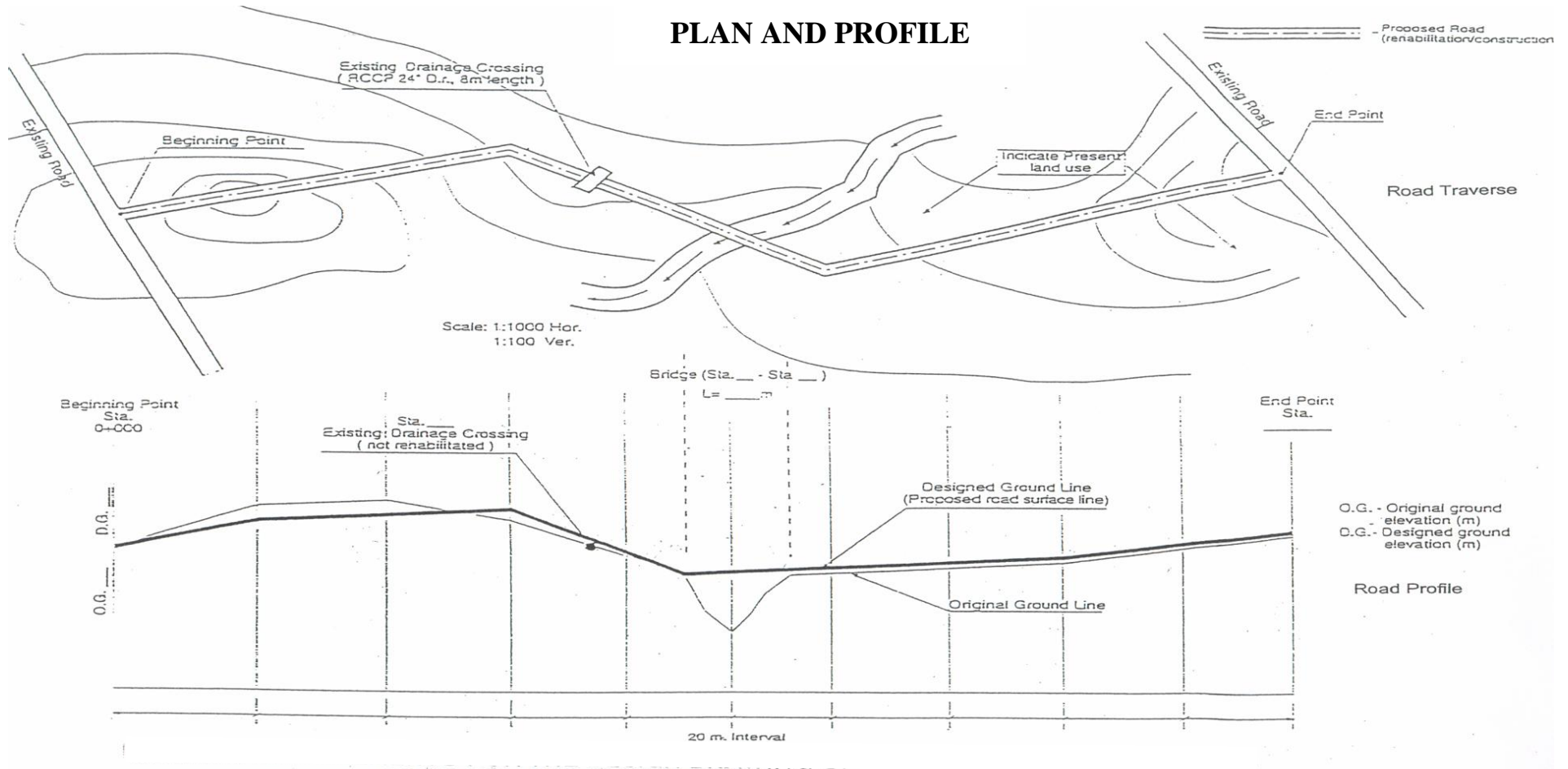
### **1.1.3. Minimum Design Standards.**

Basically, the minimum design standards for crushed gravel surfaced roads with less than 100 vpd, are as follows:

Width of carriage way	4 M
Shoulders, both sides of carriage way	1.5 M
Wearing surface, crushed gravel, base course	0.150 M

Sub-base course, up to 7.0 meters width	0.100 M
Cross-fall	3%-5%
Drainage channels, earth	V or 0.50 m wide
Embankment slope	2:1
Design Speed (kph): Flat Topography	50 kph
Rolling Topography	40 kph
Mountainous Topography	30 kph
Minimum Radius: Flat Topography	80 M.
Rolling Topography	50 M.
Mountainous Topography	50 M.
Maximum Grade: Flat Topography	5%
Rolling Topography	10%
Mountainous Topography	15%
Sight Distance (Non-Passing): Flat Topography	60 M.
Rolling Topography	50 M.
Mountainous Topography	40 M.

A Portland Cement Concrete Pavement (PCCP) or Asphalt Concrete Pavement (ACP) road may be proposed provided it is economically viable.



1.1.4. Figure 2.1 Minimum Requirements for the Design Drawings

## **2. GEOMETRIC DESIGN CRITERION**

Geometric design is the process whereby the layout of the road in the terrain is designed to meet the needs of the road users. The principal geometric features are the road cross-section and horizontal and vertical alignment. The use of geometric design standards fulfils three interrelated objectives:

- Firstly, standards are intended to provide minimum levels of safety and comfort for drivers by the provision of adequate sight distances, coefficients of friction and road space for vehicle manoeuvres;
- Secondly, they provide the framework for economic design; and,
- thirdly, they ensure a consistency of alignment.

The design standards adopted must take into account the environmental road conditions, traffic characteristics, and driver behaviour.

### **2.1 Approach to Design**

#### **2.1.1. Selection of design standards**

2.1.1.1. The selection of design standards is related to road function, volume of traffic and terrain, with additional procedures for the recognition and appropriate treatment of potential hazards (Tables 1.1 and 1.2). Opportunities for the relaxation of standards have also been identified.

2.1.1.2. A basic assumption in the approach is that drivers receive clues about the standard of the road from local surrounding features such as the terrain, levels and types of flow, as well as geometric elements. Additional design consideration or special signing will only be necessary where the information available to the driver may lead to incorrect interpretation and consequent danger.

#### **2.1.2. Cross-sectional considerations**

Cross—section parameters are related to traffic flows of all types, and will vary with the requirements of vehicular traffic and with the needs of pedestrians and non—motorised vehicles. In many developing country situations, it will be necessary to ‘consider cost effective ways of segregating non-motorised traffic at the earliest stage in the design process.

#### **2.1.3. Design speed**

Design speed is used as an index which links road function, traffic flow and terrain to the design parameters of sight distance and curvature to ensure that a driver is presented with a reasonably consistent speed environment. In practice, most roads will only be constrained to minimum parameter values over short sections or on specific geometric elements.

#### **2.1.4. Safety**

There is very little information from developing countries on the effects of changes in standards on accident rates. Indeed, equivalent information from developed countries is also limited. Highway engineering safety is usually assumed to be optimised by linking geometric elements to a design or operating speed, so that the resulting geometry has a consistency, which reduces the likelihood of a driver being presented with an unexpected situation. This concept of driver expectation forms the basis of this set of design standards.

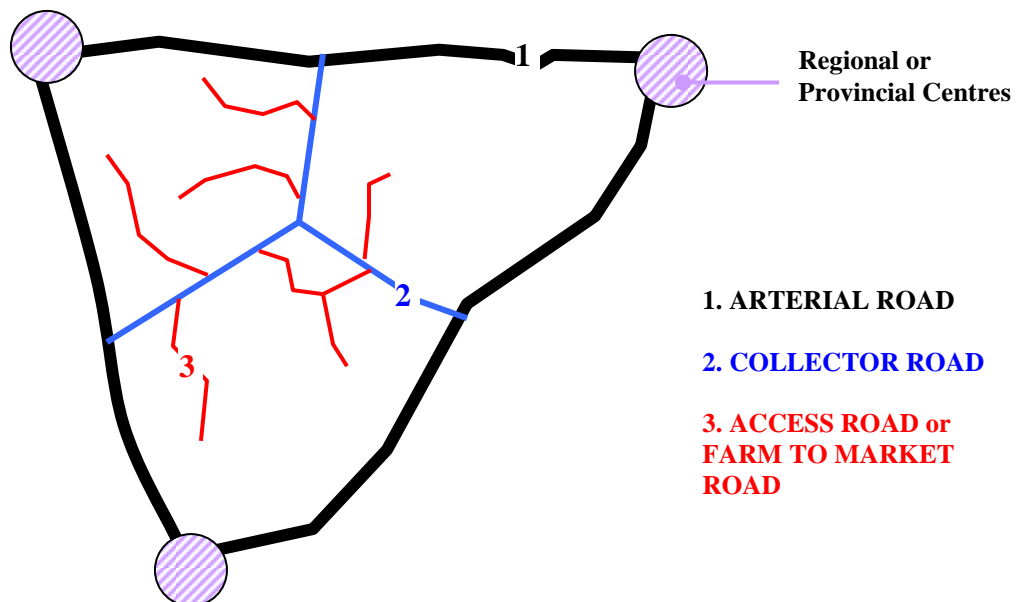
## 2.1.5. Economic design

2.1.5.1. Designs should be justified economically, and the optimum choice will vary with both construction and road user costs. Construction costs will be related to terrain type and choice of pavement construction, whereas road user costs will be related to level and composition of traffic, journey time, vehicle operation and road accident costs. Methods of determining these costs are given in Overseas Road Note 5 (TRRL Overseas Unit 1988).

2.1.5.2. The most economic designs will often not involve the use of minimum standards, as levels of traffic may be such that the additional vehicle operating cost, accident, and travel time saving benefits from wider, straighter and shorter roads may more than offset the extra construction costs needed.

2.1.5.3. As flows increase, vehicle—to—vehicle interactions become more important and congestion may result in increases in journey times and accident risk if additional lanes are not added. The scope of this Note has been limited to single carriageway roads, and consideration of the possible introduction of dual carriageways should be made when flows approach 15,000 vehicles per day.

### 2.1.6. Figure 1.1 Roads hierarchy and function



2.1.6.1. Arterial roads are the main routes connecting national and international centres. Traffic on them is derived from that generated at the urban centres and from the interurban areas through the Collector and Access road systems. Trip lengths are likely to be relatively long and levels of traffic flow and speeds relatively high. Geometric standards need to be adequate to enable efficient traffic operation under these conditions, in which vehicle to vehicle interactions may be high.

2.1.6.2. Collector roads have the function of linking traffic to and from rural areas, either direct to adjacent urban centres, or to the Arterial road network. Traffic flows and trip lengths will be of an intermediate level and the need for high geometric standards is therefore less important.

2.1.6.3. Access roads (Farm to Market Roads) are the lowest level in the network hierarchy. Vehicular flows will be very light and will be aggregated in the Collector road network. Geometric standards may be low and need only be sufficient to provide appropriate access to the rural agricultural, commercial and population centres served. Substantial proportions of the total movements are likely to be by non-traffic.

2.1.6.4. Whilst this hierarchy is shown simplistically in Figure 1.1, in practice there will be many overlaps of function and clear distinctions will not always be apparent on functional terms alone. This hierarchy should not be confused with the division of administrative responsibilities, which may be based on historic conditions.

2.1.6.5. For the lowest Design Class of road, it is inappropriate to design on the basis of geometric standards, and the sole criterion of acceptability will be the achievement of appropriate level of access. Design, in these situations, should be based on minimum values of radii, width and gradient for the passage of a suitable design vehicle.

**2.1.7. TABLE 1.1 GENERAL ROAD STANDARDS**

Road Function	Design Class	Traffic *(ADT)	Surface Type	Width (m)		Maximum Gradient %	Terrain/Design Speed		
				Carriage way	Shoulder		Mountainous	Rolling	Level
ARTERIAL	A	5,000-15,000	Paved	6.5	2.5	8	85	100	120
	B	1,000-5,000	Paved	6.5	1.0	8	70	85	100
COLLECTOR	C	400-1,000	Paved	5.5	1.0	10	60	70	85
	D	100-400	Paved/ Unpaved	5.0	1.0 <sup>+</sup>	10	50	60	70
ACCESS	E	20-100	Paved/ Unpaved	4.0	1.5 <sup>+</sup>	15	40	50	60
	F	< 20	Paved/ Unpaved	2.5/3.0	Passing Bays	15/20	N/A	N/A	N/A

\* The two way traffic flow is recommended to be not more than one Design Class step in excess of first year ADT.

+ For unpaved roads where the carriage way is gravelled, the shoulders would not normally be gravelled; however, for Design Class D roads, consideration should be given to graveling the shoulders if damage occurs.

**2.1.8. TABLE 1.2: SPEED RELATED DESIGN PARAMETER**

Design Speed (km/h)	Stopping Sight Distance (m)	Minimum Curvature Values					Minimum Safe Overtaking Sight Distance (m)*
		Horizontal (m)		Vertical Curves (m)			
		Paved (10% Super elevation)	Unpaved (Zero Super elevation)	Crest K to Object on Road	Crest K to Road Surface	Sag K for Comfort	
<b>Two Lane</b>							
120	230	450	--	120	250	22.6	590
100	160	320	--	60	125	13.1	430
85	120	210	--	30	70	8.1	320
70	85	130	190	16	35	4.8	240
60	65	85	125	10	20	3.5	180
50	50	60	80	5	11	2.2	140
40	35	30	40	3	6	1.3	N/A
30	25	15	20	1.5	3	0.7	N/A
<b>Single Lane</b>							
60	130	85	125	25	20	3.5	N/A
50	100	60	80	15	11	2.2	N/A
40	70	30	40	7	6	1.3	N/A
30	50	15	20	4	3	0.7	N/A

\* These values are the normal minimum assuming that an overtaking vehicle may safely abandon the manoeuvre if an opposing vehicle comes into view. The values should be available continuously in all places where overtaking is permitted

Note: the following assumptions have been made in calculating the above:

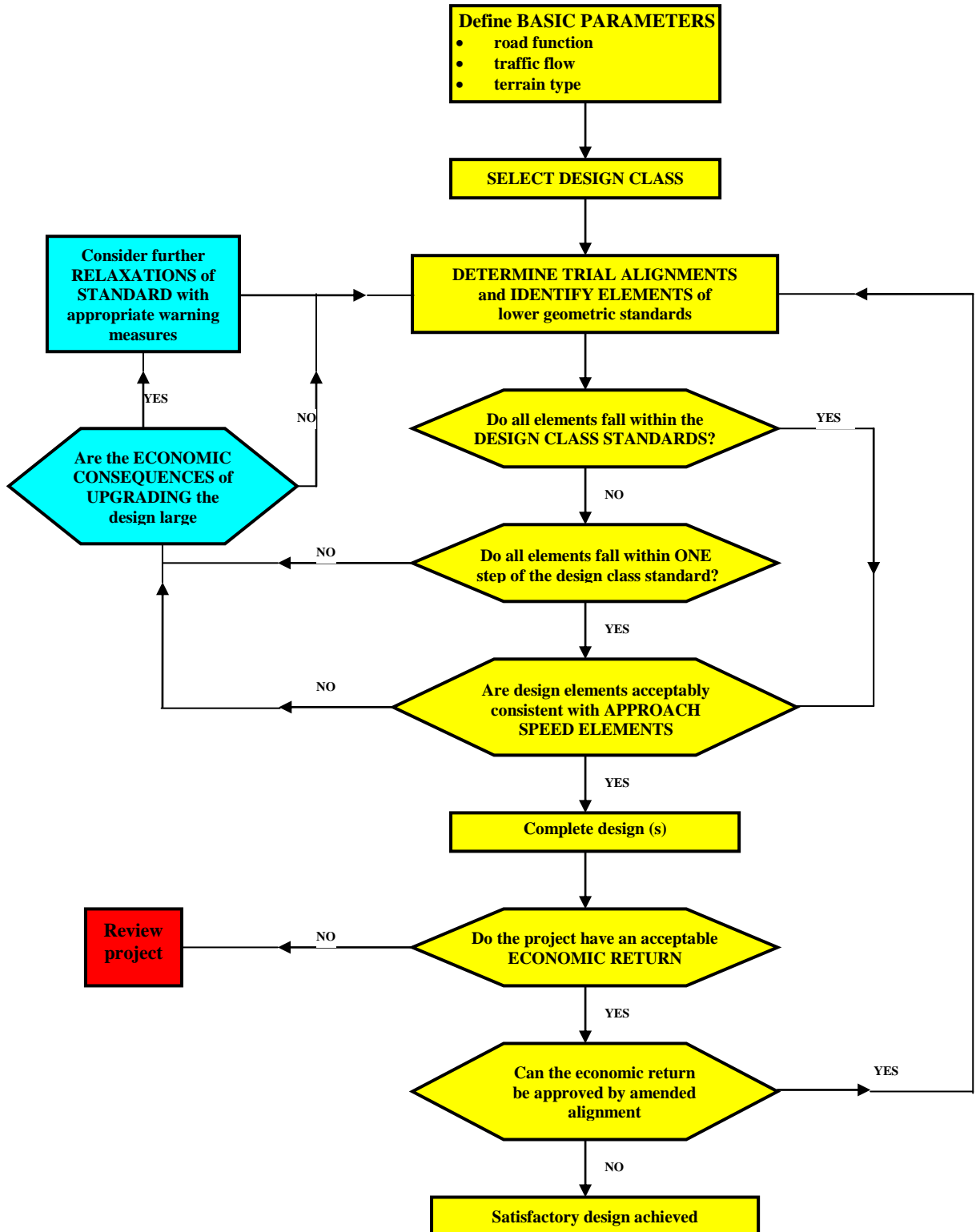
- Reaction time of 2 sec.

- Eye height of 1.05m. Object height of 0.2m for stationary object on the road and 1.05m for approaching vehicle. (Zero object height values have been included for use where it is necessary to see the road surface e.g. approaching a ford or drift.) The values for single lane roads have been based on the assumption that approaching vehicles should be able to stop safely before colliding.

- The following values of side and longitudinal friction factor were taken to estimate acceptable values of horizontal curvature for both paved and unpaved conditions.

Design Speed (km/h)	100	85	70	60	50	40	30	100
Side friction factor	0.15	0.18	0.20	0.23	0.25	0.30	0.33	0.15
Longitudinal friction factor	0.37	0.40	0.43	0.47	0.50	0.55	0.60	0.37

2.1.9. Figure 1.2 The Design Process



## Relaxation of Standards

2.1.9.1. The standards summarised in Tables 1.1 and 1.2 are intended to provide guidance for designers rather than to be considered as rigid minima. The justification for construction of a particular road will almost always be based on a detailed economic appraisal, and relaxations of standards may be essential in order to achieve an acceptable level of return on investment. In other circumstances, an already acceptable rate of return may be increased substantially by the inclusion of a short section of substandard road where achievement of the design standard would be expensive, although the safety implications of this would need serious consideration.

2.1.9.2. Relaxation of one Design Class step implies design to the 50th percentile rather than the 85th percentile speed. Relaxation of two Design Class steps reduces the design to the 15th percentile speed. Experience in the UK has shown that reduction of design parameters by one step, equivalent to a 17 per cent reduction, is likely to have little effect on safety. Normally, a relaxation of two steps, equivalent to a 30 per cent speed reduction, should not significantly increase risk where appropriate signing or other warning measures, such as bend marker posts, are provided. On low flow roads where most of the drivers will be regular users, the increased risk will be less significant and the resultant number of accidents should be negligible. Greater care and consideration should be given to relaxations on high flow/high speed alignments.

2.1.9.3. In special circumstances, where standards have been reduced on successive design elements, further relaxations may be made based on those reduced approach speeds. Sight distances, and the potential accident risk as a result of driver error, would need to be considered on a site—specific basis.

2.1.9.4. Reductions in standards should only apply to stopping distances and curvature, and suitable values have been included in Table 1.2. Widths should not be reduced as they are particularly flow related, and additional widening may be required on curves with the tighter radii.

## 2.2 Cross-Section

### 2.2.1. Basic Considerations for Determining Widths

2.2.1.1. Road width should be minimised so as to reduce the costs of construction and maintenance whilst being sufficient to carry the traffic loading efficiently and safely. Recommended values are given in Table 1.1.

2.2.1.2. For Access roads with low volumes of traffic (<100 ADT), single lane operation is adequate as there will be only a small probability of vehicles meeting, and the few passing manoeuvres can be undertaken at very reduced speeds using either passing places or shoulders. Provided sight distances are adequate for safe stopping, these manoeuvres can be performed without hazard, and the overall loss in efficiency brought about by the reduced speeds will be small as only a few such manoeuvres will be involved. It is not cost—effective to widen the running surface in such circumstances and a basic width of 3.0 metres will normally suffice. In some situations, 2.5 metres will allow effective passage.

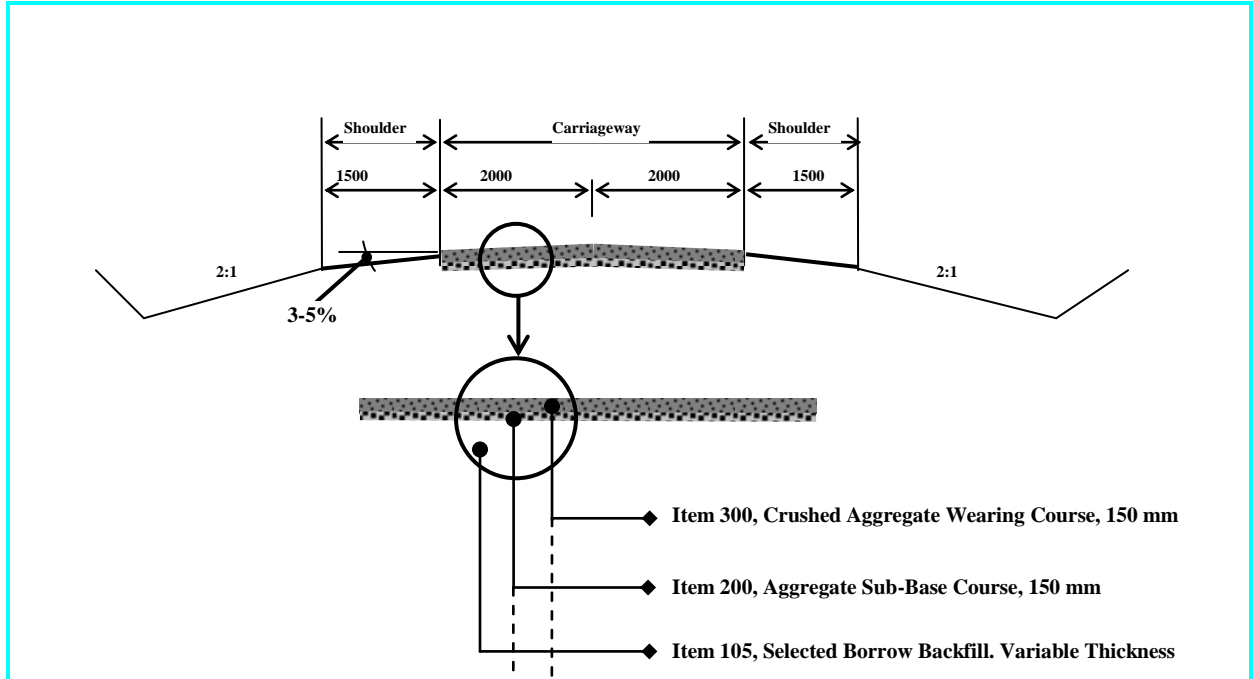
2.2.1.3. On roads with medium volumes of traffic (100—1000 ADT), the numbers of passing manoeuvres will increase and pavement widening will become worthwhile operationally and economically. However, in view of the generally high cost of capital for construction in developing countries and the relatively low cost of travel time, reductions in speed when approaching vehicles pass will remain acceptable for such flow levels and running surface widths of 5.0 and 5.5 metres are recommended. For Arterial Roads with higher flows (> 1000 ADT), a running surface 6.5 metres wide will allow vehicles in

opposing directions of travel to pass safely without the need to move laterally in their lanes or to slow down.

2.2.1.4. Typical cross—sections are shown in Figure 2.1.

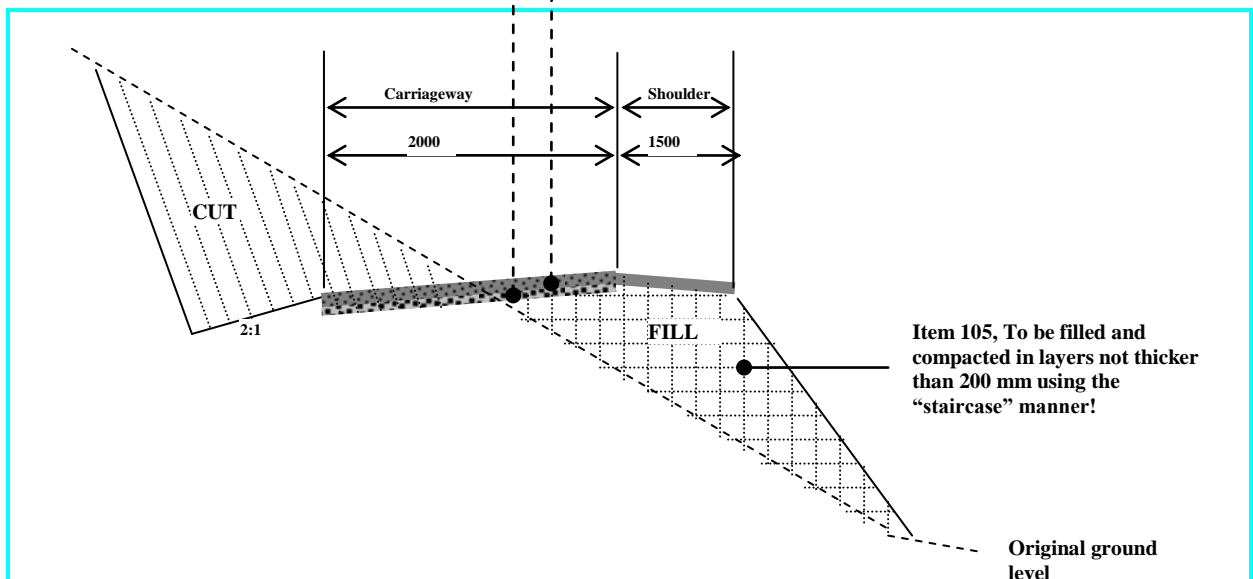
2.2.2. Figure 2.1 Typical cross-section (Dimension in mm)

Embankment (or fill) section



Cut section

(allowing narrower carriage way and only one shoulder)



### **2.2.3. Gradient**

2.2.3.1. Vehicle operations on gradients are complex and depend on a number of factors: severity and length of gradient; level and composition of traffic; the number of overtaking opportunities on the gradient and in its vicinity.

2.2.3.2. For very low levels of traffic flow with only a few four—wheel drive vehicles, the maximum traversable gradient is in excess of 20 percent. Small commercial vehicles can usually negotiate an 18 per cent gradient, whilst two—wheel drive trucks can successfully tackle gradients of 15 per cent except when heavily laden. These performance considerations have formed the basic limiting criteria for gradient as shown in Table 1.1.

2.2.3.3. Gradients of 10 per cent or over will usually need to be paved to enable sufficient traction to be achieved, as well as for pavement maintenance reasons. There will often be considerable non—motorised movement on the lower Design Class roads and, whilst pedestrian and animal movements are possible on very steep inclines, some laden animal drawn carts may find steep grades difficult to traverse because of a lack of grip.

2.2.3.4. As traffic flows increase, the economic disbenefits of more severe gradients, measured as increased vehicle operating and travel time costs, are more likely to result in economic justification for reducing the severity and/or length of a gradient. On the higher design classes of road, the lower maximum recommended gradients (Table 1.1) reflect the economics, as well as the need to avoid the build up of local congestion. However, separate economic assessment of alternatives to long or severe gradients should be undertaken where possible or necessary. An estimation of vehicle operating cost savings may be made from relationships such as those incorporated in the TRRL road investment model (micro—RTIM2), or the World Bank's highway design and maintenance standards model (HDM--III).  
y parabolic, in profile.