4 Cross-Sections

4.1 Carriageways and Shoulders

The choice of cross-section is crucial to obtaining a cost-effective solution to meeting traffic needs. Most of our roads are built on embankments and every extra metre of crest width adds considerably to the cost. The principal cross-sectional elements are:

- carriageway – the part of the road formation carrying moving vehicles – divided into one or more traffic lanes
- shoulder – the strip along the edge of the carriageway for use by stopped vehicles and often NMVs and pedestrians
- embankment side slopes.

Carriageway and shoulder widths should be the minimum necessary to carry the traffic volume efficiently and safely. The cross-sections set out in this manual are based on a comprehensive evaluation of many alternatives and they represent the economic optimum. Operational and safety considerations have also been taken into account.

There are five basic carriageway widths within the six Design Type configurations:
3.7m wide - This is the standard single lane carriageway width, and is suitable for the more lightly-trafficked Feeder Roads. Vehicles travelling in opposing directions can pass each other by putting their outer wheels on the shoulder.
5.5m wide - This is a minimum width two-lane carriageway. Large vehicles can pass each other at slow speed.
6.2m wide - This is the lowest economic cost option for a very wide range of traffic volumes. It allows most vehicles to pass with sufficient clearance to avoid the need to slow down or move aside.
7.3m wide single - This is a high standard two-lane single carriageway.
7.3m wide dual - This is a high standard carriageway as one half of a dual 2-lane road.
11m wide dual - This is a three-lane carriageway as one half of a dual 3-lane road.

The option of an 11m wide single carriageway road, as proposed in RMSS, has not been adopted because of concerns that the wide carriageway would encourage unsafe overtaking. British experience with 11m single carriageway roads is that, whilst their overall safety record is good, they do have a higher-than-average proportion of overtaking accidents.

Shoulders are essential for safety and capacity, and must be provided on all roads. Optimum widths for shoulders are 1.2m, 1.5m, and 1.8m. All shoulders must be paved in order to be durable and perform effectively in all weathers. This can be achieved either by extending the main pavement or using a different construction, such as double bituminous seal treatment. Factors to consider when designing shoulders include:

- the shoulder needs to be strong enough to take all vehicles in any weather and without needing much maintenance

- shoulders that are to be used by NMVs and pedestrians must have a good-quality smooth surface – otherwise NMVs and pedestrians will use the carriageway instead
- using a different surface to that of the carriageway makes the shoulder look different and this helps emphasise that it has a different function
- it is essential to use edge lines (preferably made of thermoplastic) to mark the divide between carriageway and shoulder
- there should be no difference in level between the carriageway and the shoulder – an edge drop could discourage NMVs, baby taxis and tempos from using the shoulder and could be hazardous, especially for motorcyclists.

On dual carriageway roads (Type 1 and 2) there must be a 0.3m wide shoulder on the right-hand side of the carriageway next to the median. The divide between the carriageway and shoulder must be marked with an edge line.

4.2 Design Type Cross-Sections

Figure 4.1 gives an overview of the cross-sections and shows the progression from single lane road (Type 6) to dual 3-lane road (Type 1). Figures 4.2 – 4.7 repeat the standard cross-sections but give further information, including the design capacity and the options available for handling NMVs.

The design capacities are very much the maximum possible and in practice roads may be upgraded to the next highest standard some time before these capacities are reached. All widening works (or new construction) to Type 4, 5, and 6 standards involve overwidening the embankment to the next highest design category, so that, if traffic grows faster than forecast, the road can be upgraded by just widening the pavement. The validity of the design capacities is partly dependent on the validity of the assumptions on NMV/MV mix (indicated in the notes below the figures). Where there is good reason to believe that these assumptions will not apply the cross-section may need to be adjusted – this is particularly the case with Type 6 where it is assumed that over 70% of the PCU capacity will be taken up by NMVs.

4.3 Provision for NMVs and Pedestrians

One of the particular characteristics of Bangladesh roads is the large number of non-motorised vehicles and pedestrians. This has many implications for road design. Local surveys of NMV and pedestrian flows are essential to provide a firm basis for deciding how to provide for these road users. Failure to provide properly for NMVs will significantly reduce the traffic capacity of the road and be a cause of accidents.

Shoulders are to be provided on all roads for use by NMVs. On heavily-trafficked sections, such as through towns and villages it will be necessary to provide separate NMV lanes. See below for more detailed guidance.

Separate NMV lanes should be provided on Type 2, 3 and 4 roads where the design year NMV PCU/hr exceeds 400 (50 PCU/hr for Type 2) or there are clear operational and safety benefits. Type 1 dual carriageway roads should always have separate NMV lanes, for capacity and safety reasons. They should only be omitted where it is feasible to prohibit NMVs entirely. Figure 9 shows three options for the layout of NMV lanes, depending on the road environment. The absolute minimum width of an NMV lane could be 2m where there is a hard surfaced shoulder to enable passing other slower or stationary NMVs. Normally 3m is

needed as a minimum and this can accommodate a maximum of 513 PCU/hr. For the flows:width relationship see Table 4.1.

Table 4.1 NMV Lane Capacities

NMV lane width (m)	Flow per lane (PCU/hr)
3.0	513
3.6	645
4.2	732
4.8	794
5.4	901
6.0	1015

Source: Tables 6.40, 6.47, RMSS Vol. V11A
Note: Capacities are for Level of Service 'D'

The provision of an NMV lane on one side of the road only is not recommended, because it is unlikely that more than half the NMVs would use it.

Most towns and villages will have sufficient NMV traffic to warrant the provision of separate NMV lanes. A detailed traffic survey should be carried out to determine how far to extend the NMV lanes. As a guide, the RMSS found that on average the NMV flow dropped significantly after about 1km from the centre of the built-up area. Note though that on roads with villages every few kilometres the NMV traffic is likely to be fairly constant.

Care is needed with the design and layout of NMV lanes in order to make them as convenient and easy to use as possible. They must be well constructed with a smooth durable surface, and should be marked with the rickshaw symbol (sign F19).

In most situations pedestrians can share the paved shoulder or NMV lane with the NMVs. However, where there are a lot of pedestrians and near-capacity NMV flows or high-speed traffic it may be necessary to provide a separate footway. Typically this could be a 1.5m wide footway benched into the embankment side slope about 0.5m below carriageway level. It should be designed for ease of use and must connect with footways across bridges and culverts. The footway surface must be smooth, durable and well-drained.

4.4 Bus Bays and Stopping Places

Buses stopping on the carriageway to pick up or set down passengers will interfere with traffic flow and can be a cause of accidents. Bus bays which enable buses to pull off the carriageway can be of benefit provided that they are used. Proper surveys and studies must be carried out to determine exactly where the buses will stop. Experience shows that it is very difficult to make drivers use bus bays unless they are located exactly at the point of maximum passenger demand. RHD's Road Safety Division can provide design advice. When building or rehabilitating roads through towns it is essential to consider the needs of buses, some of which may remain stopped for a considerable period of time. If suitable hard standing areas are not provided the buses will wait on the carriageway causing congestion and accidents.

4.5 Traffic Calming Through Towns and Villages

Most accidents on rural roads in Bangladesh happen in towns and villages, and the accidents almost always involve a vehicle which is speeding through the centre. Projects which improve roads through towns and villages may make the accident situation worse because speeds will increase. In order to prevent this it is essential that traffic calming be applied. Traffic calming is the term used to describe self-enforcing engineering measures that reduce the speed of motor vehicles. Lower speeds reduce both the likelihood of an accident happening and the severity of injuries if it does occur. Effective traffic calming results in a better environment for all and improved safety for vulnerable road users (pedestrians, cyclists, rickshaw users). The engineering measures that can be used to calm traffic include:

- false roundabouts (a roundabout where there is no junction)
- speed humps
- road narrowings and deflections
- footway widening
- using upright signs / kerbs / planting / carriageway markings to form “gates” at the entrance to the town or village
- rumble strips that make a noise and give a slight jolt when vehicles go over them.

To have any chance of being effective the individual measures must be implemented as part of an overall traffic calming plan for each town and village. Preparing these plans requires specialist experience, and assistance should be sought from RHD’s Road Safety Division.

4.6 Lateral and Vertical Clearances

Trucks are typically just over 4m high. To allow for adequate vertical clearance and the transport of abnormal loads 5.7m headroom should be provided when designing new roads and structures. This also makes some allowance for headroom being lost when road pavements are given overlays. The headroom must be available over the full width of the road formation. There may be special requirements on some roads and this should be checked with the RHD’s field divisions.

The lateral clearance, measured between the outer edge of the shoulder and roadside objects should be a minimum of 1m. In difficult situations an absolute minimum clearance of 600mm can be accepted. Where there is no shoulder, the respective clearances are 1.5m and 1m.

Many accidents happen when vehicles run off the road and hit a roadside object. Collisions with trees are commonplace and often result in death or serious injury. Ideally there should be a 4m wide clear zone beyond the shoulder that is kept free of roadside hazards. For curves with a radius of less than 600m the clear zone width on the outside of the curve should be doubled.

It is also important to check that roadside signs, poles, bridge abutments, trees etc., do not interfere with sight distances on curves. Tree planting alongside new roads is beneficial but care should be taken to reduce the hazard risk.

4.7 Crossfall

Crossfall is the slope of the carriageway or shoulder that enables water to drain away. Carriageway crossfall must be sufficient to provide good surface drainage but not so steep as

to cause problems for drivers. On two-way single carriageway roads the carriageway is normally cambered to form an inverted 'V' which may be rounded at its highest point, the crown. On dual carriageway roads the carriageway normally slopes away from the median. At curves the carriageway and shoulder profile may change – see Section 5.3. The standard crossfall for paved carriageways is 3%.

Shoulders having the same surface as the carriageway may have the same crossfall, but generally shoulder crossfalls will be a little steeper - normally 5%. See Section 5.3 for advice on shoulder crossfall on curves with superelevated carriageways.

4.8 Drains

Detailed advice on the design of road drains is outside the scope of this manual. However, key points to consider in the design are:

- The need for cross drainage, road surface drainage, and sub-surface drainage
- Drain design should prevent siltation (too shallow a fall) and excessive scour (too steep a fall)
- The side slopes next to the road should be flat enough to reduce the risk of errant vehicles overturning (maximum slope of 5 horizontal to 1 vertical)
- Open lined drains should be in the form of shallow dishes rather than steep-sided U or V-sections
- In built-up areas channel drains deeper than 250mm should be covered for the safety and convenience of both pedestrians and vehicles
- The drain should terminate or run-out in a satisfactory manner without risk of causing erosion or other problems
- The drain should be capable of being cleaned and maintained easily.

It is not easy to design drains that can cope with the expected flow and yet are safe, affordable and easy to maintain, so compromises are usually required.

4.9 Embankments

Rural roads in Bangladesh are typically on high embankments. The standard side slope for embankments is 2 horizontal and 1 vertical. These have proved to be quite stable when covered in vegetation. The slope is dangerous however and any vehicle going down it will almost certainly overturn. Every year many people are killed and injured in accidents of this kind. Low embankments up to 1.5m in height should ideally have flatter side slopes (3 horizontal / 1 vertical, or flatter). Unfortunately it would be enormously expensive to provide these forgiving slopes on higher embankments, and instead efforts should be made to try and contain out-of-control vehicles. The installation of safety barrier may be cost-effective at very hazardous sites, but it is too expensive for general use. The planting of soft trees and bushes near the top of the side slope may help to slow down and contain runaway vehicles. Road Safety Division can provide advice on this.

4.10 Design Levels

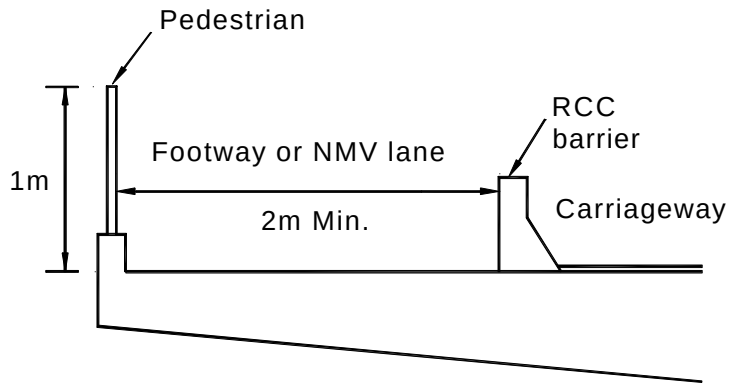
It is normal practice to build roads so that the carriageway surface will have a freeboard of 1.0m above the highest flood level recorded in the locality. Information on local flood levels can be obtained from RHD field divisions or the district administrations.

4.11 Cross-Sections at Bridges and Culverts

The design of bridges and culverts is outside the scope of this manual, but it is obvious that safety and capacity will be affected if the road cross-section is not maintained across these structures. The key points to consider are:

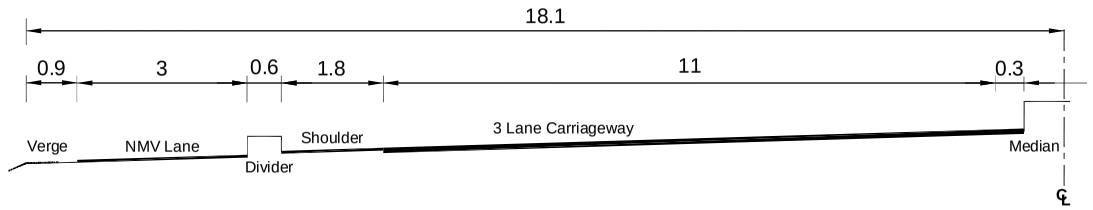
- Carriageway and shoulder narrowings are particularly dangerous on high-speed roads;
- If the shoulder is not continued across the structure, NMVs will move out onto the carriageway in front of fast-moving vehicles and there may be accidents;
- Footways are conventionally provided on structures with parapets, but the accident risks at the site need to be assessed carefully especially where footways can only be provided by omitting the shoulders; take account of the relative volumes of pedestrian and NMV traffic, the speed and volume of motorised traffic and the length of the span;
- Where there are significant pedestrian and NMV flows the best solution is to separate them from fast-moving vehicles with a safety barrier – see Figure 4.10;
- Where there are very high pedestrian and very high NMV flows separate footways and NMV lanes should be considered;
- It is RHD policy to design new bridges for a minimum of two lanes on all roads including feeder roads - where, exceptionally, a single lane bridge is planned the carriageway should be a maximum of 3.7m wide between kerbs in order to avoid confusion over whether the bridge is for one-way or two-way traffic.

Figure 4.10 Segregated NMV Lane or Footway on Bridges



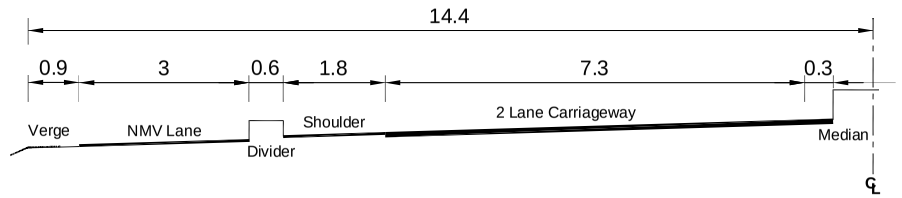
Type 1 Dual 3 lane carriageway with NMV lanes

Class 1 roads must always have NMV lanes

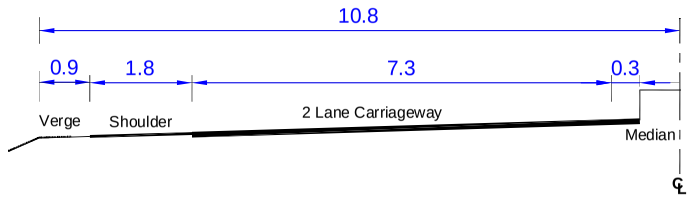


Type 2a Dual 2 lane carriageway with NMV lanes

For use where there are many NMVs, such as through towns and villages

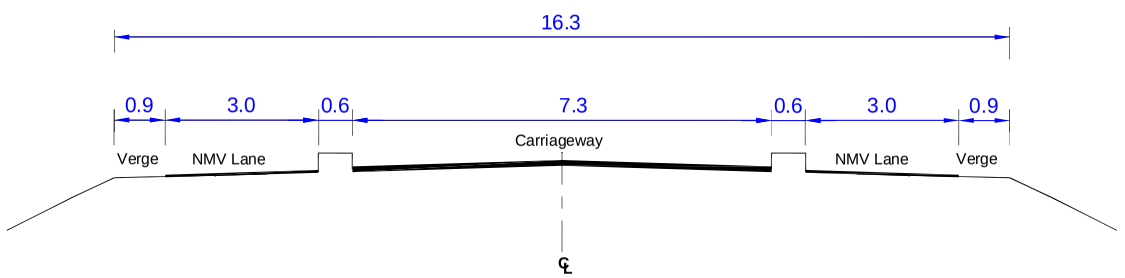


Type 2 Dual 2 lane carriageway



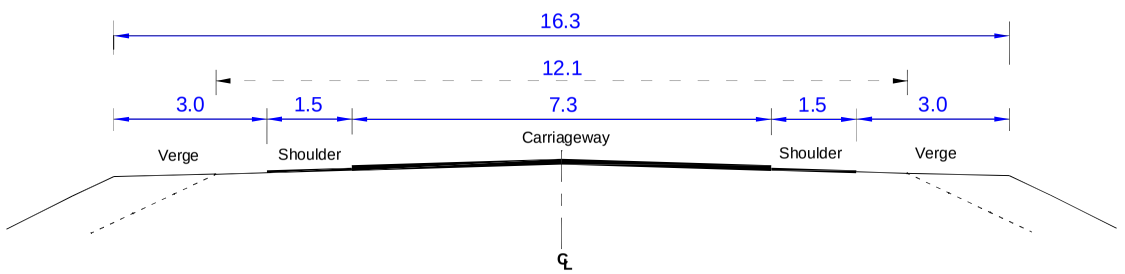
Type 3a 7.3m carriageway with NMV lanes

For use where there are many NMVs, such as through towns and villages



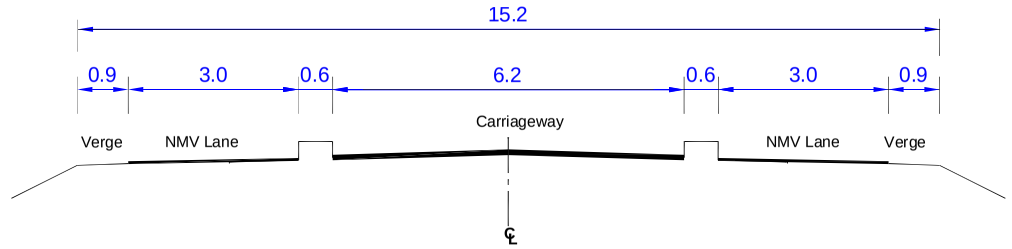
Type 3 7.3m carriageway

If it is unlikely that NMV lanes will ever be needed the road can be built with a crest width of 12.1m.

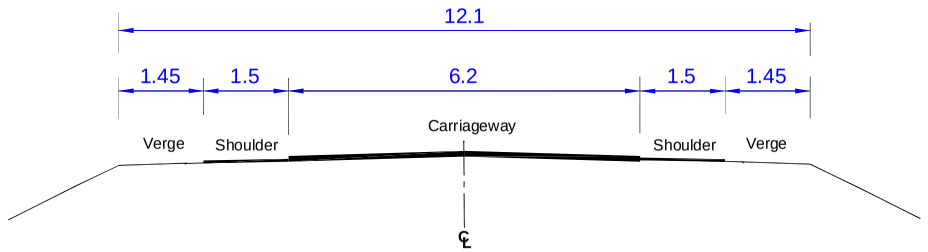


Type 4a 6.2m carriageway with NMV lanes

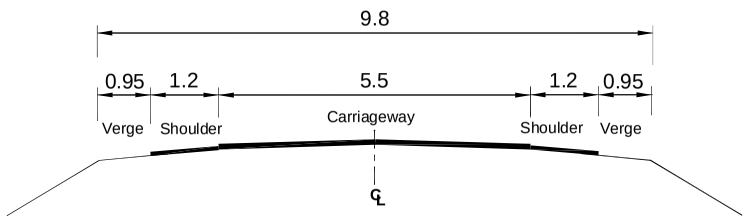
For use where there are many NMVs, such as through towns and villages



Type 4 6.2m carriageway with 1.5m shoulders



Type 5 5.5m carriageway



Type 6 3.7m single lane carriageway

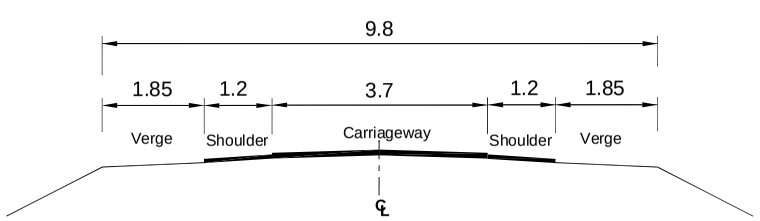


Figure 4.1 Overview of cross-sections

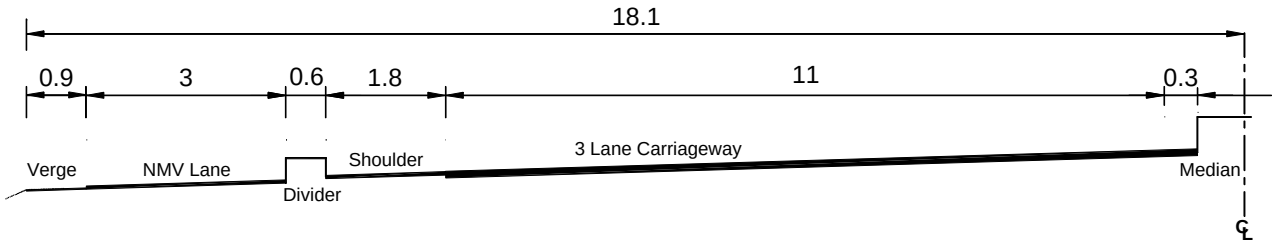
Notes

These are RHD standards and other cross-sections are only permissible in exceptional circumstances and with the approval of the Chief Engineer.

The cross-sections for Design Types 3 - 6 have extra-wide embankments in order to enable the road to be easily upgraded as traffic volumes grow.

Refer to Figures 4.2 - 4.7 for details of design capacities.

Figure 4.2 Design Type 1 Dual 3-lane 11m carriageway



Width of sectional elements (m)		Design Capacity
Crest	36.2	Maximum capacity: 8500 PCU/hr
Median	1.0	(assumed NMV/MV ratio of 0.13)
Carriageway	11.0	
Shoulder (L) – paved	1.8	
Shoulder (R) – paved	0.3	
Divider	0.6	
NMV lane	3.0	
Verge	0.9	

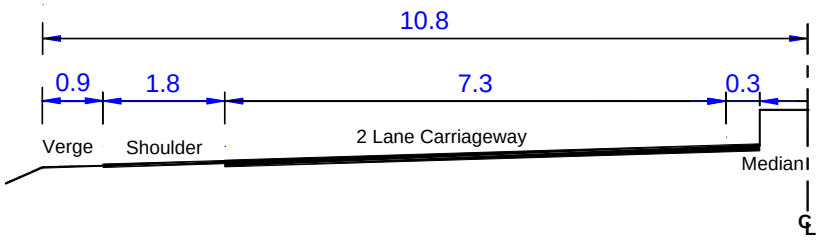
NMV provision

NMVs will use the separate NMV lane. Separation can be achieved in any of the three ways indicated in Figure 4.8. A standard width NMV lane is shown but this may need to be wider if NMV flows are high – see Section 4.3. Exceptionally the NMV lane may be omitted where it is thought to be feasible to prohibit NMVs from using the road.

Median

See Figure 4.9 for alternative designs.

Figure 4.3 Design Type 2 Dual 2 lane 7.3m carriageway



Width of sectional elements (m)		Design Capacity
Crest	21.6	Maximum capacity: 4500 PCU/hr
Median	1.0	(assumes that NMVs are either prohibited or are less than
Carriageway	7.3	50 PCU/hr)
Shoulder (L) – paved	1.8	
Shoulder (R) – paved	0.3	
Verge	0.9	

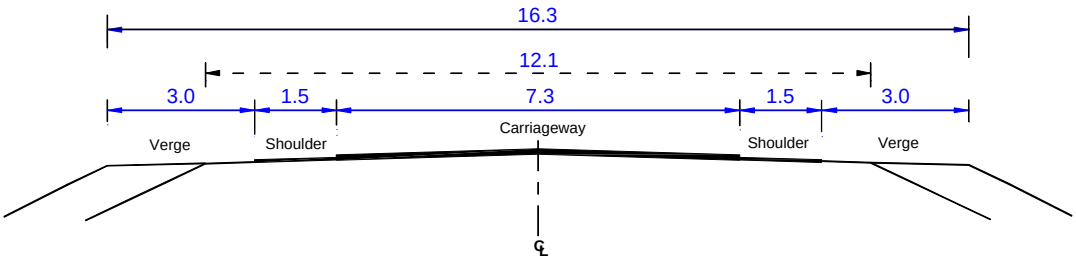
NMV provision

NMVs will use the shoulder. If the Design Year NMV PCU/hour exceeds 50 adopt the Type 2a cross-section which incorporates separate NMV lanes.

Median

See Figure 4.9 for alternative designs.

Figure 4.4 Design Type 3 7.3m carriageway



Width of sectional elements (m)		Design Capacity
Crest	16.3	Maximum capacity: 2100 PCU/hr
Carriageway	7.3	(assumed NMV/MV ratio of 0.2)
Shoulder – paved	1.5	
Verge	3.0	

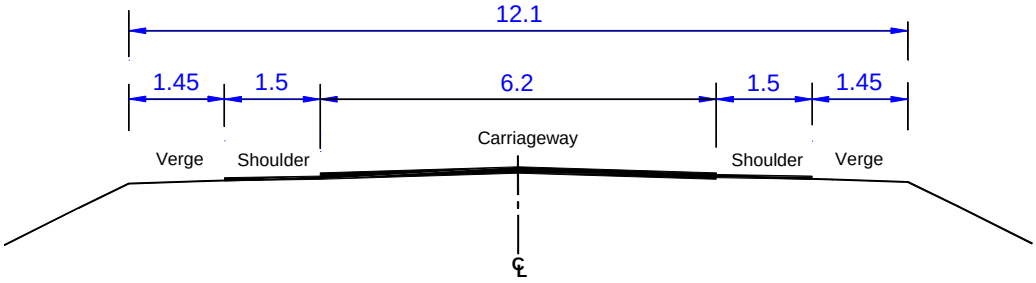
NMV provision

NMVs will use the paved shoulder. Consider providing separate NMV lanes (Type 3a cross-section) if the DY NMV PCU/hr exceeds 400 – see Figure 4.8.

Crest width

The extra-wide embankment permits the future addition of NMV lanes. If it is unlikely that these will ever be needed the verge need only be 0.9m wide, making the crest width 12.1m.

Figure 4.5 Design Type 4 6.2m carriageway



Width of sectional elements (m)		Design Capacity
Crest	12.1	Maximum capacity: 1600 PCU/hr
Carriageway	6.2	(assumed NMV/MV ratio of 0.14)
Shoulder – paved	1.5	
Verge	1.45	

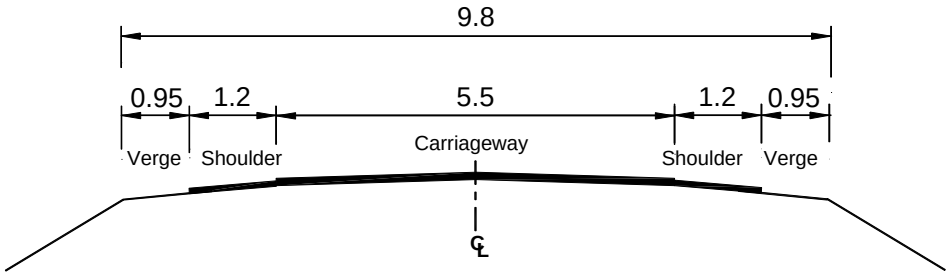
NMV provision

Where DY NMV PCU/hr exceeds 400 consider providing separate NMV lanes (Type 4a cross-section) – see Figure 4.8.

Upgrading

The extra-wide embankment permits upgrading to Type 3 standard.

Figure 4.6 Design Type 5 5.5m carriageway



Width of sectional elements (m)		Design Capacity
Crest	9.8	Maximum capacity: 800 PCU/hr
Carriageway	5.5	
Shoulder – paved	1.2	
Verge	0.95	

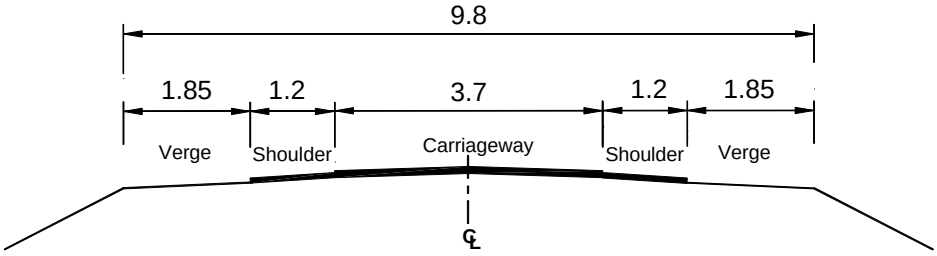
NMV provision

NMVs will use the carriageway and the shoulder, so it is essential that there is no difference in level between the two.

Upgrading

The extra-wide embankment permits upgrading to Type 4 standard.

Figure 4.7 Design Type 6 3.7m single lane carriageway



Width of sectional elements (m)		Design Capacity
Crest	9.8	Maximum capacity: 400 PCU/hr
Carriageway	3.7	(assumed NMV/MV ratio of 2.5)
Shoulder – paved	1.2	
Verge	1.85	

NMV provision

NMVs will use the carriageway and the shoulder, so it is essential that there is no difference in level between the two.

Upgrading

The extra-wide embankment permits upgrading to Type 5 and Type 4 standards.

Capacity

The design capacity of 400 PCU/hr is only achievable with good, well-maintained shoulders and when most of the vehicles are NMVs.

Figure 4.8 Typical NMV Arrangements at Bazar & Hats

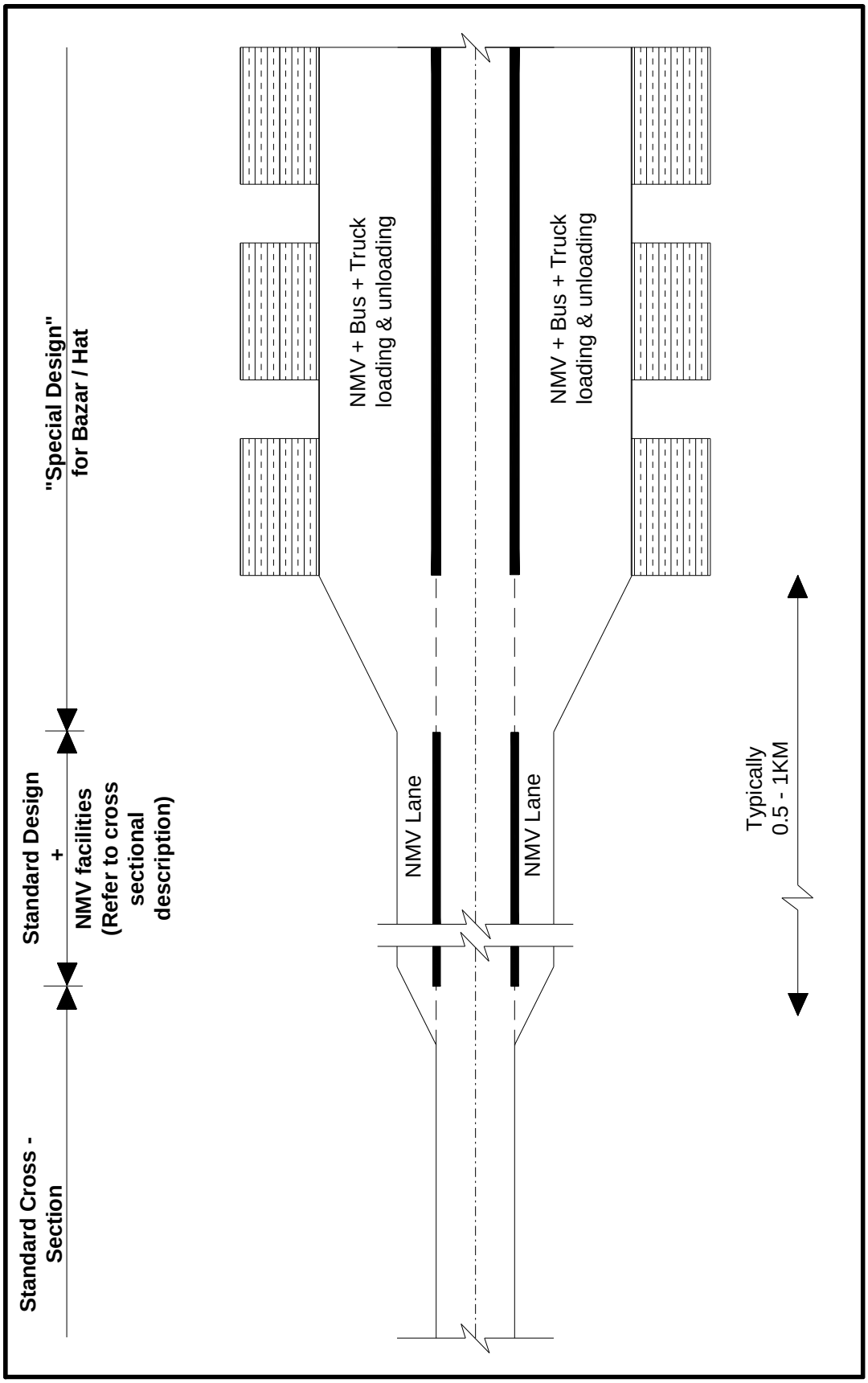
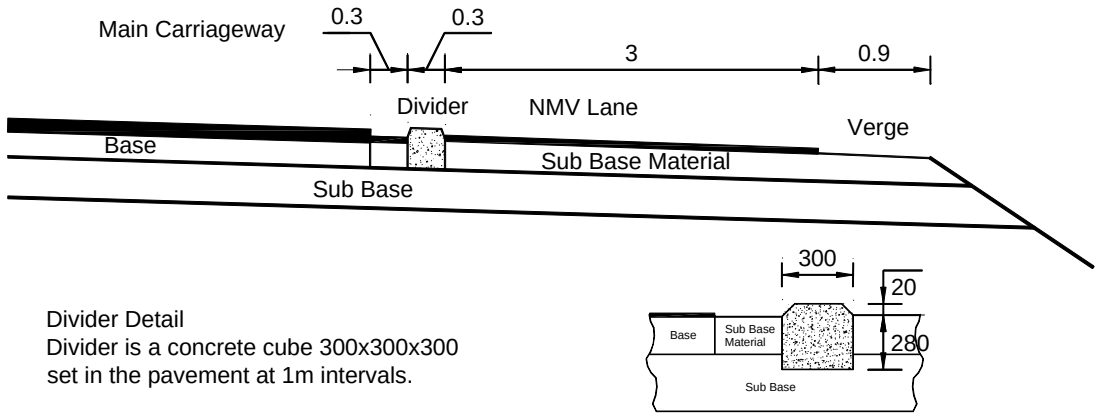


Figure 4.8 NMV Lane Designs

Shown are generalised designs – other designs may be acceptable

A. Rural sections – between towns and villages

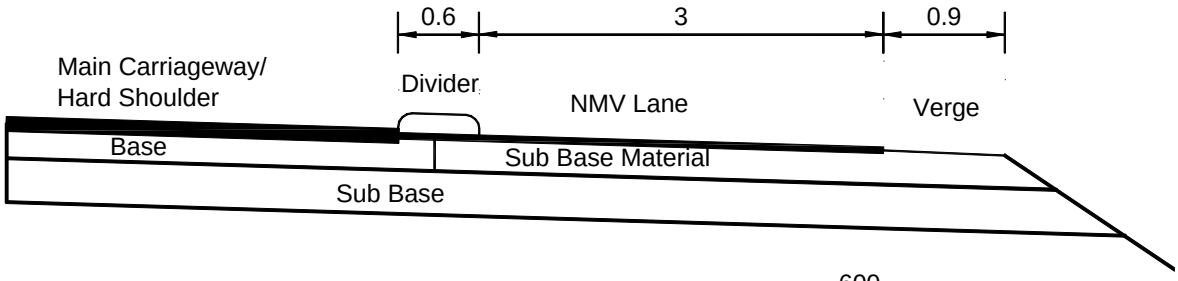
Cross Section



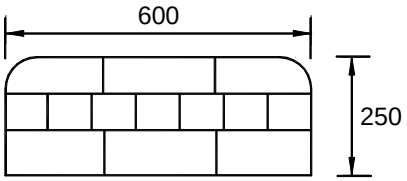
Divider Detail
Divider is a concrete cube 300x300x300 set in the pavement at 1m intervals.

B. Towns and villages (low pedestrian and NMV flows)

Cross Section



Divider Detail
Brick divider to be constructed on a mortar pad directly on the road surface. Gaps are to be left in the brick work to let the carriageway drain through to the NMV lane. Width of divider should be increased if there are many pedestrians.



C. Towns and villages (high pedestrian and NMV flows)

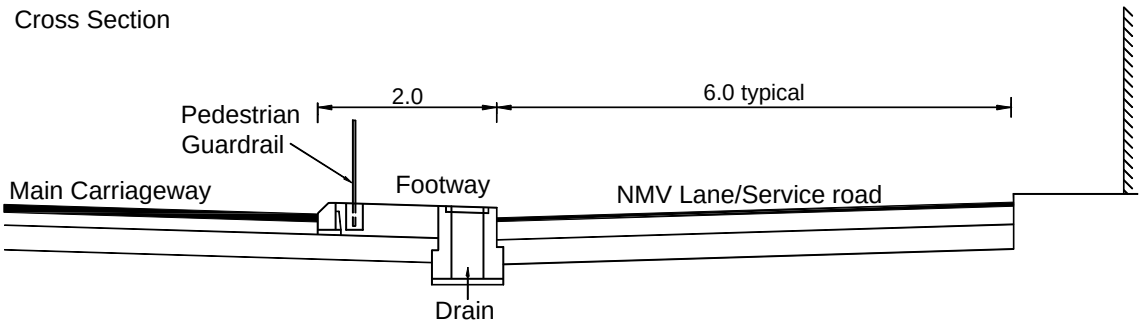
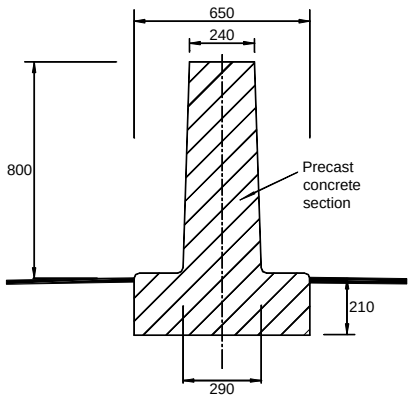

Cross Section
2.0
6.0 typical
Pedestrian
Guardrail
Main Carriageway
Footway
NMV Lane/Service road
Drain

Figure 4.9 Median Designs

The New Jersey Safety Barrier is the prefered divider on RHD roads. Two alternative types of median are illustrated below. These are generalised designs and other designs may be acceptable. The reinforced concrete safety barrier (such as the New Jersey Safety Barrier) is the safest option for busy, high-speed roads, because it will stop any out-of-control vehicle from crossing into the opposite carriageway. The island divider will stop some but not all vehicles – however it is much cheaper and does provide a refuge for pedestrians when they are crossing the road.

Medians should begin only in low-speed situations such as just after roundabouts or at the start of the minor arm of a T-junction. Adequate warning signs and hazard markers must be provided. The number of openings in the median must be kept to an absolute minimum for safety reasons. Where openings cannot be avoided a separate lane should be provided for turning traffic, and drivers of turning vehicles must be given a good view of oncoming traffic.

RCC Safety Barrier



Island divider

