SECTION 4

DESIGN of FOREST ROAD LAYOUT

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4.1 INTRODUCTION

1. A primary purpose of road design is to provide the optimum road geometry for the vehicle sizes and traffic volume anticipated. This must include consideration of efficiency and environmental impact.

2. Forest roads are low cost, low speed roads. The nominal design speed is usually taken to be 25 kph. Forest road design can be very complex. It requires technical and professional expertise and experience to provide practical and economic solutions. The roads are intended to be all-year but not all-weather roads.

3. The ideal road would consist of smooth flowing lines, with neither sharp curves nor steep gradients to offer interference to vehicle movement.

4. Harvesting facilities should be designed into the road at the outset. The design of these facilities follows consultation with the forest district staff, and after consideration of the proposed intensity and methods of harvesting.

5. Safety must never be compromised.

4.2 DESIGN CRITERIA

1. At design stage, the main points which could influence the final geometry are set out below.

2. Safety during construction and in subsequent use must always be considered.

3. Terrain restrictions will influence

- vertical and horizontal alignments;
- felling widths;
- excavation and fill slopes, soil and rock side slopes, and measures to maintain stability and mitigate bank erosion;
- the availability of borrow pits or roadside side slope excavation for construction materials;
- carriageway pavement design;
- drainage and ditch provision; and
- bridge and culvert positions and approaches.

4. Harvesting requirements will dictate

- the need, purpose and future usage of a road;
- volume and intensity of traffic;
- all year use, or use restricted by season and / or climate; and
- harvesting facilities.

- and have an influence on

- vehicle size and type; and
- the need for turn-rounds and passing bays.

5. The economics of the various options will have a considerable influence on the final choice of road line.

4.3 VERTICAL ALIGNMENT - MAXIMUM GRADIENT

1. Forest roads are normally constructed of water-bound macadam. This form of construction has limitations for traction, particularly under wet or frozen conditions.

2. The nominal maximum gradient shall be 10 % on straights or horizontal curves that do not require road widening (see Section 4.8). Where possible, however, gradients should be maintained within the middle range (3-7%) to avoid both flat gradient effects (e.g. potholing) and steep climbs. Given the normal methods of setting out a forest road, an accuracy tolerance of 0.5% is considered reasonable.

3. Gradient should be measured between tangent points (TP) as shown schematically in Figure 4.1.

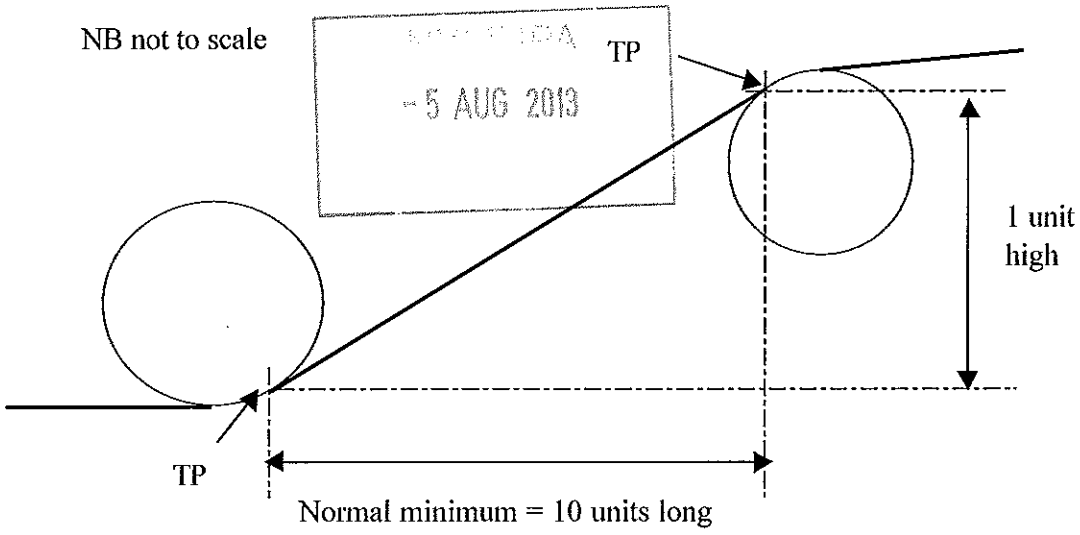


Figure 4.1 Method of Measuring Gradient

1. Experience has shown that short lengths (< 200m) of steeper gradient (= 12.5%) within an overall gradient of 10%, can be accommodated on water-bound surfaces in good conditions. However, this relaxation must be used with caution, and only where it can be safely accommodated within the prevailing geometry.

5. It is difficult for lorries to move off from rest on a steep gradient. Where possible, stacking bay locations should be planned for points where the gradient is no steeper than 5%, or where the gradient can be slackened over a short length.

6. Where possible, turn-rounds should be located on a gradient of less than 5 % to ease loading, increase stability when manoeuvring and aid traction.

7. Use should be made of the recommendations in Section 4.8 for gradient combined with horizontal bends. This advice is based upon experience.

8. It should be noted that unbroken lengths of maximum gradient could, in themselves, represent a barrier to movement. This would depend on the actual length, the condition of road and surfacing, weather conditions, etc.

9. A bituminous surface will allow lorries to negotiate much steeper gradients (~ 16%). Such a surfacing is expensive both to construct and to maintain. However, in some circumstances this could save considerable road building costs.

10. To facilitate movement from rest, wherever possible approach gradients to junctions should be limited to 5%.

4.4 VERTICAL ALIGNMENT - MINIMUM GRADIENT

1. Water-bound macadam gives rise to problems of surface water disposal. Standing water on the surface rapidly leads to saturation, a reduction in strength and the formation of potholes.

2. Roads constructed with a longitudinal gradient will always shed water better than roads that are essentially level. This is especially important in the bottom of sag curves. Such lengths should be kept to a minimum.

3. The recommended minimum longitudinal gradient is 2%.

4.5 VERTICAL CURVES

1. The maximum intersection angle should be when two 10% gradients meet at a summit or sag.

2. It is essential to provide a vertical curve at such intersections to maintain sight distances, reduce grounding of long vehicles and for user comfort. From experience, the following minimum values are suggested.

Algebraic difference	Sag Curve		Summit Curve	
	minimum Length	rise above I.P	minimum Length	Drop Below I.P.
%	m	m	m	m
14	50	0.87	35	0.62
16	56	1.1	45	0.89
18	63	1.39	52	1.15
20	69	1.69	59	1.44

4.6 HORIZONTAL ALIGNMENT

1. The recommendations which follow are based upon the normal 16.5m length articulated vehicle permitted under the Road Vehicle (Construction and Use) Regulations 1986.

2. In general, a rigid vehicle (even with drawbar trailer) will perform most manoeuvres within the space required by a large articulated vehicle.

3. The design width for new construction and upgrading will be 3.4m on a straight carriageway. This width will have a tolerance of 0.2m resulting in an actual minimum width of 3.2m (but see Para. 1.1.5 & 6).

4. The tolerance quoted above has been introduced to take account of the normal construction methods used for forest roads. Every effort should be made to achieve the nominal design width.

5. The widths quoted above refer to running surface. This width does not include any berms, safety margins or side slopes of any description. (See Figure 5.6.)

4.7 HORIZONTAL CURVES

1. Circular curves will normally be used for horizontal bends. The recommendations which follow are based upon the outside radius, the line normally followed by the outside front wheel of an articulated vehicle.

2. Because of the assumed low vehicle speed, transition curves will not normally be provided.

3. To allow for trailer wheel cut-in, bends will normally be widened on the inside as recommended in Section 4.8 and shown in Figure 4.2.

4. Straight transition lengths are normally used to gain the additional width. Recommendations are given in Section 4.8.

5. If widening on the outside of the bend is unavoidable, the transition lengths should be increased by 10m.

6. Intermediate values can be obtained from the table by interpolation.

7. There is no need to widen curves of radius 90m or greater, or where the deflection angle is less than 15°.

8. It should be noted that bends below 45m radius cannot be safely negotiated at 25 km/hr by articulated vehicles.

4.8 HORIZONTAL CURVE RECOMMENDED WIDTHS AND GRADIENTS

Deflection of circle From chord of length for setting out (m)			Outside Radius	Minimum Widths For Maximum Angle of Deflection (°)				Transition Straight Length	Maximum Desirable gradient on outside radius
15m	20m	30m		15	45	90	180	**	**
				Running surface width					
m	m	m	m	m	m	m	m	m	%
0.3	0.6	1.3	90	3.4	3.4	3.4	3.4	-	10
0.5	0.8	1.9	60	3.4	3.8	4.0	4.0	20	8
0.6	1.1	2.6	45	3.4	4.0	4.5	4.5	20	7
1.0	1.7	4.0	30*	3.4	4.4	5.0	5.1	25	6.5
1.2	2.1	5.0	25		4.6	5.1	5.3	30	5
1.5	2.7	6.8	20		4.9	5.6	5.9	30	4.5
2.0	3.8		15			6.3	7.0	40	4
			10***				10.0	40	5 on diagonal

* Preferred minimum radius

** Figures based on experience

*** Absolute minimum hairpin

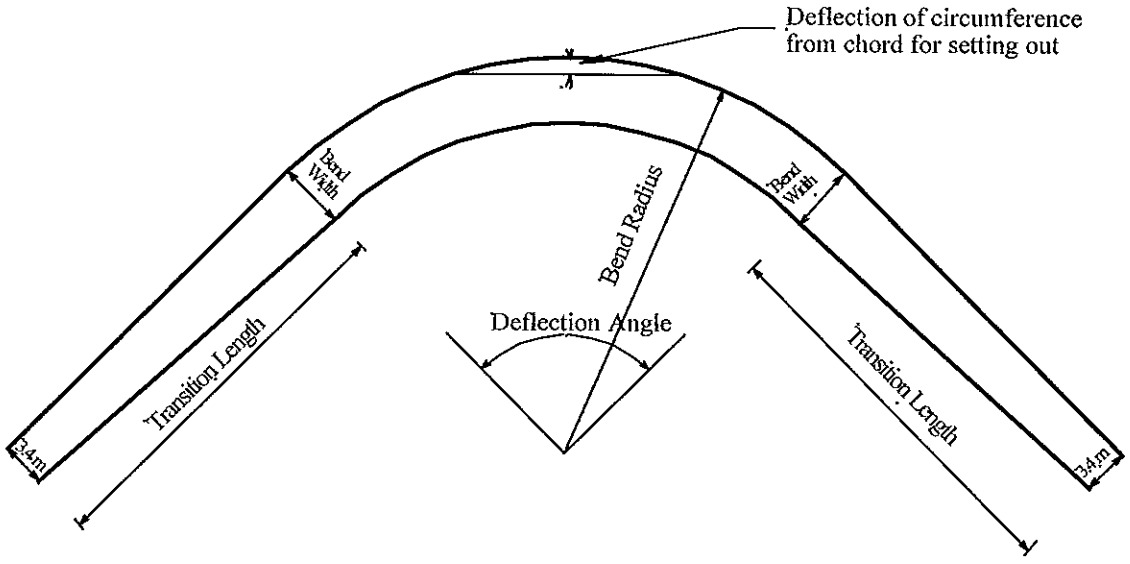


Figure 4.2 Bend Widening

4.9 BRIDGE APPROACHES

1. Approaches to bridges should be straight in the line of the bridge for as far as possible to allow the vehicle to be properly aligned on the bridge deck.

2. The minimum straight should be 20m.

3. Where a bend is close to a bridge, the widening and transition lengths recommended in Section 4.8 would allow a vehicle to be properly aligned.

4. Allowing the vehicle to "overshoot the bridge" can reduce the overall length required. Such approaches are only usable at very low speeds. Designs can be obtained from Forestry Civil Engineering Head Office. Sample outline designs are shown at Figure 4.3 at the end of this section.

4.10 TURN – ROUNDS

1. Turn-rounds need to be provided at or very near the end of every lorry road.

2. Additional turn-rounds are useful at about 1km intervals on long lengths of forest road where there are no junctions or other turning facilities.

3. Where possible, turn-rounds should be situated at the top or bottom of slopes, or on harvesting coupe boundaries.

4. Where possible, the turn-round should be positioned to be used empty.

5. It is preferable to reverse turn into the bank and not over the (weaker) edge.

6. It is preferable to reverse turn onto the driver's side to avoid blind spots.

7. The shape of the turn-round can be dictated by terrain, use as a harvesting facility, or preference. Use as a harvesting facility is not recommended as there is a tendency to limit the effectiveness of the structure for its prime purpose. The normal options are

- 'T' shaped (see Figure 4.4 at the end of this section);
- 20m 'U' turn;
- 16.5m Offset 'U' turn which is very tight for articulated vehicles and only sensible to use in very restricted locations. It is unsuitable for drawbar trailer lorries;
- Circular turn-rounds are possible down to 11m radius, but 25m transitions are required both in and out. There is a tendency for this type of turn-round to get clogged with mud and brash during harvesting operations;
- Aberfoyle turn round for use in restricted situations. A more complicated manoeuvre than for the Offset U turn is required.

Designs for the 'U' and 'Aberfoyle' turn-rounds can be obtained from Forestry Civil Engineering Head Office.

4.11 PASSING BAYS

1. Normal width forest roads do not permit vehicles to pass on the carriageway.

2. Passing places should be provided where deemed necessary. For a sample design, see Figure 4.5 at the end of this section.

3. Because it is difficult for articulated lorries or lorries with trailers to reverse any distance, consideration should be given to ensuring that passing places are inter-visible.

4.12 ACCESSES ONTO THE PUBLIC ROAD

1. New or improved accesses onto the public road will need to be approved by local highways/roads authorities. New or improved accesses onto a classified public road will also need to go through the planning process (see Section 2.4).

2. Relaxation of the standards is sometimes possible where previous use of an access can be demonstrated or predicted traffic volumes are low.

3. On a busy public road, it is undesirable for a lorry turning left (whether into or out of the access) to have to cross the public road centreline. A possible layout for a 90° junction with a 'major' public road is shown at Figure 4.6 at the end of this section.

4. One-way skewed accesses can be used to reduce earthworks or to divert traffic in a chosen direction. An example is shown at Figure 4.7 at the end of this section.

5. Most local highways/roads authorities will require some bituminous material to be laid in the immediate vicinity of a public road. Such work should be carried out to their required specification.

6. Particular care will be required with regard to visibility splays from the forest road onto the public road. Many local highways/roads authorities will specify minimum requirements. The maintenance of such splays should receive the necessary attention.

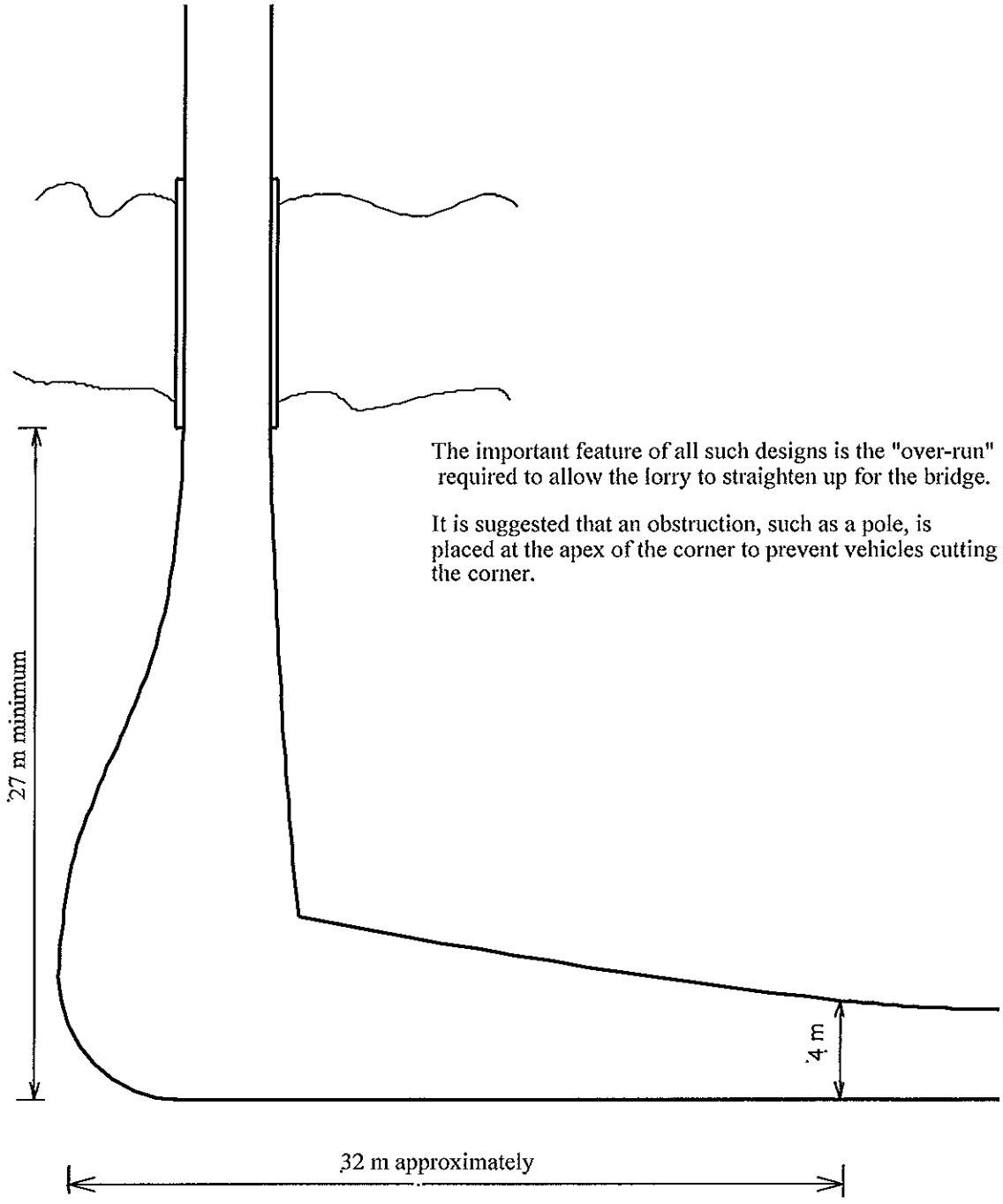


Figure 4.3(a) Restricted Bridge Approach

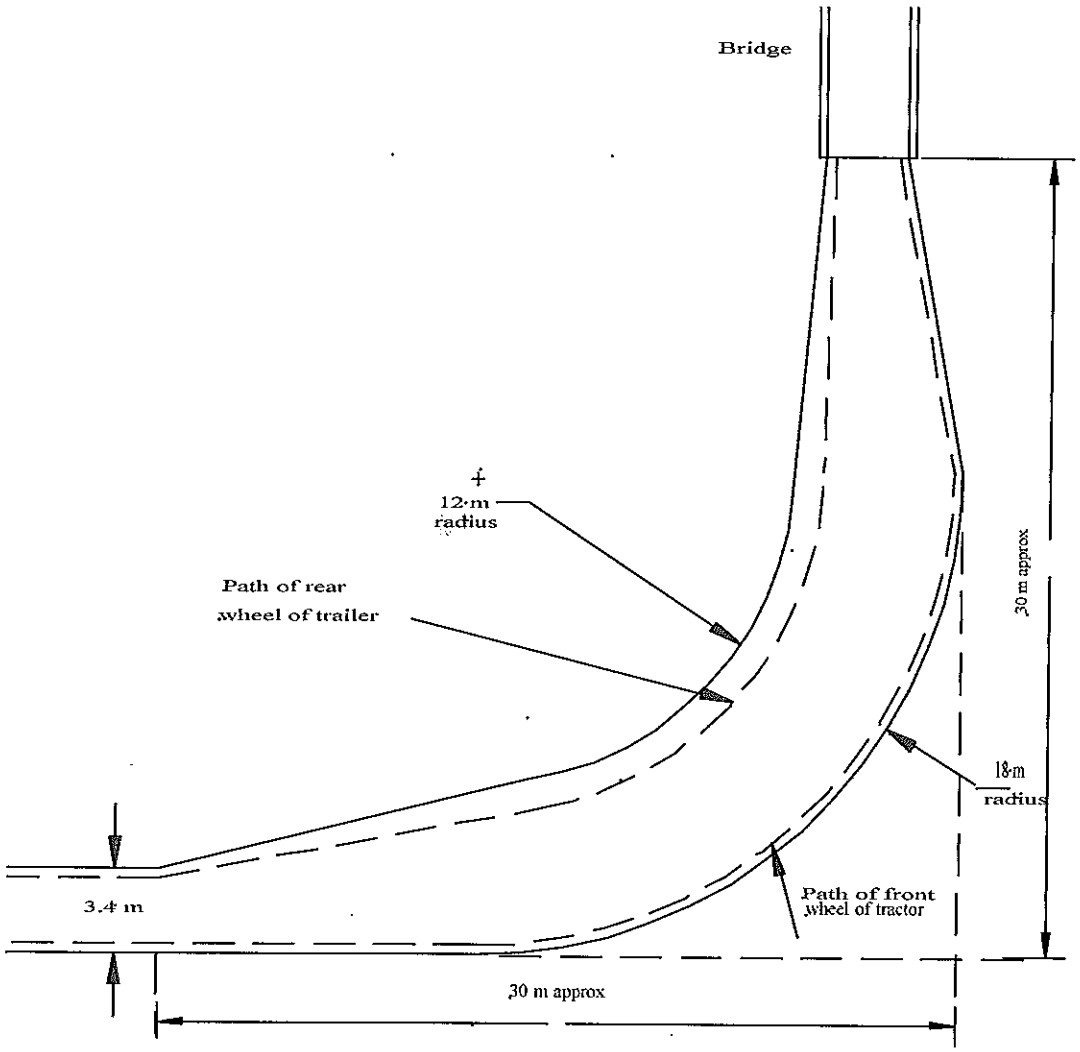
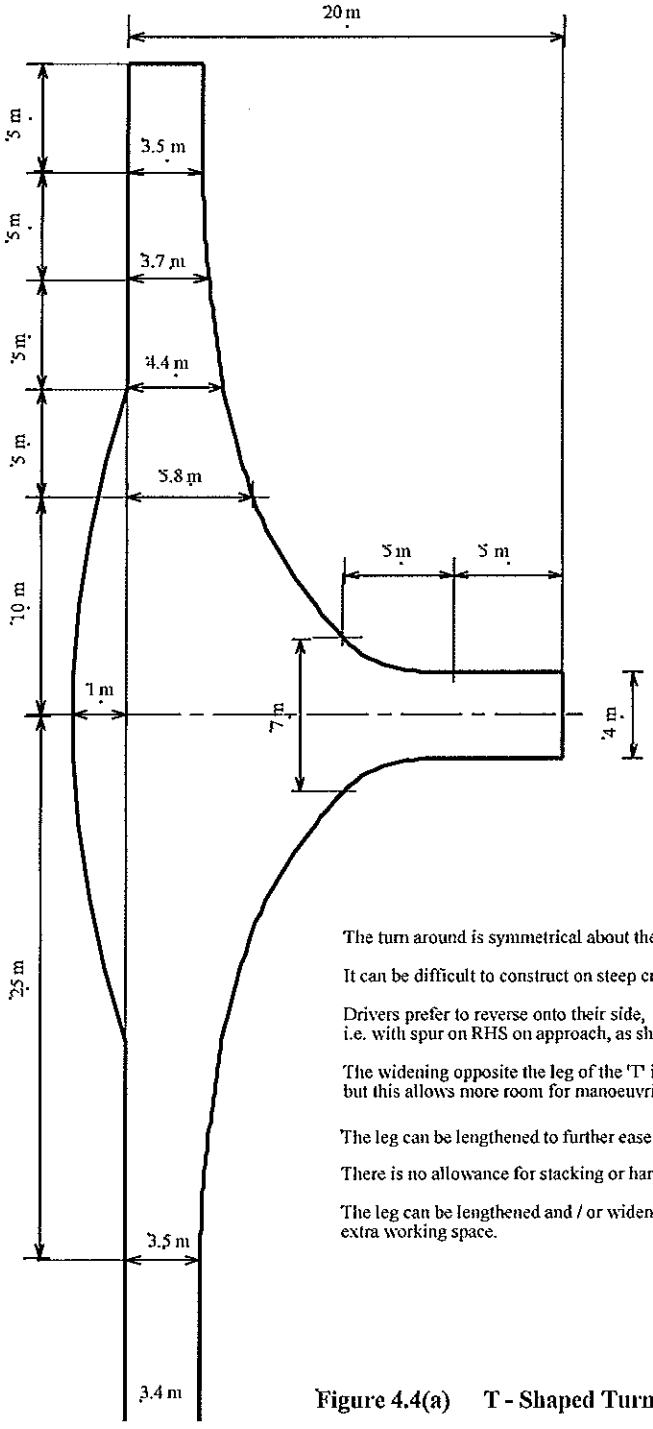


Figure 4.3 (b) Restricted Bridge Approach



The turn around is symmetrical about the spur leg.

It can be difficult to construct on steep cross-falls.

Drivers prefer to reverse onto their side, i.e. with spur on RHS on approach, as shown.

The widening opposite the leg of the 'T' is optional, but this allows more room for manoeuvring.

The leg can be lengthened to further ease manoeuvring.

There is no allowance for stacking or harvesting.

The leg can be lengthened and / or widened to provide extra working space.

Figure 4.4(a) T - Shaped Turn Around

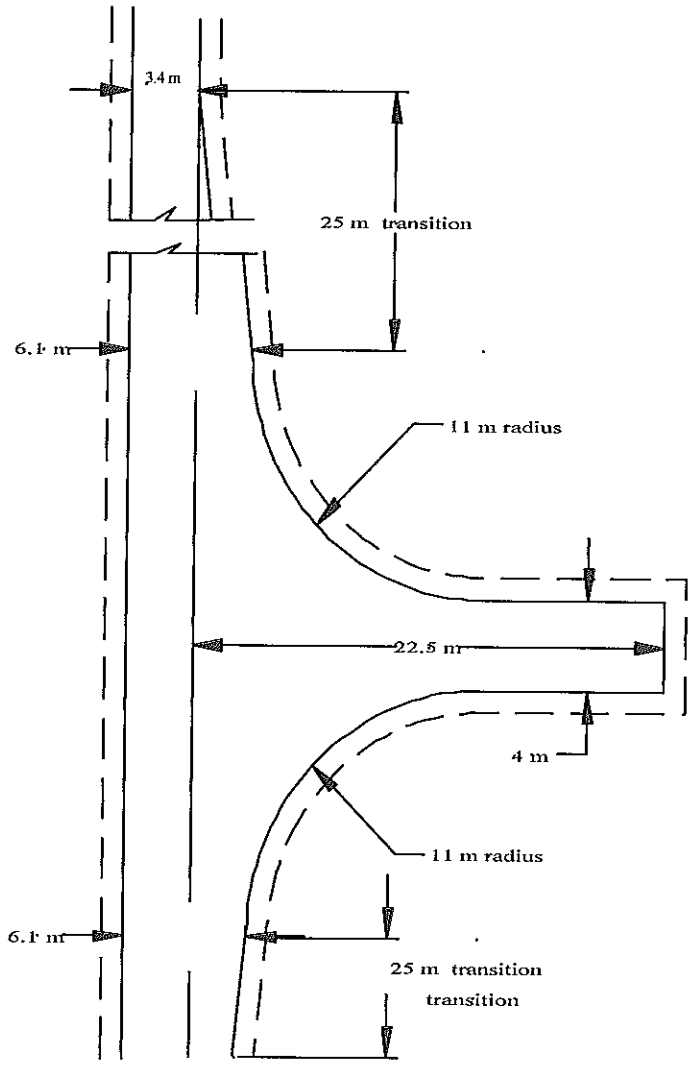
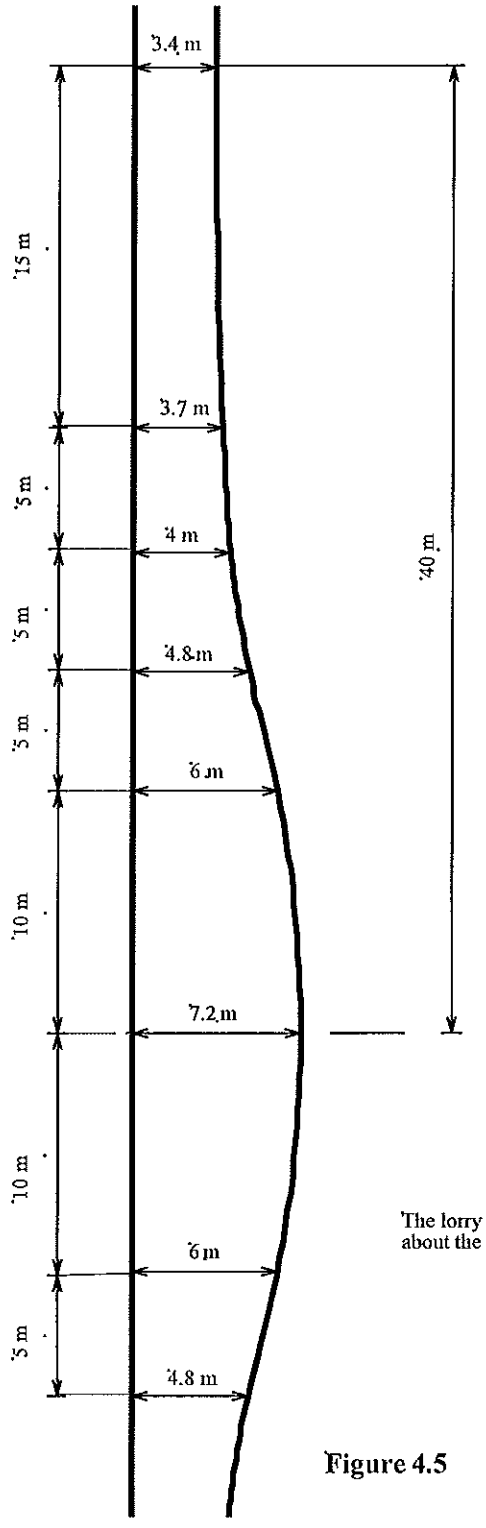
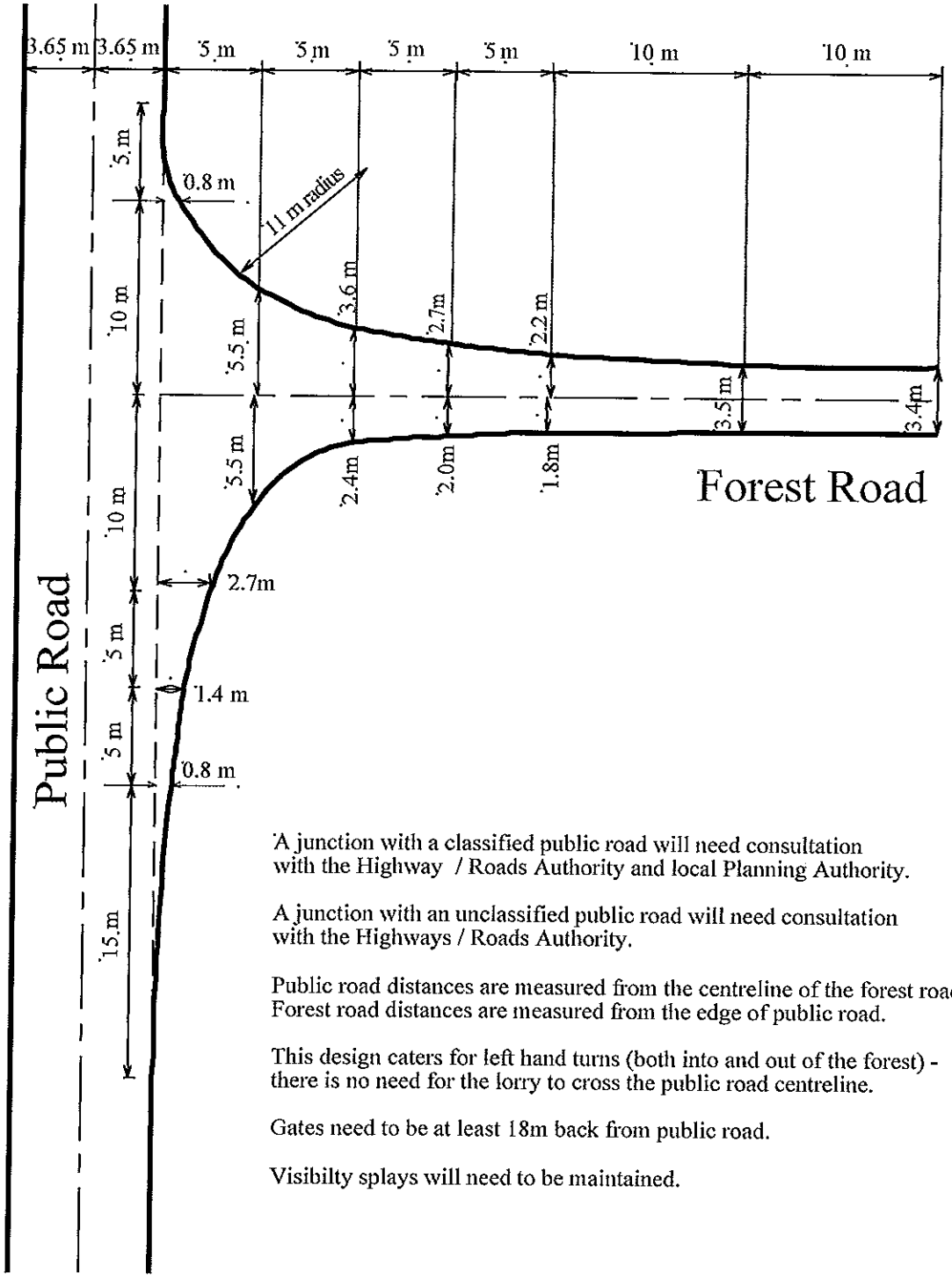


Figure 4.4 (b) **T - Shaped Turn Around**



The lorry passing bay is symmetrical about the centre line

Figure 4.5 Lorry Passing Bay



A junction with a classified public road will need consultation with the Highway / Roads Authority and local Planning Authority.

A junction with an unclassified public road will need consultation with the Highways / Roads Authority.

Public road distances are measured from the centreline of the forest road. Forest road distances are measured from the edge of public road.

This design caters for left hand turns (both into and out of the forest) - there is no need for the lorry to cross the public road centreline.

Gates need to be at least 18m back from public road.

Visibilty splays will need to be maintained.

Figure 4.6 Major Public Road Junction

Consultation is required with the Highway / Roads Authority (and local Planning Authority if road classified).

Reducing the junction angle reduces the earthworks, but increases the interface, (hence possible increase in surface treatment and longer ditch piping).

Increasing junction angle reduces the need for carriageway support.

Set forest road gate 18m back from edge of public highway.

Keep gradient to 5% on approach to forest road gate.

Visibility splays will need to be maintained.

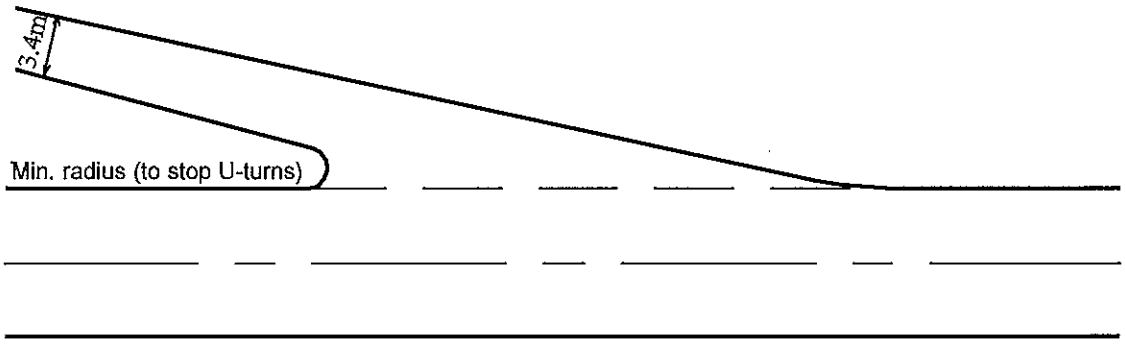


Figure 4.7 Skewed Minor Public Road Junction