RECOMMENDED PRACTICE
FOR
SIGHT DISTANCE ON RURAL HIGHWAYS

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1. INTRODUCTION

1.1. Ability to see ahead is of profound importance for the safe and efficient operation of vehicles on a highway. If greater safety is to be built into highway alignments, the design must ensure sight distance of adequate length in different situations to permit drivers enough time and distance to control their vehicles so as to avoid unforeseen accidents.

1.2. In 1950, the Specifications and Standards Committee had published a Paper on sight distances (Paper No. 149, "Standards for Sight Distances for Highways", IRC Journal Vol. XV-1) which has remained the mainstay of highway practice in the country so far. There have been significant developments since then. Taking these into account, revised recommendations on this subject have been evolved for uniform adoption on all rural highways. The present Recommended Practice was approved by the Specifications and Standards Committee in their meeting held on the 12th and 13th December, 1975 subject to a few modifications and later it was approved by the Executive Committee in their meeting held on the 14th April 1976 and by the Council in their 87th meeting held on 27th August 1976.

1.3. In applying this standard, effort should not be to limit the design of any highway to the minimum values laid down. Where conditions are favourable, good engineering practice will lie in adopting more liberal values, particularly for stopping sight distance.

2. STOPPING SIGHT DISTANCE

2.1. General

2.1.1. Stopping sight distance is the minimum sight distance for which all roads must always be designed, regardless of any other consideration. It is the clear distance ahead needed by a driver to stop his vehicle before meeting a stationary object in his path on the road.

2.1.2.   Stopping distance has two components:

(i) the distance travelled during perception and brake reaction time; and

(ii) the distance travelled during the time brakes are under application till the vehicle comes to a stop.

2.2.   Perception and Brake Reaction Time

2.2.1.   Perception and brake reaction time is the time interval between the instant the driver sights a dangerous object for which a stop is necessary and the instant the brakes are applied.

2.2.2.   Perception and brake reaction time depends on a variety of factors, viz., age, sex, alertness and visual acuity of the driver, atmospheric visibility, vehicle design, the size and type of the object etc.   For purposes of highway design, the total reaction time should be large enough to cover nearly all drivers and highway conditions.   A value of 2.5 seconds is considered reasonable for most situations.   The distance travelled during this time will be given by the expression:

$$d_1 = 0.278\ Vt$$

where d_1 = distance travelled during total reaction time in metres;

V = speed in kmph; and

t = the perception and reaction time in seconds.

2.3.   Braking Distance

2.3.1.   Braking distance is the distance required a vehicle to come to stop after the brakes are applied.   On a level road, assuming friction remains constant during the period of deceleration, braking distance is given by:

$$d_2 = \frac{V^2}{254f}$$

where d_2 = braking distance in metres;

V = speed in kmph; and

f = coefficient of longitudinal friction between vehicle tyres and road pavement.

2.3.2.   The value of the coefficient of friction varies with speed, tyre pressure, condition of tyre tread, type and condition of pavement, and whether the surface is wet or dry.   For design purposes, the value should encompass nearly all significant pavement

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surface types and field conditions, and should be safe for tyres in reasonable condition. Based on these considerations, design values for coefficient of friction at different vehicle speeds are given in Table 1.

TABLE 1.   STOPPING SIGHT DISTANCE ON RURAL HIGHWAYS

Speed kmph	Perception and brake reaction		Braking		Safe stopping sight distance (metres)	
	Time (seconds)	Distance (metres)	Coefficient of longitu- dinal friction	Distance (metres)	Calculated values	Rounded off values for design
20	2.5	14	0.40	4	18	20
25	2.5	18	0.40	6	24	25
30	2.5	21	0.40	9	30	30
40	2.5	28	0.38	17	45	45
50	2.5	35	0.37	27	62	60
60	2.5	42	0.36	39	81	80
65	2.5	45	0.36	46	91	90
80	2.5	56	0.35	72	118	120
100	2.5	70	0.35	112	182	180

2.4. Design Values

2.4.1.   Minimum stopping sight distance is given by the sum of the components d_1 and d_2 discussed in preceding paragraphs. Calculated and rounded values of stopping distance for different vehicle speeds are given in Table 1. For application of values in this table, the speed chosen should be the same as the design speed of the road.

2.5. Effect of Grade

2.5.1.   The braking distance of a vehicle is longer on down-grades and shorter on upgrades. The braking distance formula amended to take the effect of grades into account is :

$$d_2 = \frac{V^2}{254\,(f \pm 0.01G)}$$

in which G is the longitudinal grade in per cent (positive for upgrade and negative for downgrade) and other terms are the same as previously defined.

2.5.2. Correction for grade should not be applied on undivided roads with two way traffic, but must invariably be considered for divided highways which have independently designed profiles.

2.6. Criterion for Measurement

Safe stopping sight distance is measured between two points, one 1.2 m above the carriageway standing for in driver's eye and the other 0.15 m height representing the object.

3. OVERTAKING SIGHT DISTANCE

3.1. Design Criteria

3.1.1. For a higher level of service on undivided roads, it is necessary that vehicles moving at design speed should be frequently able to overtake vehicles slower than them. Since overtaking manoeuvre involves the occupation of road space normally used by opposing traffic, drivers must have sufficient sight distance available to them so that the whole operation can be accomplished with safety. Optimum condition is one in which the overtaking driver can follow the vehicle ahead for a short time while he assesses his chances of overtaking, pull out, overtake, and return to his own side of the road before meeting any oncoming vehicle.

3.1.2. In actual practice, there may be occasions to consider multiple overtakings where two or more vehicles overtake another vehicle, or are themselves overtaken in a single manoeuvre. It is, however, not practical to assume such conditions in developing minimum sight distance criteria. Sight distance values recommended here pertain basically to overtaking manoeuvres involving single vehicles. Longer sight distances are generally available along road alignments, e.g., in long relatively level sections, where an occasional multiple overtaking can take place without difficulty.

3.1.3. For computing minimum overtaking sight distance, certain assumptions for traffic behaviour are necessary. The assumptions made are :

(i) The vehicle being overtaking is travelling at a uniform speed which is 16 km per hour less than the design speed of the road ;

(ii) The overtaking vehicle follows the vehicle ahead for a short while to perceive the clear road ahead before beginning the overtaking movement;

(iii) Overtaking is done by accelerating rapidly to the design speed and is regarded as having been completed when the overtaking vehicle returns to its own side of the road ; and

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(iv) Overtaking once begun is finished in the face of an oncoming vehicle travelling at design speed in such a way that the latter arrives alongside the former just at the completion of the manoeuvre.

3.1.4. Observations in the U.S.A. and elsewhere have shown that the overtaking manoeuvre takes roughly 8 to 14 seconds for a vehicle closing at the design speed. To this should be added the distance travelled by an opposing vehicle during the time of overtaking manoeuvre to minimise the chance of a collision while the overtaking vehicle is on right-hand side of the road. Conservatively, this distance should be the distance traversed by an opposing vehicle during the entire time of the overtaking manoeuvre. But this makes the overtaking distance too long and is seriously open to question. During the first phase of the overtaking manoeuvre when the overtaking vehicle has not yet pulled abreast of the vehicle being overtaken, the former can always return to its own side if an oncoming vehicle is sighted. The interval of the first phase manoeuvre is about one-third the total time required for overtaking. On this basis, the element in the overtaking sight distance for the opposing vehicle can be reasonably taken to be the distance it traverses during two-thirds of the actual time for overtaking. The opposing vehicle is assumed to travel at design speed during this period.

3.2. Design Values for Overtaking Sight Distance

3.2.1. Using the above assumptions, safe overtaking sight distances for different speeds have been calculated in Table 2 and rounded off values are given for design purposes.

TABLE 2. OVERTAKING SIGHT DISTANCE FOR TWO-LANE HIGHWAYS

Speed kmph	Time component, seconds			Safe overtaking* sight distance (metre)
	For overtaking manoeuvre	For opposing vehicle	Total	
40	9	6	15	165
50	10	7	17	235
60	10.8	7.2	18	300
65	11.5	7.5	19	340
80	12.5	8.5	21	470
100	14	9	23	640

* Rounded off values

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3.2.2 The design values in Table 2 pertain to overtaking of a vehicle by a passenger car at level grade. On upgrades, the sight distance required would be more due to reduced acceleration of the overtaking vehicle and the likely speeding up of the vehicle from opposing direction. These factors are somewhat compensated by the loss in speed of the overtaken vehicle which may frequently be a heavy truck. No separate design values are, therefore, recommended for application on grades.

3.3. Application

3.3.1. On single carriageways with two-way traffic (i.e., undivided roads of single or two-lane width), normally the attempt should be to provide overtaking sight distance in as much length of the road as possible. Conditions ideal for this application will be—

(i) straight sections of road with isolated overbridges or summit vertical curves where the provision of overtaking sight distance would result in unobstructed sight distance over a long length of the road; and

(ii) relatively easy sections of terrain adjacent to long reaches with no opportunity for overtaking at all, e.g., at the ends of an excessively winding road in hilly/rolling country.

3.3.2. In sections where application of overtaking sight distance is considered impractical for reasons of economics or otherwise, as in an undulating terrain, as far as feasible the design should aim at providing the intermediate sight distance discussed in para 4. Where visibility corresponds to these conditions, drivers should be cautioned about the limited sight distance for overtaking through appropriate speed limit signs. The posted speed should be that at which the overtaking manoeuvre can be completed with full safety, vide Table 2.

3.3.3. At summit curves and horiozntal curves not satisfying requirements of even the intermediate sight distance, it will be necessary to provide restrictive pavement markings in accordance with IRC : 35-1970 "Code of Practice for Road Markings (with paints)". Where the road section involved is long, "No Overtaking" signs should be installed at the beginning and at intervals.

3.4. Criterion for Measurement

Overtaking sight distances is measured between two points both 1.2 metre above the carriageway, one standing for the driver eye height and the other for the height of object above the road surface.

4. INTERMEDIATE SIGHT DISTANCE

4.1. Design Values

4.1.1. Sections of roads where the customary overtaking sight distance cannot be provided should be designed, as far as possible, for "intermediate sight distance" which is defined as twice the normal safe stopping distance. It is the experience that inter-mediate sight distance improves visibility appreciably and affords a reasonable chance to drivers to overtake with caution.

4.1.2. Recommended values of intermediate sight distance for different speeds are given in Table 3.

TABLE 3. INTERMEDIATE SIGHT DISTANCE FOR TWO-LANE HIGHWAYS

Speed kmph	Intermediate sight distance (metre)
20	40
25	50
30	60
40	90
50	120
60	160
65	180
80	240
100	360

4.2. Application

As explained in paras 3.3.2. and 3.3.3.

4.3. Criterion for Measurement

Intermediate sight distance is measured between two points 1.2 metre above the carriageway.

5. HEADLIGHT SIGHT DISTANCE AT VALLEY CURVES

5.1. During day time, visibility is hardly a problem on valley curves. But for night travel the design must ensure that the road-

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way ahead is illuminated by vehicle headlights for a sufficient length which enables the vehicle to brake to a stop, if necessary. This is known as the headlight sight distance and is equal to the safe stopping sight distance given in Table 1. From safety considerations, it is essential that valley curves should be designed to provide for this visibility.

5.2. Criterion for Measurement

For designing valley curves, the following criteria should be followed to ensure the headlight sight distance :

(i) height of headlight above the road surface is 0.75 m;

(ii) the useful beam of headlight is one degree upwards from the grade of the road; and

(iii) the height of object is nil.

6. SIGHT DISTANCE FOR DIVIDED HIGHWAYS

6.1. On divided highways with 4 or more lanes, it is not necessary to provide overtaking sight distance as required for single carriageways with-two-way traffic. However, sight distance adequate for safe stopping for the design speed vide Table 1 must be ensured at all points along the highway. In fact it will be a good practice to design for somewhat more liberal values to make allowance for the time a driver takes to recognise whether a vehicle ahead has stopped and, if it has, whether it is on the carriageway or the shoulder.

7. SIGHT DISTANCE ON HORIZONTAL CURVES

7.1. Sight distance across the inside of horizontal curves is an important element of design. Lack of visibility in the lateral direction may arise due to obstructions like walls, cut slopes, buildings, wooded areas, high farm crops etc. The straightforward manner of achieving the necessary setback in these situations is to remove the obstruction. If somehow this is not feasible, alignment of the road may need adjustments. Preferably each such case should be studied separately to determine the best course to adopt.

7.2. The setback distance to give the desired sight distance on the inside of horizontal curves can be calculated from the

following equation (see Fig. 1 for definitions):

$$m = R - (R-n) \cos \theta$$

where $\theta = \dfrac{S}{2(R-n)}$ radians

m = the minimum setback distance to sight obstruction in metres at the middle of the curve (measured from the centre line of the road);

R = radius at the centre line of the road in metres

n = distance between the centre line of the road and the centre line of the inside lane in metres;

and S = sight distance in metres.

In the above equation, sight distance is measured along the middle of inner lane. On narrow, single-lane roads, this refinement is not necessary and the setback distance should be provided with respect to the centre-line of the road, i.e., assuming 'n' to be zero.
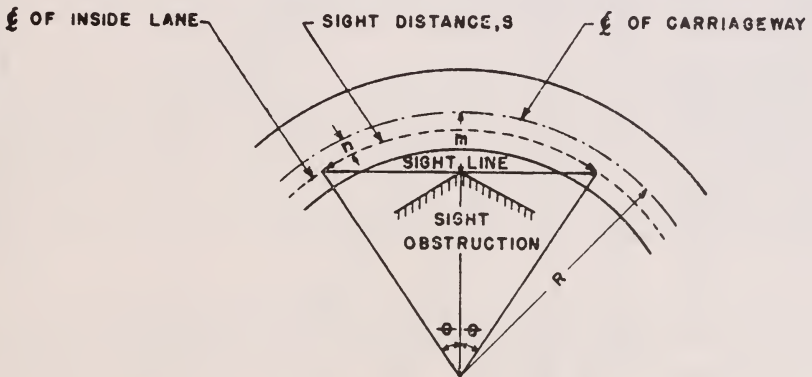

Fig. 1. Visibility at horizontal curves

7.3. Utilising the above equation, design charts for lateral clearance corresponding to the safe stopping distance are given in Fig. 2 for two-lane roads. The plotted values relate basically to circular curves longer than the design sight distance. For shorter curves, the values of setback distance found from Fig. 2 will be somewhat on the higher side, but these can any way be used as a guide.
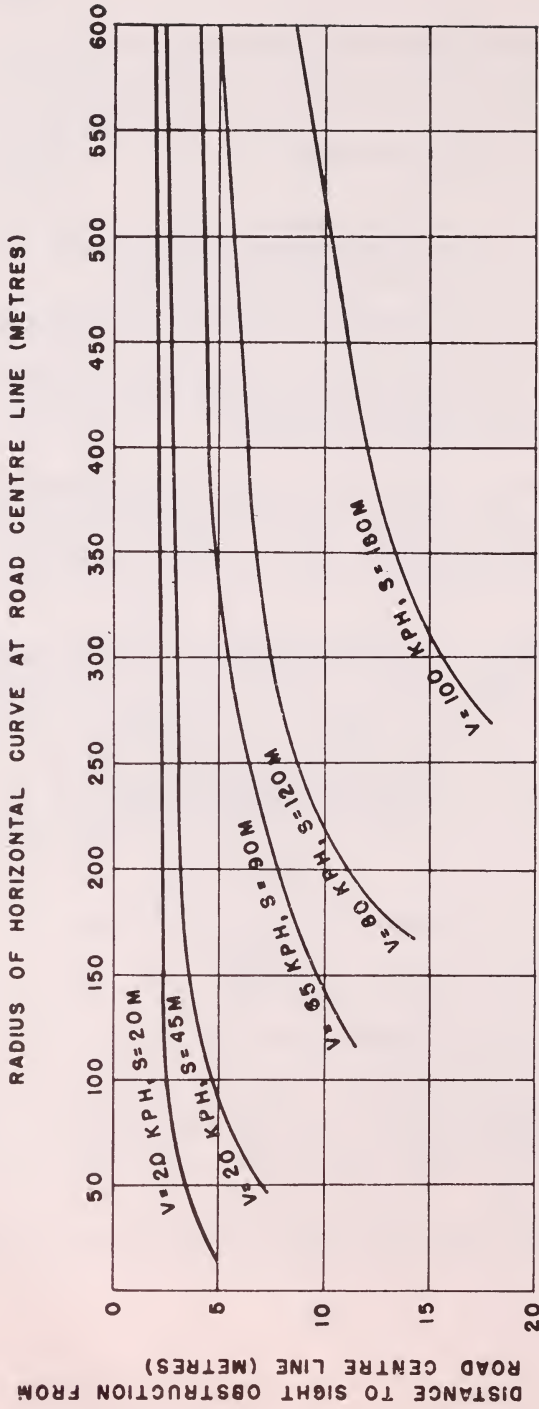
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Fig. 2. Minimum setback distance required at horizontal curves on two-lane roads for safe stopping sight distance

7.4. Lateral clearance for overtaking or intermediate sight distance could be computed similarly. Calculations would, however, reveal that the setback distance required will usually be too large to be economically feasible except on very flat curves.

7.5. When there is a cut slope on the inside of the horizontal curve, a practical consideration in providing the setback distance is the average height of sight line above the ground level. For stopping sight distance, the average height can be assumed as 0.7 m since the height criteria are 1.2 m for the eye and 0.15 m for the object. Cut slopes should be kept clear above this height at the midpoint of the sight line by cutting back the slope or benching. In the case of meeting or overtaking sight distance, height of sight line above the ground would be 1.2 metre.

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

8. MEASURING AND RECORDING SIGHT DISTANCES GRAPHICALLY

8.1. Provision of the required sight distance should receive care right from early stages when the alignment of a highway is still flexible and subject to adjustments. Quick appraisals are best had by graphical means. By determining the available sight distance graphically from plans and profile drawings, and recording it at convenient intervals, deficiencies in visibility can be detected in time so that necessary modifications could be made before detailed design.

8.2. Horizontal sight distances can be directly scaled from plans on which obstructions to visibility such as buildings, plantation, hill slopes etc., have been marked. The measurement is done with the help of a straight edge.

8.3. Measurement of vertical sight may be done from plotted profiles of the highway. A transparent straight edge with parallel edges 1.2 m apart and a dotted line 0.15 m from the upper edge as per the vertical scale of the profile is the tool employed for these measurements. The transparent strip is placed on the profile with the lower edge at the station for which available sight distance is desired and the strip revolved about this point till the upper edge touches the profile. Stopping sight distance available is then the

distance between the first station and the point of intersection of the dotted line with the profile. Overtaking and intermediate sight distances will be the distance between the initial station and the point where the lower edge of the strip meets the profile.

8.4. The horizontal and vertical sight distance whichever is smaller should be recorded on the plan—L section drawings. The available sight distance for stopping and overtaking should be shown in two separate columns below the profile drawing. Such records take up very little space on the drawings but are invaluable for highway design. These can also be used for fixing boundaries of the no-passing zones.

9. SIGHT DISTANCE AT INTERSECTIONS

9.1. General

9.1.1. Visibility is an important requirement at intersections. To avoid collisions, it is essential that sufficient sight distance is available along the intersecting roads and their included corners, to enable the operators of vehicles simultaneously approaching the intersection to see each other in time.

9.1.2. At-grade intersections can be broadly grouped under two headings:

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

(ii) 'Priority intersections', like minor-major road intersections, where one road takes virtual precedence over the other. Traffic on the minor road may be controlled by STOP on GIVE WAY signs/road markings, making it clear that the other road has the priority.

9.2. Uncontrolled Intersections

9.2.1. At these intersections, visibility should be provided on the principle that the drivers of vehicles on either highway are able to sight the intersection and the intersecting highway in good time to be able to halt their vehicles if that becomes essential. The area for clear visibility should be determined with respect to the stopping sight distance for each highway corresponding to the design speed, Table 1.

9.2.2. Minimum sight triangles in the included corners of uncontrolled intersections, which must be kept free of all obstructions to sight, could be demarcated as illustrated in Fig. 3. If visibility conditions upto this standard are ensured, drivers of vehicles will be able to either stop or adjust their speed in the event of a dangerous situation ahead.

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V_1, V_2—DESIGN SPEED OF ROAD
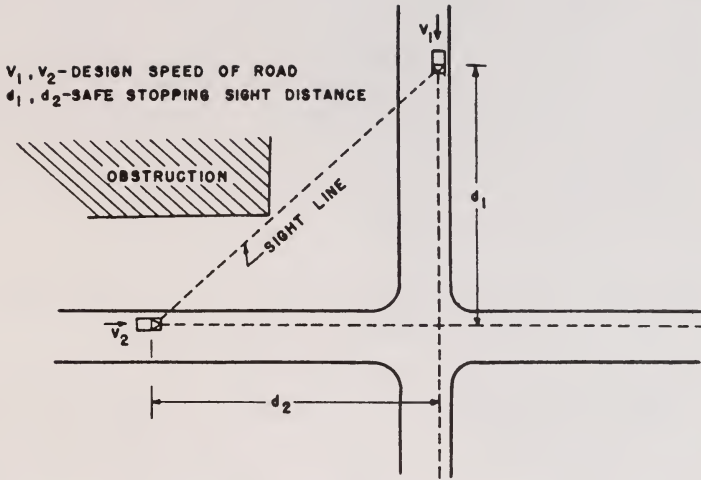d_1, d_2—SAFE STOPPING SIGHT DISTANCE

Fig. 3. Minimum sight triangle at uncontrolled intersections

9.2.3. Occasionally, the size of the sight triangle available may be less than the desirable minimum due to presence of an obstruction which cannot be removed except at prohibitive cost. In such circumstances, the vehicles must be appropriately warned to travel at speeds corresponding to the available sight distance and not at the design speed of the highway. One solution can be to permit vehicles on one of the roads to travel at the design speed and evaluate the corresponding critical speed for the other road which might be posted. Alternatively, the approach speed for both the roads could be restricted in accordance with the sight triangle available by installing suitable speed limit signs.
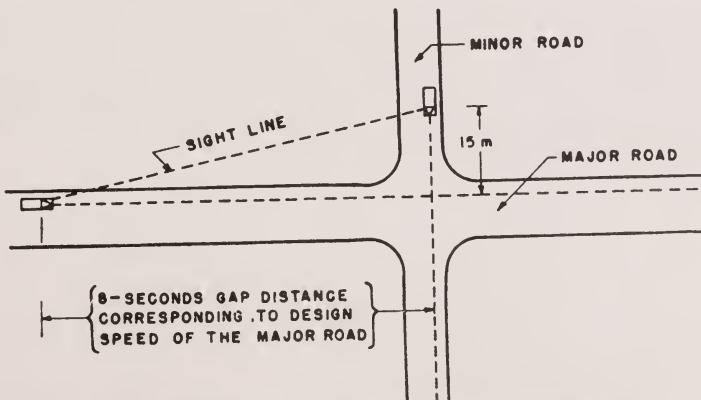

Fig. 4. Minimum sight triangle at priority intersections

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9.3. Priority Intersections

9.3.1. On priority intersections, the visibility provided should be such that drivers approaching from the minor road are able to see vehicles on the major road in adequate time and to judge whether the required gap is available in the main road traffic stream for a safe crossing so that the vehicle could be brought to a halt, if necessary. For this purpose, a minimum visibility distance of 15 m along the minor road is recommended.

TABLE 4. MINIMUM VISIBILITY DISTANCES ALONG MAJOR ROADS AT PRIORITY INTERSECTIONS

Design speed of major road (kmph)	Minimum visibility distance along major roads (metres)
100	220
80	180
65	145
50	110

9.3.2. Visibility distance along the major road depends on the time required by the driver on the minor road to perceive the traffic conditions on the intersection, evaluate the gaps in the vehicle stream, take a decision about actual crossing, and finally to accelerate the vehicle to complete the manoeuvre. The total time required for these operations may be taken as 8 seconds. On this basis, the sight triangle at priority intersections should be formed by measuring 15 m along the minor road and a distance along the major road equal to 8 seconds travel at the design speed. This is illustrated in Fig. 4. Visibility distances (rounded values) corresponding to 8 seconds travel time are set out in Table 4.

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