RECOMMENDED PRACTICE FOR TRAFFIC ROTARIES

THE INDIAN ROADS CONGRESS

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RECOMMENDED PRACTICE FOR TRAFFIC ROTARIES

1. INTRODUCTION

1.1. This Recommended Practice on Traffic Rotaries updates the original Paper on Traffic Rotaries prepared by the Specifications and Standards Committee and published in 1955 in Volume XIX of the Journal of the Indian Roads Congress.

The draft Recommended Practice was first examined by the following Group of the Traffic Engineering Committee constituted by the Specifications and Standards Committee in thei meeting held on the 1st February, 1974.

H.C. Malhotra	*—Convenor*
L.R. Kadiyali	*—Member-Secretary*
Dr. N.S. Srinivasan	*—Member*
R.P. Sikka	*—Member*

The Specifications and Standards Committee in their meeting held on the 5th of March, 1976 approved the modified draft with certain further improvements and authorised the following members to jointly modify the text and pass on the final draft for the consideration of the Executive Committee:

A.K. Bhattacharya
Dr. N.S. Srinivasan
R.P. Sikka

The revised draft was finally approved by the Executive Committee and the Council in their meetings held on the 22nd December, 1975 and 3rd January, 1976 respectively.

1.2. At-grade intersections have points of conflict which are potential hazards. Their design should provide for the drivers to readily discern the danger and make the necessary manoeuvres to negotiate the intersection with adequate safety and minimum of interference between vehicles.

A traffic rotary is a specialised form of "at-grade" intersection where vehicles from the converging arms are forced to move round an island in one direction in an orderly and regimented manner and "weave" out of the rotary movement into their desired directions.

By the very nature of the function, the design of the rotary elements needs special considerations, depending upon each site requirement. No standard designs can be fitted into any given set of site conditions, and each case has to be separately dealt with. This Recommended Practice lays down the guiding principles governing the design of traffic rotaries.

The recommendations given here do not cover 'miniroundabouts' which have lately been tried out in the United Kingdom.

2. DEFINITIONS (see also Fig. 1.)

(1) At-grade intersection : An intersection where all roadways join or cross at the same level.

(2) Diverging : The dividing of a single stream of traffic into separate streams.

(3) Intersection angle : The angle between two intersection legs.

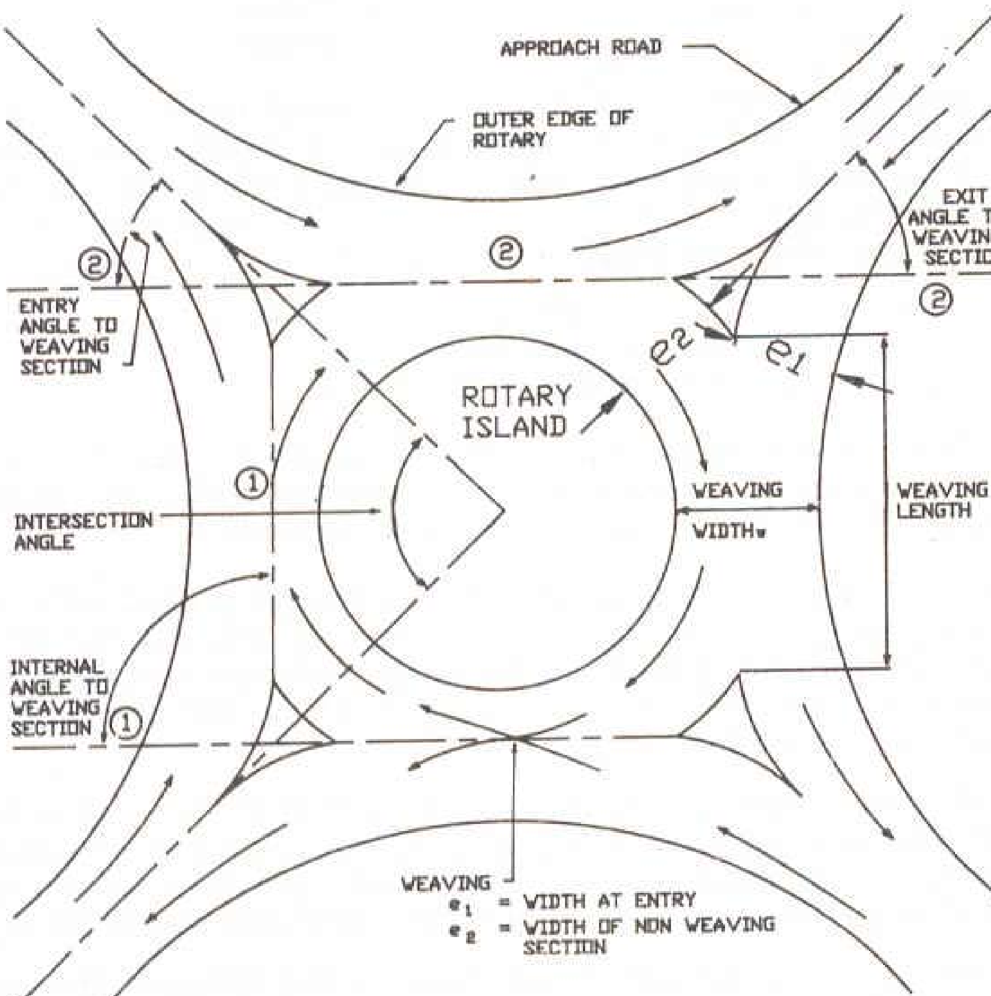

Fig. 1. Rotary elements

(4) Merging : The converging of separate streams of traffic into a single stream.

(5) Rotary Intersection : A road junction laid out for movement of traffic in one direction round a central island.

(6) Rotary Island : A traffic island located in the centre of an intersection to compel movement in a clock-wise direction and thus substitute weaving of traffic around the island instead of direct crossing of vehicle pathways.

(7) Weaving : The combined movement of merging and diverging of traffic streams moving in the same general direction.

(8) Weaving Length : The length of a section of a rotary in which weaving occurs.

3. GENERAL GUIDELINES FOR SELECTION OF ROTARY INTERSECTIONS

3.1. Advantages of rotary intersections

The advantages of traffic rotaries are :

(a) An orderly and regimented traffic flow is provided. Individual traffic movements are subordinated in favour of traffic as a whole.

(b) All traffic proceeds at a fairly uniform speed. Frequent stopping and starting are avoided.

(c) Weaving replaces the usual crossing movements at typical at-grade intersections. Direct conflict is eliminated, all traffic streams merging or diverging at small angles. Accidents occuring from such movements are usually of a minor nature.

(d) Rotaries are especially suited for intersections with five or more intersection legs though these can also be adopted at intersections with 3 or 4 legs.

(e) For moderate traffic, rotaries are self-governing and need no control by police or traffic signals.

3.2. Disadvantages of rotary intersections

(a) As the flow increases and reaches the capacity, 'weaving' generally gives way to a 'stop and go' motion as vehicles force their way into the rotary, being followed by vehicle waiting in the queue behind them. Under such conditions, vehicles, once having got into the rotary, may not be able to get out of it, because of vehicles across their path and the rotary may 'lock-up.' Once the rotary has 'locked-up', the movement of vehicles completely stops and the traffic will have to be ultimately sorted out by the police.

(b) A rotary requires a comparatively larger area and may not be feasible in many built-up locations.

(c) Where pedestrian traffic is large, a rotary by itself is not sufficient to control traffic and has to be supplemented by traffic police.

(d) Where the angle of intersection between two roads is too acute, it becomes difficult to provide adequate weaving length.

(e) The provision of rotaries at close intervals makes travel troublesome.

(f) Traffic turning right has to travel a little extra distance.

3.3. Guidelines for selecting a rotary type of intersection

Considering the above advantages and disadvantages of traffic rotaries and the general experience gained in their provision in this country and abroad, the following general guidelines may be kept in view when adopting a rotary design at an intersection :

(a) Circumstances where rotaries are an appropriate method of intersection control are largely dependent on the layout of the site, proportion of right turning traffic and the traffic characteristics of the routes. Rotaries are not generally warranted for intersections carrying very light traffic. These could be a good choice though for moderately busy intersections in urban and suburban areas, and also sometimes rural areas, where otherwise the alternative may be to go in for a complicated channelised layout or traffic signals. Normally the lowest traffic volume for which rotary treatment should be considered is about 500 vehicles per hour, of course, there could be exceptions from this rule depending on factors peculiar to the individual sites.

(b) Rotaries are most adaptable where the volumes entering the different intersection legs are approximately equal.

(c) The maximum volume that a traffic rotary can handle efficiently can be taken as about 3,000 vehicles per hour entering from all intersection legs.

(d) Rotaries are advantageous in locations where the proportion of right turning traffic at a junction is high. As a rough guide, it may be assumed that at a four-legged junction, a rotary is more justified than traffic signal control if the right-turning traffic exceeds about 30 per cent of all approaching traffic.

(e) A rotary is preferable if there are other junctions so near that there would be insufficient space for the formation of queues.

4. SHAPE OF ROTARY ISLAND

4.1. The shape and disposition of the rotary island depends upon various factors such as the number and disposition of the intersecting roads and the traffic flow pattern. The design of the rotary is developed by connecting the one-way entrance and exit roads to form a closed figure with at least the minimum weaving lengths interposed between two intersecting legs and then adjusting for the minimum radius of the rotary corresponding to the design speed. In doing so, it may be necessary to try out a number of alternatives, before selecting the best. While finalising the shape of the rotary island, traffic streams within the rotary should be given dominance over the streams of traffic entering from different roads. Asymmetric shapes, either wholly curved or with a combination of straight and curves may often provide the only satisfactory solution. The possibility of realigning one or more of the intersecting legs could also be considered to achieve the minimum weaving lengths and the desired intersection angles. Some of the more common shapes and disposition of the rotary islands are discussed below.

4.2. Circular

A circular shape is suited where roads of equal importance intersect at nearly equal angles and carry nearly equal volume of traffic, Fig. 2. Under these conditions, with a circular shape, a constant and regular flow is achieved.

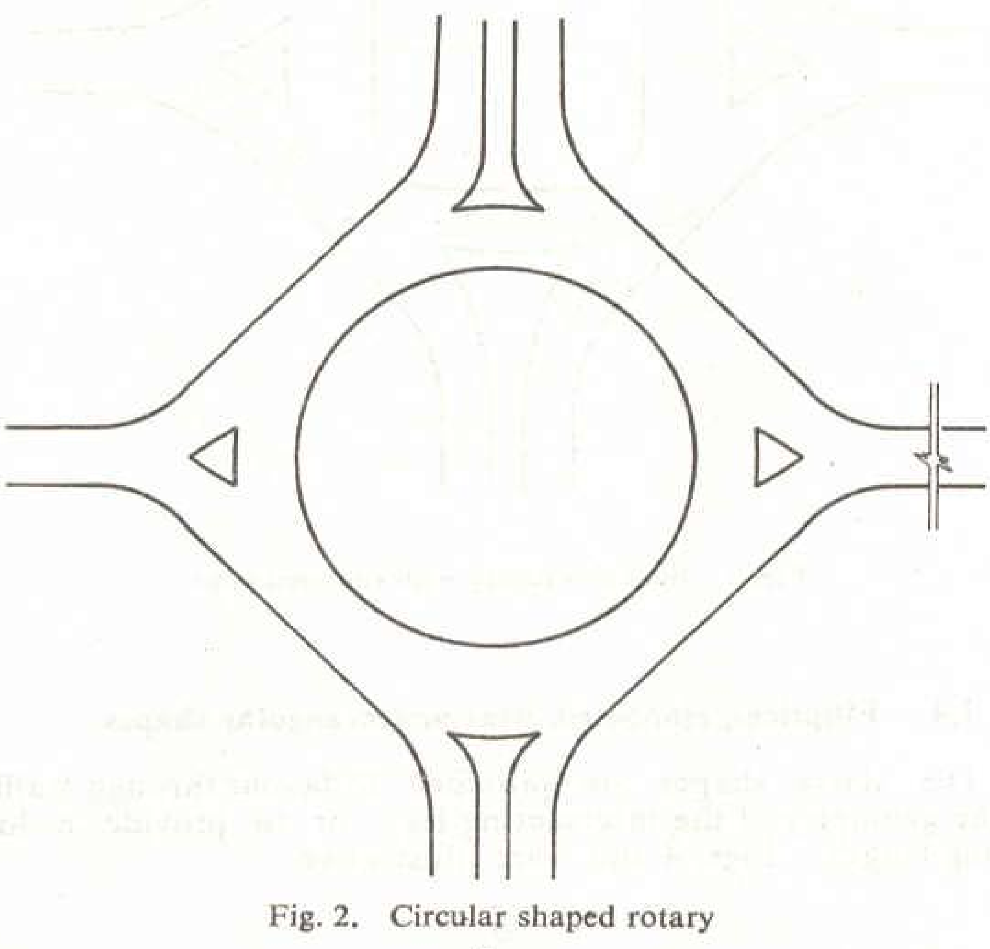

Fig. 2. Circular shaped rotary

4.3. Squarish with rounded edges

This is a modification of the circular shape and is composed of four straights or four large radii curves roughly forming four sides of a square, Fig. 3, and four small radii curves at the corners. The advantage of this layout is that it is suitable for predominantly straight a head flows.

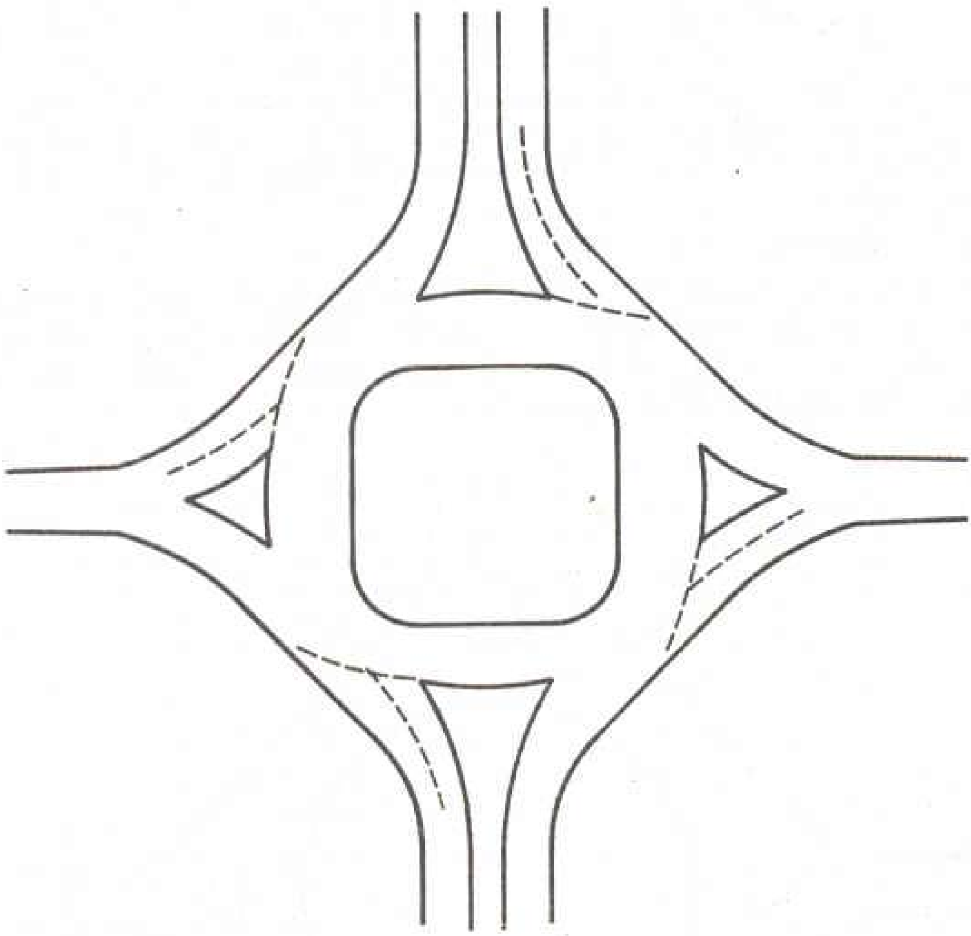

Fig. 3. Squarish rotary with rounded edge

4.4. Elliptical, elongated, oval or rectangular shapes

The above shapes are provided to favour through traffic, to suit the geometry of the intersecting legs, or to provide a longer weaving length. Figs. 4 and 5 are illustrative.

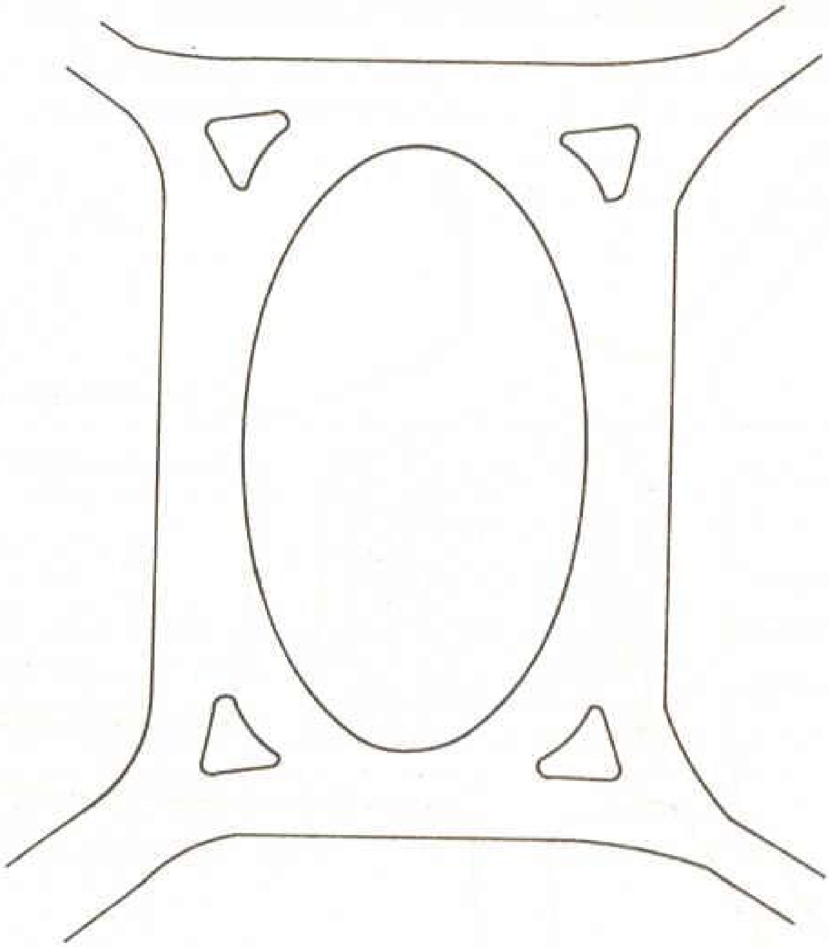

Fig. 4. Elliptical rotary

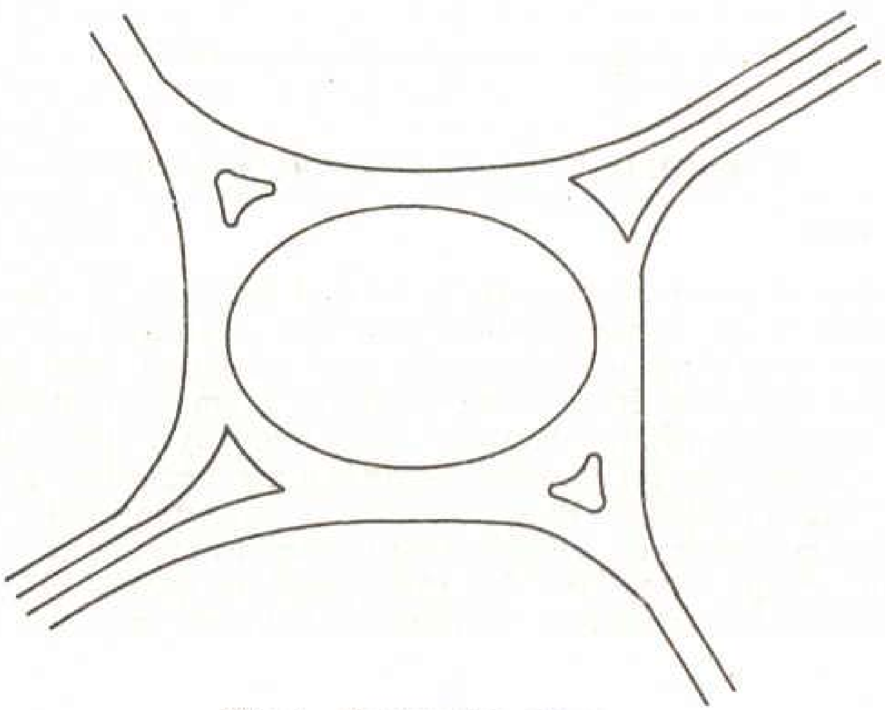

Fig. 5. Rectangular shape

4.5. Complex intersection with many approaches

Fig. 6 gives a layout of a complex intersection whose shape is dictated by the existence of a large number of approaches.

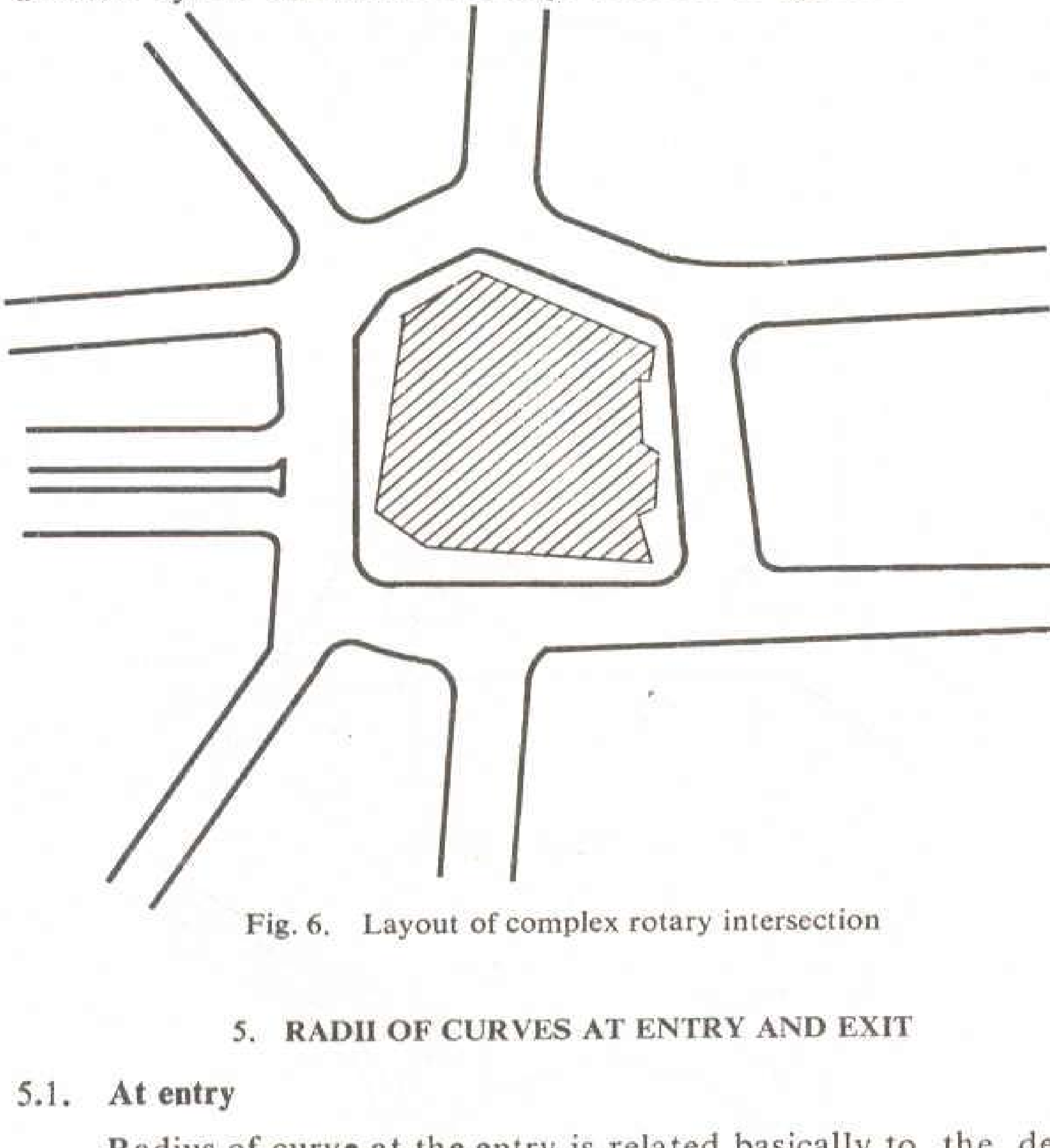

Fig. 6. Layout of complex rotary intersection

5. RADII OF CURVES AT ENTRY AND EXIT

5.1. At entry

Radius of curve at the entry is related basically to the design speed, amount of superelevation and the coefficient of friction. Since major intersections like rotaries are provided with advance information signs and drivers travel through them with anticipation of more critical conditions than on open highways, the values of coefficient of friction for purposes of design are regarded as higher than for other locations. Based on overall considerations, Table 1 below gives guidance for the selection of radii of curves at entry. In this table, range of values for the radius is given. The lower value is meant to ensure easy entrance of vehicles into the rotary, and the higher value to guard against any tendency for over-speeding.

TABLE 1

Rotary Design Speed V (K.P.H.)	*Suggested Values of Radius at Entry (metres)*
40*	20—35
30**	15—25

* Speed generally suitable for rotaries in rural areas.

** Speed generally suitable for rotaries in urban areas and other restricted locations.

5.2. At exit

The radii of the curves at exit should be larger than that of the central island and at entry so as to encourage the drivers to pick up speed and clear away from the rotary expeditiously. For this reason, the radius of the exit curves may be kept about $1\frac{1}{2}$ to 2 times the radius of the entry curves. If, however, there is a large pedestrian traffic across the exit road, radii similar to those at entrances should be provided to keep the exit speeds reasonably low.

6. RADIUS OF CENTRAL ISLAND

Theoretically, the radius of the central island should be equal to the radius at entry. In practice, however, the radius of the central island is kept slightly larger than that of the curve at entry, this being an attempt to give a slight preference to the traffic already on the rotary and to slow down the approaching traffic. A value of 1.33 times the radius of entry curve is suggested as a general guideline for adoption.

7. WEAVING LENGTH

The weaving length determines the case with which the vehicles can manoeuvre through the weaving section and thus determines the capacity of the rotary. The weaving length is decided on the basis of factors such as the width of the weaving section, the average width of entry, total traffic and the proportion of weaving traffic in it. The formula relating all these parameters is given in para 11 dealing with capacity of the rotary. As a general rule, effort should be made to keep the weaving length at least 4 times the width of the weaving section. The following minimum values of weaving lengths for different design speeds should be observed :

Design Speed (K.P.H.)	*Minimum Weaving Length (metres)*
40	45
30	30

In order to discourage speeding in the weaving sections, the maximum weaving length should be restricted to twice the values given above.

8. WIDTH OF CARRIAGEWAY AT ENTRY AND EXIT

The carriageway width at entrance and exit of a rotary is governed by the amount of traffic entering and leaving the rotary. When deciding upon the width, the possible growth of traffic in the design period should be considered. It is recommended that the minimum width of carriageway be at least 5 metre with necessary widening to account for the curvature of the road. Table 2 gives the value of the width of carriageway at entry inclusive of widening needed on account of curvature.

TABLE 2

Carriageway width of the approach road	*Radius at entry (m)*	*Width of carriageway at entry and exit (m)*
7 m (2 lanes)	25—35	6.5
10.5 m (3 lanes)		7.0
14 m (4 lanes)		8.0
21 m (6 lanes)		13.0
7 m (2 lanes)	15—25	7.0
10.5 m (3 lanes)		7.5
14 m (4 lanes)		10.0
21 m (6 lanes)		15.0

9. WIDTH OF ROTARY CARRIAGEWAY

9.1. Width of non-weaving section

The width of non-weaving section of the rotary, Fig. 7, should be equal to the widest single entry into the rotary, and should generally be less than the width of the weaving section.

9.2. Width of weaving section

The width of the weaving section of the rotary should be one traffic lane (3.5 m) wider than the mean entry width thereto. Referring to Fig. 7

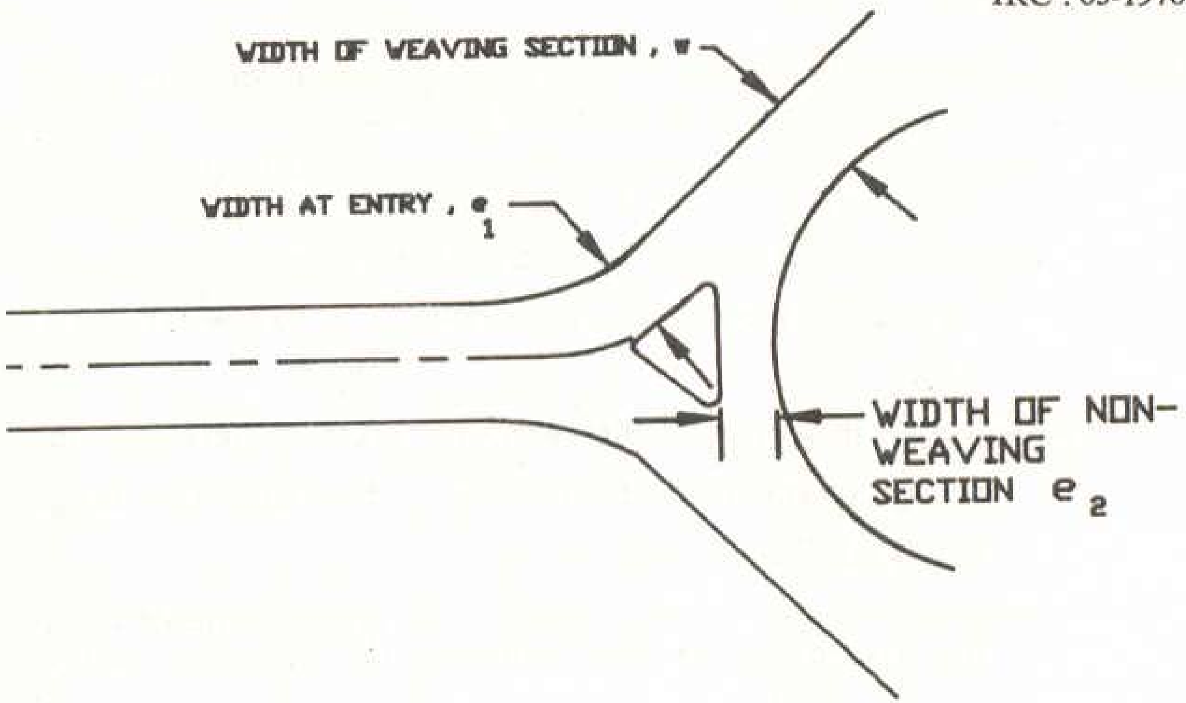

Fig. 7. Width of rotary carriageway

$$w = \frac{e_1 + e_2}{2} + 3.5$$

10. ENTRY AND EXIT ANGLES

Entry angles should be larger than exit angle, and it is desirable that the entry angles should be 60° if possible. The exit angles should be small, even tangential. An idealised design showing entry angles of 60° and exit angles of 30° is shown in Fig. 5. This condition can only be achieved by staggering the approach roads.

11. CAPACITY OF THE ROTARY

It is important that the geometric design evolved for the rotary should be able to deal with the traffic flow at the end of the design period on the rotary. The practical capacity of a rotary is really synonymous with the capacity of the weaving section which can accommodate the least traffic. Capacity of the individual weaving sections depends on factors such as (i) width of the weaving section (ii) average width of entry into the rotary (iii) the weaving length and (iv) proportion of weaving traffic and could be calculated from the following formula :

$$Q_p = \frac{280\, w\left(1 + \frac{e}{w}\right)\left(1 - \frac{p}{3}\right)}{1 + \frac{w}{l}}$$

Where Q_p=Practical capacity of the weaving section of the rotary in passenger car units (Pcu) per hour.

w=width of weaving section in metres (within the range of 6—18 m)

e=average entry width in metres (i.e., average of 'e_1' and 'e_2', as in Fig. 8), $\frac{e}{w}$ to be within a range of 0.4 to 1.00

l=length in metres of the weaving section between the ends of channelising islands ($\frac{w}{l}$ to be within the range 0.12 and 0.4)

p=proportion of weaving traffic, i.e., ratio of sum of crossing streams to the total traffic on the weaving section ($p=\frac{b+c}{a+b+c+d}$ as in Fig. 8), range of p being 0.4 to 1.0

The passenger car unit equivalents may be taken as follows :

Cars and light commercial vehicles (including 3 wheelers)	1.0
Buses and medium and heavy commercial vehicles	2.8
Motorcycles and scooters (2 wheelers)	0.75
Pedal cycles	0.5
Animal drawn vehicles	4 to 6

The following adjustments in the capacity calculated by the above formula are suggested :

(i) Where the entry angle (see Fig. 1 for definition) is between 0° and 15°, deduct 5 per cent from the capacity of the weaving section.

(ii) Where the entry angle is between 15° and 30°, deduct 2½ per cent from the capacity of the weaving section.

(iii) Where the exit angle (see Fig. 1 for definition) is between 60° and 75°, deduct 2½ per cent from the capacity of the weaving section.

(iv) Where the exit angle is greater than 75°, deduct 5 per cent from the capacity of the weaving section.

(v) Where the internal angle (see Fig. 1 for definition) is greater than 95°, deduct 5 per cent from the capacity of the weaving section.

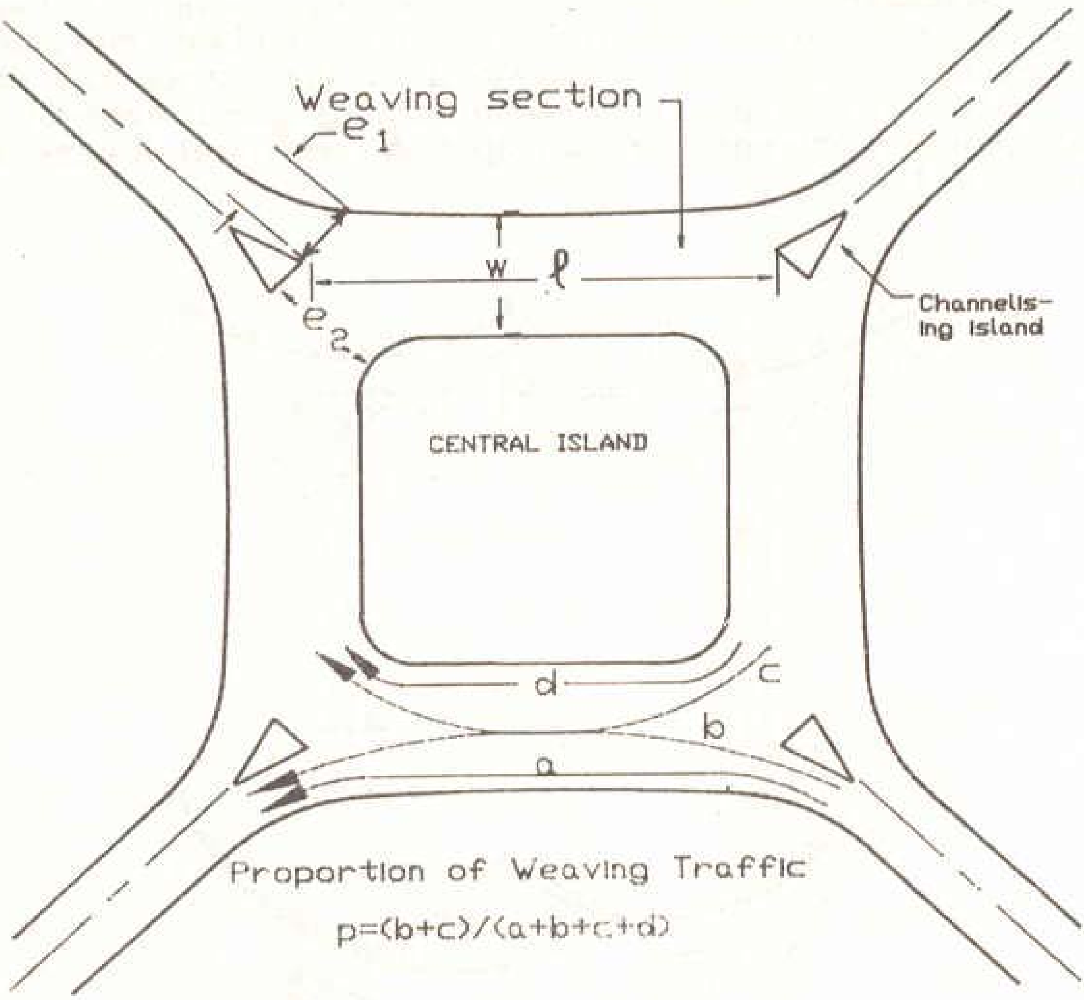

Fig. 8. Relevant dimensions of weaving section and proportion of weaving traffic for use in capacity formula for rotaries

(vi) Where the pedestrian flow at exit from the roundabout exceeds 300 per hour, an arbitrary deduction of one-sixth should be made in the practical capacity of the preceding weaving section.

While designing, care should be exercised that weaving sections are adequate for the required capacity so that merging and diverging manoeuvres take place smoothly. As a major disadvantage with rotaries is the reduction in speed, the weaving sections should preferably be kept slightly longer than just necessary for capacity, say 33 to 50 per cent more.

The capacity of a rotary can be increased above the value given in the above equation by signalizing the rotary intersection or introducing the off-side priority rule.

12. CHANNELISING ISLANDS

Channelization reduces the area of conflict between intersecting traffic streams and promotes orderly and safe movement. Channelizing islands must be provided at the entries and exits of a rotary. The shape of the channelizing island depends on actual conditions obtaining at each site. A few typical designs are illustrated in Fig. 9.

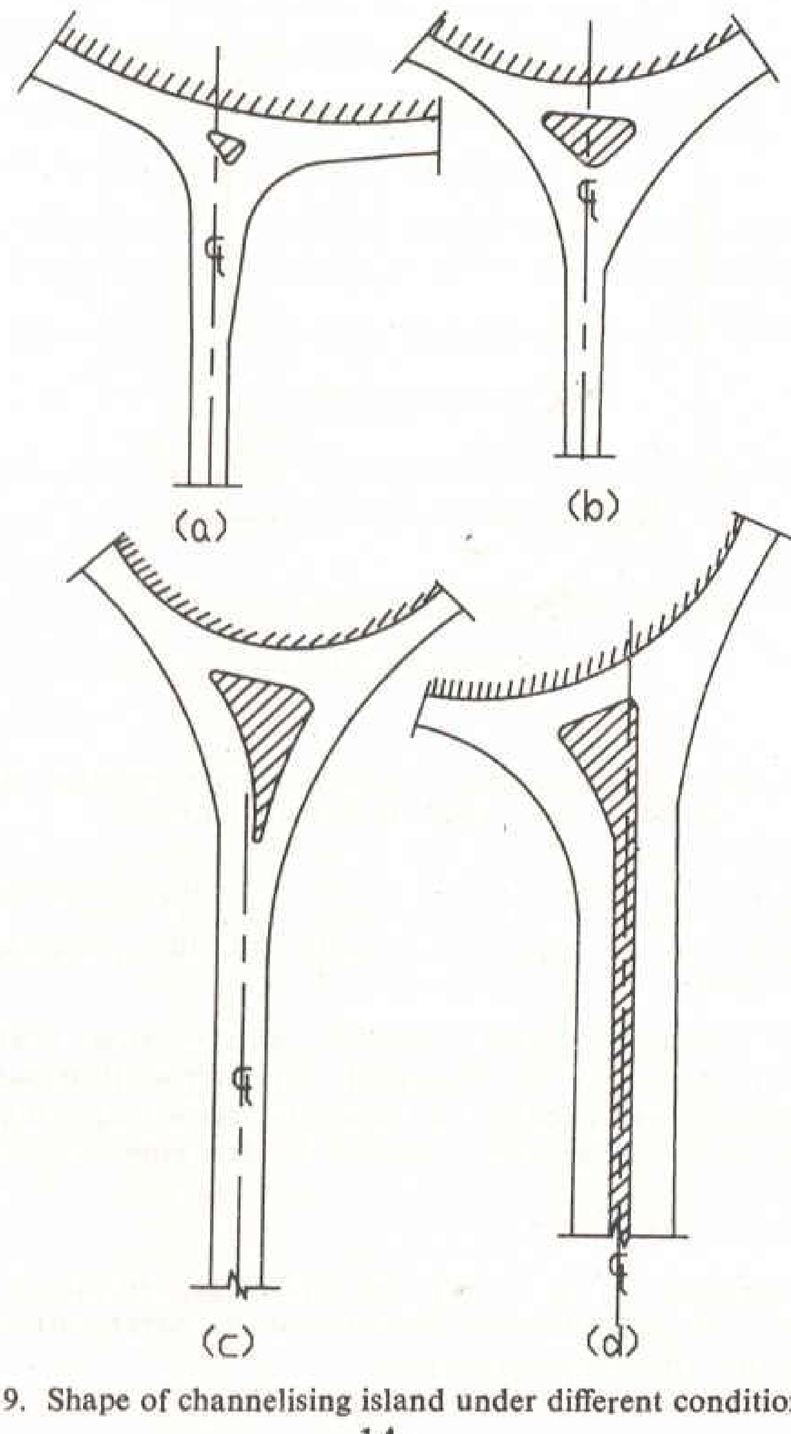

Fig. 9. Shape of channelising island under different conditions

How channelising islands can help in reducing speed at entry and encourage rapid exit can be seen from the principles of their design illustrated in Figs. 10 and 11.

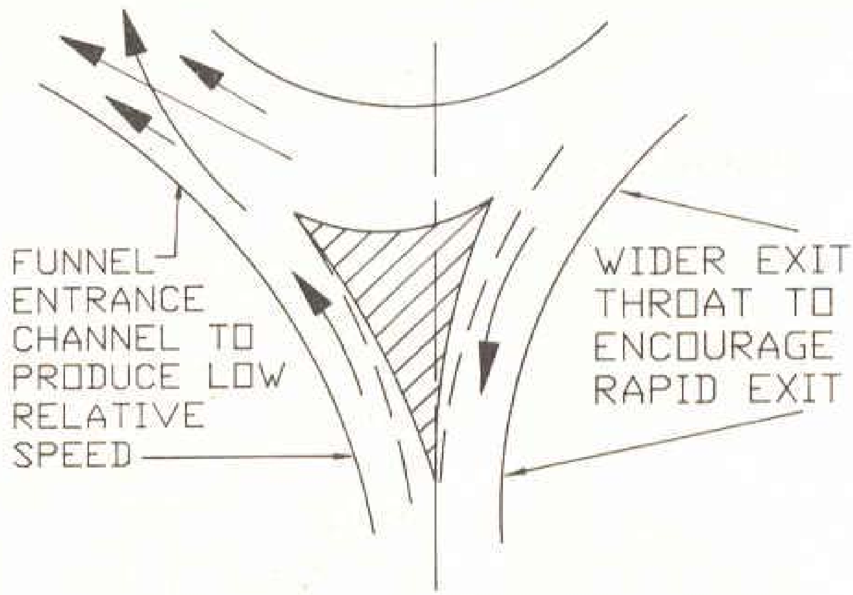

Fig. 10. Channelising island with funnel entrance and wider exit throat

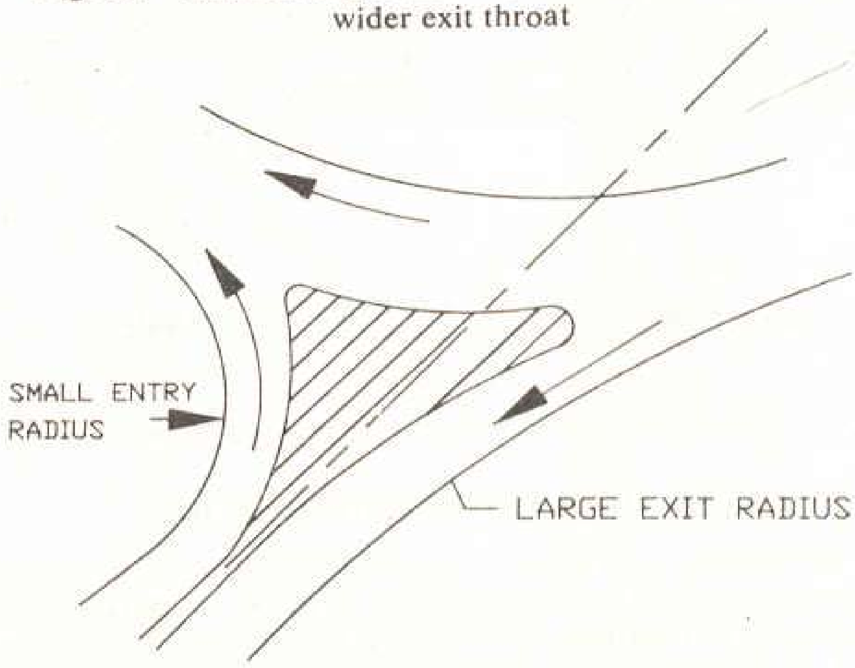

Fig. 11. Channelising island for skewed entry and exit

13. OUTER CURB LINE

The external curb line of weaving sections should not normally be re-entrant, but consist of a straight or large radius curve of the same sense as the entry and exit curves, Fig. 12. Such an arrangement eliminates waste of area which is not likely to be used by traffic.

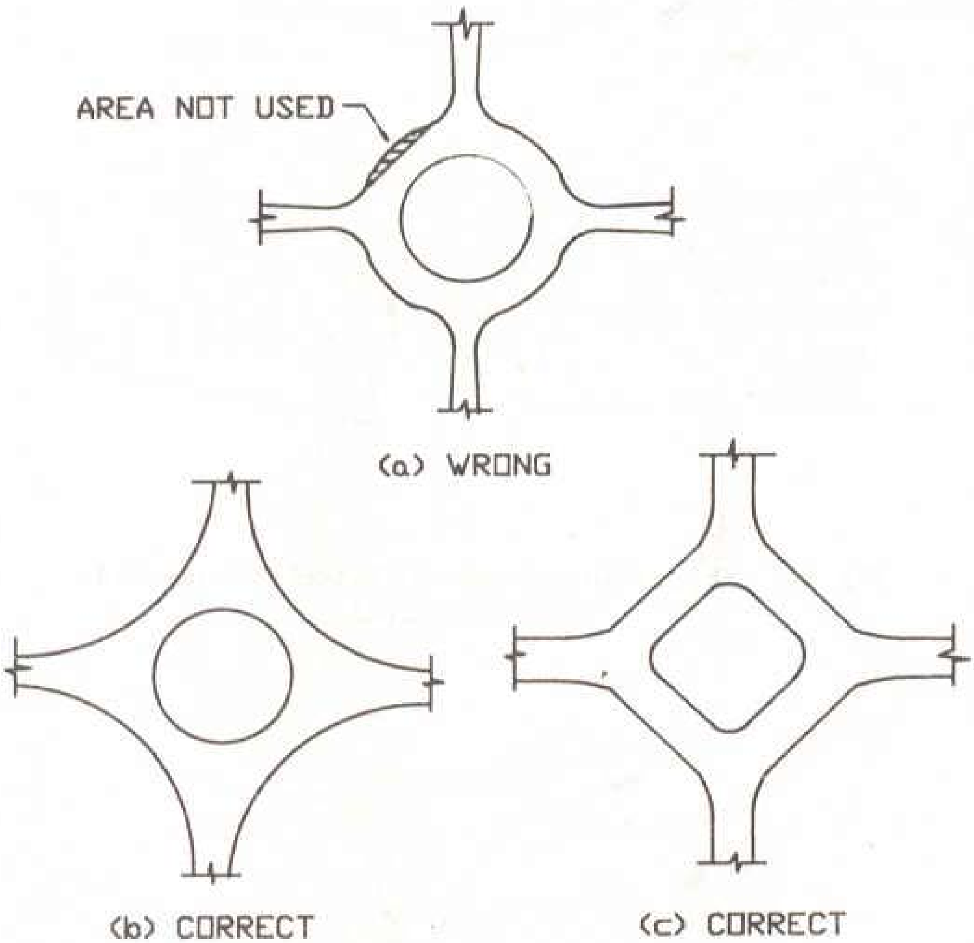

Fig. 12. External curb line of weaving sections

14. CAMBER AND SUPERELEVATION

Since the rotary curvature is opposite to that of entry and exit, vehicles, especially top-heavy buses and trucks, experience difficulty in changing over from one cross-slope to another in the opposite direction. It is, therefore, recommended that the algebraic difference in the cross-slopes be limited to about 0.07. The superelevation should be limited to the least amount consistent with design speed. The crown-line — which is the line of meeting of opposite cross-slopes—should, as far as possible, be located such that vehicles cross it while travelling along the common tangent to the reverse curve. Channelising islands should be situated on the peak with the road surfaces sloping away from them to all sides. Whenever possible, the cross-slope at an entrance should be carried around on the outer edge of the rotary to the adjacent exit, altering the slope slightly to suit the curvature in the rotary and the exit. A typical disposition of cross-slopes in a rotary is indicated in Fig. 13.

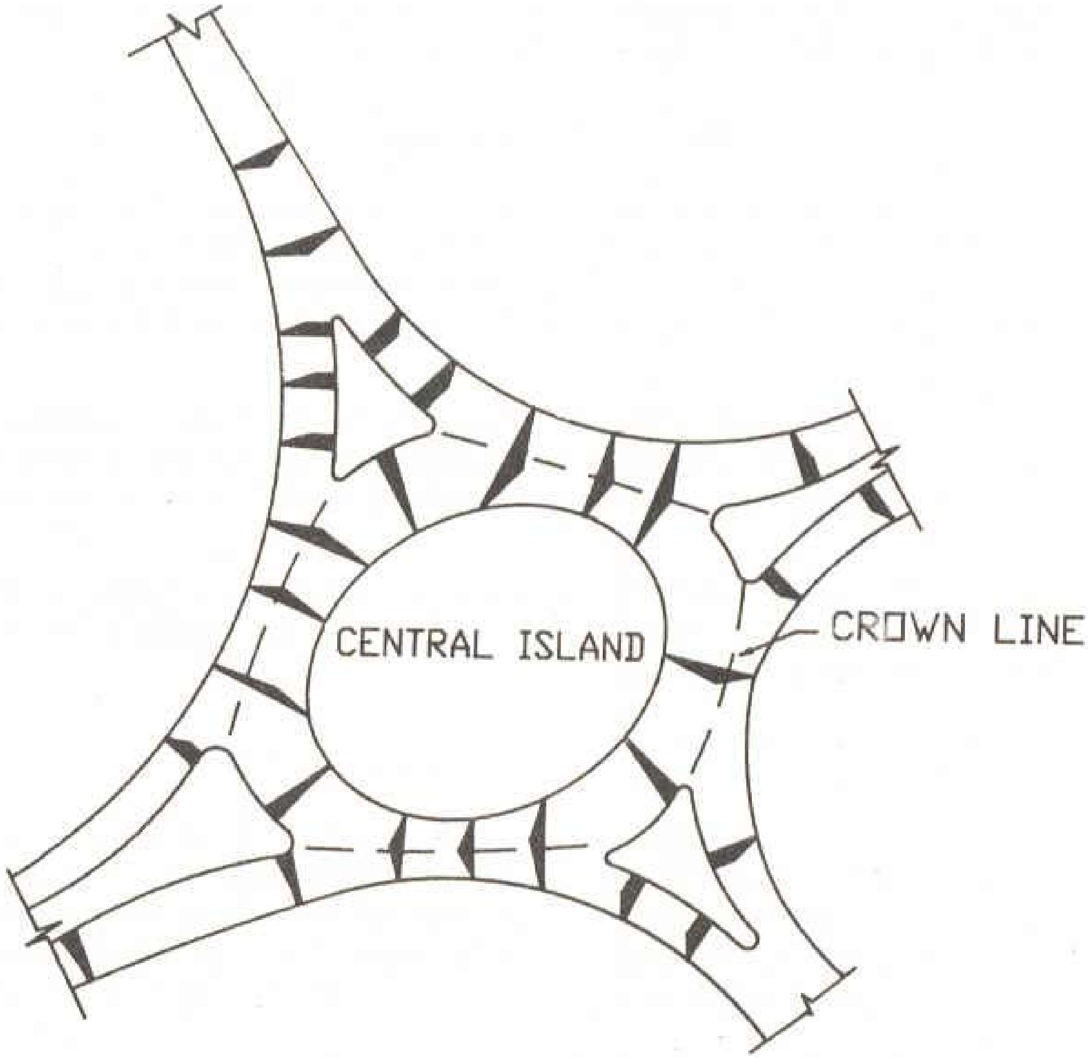

Fig. 13. Camber and superelevation at rotary

15. SIGHT DISTANCE

15.1. On approaches to the rotary, the sight distance available should enable a driver to discern the channelising and rotary islands clearly. A stopping sight distance appropriate to the approach speed should be ensured.

15.2. On the rotary itself, the sight distance should be adequate for vehicles first entering a rotary to see vehicles to their right at a safe distance. Similarly, once a vehicle is on a rotary in the middle of a weaving section, it should be possible for it to see another vehicle ahead of it in the next weaving section at a safe distance. In both the above cases, the stopping sight distance appropriate to the design speed in the rotary could be taken as the minimum to be provided. As a general guideline, the sight distance for the 30-40 KPH speed should range between 30 to 45 m.

16. GRADES

A rotary should preferably be located on level ground. It may be sited to lie on a plane which is inclined to the horizontal at not more than 1 in 50. It is, however, not desirable that a rotary be located in two planes having different inclinations to the horizontal.

A rotary may, with advantages be located on a summit. Such locations assist deceleration while approaching and acceleration while leaving the rotary. But it is essential that sufficient sight distance is available.

Rotaries in valleys always provide a full view to the approaching vehicles, but are likely to induce greater approaching speeds and have drainage difficulties.

17. CURBS

The curbs for channelising and central islands should be either vertical curbs or mountable curbs. In rural sections, it is desirable that the height of the curb of the central island is not more than 225 mm and a mountable type is preferable. In urban areas, the curb of the central island should not be so high as to obstruct visibility.

The curbs at the outer edges of rotary and at the approach roads (see Fig. 1) should preferably be of the vertical type in built-up areas to discourage pedestrians from crossing over. In such areas, the approaches should be provided with curbs upto a minimum distance of 30 metre from the point where the flaring of the approach starts. To aid quick drainage, for instance at the periphery of the rotary island, a combined curb and gutter type of section will be more desirable. Curbs at outer edges and at approaches can be omitted in open sections of rural highways, but suitable formation indicators may be placed at the edges of the roadway.

18. PEDESTRIANS AND CYCLES

Pedestrian crossings should be suitably provided as shown in Fig. 14.

It is desirable to segregate the cyclists by providing separate cycle tracks. The I. R. C. Recommended Practice for the Design and layout of Cycle Tracks (IRC: 11-1962) should be followed. A typical layout is shown in Fig. 14. Where the channelising island is short, as indicated at 'A' in the Figure, the cycle track should be led behind its tail. But where the island is long, as at 'B' in this Figure; a gap should be left in the island to accommodate the cycle track.

It is desirable to provide flashing signals to warn about pedestrian and cyclist-crossings at rotary legs.

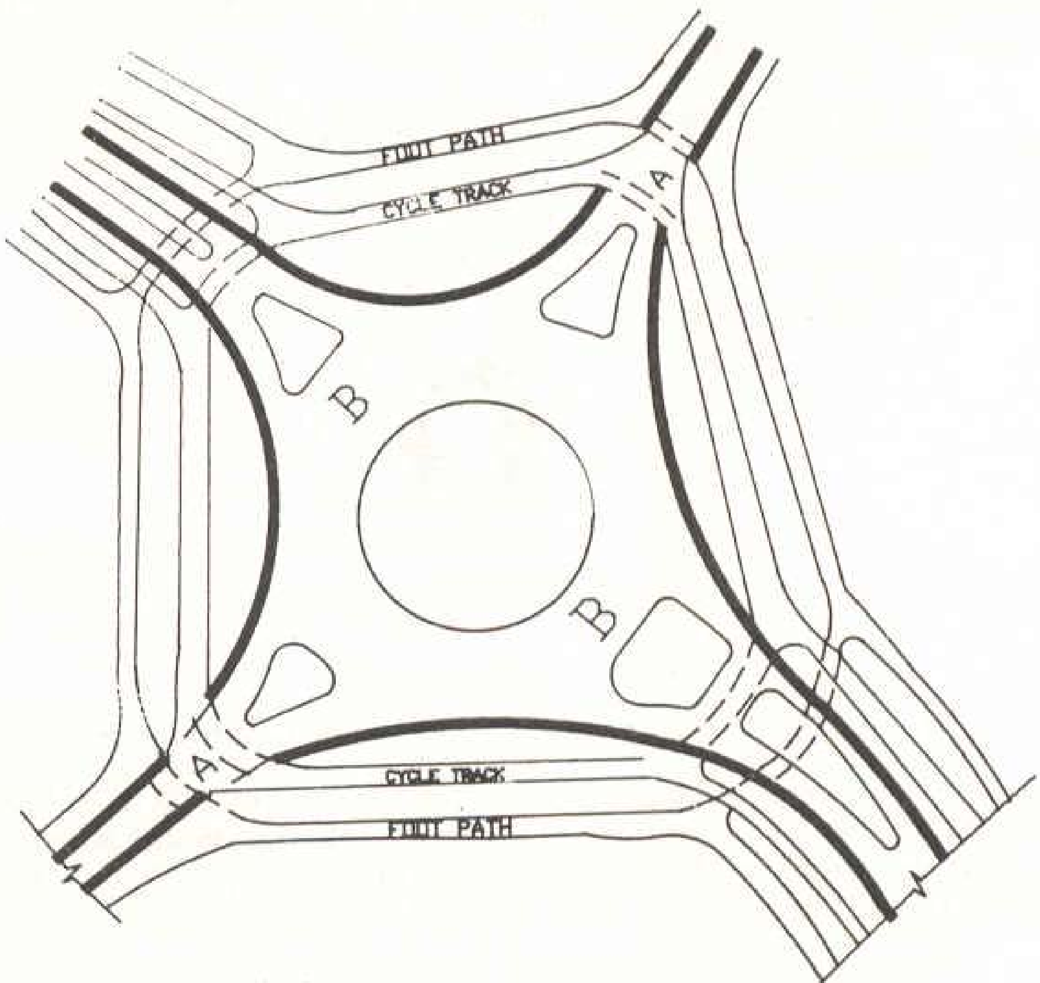

Fig. 14. Layout of cycle tracks and footpaths at a rotary

19. SIGNS AND MARKINGS

Rotaries require to be adequately designed both for day and night travel. A red reflector about one metre above the road level or a vertical cluster of such reflectors at a height of 0.3 to 1.0 m high should be fixed an the nose of each directional island, and on the curb of the central island facing the approach roads.

Curbs of the central and channelizing islands should be painted with vertical black and white stripes, each 500 mm wide, to improve visibility. All pedestrian and cyclist crossings should be provided with suitable pavement markings in accordance with IRC: 35—1970 "Code of Practice for Road Markings (with paints)".

Exit roads should be indicated by signs and directional arrows placed both on the edge of the central island and the directional islands, or in the absence of the latter, at the corner of the exit roads and facing the approaching vehicles.

The standard warning sign indicating the presence of a rotary, which should be put up in advance, is given in Fig. 15.

Fig. 15. Warning sign—rotary

20. ILLUMINATION

Illumination of the rotary junction at night is very desirable.

If the central island is small, viz., less than 20 m in diameter, satisfactory result is obtained by a single lantern having a symmetrical distribution and mounted centrally at a height of 8 metres or more, mounting height of 9-10 m is often advantageous.

For larger diameter central islands, the principles illustrated below may be used, Fig. 16.

(a) Lanterns A to be provided above the curb of the central island in line with each approach traffic lane; the back of these lanterns should be obscured.

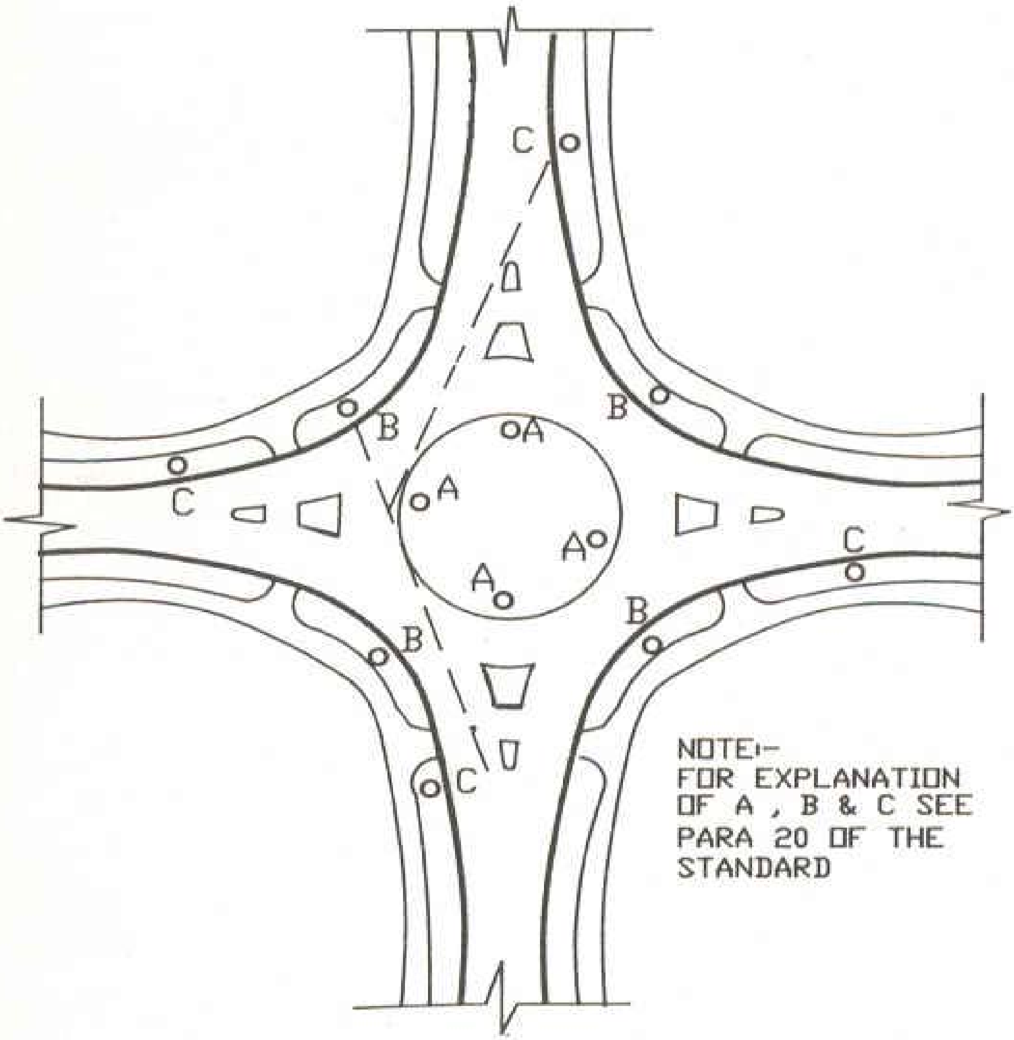

Fig. 16. Illumination of rotary

(b) Lanterns B, one or more in number, to be provided above each section of the outer curb of the rotary, for rotaries having central islands of 30 m or more diameter.

(c) Lanterns C to be provided especially when pedestrians cross at the channelizing island.

In general, the street lighting lanterns should not be mounted on the channelizing islands.

21. LANDSCAPING

A rotary provides ample scope for effective development of the landscape. But all such development should only be ancillary to the essential object of traffic control, viz., the reduction in the speed of vehicles and the advance indication of the paths to be followed by vehicles. Planting on the central island should block off the view of approaching headlights so that an impression is not created that a road runs straight through. But once the motorist has entered the rotary, it is desirable that he gets an unobstructed view for adequate distance along the chord of the curve to be able to pick off the particular exit road that he wishes to take. Overhead electric and telephone cables should be discouraged.

22. DRAINAGE

Adequate attention should be paid to drainage within the area of the rotary junction. Particularly, the water likely to accumulate at the edges of the rotary island should be drained by means of curb and gutter section having an outlet to underground pipes through appropriately placed gulley traps.